# Civil UAV Type Certification:
# DoD Mishap Analysis 2000-2009 and FAA Certification Roadmap

By

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Abstract

The Federal Aviation Administration (FAA) has issued memorandums which support the use of flight activities which can demonstrate that proposed operation can be conducted at an acceptable level of safety. This paper examines the existing data available from the Air Force on Unmanned Air System (UAS) reliability, and attempts to apply that information to UAS FAA certification. This will allow UAS to operate more freely in the National Airspace System (NAS).

The current state of UAS operations is assessed from the Safety Investigation Board One-Line Summaries and Judge Advocate General Accident Investigation Board executive summaries. This data is categorized and aggregated to show sources of failure and the impact of those failures on the system. Detail failure trends are derived from the data that show gaps in airworthiness. This data is then tested against the applicable subset of Part 25 rules for sufficiency as a Means of Compliance (MOC). The gaps in sufficiency are discussed, and alternative methods for knowledge acquisition are examined for their sufficiency as MOC. The uniqueness of UAS safety, new risks and reduced risk, is discussed finally, and a plan is proposed to reduce certification burden in a post-production environment for this new Type Class of Vehicle. The result is a hypothetical set of UAS rules and means of compliance that supports UAS incorporation in the NAS by the 2015 deadline specified in recent federal law.

## Acknowledgments

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Table of Contents

List of Tables

List of Figures

List of Abbreviations

| | |
|---|---|
| 14CFR | Title 14 of the Code of Federal Regulations – Aeronautics and Space |
| 49CFR | Title 49 of the Code of Federal Regulations - Transportation |
| AIB | Accident Investigation Board |
| AFSC | Air Force Safety Center |
| CAA | Civil Aeronautic Authority |
| COA | Certificate of Wavier or Authorization |
| FAA | Federal Aviation Administration |
| DoD | Department of Defense |
| HALE | High Altitude Long Endurance |
| MALE | Medium Altitude Long Endurance |
| MOC | Means of Compliance |
| NAS | National Airspace System |
| Part 23 | 14CFR Part 23 – Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes |
| Part 25 | 14CFR Part 25 – Airworthiness Standards: Transport Category Airplane |

| | |
|---|---|
| Part 26 | 14CFR Part 26 – Airworthiness and Safety Improvements for Transport Category Airplanes |
| Part 33 | 14CFR Part 33 – Airworthiness Standards: Aircraft Engines |
| Part 35 | Airworthiness Standards: Propellers |
| SIB | Safety Investigation Board |
| RPV | Remotely Piloted Vehicles |
| Title 10 | U.S. Code Title 10 – Armed Forces |
| TC | Type Class |
| UAV | Unmanned Air Vehicle |
| UAS | Unmanned Air System |

Causation Categories:

| | |
|---|---|
| LL | Lost Link |
| RP | Reduced Perception |
| HL | Hard Landing |
| RE | Reliability |
| PE | Pilot Error |
| ME | Maintenance Error |

ENV Environmental

=== Unclassified

Reliability Categories:

PWP Power Plant

AP Auto Pilot

EE Electrical

HD Hydraulic

STR Structural

## 1. Background

The Federal Aviation Administration (FAA) has an over arching goal to ensure the airworthiness of aircraft flying in the National Airspace (NAS). Typically, this airworthiness is demonstrated during the engineering design and initial testing of a new system. Policy and regulation dictate that for a new system to have access to the NAS, that system must demonstrate an acceptable level of safety. This safety assessment must conform to the existing set of regulations presented in Title 14 of the Code of Federal Regulations – Aeronautics and Space (14CFR). These regulations have been developed over time to ensure the air system designers address airworthiness issues that have affected aircraft safety in the past and to ensure that all vehicles in the market are starting from the same minimal level of safety required to sustain the operational confidence necessary for a large air commerce system to exist.

However, there are situations where aircraft move though design, manufacturing, and flight test phases with limited FAA involvement (e.g., agricultural, experimental, and military aircraft). In these situations, such aircraft are flown in a highly restrictive manner or certified for flight by a body outside the FAA (i.e., the Department of Defense (DoD)). Unmanned air systems (UAS) are such systems.

Such evolution of a system, outside FAA certification, is not unprecedented. UAS are now moving down a path similar to certification as agricultural aircraft after the dawn of aviation. These aircraft were developed prior to the codification of civil air regulations and presented a challenge to certification under the new rules. Their barn storming developmental roots was compensated for by the restriction of the space they operated in. The risk created by these barn built amateur aircraft was deemed completely segregated from non-consenting citizens. The pilot consented to operation of this experimental airframe, and the landowner consented to its operation on his property. Today, agricultural planes are certified to 14CFR Part 23 – Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes (Part 23) minus a list of allowed exemptions that the Administrator found inappropriate for that aircraft Type.

UAS have moved beyond niche systems, and their success has suggested numerous applications beyond the DoD. Future unrestricted use of UAS in the NAS will therefore require some form of "catch up" certification to account for those activities that were not conducted jointly with the FAA during design, manufacture, and initial certification of the small fleet of large UAS whose operational reliability would impact the safety of the NAS. To accomplish post-production certification, the FAA has issued memorandums which support the use of flight activities which can demonstrate that proposed operation can be conducted at an acceptable level of safety. This implies that some form of risk assessment can be applied to proposed operations by making use of data from fleet operations that would offset the amount of supplement testing and observation required to prove airworthiness.

This thesis examines the available data from two sources of operational activity between FY2000-FY2009. The thesis looks to the data for use in certification of the Large UAS in question, and proceeds with an assessment of the current safe level of these systems based on that data. This paper outlines a process by which UAS certification for operations in the NAS could be achieved. Based on the existing training of pilot and crew, the technology depended on for navigation, and the graceful mission of the UAS in question, the transport rules of Part 25 are the most applicable to current Medium and High Altitude Long Endurance (MALE and HALE) UAS. These regulations could be applied to a UAS minus a list of exemptions that account for the reduced safety risk posed by UAS. The existing fleet data is reviewed for its sufficiency in fulfilling the remaining applicable Part 25 rules, and supplemental means of compliance are discussed that would fulfill the remaining certification burden that exists for these aircraft with the anticipation of their operation in the NAS under the 2015 mandate.

## 1.1. UAVs Examined in This Study

### 1.1.1. Predator

The RQ-1 first entered service in April of 1996. It is the earliest and smallest system of interest to this study. It has a wing span of 55 ft, 1130 lb dry weight, and a max payload of 450 lbs. The original mission of the RQ-1 is intelligence, surveillance, and reconnaissance. The "R" is a Department of Defense designation for reconnaissance aircraft. The "Q" designates an unmanned system, and the "1" designate that is the first remotely piloted vehicle fielded by the DoD. In 2002, the fleet began conversion to "MQ-1". This came with the addition of 2 Hard Points. Most popularly used for the attachment of two 110lb Hellfire missiles. The "M" is the DoD designation for multi-role. A general summary of MQ-1B specs can be found below in Table 1.1.1.1. To get a better grasp of scale, the predator RQ-1 is shown with personnel in Figure 1.1.1.1. (1)

**Contractor:** General Atomics Aeronautical Systems Inc.
**Power Plant:** Rotax 914F four cylinder engine
**Power:** 115 horsepower
**Wingspan:** 55 feet (16.8 meters)
**Length:** 27 feet (8.22 meters)
**Height:** 6.9 feet (2.1 meters)
**Weight:** 1,130 pounds ( 512 kilograms) empty
**Maximum takeoff weight:** 2,250 pounds (1,020 kilograms)
**Fuel Capacity:** 665 pounds (100 gallons)
**Payload:** 450 pounds (204 kilograms)
**Speed:** Cruise speed around 84 mph (70 knots), up to 135 mph
**Range:** Up to 770 miles (675 nautical miles)
**Ceiling:** Up to 25,000 feet (7,620 meters)
**Armament:** Two laser-guided AGM-114 Hellfire missiles
**Crew (remote):** Two (pilot and sensor operator)

Table 1.1.1.1 – MQ-1B System Specifications. (1)


Figure 1.1.1.1 – RQ-1 Predator Drone being taxied by personnel

### 1.1.2. Reaper

The MQ-9 Reaper first entered service February 2001. Sometimes it is called the Predator B. It is a scaled up version of the MQ-1 Predator. The wing span is increased to 66 ft. The power plant is upgraded to a Honeywell TPE331-10GD turbo prop producing 900 hp. The dry weight rose considerably considering the 20% increase is span. This is mostly due to an increase in fuselage size and wing reinforcement. The dry weight is 4,900lbs enabling a payload increase to 3,750 lbs. This aircraft is designed from day one to carry munitions. The primary role of this system is hunter/killer. Unlike the MQ-1, which was retrofit 6 years into service, the MQ-9 has 6 hard mounts to carry mostly Hellfires and JDAMs. The general specifications of the MQ-9 are found in Table 1.1.2.1. A picture of the Reaper next to personnel is shown in Figure 1.1.2.1 for perspective. (2)

| |
|---|
| **Primary Function:** Remotely piloted hunter/killer weapon system<br>**Contractor:** General Atomics Aeronautical Systems, Inc.<br>**Power Plant:** Honeywell TPE331-10GD turboprop engine<br>**Max Power:** 900 shaft horsepower<br>**Wingspan:** 66 feet (20.1 meters)<br>**Length:** 36 feet (11 meters)<br>**Height:** 12.5 feet (3.8 meters)<br>**Weight:** 4,900 pounds (2,223 kilograms) empty<br>**Maximum takeoff weight:** 10,500 pounds (4,760 kilograms)<br>**Fuel Capacity:** 4,000 pounds (602 gallons)<br>**Payload:** 3,750 pounds (1,701 kilograms)<br>**Speed:** Cruise speed around 230 miles per hour (200 knots)<br>**Range:** 1,150 miles (1,000 nautical miles)<br>**Ceiling:** Up to 50,000 feet (15,240 meters)<br>**Armament:** Combination of AGM-114 Hellfire missiles, GBU-12 Paveway II and GBU-38 Joint Direct Attack Munitions<br>**Crew (remote):** Two (pilot and sensor operator) |

Table 1.1.2.1 – MQ-9 System Specifications (2)

Figure 1.1.2.1 – MQ-9 being taxied by personnel.

### 1.1.3. Global Hawk

The RQ-4 is the largest UAS in service as of the end of this study. It has a wingspan of 112ft and Rolls-Royce-North American F137-RR-100 turbofan engines. The payload is less than the MQ-9 at only 3,000lbs. This gives the aircraft unparalleled high altitude, long endurance capability. Its primary function is intelligence, surveillance, and reconnaissance. None of the aircraft in the study were weaponized. It first flew in 1995 as an Advanced Concept Prototype and is intended as a superior replacement to the U-2 spy plane. The general specifications for the RQ-4 are found in Table 1.1.3.1. A picture of the Global Hawk next to personnel is shown as Figure 1.1.3.1 for perspective. (3)

| |
|---|
| **Primary function:** High-altitude, long-endurance ISR |
| **Contractor:** Northrop Grumman (Prime), Raytheon, L3 Comm |
| **Power Plant:** Rolls Royce-North American F137-RR-100 turbofan engine |
| **Thrust:** 7,600 pounds |
| **Wingspan:** 130.9 feet (39.8 meters) |
| **Length:** 47.6 feet (14.5 meters) |
| **Height:** 15.3 feet (4.7 meters) |
| **Weight:** 14,950 pounds (6,781 kilograms) |
| **Maximum takeoff weight:** 32,250 pounds (14628 kilograms) |
| **Fuel Capacity:** 17,300 pounds (7847 kilograms) |
| **Payload:** 3,000 pounds (1,360 kilograms) |
| **Speed:** 310 knots (357 mph) |
| **Range:** 8,700 nautical miles |
| **Ceiling:** 60,000 feet (18,288 meters) |
| **Armament:** None |
| **Crew (remote):** Three (LRE pilot, MCE pilot, and sensor operator) |

Table 1.1.3.1 – RQ-4 Global Hawk System Specifications (3)

Figure 1.1.3.1 – RQ-4 Global Hawk being taxied by personnel.

1.2. FAA

The FAA mission is to provide the safest, most efficient aerospace system in the world. The FAA certifies all aircraft, airlines, and airmen that operate in the Nation Airspace System (NAS). For more than five decades, the Federal Aviation Administration has compiled a proven track record of introducing new technology and aircraft safely into the NAS. Most recently, the agency is working to ensure the safe integration of UAS in the NAS. The FAA's sole mission and authority, as it focuses on the integration of unmanned aircraft systems, is safety. Title 14 – Aeronautics and Space already exists to govern the operations of the FAA, how it makes rules, and the minimum design and operation standards that govern all existing aircraft that operate in the NAS. The FAA already is already moving forward with procedures and standards to allow operation of very small and small publicly operated UAS in the NAS. These aircraft all weigh less than 25 lbs and operate at altitudes less than 400 feet, 5 miles away from airports, and within line of sight (AC91-57). These rules do not apply to the aircraft reviewed in this study. The large UAS, operated primarily by the military, are too large to be governed by recent rules and are not allowed to operate freely in the NAS. The FAA currently requires application for one-time Certificate of Wavier or Authorization (COA) for each Large UA operating is the NAS. These COA dictate a time restricted operation window and a chaser aircraft to escort the aircraft through the airspace maintaining visual line of site. The airspace is shut down in sequential blocks to keep the UA segregated from manned air traffic. This procedure prohibits routine access to the NAS by the non-certified UAS.

The National Defense Authorization Act and the 2012 FAA Reauthorization Act mandates that UAS will be integrated into the NAS by 2015 (10). For this to happen, two things must happen. Rules must be drafted to regulate the safety of unmanned system in design, construction, and operation; a new part to address this new Type Class of aircraft currently not allowed or governed, UAS. Second, to show that these new aircraft meet the to-be drafted standard, there must be Means of Compliance (MOC) to these rules. These means come in the form of data that show a certain level of proof, which supports the applicant’s claims of airworthiness. The level of proof necessary should also be reviewed in the context of UAS reduced risk to minimize certification burden. In the end, the FAA has sole authority to approve the design, construction, and operation of air vehicles operating in the NAS.

### 1.3. NAS

The National Airspace exists over the United State, its Territories, and much of the surrounding ocean. This volume is under the sole authority of the FAA. This airspace is divided in to different Classes of airspace labeled A-G to facilitate operation of different levels of aircraft technology and handle the densest traffic spaces efficiently and safely. The FAA also designates restricted airspace that is handed over to other authoritative bodies (e.g. DoD, DoE) for security, experimentation, and training purposes. By the powers delegated in Title 49, the FAA has the authority to determine the risk of all non-authorized vehicles in the airspace and shutdown airspace around these vehicles in proportion to the perceived threat to protect the flying public from harm. This includes vehicles operated by the DoD. The DoD has authority under Title 10 of the United States Code to operate with only regard to presidential authority during "defense of territory". These conflicting authorities allow the current standoff in UAS operation in the NAS.

## 1.4. AFSC

Because the DoD operates outside the FAA, it has its own internal safety agency, the Air Force Safety Center (AFSC). The AFSC in a new organization, activated in 1996 (8) which consolidated all safety functions of USAF at Kirtland AFB, in Albuquerque, NM. The organization's mission is to prevent mishaps, and preserve combat capability. The center oversees mishap investigations, evaluates corrective actions, and ensures implementation of these actions. The AFSC also maintain the mishap database for USAF. This database contains all the Safety Investigation Board (SIB) reports. These boards are convened under the authority of AFI 91-204(4). These are privileged (classified) reports that extensively describe the details of each mishap. These mishaps are categorized in classes A through E. Class A is the most severe meaning the mishap resulted in fatality, total disability, more than a million in private property damages, or total loss of vehicle. Because of the nature of this study and in defense to the concept of privilege, the Auburn research team was never granted access to the full SIB reports. Instead, the AFSC sent "One Line Descriptions" of the Mishap cause and resulting UA damage. This is a severe reduction in information. The original SIB reports are 10-20 pages in length. An example of an AFSC data Element is shown in Table 1.4.1.

| | |
|---|---|
| RPA ID Number | 43 |
| Fiscal Year | 2009 |
| Mishap Class | C |
| Accident Category | Aviation |
| Accident Sub-category | Unmanned Aerial Vehicle |
| One-liner Description | MQ-1; OIL LOSS; ENGINE DESTROYED |
| Additional Damage Description | Aircraft engine was destroyed |
| | |
| | |
| This RPAs Age | 11 |
| Total Number of RPAs This FY | 171 |
| This FY Fleet Avg Age (YRS) of This Model RPAs | 5.8 |
| MDS Category | RPA |
| Visibility Conditions | Visual Meteorological Conditions (VMC) |
| Operational Contingency | Yes |
| WX Note: | Dust/Ash |
| Additional Note: | |

Table 1.4.1 – Sample Data Elements Available from the Air Force Safety Center

## 1.5. AIB

Accident Investigation Boards are convened under the authority of AFI 51-503(8). These committees are assembled to investigate all Class A accidents. These investigations are completely separate from the SIB investigation. The purposes of these AIB investigations are to provide a publicly-releasable report of the facts and the circumstances surrounding the accident, to include a statement of opinion on the cause or causes of the accident, and to gather and preserve evidence for claims, litigation, disciplinary, and adverse administrative actions. In contrast, the primary purpose of a SIB investigation is to find the cause of an accident in order to take preventative action. The AIB report summaries being publically available provided a wealth of information beyond that originally released by the AFSC. The ASFC data we received was approximately 2-4 sentences of narrative material per mishap while the AIB summaries are approximately 300-500 words.  Without the incomparable detail of these summaries, the detailed case studies and trend analysis would not have been possible.  It is important to note that these AIB summaries had to be found independent of the AFSC.  It is also important to note that the count of Class A UAS incidence between FY2000-FY2009 are different.  To date the number of AIB reports are too incomplete to provide meaningful assessment of MQ-9 reliability.  Only 2 reports have been published for MQ-9 while 9 Class A incidences are listed in the AFSC data set.  Also, the AFSC data does not contain tail numbers or precise mishap dating.  This intentional ambiguity makes correlation of AIB mishaps to AFSC mishaps unreliable. Acquisition of the remaining AIB reports would be a meaningful follow on work.

EXECUTIVE SUMMARY
AIRCRAFT ACCIDENT INVESTIGATION
MQ-IB PREDATOR S/N 03-3112
DEPLOYED LOCATION
17 January 2007

On 17 January 2007 at 2035Z, an MQ-1B PREDATOR, S/N 03-3112, 15th Reconnaissance Squadron, Creech AFB, Nevada, crashed during a reconnaissance mission while operating from a deployed location in the Central Command Area of Responsibility. Upon ground impact, the unmanned aircraft was severely damaged with losses valued at $4,160,391.00 No one was injured in the accident. Other than the Mishap Aircraft (MA), there was no damage to government or private property. There was very limited media interest. Approximately 14 hours into a 20 hour sortie, the aircraft sustained a momentary (two (2) seconds) drop in engine rotations per minute (RPM) followed 15 minutes later by catastrophic engine failure. Data logger analysis of changes in RPM, oil pressure, turbo oil temperature, and propeller pitch subsequent to the original two second RPM drop indicate the engine was failing over a period of approximately 15 minutes. However, monitored engine parameters remained within normal ranges until approximately the last minute before the engine seized. Therefore, the MA did not generate any form of caution or warning to the pilot of the impending failure until approximately 60 seconds prior to the engine completely failing.

There is clear and convincing evidence that the first point of failure was a crack in the crankshaft which propagated over time to the area of the #4 connecting rod bearing. The # 4 connecting rod ultimately failed and wedged itself in the opposing #3 cylinder causing the crankshaft to immediately stop approximately 15 minutes after the initial two second drop in engine RPM.

The pilot took appropriate actions to establish a glide to an unpopulated area with the intent to land the MA via KU band (satellite) control. By telephone, the Combined Air Operations Center (CAOC) directed the Mission Commander (MCC) to crash the MA rather than attempt a landing if there were no friendly personnel to secure the aircraft. The CAOC decision was based on the classified equipment the MA was carrying and the two Hellfire missiles. The CAOC determined that there were no friendly forces to secure the MA on the ground nearby so the Mishap Pilot 2 (MP2) intentionally crashed the MA into an unpopulated area. The remains of the MA and all classified equipment and weapons were recovered.

*Under 10 US.C. 2254(d), any opinion of the accident investigators as to the cause of, or the factors contributing to, the accident set forth in the accident investigation report may not be considered as evidence in any civil or criminal proceeding arising from an aircraft accident, nor may such information be considered an admission of liability by the United States or by any person referred to in those conclusions or statements.*

MQ-IB, S/N 03-3112 17 January 2007

Figure 1.5.1 – Sample AIB Executing Summary Report

## 1.6. Title 14 of the Code of Federal Regulations – Aeronautics and Space (14CFR)

Before 1926, access to the national sky was completely unregulated. Because of the high incident of death amongst daredevil socialites, the aviation industry asked congress to regulate air activity(16). The public saw that regulation could improve safety and encourage growth in aviation. In 1926, congress passed the Air Commerce Act. The law established airways, standardized navigation and traffic control tools, and set a process for certifying pilots and aircraft. During the early days of regulation, the accident rate was much higher than it is today. In 1929, there were 51 incidences or about 1 accident per $10^6$ passenger flight miles (17).

In the initial system, there was a conflict of interest in the certifying body, the Bureau of Air Commerce. The agency was commissioned to both promote air commerce, and, at the same time, find and publish the causes of aeronautical accidents. The agency was reluctant to admit that the accidents may have been related to their own rules and procedures. In 1935, Sen. Bronson M. Cutting was killed when his DC-2 crashed killing all aboard. The investigation of his death by congress came to a different conclusion than the investigation by the Bureau of Air Commerce. This led congress to pass the 1938 Civil Aeronautics Act. This established a new separate safety authority, the Civil Aeronautics Authority (CAA)(16).

The CAA's Air Safety Board worked independent of the Bureau of Air Commerce to conduct accident investigations and recommend corrective actions. This agency grew, and in 1940, President Franklin D. Roosevelt split the authority again into two agencies: the Civil Aeronautics Administration (CAA), and the Civil Aeronautics Board (CAB). The CAA took responsibility for air traffic control, airmen, and aircraft certification, safety enforcement, and airway development. The CAB assumed safety rulemaking, economic regulation of airlines, and accident investigation(14).

The National Air System continued to grow without legislation until 1958 when a series of mid-air incidents caused a new interest in Air Traffic Control. The NAS, at the time, had two control system, one military and one civilian. The separation of traffic knowledge was responsible for some of the mid-air collisions. The 1958 Federal Aviation Act was signed in response. This legislation consolidated the Nation Airspace into one system while assuring the military would get control of the airspace during war time. Rulemaking was transferred back into the newly created Federal Aviation Agency which replaced the CAA while the CAB focused of accident investigation(14).

In 1966, the agency was moved out of the Department of Commerce and into its own cabinet level office, the Department of Transportation. This changed it from an agency to an administration and transferred the accident investigation authority of the CAB into the National Transportation Safety Board. In 1974, the National Transportation Safety Board became completely independent of the DOT, giving us our two largest civil transportation agencies as they exist today. These organizations work in independent cooperation and mutual oversight to respond to air mishaps and transform aircraft and air traffic control into the safest mode of transportation in the country(14). As of the start of this study, the NAS has a safety rate of about 3 deaths per $10^{10}$ passenger miles, or a reduction in fatality of 3000 fold since the days of the Bureau of Air Commerce(13).

The regulations themselves have evolved along with the changes in organizational structure. Figure 1.6.1 shows a visual history of the path of regulatory change with the motivating events on the left. The first rules were called Bulletin 7 (12). The rules were informal because the Aeronautical Branch of the Department of Commerce was still only a branch of the Department of Commerce. Several of the Aeronautics Branch were dependent on other division of the Department over which they had no authority (16). Then the Bureau of Air Commerce was created consolidating all the functions of the organization under one command structure giving the director authority over the work force involved in promoting and regulating air commerce. This is when the rules of the skies were first codified in the Civil Air Regulations (CAR). The death of Sen. Bronson M. Cutting (R-NM) in 1935 and the following discrepant cause finding of the two investigations, Congress and BAC, led to the separation of regulation of transport aircraft and small personal aircraft, CAR 4a and 4b (16). The system evolved with the introduction of Rotorcraft and the evolving separation of powers (e.g. operations, regulation, and investigation). The system of rules that exists today consists of several parts that have themselves evolved in response to new system hazards but have remained in the same hierarchy and interrelation. Figure 1.6.2 shows a list of 14CFR parts most pertinent to airworthiness certification. All product certification starts with Part 21 Certification Procedures for Products and Parts. Then the applicant is directed to the particular aircraft type for which they are seeking approval for. The main categories here are airplanes, normal and commuter category, Part 23, and transport category, Part 25, and rotorcraft, normal category, Part 27, and transport category, Part 29. These parts in turn refer the applicant to various component parts such as engine, propeller, and noise depending on the aircraft's complexity (12). In general, normal category aircraft have simpler rules that require more stout and robust airframes. This accounts for a reduced amount of design knowledge and the reduced skill and technical tools of the persons responsible for operation and inspection of these aircraft in service. Transport category which are larger and impart a larger risk on revenue providers are much more regulated, but, in return for the extra design knowledge burden, they are allowed to be more elegant and efficient aircraft that take into account the risk reduction during operation that come from higher personnel training, and the increased environmental and conditional knowledge that is available with more sophisticated methods of aircraft and environmental observation. As an example, Part 23 normal aircraft must be able to pull 6Gs in a vertical roll while a Part 25 must only pull 2.5Gs (5). Also Part 25 aircraft in general take much more use of 14CFR 25.571(25.571) than Part 23 category aircraft take advantage of 23.573, both concern the damage tolerance of vehicles, because organizations operating Part 25 aircraft generally have a larger more equipment maintenance staff which is capable more frequent and detailed inspection of the fleet.

