Training Deficiencies in Airport Surface Operations at Night

by

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ABSTRACT

There are significantly higher rates of pilot error events during surface operations at night than during the day. Events include incidents, accidents, wrong surface takeoffs and landings, hitting objects, turning on the wrong taxiway, departing the runway surface, among others. There is evidence to suggest that these events are linked to situational awareness. Improvements to situational awareness can be accomplished through training to instruct pilots to increase attention outside of the cockpit while taxiing at night. However, the Federal Aviation Administration (FAA) night time requirements are relatively low to obtain a private pilot certification. The purpose of this study was to determine the effect of flight training experience on conducting safe and incident-free surface operations at night, collect pilot opinions on night training requirements and resources, and analyze the need for night time on flight reviews. A survey was distributed to general aviation pilots and 239 responses were collected to be analyzed. The responses indicated a higher observed incident rate at night than during the day, however there were no significant effects of night training hours or type of training received (Part 61, Part 141/142, or both) on incident rate. Additionally, higher total night hours improved pilot confidence at night and decreased incident rate. The overall opinions indicated that FAA resources on night flying were effective in providing support, but overall pilots were not in support of or against adding night time requirements to flight reviews and found night training requirements to be somewhat effective.

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Training Deficiencies in Airport Surface Operations at Night

Training and safety are two of the most important aspects of the field of aviation. Pilots, air traffic controllers, dispatchers, and other positions within the aviation industry undergo extensive and continuous training to stay competent, current, and safe. Safety is a topic the Federal Aviation Administration (FAA) is constantly exploring and improving. One way the FAA improves safety is by changing and adapting certification standards and recurrent training standards. Another is to encourage pilots to seek out training and educational material published by the FAA (Federal Aviation Administration [FAA], 2013).

Of particular interest to the FAA recently have been runway incursions, formally defined as "any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle, or person on the protected area of a surface designated for the landing and takeoff of aircraft" (FAA, 2016b). Such incidents may include entering a runway without a clearance from ATC, landing without a clearance, or issuing a takeoff clearance that would create a collision hazard, among others. In the United States alone, an average of three runway incursions occur every day, and 60% of runway incursions are caused by pilots (FAA Safety Briefing, 2014).

Due to many reasons such as pilot error, weather, or operational error, incidents can occur during surface operations in addition to runway incursions. Rates of incidence are particularly high among general aviation pilots, or pilots operating under the Code of Federal Regulations Part 91 as private carriage and flight training (FAA Safety Briefing, 2014). Part 91 also includes any commercial flight not considered common carriage such as a corporate flight. In addition to this, there is a statistical significance when comparing the rate of incidence among general aviation pilots conducting surface operations at night versus during daylight hours (Whittard, 2019).

This difference may be attributed to the training requirements for private pilots being relatively low. Only 10 night landings and three hours of night flying are required to become certified as a private pilot (14 C.F.R. Part 61, 2019). Once a private pilot certificate is earned, it never expires and must stay current through a flight review that is required to have been done within the previous 24 calendar months (14 C.F.R. Part 61, 2019). With the flight review requiring no night training review, a pilot may conduct night flights throughout the rest of their aviation career solely with the three initial night hours required during initial training.

The purpose of this study is to determine the effect of flight training experience on conducting safe and incident-free surface operations at night, collect pilot opinions on night training requirements and resources, and analyze the need for night time on flight reviews. The responsibility of safe operation lies with many parties. The FAA is responsible for establishing training standards that will reduce the potential for hazardous situations. Flight schools and instructors are responsible for training students to conduct all phases of flight at any time of day in a safe manner. Additionally, pilots have the responsibility to continue striving for safety and completing currency training and review throughout their careers.

Literature Review

Types of Error

Surface operations for pilots include more than taxiing onto, taking off from, and landing on the runways themselves. From the moment the engine or engines are started, the pilot must taxi from the parking ramp to the taxi route to the runway, then take off from the runway. After reaching the next airport, the pilot must land on the runway, taxi off, and get back to the parking ramp safely. This is done every day by pilots in all kinds of conditions, including low visibility, high visibility, night, day, on wet surfaces, dry surfaces, or icy surfaces, and at busy, small, underfunded or uncontrolled airports.

Runway incursions, surface incidents, and surface events are all errors that can occur when there is an unauthorized movement within a runway, movement area, or any movement that could affect the safety of flight (FAA, 2013). These surface errors can be classified into several categories according to type of error including pilot deviations, operational errors, or environmental influences. The following discussion includes all types of civilian operations including commercial and general aviation.

A study of data drawn from the Aviation Safety Reporting System (ASRS) classified 72% of runway incursions by civilian operators as pilot deviations (Cistone, 2014). According to the FAA (2016), a pilot deviation is defined as "the actions of a pilot that result in the violation of a Federal Aviation Regulation" (p. 14-30). Supporting this, Campbell (2015) conducted a study of data also drawn from the ASRS database of civilian operations from 2013-2014. This study revealed that 119 of 188 reports (63%) of runway incursion were due to pilot deviation.

Contrary to these indications, the Australian Transportation Safety Bureau (2010) found the primary factors contributing to misaligned takeoffs were environmental factors. Environmental factors include the physical layout of the airport, weather, and confusing taxiway markings/lighting among others. The Australian Transportation Safety Bureau (2010) then named operational factors as being relatively common. Operational errors are defined as events that occur due to error on the part of Air Traffic Control.

To focus on the category of pilot deviations, error can be further classified into more navigational categories. Hooey and Foyle (2001) studied errors during the taxi portion of surface operations and created a taxonomy of three classes of pilot navigational errors. These include planning, decision, and execution errors. For example, planning could include an erroneous taxi plan that was then executed correctly whereas decision errors arise when intersections or turns are incorrectly identified and execution errors involve carrying out the taxi incorrectly. Hooey and Foyle (2006) observed 150 high-fidelity simulations and found 26 navigation errors (17.3%). These navigation errors all fall under the category of pilot error. Because of the high incidence of pilot error, in both studies collecting ASRS data and simulated events, this research will focus on pilot error and exclude data on operational and environmental errors.

