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An Analysis of Preflight Inspection Practices in the Collegiate Training Environment

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IN THE COLLEGIATE TRAINING ENVIRONMENT

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Abstract

Preflight inspections are a crucial part of flight operations and are required by the Federal Aviation Administration prior to flight. A properly performed preflight by an educated and experienced pilot follows a standard procedure and permits detection of conditions that render an aircraft un-airworthy. A study at Western Michigan University was conducted to determine the effectiveness of this normal procedure in the collegiate training environment. Results indicate the standard procedures for preflight inspections and good supporting habits are in place, but some complacency and a lack of understanding of the standard procedure prevents it from being totally effective among less experienced pilots. Recommendations to enhance safety and performance within this sector of the training industry conclude the findings and discussion of this study.

Key Terms

Airworthy. The aircraft conforms to its type design and is in a condition for safe operation (14 CFR §3.5, 2005).

Aeronautical Decision-Making. The systematic approach to the mental process used by pilots to consistently determine the best course of action in response to a given set of circumstances (FAA, 2008c).

Complacency. Self-satisfaction especially when accompanied by unawareness of actual dangers or deficiencies (Merriam-Webster, n.d.).

Hangar Rash. Minor incidents involving damage to aircraft that typically originate due to improper ground handling in and around a hangar, other aircraft or objects on the ground (Hangar Rash, 2014).

Human Factors. The science of understanding the properties of human capability, the application of this understanding to the design, development, and deployment of systems and services, and the art of ensuring successful application of the principles into the appropriate environment (FAA, 2008a).

Ramp Check. An impromptu inspection conducted by an FAA inspector to determine aircrew and aircraft compliance with regulations and procedures.

Scenario-Based Training. A form of problem-based learning in which the student must complete a realistic scenario using aeronautical decision-making (FAA, 2008b).

Situational Awareness. The perception of the elements in ones environment, the understanding of their meaning, and the projection of their states in the future (Endsley, 1988).

Introduction

The successful completion of a safe flight operation requires a preflight inspection of the aircraft prior to departure. The pilot in command (PIC) must conduct a visual "once over" to ensure everything is in an acceptable condition. Should a component be in an abnormal state, it is the pilot's responsibility to detect the discrepancy and determine the next course of action as laid out in 14 CFR §91.213. Otherwise the aircraft demonstrates airworthiness and the operation may proceed as intended. Multiple avenues for quality training exist—part 61 schools at local airports, industry giants such as Flight Safety, and part 141 schools such as Western Michigan University. This study aims to determine the effectiveness of normal preflight inspection practices in the collegiate training environment.

Purpose of a Preflight Inspection

Aircraft are complex machines with extensive surface area and multitudes of integrated systems. A satisfactory preflight inspection provides an overview of aircraft health while targeting specific areas and critical information, e.g. engine components and parameters. Documents crucial to the aircraft, such as the Airplane Flight Manual (AFM) and airworthiness certificate, must be on board the aircraft, and systems, such as the electrical and hydraulic systems, must be functioning within set tolerances (Civil aircraft flight manual, marking, and placard requirements, 14 CFR § 91.9, n.d.; Civil aircraft: Certifications required, 14 CFR §91.203, 2010). Some items are as simple as ensuring doors latch securely, because an unsecured door can be a nuisance as well as a safety hazard.

On July 12th, 1993, a Cessna 402C impacted the ground shortly after departure from Las Vegas McCarren International Airport. All three souls were fatally injured and the airplane was completely destroyed. Post crash investigation revealed the pilot had failed to close and secure the baggage door prior to departure (NTSB, 1994). No witnesses had observed the pilot's visual inspection of the aircraft while he was loading for the trip; however, several did note that the door was open during takeoff and initial climbout. The NTSB further found the door fasteners for the left nose baggage door intact, with no bending or tearing, whereas the right nose baggage door fasteners were bent and twisted with the door still attached to its hinges. These findings indicate the right baggage door was latched and damaged in the crash whereas the left door was unlatched and entirely disconnected upon impact (NTSB, 1994). Had the pilot confirmed through a proper methodical preflight inspection that the door was latched, he could have avoided the fatal distraction altogether.

A 2010 study conducted by NASA analyzed accident investigation data for loss of control (LOC) accidents between 1988 and 2004, and they found inadequate preflight inspection practices to be a contributing factor in 54 LOC accidents among Part 91 operators (Reveley, Briggs, Evans, Sandifer, & Jones, 2010). Poor practices include items such as failure to remove cowl plugs, pitot covers and gust locks, fuel/oil mismanagement, and failure to ensure doors are secure as occurred in Las Vegas in 1993 (Reveley, Briggs, Evans, Sandifer, & Jones, 2010). Aircraft manufacturers, such as Cirrus Design Corporation, provide a checklist for use during preflight inspections with prevention in mind. Flight instructors train their pupils to follow these procedures and understand their merits. The

preflight inspection is not a trivial matter; it is designed to resolve potential problems prior to flight (Heyde, n.d.).

The Federal Aviation Administration (FAA) requires private and commercial pilot applicants to demonstrate understanding of preflight inspection practices. In addition, they specifically state that there must be reference to a checklist during the procedure (FAA, 2011a; FAA, 2011b). Besides the manufacturer provided resources, pilots also have the Airplane Flying Handbook, a comprehensive guide to aviating, for guidance. This publication provides an overview for every maneuver and phase of flight beginning with the preflight inspection. With the Internet so readily accessible, an informed preflight inspection can and should be the norm.

Many factors influence the outcome of a preflight inspection—weather, time pressures, stress, and fatigue to name a few (Garrison, 2003). Awareness of their presence and actions to mitigate their effects are paramount to properly completing the procedure. According to Flight Training magazine, inadequate preflights often result from "insufficient training or complacency (Heyde, n.d.)." People can only perform as well as they have been trained and within the limits of their experiences. Preflighting may appear to be a simple task, but it is more than glancing at a checklist and wiggling the flight controls. Preflight inspections require an understanding of normal and abnormal conditions; they are a demonstration of the very active—to some, overrated—process of aeronautical decision-making (ADM).

Preflighting the Cirrus SR20

A complete preflight inspection begins not at the Cirrus SR20 itself, but with the maintenance logbooks. The pilot in command (PIC) is responsible for determining that the

aircraft is airworthy prior to boarding with intent for flight (Civil aircraft airworthiness, 14 CFR §91.7, n.d.). Ensuring compliance with all required inspections, airworthiness directives, and additional maintenance procedures precedes the physical part of the inspection. Once compliance has been verified, the PIC may head out to the airplane.

The preflight inspection continues with a visual once-over as the pilot approaches the airplane. During this phase, he or she is looking for blatantly obvious issues, such as flat tires, bent propeller blades, or hangar rash. Should all be in order, a quick check of fuel and oil levels is taken to determine if more of either fluid must be added or carried along prior to departure.

Next, the preflight procedure moves to the cabin with the remainder of the inspection being conducted with reference to the "Preflight Inspection" checklist developed by Cirrus Design Corp. and modified by Western Michigan University (Cirrus Design Corporation, 2003; Western Michigan University, 2011). All items beyond this point are inspected per the procedures laid out by Cirrus Design Corp. and Western Michigan University. Door operation is checked to ensure proper opening, closing, and latching, and seats are adjusted to confirm locking mechanisms function properly. Once the pilot is situated comfortably in the cabin, he or she locates the following documents and verifies all are valid for the flight:

- Supplements
- Placards
- Airworthiness certificate
- State and federal registrations
- Radio station license (if applicable)

- Operating handbook (or AFM)
- Current weight and balance (Civil aircraft flight manual, marking, and placard requirements, 14 CFR § 91.9, n.d.; Civil aircraft: Certifications required, 14 CFR §91.203, 2010).

It should be noted that the airworthiness certificate is *required* to be visible to all occupants as they board, and that the AFM must match the registration and serial number of the airplane (Civil aircraft: Certifications required, 14 CFR §91.203, 2010). Following the documents check, the PIC carries out systems diagnostic checks beginning with the electrical system. Voltage and amperage should be within defined limits, flaps should fully deploy, lights must be functioning, the stall warning horn inlet clear, fuel gauges must indicate zero or greater, and all circuit breakers must be checked and reset unless otherwise noted. Finally, the emergency egress hammer must be in the center console and the fire extinguisher charged—determined by hefting—and easily accessible (Cirrus Design Corporation, 2003; Western Michigan University, 2011).