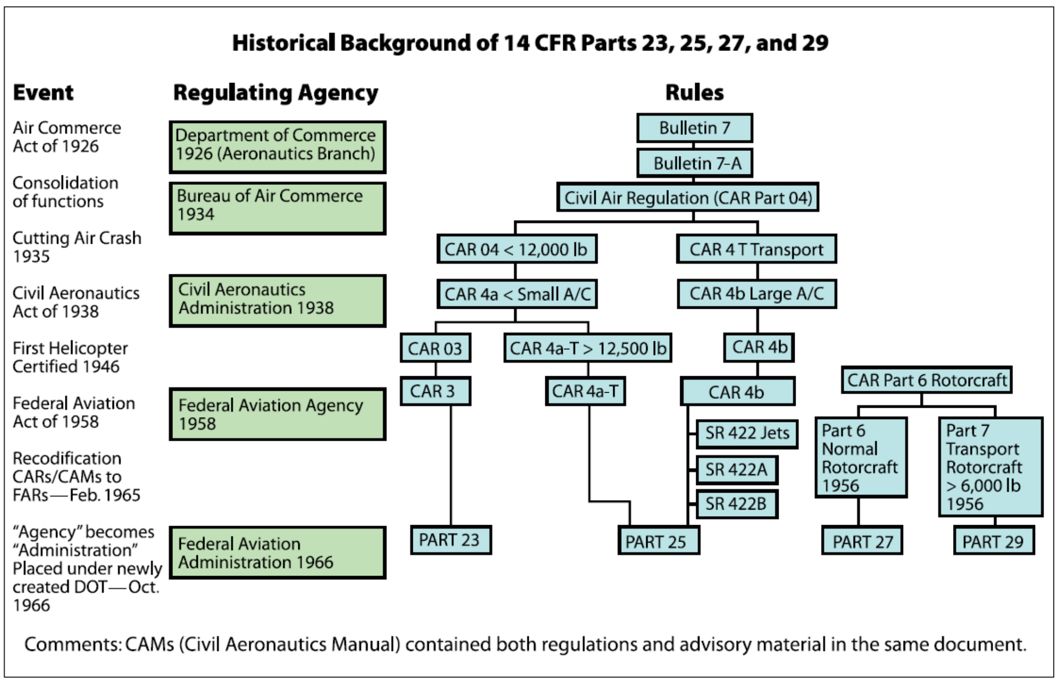


Figure 1.6.1 – Timeline of Agency and Rule Changes (12)

| | |
|---|---|
| Part 1: | Definitions and Abbreviations |
| Part 13: | Investigative and Enforcement Procedures |
| Part 21: | Certification Procedures for Products and Parts |
| Part 23: | Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes |
| Part 25: | Airworthiness Standards: Transport Category Airplanes |
| Part 33: | Airworthiness Standards: Aircraft Engines |
| Part 34: | Fuel Venting and Exhaust Emission Requirements for Turbine Engine Powered Airplanes |
| Part 35: | Airworthiness Standards: Propellers |
| Part 39: | Airworthiness Directives |
| Part 43: | Maintenance, Preventive Maintenance, Rebuilding, and Alteration |
| Part 45: | Identification and Registration Marking |
| Part 47: | Aircraft Registration |
| Part 65: | Certification: Airmen Other Than Flight Crewmembers |
| Part 91: | General Operating and Flight Rules |
| Part 121: | Operating Requirements: Domestic, Flag, and Supplemental Operations |
| Part 125: | Certification and Operations: Airplanes Having a Seating Capacity of 20 or More Passengers or a Maximum Payload Capacity of 6,000 Pounds or More; and Rules Governing Persons on Board Such Aircraft |
| Part 135: | Operating Requirements: Commuter and On Demand Operations and Rules Governing Persons on Board Such Aircraft |
| Part 145: | Repair Stations |
| Part 183: | Representatives of the Administrator |

Figure 1.6.2 – List of FAA regulations related to airworthiness certification (12)

The FAA and the rules that govern its action, 14CFR, are not static entities. The FAA and 14CFR have changed to respond to new technology, new traffic densities, and new modes of failure. They are a consolidated body of organizations and rules that have evolved to include powers such as peacetime operation of military aircraft, and tolerable mishap rates. The current system must evolve to efficiently regulate and incorporate new classes of aircraft. 14CFR does not yet include Unmanned Air Systems. 14CFR does not currently govern the design of these vehicles, nor their operation in the NAS.

## 2. Methodology

### 2.1. Failure Mode Typology and Categorization

The first step in the assessment of the two data sets is creating a categorization scheme. The AFSC mishap summary data came in two excel files: ‘VER_3.2_Auburn Expanded DataFY2000-FY2004.xls’ and ‘VER_3.1_Auburn Expanded DataFY2005-FY2009Product.xls’. The AFSC data, being the more complete set of mishap records, is surveyed first to come up with list of general categories that encompassed the causal mechanisms of the mishaps. These categories are broad and few in number. I conducted an initial survey to create a simple set of cause categories. This small set makes presentation of the data very accessible to a larger stakeholder audience and speed the team assessment process. This survey came up with the categories Lost Link (LL, the initial concern of the FAA that led to this study), Reduced Perception (RP), Hard Landing (HL), Reliability (RE), Maintenance Error (ME), Pilot Error (PE), and Environment (ENV) which made the independent assess of the research team produce uniform comparable results. These categories are 96% successful in categorizing the causation of these mishaps. The remaining 4% did not contain any information to facilitate categorization. These mishaps are all class E, the least severe mishap class.

A clear majority of the mishaps are shown to be caused by reliability failures. That category is divided into sub categories to give more detail into the mishap causation trends: Power Plant (PWP), Auto Pilot (AP), Electrical (EE), Hydraulic (HD), and Structural (STR).

This typology is reviewed against the AIB data with 100% classification success. The breakdown of the Reliability category gave greater fidelity to the main causal categories and allows remote and non-remote failures to be more finely separated. Remote failures are categorized as the sum of failures caused by lost link, reduced perception, hard landing, and autopilot. The remainder is considered non-remote. These failures occurred because of causes that also exist in manned aviation.

To improve objectivity and confidence, a panel of three investigators performed the categorization: an unbiased graduate mathematician, a senior aerospace analyst, and an industry airworthiness analyst. The three person panel also developed a structure to resolve differences in interpretation of the presented data. Each member went through the 240 AFSC mishap summaries and then met to compare their results. The initial categorization resulted in 90% agreement. Some areas regarding undue pilot burden and maintenance skill required debate, but, in the end, consensus was reached by the group on all mishaps.

The executive summaries for the AIB reports are created from the full unprivileged reports. The researchers took the available versions of these reports and summarized them with a focus on causation. A spreadsheet was created using data elements similar to the AFSC summary: fiscal year, model, visibility, phase of flight, summary of damage, cause summary, and damage summary. This reduced format is categorized into the same categories as above. Causal summaries that were ambiguous or led to conflicting categorizations were taken back to the original text and debated to achieve uniform categorization.

The higher level of fidelity in the AIB reports made classification of failure modes more precise than with the available SIB data. The AIB reports a qualitatively similar but quantitatively somewhat different result. That is, the same causes were identified and occurred in frequency at about the same order of magnitude. However, the SIB reports resulted in failure modes being assigned different percentages of the total causes. This was due to both a higher fidelity description of the event and the fact that not all of the summary AIB reports could be located. The shortage of reports degrades the breakout of the proportions for the failure rates and relegates the AIB data to being most valuable in this report as a guide for the gap analysis. Nevertheless, the breakouts of mishap rate proportions appear to be valuable for demonstrating how the complete analysis should be carried out in a follow-on effort using the complete set of full AIB reports.

### 2.2. Gap Analysis

The gap is focused on potential gaps between UAV experience and 14CFR which govern all other flight operations in NAS. As an example of how these gaps may be bridged, Part 25 is surveyed. First each regulation in the part is considered for its applicability to UAS. Then the current available data is exaimined for its sufficiency as a Means of Compliance to the individual applicable regulations. Next, different modes of knowledge accumulation are examined for a possible testing only Means of Compliance. It was the opinion of the investigation team that DoD would be more accepting of a pure testing based certification because minimal design knowledge would be transferred into unprivileged sources. The applicable regulations are reviewed again for the sufficiency of flight and ground testing at providing Means of Compliance. Then, traditional analysis is examined as a Means of Compliance to the UAS applicable regulations. This process is very broad in nature and was done with current MALE and HALE aircraft in mind.

A more detailed look at incorporation gaps in achieved through detailed case study of the AIB executive summary. During the study of the AIB reports, more detailed common causes are discovered.  These reports are collected and the original text of the AIB are studied in depth to look at the Gaps in airframe airworthiness.  These gaps are compared to current 14CFR regulations to determine whether enforcement of current regulation would be sufficient in restoring airworthiness or if new rules need to be drafted to manage the risk from UAS introduction.

## 3. Failure Trends

### 3.1. Fleet Wide Mishap Classification

The analysis of the SIB reports resulted in the following typology of failure modes: lost link (LL), reduced perception (RP), hard landing (HL), reliability (RE), maintenance personnel error (ME), pilot error (PE), environmental (ENV), or unable to classify (==).

These categories are defined below. Lost Link (LL) is the loss of communication, command, or control to or loss of awareness information from the UA. This could be caused by lost line of sight, range exceedence, or loss of transmission capability. Reduced perception (RP) captures all elements of the operator's physical detachment from the UA and the resulting perception loss. Reduced perception is the insufficient awareness to properly react to system changes. This could be the reduction in visual resolution, view angle, and pan rate that results from fly by video dependence. Reduced perception also covers the lack of inertial and vibration forces that come from maneuvers and equipment both functioning and malfunctioning, and lack of hearing. The reaction times of an operator are also impaired by data transit speeds. When systems are in remote areas, they are guided by satellite uplink. This can impart up to a 2 sec delay between perception and action. This pushes human reaction times and creates artificial instability. Hard landing (HL), while the causes may be diverse, is simply a directed landing at above the allowed decent rate. Reliability (RE) is group of all physical failures of the UAS: electrical, mechanical, and software. Maintenance error (ME), and Pilot error (PE) divide the human factor into major interfacers with the UA. Environmental (ENV) captures all outside factors that result in vehicle mishap. This includes bird strike, gusts, storms, and reduced visibility.

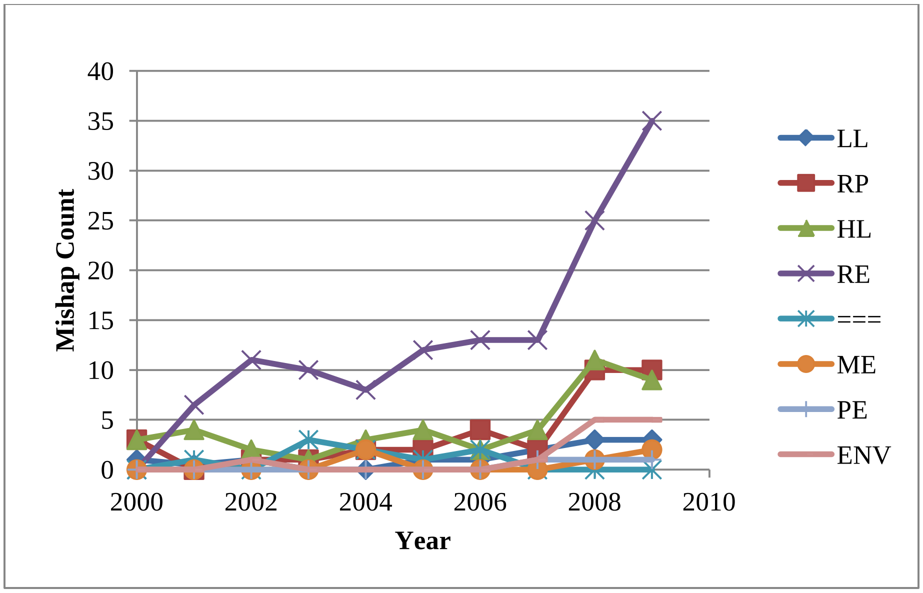


Figure 3.1.1 – Cause Mishap Frequency – All Classes – AFSC

From Figure 3.1.1, the three break away causes of mishaps are reliability, reduced perception, and hard landings. Hard landings are themselves a product of gust sensitivity, insufficient authority, and reduced perception. Reliability shows the highest incidence by 3 fold. This category is broken down in Figure 3.1.2. Most of the reliability factors appear to be controlled below a threshold of 5 per year, auto pilot and electrical being the most active controlled cause. Electrical failures could be on a delayed rise, but additional later years must be included to draw conclusions. The biggest and most divergent of the reliability failure modes is power plants. Figure 3.1.3 shows the summary break of the All Classes of Mishap break down. From the pie chart, Reliability accounts for over 50% of all UAS incidences. Also if LL, RP, HL, and AP are summed together a metric of the remote failures can be found. These sum to 47% or almost half of all UAS mishaps. This means that more than half of all UAS mishaps result from failure of systems that already exist on manned aircraft. Also, it's important to point out that pilot error only accounts for 1.2% of all mishaps. In civil aviation where equipment failures are substantially less likely, pilot error is the cause of over half of incidents. Figure 3.1.4

shows the breakdown of reliability mishaps. The dominant modes are power plant, auto pilot, and electrical, in that order. Power plant reliability is the largest single contributor of UAS incident causing 33% of all mishaps or 63% of all reliability mishaps. This is double the contribution of any other category.

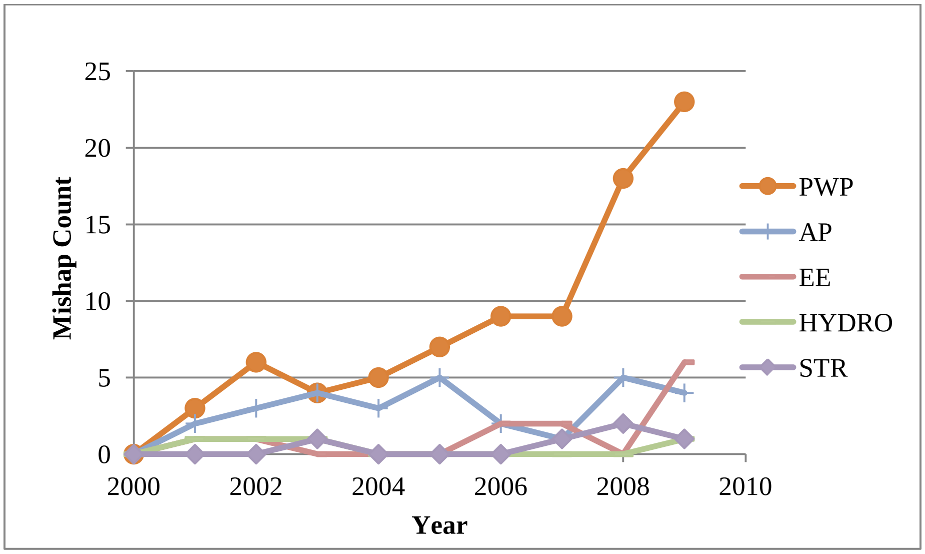


Figure 3.1.2 – Reliability Cause Mishap Frequency – All Classes - AFSC

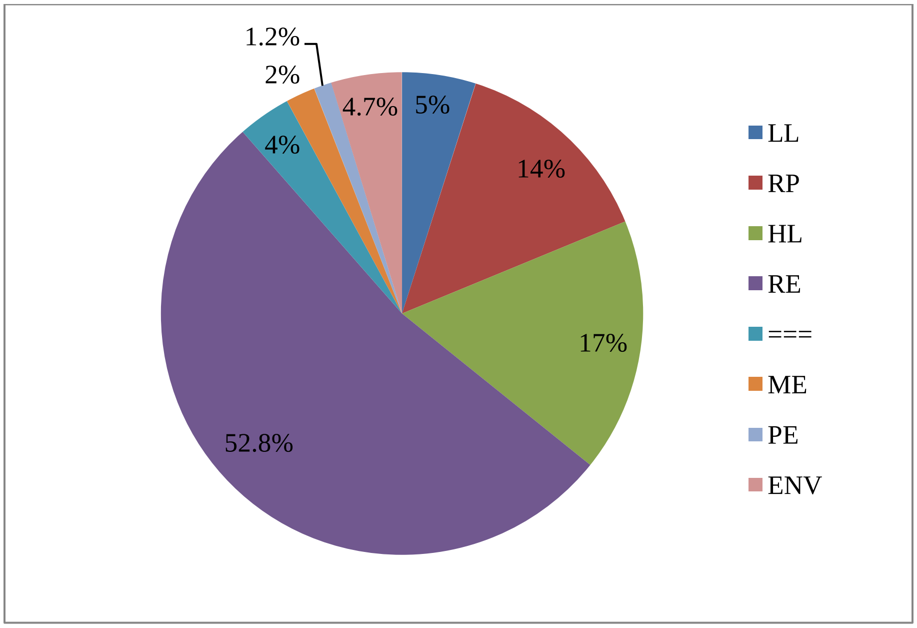


Figure 3.1.3 – Cause Mishap Breakdown – All Classes - AFSC

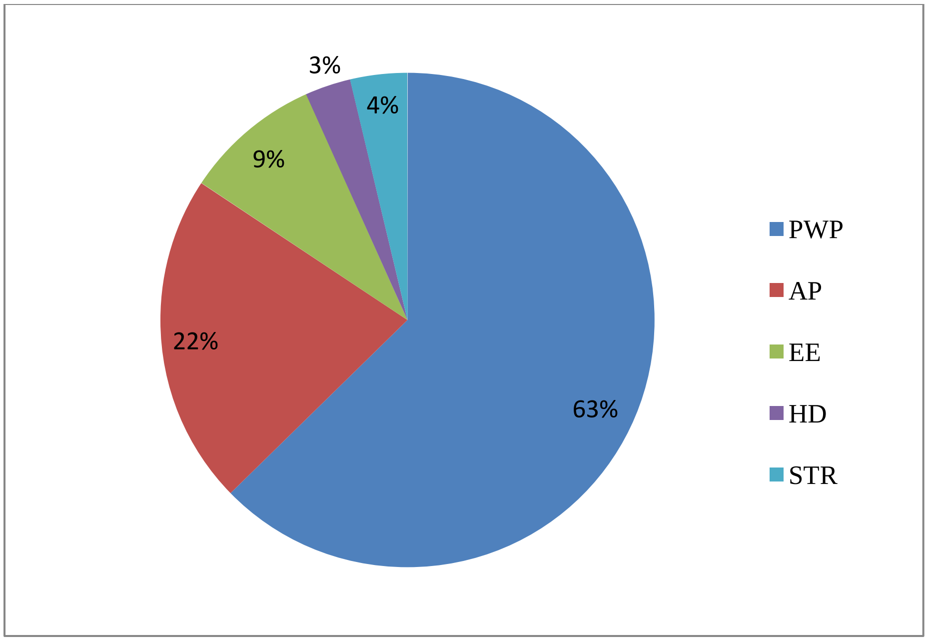


Figure 3.1.4 – Reliability Cause Mishap Breakdown – All Classes – AFSC

The next analysis is per vehicle type. Figure 3.1.5 shows the mishap count over time broken down by vehicle type. The majority of reported incidence occurred with the RQ-1/ MQ-1 Predator. This is confirmed by Figure 3.1.7. The predator is the first, smallest and most numerous of the vehicle types covered in this study. The first trend is in the reliability of the ground control station. All drones operate from the same Multi-platform control station originally developed for the RQ-1 Predator. The first five years of operation resulted in no incidents, but towards the end of the decade, two incidents emerge. From Figure 3.1.5, it appears that mishap counts are running away exponentially for the MQ-1 and MQ-9, but, to look at future trends, the actually flight hours need to be taken into account. Figure 3.1.6 also shows an exponential growth in flight hours. Figure 3.1.7 shows the All Class incident rate of the three airframes studied. The trends appear log-linear, and the incident rate for all aircraft is reducing, even if the rate is slow. For more on rate trend analysis see Section 3.13. Most aircraft years lie between 3E-3 to 3E-4 Mishaps per flight hour. In contrast, the current tolerance of hazardous conditions, analogous to the sum of all incidences Class B through E incidence, is $10^{-7}$ or 3 to 4 orders of magnitude less frequent than demonstrated.

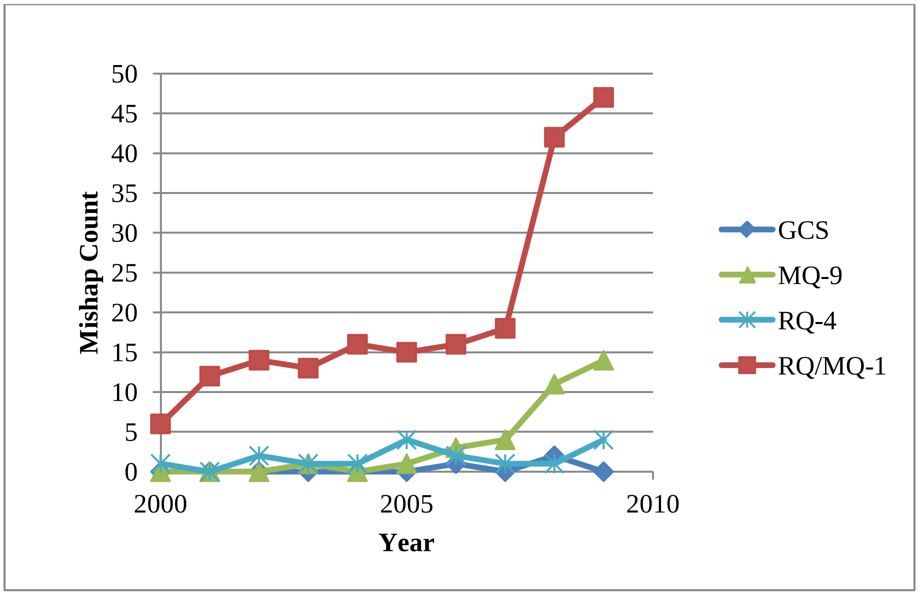


Figure 3.1.5 – Vehicle Mishap Frequency – All Classes – AFSC

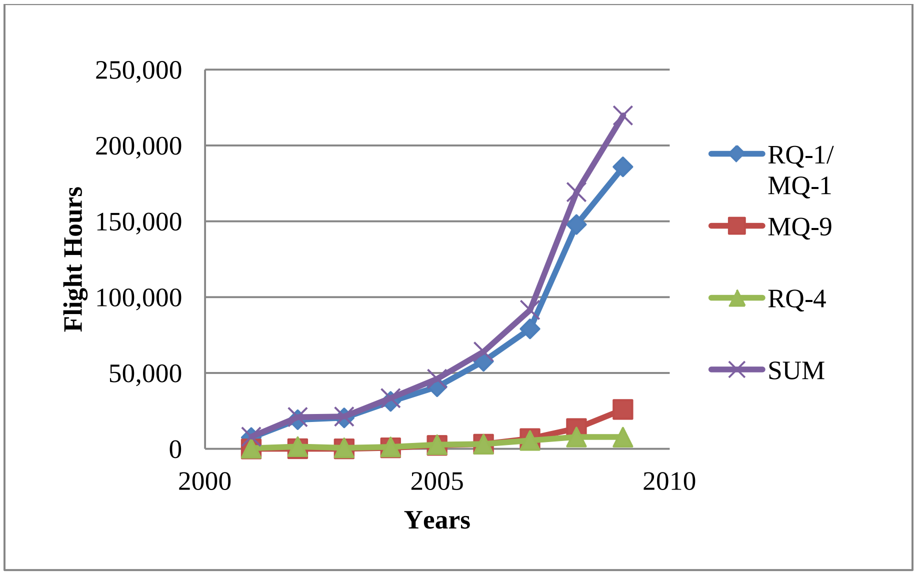


Figure 3.1.6 - Vehicle Annual Flight Hours

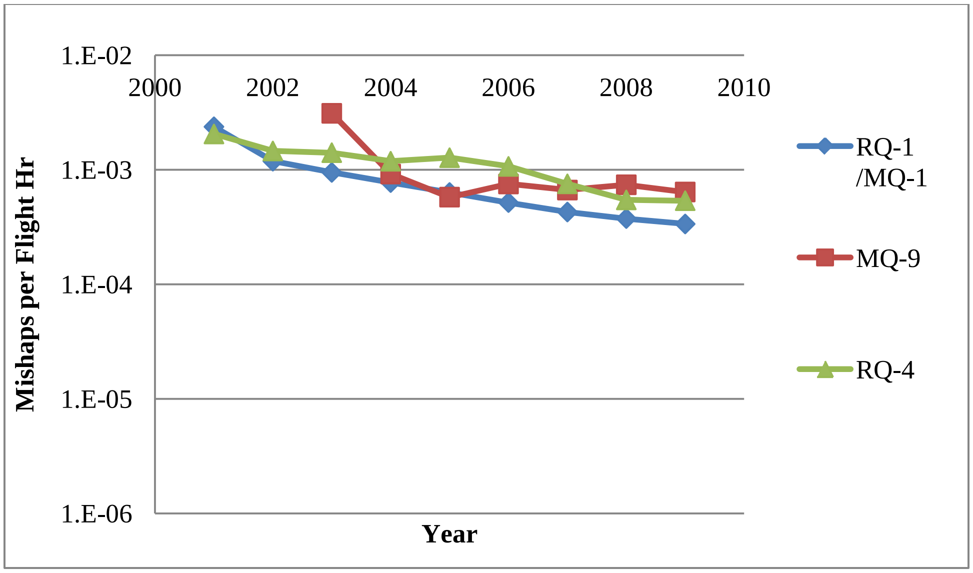


Figure 3.1.7 – Vehicle Mishap Rate – All Classes - AFSC

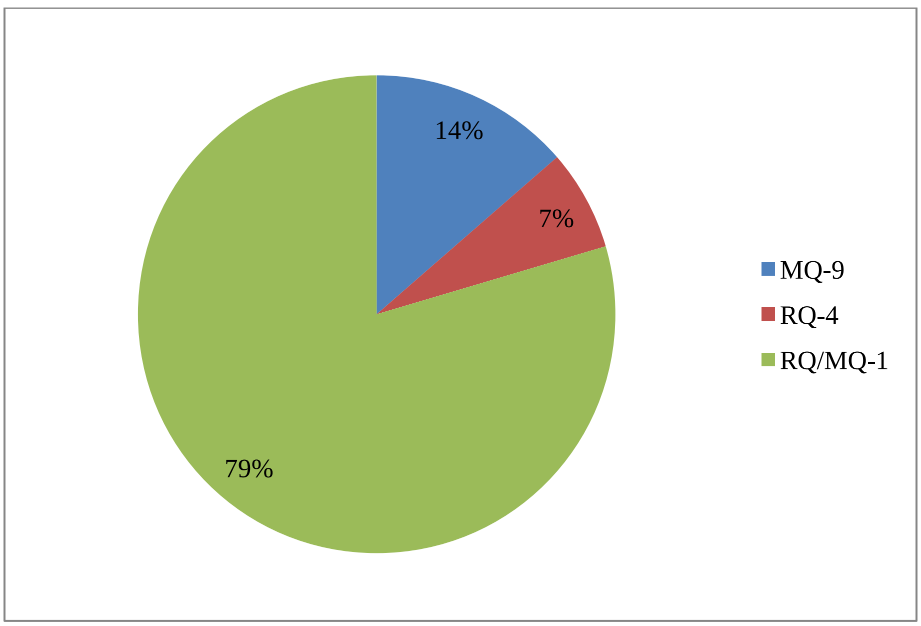


Figure 3.1.8 – Mishap Vehicle Breakdown – All Classes – AFSC

The AFSC has classification system Class A-E. Since there are no passengers, the damages, so far, have been purely financial. Table 3.1.1 explains the damage associated with each Class. Because there are no Class D Mishaps and in the authors opinion, some of the Class E would cost more than $1000 to restore capability, some of the Class E events may be worthy of a Class D status. The damage is approximately equally spread between Classes A, C, and E, as shown in Figure 3.1.9. This means that Class A is still within an order of magnitude of the overall mishap rate.

| | |
|---|---|
| Class A | $1,000,000 or More in Damages or Loss of Aircraft |
| Class B | $200,000 to $999,999 in Damages |
| Class C | $20,000 to $199,999 in Damages |
| Class D | $1,000 to $19,999 in Damages |
| Class E | Less than $1000 in Damages |

Table 3.1.1 – AFSC Damage Classification

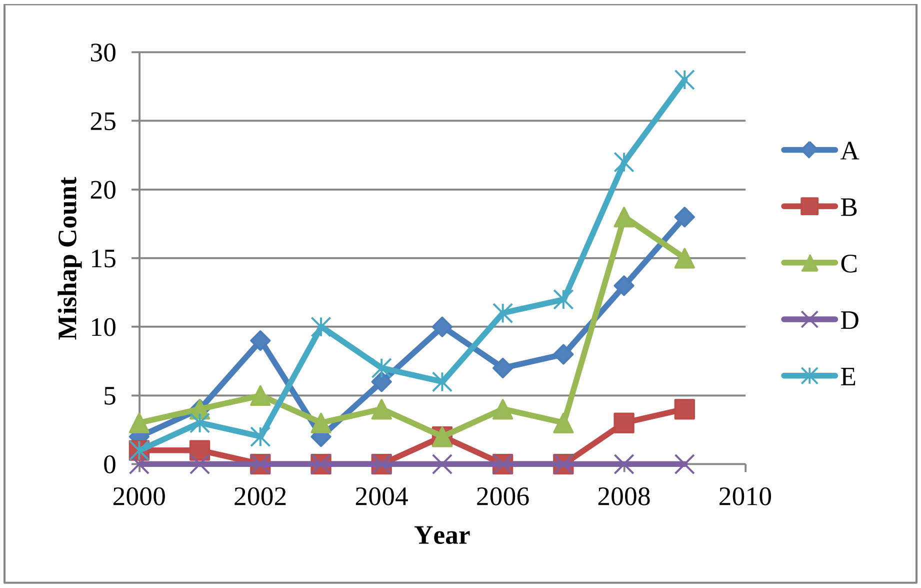


Figure 3.1.9 – Class Mishap Frequency – AFSC

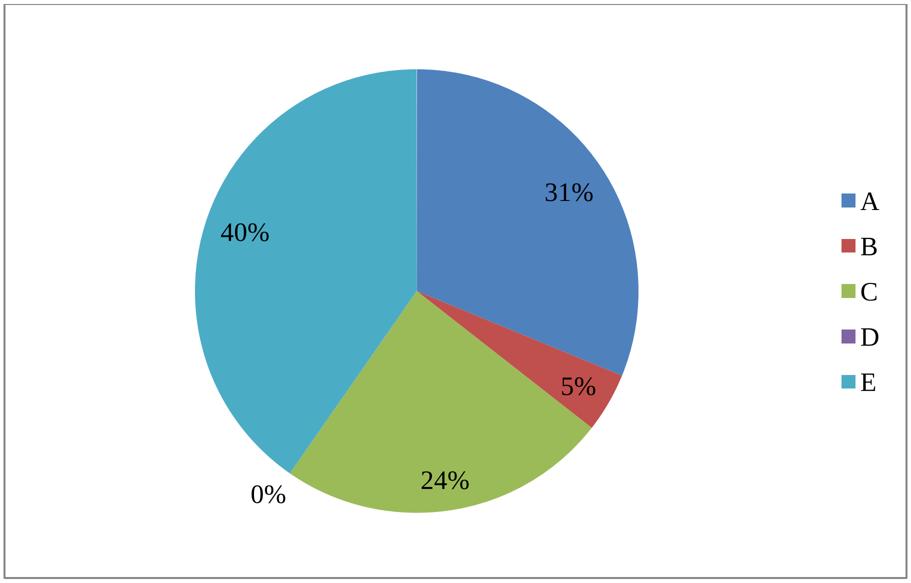


Figure 3.1.10 – Class Mishap Breakdown – AFSC

The mishap class of most importance is Class A, especially the ones that do not involve a hard landings. Figures 3.1.11 and 3.1.13 show the cause frequency temporal trends and breakdown for all AFSC Class A incidents. Reliability, the main cause of mishap, accounts for a slightly larger 57.0% of mishaps, up from 52.8% for All Classes. Lost link, one of the commissioning issues of this study, shows twice the impact on Class A incidences. What's more interesting is the porposing that shows up in the data when Class A mishaps are broken out. The reliability, power plant, and auto-pilot cause plots show smooth increases in annual frequency when All Classes are plotted, but the Class A data has a very distinct 3-4 year slow rise and sharp reaction cycle, as shown in Figure 3.1.11 and 3.1.12. In our May 17th 2011 meeting with DoD/FAA concerning this data they said the 2010 reliability numbers were "much better" adding a 3rd hump to our Class A Charts.