Contributing Factors

Pilot deviations can be broken down further into contributing factors. Difiore and Cardosi (2006) analyzed reports in the ASRS database filed by pilots at 34 of the busiest airports in the United States, finding 55% of reports cited communication as the main causal factor. Inadequate position awareness was found in 40% of reports with 25% of reports attributed to skill-based errors and 23% to airport surface issues. Cistone (2014) supported these findings by citing pilot confusion for 39% of pilot deviation reports, and lack of positional awareness and pilot distraction each accounted for 10% of reports.

Additionally, Cistone (2014) claimed that when it comes to the nature of surface errors, the predominant causal factor was skill-based errors. Skill-based errors are then followed by physical environment, communications, coordination, planning, and decision errors. Skill-based errors are categorized further into sub-factors such as inadequate visual lookout, failure to maintain control, and failure to maintain clearance (Cistone, 2014). The Aircraft Owners and Pilots Association (n.d.) does not classify surface errors specifically, but does name several contributing factors. Included in these contributing factors are inadequate preparation that leads to disorientation, lack of focus, and lack of situational awareness.

General Aviation

General aviation is a term used to describe a wide range of flying scenarios including any civilian operations except by an air carrier. This can include training, sightseeing, personal flying, corporate flights, and emergency medical services. (FAA, 2016a). Out of all the reported surface errors in the ASRS database, 72% were caused by pilot error (Cistone, 2014). However this included Part 121, 129, 91, 125, 135, and 137 operations. This research will analyze specifically Part 91 operations, or general aviation operations. If reports are isolated to general aviation operations, the portion of incidents attributed to pilot deviations make a notable increase from 1998 to 2001. In 1998 ASRS reports indicated 65% of incidents were due to pilot deviations, which rose to 72% in

2000 and 77% in 2001 (Campbell,2015). Cistone (2014) indicated that general aviation operations have more than double the amount of skill-based errors due to pilot error than commercial operations.

One causal factor of these skill-based errors was inadequate visual lookout which made up just 11.1% of commercial operation ASRS reports in contrast to 45.8% of general aviation reports (Cistone, 2014). Supporting this statistic, Zhang et al. (2019) indicated that in order to successfully execute surface operations, pilots rely on external navigation markings such as airport signage. If general aviation pilots are prone to inadequate visual lookout, it would be expected to find a higher number of surface incidents among Part 91 pilots.

Nighttime Conditions

Low Visibility Conditions

Surface deviations occur in all visibility conditions and times of day, however there is a statistically significant difference in events that occur during the day versus night. A quantitative analysis of general aviation incidents between 2013 and 2018 occurring on the surface of the airport at night and during the day was completed. Whittard (2019) found that 19.5% of incidents were characterized as pilot confusion at night whereas 5.6% of day incidents were due to pilot confusion. A chi square test revealed the difference in these incidents was significant, meaning that it is unlikely that by chance there is a higher rate of pilot error on the surface at night.

Figure 1

Surface Deviations at Night

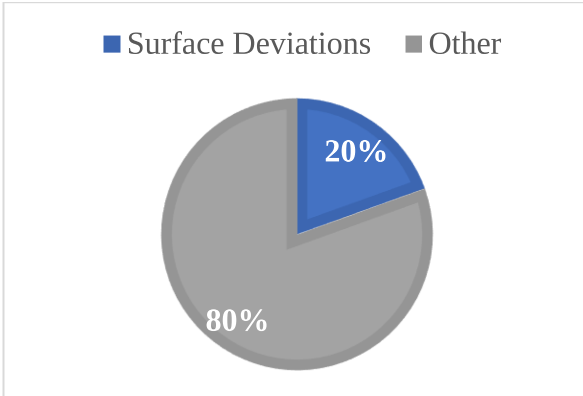
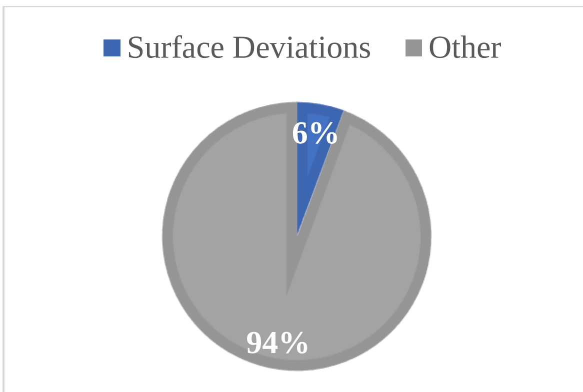


Figure 2

Surface Deviations during the Day



Pilots have a reduced amount of visual cues available to them to navigate safely at night. The Australian Transportation Safety Bureau (2010) points out that pilots must rely on lighting patterns and the visual field illuminated by the aircraft lights at night. This is a much more limited amount of visual cues than are available for day flights, and may contribute to the higher rate of incidence.

However, Cistone (2014) concluded that high percentages of surface deviations at night may be attributed to more than the precondition of low visibility operations, such as skill-based errors by pilots. Supporting this was Hooey and Foyle's (2006) study of surface operations. This revealed that pilots committed navigation errors in 17% of trials in low-visibility and night conditions. All but one of these errors occurred in night visual meteorological conditions (VMC) which is the highest visibility condition for pilots. Only one error occurred during the day, despite the day conditions being as low as 700 feet of forward visibility. This would suggest nighttime errors are not inherently due to low visibility conditions or more would have been committed in the lower visibility day conditions.

Furthermore in classifying environmental preconditions, it was found that commercial operational errors were by far attributed mostly to obstructed visibility as one might expect in nighttime conditions. Despite this, general aviation operations had more than twice as many reports attributed to object location on airport surface (Cistone, 2014). It can be inferred that in general aviation operations, visibility conditions are a much smaller contributing factor and as such nighttime should not lead to an increase in surface errors. Because surface incidents do increase after dark, error must not be due entirely to the precondition of low-visibility.