From the cabin, preflight procedures move to the exterior of the plane. The pilot should be inspecting the general condition for skin damage and delamination, that all hinges, hinge pins, screws, bolts, and safety wires are secure, for proper control surface movement and clearance, and for fluid leaks around reservoirs and lines such as for the fuel, oil, and braking systems. These general checks occur throughout the inspection, flow from cabin to tail, tail to right wing, right wing to nose, nose to left wing, and back to the cabin. When initially departing the cabin, the pilot, now on the left side of the fuselage, ensures antennas are secure and in good condition, that the wing/fuselage fairing shows no separation, that the baggage door is secure, for a clear static port, and that the parachute

cover is not cracked, dented, or displaying signs of deployment (Cirrus Design Corporation, 2003; Western Michigan University, 2011).

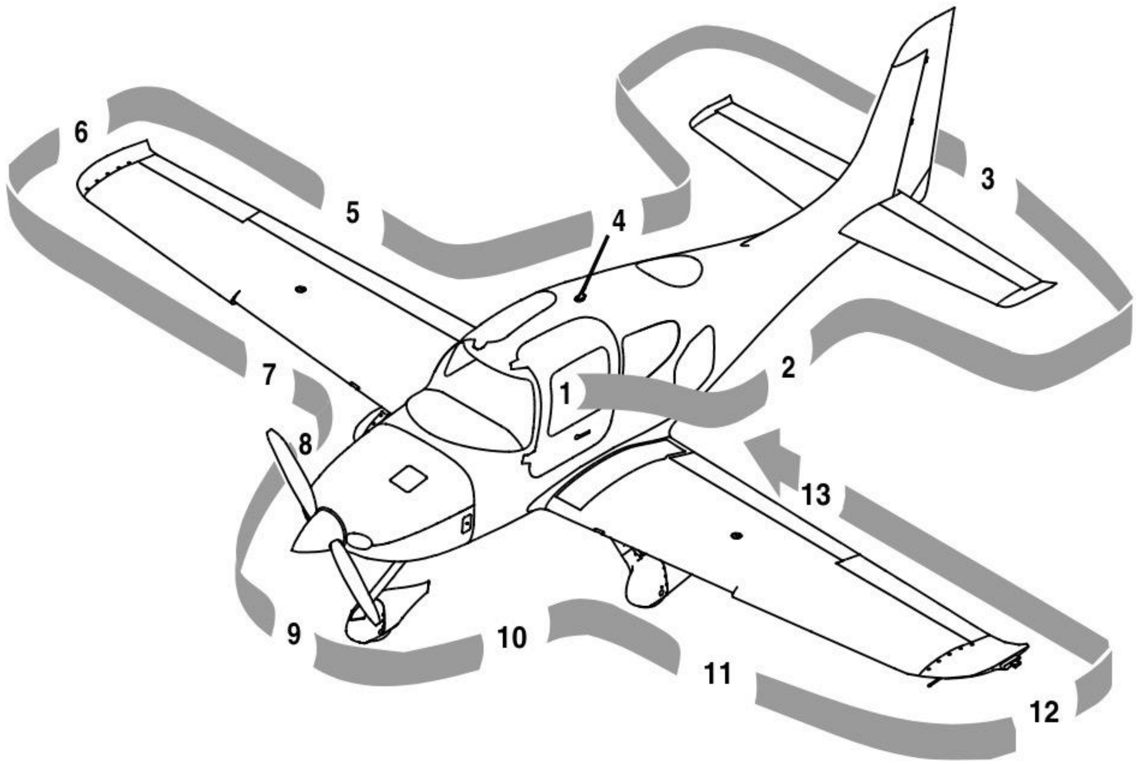


Image 1: Preflight Inspection Flow Procedure about the Cirrus SR20 (Cirrus Design Corporation, 2003)

The tail section, or empennage, of the airplane requires an inspection of the tailskid to determine if abnormal ground contact was made on prior flights. Horizontal and vertical stabilizers, along with elevator and rudder respectively, should show solid attachment with free movement and noticeable cable tension. Both ground adjustable trim tabs should be riveted securely to the control surfaces. Comparing control surface movement with the side stick is imperative; reversed control cable rigging can cause serious problems even before the airplane leaves the ground. Lastly, the navigation antennas should be attached securely and free of damage (Cirrus Design Corporation, 2003; Western Michigan University, 2011).

After the empennage, the inspection flow takes the pilot to the right side of the fuselage. Maintenance panels and fairings should be flush with the fuselage and the static button clear of obstructions. The right flap rub strip is viewed for indications of flap-wing contact during operation and all actuation arms and associated securing mechanisms checked for movement. The aileron is then moved to full up and down deflection positions to check for hesitation-free movement, and the direction of control yoke movement confirmed to correspond with proper control rigging. Finally, the trim tab must be snugly attached, its rivets in good condition (Cirrus Design Corporation, 2003; Western Michigan University, 2011).

As the pilot rounds the wingtip, he or she ensures the assembly is attached securely and that the fuel vent is unobstructed. Working up the wing to the fuselage, the leading edge is inspected for any form of damage. The stall strips must be cemented in place and the cabin air vent clear of debris. While here, the wheel pant and fairing must be checked for security, the tire inspected for proper inflation and tread depth, and the brake temperature indicator viewed for any change in color. Once the fuel drains have been sampled and the fuel quantity determined, tie-down ropes and wheel chocks may be removed (Garrison, 2003; Cirrus Design Corporation, 2003; Western Michigan University, 2011).

Next up is one of the most important portions of the preflight inspection—the nose. The engine, propeller and accessories are the heart and soul of an airplane, and they must receive tender love and care. The pilot inspects the engine cowling first for secure attachment, followed by the exhaust pipe to ensure it has little movement and is clear of blockages. The transponder antenna must be in good condition, and the gascolator drained

and sampled for fuel contaminants. Being able to see forward at night tends to be helpful; therefore the landing light lens should be clean and clear. The nose gear strut, fairing, and pant must show limited wear and tear and be firmly attached to the rest of the nose. Nosewheel tire inflation and tread depth should be checked just as with the left main landing gear. The spinner and propeller hub should show firm attachment, be in excellent condition, and be free of leaks. Each propeller blade must be inspected for cracks, nicks, indentations, and anything else that might threaten its integrity. The engine air inlets must be clear of obstructions, and the alternator belt checked for proper tension. Lastly, a brief inspection of visible engine components may be completed (Cirrus Design Corporation, 2003; Western Michigan University, 2011).

Moving to the left side of the nose brings the pilot to the home stretch. Here, the engine oil level must be six to eight quarts and an additional check of visible engine components completed. Besides the external power door attachment and hopefully unobstructed pitot tube orifices, every other check is identical to the right side of the nose and the right wing. The preflight inspection is complete once the pilot reaches the left wing/fuselage fairing. Tie-down ropes, chocks, fuel sumps, and baggage can be properly stowed in the baggage compartment, and the flight may progress should no discrepancies have been noted or require further attention (Cirrus Design Corporation, 2003; Western Michigan University, 2011).

Methodology

The purpose of this study was to investigate preflight inspection practices in the collegiate training environment to determine the effectiveness of standard inspection procedures. Conducting the research required an airplane, participants, and a means of observing and cataloging completed preflight inspections. The airplane was from Western Michigan University's training fleet, participants were recruited from flight courses at the College of Aviation and from the part-time and staff flight instructors, and the act of recording data was completed on the forms in appendices D and E. Following the conclusion of the study, all collected information was compiled using Microsoft Office Excel and Word and then subsequently examined.

The Aircraft

Western Michigan University's College of Aviation boasts a fleet of technically advanced aircraft consisting of Cirrus SR20 airplanes. A Cirrus was temporarily removed from service and rendered un-airworthy by several intentionally placed abnormal conditions, commonly called squawks, that could adversely affect a real flight. These squawks included: simulation of a brake overheat on the left main landing gear, simulation of a tail strike, removal of two required placards, the Cirrus Airframe Parachute System (CAPS) pin tag and Pilot's side "Grab Here" sticker, replacing the serviceable fire extinguisher with an empty unit, loosening the right hand fuel cap in a manner that prevents a secure latch, and obstructing the right hand exhaust pipe with oil rags. Pictures of these squawks are attached in Appendix C. The un-airworthy airplane was then placed in a hangar and connected to ground power.