The next points of interest are the categories that drop out off the mix when only Class A mishaps are considered. First, all Class A mishaps are described in sufficient detail to be categorized. The typology created is 100% successful in categorizing the data. Next, looking at the general cause data, all personnel error is removed from the breakdown shown in Figure 3.1.13., meaning besides the reduced perception of the platform, all issues are technical in nature. Moving to the reliability cause breakdown, shown in Figure 3.1.14, structural and hydraulic failures drop from the list. It is important to note that the MQ-1, which provides the most mishap data, is controlled by servos which are a source of mishap that will be talked about later in Sections 3.2 and 3.12.2. Last, while power plant, and auto-pilot failures account for the same percentage of mishaps, Figure 3.1.14 shows that electrical failures take up the complete residual of reliability failures, a 50% increase in contribution.

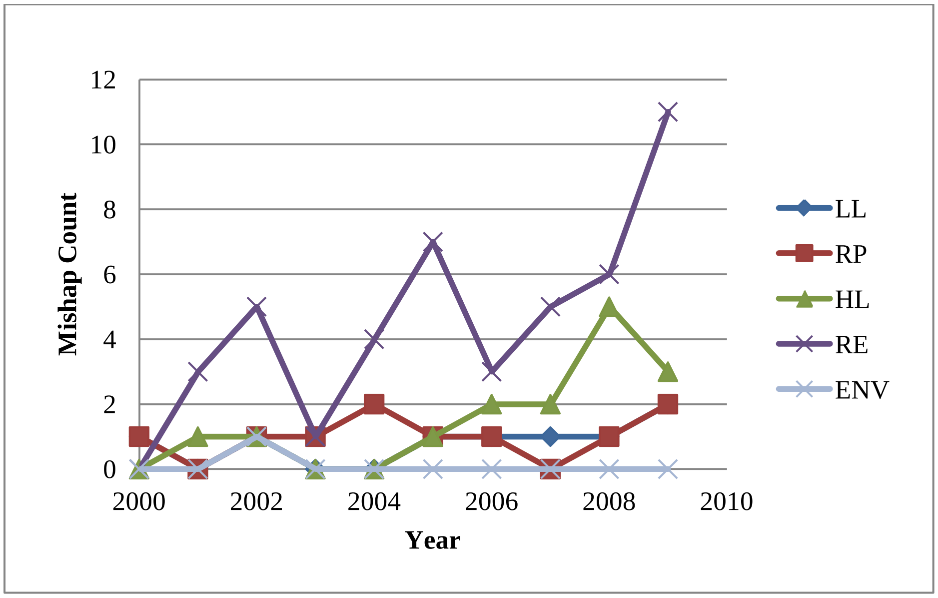


Figure 3.1.11 – Mishap Cause Frequency –Class A - AFSC

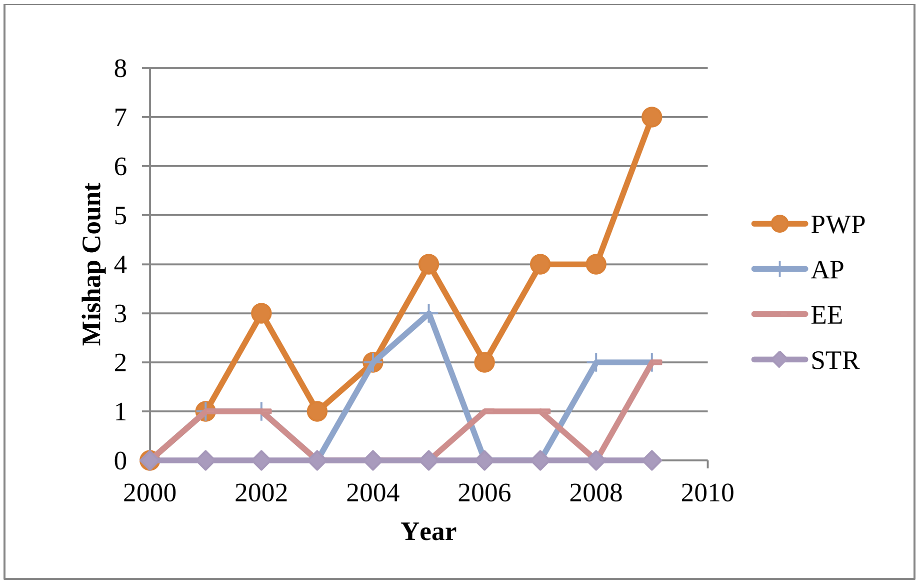


Figure 3.12 – Mishap Cause Frequency –Class A – AFSC

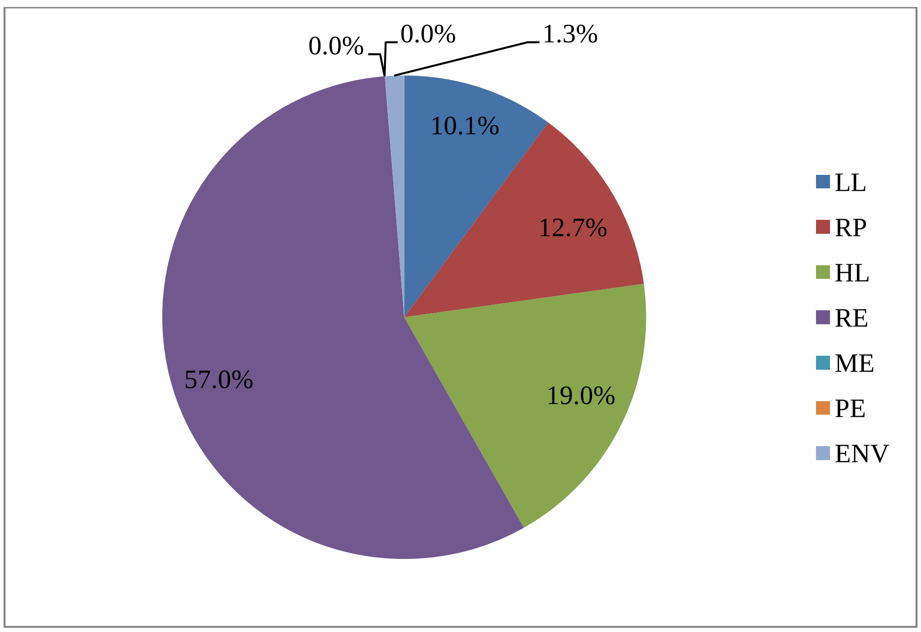


Figure 3.1.13 – Mishap Cause Breakdown – Class A - AFSC

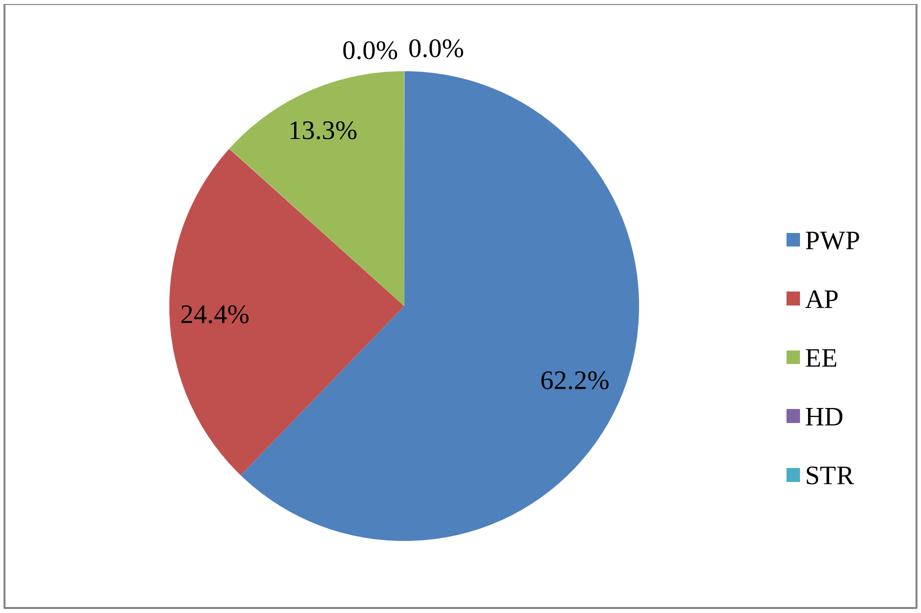


Figure 3.1.14 – Reliability Mishap Cause Breakdown – Class A – AFSC

Figures 3.1.15-17 show trends by vehicle. The porposing trend is very distinct in the RQ-1/ MQ-1 Predator Data. Surprisingly given the great range of service hours accumulated, the Class A Mishap rate falls in a tight band. These rates are also all trending downward with time. Last, the mix of vehicle mishaps is approximately unchanged at the Class A level, as shown in Figure 3.1.17.

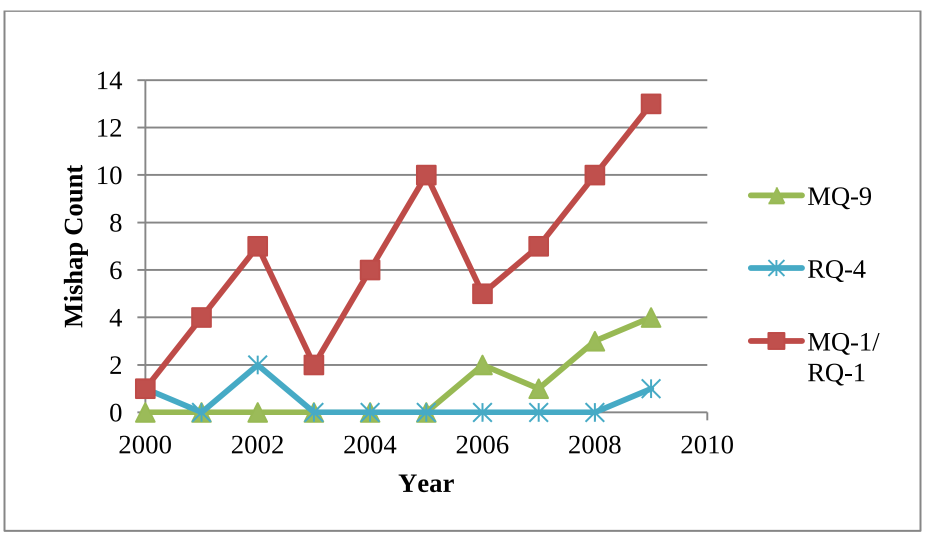


Figure 3.1.15 - Vehicle Mishap Frequency – Class A – AFSC

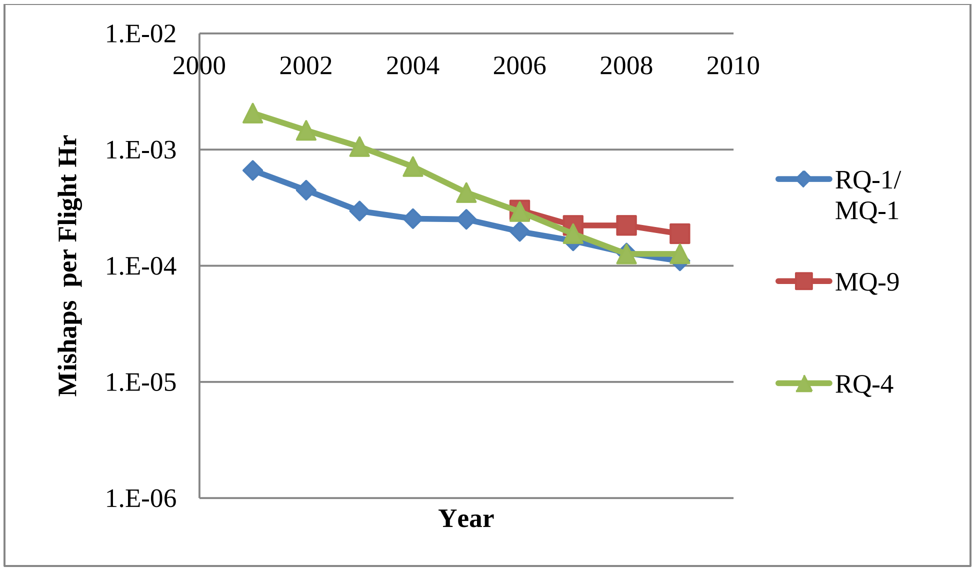


Figure 3.1.16 – Vehicle Mishap Rate – Class A – AFSC

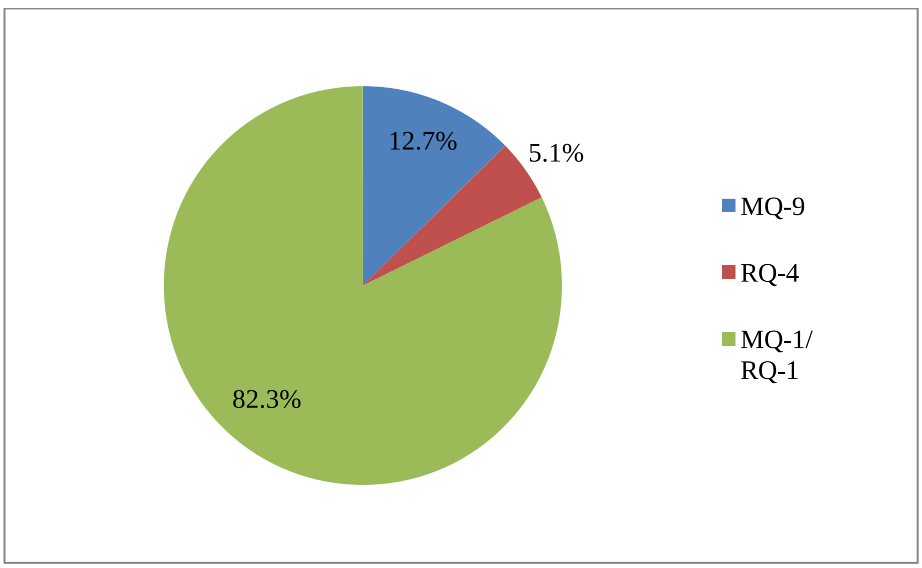


Figure 3.1.17 – Vehicle Mishap Breakdown – Class A – AFSC

The AIB executive summaries are immensely helpful in attributing detailed cause to the incidence they record, but, looking at Figure 3.1.19-3.1.20, the number of unreported incidents is very high. As an example, in 2007 thru 2009 88% percent of MQ-9 incidence went undisclosed by the AIB. In most years of this study, over 30% of the RQ-1/ MQ-1 mishaps are not reported by the AIB. As a whole, 35.4% of AFSC mishaps do not have AIB reports. The correlation of missing reports is further hindered by the fact that the two data sets use different unique airframe identifiers. The AIB uses UAS serial numbers of 6 digits. The AFSC data set uses an RPA ID number of 3 digits. The RPA ID is not temporally or minor model sequential. This makes confidence in the causation trends, extracted from this data set as a whole, very low. However, there are things the data can show about the ambiguity of the AFSC data. There are some gross discrepancies in the data trends. Figure 3.1.24 shows the cause mishap breakdown. The first difference is in the role of personnel error. In Figure 3.1.13, there are no mishaps attributed to personnel in the AFSC Class A data, but, in Figure 3.1.24, 13.7% of AIB incidents can be attributed to personnel. This existence contradicts the AFSC data set. There are also some less firm trends that over balance the lack of reporting. The breakdown also shows a complete lack of reduced perception mishaps. Figure 3.1.25 shows the AIB break down of Reliability mishaps. The AIB data shows 300% increase in the role of Electrical Failures, 21.6% AIB over 7.6% AFSC. Count-wise the AIB is higher, 11 AIB mishaps over 6 ASFC. The meaning of the trends is undercut by the incompleteness of the AIB data set, but it is firm evidence as to the importance of follow on work to acquire the entire AIB or possible SIB reports for these incidences.