Situational Awareness

Zhang et al. (2019) stated that excessive mental workload and inadequate situation awareness consistently led to increasing the chance of pilot error. As such, poorer situational awareness causes pilots to make more errors. Therefore Zhang et al. (2019) claimed nighttime conditions have the potential to contribute to navigation errors as nighttime is associated with an increase in mental workload and decrease in situational awareness. Zhang et al.'s (2109) simulation study conducted in nighttime conditions indicated a decrease in disorientation with an increase in pilot visual lookout. Low situational awareness is often named as a top contributing factor in the previously mentioned studies on skill-based errors.

The Australian Transportation Safety Bureau (2010) suggested that distraction arises when multiple tasks are competing for a pilot's attention, distracting from the original focus of the operation. Continued support for the claim that surface deviations due to pilot error are the result of lack of situational awareness, Zhang et al. (2019) conducted a simulator study to explore the effect of time of day on navigation while tracking eye movement. It was found that the fixation rate inside the cockpit during day operations was higher whereas night operations resulted in a higher fixation outside the cockpit. More focus outside the cockpit should indicate a higher situational awareness. This was confirmed by the results of the study as more errors occurred in the daytime conditions. With more focus and longer fixation time on the important cues outside the cockpit, the pilots had increased situational awareness. Therefore, there was no higher error rate at night as the pilots maintained a higher degree of situational awareness than during the day simulations.

Decision Making

Situational awareness is crucial for good decision making which is in turn important to pilots during surface operations. Lange et al. (2011) researched the decision-making process of the brain based on presented stimuli. In this study, participants were presented with arrows on a screen that were either low or high visibility and the participant was asked to indicate the direction. Lange et al. (2011) indicated, "strategic effects on decision-making strongly depend on the awareness level of the stimuli". Awareness was strongly reduced with visibility as the participants were unable to tell how accurately they had chosen a direction of lower visibility arrows versus higher visibility arrows. This suggests the accumulation rate of evidence is different for low and high visibility stimuli. Additionally, the magneto-encephalographic recorders indicated the initial perception of an arrow was identical in both low visibility and high visibility arrows, it was the processing of the arrow stimuli that was delayed in low visibility. This suggests low visibility environments cause a delay in processing of information, possibly leading to lower situation awareness.

It is clear that pilots need more focus in these low visibility environments in order to improve decision-making skills. In Zhang et al.'s (2019) eye-tracking study, the increased fixation at night lead to the ability of the pilot to process the visual information and increase the effectiveness of their decision-making process. This explains the lower error rate in the night simulations.

Training

Provided that surface deviations occur not because there is low visibility at night, but because general aviation pilots do not have the situational awareness that is necessary for the decision-making process in low-visibility environments, it is necessary to analyze the training general aviation pilots receive. In order to become a private pilot, the FAA requires 40 hours at a minimum of flight training. Three of these hours must be conducted at night while obtaining a minimum of 10 night landings. In order to stay current and continue to use the privileges of their private certification, a pilot must receive a flight review every 24 calendar months. This flight review is conducted with a flight instructor and includes at least one hour of ground and one hour of flight. The elements of a flight review are performed mostly at the discretion of the instructor conducting the review, therefore night training may not be included (14 C.F.R. Part 61, 2019). Some pilots may choose to do additional training for night operations, while others may choose to forgo additional training while still maintaining the privilege to fly at night under their private certificate.

Instrument Rating

Some contend that flying at night should require an instrument rating. Shao, Guindani, and Boyd (2015) claim this would enhance safety for general aviation pilots that choose to fly in reduced visibility, or encounter unanticipated loss in visibility. Private pilots cannot fly without visual reference to the horizon, however night conditions do not qualify as losing visual reference with the horizon. Boyd (2015) argues that night flights under visual conditions should still be conducted under instrument flight rules, requiring an instrument rating in order to avoid accidents where pilots fail to maintain terrain clearance. To obtain an instrument rating, at least 50 hours of additional training would be required along with the knowledge requirements (14 C.F.R. Part 61, 2019). Boyd (2015) contends the high proportion of fatal accidents at night with non-instrument rated pilots calls for increased training. However limiting private pilots to day hours unless the pilots underwent the additional training of an instrument rating would be a major change for general aviation operators.

Scenario Based Training

An alternative to requiring an instrument rating is improving training techniques or requirements. Generally, private pilot flight training has used repetitive behavior and an emphasis on knowledge acquisition to prepare students for their certification. This is useful in learning maneuvers but does not help aeronautical decision making. However, constructivism is a different approach to learning in which students are able to apply problem solving skills to a scenario. It allows the student to develop better situational awareness through exposure to a realistic and complex environment (Ayers, 2006).

Constructivism would allow students to develop a higher situational awareness for night flying during training without the need to get an instrument rating. This might be incorporated as extra night training in different environments, higher night standards on the private pilot check ride, or inclusion of scenario based training on flight reviews. The purpose of this study is to determine the effect of flight time and training experience on airport surface deviations at night, pilot attitudes toward night training, and pilot experience and attitudes toward night training portions of flight reviews.

Methodology

Participants

The participants for this study were pilots who were rated at least as private pilots and excluded any that were rated as an Air Transport Pilot. The purpose of this exclusion was to limit the survey to general aviation. These pilots were recruited directly from flight training schools as well as through the University Aviation Association to reach pilots across the United States. Overall, 399 responses were collected. After student pilot responses, Air Transport Pilot responses, and incomplete responses were removed, 239 responses were included in the data analysis. The responses included 61 private pilots, 45 instrument-rated pilots, 44 commercial pilots, and 89 flight instructors.

Research Instrument

The participants in this study completed a descriptive type survey questionnaire to collect qualitative and quantitative data in the form of opinions as well as flight hour and incident totals (Appendix B). This survey was anonymous and proctored through an online service to be answered on a personal device. The developed survey included 25 questions broken up into three sections:

1. Applicant profile and experience
2. Personal observation of surface deviations
3. Opinions section

Survey Design

The first section of the questionnaire collected background information on applicants including flight hours acquired during training and if they had received a flight review. Additionally, respondents indicated pilot certificate held in order to include only pilots in the general aviation environment.