Conducting the Preflight Inspections

Participants reported individually to the hangar at a scheduled time. Only the principle investigator who would be observing each inspection and the current participant were allowed in visual range of the airplane at any time. After a short briefing, each participant was asked to complete a questionnaire, attached in Appendix D, prior to conducting his or her preflight inspection. All were instructed to perform the procedure as they normally would. At the cue “go” from the investigator, each participant began the preflight inspection and a timer was started to keep track of the length of both the internal and external phases of the process. The investigator shadowed the participants throughout their preflight inspections while taking notes on the data sheet (Appendix E) about participant actions, such as omitted checklist items and abnormal or exceptional behaviors, and answering generic questions about the quality of the inspection. Criteria for positively inspecting an item or identifying a squawk included verbal acknowledgement, definite, focused visual contact, tactile interaction, or a combination thereof. Participants were instructed to verbalize “done” as a cue for the observer to stop the timer.

Results

A total of thirteen participants volunteered for this study. Basic information, contained within Table 1, was collected via the Pre-Inspection Questionnaire (Appendix D). Of the thirteen participants, nine held a commercial pilot license while four held a private pilot license. Eight of the nine commercial pilots also held certified flight instructor (CFI) certificates, and seven of those individuals actively provided flight instruction at the College of Aviation. The number of flight hours per participant ranged from 100 hours to 3,000 hours. Three participants were also members of the College of Aviation flight team and two participants were fleet maintenance personnel. Though the majority of participants were flight instructors, a satisfactory spectrum of experience levels was obtained based on flight time, certificate level, and additional responsibilities.

Table 1: Participant Information

Participant Number	Certificate 1	Certificate 2	Flight Hours	Flight Team	Maintenance	WMU Flight Instructor
1	PPL	IA	150			
2	PPL	IA	150			
3	CPL	CFI	325			Yes
4	CPL	CFI	300			Yes
5	CPL	CFI	1400			Yes
6	CPL	CFI	750	Yes		Yes
7	PPL		100			
8	PPL		163			
9	CPL		975		Yes	
10	CPL	CFI	3000		Yes	
11	CPL	CFI	380			Yes
12	CPL	CFI	350	Yes		Yes
13	CPL	CFI	370	Yes		Yes

Table 2 displays the remainder of the Pre-Inspection Questionnaire responses. Participants were asked to rate the importance of the preflight inspection and provide an estimate for the ideal length of said procedure performed on a Cirrus SR20. Importance

rankings, based on a scale from one to ten with one being of no importance and ten being of greatest importance, ranged from seven to ten. The average importance from this sample comes in at 9.23 on the ten-point scale. Such a high rating indicates that many individuals consider the preflight inspection integral to a flight. Opinions of the adequate duration of a preflight inspection spanned a more significant range of values from five to thirty minutes. The majority of participants report a duration of 10-20 minutes to be sufficient. This figure corresponds with Flying Magazine, which claims a thorough preflight inspection should take 15-20 minutes (Bergqvist, 2012). When asked if the checklist is carried on person for use during the inspection, nine participants responded with "Yes" and four responded with "No". According to the FAA, the preflight inspection must be conducted with reference to and in accordance with a checklist (FAA, 2004; FAA, 2011a; FAA 2011b). Four individuals in this study did not follow this particular FAA guidance. All but one of the participants answered the final question, "How would you respond to a situation that results in an un-airworthy aircraft," by circling the letter corresponding with "talk to a maintenance technician." The individual who circled the letter corresponding to "address the issue myself and then fly the airplane" is a certified Airframe and Powerplant (A&P) mechanic. A&P mechanics are authorized to perform and approve maintenance on aircraft.

Table 3 contains the data collected during the observation phase of each preflight inspection. Note that the "Other IDs" column indicates the quantity of unplanned squawks a participant identified. The average length of preflight inspections was found to be 12.93 minutes. In all cases, the interior portion required less time than the exterior portion. This seems sensible, as the exterior inspection has significantly more items and surface area to peruse. One outlier, participant 2, likely skews the data toward a longer overall inspection

duration. With the exception of this participant, interior inspection length remained consistently between 3.5 and 5 minutes. The extreme nature of the outlier data may be attributed to various abnormal factors introduced by the scenario of the study. These factors are discussed later in the Factors Influencing Participant Actions section.

Table 2: Pre-Inspection Questionnaire Responses

Participant Number	Importance of Preflight	Length of Preflight (minutes)	Checklist Use During Inspection	Post Inspection Action
1	8	10	Yes	C
2	10	20	Yes	C
3	10	15-20	Yes	C
4	9	5-30	Yes	C
5	10	25	Yes	C
6	10	15-20	Yes	C
7	10	10	Yes	C
8	10	10-15	Yes	C
9	7	10	No	B
10	10	15	No	C
11	9	15-20	No	C
12	9	10-12	No	C
13	8	10-15	Yes	C

Table 3 shows that 84%, or 11, of the participants actually used the checklist and the manufacturer recommended flow procedure during their inspections. Unexpectedly, two of the four individuals who claimed to not carry the checklist with them and reference it during their inspections actually did so during this study. If they normally use a memorized form of the preflight inspection, something about the study must have influenced them to carry the checklist and reference it throughout the scenario. Again, these factors are discussed later in Factors Influencing Participant Actions.

Table 3: Inspection Data Sheet and Statistics

Participant Number	Duration of Inspection (minutes)	Interior (minutes)	Exterior (minutes)	Using Checklist	Using Flow	Quantity Omitted Items	Squawks Identified	Quantity Abnormal Behaviors	Other IDs
1	9.45	4.50	4.95	Yes	Yes	3	0	4	1
2	23.15	14.05	9.10	Yes	Yes	1	4	4	
3	11.40	4.20	7.20	Yes	Yes	6	2	1	
4	9.90	3.80	6.10	Yes	Yes	2	2	2	
5	17.25	6.80	10.45	Yes	Yes	5	1	3	1
6	12.60	4.70	7.90	Yes	Yes	3	2	3	1
7	11.10	4.10	7.00	Yes	Yes	5	2	1	
8	16.10	4.85	11.25	Yes	Yes	5	3	4	
9	17.10	4.50	12.60	No	Yes	2	5	4	
10	12.10	4.95	7.15	No	No	1	4	1	
11	10.35	4.20	6.15	Yes	No	3	2	2	
12	10.60	3.65	6.95	Yes	Yes	2	2	1	
13	7.05	3.20	3.85	Yes	Yes	4	2	2	

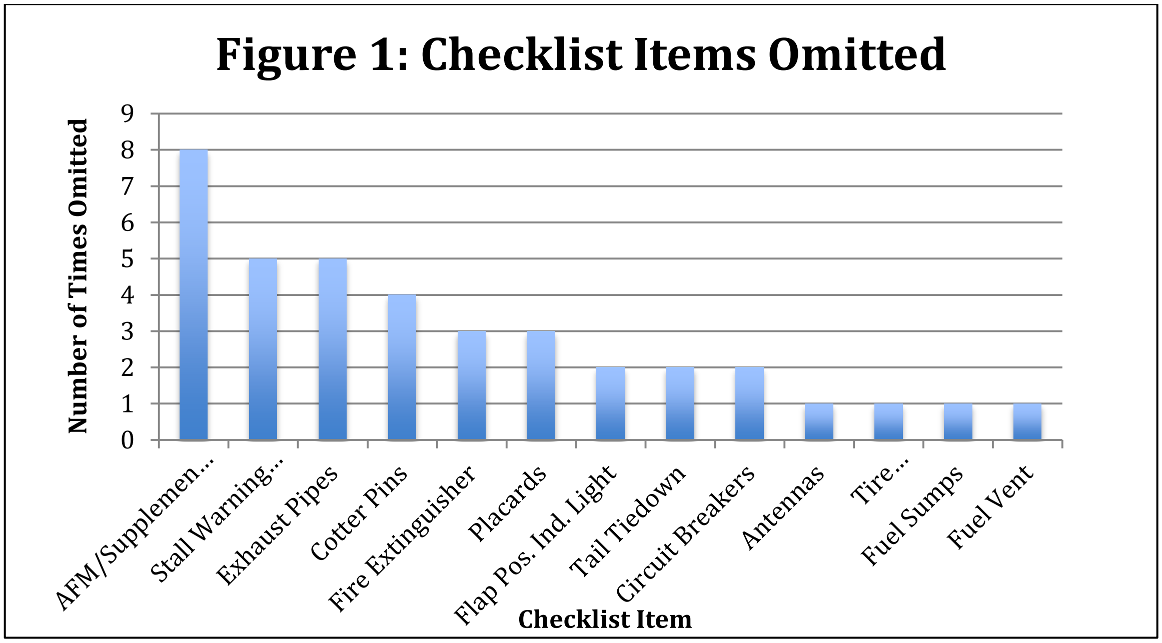
Mean	12.93	5.19	7.74			3.23	2.38	2.46	
Median	11.40	4.50	7.15			3.00	2.00	2.00	
Max	23.15	14.05	12.60			6.00	5.00	4.00	
Min	7.05	3.20	3.85			1.00	0.00	1.00	
Range	16.10	10.85	8.75			5.00	5.00	3.00	
% Using				84.62%	84.62%				