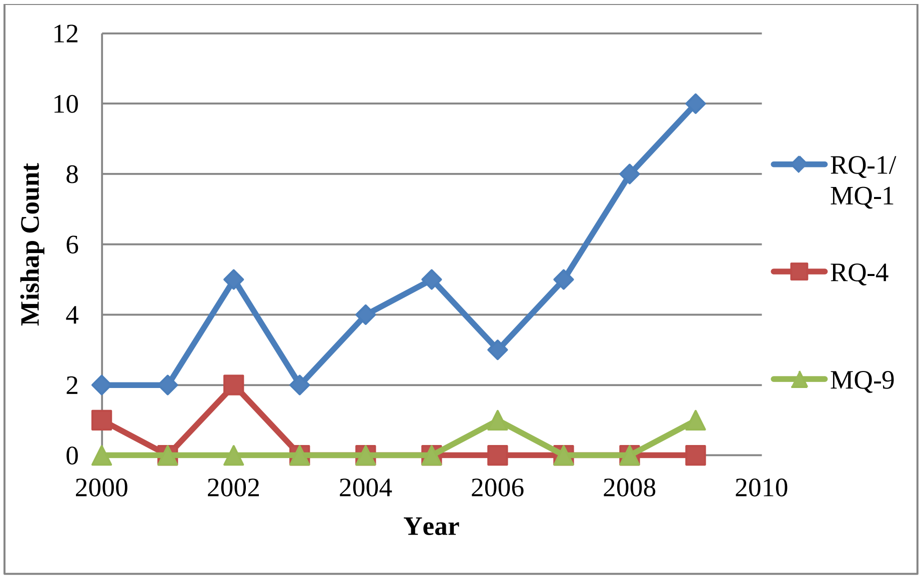


Figure 3.1.18 – Vehicle Mishap Frequency – Class A – AIB

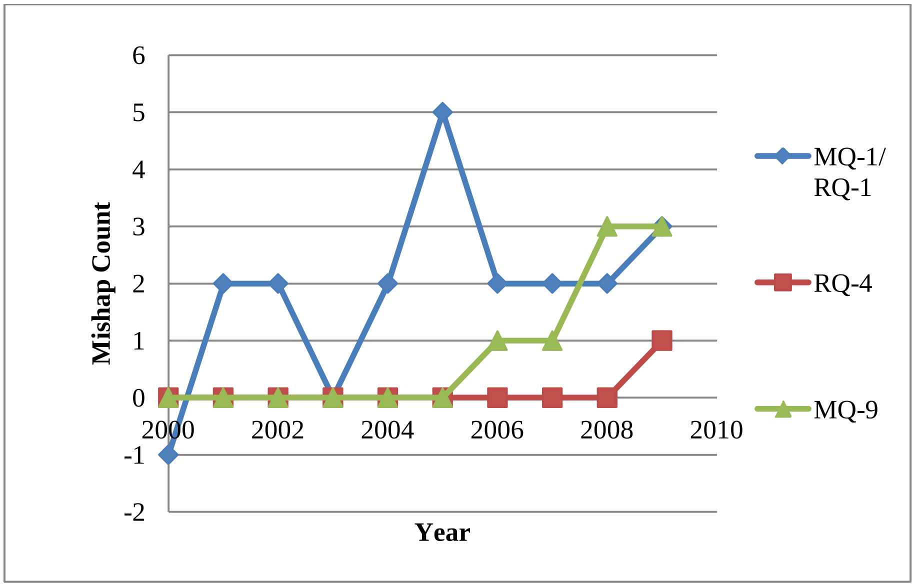


Figure 3.1.19 – Vehicle Mishap Count Discrepancy – Class A – AIB

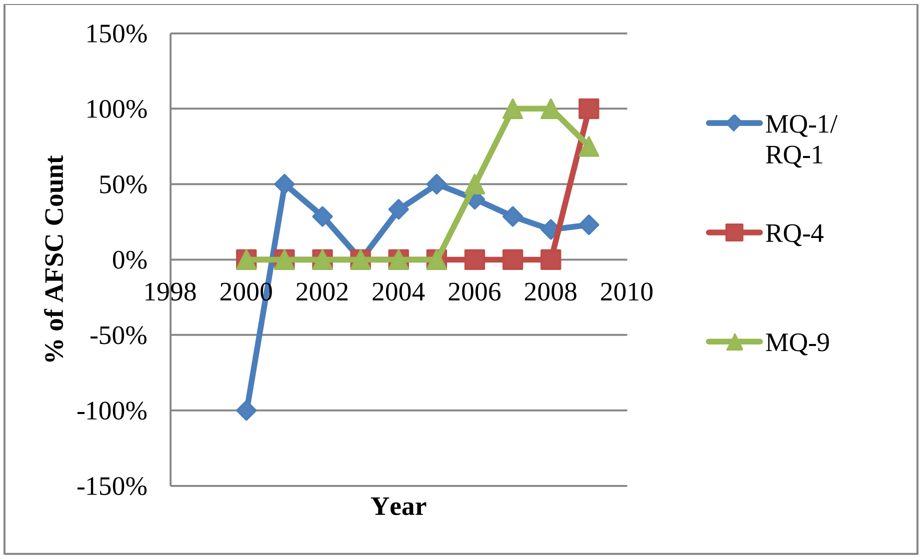


Figure 3.1.20 – Percent Discrepancy (AFSC-AIB/AIB) in Vehicle Mishaps – Class A

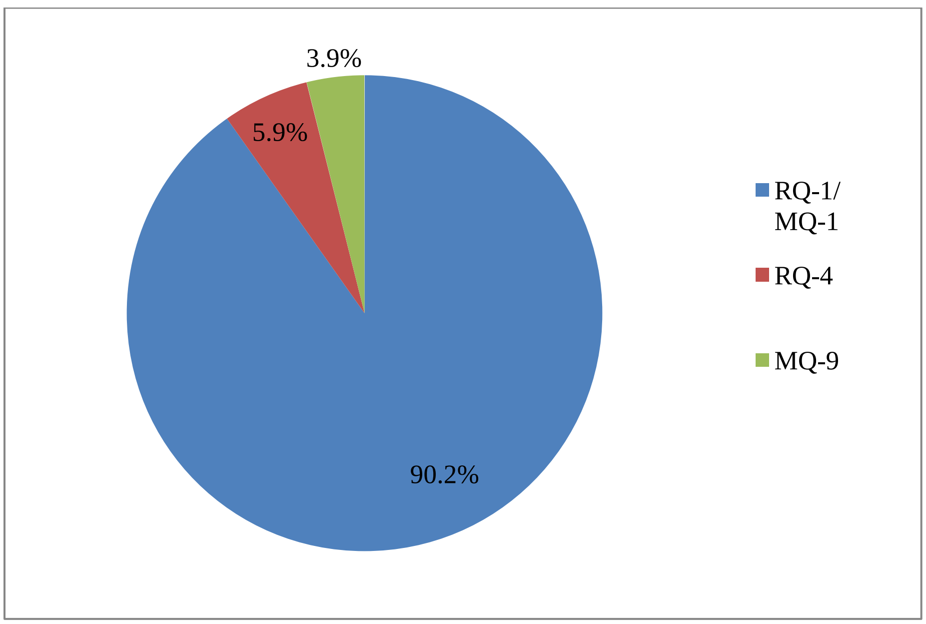


Figure 3.1.21 –Mishap Breakdown by Vehicle – Class A – AIB

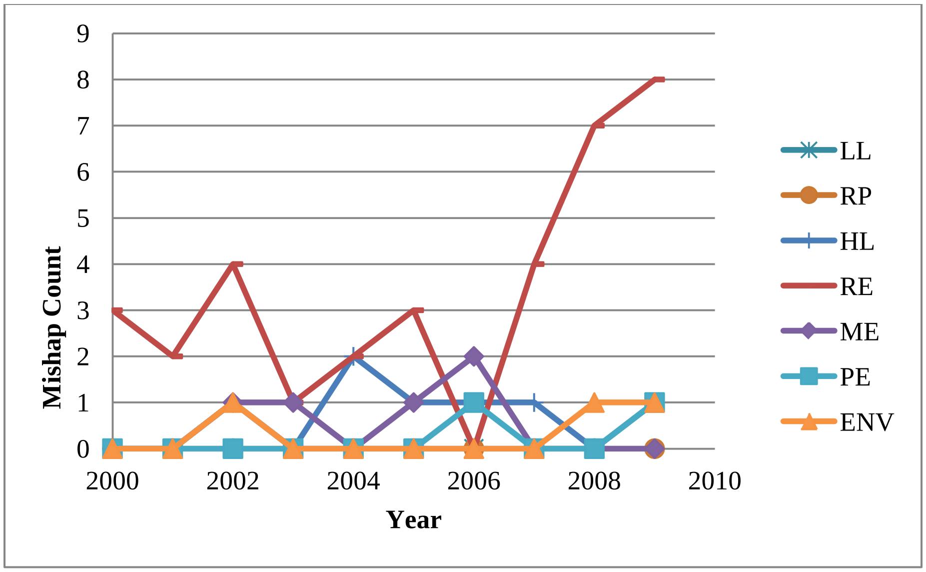


Figure 3.1.22 – Cause Mishap Frequency – Class A – AIB

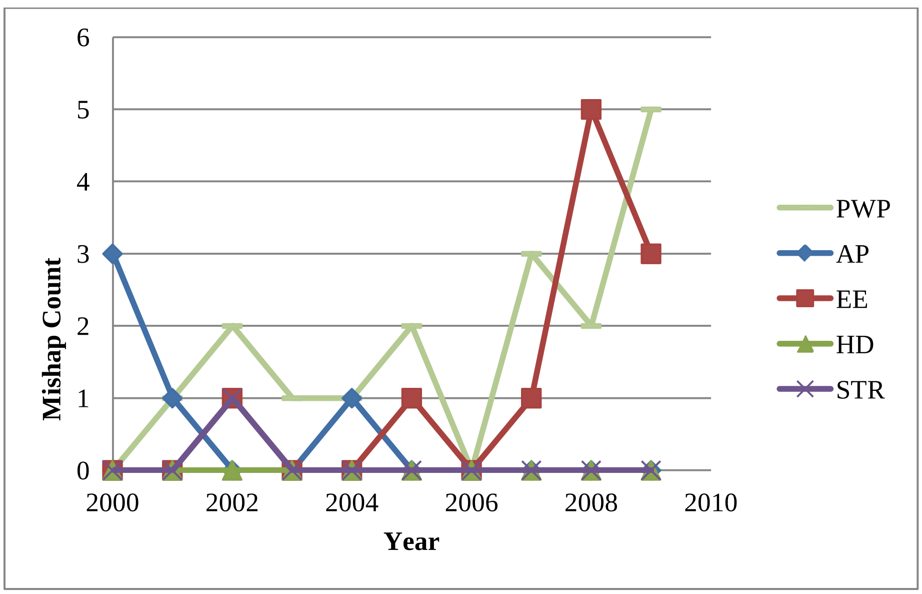


Figure 3.1.23 – Reliability Mishap Frequency – Class A – AIB

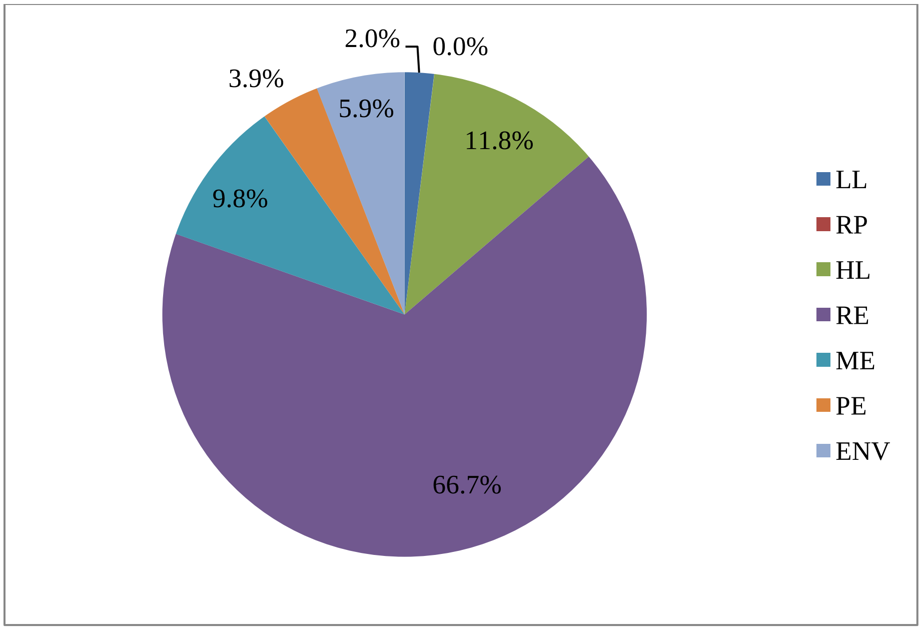


Figure 3.1.24 – Cause Mishap Breakdown – Class A - AIB

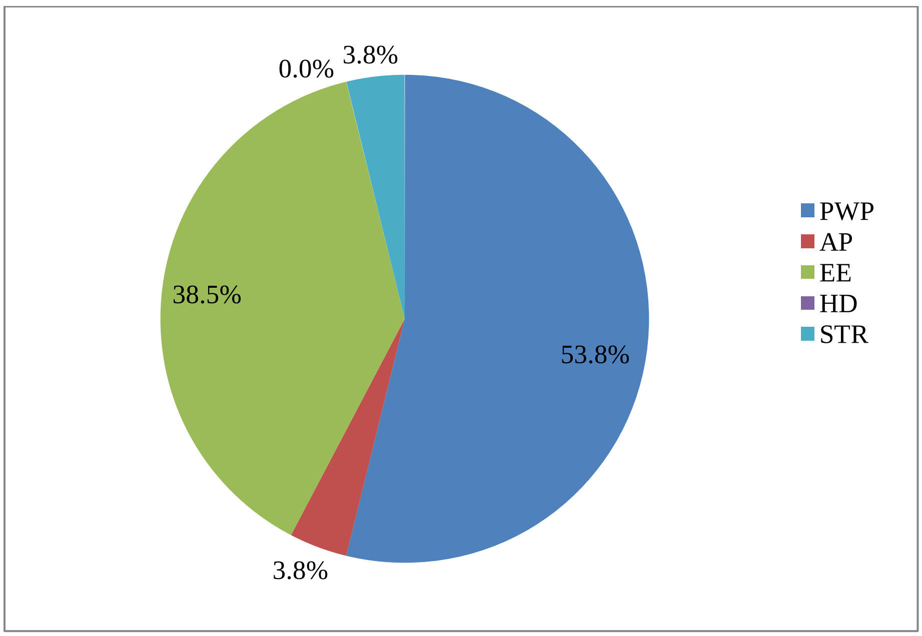


Figure 3.1.25 – Reliability Cause Mishap Breakdown – Class A – AIB

3.2. RQ-1/ MQ-1 Predator Mishap Classification

Because RQ-1/ MQ-1 UAS differ so much in size, payload, construction, and power plant, more precise trends can be found if these aircraft are broken out and considered individually. First examined is the RQ-1/MQ-1 Predator. This is the first UAV fielded by the DoD hence the "-1". It is the smallest UAV in this study, and the only one to have its mission changed during the production run. It is also the most popular large UAV in service. RQ-1/MQ-1 has accumulated 591,000 flight hours and 199 of the 253 mishaps reported by AFSC. The data in Figure 3.2.1 looks smooth with no cyclic patterns. Reliability is the breakaway cause for a majority of mishaps, 55.5% according to Figure 3.2.3. The largest cause of reliability mishaps is power plants, 35.2%. These rate and ratios are very similar to the total fleet data, but what is more interesting at this level is the break out of individual cause mishap rates.

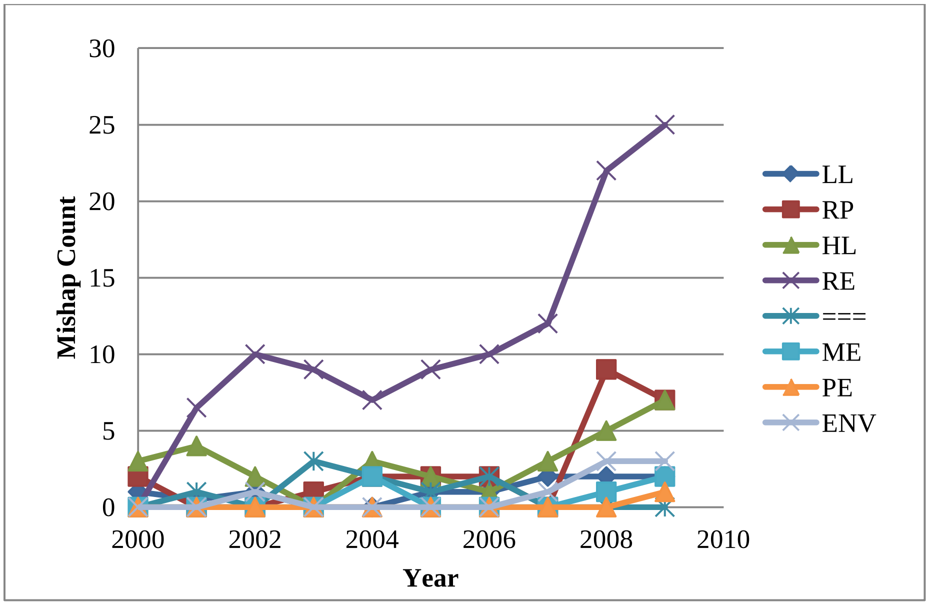


Figure 3.2.1 – RQ-1/ MQ-1 – Cause Mishap Frequency – All Classes – AFSC

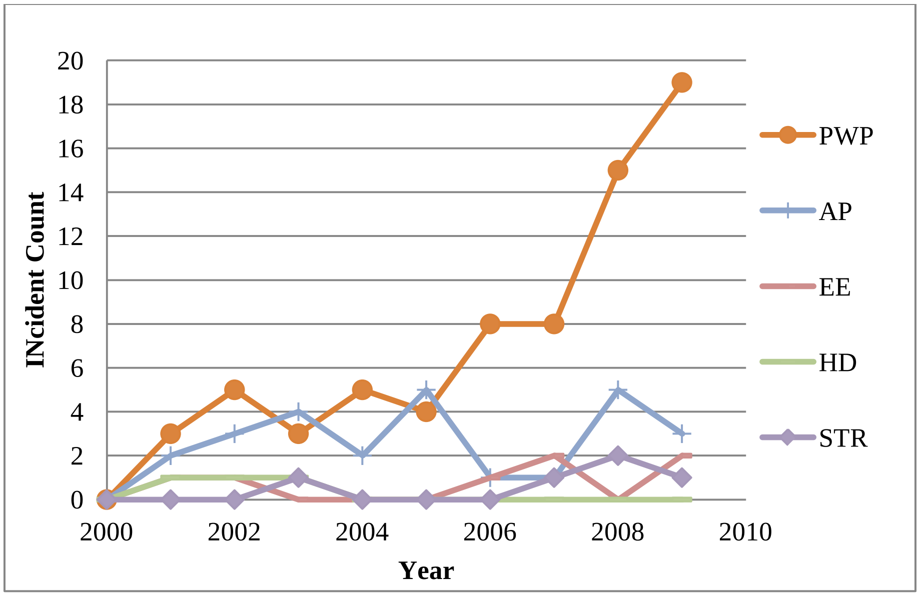


Figure 3.2.2 – RQ-1/ MQ-1 – Reliability Cause Mishap Frequency – All Classes – AFSC

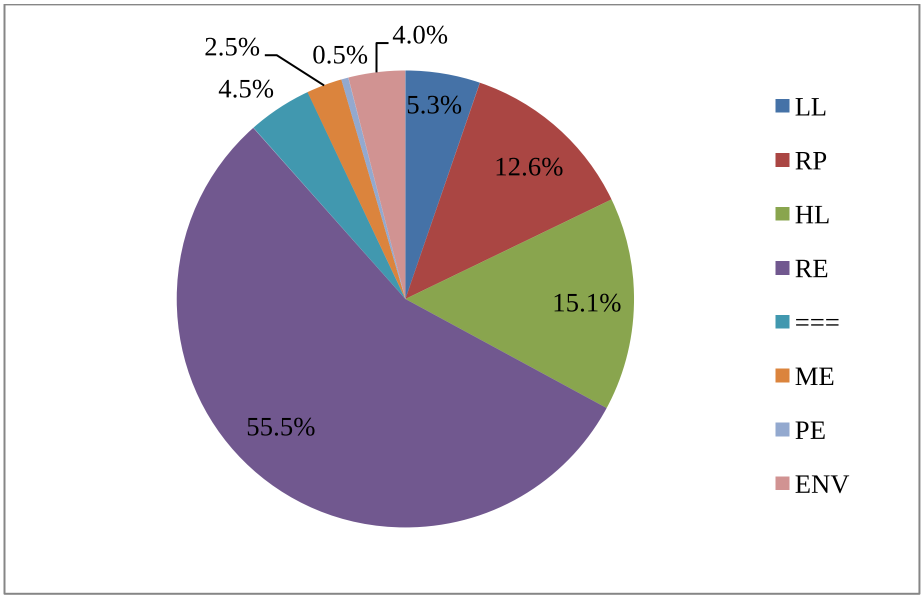


Figure 3.2.3 – RQ-1/ MQ-1 – Cause Mishap Breakdown – All Classes – AFSC

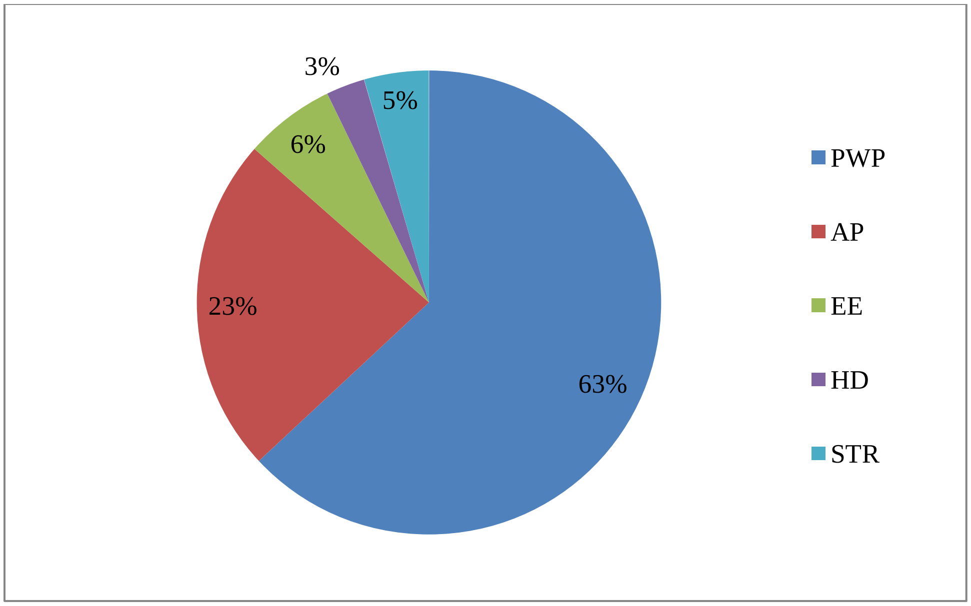


Figure 3.2.4 – RQ-1/ MQ-1 – Reliability Cause Mishap Breakdown – All Classes – AFSC

Figures 3.2.5 and 3.2.6 show the cause and reliability cause mishap rates. All the causes start out at $1 \times 10^{-3} – 1 \times 10^{-4}$ at the beginning of the decade and decay a full order of magnitude over the decade to $1 \times 10^{-4} – 1 \times 10^{-5}$. This puts lost link in the realm of current Active Control failure limits of $10^{-5}$, 14CFR 25.672. The autopilot, Figure 3.2.6, is approaching a reliability of $5 \times 10^{-5}$. Power Plant reliability is still at $10^{-4}$, which is very far from the Hazardous Condition limit $10^{-7}$.

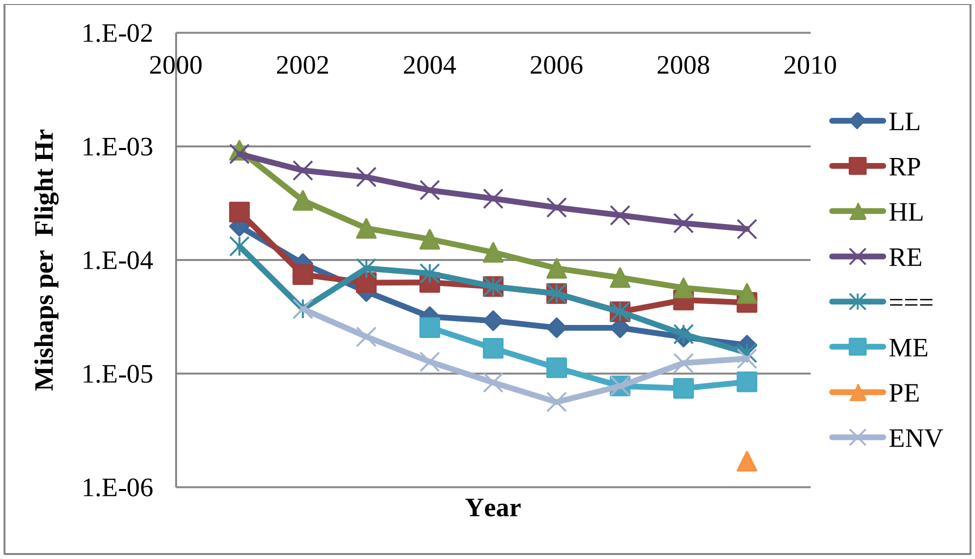


Figure 3.2.5 – RQ-1/ MQ-1 – Cause Accrued Mishap Rate – All Classes – AFSC

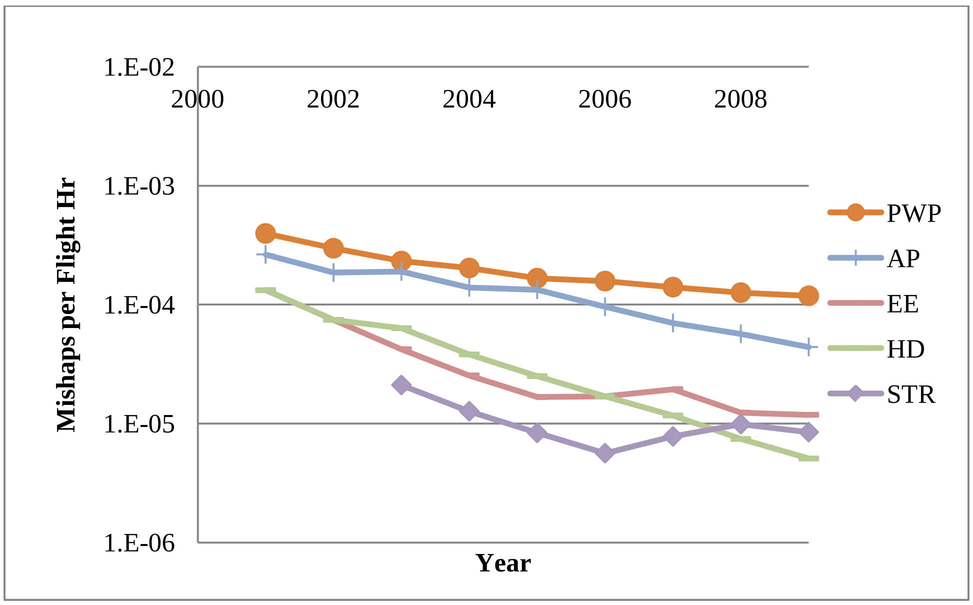


Figure 3.2.6 – RQ-1/ MQ-1 – Reliability Cause Accrued Mishap Rate – All Classes – AFSC

Figures 3.2.7 and 3.2.8 show the cause frequencies for Class A mishaps. The porposing trend is even more pronounced in the RQ-1/ MQ-1 data than in the general fleet. Consider for example, Reliability, Power Plant, and Autopilot frequency in Figures 3.2.7 and 3.2.8. Figures 3.2.9 and 3.2.10 show no significant change in breakdown ratios.

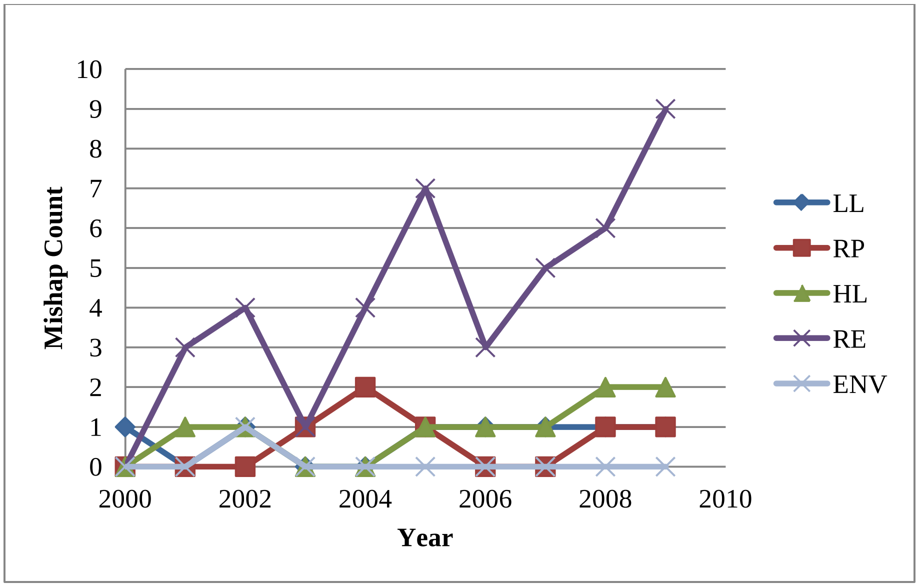


Figure 3.2.7 – MQ-1/ RQ-1 – Cause Mishap Frequency – Class A – AFSC

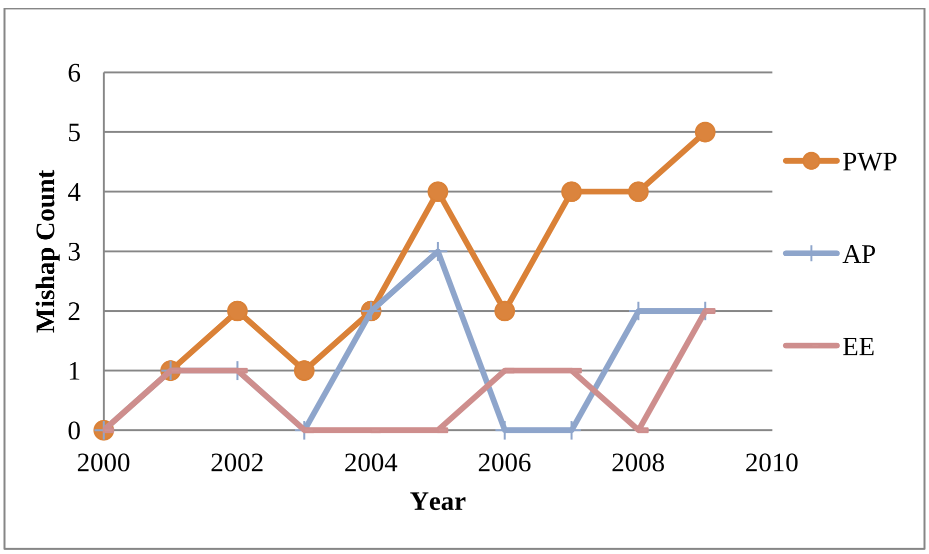


Figure 3.2.8 – RQ-1/ MQ-1 – Reliability Cause Mishap Frequency – Class A – AFSC

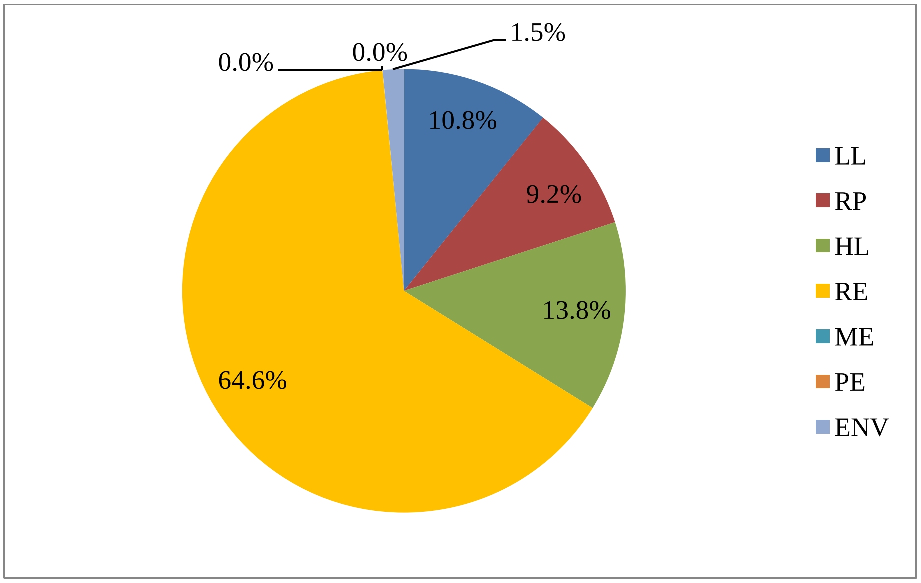


Figure 3.2.9 – RQ-1/ MQ-1 – Cause Mishap Breakdown – Class A – AFSC

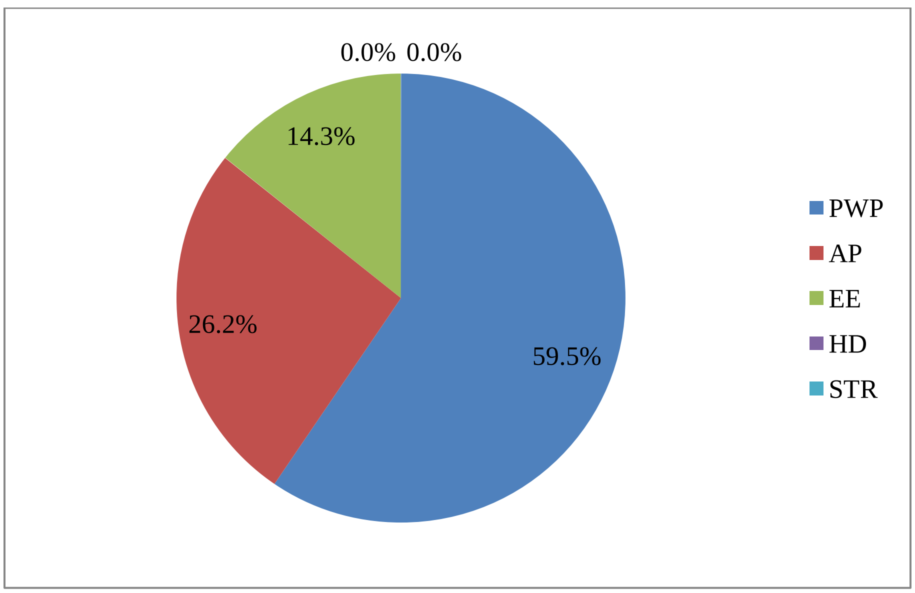


Figure 3.2.10 – RQ-1/ MQ-1 – Reliability Cause Mishap Breakdown – Class A – AFSC

Figures 3.2.11 and 3.2.12 show Class A mishap rates in the AFSC data. All the causes start out at 4 x $10^{-4}$ – 4 x $10^{-5}$ at the beginning of the decade, and decay an order of magnitude over the decade to 7x $10^{-5}$ – 2x $10^{-6}$. Lost link is trending towards $10^{-5}$. The autopilot, as shown in Figure 3.2.12, is also approaching a reliability of $10^{-5}$, both approach the failure tolerance for active controls. If autopilot is developed to have acceptable sense and avoid, the system will required a double fault to produce a mishap. This means a mishap rate of $10^{-10}$ which actually meets the current catastrophic mishap tolerance of $10^{-9}$, hypothetical, but promising.