The second section of the questionnaire allowed participants to indicate personal observations or experience. This included personal incidents or events that may have occurred, or ones observed of a student or co-pilot. Additionally, data was collected from both night experience and day experience. The expectation was that there would be more incidents occurring in daylight hours due to the higher volume of flights during this time.

The last section of the survey questioned participants on opinions. This included effectiveness of FAA night training requirements, effectiveness of guidance put forth by the FAA, and confidence levels of the pilots on their abilities. Responses were collected on the need for night time on flight reviews. Additionally, there were open-ended questions collecting recommendations on improving situational awareness at night.

Data Analysis

Collected data was sorted and analyzed using a variety of methods. Answers were displayed using histograms and cross-tabulated in order to display relationships between the number of events and training experience. Additionally, several types of analysis of variances were run after data was analyzed for normal distribution and heterogeneity of variance. The analyses were run with group splits for total time, night training time, and total night time. The groups were split as evenly as possible by total time with low time group having between 60-185 hours. The medium hours group had between 188-375 hours, and the high time group had between 380-10000 hours. To determine the group split for night training time, the responses were organized by night training hours and split as evenly as possible into three groups. The low hours group had between 3-14 night hours during training. The medium hours group had between 14.5- 28 night hours, and the high time group had received between 30-115.2 night hours during training. The total night hours group split was again split evenly total night time. The low hours group had between 3-20 night hours. The medium night hours group had between 21-50 night hours, and the high time group had between 51-1503 total night hours. Lastly, open-ended questions were manually sorted for their qualitative responses and included in further discussion.

Results

Analysis

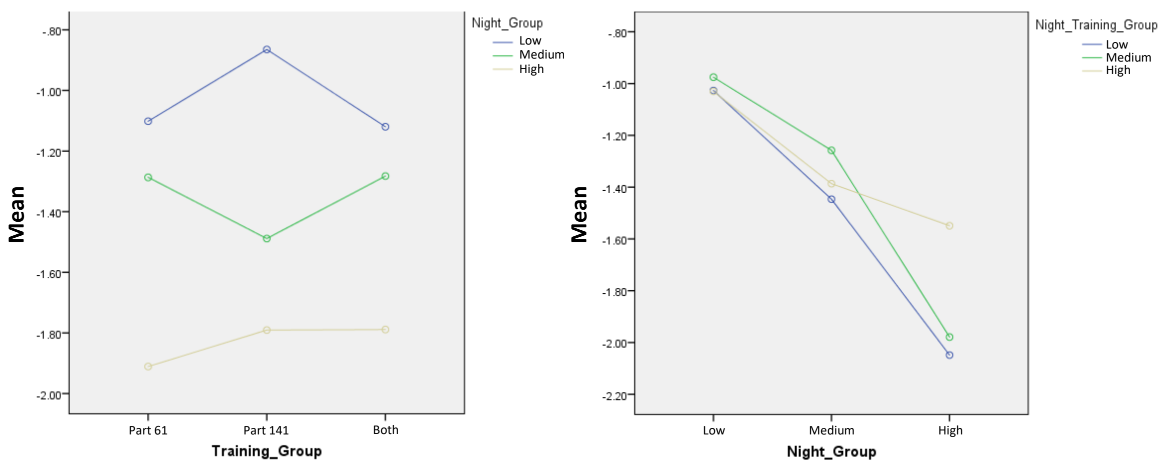
Rate of Events

There were 426 total reported night events and 915.5 total reported day events. This number was not a whole number due to estimates made by respondents. The responses were analyzed for significance between day and night incidents. Number of event occurrences were combined from questions 12 and 16 and questions 14 and 18. These questions requested participants to indicate how many times they had, or almost had, an event or witnessed an event during the day and night. These totals were then calculated into rates of event occurrence by day flight hours or night flight hours. The events were calculated as a rate per night or day flight hour respectively which reduced the confounding factors associated with the large difference between day hours and nights hours expected with every pilot. Without this correction, there would be more incidents occurring during the day as there are more opportunities for this to happen. The rates were transformed by log10 in order to pass tests of normality. Then a one-tailed t-test was performed on the data that revealed the mean rate of incidence was significantly different for the two groups $t(64)=13.24$, $p<.001$. The positive t-value supports the hypothesis that the rate of event occurrence is higher for night events than for day events.

Further analyses of night incidents specifically were conducted to determine if there was a significant effect of type of training received, training hours conducted at night and total night hours on number of incidents occurring at night. This was done through a 3X3X3 ANOVA with type of training received (Part 61, Part 141/142, both), total night time (low, medium, high) and training night time (low, medium, high) as factors. Initially, the rate of events had to be transformed by log10 in order to satisfy the tests for normality. The overall ANOVA revealed a main effect of the total night hours $F(2,75) = 23.8$, $p<.001$.

Figure 3

Mean Rate of Events



As seen in Figure 3, the effect had no significant interactions. To interpret the main effect, a simple effects analysis was performed using a Bonferroni-corrected one-tailed t-tests (night hours group). Total night hours low and medium had a significant effect, $t(60)=2.3$, $p=.012$ indicating the low night hours group had a significantly higher number of night events per night hour than the medium hours group. Total night hours medium also had a significantly higher rate of night events than the high hour group, $t(65)=4.5$, $p<.001$. Lastly, total night hours low and high indicated a significant effect of $t(65)=5.5$, $p<.001$, indicating the low hours group had a significantly higher rate of night events.

Type of Events

Respondents were asked to indicate if they had, or almost had one of the following events occur:

- Had an incident or accident
- Turned onto the wrong taxiway
- Departed the runway surface
- Hit an object on the surface
- Taken off from the wrong runway or taken off from a taxiway
- Had a wrong surface landing
- Required progressive taxi instructions

These categories were tabulated separately for day time occurrence and nighttime occurrence. The answers from questions 11, 13, 15, and 17 (Appendix B) are displayed in histograms to reveal types of incidents.