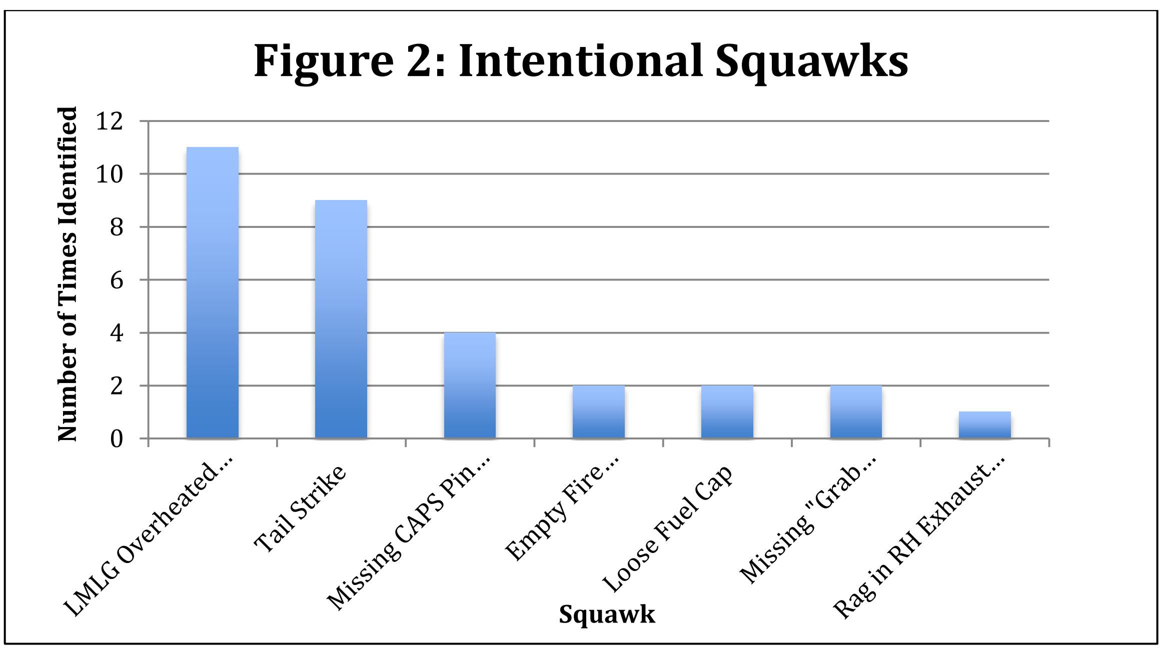
No relationship seems to exist between using the checklist and flow procedure and the number of checklist items omitted or discrepancies correctly identified, as the participants that used the proper methods collectively missed the most and the least number of items. At the same time, participants that used only one or neither of the proper methods missed no fewer items or correctly identified no more discrepancies than those that did use the proper methods. Finally, every participant displayed at least one abnormal behavior, or an action not typically manifested during preflight inspections. In most cases, they were improper or negligent actions; however, in other instances the participant showed impressive situational awareness or exceptional airmanship. The details of these behaviors are discussed further on in this section.

The next two figures, 1 and 2, show the type and quantity of checklist items omitted and the type and quantity of squawks successfully identified, respectively. The data in Figure 1 displays several unexpected trends. The AFM and supplements case are required documents for every flight (Civil aircraft flight manual, marking, and placard requirements, 14 CFR §91.9, n.d.). More than half of the participants either didn't attempt to locate them or did not sufficiently examine them to ensure they corresponded to the aircraft. Next, the stall warning horn inlet is a major component in a system that alerts the pilot of an approaching aerodynamic stall. Several participants did not inspect the inlet on the leading edge of the right wing or did so at such a distance as to render the check ineffective. Lastly, though only three participants skipped the fire extinguisher check, the majority of participants failed to determine if it was charged and secure. They merely confirmed one was present.

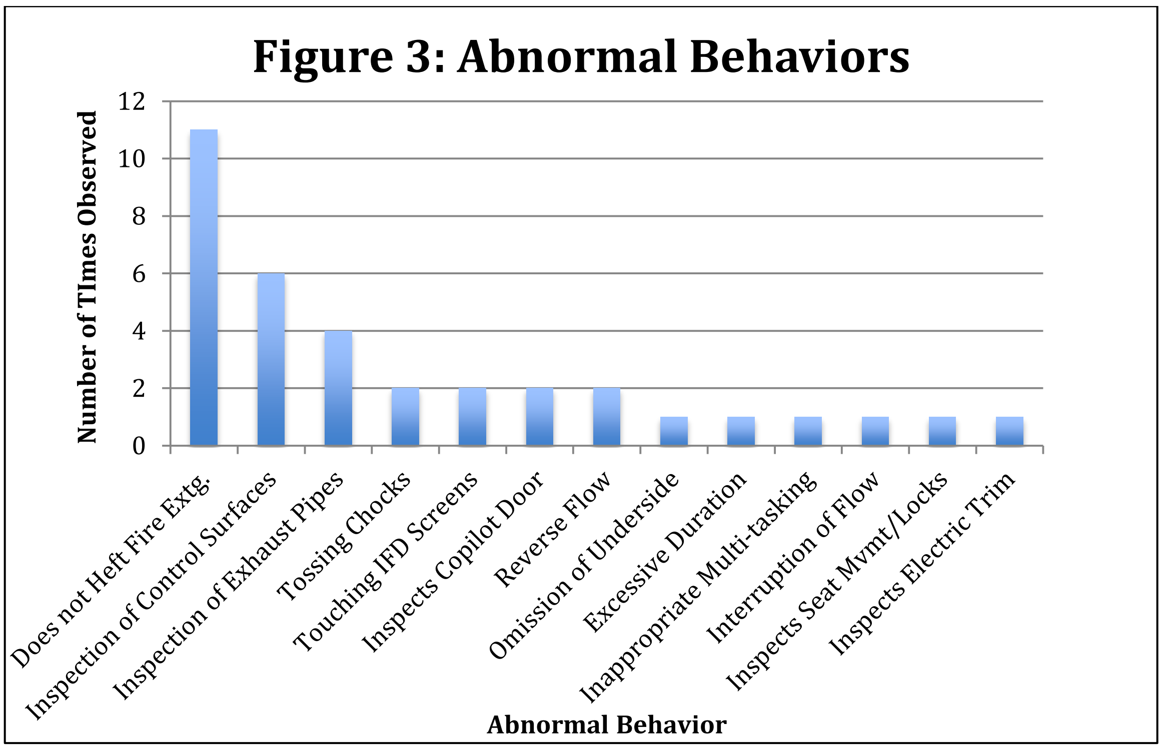
Figure 2 findings have similar results. The sample group easily identified the

overheated brake indication and the tail strike, but had much more difficulty with the remaining squawks. The two most likely to cause complications in flight, obstructed exhaust pipes and an unsecure fuel cap, were detected least often. Additionally, only two participants correctly identified the useless state of the fire extinguisher.





Finally, Figure 3 contains the various forms of abnormal behavior observed during the preflight inspections. Disconcertingly, nearly all participants did not check that the fire extinguisher was sufficiently charged with a properly secured pin. Next, a surprising number of participants did not properly inspect the flight control surfaces, an action which could have destructive consequences even prior to flight. Several participants ensured the passenger side door opened, closed, and latched securely while another went so far as to check seat movement and locking mechanisms on that same side as well. Indeed, some ingenuity, likely due to experience, resulted in a handful of novel inspection practices.



Discussion

Western Michigan University has a reputable aviation training program. Based on the above data, the majority of participants use the Cirrus checklist and conduct their preflight inspections with a controlled flow procedure. These preflight inspection procedures can identify major discrepancies, such as a potential tail strike or overheated brakes, but seem to be missing other crucial items such as the fire extinguisher and exhaust system. Even further, there seems to be a lack of understanding about what to look for at key points in the process, such as flight control movement with respect to the control yoke in the cockpit. A multitude of factors contribute to these shortcomings, including time pressures, the mission, supervision, complacency, and training practices.