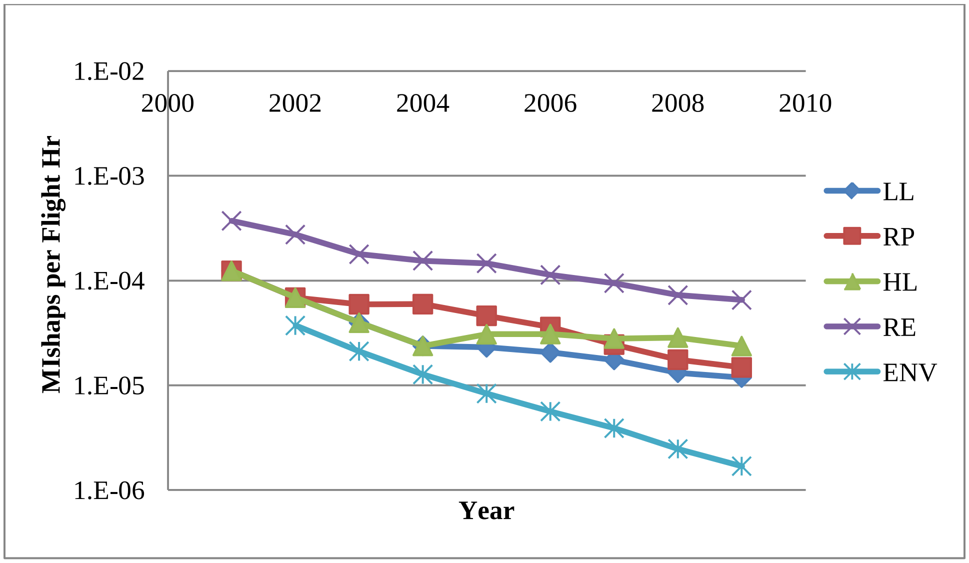


Figure 3.2.11 – RQ-1/ MQ-1 – Causation Accrued Mishap Rate – Class A – AFSC

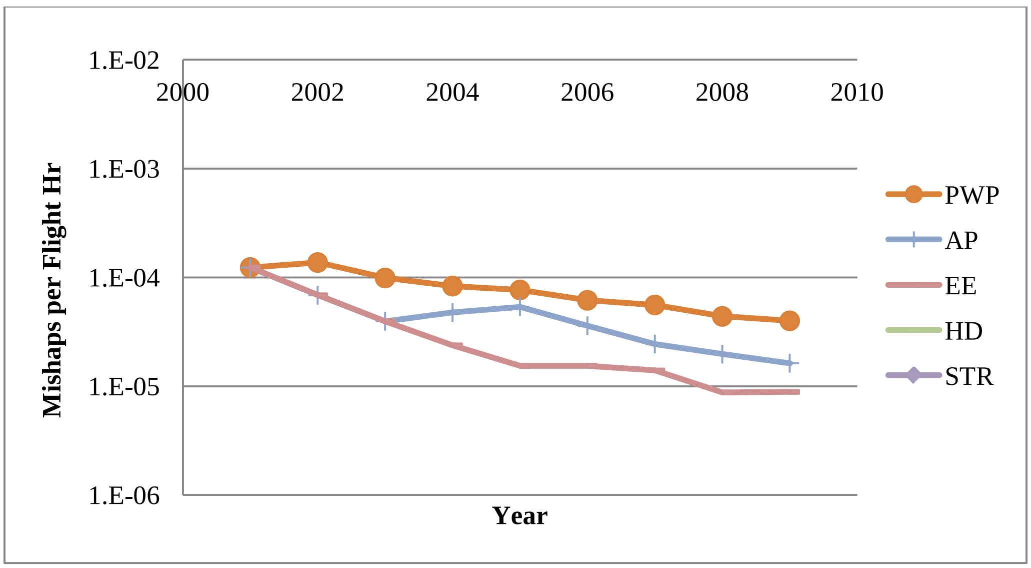


Figure 3.2.12 – RQ-1/ MQ-1 – Reliability Causation Accrued Mishap Rate – Class A – AFSC

The trends shown in Figures 3.2.13 through 3.2.16 are almost identical to those shown in Figures 3.1.21 through 3.1.24. The reactionary porposing shown in the AFSC data is indiscernible. Auto Pilot accounts for a larger fraction.

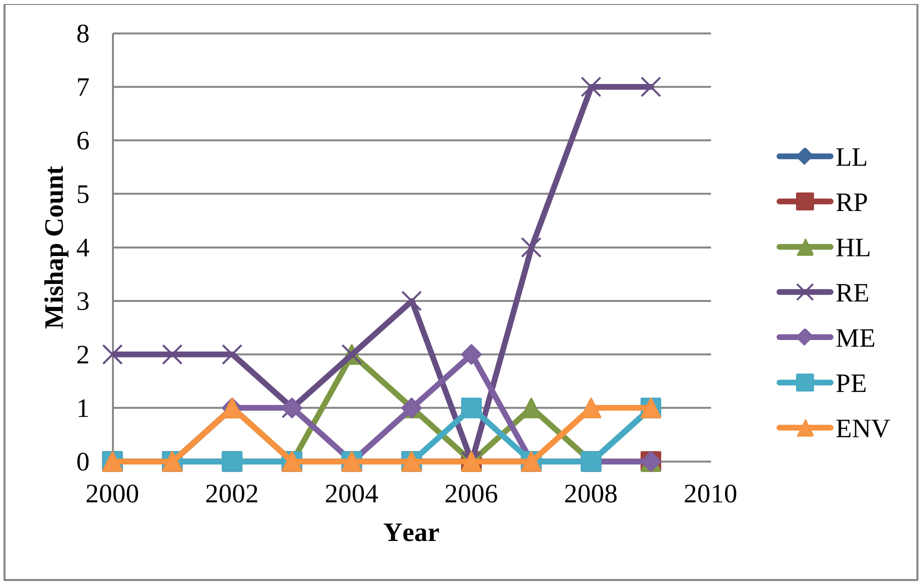


Figure 3.2.13 – RQ-1/ MQ-1 – Cause Mishap Frequency – Class A – AIB

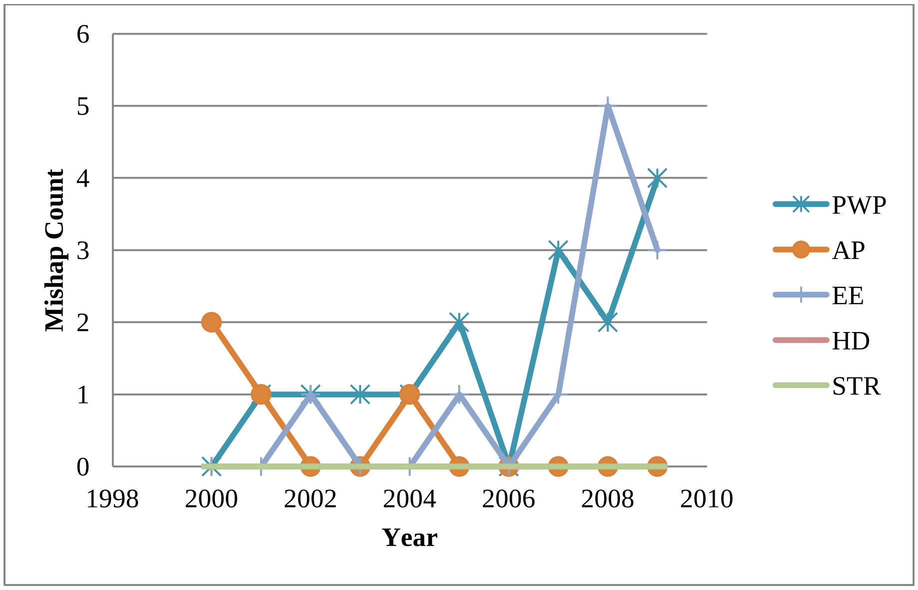


Figure 3.2.14 – RQ-1/ MQ-1 – Reliability Cause Mishap Frequency – Class A – AIB

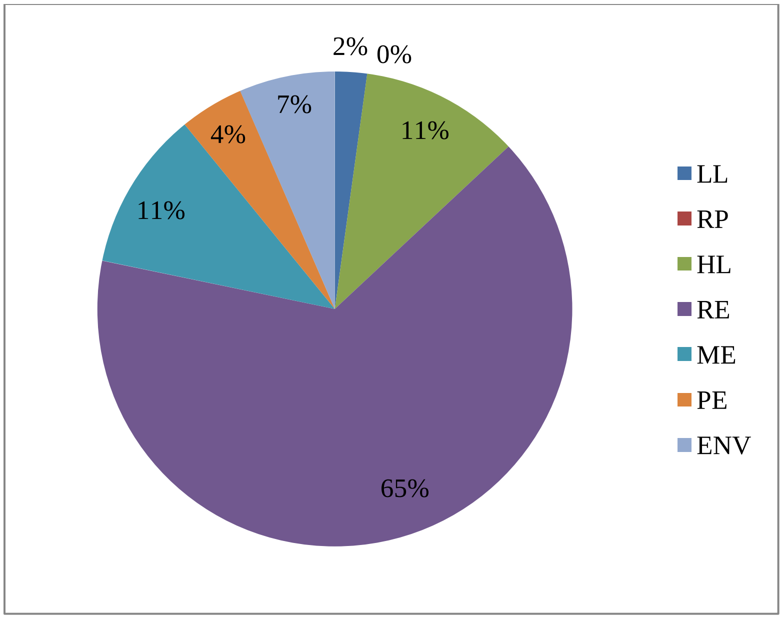


Figure 3.2.15 – RQ-1/ MQ-1 – Cause Mishap Breakdown – Class A – AIB

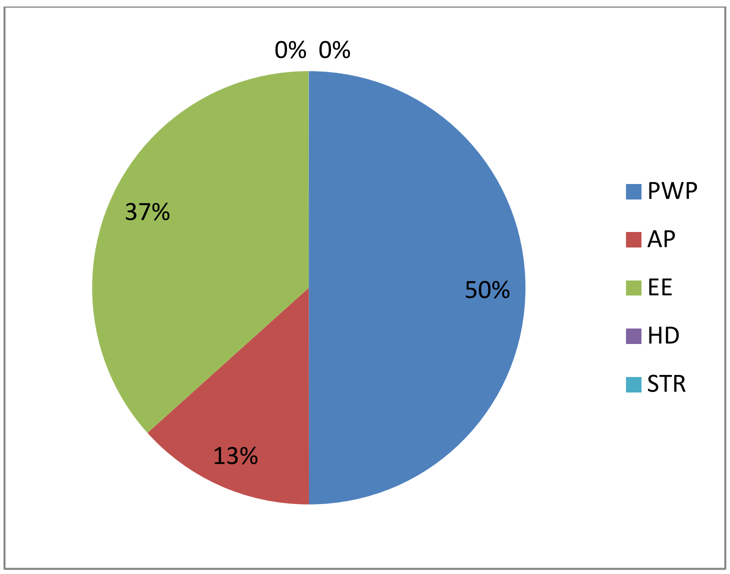


Figure 3.2.16 – RQ-1/ MQ-1 – Reliability Cause Mishap Breakdown – Class A – AIB

3.3. MQ-9 Reaper Mishap Classification

The MQ-9 Reaper, also called the Predator, is the second generation MALE UAS from General Atomics. The maturity of the platform design can be seen in the breakdown of mishaps, even if the annual mishap rate does not reflect this. Figure 3.3.1 shows that reliability does not become an issue in the airframe until 4 years after entry into service. The main causes of mishap during the first 4 years are hard landings and reduced perception. These are both remote failures. Looking at Figure 3.3.2 another mature trend arises. The electrical failures follow the mechanical ones. In general, reliability plays a much smaller role, 35.3%, in causing mishaps, as shown in Figure 3.3.3. However, inside reliability power plants account for 72.7% of reliability mishaps, or 23.5% overall contribution. Also of note, no personnel mistakes appear to have contributed to mishaps. Without more data no additional conclusions can't be made from that fact.

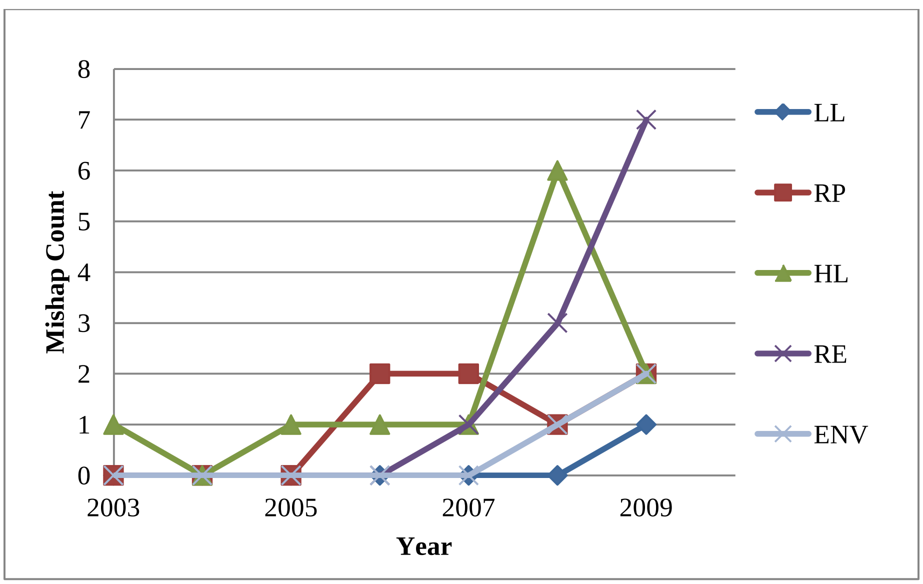


Figure 3.3.1 – MQ-9 Cause Frequency – All Classes - AFSC

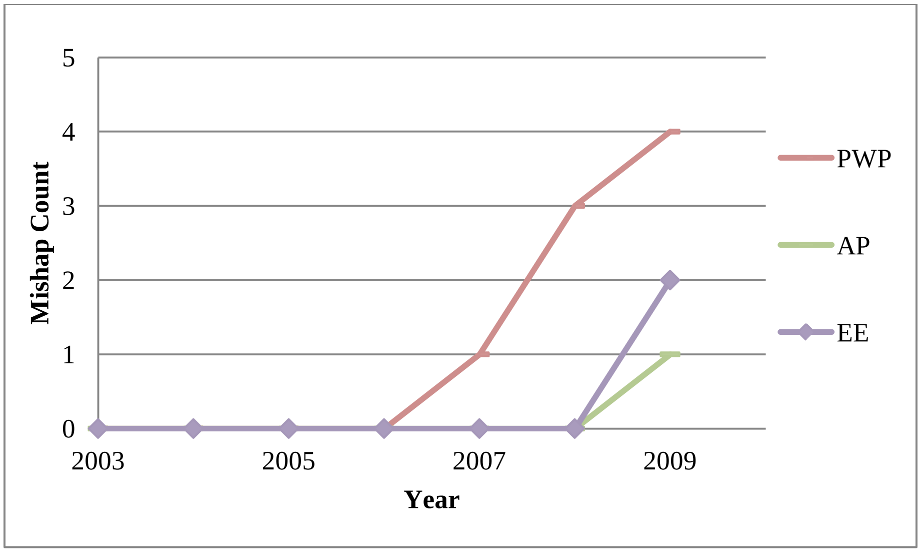


Figure 3.3.2 – MQ-9 Reliability Cause Frequency – All Classes – AFSC

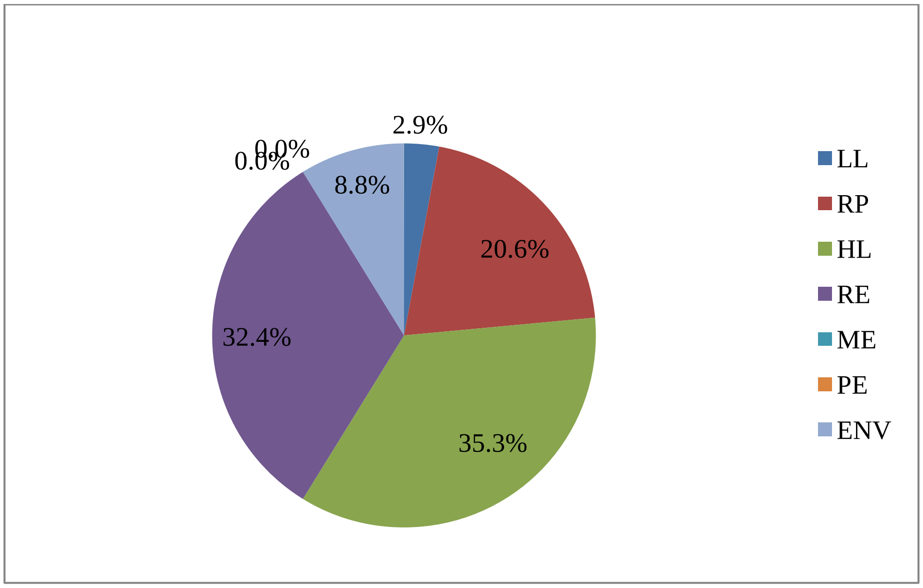


Figure 3.3.3 – MQ-9 Cause Mishap Breakdown – All Classes - AFSC

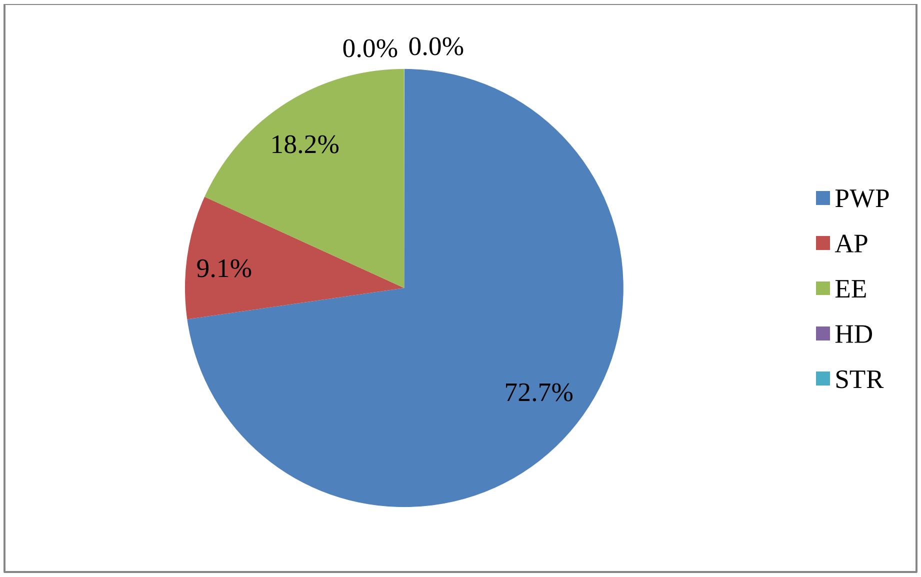


Figure 3.3.4 – MQ-9 Reliability Cause Mishap Breakdown – All Classes – AFSC

The MQ-9 has only accumulated 50,000 hours so it is still early in its development curve and still has a lot of maturing to do. The hard landing mishap rate is significantly higher than the current MQ-1 rate. It's still 4 x $10^{-4}$ at the end of the decade, and compare that to start of the study, 3 x $10^{-3}$. The rest of the causes are still $10^{-4}$, which is 3 to 4 orders of magnitude higher than transport aircraft.

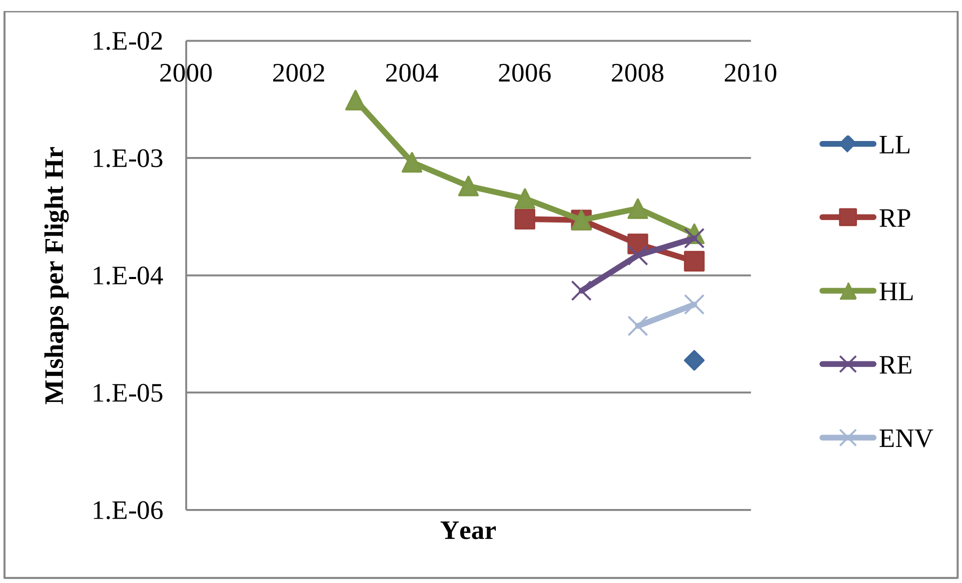


Figure 3.3.5 – MQ-9 Cause Mishap Rate – All Classes - AFSC

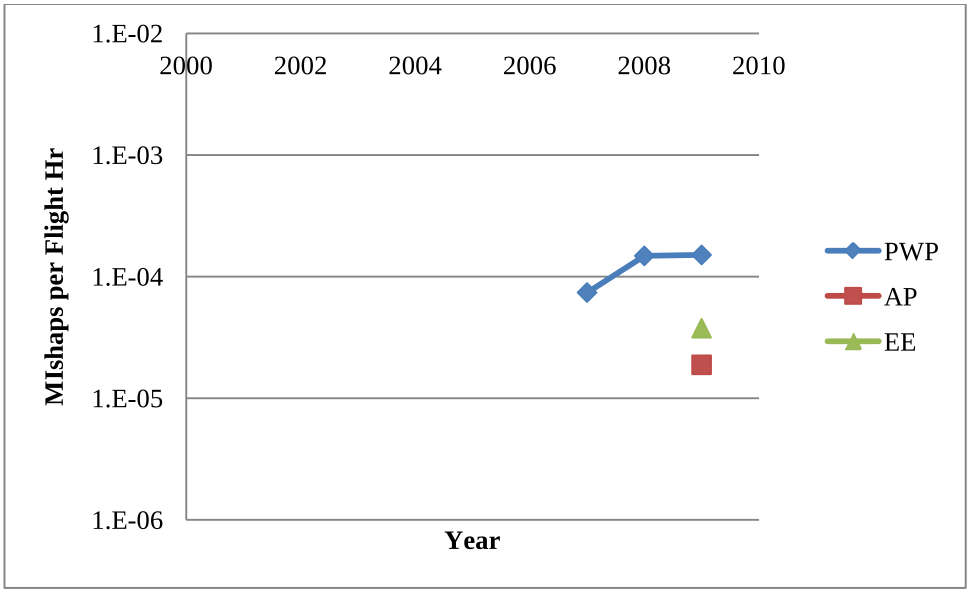


Figure 3.3.6 – MQ-9 Reliability Cause Rate – All Classes – AFSC

For Class A mishaps, the causation becomes very simple. There is only one type of reliability that has caused a vehicle loss, power plant as shown in Figure 3.3.8. As show in the All Class data, remote failures dominate the mishap causes, as shown in Figures 3.3.7 and 3.3.8. Remote failures account for 80% of MQ-9 mishaps. Figure 3.3.9 shows the accrued mishap rate. The figure shows that there are only a few data points to go by, but one trend that appears to be different is the hard landing rate. The hard landing rate has almost no downward slope.

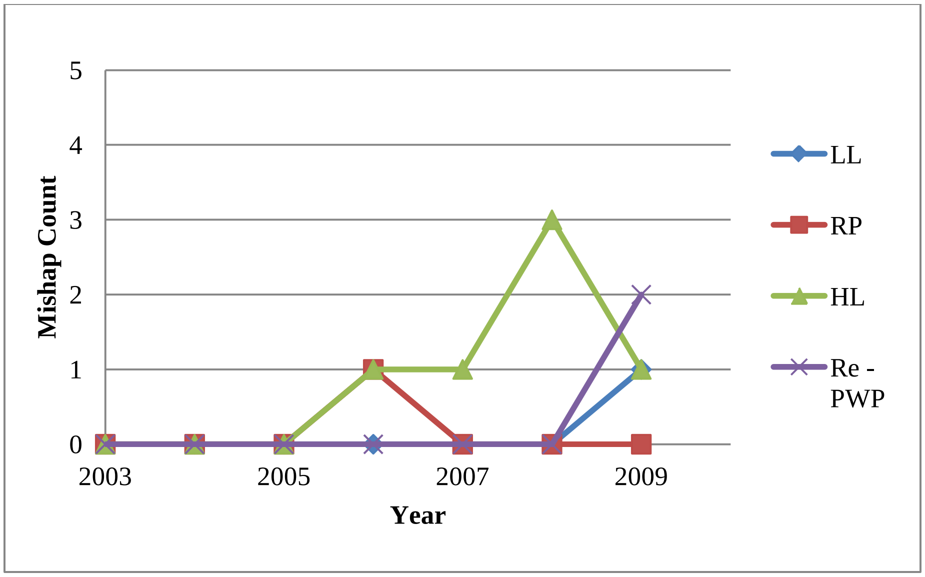


Figure 3.3.7 – MQ-9 – Causation Mishap Frequency – Class A – AFSC

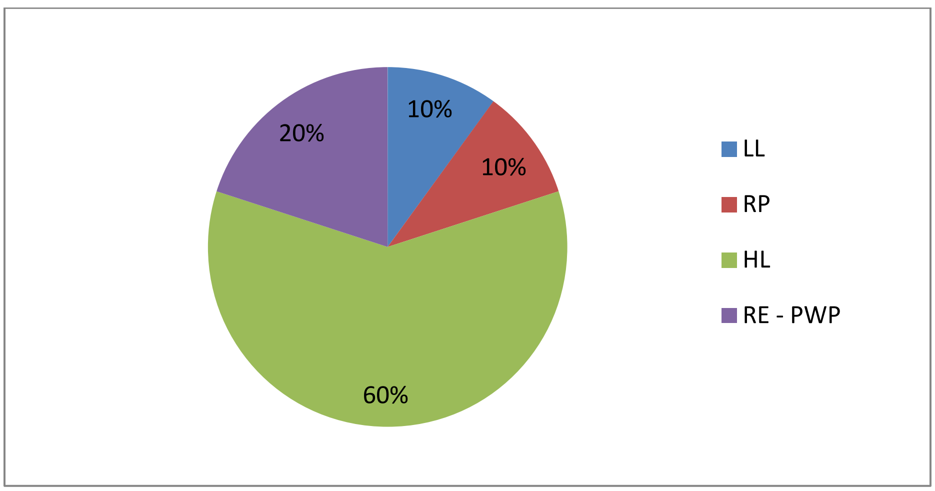


Figure 3.3.8 – MQ-9 – Causation Mishap Breakdown – Class A – AFSC

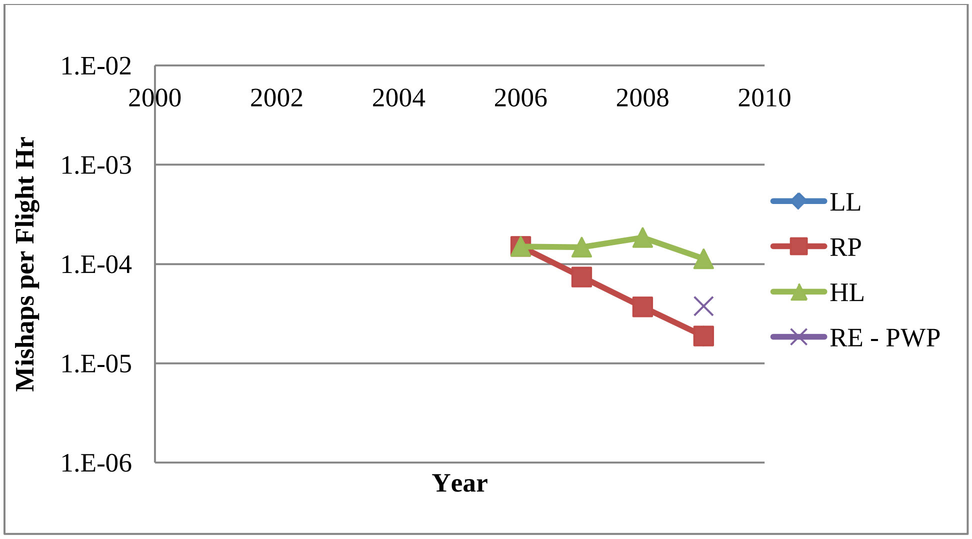


Figure 3.3.9 – MQ-9 – Causation Mishap Rate – Class A – AFSC

The AIB data, shown in Figures3.3.10 and 3.3.11, are included only to show the lack of inference that can be made from 2 data points when 8 points are missing from the record.