Figure 4

Type of Event Occurring by Pilot

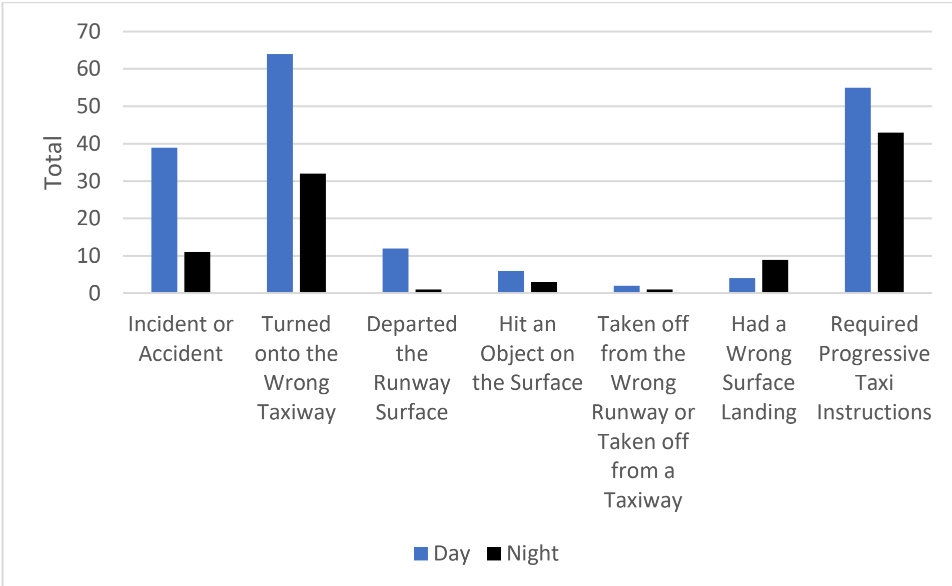


Figure 4 depicts the 7 categories of events by day and by night. It can be observed that although turning onto the wrong taxiway is the most common event during the day, the most common event at night is requiring progressive taxi instructions. Additionally, though most of the events have much higher reports by day due to the number of hours comparatively flown during the day, there were more wrong surface landings reported at night.

Next, respondents who had worked as a flight instructor were asked to report types of events that they observed a student or co-pilot doing or almost doing from the same categories. Answers were again tabulated by time of day.

Figure 5

Type of Events Observed of Students/Co-Pilots

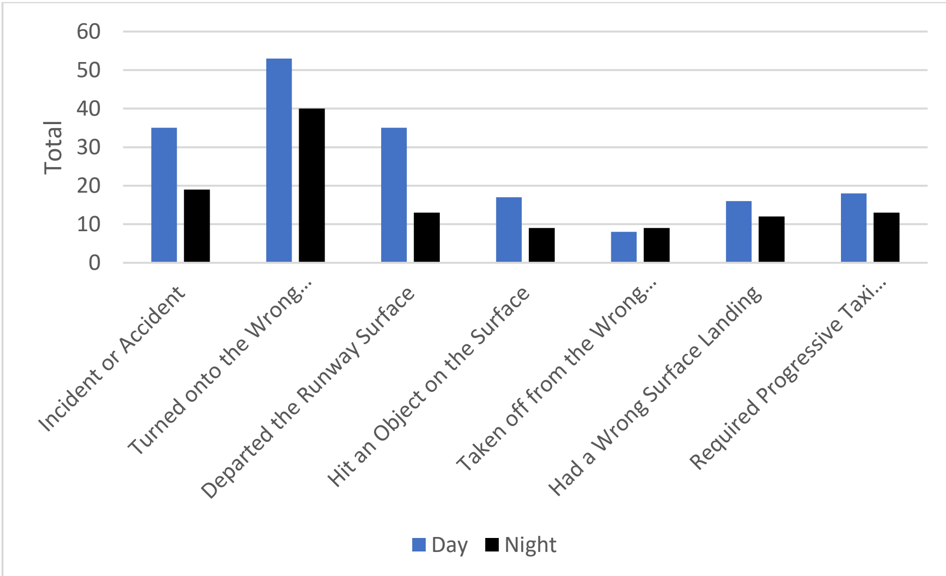


Figure 5 depicts the 7 categories of events with the data that instructors had observed of their students or co-pilots. It is interesting to note that despite the higher number of day time hours, many of these events were closer in number between day/night as were reported by the pilots of themselves. In this set of data, more wrong surface takeoffs were reported at night than during the day, in contrast to the previous figure which had more wrong surface landings during the night than during the day. Tables 1, 2, 3, and 4 depict the cross-tabulation of event counts for part of training received, whether Part 61, Part 141/142, or both. Of the 239 total responses, 89 received their licenses under Part 61, 93 respondents by Part 141/142, and 57 respondents received training from both parts.

Table 1

Type of Event Occurrence by Pilot, Day

Type of Event	Part 61	Part 141/142	Both	Total
Incident or Accident	22	7	5	34
Turned onto the Wrong Taxiway	34	22	25	81
Departed the Runway Surface	22	11	7	40
Hit an Object on the Surface	21	8	3	32
Taken off from the Wrong Runway or Taken off from a Taxiway	24	9	3	36
Had a Wrong Surface Landing	26	23	15	64
Required Progressive Taxi Instructions	33	28	25	86

Table 2

Type of Event Occurrence by Pilot, Night

Type of Event	Part 61	Part 141/142	Both	Total
Incident or Accident	3	6	3	12
Turned onto the Wrong Taxiway	11	13	18	42
Departed the Runway Surface	2	5	5	12
Hit an Object on the Surface			1	1
Taken off from the Wrong Runway or Taken off from a Taxiway			1	1
Had a Wrong Surface Landing		3		3
Required Progressive Taxi Instructions	6	11	12	29