Case Study: The Importance of Following Procedures

On May 31, 2014, a Gulfstream IV business jet attempted to depart from Lawrence G. Hanscom Field in Bedford, Massachusetts. The airplane failed to rotate and liftoff, eventually exiting the runway and coming to rest in a ravine. All onboard perished and the airframe was destroyed. Upon investigation the NTSB found that neither pilot disengaged the flight control gust lock, a mechanism for preventing control surface movement in windy conditions on the ground, or performed a basic flight control check. In other words, the aircraft was unable to rotate and establish a pitch attitude to lift off of the runway. A review of the pilots' previous 175 flights revealed habitual noncompliance with standard operating procedures (SOPs) and checklists. The crew fully completed flight control checks on only two of those previous missions (NTSB, 2015).

In September 2015, the NTSB published a Safety Alert pertaining to checklist usage to prevent overlooking even "insignificant" items. The Board strongly urges pilots to follow

SOPs and use checklists as the memory aids they are designed to be (NTSB, 2015). Both types of documents and procedures are designed to help "counteract human performance vulnerabilities." The FAA, the NTSB, and WMU each mention "with reference to," "in accordance with," "adherence to," or "use of" checklists for preflight inspection and subsequent aviating actions to mitigate the risk of overlooking crucial tasks (FAA, 2004; FAA, 2011a; FAA, 2011b, Western Michigan University, College of Aviation, 2015). The individuals in this study and other pilots who choose not to use a checklist during the preflight inspection of their aircraft do themselves and their passengers a great disservice.

Factors Affecting Pilot Performance During a Preflight Inspection

Human factors play a major role in the aviation industry. People are the lifeblood of aviation, but all too often its greatest downfall. Human factors may be described as a person's abilities, limitations, attitudes, and characteristics as they apply to all facets of aviation activities. The term encompasses everything to do with the human effect on the planning, procedures, and outcome of a flight, including not just the pilots' influence, but air traffic controllers, maintenance technicians, ground handlers, and administrators (Graeber, n.d.). This study focuses mainly on the pilot side with influences from maintenance personnel (maintenance practices) and college flight administration (standard operating procedures).

Under normal conditions, a pilot performing a preflight inspection is exposed to several forms of pressure. The most notable of these pressures is time. Aviation relies heavily on a schedule, even in the collegiate training environment. Individuals may feel the demand of a tight schedule and allow the pressure to affect the quality of an inspection by rushing through it. The crew's mission can also influence a pilot to vary his or her

performance. Perhaps the flight will only be conducted in the local training area, so no check of survival equipment is completed or additional oil stowed. In contrast, the flight may be traveling great distances, resulting in a thorough preflight that includes heavily scrutinizing survival equipment and taking extra operating fluids, such as engine oil or hydraulic fluid. Some missions, such as that of the Life Flight Network, require crews to respond rapidly to a medical emergency. Seemingly nonessential items may be neglected in favor of saving time and therefore, another's life. Other factors that may impact an operation include pilot fatigue, comfort level (due to temperature, humidity, or illness), time of day, weather, and company culture (Garrison, 2003). All of these pressures place stress on a pilot to complete the mission at hand in a particular manner. The pilot must be aware of stressors affecting his or her decision making, manage that pressure, and plan accordingly to perform the procedure to the same high standard every single time.

Factors Influencing Participant Actions

Perhaps the greatest factor affecting performance in this study was the notion of "foul play." All participants voiced concern of the airplane being intentionally rendered un-airworthy. Thus, prior to even beginning the process, every participant was biased to conduct a more meticulous inspection than normal on the sense of the study being rigged. In order to mitigate the effects of this factor, each participant was instructed several times in the pre-inspection brief to "complete [their] inspection of the aircraft as normal," as the study was designed to determine the effectiveness of normal procedures. Only one volunteer, participant 2, displayed an unusually lengthy preflight inspection, possibly to locate all of the squawks without following the standardized procedure. The remainder of the participants completed their inspections in a more or less typical manner, occasionally

backtracking to reexamine an item.

The second factor, another unique to this study, was the investigator. Most participants conduct their preflight inspections without supervision, as they are expected to understand the procedure and be able to complete it properly upon reaching the private pilot level. Reintroducing an observer affected several participants, a few reporting the discomfort prior to beginning their inspections. One participant several times attempted to solicit the un-airworthy conditions from the investigator while another sought conversation for the entire duration. Those that reported discomfort showed markedly more reliance on the checklist than those that did not. It is also possible that some participants were influenced by the investigator's presence to use the checklist more often. This may be the case of the two participants who responded in the pre-inspection questionnaire that they do not use the document at all during their preflight inspections but did so during this study.

The next factor, preflighting without intent for flight, does occur in the normal training environment. However, most preflight inspections are conducted under the assumption that flight will follow. These inspections have more incentive to be proper and complete and are carried out with respect to a given mission as mentioned in the previous section. The inspections for this study were conducted in a hangar under the premise that the pilot would depart for a day visual flight rules flight. Complacency could have resulted from the lack of intent for actual flight, though the degree to which this factor affected the study is unclear.

Additional factors, such as hazardous attitudes and the learning process, with deeper ties to human factors research, may affect preflight inspections. In nearly all cases,

a flight will depart a home airport and arrive safely at the intended destination without incident. No one can argue with incident-free flight operations, but such impressive safety records can lead to the hazardous attitude of invulnerability. A pilot with this attitude has the mentality that bad things "won't happen to me" (FAA, 2008c). Through this sense of invulnerability comes complacency, or a certain degree of laziness, in routine procedures. Complacency results in skipping checklist items, not considering the implications of various actions, and a significant loss of situational awareness. With regards to this study, complacency most often took the form of not confirming the fire extinguisher's status. Normally it is charged and secure, so "why would today be any different? Nothing bad ever happens anyway." Similarly, the high number of participants who improperly inspected or omitted the AFM and supplements likely assumed that they were always present, always corresponded to the aircraft, and that a ramp check was not in their horoscopes that day. Regardless of the probability of an in-flight fire, encounter with an FAA inspector, and/or ideal past experiences, these items must be checked before every flight, if not to follow the rules, then as a precautionary measure.

Every pilot today must give credit to his or her past flight instructors. These patient individuals are tasked with imparting a substantial amount of information, complex concepts, and tips for quality decision-making on their pupils. Regardless of an instructor's background or experiences, no one is infallible. An instructor's complacency due to a negligent mindset and exceptional good fortune could result in poor teaching practices that leave a student with gaps in critical knowledge areas. Responsibility rests with the instructor to seek out these holes through regular evaluation and scenario-based training, a form of problem-based learning in which a student must work a realistic situation through

ADM. A student should receive additional training for any areas deemed weak after which he or she is then responsible for remaining proficient and informed after learning a concept. Participants in this study learned from their instructors and executed the preflight inspection procedure within the limits of their knowledge, training, and experience. The habits of their flight instructors, inherited through training, had a profound impact on their performance. Pilots with less experience such as the majority of participants in this study are more likely to be affected by their instructors than those pilots with more experience who have been outside this environment for a great amount of time.

Abnormal Behaviors

Taking into account the information above, one can more closely examine the abnormal behaviors in this study. For example, neglecting to heft the fire extinguisher goes without saying—the instructor never demonstrated this action, failed to continuously reinforce it, or the student grew lazy. The importance of the check may be underemphasized by the lack of incidents requiring it, leading to complacency because "nothing bad ever happens."

The flight control inspection offers a more comprehensive analysis based on the factors discussed throughout this section. First, foul play may have been expected, but attempts to mitigate the threat were misdirected. Rather than looking for reversal of control cable rigging, participants were more concerned with alterations to the control surfaces themselves. Such alterations include improper hinge movement, missing or unsecure bolts and pins, damage to the structure, or even tools left in unusual places. Second, the presence of the investigator could have made the participants unsure of what

to look for due to the unusual supervision. Next, the fact that there was no intent for flight could have led to complacency in the procedure. Without the motivation of going flying, the implications of an inadequate preflight carry little weight. Similarly, Western has rarely, if ever, had a control rigging issue with its aircraft, a stellar reality that leads to an attitude of invulnerability or apathy. Again, if nothing bad ever happens, why would it happen now? Finally, a lack of understanding of flight control systems could make the task intimidating. The image below, credit of ASA online ground school (2012), diagrams control yoke movement with respect to the control surface movement.