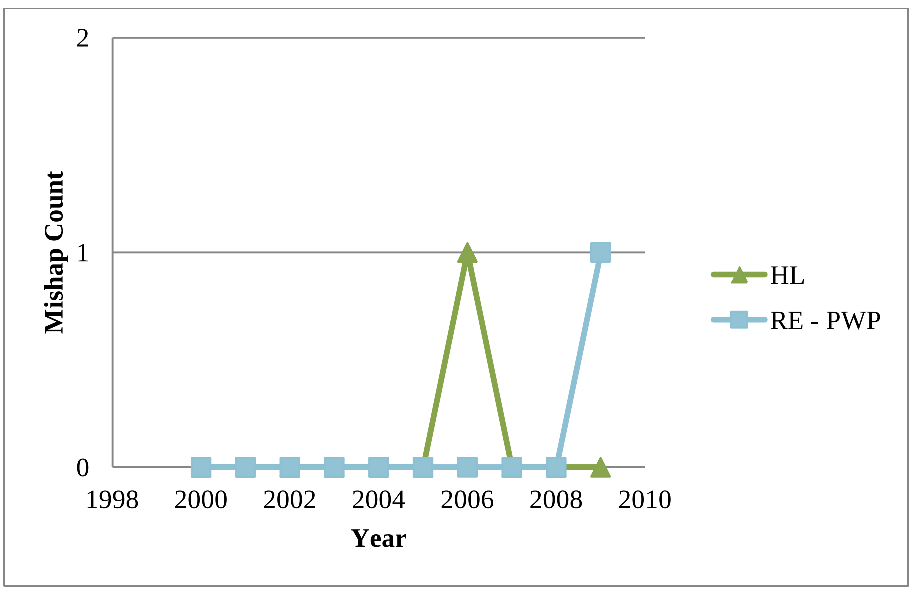


Figure 3.3.10 – MQ-9 – Cause Mishap Frequency – Class A – AIB

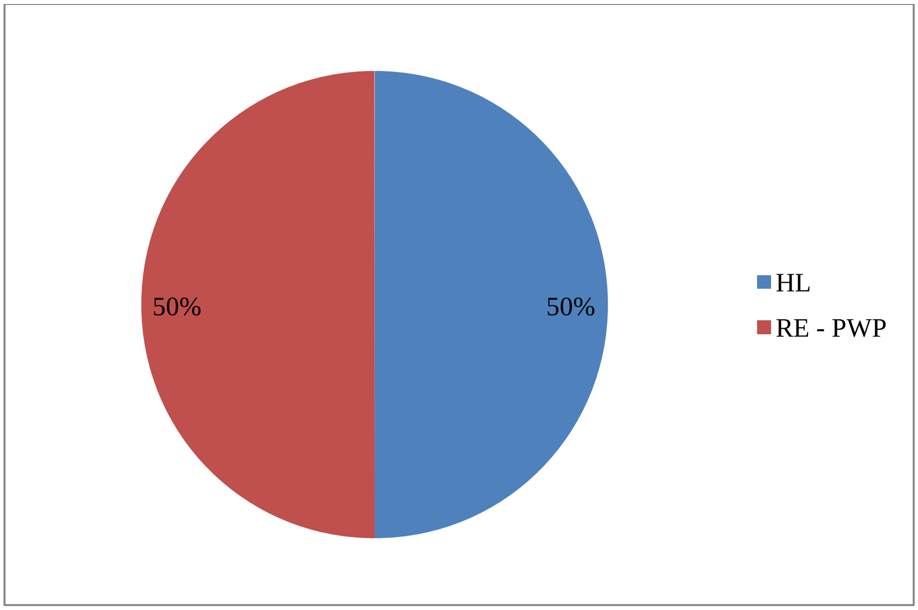


Figure 3.3.11 – MQ-9 – Cause Mishap Breakdown – Class A – AIB

3.4. RQ-4 Global Hawk Mishap Rate

The RQ-4 shows very similar trends as the MQ-1 even as the number of mishaps and flight hours does not give the fidelity to see growth. The RQ-4 is the largest and most expensive drone in this study. The level of reduced perception shown in these figures is questionable because the AFSC and AIB data disagree, more in the RQ-4 AIB discussion. The RQ-4 also implemented auto-landing navigation, which can be seen in the lack of Hard Landings, as shown in Figures 3.4.1 and 3.4.2. Power plant reliability is still a major issue in this platform accounting for 35.3% of all Rq-4 mishaps, as shown in Figures 3.4.3.

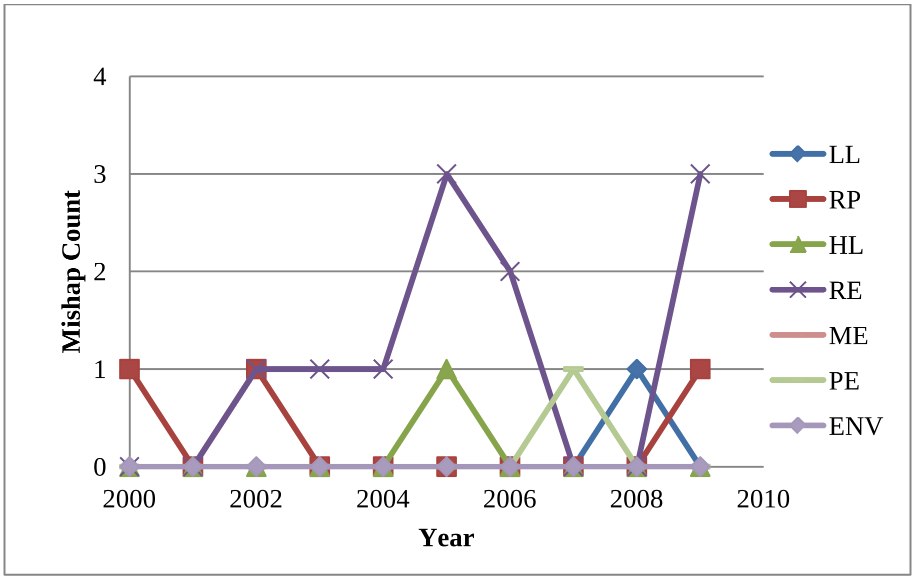


Figure 3.4.1 – RQ-4 – Cause Mishap Frequency – All Classes – AFSC

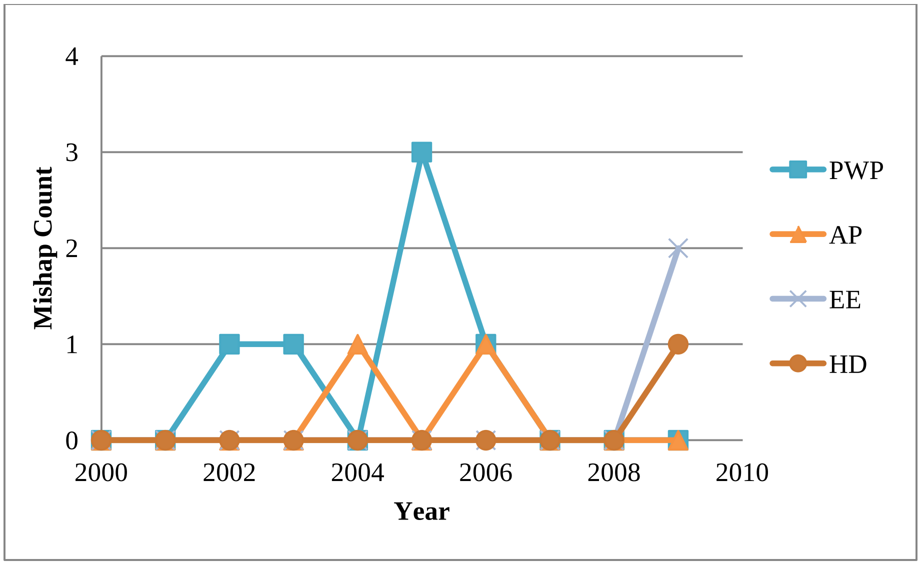


Figure 3.4.2 – RQ-4 – Reliability Cause Mishap Frequency – All Classes – AFSC

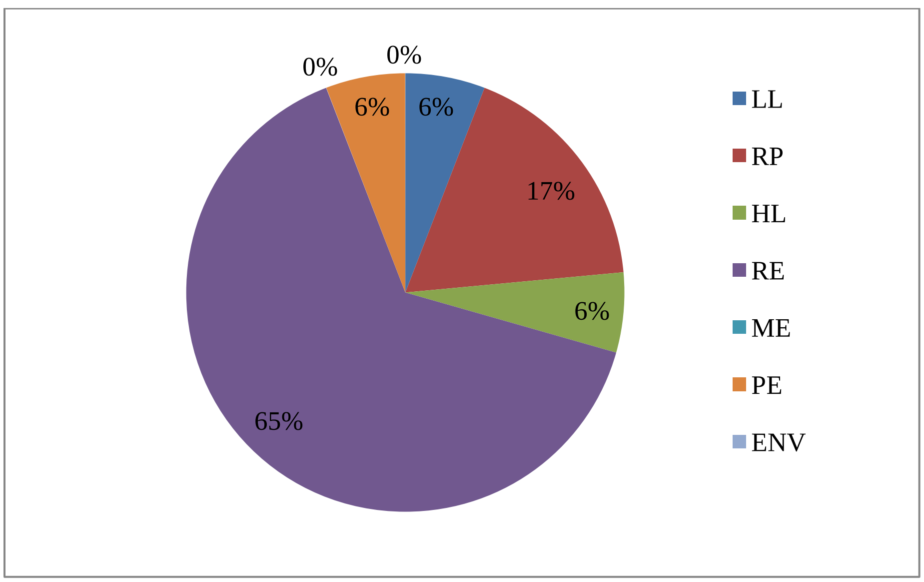


Figure 3.4.3 – RQ-4 – Cause Mishap Breakdown – All Classes – AFSC

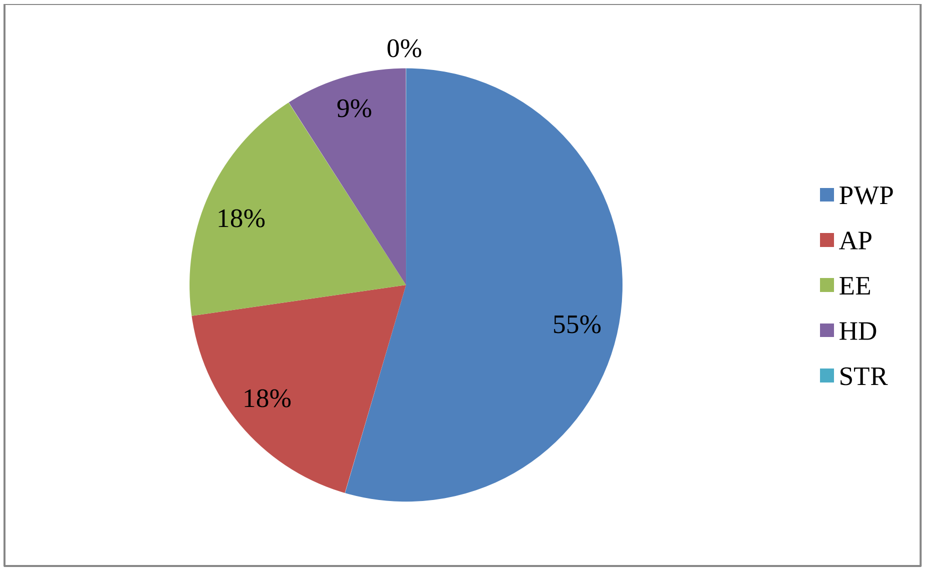


Figure 3.4.4 – RQ-4 – Reliability Cause Mishap Breakdown – All Classes – AFSC

Because of the extremely low flight hours and early unreliability, the RQ-4 started service with a horrible crash record Figures 3.4.3 and 3.4.4. The end year rates are comparable to the RQ-1 performance; however, the slopes are more dramatic. This suggests a faster rate of improvement.

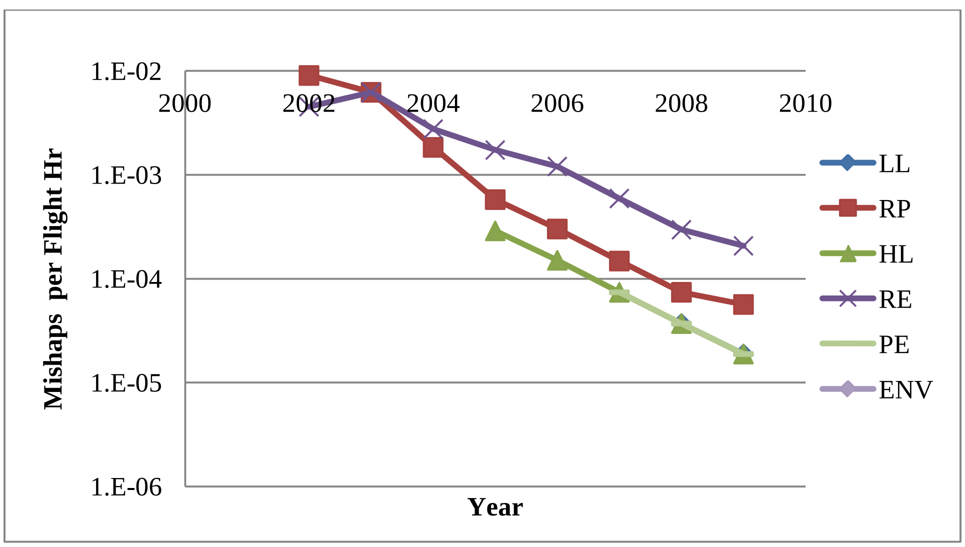


Figure 3.4.5 – RQ-4 – Cause Accrued Mishap Rate – All Classes – AFSC

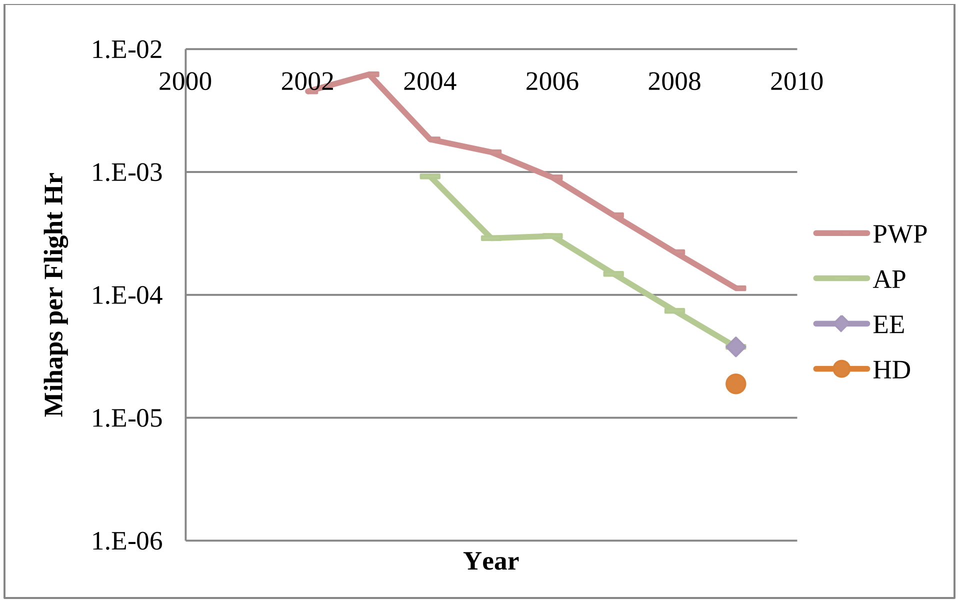


Figure 3.4.6 – RQ-4 – Reliability Cause Accrued Mishap Rate – All Classes – AFSC

According to the AFSC data, reduced perception is the main cause of Class RQ-4 mishap, Figures 3.4.7 and 3.4.8, accounting for 75% of lost aircraft. The rate of incident is comparable to the other aircraft.

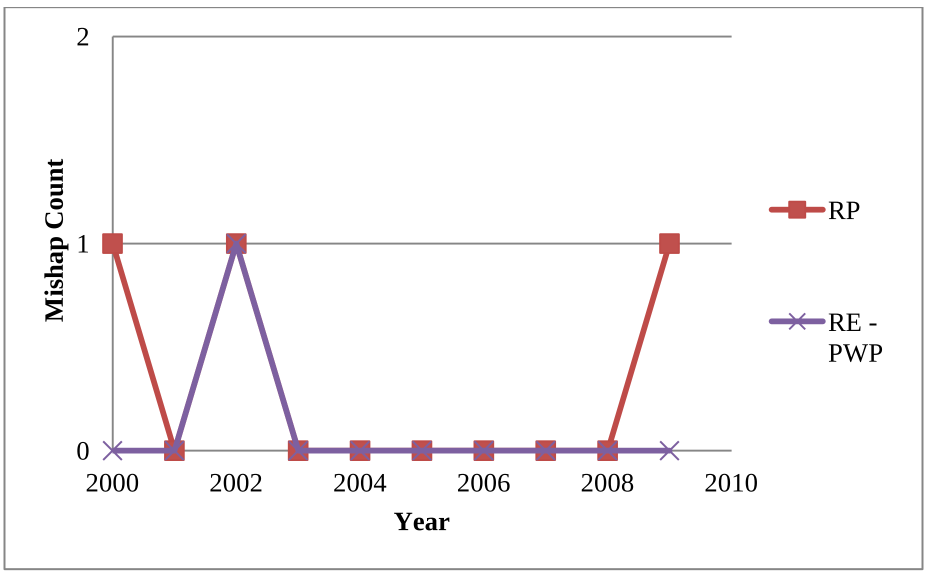


Figure 3.4.7 – RQ-4 – Cause Mishap Rate – Class A – AFSC

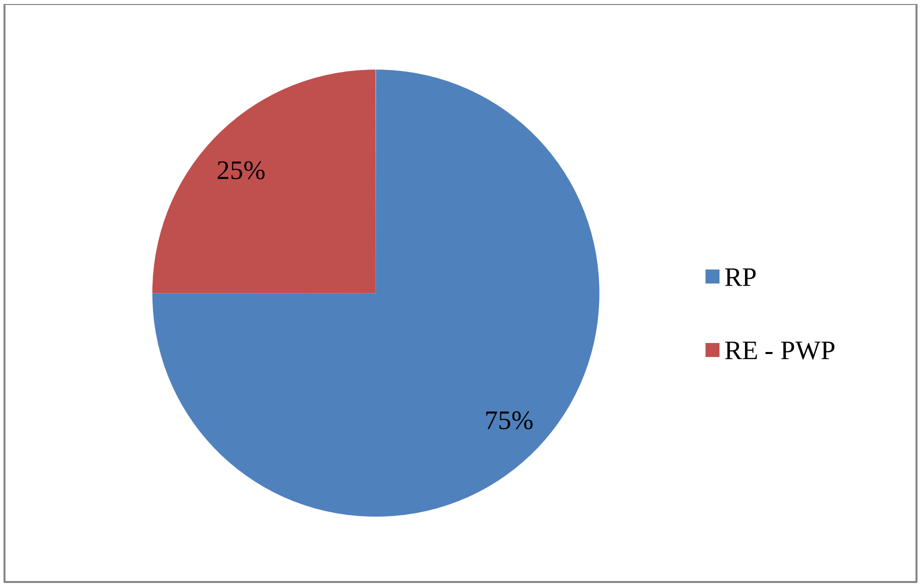


Figure 3.4.8 – RQ-4 – Cause Mishap Breakdown – Class A – AFSC

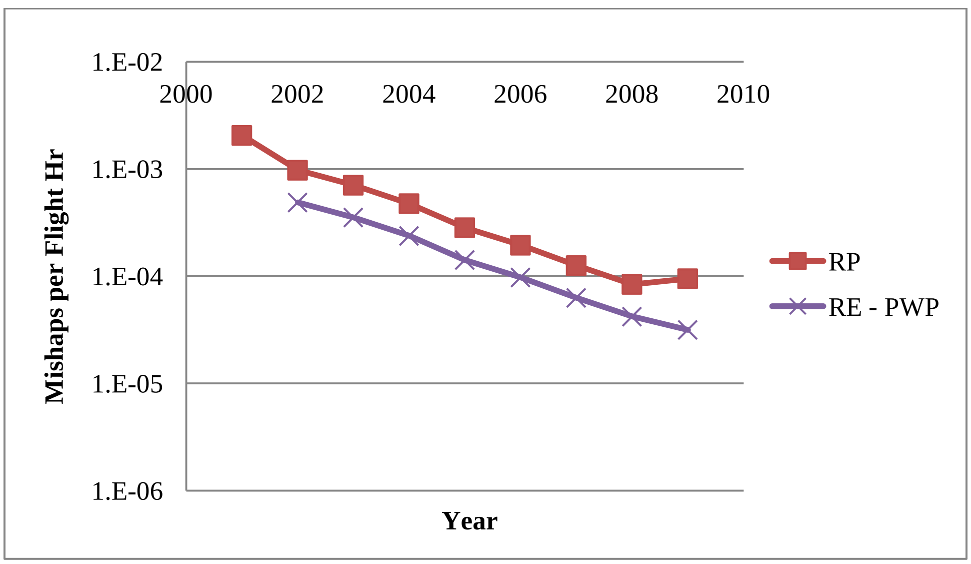


Figure 3.4.8 – RQ-4 – Cause Mishap Rate – Class A – AFSC

The AIB data here, while incomplete, shows a different story than the AFSC data. The three mishaps match up exactly with the times of the first three AFSC data, but the cause determination is different. In 2000, the AFSC data brought the determination reduced perception while the AIB report brought the determination autopilot failure. Likewise, the 2002 reduced perception mishap is determined to a structural reliability issue.

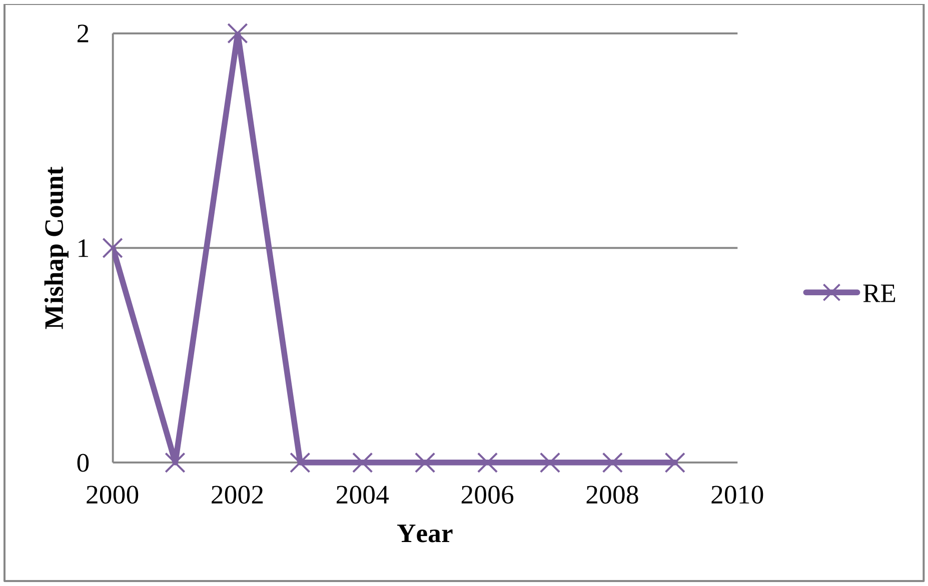


Figure 3.4.9 – RQ-4 – Cause Mishap Frequency – Class A – AIB

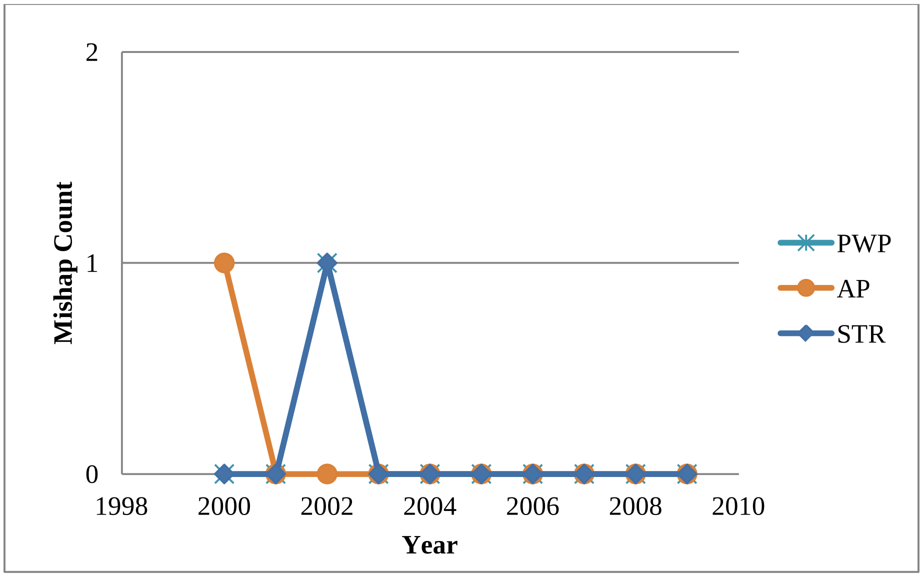


Figure 3.4.10 – RQ-4 – Reliability Cause Mishap Frequency – Class A - AIB

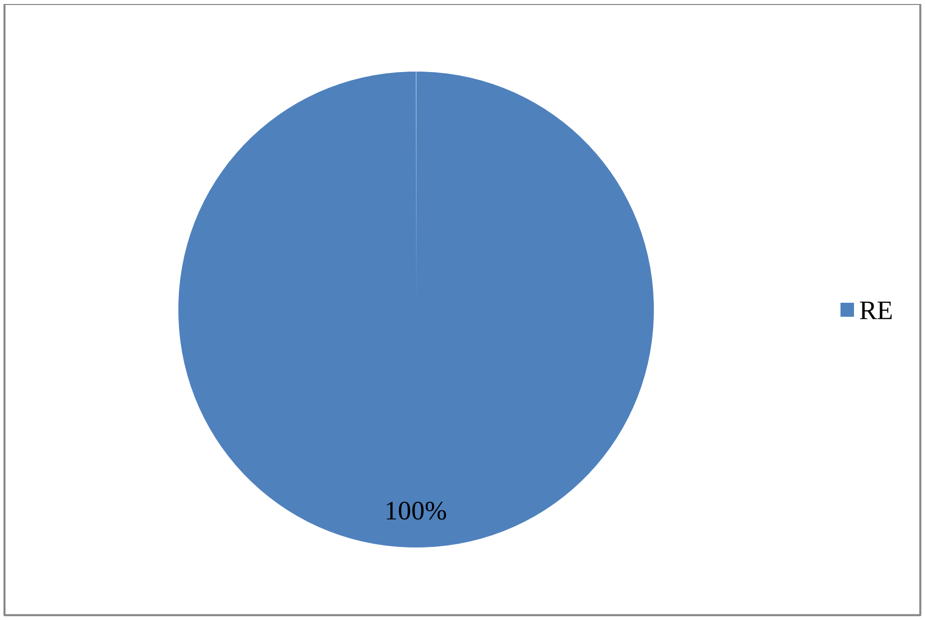


Figure 3.4.11 – RQ-4 – Cause Mishap Breakdown – Class A - AIB

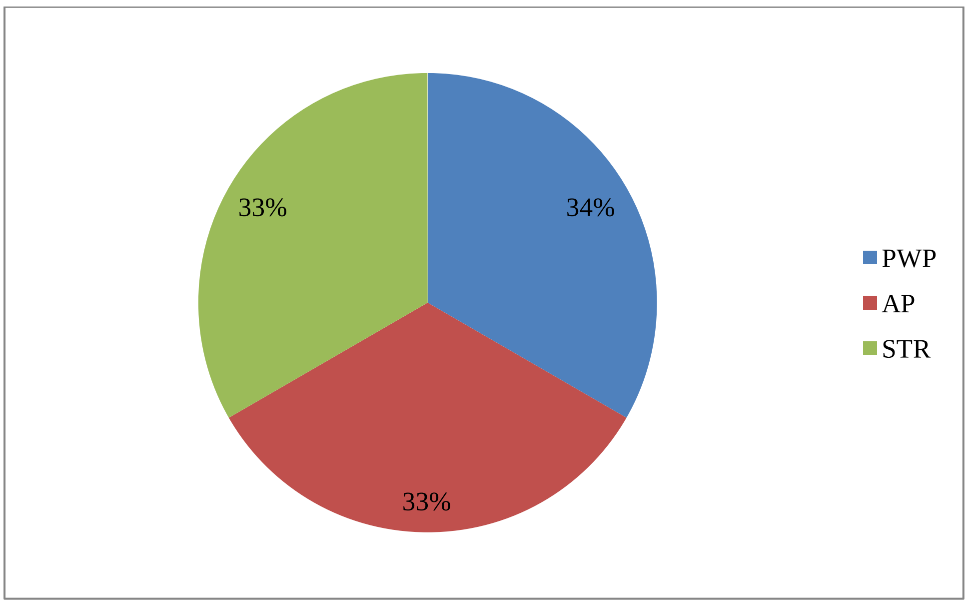


Figure 3.4.12 – RQ-4 – Reliability Mishap Breakdown – Class A – AIB

### 3.5. Causal Trends

While the AFSC data is a more complete data set and can be used to determine the number of incidents that occurred, the SIB one-line summaries lacked the detail to give any further insight into the exact cause of the incident so more detailed trends could be discovered. This section looks at the AIB reports in detail and common causes found.