Table 3

Type of Event Occurrence by Student or Co-Pilot, Day

Type of Event	Part 61	Part 141/142	Both	Total
Incident or Accident	2	10	5	17
Turned onto the Wrong Taxiway	3	8	7	18
Departed the Runway Surface		2	6	8
Hit an Object on the Surface	3	5	8	16
Taken off from the Wrong Runway or Taken off from a Taxiway	5	16	14	35
Had a Wrong Surface Landing	5	11	15	31
Required Progressive Taxi Instructions	9	22	22	53

Table 4

Type of Event Occurrence by Student or Co-Pilot, Night

Type of Event	Part 61	Part 141/142	Both	Total
Incident or Accident	3	5	5	13
Turned onto the Wrong Taxiway	3	7	10	20
Departed the Runway Surface	2	3	7	12
Hit an Object on the Surface		1	8	9
Taken off from the Wrong Runway or Taken off from a Taxiway	1	6	2	9
Had a Wrong Surface Landing	1	5	7	13
Required Progressive Taxi Instructions	5	18	16	39

Effect of Training on Pilot Opinions

Data collected from section 3 of the survey on pilot opinion was analyzed first by type of training received. Responses were split into groups initially by their training experience, whether Part 61, Part 141/142, or both. A multivariate analysis of variance, or MANOVA, was run to reveal whether there was a significant effect of these groups on pilot confidence level in taxiing at night, opinion on effectiveness of FAA training requirements, and effectiveness of FAA night training resources. Before performing the MANOVA, each factor satisfied the tests for normality and homogeneity of variance. The MANOVA revealed that there was no significant effect of type of training received (Part 61, Part 141/142, or both) and pilot confidence in themselves taxiing at an unfamiliar airport at night or during the day. There was also no significant effect of type of training on opinion of FAA airport surface operations at night guidance and resources which respondents were asked to rank 0-10 on effectiveness. When respondents ranked the effectiveness of FAA night training requirements for private pilots (3 hours of night flight training to include one cross-country flight of over 100 nautical miles total distance; and 10 night takeoffs and 10 night landings to a full stop at an airport per 14 CFR 61.109), it was found that type of training had no significant effect, $F(8, 460)=.958$, Wilks' Lambda=.968, $p=.469$.

To determine if there was a significant effect of night training hours on confidence in taxiing at night, opinion on effectiveness of FAA training requirements, and effectiveness of FAA night training resources, a MANOVA was performed. The data was split into three groups, low medium and high night training time in order to run this analysis. Before performing the MANOVA, each factor was tested for kurtosis and skewness. The MANOVA revealed that there was no significant effect of the amount of night training hours and the pilots' overall opinion of effectiveness of FAA guidance and resources, FAA requirements for private pilot, and pilot confidence in taxiing, $F(8, 460)=.511$, Wilks' lambda=.018, $p=.848$. This indicates pilot confidence during surface operations is unaffected specifically by the number of night training hours received. Pilot opinion on FAA resources also is unaffected by the night training hours. Lastly, the number of night flight hours obtained during training has no effect on pilot opinion regarding the effectiveness of FAA night training requirements. Opinions and confidence therefore are comparable despite the training environment.

The confidence level of pilots for taxiing at an airport at night was also analyzed in relation to the total number of hours each participant had. This was done using a one-way ANOVA.

Table 5

ANOVA Results Total Hours and Confidence in Taxi

Descriptives				Statistic	Std. Error
Rate your confidence with taxiing at any airport at night.	Mean			6.58	.116
	95% Confidence Interval for Mean	Lower Bound		6.35	
		Upper Bound		6.81	
	5% Trimmed Mean			6.60	
	Median			7.00	
	Variance			3.236	
	Std. Deviation			1.799	
	Minimum			2	
	Maximum			10	
	Range			8	
	Interquartile Range			3	
	Skewness			-.099	.157
	Kurtosis			-.240	.314

ANOVA

Rate your confidence with taxiing at any airport at night.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	48.525	2	24.262	7.935	.000
Within Groups	721.634	236	3.058		
Total	770.159	238			

Table 5 shows the mean rating of confidence for pilots taxiing at any airport at night in three groups based on total hours (low, medium, and high). The data was first tested to be within acceptable ranges of skewness and kurtosis in order to determine normality. The one-way ANOVA revealed a significant effect of total hours on the pilot confidence in taxiing at an airport at night, $F(2, 236) = 7.9$, $p<.001$. This indicates pilots' confidence is not equal for all three total hours groups. To further break down this significant effect, a Bonferroni-corrected two-tailed t-test was performed which revealed the only significant differences in confidence were between the low time and high time group, $t(157)= -3.9$, $p<.001$ as well as the medium and high time groups, $t(157)=-2.8$, $p=.003$. The test indicated the low time had significantly lower confidence in comparison to the high time group, and the medium time group also had significantly lower confidence levels in comparison to the high time group. The low and medium time groups had no significant difference in confidence in relation to each other.

Overall, there were mixed opinions when it came to pilot confidence in taxiing as well as opinion on FAA resources and requirements. On a scale of 0-10, the average respondent felt they were at an 8.3 in confidence taxiing during day, or fairly confident. However the average respondent ranked themselves at a 6.6 confidence for taxiing at night, or only somewhat confident. A one-tailed t-test revealed the pilot confidence to be significantly higher during the day than at night, $t(238)=22.2$, $p<.001$. Training and resources from the FAA on night surface operations were rated on average as a 7 effectiveness on a scale of 0-10, or somewhat effective. Night requirements for private pilots on average were rate as 5.7 by respondents on a scale of effectiveness from 0-10, indicating that pilots are fairly neutral on whether the requirements are effective or ineffective.