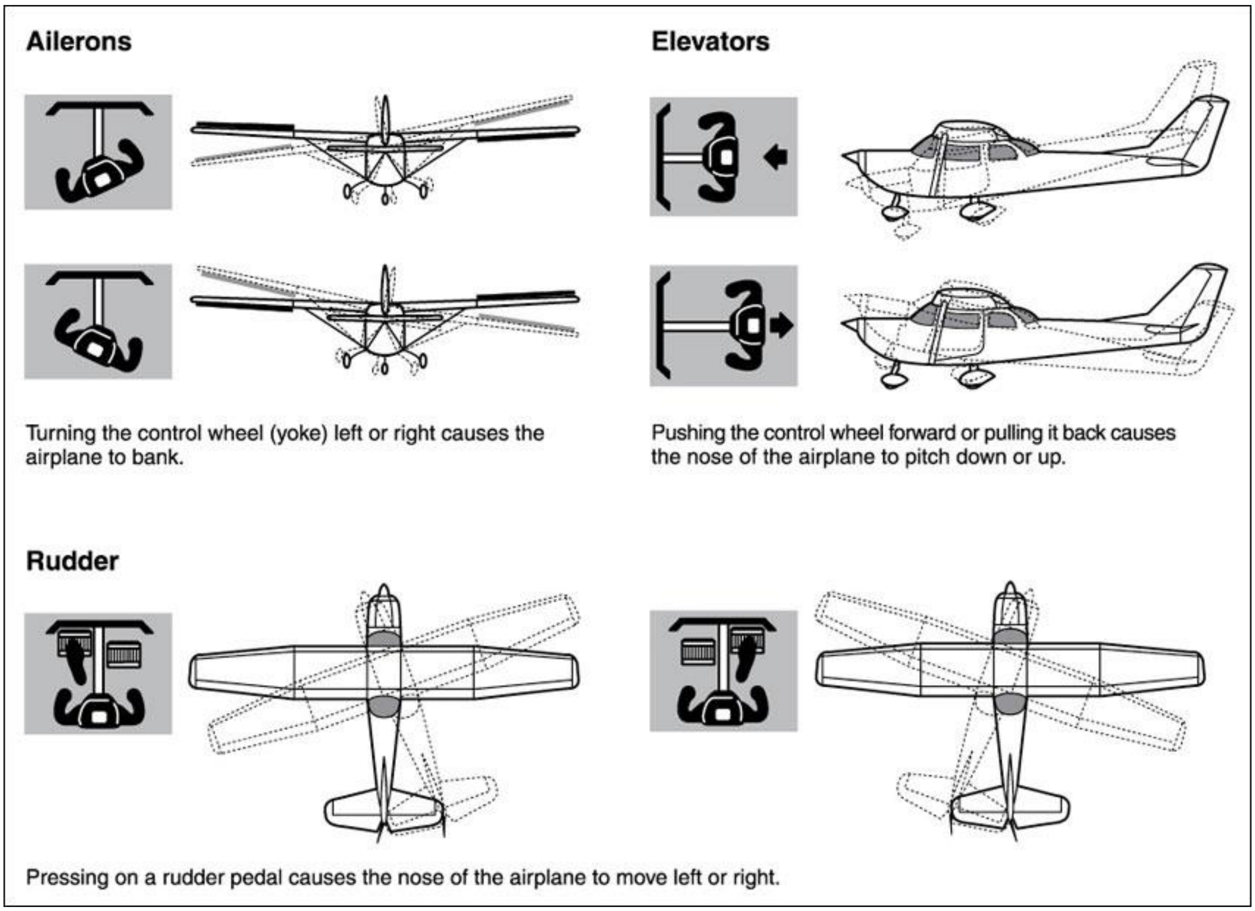


Image 2: Flight Control Movement with Respect to the Control Yoke

When the right aileron is deflected downward, the left aileron should be deflected upward and the yoke should rotate left. When the right aileron is deflected upward, the left

aileron should be deflected downward and the yoke should rotate right. When the elevator is deflected downward, the control yoke should move forward and vice versa for opposite movement. The rudder is a simpler system: deflection of the rudder to the right results in the right pedal moving forward and vice versa for deflection to the left. A properly studied, trained, and experienced pilot can detect unusual cable movement and reversed rigging. In this study, the lack of intent for flight and lack of understanding are the most plausible reasons for improper control surface inspection.

Other abnormal behaviors, including the touching of the IFD screens, inspection of the exhaust pipes, tossing of chocks, omission of the underside of the plane, and interruption of the flow procedure may be due to accidently overlooking an item this time or a lack of reinforcement through instruction or experience. The reverse flow procedure is quite an oddity. This methodology is neither standard practice nor reinforced through training. When queried about it, both participants stated it was "how [they] have always done it." However, since a reverse flow is never mentioned in the Cirrus SR20 AFM or WMU FOM or online pilot briefings, it is unknown how this habit was developed (Western Michigan University, College of Aviation, L01 preflight – cockpit module; Western Michigan University, College of Aviation, L01 preflight – external module). Even more surprising is the fact that these individuals, along with those who did not use a checklist, omitted very few items and located nearly all of the discrepancies. This peculiarity likely stems from the greater amount of Cirrus experience these individuals held over other the participants.

Participants with Additional Responsibilities

An interesting situation also arose between those participants with additional responsibilities. The three volunteers on the WMU flight team compete in the preflight

inspection event in National Intercollegiate Flying Association competitions. Though trained to spot abnormalities on Cessna 150s, 152s, 172s, and a number of other aircraft, they have received little competition training on the Cirrus SR20. Even so, they were expected to perform to a higher standard (omitting the fewest checklist items and detecting the most discrepancies) than those that were not flight team members. The two maintenance technicians regularly maintain, inspect, and operate the college's fleet, granting them a remarkable amount of experience with more than just flying the airplanes. While the flight team members did not locate as many discrepancies, they performed exceptionally well with the checklist, more so than those who were neither flight team members nor maintenance technicians. The maintenance technicians likewise demonstrated adherence to the checklist, except they also detected several more squawks than the flight team members. This incongruity is likely due to the maintenance personnel's varied experience with the aircraft, which affords them a broader working knowledge than the remaining participants of what to look for throughout the inspection process.

Conclusion

The collegiate flight training environment follows a structured training regime in order to produce the next generation of professional pilots. A program such as that offered at Western Michigan University strives to educate to the highest level, and in many ways succeeds at this goal. However, few systems hold a perfect record, and collegiate flight training programs are no exception. The results of this study are not indicative of the College of Aviation or the training environment as a whole, because the sample was neither large enough nor randomly selected. Nonetheless, the results seem to indicate the presence of the fundamentals for carrying out standardized preflight inspections, but highlight complacency, non-standardization, and occasional misunderstanding. Pilots completing the preflight inspection procedure seem to be blindly following the checklist and only identified the most blatantly obvious squawks.

Recommendations

General practice for teaching preflight inspection procedures involves significant instructor involvement for the first few preflights, after which the students conduct them on their own with limited supervision and minimal instructor input. As long as the proper methodology is taught initially, additional training, when needed, on neglected and key indicator areas should be enough to create a safe aviator. Unfortunately, this practice appears to be ineffective. The following recommendations are made in an effort to improve the conduct of preflight inspection practices in the collegiate training environment.

Several changes to early-stage and transition-type instructional practices would lead to better preflight inspections. First, once the procedure has been introduced and good airmanship reinforced, observation should continue for a greater length of time.

Ensuring the procedure is properly completed every time is crucial to developing good habits. Second, a greater emphasis should be placed on areas that commonly indicate that problems are present, such as the empennage, landing gear, and nose. For example, a tail strike may result from a hard landing that damages the gear, propeller, and engine in addition to the rear of the plane. Third, many examples of un-airworthy conditions should be shown and explained to trainees. Small deviations are often noted during an inspection, but are just as often downplayed or ignored. In reality, these discrepancies could indicate bigger problems. Pilots must be capable of not only detecting such issues, but also be able to think about the implications and take appropriate action. For example, the weight of a partially discharged or empty fire extinguisher can be compared to that of a full unit. A short discussion of what this situation could mean and how to remedy it should follow. Lastly, once the trainee conducts the procedure on his or her own, the instructor should randomly observe an inspection to check up on the pilot's practices. Reinforcement may be necessary.

For aviation professionals fresh out of the training environment, disciplined self-study can assure continued great performance. Resources, such as the AFH, ASA ground school, and industry magazines are easily accessible for current practice information. Online courses through faasafety.gov and AOPA's webinars and Air Safety Institute are constantly developed and updated to provide additional interactive material. Simply practicing the procedure and conducting self-evaluations can help a pilot identify problem areas and reinforce good habits. Lastly, regularly enlisting the help of a CFI ensures another trustworthy opinion is available. Ultimately, continued attention to detail should lead to more professional, safe, and quality aviators for the future.

In order to obtain results more characteristic of the population, the principle investigator could gather a greater sample size selected at random. Rather than soliciting volunteers from courses, a scenario could be devised wherein random individuals are dispatched the un-airworthy airplane. The principle investigator would then ensure that the pilot wishes to participate, and the preflight inspection would continue as in the study described within this paper. Various other permutations of the pre-inspection questionnaire, squawks, and post-inspection questions could be tailored to the new project design.