#### 3.5.1. Power Plant

Power plant system failures accounted for the largest fraction of mishaps and catastrophic incidents. Looking deeper into the cause of failure in this system reveals a wide variety of causes. Broadly, mishaps occurred from both mechanical and electrical causes. There is evidence of poor initial quality. On17 Jan 07, a MQ-1B crash occurred from initial manufactured quality of the crankshaft which cascaded into full engine seizure. On 19 Nov 09, a MQ-1B crashed because the quill shaft had been improperly quenched during heat treatment. These cracks lead to early fatigue failure of the variable pitch prop mechanism. On 30 Jun 07, the MQ-1B crashed from improper soldering of the Ignition Module. This redundant system was not designed to fail safe. The excessive heat due improper enclosures design and the intolerance of the second ignition system to over flow current from the first system's failure proves the system is not designed to fail safe, and the second system was an insufficient back-up. If the ignition system was held to 33.37 and 33.28.d.3 and f, this would not have occurred. As well as design and construction of materials 25.603 and 25.619.

Determinate assembly and routing is another issue that pervades over power plant failure. 5 MQ-1 were lost from systems that were not designed with determinate assembly. When taken apart they could be put back in more than one way, and no marking were given to prevent that. On 20 March 09, a mishap was caused by an improperly assembled oil temperature control valve. In three other cases, mishap was cause by the mechanics routing fuel, oil, and vacuum lines in a way the original designer had not thought about, in most cases, draping the line over the exhaust manifold. The other systemic cause of failure in the MQ-1 power plant is the Variable Pitch Prop Mechanism.

This Variable Pitch Prop Mechanism of the RQ-1/ MQ-1mechanism itself has several vulernerable modes of failure. Failure of this single mechanism has caused 6 Class A incidents totaling $24 million in losses. The mechanisms failure history is a good case study for UAS as a whole. The failures have come from both mechanical and electrical sources. The electrical failures of this system were centered in the improper manufacture of the servo motors, and the mechanical failures centered around the quill shaft that directly controlled propeller pitch and the bearing isolating this shaft from propeller rotation. The failure of this mechanism, while small, lead to unforeseen consequences in larger system. Below are two example exerts from AIB reports three years apart: 30 March 2005 and 19 Oct 2009.

> **"**There is clear and convincing evidence that this mishap was caused by the failure of the pilot bearing that encases the variable pitch propeller quill shaft. Damage analysis of the pilot bearing and quill shaft suggests a long duration, progressive failure within the unit. The failed pilot bearing, which is supposed to allow the propeller shaft to spin freely around the fixed quill shaft, caused enough friction to torsionally sheer the adapter which holds the quill shaft in place. The engine anomaly occurred during the initial sheering action as heavy drag was being placed on the engine via the propeller shaft. Once the adapter sheered, the quill shaft then unscrewed itself from the variable pitch propeller servo and drove the propellers to a negative pitch setting causing severe drag and high sink rates."

> "The Accident Investigation Board President found by clear and convincing evidence that the cause of the mishap was the failure of the quill shaft bearing which caused the variable pitch propeller quill shaft to engage and then turn with the propeller shaft, dramatically and uncorrectably altering the pitch of the propeller blades which impacted engine performance and thrust setting at an extremely low altitude and made the aircraft unrecoverable. The bearing failure was attributed to the use of a bearing installation tool worn and used beyond the

> designed specifications which damaged the roller bearing case during installation."

In both incidences, the pilot bearing seized shearing the quill shaft causing the shaft to unscrew itself from the servo. This pushed the propeller to a negative pitch angle creating negative thrust. This slowed the aircraft to an unrecoverable speed. This also had another unintended consequence. Because of the power plant orientation and packaging, the reversal of air across the engine caused a starvation of the intake. This caused the engine to bog down and lose power.

Because the exact crash details are unknown in the summary level details of the AIB executive summaries, absolute confidence in cause is not available in the current information. Instead a list a possible causes is developed, and verification testing suggested to prove causation.

The first cause could be loading outside the design envelope. The propeller passes very close to the lower control surfaces. This buffeting could cause super cycling of the mechanism covered in 25.251, or super cycling could be the result of internal aeroelastics. Either way this could be tested with standard whirl flutter testing, varying environment and operation to cover the design flight envelope. The environment and usage could also have higher variation than the original design to cause high cycles failure. Long term instrumented monitoring of fleet would provide sufficient data to confirm environmental and operational envelope.

The other cause could be simply inferior part or maintenance procedure. This would indicate that the original design flight loads are sufficient to a produce an airworthy part, but part or procedure do not fulfill or sustain part function. To test this theory would be less expensive because it could be done on the ground with a sub-assembly. If the part fails under the original design load envelope, inferior part or procedure is the cause. It is interesting to note, in the reports the 200 hr rebuild of this component is mentioned several times. AC 35.42 says propeller components should withstand cyclic loading for a minimum of 1000hr without maintenance.

Either way, this failure should prohibit continued flight. 25.933b says specifically that one fault should not result in the reversal of thrust. If the fault would only result in some minimum flight regime setting sufficient to sustain continued flight all the way home, the fault would only be a hazardous flight condition which 100x more tolerable.

### 3.5.2. Lost Link

The UAS in this study have two forms of remote awareness, command, and control: a Ku band Satellite link and a direct line of sight RF connection. The link to and from the UAS are separate and can fail separately. While only 8% of the mishaps in the AIB reports are considered caused by lost link, 15 of the 51 or 29% AIB mishaps summaries report a loss of link during terminal operation. Some are system faults; some come from the limited view angle of the transmission devices; some are cause by the speed of the maneuver. If UAS are to be allowed in the NAS, their connection to pilot should be at least $10^{-5}$, the same as existing active control standards, 25.672. Also, this connectivity cannot be maneuver dependant. During active maneuver is when connectivity is most important. In addition, for lost link to be a tolerated inconvenience rather than a threat to Air Safety, the command link need must be re-established automatically. In some cases it was impossible to reestablish command connection. A few of the UAS were able to regain video and telemetry but were never able to regain command. If reliability and reconnectivity are improved, the reliability of this system does not have to approach $10^{-9}$. That level connectivity is out of the reach of current communication technology and network coverage. Last, the speed of the link is an important factor in UAS stability. When the system is controlled via satellite link, the delay time from command to maneuver to video and telemetry confirmation can be as long as 2 secs. In a few incidences, the UAS enters a violent porposing. This is initiated by a maneuver and causes the UAS to oscillate divergently because of feedback delay until link is lost, and the UAS is destroyed.

3.5.3. Auto Pilot

In order for lost link to be a manageable issue, auto pilots must be a reliable back up to direct control. To start, this means that the programming should be thoroughly tested. On 11 Dec 03 an RQ-1L was lost because the software connection set the pitch stick 9 degrees high without notifying the mishap pilot. On 14 Sep 00, the pilot was able to dump the RAM of the Primary Control Module with a single unintelligent trigger pull. Also, as stated earlier, the AP needs code to attempt Ground Control System reconnect from its end.

The next comments involve the capability and knowledge of the Auto Pilot control. The current auto-pilot is completely unaware of its surrounding. UAS knows position and altitude, but in a few cases when the UAS went to Lost Link profile it did not maintain the proper altitude. Also in this autonomous state, the aircraft is unaware of weather or terrain (i.e. mountains). While current sense and avoid attempts to guide UAS well clear of uncooperative aircraft, these systems are not currently successful. The capability to see weather and large static terrain features already exists. If Large UAS incorporated these capabilities at least 6 of the UAS in this study could have survived their Lost Link conditions. The last comment is about design knowledge of vehicles limits and dynamic response of wings. On 30 Mar 01, a RQ-1L pitot heater was left off causing the pitot tube to ice over. The pilot turned the pitot tube heater on to alleviate the problem. When the blockage melted off, the plane violently pitched up to restore altitude. This buckled and detached the left wing. The long flexible wings of these aircraft make dynamic prediction more difficult but not impossible. The limit strength of these UAS are known quantities. While a pilot should have the authority to overpower deterrents and rip the wings off in an attempt to save the craft and people on the ground, autopilots should not have this authority, and the internal mass models should be of sufficient fidelity to know dynamic position.

3.5.4. Hard Landing / Reduced Perception

One interesting indication of the reduced perception is seen in the Class E environmental mishaps. A large number of these incidences are bird strikes, something pilots would usually avoid at these speeds. Reduced perception is the “inherent design flaw” of a remotely operated platform. Remote command takes from the pilot the ability to “fly by the seat of his pants”. UAS are much more dependent on the ability to feel than originally thought. The GCS offers no G-forces, no vibrational feedback. This positive and negative feedback give the pilot operational confidence. Vibration and auditory feedback eases the burden of situational awareness. On 26 Mar 07, a MQ-1B crashed during landing because the pilots attitude and position reference was lost during landing approach. The following passage shows how flying by video limits field of vision and takes away scale sensitivity.

> There is clear and convincing evidence the mishap was caused by pilot error. The mishap pilot (MP) misjudged the RPA height above touchdown and confused the initial bounce with a normal aircraft response to his flare inputs. This confusion resulted in the MP setting a neutral pitch input with the erroneous perception that such an input would hold the attitude observed during the bounce. Instead, the neutral pitch input commanded the aircraft to return to its previously trimmed state. As commanded, the aircraft returned to approximately 4-degrees nose low and impacted the runway. Following the subsequent bounce, the MP initiated a go-around; however, he failed to provide the necessary pitch input to establish the go-around attitude. Instead of commanding a nose high pitch

> attitude, the actual pitch inputs commanded the aircraft nose low on each subsequent bounce. There is clear and convincing evidence that the aircraft hit the runway nose low on the fourth bounce with sufficient velocity to break the gear, and the fifth bounce damaged the multi-spectral targeting system beyond repair. Substantially contributing factors to the mishap are the lack of visual cues and the lack of cues to provide perception of body position and movement in the ground control station. The unique flight control logic and lack of pilot feedback also substantially contributed to this mishap. The lack of cues is part an inherent design flaw making the system conducive to the types of perceptual errors that occurred during the mishap sequence. These perceptual errors, unique flight control logic, and lack of pilot feedback combined to create a situation in which the aircrew was unable to recognize the proper control inputs necessary to effect recovery.

While there is no practical way to re-insert the full fidelity of the G-forces and vibrations back into the Ground station, there are some senses that can be added back. None of the UAS in this study have on board audio. On board audio would give the ability to broadly monitor on board health. Onset of noise can be a sign of impending equipment failure, as well as the end of an expected operational noises. Reduced perception will always be a part of UAS operation. It will dictate the requirement of auto-pilot systems, but awareness can be created to safely operate UAS beyond line of sight.

#### 3.5.5. Improper Envelope Review

This is an example of haste in rapid development and deployment of technologies. The RQ-1 was originally designed as an intelligence, surveillance, and reconnaissance drone. The entire payload is stored internally. The CG envelope is expanded with the addition of two hell fire missiles weighing approximately 110 lbs each. The aircraft is completely capable of operation with the extra weight, but the CG envelope was expanded without proper investigation of the expansion in conjunction with the variation of operational environment. When one missile is fired, a static moment is left from the single missiles imbalance. This is tolerable when the air is still, but when the aircraft is in cross wind gusts of sufficient strength the asymmetry of roll authority can be too much to handle. The aircraft goes into an unrecoverable spin. Payload and aircraft CG's need to analyzed across environmental and operational conditions before they are deemed airworthy. This means varying winds, temperatures, and densities. This also means examining the effect of single point failures, like variable pitch prop mechanisms, control surfaces, available horsepower, and control delay.

### 3.5.6. Residual Control and Other Design for Robustness

One theme that pervades this study is the effect of single point failures. 14CFR being a reactionary set of rules has robustness built in to it. A single bearing in the variable pitch prop mechanism should not cause a reversal of thrust. On the same note, the lower control surface failures should not result in a system fatality. Four MQ-1 are lost from insufficient control after a tail control surface malfunctioned. These aircraft are too valuable, and the risk to the domestic public is too high to be intolerant of single point failures. This system is also poorly designed because it also suffers from determinate assembly issues. If these systems cannot fail safe, 14cfr has other concept of reliability that can be practiced.

For hard quench parts like the quill-shafts which for this example cannot be made redundant and which operate in high cycle environments, Safe-Life is the proper method of certification. This means that the operational environment is understood well through conservative testing. A life span is created with proper severity and duration. Then the part is tested to a multiple of this duration to show compliance, say 3 times the expected service life. Once certified, the parts are allowed to be used for the designated Safe-Life, after which they must be replaced or inspected to a level of detail to insure no cracks have formed in the part surface.  Techniques such as Magnetic Particle Inspection and Dye Penetrant Inspection are very sensitive to surface flaws and can guarantee the part is starting over in an as-new condition.

A single control surface failure should not compromise the control of the aircraft, or that failure should be made extremely improbable.  With proper design, residual control of a fault tolerant system could be a more cost effective solution.  Residual control is a necessity especially for a combat vehicle but also civil UAS.  This residual control should be satisfactory without requiring exceptional skill, either, because these systems need be usable by the general population if the UAS system is to grow.

3.6. Predicted Mishap Rate and Rate Trends

Figure 3.6.1 shows how maturity has progressed in each model.  Rather than showing the accrued mishap rate vs. year, this figure shows accrued mishap rate vs. accrued flight hour.  While still in a tight band, it shows the MQ-1, the first UAS in service, has a higher rate of incident than the later programs.  Figure 3.6.1 also shows the RQ-4, the most expensive and airplane like in construction to be making a much steeper improvement in mishap rate.

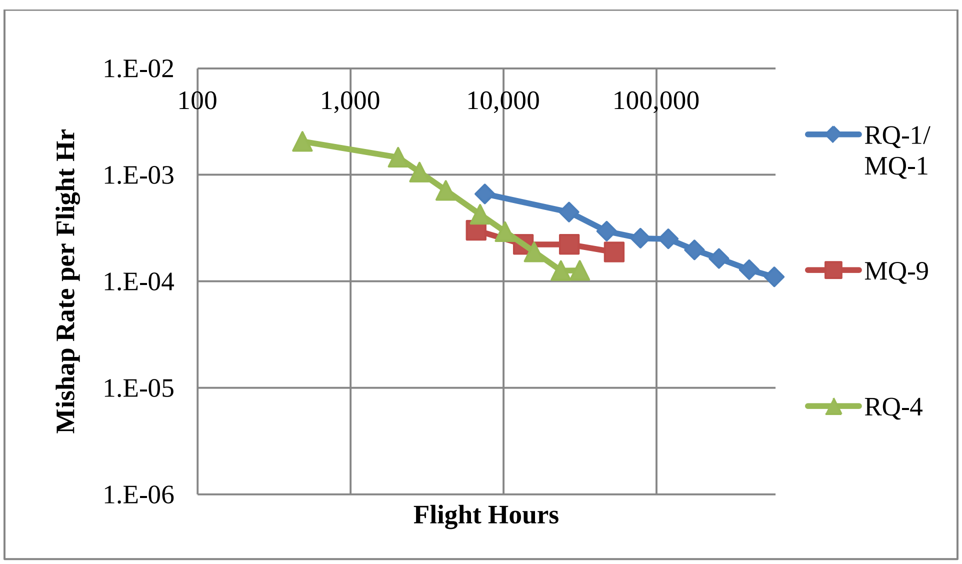


Figure 3.6.1 – Vehicle Accrued Mishap Rate vs Accrued Flight Hours – Classes A – AFSC

Figure 3.6.2 shows the Class B-E incidents i.e. the non-catastrophic incidents. These incidents are ones that could be tolerated as hazardous conditions because they are not catastrophic. The interesting trend here is how tight and flat all the curves are. Figure 3.6.3 uses essentially the same parameter. Here the Log10 of the mishap rate is plotted to ease data trending. Each vehicle is modeled using a linear regression. The MQ-9 first data year 2003 is removed as an outlier. The results are interesting. First, in Figure 3.6.3, the RQ-4 has a very slight positive slope on the rate of hazardous incidents. The mishap trend can at least be called flat. This means something must be done, priority wise, to implement lower level corrective actions before these hazardous mishaps can come down to tolerable levels. The MQ-9 can also be considered flat since it won't reach tolerable levels for over 200 years. The RQ-1 / MQ-1 is the only vehicle that will meet levels in this century, but do to the short time span of this study, all UAS have an approximately flat trend in their rate of hazardous mishaps.

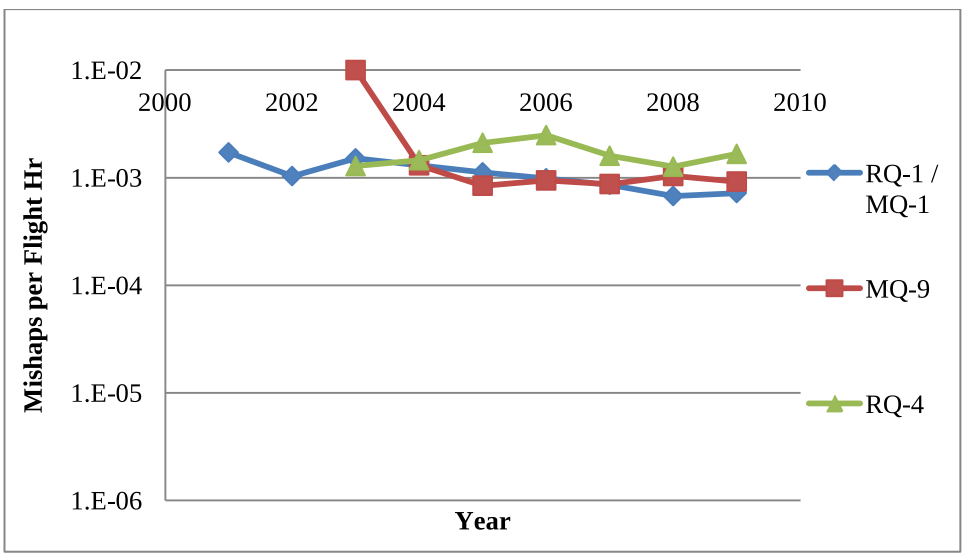


Figure 3.6.2 – Vehicle Accrued Mishap Rate– Classes B-E – AFSC

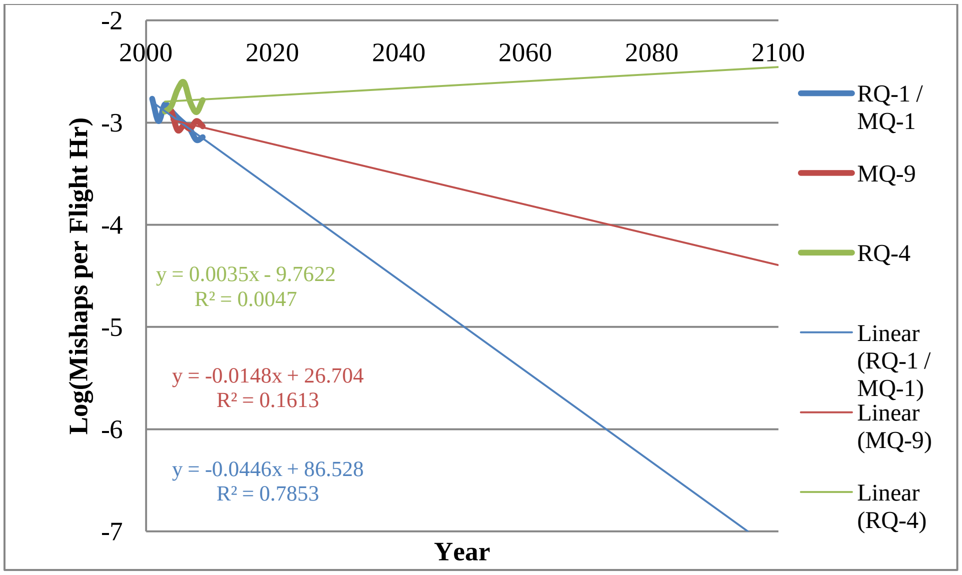


Figure 3.6.3 – Vehicle Mishap Rate w/ Forecast – Classes B-E – AFSC

Figure 3.6.4 shows the rate of catastrophic incident in UAS. These curve have a much more deliberate downward slope. The log10 of these values is plotted in Figure 3.6.5. The linear regression of this is much more reliable. The lowest $R^2$ is 0.86 which is the MQ-9. The RQ-4 like shown in Figure 3.6.1 will achieve certifiable crash rate in 30 yrs. This is substantially after the 2015 deadline imposed by the 2012 FAA reauthorization (10). Even this trend is extrapolated to far, but the point is made that the rate of incident reduction is very slow and very far from acceptable rates for aircraft currently certified to fly in the National Airspace System, NAS.

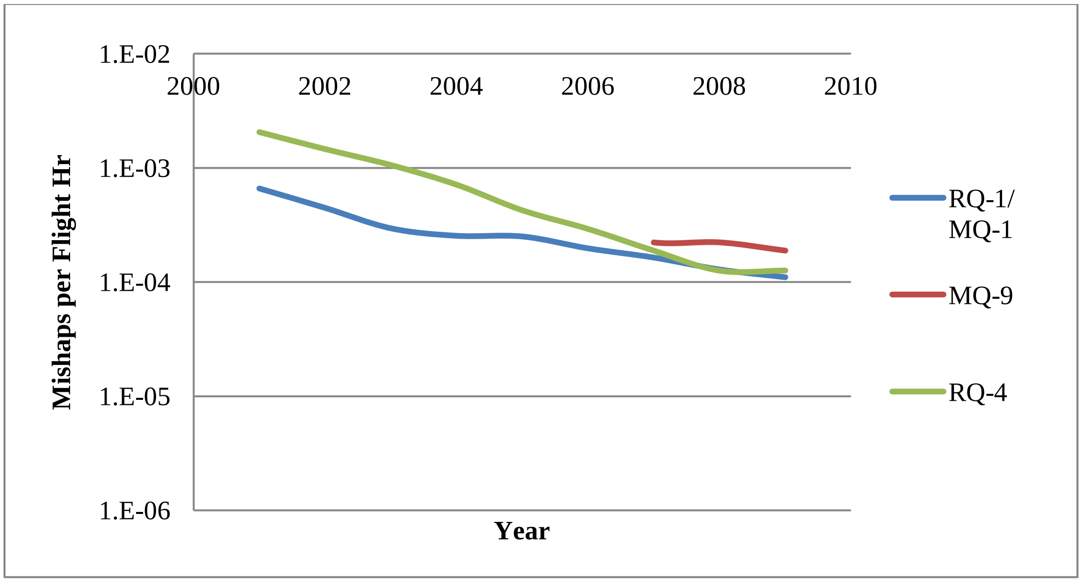


Figure 3.6.4 – Vehicle Accrued Mishap Rate – Class A – AFSC

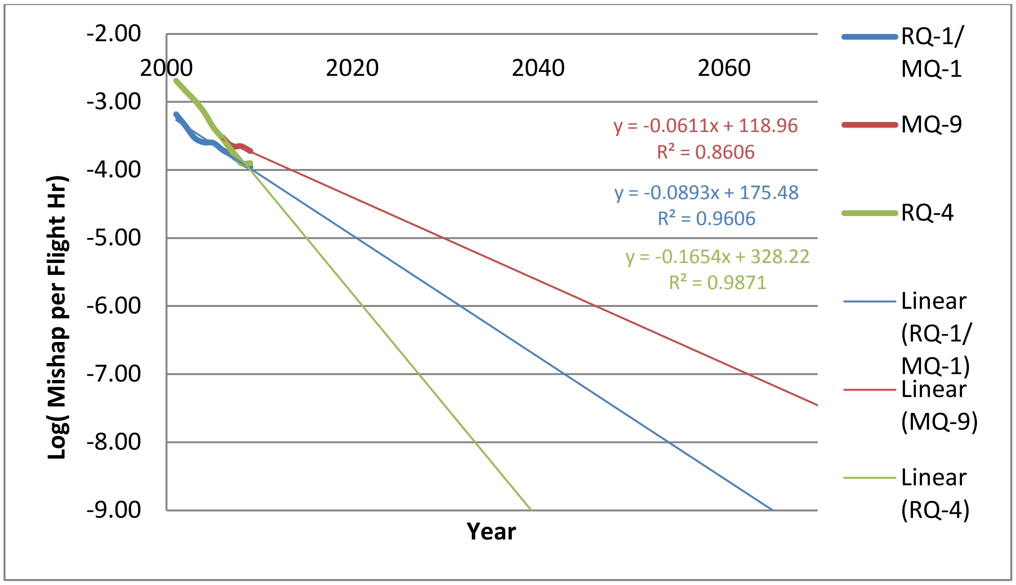


Figure 3.6.5 – Log(Vehicle Accrued Mishap Rate) w/ Forecast – Class A – AFSC

# 4. FAR for UAV

## 4.1. Current Standards

### 4.1.1. Part 23 – Agricultural Aircraft

Agriculture aircraft certification is based on the historical Part 8 of the Civil Air Regulations (CAR). Under this Part, the applicant for a new aircraft is required to show compliance with all of the airworthiness requirements of any other aircraft category prescribed by the CAR, except those requirements which the Administrator finds inappropriate for the special purpose for which the aircraft is to be used. In addition, the applicant is required to show that the aircraft has no unsafe features or characteristics that would render the aircraft unsafe when operated under its prescribed limits. The preamble for Part 8 states that for such restricted operations where public safety is not endangered, it appears unreasonable to require the same level of safety as that required for passenger carrying aircraft. The intent of Part 8 was to place the minimum possible burden consistent with public safety on the applicant for a type certificate in the restricted category (20). A recommended list of these inappropriate requirements is contained in Appendix 1 of AC 21.25(20). The appendix covers Flight, Structure, Design and Construction, and Equipment. A long list of certification requirements are waved: high speed characteristics, pressurization, flutter, trim system, emergency exits, ventilation, seatbelts, oxygen systems, navigation instruments, power plant instruments, ditching equipment, and ice protection. None of this is required to be aboard an agricultural aircraft, even the seat belts. Allowing land owner and pilot to be solely responsible for operations and liability. UAV certification could take this form allowing the applicant to create a list or the administration to recommend a list of type certificate elements they find inappropriate for safe operation in the NAS.