Open-Text Questions

Questions 23 and 25 (Appendix B) were sorted manually by similar responses. These were used for qualitative results indicating pilot opinion on training requirements and improvements in night training. Despite there being some in favor of requiring more hours or explicitly against requiring more night time, a large number of answers indicated that the hours were good but there was room for improvement. Many indicated this improvement could come from exemplary instructors or pilots taking initiative to go above and beyond the required hours. Most of the pilots indicated that airport lighting improvements and technology improvements would be the best way to enhance situational awareness at night. About 23% of responses indicated the FAA night requirements were effective. These responses indicated from personal experience that the requirements were effective to understand the risks involved and how to conduct a night flight safely. Additionally, 18% of responses felt the requirements were effective but had room for improvement. Many of these responses indicated that the expectation for the FAA requirements is that students will train more than the minimum if necessary. It is up to the pilot to continue becoming proficient through additional night-flights. These responses also indicated that depending on the situation, the requirements are adequate for pilots who will never fly at night outside of the training environment until they get to an airline or such. This contrasted to almost 47% of responses that felt the night requirements were ineffective and should be changed to require more hours, more landings, or more time at different airports, etc. The other 12% left this answer blank.

The final question of the survey collected open-text responses on how to improve situational awareness on the airport surface at night. Of the pilots that responded to this question, almost 43% mentioned improving lighting, signage, and markings on the aircraft and at airports. The next highest mention was 28% of responses that indicated pilot studying and independent practice would improve situational awareness at night. Almost 21% indicated more night training would improve situational awareness. Lastly, about 15% suggested improving technology such as the use of a G1000 or moving map on an Electronic Flight Bag. There were 39 responses left blank and close to 20 responses indicating there was nothing more to be done to improve situational awareness.

Flight Reviews

Of the 239 responses, 93 pilots had a flight review, 25.8% included night time on the flight portion of their flight review and 58% included night time on the ground portion of their flight review. The average opinion of these 93 pilots on whether night should be required on flight reviews was 5.43 on a scale of 0-10. Additionally, 81 of the 239 respondents that were flight instructors had an average opinion of 5.41 on a scale of 0-10, almost identical. The overall average of the 239 respondents was 5.43 on a scale of 0-10, indicating pilots neither agree nor disagree that night time should be required on the flight portion of a flight review.

Discussion

The results of the data revealed several significant effects. The mean rate of incidence was significantly higher for reported night events than day events by pilots, meaning there must be a reason night events are more likely to occur. Total night hours also had a significant effect on reported events. This indicates that there may not need to be an additional hours requirement in training. However, it does support several comments by respondents that it is a pilot's responsibility to become proficient in surface operations at night. More night flights can be flown outside of training in order for a pilot to increase experience and decrease number of future events at night.

When surveying pilot confidence in taxiing both during the day and night, it was found that type of training received and the number of night hours received during training had no significant effect. Pilots were just as confident or not-confident when it came to experience with training (Part 61, Part 141/142, or both). However when analyzed in relation to total flight hours, it was found that this had a significant effect on taxiing at night. This again supports the conclusion that pilots who have more experience, not necessarily more training, are more confident in surface operations at night and have fewer incidents.

In consideration of flight reviews, all pilots, flight instructors, and pilots who have received a flight review have mixed opinions that average out to neutral. There is not strong support either way for requiring more hours or not requiring more hours, just a slight lean towards the FAA requiring night time to be included on flight reviews.

Some limitations to consider for this study were the variability of survey responses. Pilots were able to answer any number of hours/incidents in this survey that might not be as accurate as official documentation such as logbooks or FAA record of pilot time. Additionally, the survey was distributed directly to several schools as well as through the UAA, which means the population sample was largely limited to pilots connected directly to the training environment. Additionally, the confound of significantly higher number of flight hours during the day versus at night is present and must be corrected for in much of the data analysis between day and night events.

Although rate of occurrence is higher for night events than day events and pilot confidence is higher taxiing during the day than at night, training experience (Part 61, Part 141/142, or both) does not seem to have a significant effect on number of surface operation events at night or pilot opinion on their own confidence and FAA resources and requirements. Number of night flight hours received during training also had no significant effect on those categories. Despite this, pilots with more night hours or more total hours had fewer incidents and higher confidence while taxiing at night, indicating a favorable view of gaining more hours and experience to safely operate at night. Additionally, pilots believe FAA guidance and resources are overall effective, and private pilot night requirements are somewhat effective as well. Lastly, pilots are neither for nor against requiring night time on the flight portion of the required flight reviews. This indicates there are not training deficiencies that lead to surface operations at night, nor strong support from pilots to require more training. However, this study can provide valuable information on what can be done by individual pilots and taught at flight schools such as increasing total night exposure and incorporating techniques in training to focus attention outside and increase situational awareness. Additionally, it is a reputable source of pilot attitude toward current FAA requirements and resources available. Further research could determine if training pilots to increase their attention outside of the cockpit would result in fewer surface incidents. Additionally, many responses indicated the usefulness of technology available to general aviation pilots. Research could include the possible use of moving maps to decrease surface events at night. Lastly, this survey was distributed directly to flight schools, so expanding the sample group to include general aviation pilots outside of the training environment could produce notably different results.

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APPENDIX A

IRB APPROVAL

ASU Knowledge Enterprise Development

EXEMPTION GRANTED

Mary Niemczyk
IAFSE-PS: Aviation
480/727-1595
Mary.Niemczyk@asu.edu

Dear Mary Niemczyk:

On 3/23/2020 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Training Deficiencies in Airport Surface Operations at Night Simulation Study
Investigator:	Mary Niemczyk
IRB ID:	STUDY00011688
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Consent Form Whittard, Category: Consent Form;• IRB Social Behavioral Protocol Whittard, Category: IRB Protocol; • Recruitment Methods Whittard, Category: Recruitment Materials; • Supporting Documents, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions);

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 on 3/23/2020.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,
IRB Administrator

cc: Megan Whittard
Michael Hampshire

Megan Whittard
Mary Niemczyk
Robert Nullmeyer

APPENDIX B

PARTICIPANT SURVEY

Night Surface Operations Experience

Start of Block: Section 1

Section 1 of 3. The following questions will build an applicant profile of your pilot experience and flight time.

Multiple Choice: Please select one answer for each of the following questions.

Q1 What is the highest level of pilot certificate that you hold?

- ○ Student pilot
- ○ Private pilot
- ○ Instrument-rated private pilot
- ○ Commercial pilot (single or multi-engine)
- ○ CFI/CFII/MEI
- ○ ATP

Q2 Under what part did you receive your training?