Summary

The importance of conducting a preflight inspection cannot be overstated—it saves lives, time, and money. Pilots do not have the ability to simply pull over to the shoulder of the road to address a problem. They must handle the situation while moving at multiple times the speed of a car, thousands of feet in the air, at great distances from a suitably paved runway surface. If a known problem could have been solved prior to flight, why was the flight launched without taking action? Preflight inspections are not intended to waste energy, be a mundane exercise, or be completed at record speed. They are designed to identify issues on the ground, so that they may be resolved prior to flight. A preflight inspection should be a routine to grow familiar with one's airframe before every launch. While current practices look great on paper, room for improvement still exists.

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Appendix A

Recruitment Script

Hello. I'm Seth Laws. I am an undergraduate student and flight instructor at the College of Aviation. I am conducting research for my honors thesis and need your help. I am looking for WMU flight students and flight instructors who have received training in the Cirrus SR-20 and are willing to complete a written questionnaire and preflight inspection of a Cirrus SR-20 aircraft. This study is designed to establish how effective WMU's preflight inspection practices are, and to develop improvements to our procedures. This will be accomplished by observing individual preflight inspections and analyzing the resulting data.

The study consists of one questionnaire and a preflight inspection, requiring approximately 20 minutes of your time. To be eligible, you must be a current WMU flight student who is enrolled in a flight course and holds at least a private pilot license, or a WMU flight instructor currently employed by the university who provides flight instruction in the Cirrus SR-20.

Your participation is entirely voluntary, and you may withdraw at any time. Participation in or withdrawal from this study will not affect your enrollment and/or employment.

To participate, please contact Seth Laws at (304) 634-7701 or seth.m.laws@wmich.edu.

What questions do you have?

Thank you for your time.

Appendix B

PREFLIGHT INSPECTION	
Cabin	
Required Documents	On Board
Avionics Power Switch	OFF
Bat 2 Master Switch	ON
PFD (left IFD)	Verify ON
Avionics Cooling Fan	Audible
Voltmeter	23-25 Volts
Flap Position Light	OUT
Bat 1 Master Switch	ON
Lights	Check Operation
Stall Warning	Test
Fuel Quantity	Check
Fuel Selector	Select Fullest Tank
IFD System Page/Sensor Tab	VERIFY Required Systems OK (green)
Flaps	100%, Check Light ON
Bat 1 and 2 Master Switches	OFF
Alternate Static Source	Normal
Circuit Breakers	IN
Fire Extinguisher	Charged and Available
Emergency Egress Hammer	Available

Left Fuselage	
COM 1 Antenna (top)	Condition and Attachment
Wing/Fuselage Fairing	Check
COM 2 Antenna (underside)	Condition and Attachment
Baggage Door	Closed and Secure
Static Button	Check for Blockage
Parachute Cover	Sealed and Secure

Empennage	
Tiedown	Remove
Horizontal and Vertical Stabilizers	Condition
Elevator and Tab	Condition and Movement
Rudder	Freedom of Movement
Rudder Trip Tab	Condition and Security
Attachment hinges, bolts and cotter pins	Secure

Right Fuselage	
Static Button	Check for Blockage
Wing/Fuselage Fairings	Check

Right Wing Trailing Edge	
Flap and Rub Strips (If installed)	Condition and Security
Aileron and Tab	Condition and Movement
Hinges, actuation arm, bolts, and cotter pins	Secure

Right Wing Tip	
Tip	Attachment
Strobe, Nav Light and Lens	Condition and Security
Fuel Vent (underside)	Unobstructed

Right Wing Forward and Main Gear	
Leading Edge and Stall Strips	Condition
Fuel Cap	Check Quantity and Secure
Fuel Drains (2 underside)	Drain and Sample
Wheel Fairings	Security, Accumulation of Debris
Tire	Condition, Inflation, and Wear
Wheel and Brakes	Fluid Leaks, Evidence of Overheating, General Condition and Security
Chocks and Tiedown Ropes	Remove
Cabin Air Vent	Unobstructed

Nose, Right Side	
Cowling	Attachments Secure
Exhaust Pipe	Condition, Security, and Clearance
Transponder Ant. (underside)	Condition and Attachment
Gascolator (underside)	Drain for 3 seconds, Sample

Nose Gear, Propeller, and Spinner	
Tow Bar	Remove and Stow
Strut	Condition
Wheel Fairing	Security, Accumulation of Debris
Wheel and Tire	Condition, Inflation, and Wear
Propeller	Condition (indentations, nicks, etc.)
Spinner	Condition, Security, Oil Leaks
Air Inlets	Unobstructed
Alternator Belt	Condition and Tension

Nose, Left Side	
Landing Light	Condition
Engine Oil	Check 6-8 Quarts, Leaks, Cap and Door Secure
Cowling	Attachments Secure
External Power	Door Secure
Exhaust Pipe(s)	Condition, Security, and Clearance

Left Main Gear and Forward Wing	
Wheel Fairing	Security, Accumulation of Debris
Tire	Condition, Inflation, and Wear
Wheel and Brakes	Fluid Leaks, Evidence of Overheating, General Condition and Security
Chocks and Tiedown Ropes	Remove
Fuel Drains (2 underside)	Drain and Sample
Cabin Air Vent	Unobstructed
Fuel Cap	Check Quantity and Secure
Leading Edge and Stall Strips	Condition

Left Wing Tip	
Fuel Vent (underside)	Unobstructed
Pitot Mast (underside)	Cover Removed, Tube Clear
Strobe, Nav Light and Lens	Condition and Security
Tip	Attachment

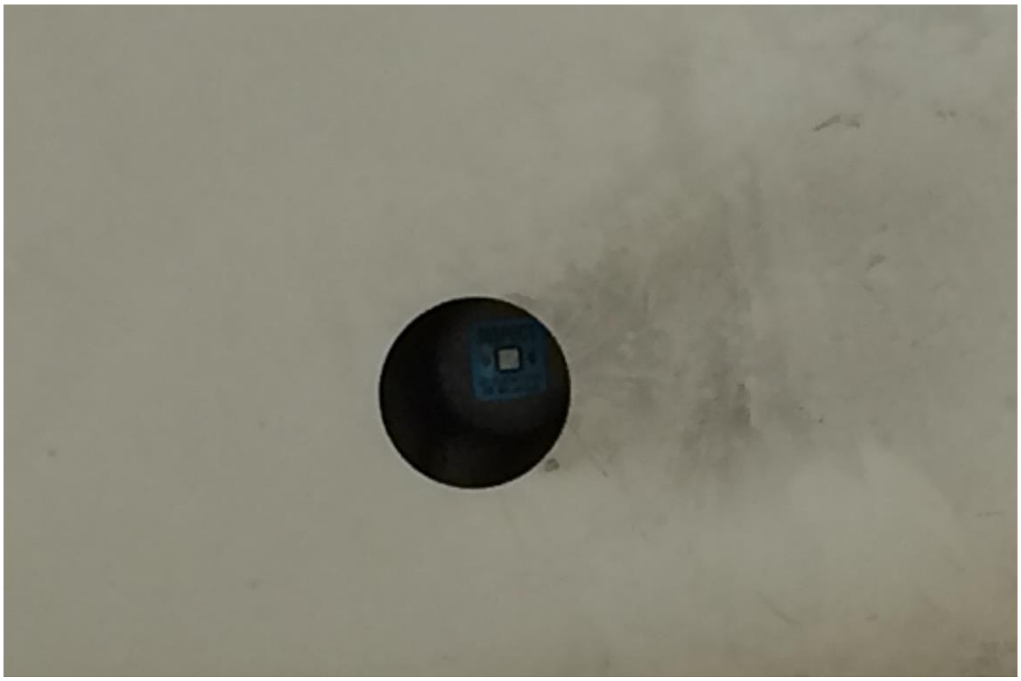
Left Wing Trailing Edge	
Flap And Rub Strips (If installed)	Condition and Security
Aileron	Freedom of movement
Hinges, actuation arm, bolts, and cotter pins	Secure

Appendix C

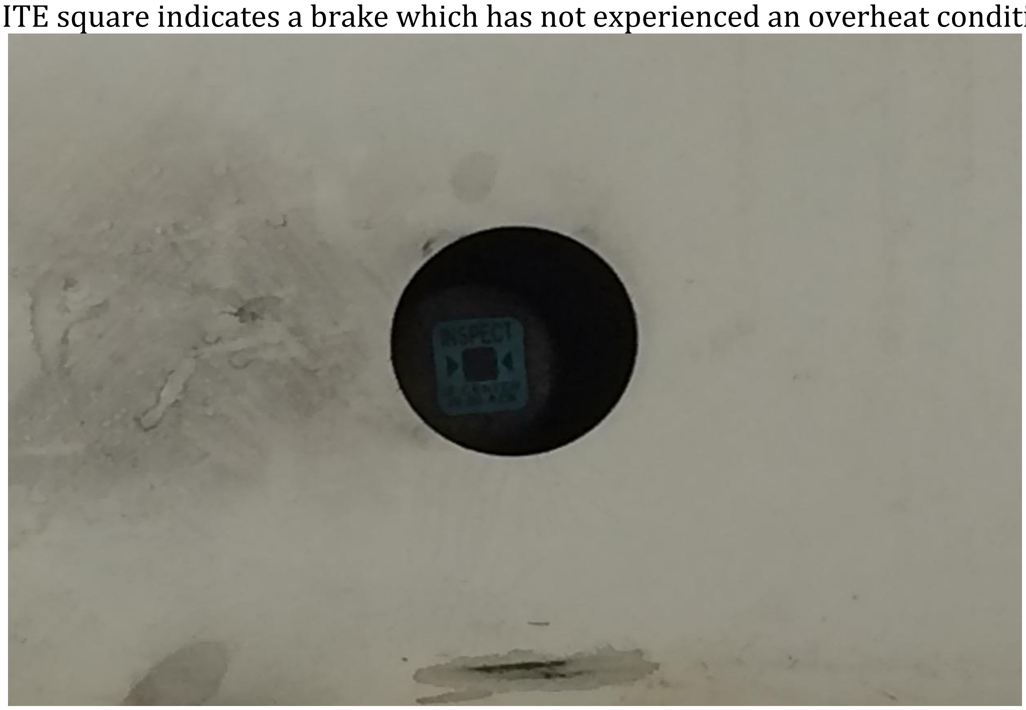
Squawks

NOTE: Not all squawks are pictured, as some conditions require movement of an item to detect.

<u>Overheated Brakes</u>:



The WHITE square indicates a brake which has not experienced an overheat condition.



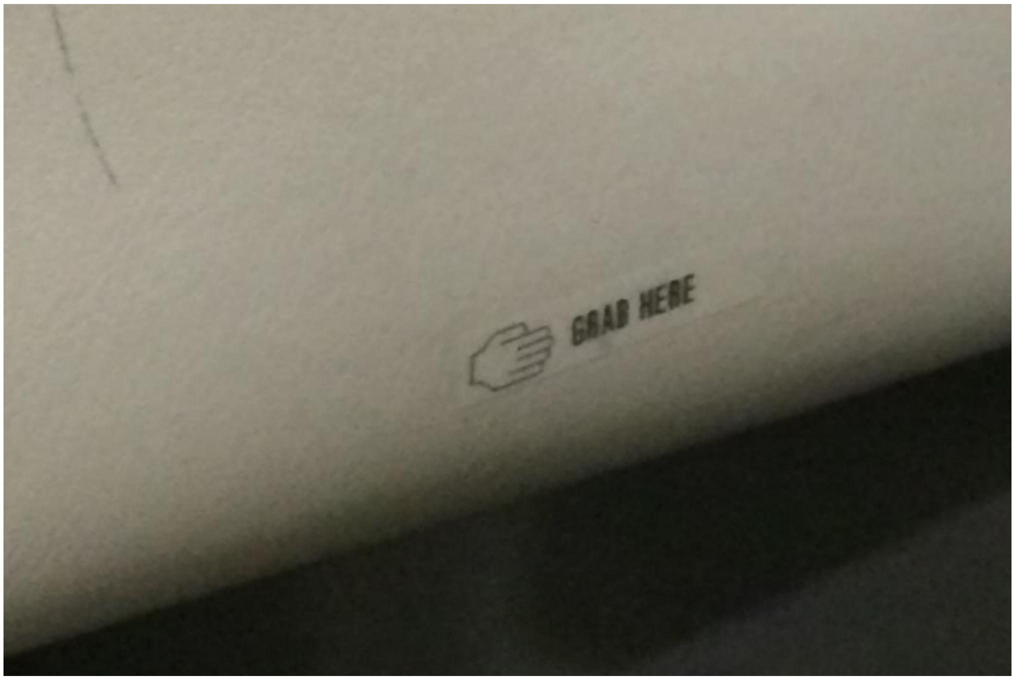
The BLACK square indicates an overheated brake condition.

Tail Strike:

The flat, grooved appearance of the bottom of the rubber tailskid coupled with the faded white paint indicates that a tail strike may have occurred.

Placards:

The CAPS pin has been inserted upside down without the "Remove Before Flight" tag.



The “Grab Here” placard as it should appear on the panel. This sticker was removed on the pilot-side panel.

Exhaust Pipe:

Disposable oil rags were inserted into the right hand exhaust pipe.

Appendix D

Inspection Questionnaire

Participant Number: __________

What certificate(s) do you currently hold? Please circle your response below.

Private Pilot License
Private Pilot License with Instrument Rating
Commercial Pilot License
CFI/I

How many total flight hours have you logged?

____

On a scale of 1 to 10, 1 being of lowest importance and 10 being of highest importance, how important is a preflight inspection? Please circle your answer below.

1 2 3 4 5 6 7 8 9 10

In your opinion, how long, in minutes, should an ideal preflight inspection of a Cirrus SR-20 take?

____

Do you carry with you and use the preflight inspection checklist during your preflight inspections?

YES / NO

If YES, why?

If NO, why?

Please do NOT turn the page until directed to do so by the student investigator.

Participant Number: __________

Please record your response to the following question *after* completing your preflight inspection.

How would you respond to a situation that results in an un-airworthy aircraft?

a. Fly the aircraft without taking any further action.
b. Attempt to fix the issue yourself, and then proceed to fly.
c. Talk to a maintenance technician, and ensure all work is logged.

If you wish to elaborate on your response, please do so below:

Appendix E

Inspection Data Sheet

Participant Number: __________ Duration of Inspection (minutes) ___________

Is the participant using the preflight inspection checklist?

YES / NO

Is the participant following the manufacturer/WMU recommended flow procedure around the aircraft?

YES / NO

Checklist Items Omitted:

Abnormal Behavior or Actions (e.g. excessive talking, rough handling of the aircraft, etc.):

Discrepancies Identified (note those which the participant identifies):

Appendix F

Preflight Questionnaire Written Responses

1. Do you carry with you and use the preflight inspection checklist during your preflight inspections?

    If YES, why?
    - As a reference, also to remember small things you may forget.
    - Redundancy
    - To skim over sections to make sure I hit everything
    - To crosscheck the flow
    - It is proper use of checklists
    - To see what to do
    - To make sure I actually use the checklist. Also to check, double check every listed item on there.
    - Do stuff in order, don't have to memorize, easier flow.
    - Just in the cockpit.

    If NO, why?
    - Normally fly acft that are out of inspections/maintenance—preflight items have been accomplished during maintenance.
    - Memory
    - Checklist memorized
    - I do a flow and then double check with checklist back in cockpit

2. How would you respond to a situation that results in an un-airworthy aircraft? If you wish to elaborate on your response, please do so below.

    - C—If the aircraft is un-airworthy, then I wouldn't feel comfortable flying it.
    - B, C—Depending on the problem, I would trouble shoot it myself. If I couldn't fix it, legally, I would speak with maintenance/check the KOL.
    - C—The right brakes were overheated, the white rectangle was black, meaning overheated brakes. Also the trail strike rubber looked worn and needed to be re-painted possibly inspected.
    - C—Call dispatch first, then maintenance check to check that they didn't give the wrong plane that might be down 4 (for) maintenance.

Appendix G

WESTERN MICHIGAN UNIVERSITY

Human Subjects Institutional Review Board

Date: October 19, 2015

To: Gil Sinclair, Principal Investigator
Seth Laws, Student Investigator for thesis

From: Amy Naugle, Ph.D., Chair Amy Naugle

Re: HSIRB Project Number 15-10-17

This letter will serve as confirmation that your research project titled "Analysis of Preflight Inspection Practices in the Collegiate Training Environment" has been **approved** under the **expedited** category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note: This research may **only** be conducted exactly in the form it was approved. You must seek specific board approval for any changes in this project (e.g., ***you must request a post approval change to enroll subjects beyond the number stated in your application under "Number of subjects you want to complete the study***)." Failure to obtain approval for changes will result in a protocol deviation. In addition, if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

Reapproval of the project is required if it extends beyond the termination date stated below.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: October 18, 2016

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