- ○ Part 61
- ○ Part 141/142
- ○ Both

Q3 Have you had a flight review?

- ◯ Yes
- ◯ No
- ◯ Does not apply

Display This Question:
If Have you had a flight review? = Yes

Q4 Have any flight reviews you have received consist of any night time?

- ◯ Yes
- ◯ No
- ◯ Does not apply

Display This Question:
If Have you had a flight review? = Yes

Q5 Have any flight reviews you have received include night information on the ground portion?

- ◯ Yes
- ◯ No
- ◯ Does not apply

Q6 Have you worked as a CFI/CFII/MEI?

- ◯ Yes
- ◯ No

Fill In Answers: Please enter a number in the following text boxes based on your flight time. Do your best to answer as accurately as possible.

Q7 Approximately how many hours do you have total?

____

Q8 Approximately how many night hours do you have total?

____

Q9 Approximately how many total hours total did you log as a flight training student?

____

Q10 Approximately how many night hours did you log as a flight training student?

____

End of Block: Section 1

Start of Block: Section 2

Section 2 of 3. The following questions will collect your personal observations of accidents/incidents/deviations that have occurred on the airport surface.

Multiple Choice: Please read the question carefully and select all of the answers that apply to you.

Q11 During the day, have you ever or have you almost... (Include all that apply)

- ▢ Had an incident or accident?
- ▢ Turned onto the wrong taxiway?
- ▢ Departed the runway surface?
- ▢ Hit an object on the surface (i.e. parked aircraft, cone, taxiway sign, etc.)?
- ▢ Taken off from the wrong runway or taken off from a taxiway?
- ▢ Had a wrong surface landing (i.e. landed on the wrong runway, landed on a taxiway)?
- ▢ Required progressive taxi instructions?
- ▢ None of the above

Display This Question:
If During the day, have you ever or have you almost... (Include all that apply) != None of the above

Q12 Approximately how many of these events total from the above question have you experienced?

____

Q13 At night, have you ever or have you almost... (Include all that apply)

- ▢ Had an incident or accident?
- ▢ Turned onto the wrong taxiway?
- ▢ Departed the runway surface?
- ▢ Hit an object on the surface (i.e. parked aircraft, cone, taxiway sign, etc.)?
- ▢ Taken off from the wrong runway or taken off from a taxiway?
- ▢ Had a wrong surface landing (i.e. landed on the wrong runway, landed on a taxiway)?
- ▢ Required progressive taxi instructions?
- ▢ None of the above

Display This Question:
If At night, have you ever or have you almost... (Include all that apply) != None of the above

Q14 Approximately how many of the events total from the above question have you experienced?

____

Display This Question:
If Have you worked as a CFI/CFII/MEI? = Yes

*

Q15 During the day, have you ever had to intervene when a student or co-pilot almost or did... (Include all that apply)

- ▢ Have an incident or accident?
- ▢ Turn onto the wrong taxiway?
- ▢ Depart the runway surface?
- ▢ Hit an object on the surface (i.e. parked aircraft, cone, taxiway sign, etc.)?
- ▢ Take off from the wrong runway or taken off from a taxiway?
- ▢ Have a wrong surface landing (i.e. landed on the wrong runway, landed on a taxiway)?
- ▢ Require progressive taxi instructions?
- ▢ None of the above

Display This Question:
If During the day, have you ever had to intervene when a student or co-pilot almost or did... (Inclu... != None of the above

Q16 Approximately how many of the events total from the above question have you experienced?

____

Display This Question:
If Have you worked as a CFI/CFII/MEI? = Yes

Q17 At night, have you ever had to intervene when a student or co-pilot almost or did... (Include all that apply)

- ▢ Have an incident or accident?
- ▢ Turn onto the wrong taxiway?
- ▢ Depart the runway surface?
- ▢ Hit an object on the surface (i.e. parked aircraft, cone, taxiway sign, etc.)?
- ▢ Take off from the wrong runway or taken off from a taxiway?
- ▢ Have a wrong surface landing (i.e. landed on the wrong runway, landed on a taxiway)?
- ▢ Require progressive taxi instructions?
- ▢ None of the above

Display This Question:
If At night, have you ever had to intervene when a student or co-pilot almost or did... (Include all... != None of the above

Q18 Approximately how many of the events total from the above question have you experienced?

____

Scale of 0-10: Please rate your answers to the following questions on a scale of 0 (lowest confidence) to 10 (highest confidence).

Q19 Rate your confidence with taxiing at any airport during the day.

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ 6
- ○ 7
- ○ 8
- ○ 9
- ○ 10

Q20 Rate your confidence with taxiing at any airport at night.

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ 6
- ○ 7
- ○ 8
- ○ 9
- ○ 10

End of Block: Section 2

Start of Block: Section 3

Section 3 of 3. The following questions will collect your personal opinions on night operation training.

Scale of 0-10: Please rate your answer to the following questions from 0 (highly ineffective) to 10 (highly effective). Then provide an explanation as to why you chose these ratings.

Q21 How effective is current guidance and resources from the FAA on airport surface operations at night?

- ◯ 0
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7
- ◯ 8
- ◯ 9
- ◯ 10

Q22 How effective are the FAA night training requirements for private pilots (3 hours of night flight training that includes one cross-country flight of over 100 nautical miles total distance; and 10 takeoffs and 10 landings to a full stop at an airport per 14 CFR 61.109)?

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ 6
- ○ 7
- ○ 8
- ○ 9
- ○ 10

Q23 Based on your previous answer, why did you rate the FAA night training requirements as ineffective or effective?

____

Scale of 0-10: Please rate your answer to the following questions from 0 (strongly disagree) to 10 (strongly agree).

Q24 The FAA should require a portion of the flight review to be conducted at night.

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ 6
- ○ 7
- ○ 8
- ○ 9
- ○ 10

Text: Please provide your opinion for the following question.

Q25 What could be done to improve situational awareness on the airport surface at night?

____

End of Block: Section 3