### 4.1.2. Airship Model for Certification and Operations

Some at the FAA suggest that UAS certification and operation be based on an airship model. The definition of an airship is an engine-driven, lighter than air aircraft, that can be steered (19). This definition means there are several aspects of airship operation and construction that do not apply to heavier than air craft and several aspects of airworthiness not covered by existing rules.

Airships, being large, slow vehicles, do not have the same concept of stability, and environmental or authoritative. The stall requirements are insufficient for UAS design because they do not address minimum controllable speed, envelope coverage of stall, or recovery from stall. The authorities needed in an airship are different during landing and balked landing. The slow speed of airships precluded Go-Around required climb rates necessary in high speed aircraft. The amount of authority required and the speed of its application would be insufficient for UAS. The required nominal climb rate for airships is vertical speed based where for other aircraft it is trajectory based, gradient of climb. Based on vehicle speed the airship climb rate maybe impossible or insufficient depending on the aircraft. Landing in general is a different operation for airships. Airships can land gracefully without engines, and loiter indefinitely until they find a suitable spot. Airships are required to restore level flight after loss of all engines. How would a UAS do this? Heavier than air craft are more dependant on their power plants. Wheels, tires, and brakes have a different function for airships. Airplane rules require acceleration-stop criteria that allow for last minute abort if engines fail on take-off. These rejected take-off loads are very severe. There are more, but it is sufficient to say airships and aircraft are different type classes for a reason. Last, airship rules do not handle the high-tech navigation, auto-pilot, and control systems required by UAS. The list of rules may be shorter for airship, but they do not sufficiently capture the necessary operations of heavier than air craft. Nor the hardening of systems for its dependency. This why AC21.17-1A "TYPE CERTIFICATION—AIRSHIPS" says the following:

> "(1) In the event that the airworthiness criteria prescribed in the ADC[18] are inadequate or otherwise inappropriate as a certification basis of an airship due to its unique design or design features, other criteria may be developed. FAA approval is required before the initial application of the airworthiness criteria as the certification basis of an airship." (19)
>
> "(3) Previously approved airworthiness criteria, when proposed for a new project, should be evaluated for currency based upon advancement of the state-of-the-art airship design, service experience, and amendments to appropriate regulations, such as parts 23 and 25 of the FAR." (19)

The operational right of way of airships also does not apply to UAS operation in the NAS. Airships are huge and slow. They have high visibilities by other craft and comparatively small speed and maneuver authority. 14CFR 91.113.d.3 says "An airship has the right-of-way over a powered parachute, weight-shift-control aircraft, airplane, or rotorcraft." This will be dangerous if applied to UAS. The visibility is much lower by other craft and the cruise speed and control authority are substantially higher. Powered parachutes, and weight-shift-control aircraft will not have the authority to dodge these craft. The fact that UAV's can't see these craft in return is cause for more sensitive sense and avoid equipment mandates, not airspace right of way.

This is why the UAS cert basis stated here uses a heavily pared down version of Part25 that allows for heavy substitution of analytic proof under a total Secondary Structure classification.

### 4.1.3. Part 25 – Transport Category

The large UAS of interest in the study are all operated by the DoD. UAS are flown by well trained pilots from standard bearing flight schools. They are repaired by certified airmen of best in class skill using enhancing inspection techniques. These UAS have robust maintenance programs that track system faults and incorporate mishap investigation findings into their maintenance and operations procedures. These aircraft will have state of the art environmental and operational awareness equipment, TCAS III, and advance autopilots capable of acting on this information. The HALE and MALE aircraft are elegant and thin. Long endurance systems do not make severe maneuvers and with sufficient AP limitations would not impart excessive loads on to the airframe. Transport category aircraft already have complex navigation that interfaces with other systems. The flutter requirements already incorporate guidance for failures of active stability systems. Part 25 has requirements for fire resistant and hardened electrical and controls systems, and incorporate fly by wire. All UAS in this study use fly by wireless command distribution. The aircraft, in general, are more elegantly designed and critically margined like large UAS. The increased knowledge and operations training allows these aircraft to be certified to lower loads than Part 23 aircraft, setting a more detailed but lower maneuverability and capability bar. For these reasons, Part 25 would be a better choice as a base line for UAS certification.

Part 25 rules are the best starting point for UAS certification, but these aircraft standards also have regulations that are inapplicable to passenger-less aircraft. The high standards are necessary for such sophisticated and elegant aircraft, but the compliance burden can be made less severe. Using the Agricultural model, Part 25 is review for individual rule applicability. The remaining rule set could provide a cert basis for 14CFR UAS Type certification.

Part 25 also has a huge proof burden that involves hundreds of hours of actual demonstration of airworthiness. The space coverage for a UAS is not as critical because of the lack of immediate passengers. If the entire vehicle is treated as secondary structure, the necessarily detailed standards of Part 25 could be met solely through written proof of quality of construction, controllability, sufficiency of design loads, and proof of structure under those loads.

### 4.2. Applicable Rules

Review of Part 25 for UAS cert basis took sustained controlled flight, structural integrity, and controlled ditching as the main priority for UAS operation in the NAS. The UA must stay in one piece, even in inoperable conditions, so the ground risk is local and infrequent. Also, the UAS must be controlled right to the moment of impact, so that its risk can be minimized from ditching. There is still no crew aboard, and if the individual systems can be hardened to tolerate neighboring failures, such as fire, there is no need for some internal safety equipment. Appendix A of this document contains the detailed examination of each rule. Out of the 397 rules in Part 25, 282, or 71% of rules are found applicable to UAS.

This means 29% or 115 rules can be ignored. The largest categories of omitted rules involve water landings, cabin safety, emergency equipment, ditching, and fire protection.

The general safety of the interior is not an issue. General requirements for accessibility, sharp edges, and ventilation are no longer necessary, but, due to the reduced size, alternate form of inspection are needed to observe the remote interior crevices in these systems. Fire safety can be considered in a different light for UAS as well. A hot structures ideology could be beneficial for UAS. As long as primary structure and systems are fire hardened, suppression systems are no longer required. The system must be sound, not comfortable.

ETOP requirement for long flights over water require extra knowledge about engine reliability and engine characteristics that are not necessary for UAS. Nor is the integrity and grace of its entrance into the water a safety concern.

This study concluded that Landing and Landing Gear rules should still apply to UAS, but these rules could be considered inapplicable under certain restrictions. These rules are retained because of the possible collateral damage of the UA skidding off uncontrolled, but this action depending on the size of the UA could be committed without any risk to other parties. The severity of the impact and the ability of the aircraft to sustain such impact are purely financial in nature, as long as fuel is still contained. The burden for malfunction would solely be on the manufacturer and operator and not necessarily create liability to any other parties. Since the main purpose of 14CFR is to protect innocent non-consenting parties, the argument could be made that certain systems are not necessary because they only provide financial risk to the risk takers themselves. Structurally UAS are, to date, much simpler vehicles. They have no high lift devices or speed brakes. For that reason, lift and drag devices are not included in this list. Also taking into account ground incident rates and physical vehicle size, acceptable safety rates to protect the public can be achieved without backup/dual control systems. This would allow UAS to be a flying test bed to improve the reliability of manned control systems.

This UAS Type Certificate(TC) is a restricted Class TC. Part of the restrictions of this certificate would include Balanced Field Length extensions, weather avoidance criteria, and daytime only operation. These operational restrictions would preclude the necessity for certain design features. The proof of these structures should also be modified as stated above to make the entire vehicle secondary structure, which would severely reduce the test burden and open up the reach of analytical substantiation based on historical and more fundamental data.

In reviewing 14CFR, one aspect of UAV operations that is wholly new to the certification plan is the issue of lost link. With the pilot removed from the aircraft, some method of wireless communication must be used to connect the pilot to the primary control system and onboard systems back to pilot. Creating a confident link that maintains the existing reliability of a pilot's physical connectivity in a manned aircraft may be outside the capabilities of current network technologies. Rather than designing in, and relying on, extreme improbability of a link failing, a lost link system should be considered as an active control with a new state of the art autopilot that provides confident residual control. This allows $10^4$x more faults in either system.

5. Compliance

5.1. Applicability of Existing Operational Data

The existing data reviewed in this research is considered as an alternative means of compliance to Part 25. However, the data submitted to date is a list of mishaps. The rate of failure documented to date is still too high to show compliance for most systems mentioned in these reports; however, there are some rules that could be shown compliant by this evidence. The UAS has successfully sustained seven bird strikes from the AFSC data. The details of these SIB reports could be used in substitute of part of the verification testing and analysis required, but a systematic coverage of the flight and control structures is needed. Also, analysis would be required to extrapolate the impact worthiness of unhit edges. Each incidents would have to be examined for the extent of satisfaction of current test standards. The number of structural failures is very low in these UAS. This could eventually be used to support Proof of Structure. The accumulated flight hours by fleet leaders could be used as proof of fatigue resistance, but the quantity of flight hours available is still insufficiently small. These are only 3 of out of 282 required rules that can be shown partially compliant through the existing data gathered in its current form.

5.2. Fleet Observation

For operational flight hours to be useful in certification, the incidence and the severity of the survived flight damage must be known, not merely a list of fatal defects. This would require some form of acceleration and/or strain data to capture the variation of the operating environment and the typical usage envelope. Once a conservative multiple of the desired cert life damage has been attained by the experimental fleet and fleet leaders, a conservative operational envelope can be derived from the data and applied to new members of the fleet, perhaps for usage in more populated airspace. Aircraft operating in this observed envelope would be fatigue airworthy for the observed service life. This experimental operational envelope would not necessarily be required to have a basis in the envelope of an aircraft's physical limits except for the fact the operational envelope must be conservative to the physical limits and must address comprehensively the expected certified operating conditions. Damage Tolerance can also potentially be partially addressed by this method, but additional knowledge about the quality of construction and initial flaw sizes would be necessary. Sensored fleet observation data could also be an excellent source for maximum gust and pilot ultimate maneuvers data for use in setting operational limits and exceedance inspections. Some unmanned systems are substantially smaller than the manned vehicles that operate in the same environment. The smaller size raises the area to mass ratio of the vehicle causing increased acceleration due to similar gust strengths. Long term fleet monitoring would provide substantially more data to derive more accurate gust acceleration spectrums. Existing regulations should be reviewed against this spectrum data to ensure the current rules contain the minimum maneuverability and stability necessary for these potentially more environmentally sensitive vehicles to operate safely. Long term data acquisition on an existing fleet could likely produce sufficient event experiences to meet some control and integrity requirements without a need to determine the maximum capabilities of the vehicle. This would reduce the amount of dedicated test vehicles and test time necessary to certify UAS in the areas addressable by fleet data. This type broad based observation would also provide superior coverage of manufacturing variation.

### 5.3. Flight and Ground Testing

Most applicable regulations will not be addressed by fleet experience alone because they involve combinations of severe maneuvers with environmental extremes or operational malfunction. Most regulations are meant to ensure sufficient capability in critical situations. These ultimate capabilities are more addressable by tailored tests designed to take the aircraft to the edges of its required capability.

As an alternative to analytic substantiation of an experimental fleet, a larger set of flight tests, ground tests, and inspections can be performed to validate a wide range of capability requirements in an existing fleet: electrical, structural, control, stability, accessibility, and operation. The applicable regulations were reviewed to isolate those in which design and regulatory knowledge could be used to develop definitive tests whose passage would demonstrate regulatory compliance. With sufficient design knowledge, it was found that a majority of the applicable regulations could be addressed by a combination of pass/fail flight test, ground test, and inspection that would divulge minimal platform capability to public record. The UAS will need substantially more sensors to verify the structural airworthiness of every component of the assembled aircraft by this method. Traditionally, flight tests are used to verify the accuracy of maneuver load predictions, and structural substantiation is done analytically to capture manufacturing and environmental variation. However, a sufficient test fleet size would provide superior coverage of manufacturing variation, but the number of required tested will be a high multiple of the analysis backed test plan necessary to prove compliance across the full environmental/operational space. A safe pure testing based cert also will have to have built in it extra conservatism that accounts for the inability to locally address local knock-down factors, like casting and fitting factors. Instead, test loads will have to be amplified by these modification factors to insure their conservative inclusion.

The review in Appendix A of this document shows these method of flight and ground testing would cover a large majority of requirements, 94%, making it a viable option for a reduced analysis certification.

5.4. Analytic Compliance

The traditional use of substantial analysis verified by minimal testing provides a very efficient means of compliance that can use existing variational data and allows future expansion of the aircrafts capability to be based on previous model data. A pure testing based approach would be more pass/fail in nature, and knowledge of the vehicles reaction is much lower fidelity without analytical extrapolation. This data would be more difficult to apply to future models without a large volume of supporting analysis. However, in some cases, analytical proof is expensive and requires a larger body of expertise than a more testing based approach; therefore, UAS certification rules should accommodate tradeoffs between these two means of compliance.

Analysis is a tremendous saver of resources. Analytical interpolation and extrapolation allows you to apply historical and variational data to the current problem saving substantial testing. As stated before, a secondary structure interpretation of UAS could be very powerful in reducing certification burden. Sophisticated analytical techniques that require exceptionally skilled personnel and software modeling that cost thousands a month are still less expensive than testing airframes that cost thousands of dollars an hour to operate. Some envelope and stability testing will still be required, but a majority of rules could be shown compliant on paper without the need for physical verification. Proof of Compliance, Proof of Structure, and Proof of

Strength rules should be modified for a total secondary structure aircraft that would allow a higher amount of proof to be generated analytically.

## 6. Summary and Conclusion

The Air Force data acquired provides a broad picture of the current state of UAS reliability. The AFSC data is complete in its number, but obscure in its detail. The AIB executive summaries lack completeness, but provide a much stronger narrative into the causes of individual events. The comparison of the data showed conflict that can only be resolved with more complete data, but it shows the accuracy of each set. The figures contained in this thesis show that reliability is improving, but at a rate that is unacceptable for FAA certification in the next few decades. Non-catastrophic mishap rate are shown to be flat, indicating some systemic change need to happen to address these lesser modes of failure before improvement will be seen. The MQ-1/ RQ-1 while causing the greatest number of incidents has also achieved the most fleet experience. Its reliability is not an extreme outlier to the other vehicles in this study vehicles. Some maturity of design is showing newer platforms fielded, but the spread in mishap rates is still tightly banded.

Physical reliability stood out as the largest cause on mishap across the fleet. The cause of many of the Class A losses is Powerplant failures. Further look in these failures showed broad sources that will not be addressed simply. Other manned causes of failure include lack of determinate assembly of components and lack of residual control of aircraft. The failures found show a lack of compliance to existing 14CFR rules and show enforcement of existing rules will be largely sufficient to improve reliability. Still, new airworthiness issues are revealed in the study. The environmental sensitivity of the vehicles is higher than manned aircraft due to high surface to mass ratios. Also, the remoteness of command and perception must be address through new regulations and new technology.

Compliance to the rules set forth is shown possible through traditional means. Pure flight testing of these UAS to compliance is possible and divulges little information to public records, but it will come at a high resource cost. Because of the reduced risk these platforms pose when confidently controlled, a modification of existing proof rules is suggested to consider the entire airframe Secondary structure. This will severely reduce the cost of Type certification of future UAS and will make existing applicable Part 25 Rules very suitable as a basis for UAS rulemaking.

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# PART 25—AIRWORTHINESS STANDARDS: *TRANSPORT CATEGORY AIRPLANES*

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| **Subpart A—General** | * | | * | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| § 25.1 Applicability. | 1 | | | | 1 | | | 1 | | | | 1 | | | 1 | | | 1 |
| § 25.2 Special retroactive requirements. | | | 1 | | | | | | | | | | | | | | | |
| § 25.3 Special provisions for ETOPS type design approvals. | | | 1 | | | | | | | | | | | | | | | |
| § 25.5 Incorporations by reference. | 1 | | | | 1 | | | 1 | | | | 1 | | | 1 | | | 1 |
| | * | | * | | | | | | | | | | | | | | | |
| **Subpart B—Flight** | * | | * | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |

| | Is Rule Applicable to UAV? Complete | Is Rule Applicable to UAV? No | Is Rule Applicable to UAV? Partial | DA Fleet History Applicability Complete | DA Fleet History Applicability No | DA Fleet History Applicability Partial | Flight Test Complete | Flight Test No | Flight Test Partial | Ground Test / Inspection Complete | Ground Test / Inspection No | Ground Test / Inspection Partial | Anlaysis/ Drawings Review Complete | Anlaysis/ Drawings Review No | Anlaysis/ Drawings Review Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *General* | * | | * | | | | | | | | | | | | | | | |
| § 25.21 Proof of compliance. | 1 | | | | | 1 | | | 1 | | | 1 | | | 1 | | | 1 |
| § 25.23 Load distribution limits. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.25 Weight limits. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.27 Center of gravity limits. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.29 Empty weight and corresponding center of gravity. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.31 Removable ballast. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.33 Propeller speed and pitch limits. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| *Performance* | * | | * | | | | | | | | | | | | | | | |
| § 25.101 General. | 1 | | | | 1 | | | 1 | | | | 1 | | | 1 | | | 1 |
| § 25.103 Stall speed. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.105 Takeoff. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.107 Takeoff speeds. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.109 Accelerate-stop distance. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | Additional Work Needed | Complete Coverage | Partial Coverage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | | | |
| § 25.111 Takeoff path. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.113 Takeoff distance and takeoff run. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.115 Takeoff flight path. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.117 Climb: general. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.119 Landing climb: All-engines-operating. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.121 Climb: One-engine-inoperative. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.123 En route flight paths. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.125 Landing. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| *Controllability and Maneuverability* | * | | * | | | | | | | | | | | | | | | |
| § 25.143 General. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.145 Longitudinal control. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.147 Directional and lateral control. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | Additional Work Needed | Complete Coverage | Partial Coverage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | | | |
| § 25.149 Minimum control speed. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| *Trim* | * | | * | | | | | | | | | | | | | | | |
| § 25.161 Trim. | 1 | | | | 1 | | 1 | | | | | 1 | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| Stability | * | | * | | | | | | | | | | | | | | | |
| § 25.171 General. | 1 | | | | 1 | | | 1 | | | 1 | | | | 1 | 1 | | |
| § 25.173 Static longitudinal stability. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.175 Demonstration of static longitudinal stability. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.177 Static lateral-directional stability. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.181 Dynamic stability. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| *Stalls* | * | | * | | | | | | | | | | | | | | | |
| § 25.201 Stall demonstration. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.203 Stall characteristics. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| § 25.207 Stall warning. | 1 | | | | 1 | | 1 | | | | | 1 | | 1 | | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| *Ground and Water Handling Characteristics* | * | | * | | | | | | | | | | | | | | | |
| § 25.231 Longitudinal stability and control. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.233 Directional stability and control. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.235 Taxiing condition. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.237 Wind velocities. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.239 Spray characteristics, control, and stability on water. | | | 1 | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| *Miscellaneous Flight Requirements* | * | | * | | | | | | | | | | | | | | | |
| § 25.251 Vibration and buffeting. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.253 High-speed characteristics. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| § 25.255 Out-of-trim characteristics. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| **Subpart C—Structure** | * | | * | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| *General* | * | | * | | | | | | | | | | | | | | | |
| § 25.301 Loads. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.303 Factor of safety. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.305 Strength and deformation. | 1 | | | | 1 | | 1 | | | | 1 | | 1 | | | | 1 | |
| § 25.307 Proof of structure. | 1 | | | | 1 | | 1 | | | 1 | | | 1 | | | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| *Flight Loads* | * | | * | | | | | | | | | | | | | | | |
| § 25.321 General. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| *Flight Maneuver and Gust Conditions* | * | | * | | | | | | | | | | | | | | | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| § 25.331 Symmetric maneuvering conditions. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.333 Flight maneuvering envelope. | 1 | | | | 1 | | 1 | | | | 1 | | 1 | | | | 1 | |
| § 25.335 Design airspeeds. | 1 | | | | 1 | | 1 | | | | 1 | | 1 | | | | 1 | |
| § 25.337 Limit maneuvering load factors. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.341 Gust and turbulence loads. | 1 | | | | | 1 | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.343 Design fuel and oil loads. | 1 | | | | 1 | | | 1 | | | 1 | | | | 1 | 1 | | |
| § 25.345 High lift devices. | | | 1 | | | | | | | | | | | | | | | |
| § 25.349 Rolling conditions. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.351 Yaw maneuver conditions. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| *Supplementary Conditions* | * | | * | | | | | | | | | | | | | | | |
| § 25.361 Engine torque. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | Additional Work Needed | Complete Coverage | Partial Coverage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | | | |
| § 25.363 Side load on engine and auxiliary power unit mounts. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.365 Pressurized compartment loads. | | | 1 | | | | | | | | | | | | | | | |
| § 25.367 Unsymmetrical loads due to engine failure. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.371 Gyroscopic loads. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.373 Speed control devices. | | | 1 | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| *Control Surface and System Loads* | * | | * | | | | | | | | | | | | | | | |
| § 25.391 Control surface loads: General. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.393 Loads parallel to hinge line. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.395 Control system. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.397 Control system loads. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| § 25.399 Dual control system. | | | 1 | | | | | | | | | | | | | | | |
| § 25.405 Secondary control system. | | | 1 | | | | | | | | | | | | | | | |
| § 25.407 Trim tab effects. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.409 Tabs. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.415 Ground gust conditions. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.427 Unsymmetrical loads. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.445 Auxiliary aerodynamic surfaces. | | | 1 | | | | | | | | | | | | | | | |
| § 25.457 Wing flaps. | | | 1 | | | | | | | | | | | | | | | |
| § 25.459 Special devices. | 1 | | | | 1 | | | 1 | | | 1 | | | | 1 | 1 | | |
| | * | | * | | | | | | | | | | | | | | | |
| *Ground Loads* | * | | * | | | | | | | | | | | | | | | |
| § 25.471 General. | 1 | | | | 1 | | | 1 | | | 1 | | | | 1 | 1 | | |
| § 25.473 Landing load conditions and assumptions. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.477 Landing gear arrangement. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
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| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| § 25.479 Level landing conditions. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.481 Tail-down landing conditions. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.483 One-gear landing conditions. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.485 Side load conditions. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.487 Rebound landing condition. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.489 Ground handling conditions. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.491 Taxi, takeoff and landing roll. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.493 Braked roll conditions. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.495 Turning. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.497 Tail-wheel yawing. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.499 Nose-wheel yaw and steering. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.503 Pivoting. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | Additional Work Needed | Complete Coverage | Partial Coverage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | | | |
| § 25.507 Reversed braking. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.509 Towing loads. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.511 Ground load: unsymmetrical loads on multiple-wheel units. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.519 Jacking and tie-down provisions. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| *Water Loads* | * | | * | | | | | | | | | | | | | | | |
| § 25.521 General. | | | 1 | | | | | | | | | | | | | | | |
| § 25.523 Design weights and center of gravity positions. | | | 1 | | | | | | | | | | | | | | | |
| § 25.525 Application of loads. | | | 1 | | | | | | | | | | | | | | | |
| § 25.527 Hull and main float load factors. | | | 1 | | | | | | | | | | | | | | | |
| § 25.529 Hull and main float landing conditions. | | | 1 | | | | | | | | | | | | | | | |
| § 25.531 Hull and main float takeoff condition. | | | 1 | | | | | | | | | | | | | | | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | Additional Work Needed | Complete Coverage | Partial Coverage |
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| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | | | |
| § 25.533 Hull and main float bottom pressures. | | | 1 | | | | | | | | | | | | | | | |
| § 25.535 Auxiliary float loads. | | | 1 | | | | | | | | | | | | | | | |
| § 25.537 Seawing loads. | | | 1 | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| *Emergency Landing Conditions* | * | | * | | | | | | | | | | | | | | | |
| § 25.561 General. | | | 1 | | | | | | | | | | | | | | | |
| § 25.562 Emergency landing dynamic conditions. | | | 1 | | | | | | | | | | | | | | | |
| § 25.563 Structural ditching provisions. | | | 1 | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| *Fatigue Evaluation* | * | | * | | | | | | | | | | | | | | | |
| § 25.571 Damage—tolerance and fatigue evaluation of structure. | 1 | | | | | 1 | 1 | | | 1 | | | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| *Lightning Protection* | * | | * | | | | | | | | | | | | | | | |
| § 25.581 Lightning protection. | 1 | | | | | 1 | 1 | | | | | 1 | | | 1 | | 1 | |

| | Is Rule Applicable to UAV? Complete | Is Rule Applicable to UAV? No | Is Rule Applicable to UAV? Partial | DA Fleet History Applicability Complete | DA Fleet History Applicability No | DA Fleet History Applicability Partial | Flight Test Complete | Flight Test No | Flight Test Partial | Ground Test / Inspection Complete | Ground Test / Inspection No | Ground Test / Inspection Partial | Anlaysis/ Drawings Review Complete | Anlaysis/ Drawings Review No | Anlaysis/ Drawings Review Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Subpart D—Design and Construction** | * | | * | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| *General* | * | | * | | | | | | | | | | | | | | | |
| § 25.601 General. | 1 | | | | 1 | | | 1 | | | | 1 | | | 1 | | | 1 |
| § 25.603 Materials. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.605 Fabrication methods. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.607 Fasteners. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.609 Protection of structure. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.611 Accessibility provisions. | 1 | | | | 1 | | | 1 | | 1 | | | 1 | | | | 1 | |
| § 25.613 Material strength properties and material design values. | 1 | | | | 1 | | | 1 | | 1 | | | 1 | | | | 1 | |
| § 25.619 Special factors. | 1 | | | | 1 | | | 1 | | | 1 | | 1 | | | 1 | | |
| § 25.621 Casting factors. | 1 | | | | 1 | | | 1 | | 1 | | | 1 | | | | 1 | |
| § 25.623 Bearing factors. | 1 | | | | 1 | | | 1 | | 1 | | | 1 | | | | 1 | |
| § 25.625 Fitting factors. | 1 | | | | 1 | | | 1 | | 1 | | | 1 | | | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | Additional Work Needed | Complete Coverage | Partial Coverage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | | | |
| § 25.629 Aeroelastic stability requirements. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.631 Bird strike damage. | 1 | | | | | 1 | | 1 | | 1 | | | 1 | | | 1 | | |
| | * | | * | | | | | | | | | | | | | | | |
| *Control Surfaces* | * | | * | | | | | | | | | | | | | | | |
| § 25.651 Proof of strength. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.655 Installation. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.657 Hinges. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| *Control Systems* | * | | * | | | | | | | | | | | | | | | |
| § 25.671 General. | 1 | | | | 1 | | | 1 | | | 1 | | | | 1 | 1 | | |
| § 25.672 Stability augmentation and automatic and power-operated systems. | 1 | | | | 1 | | 1 | | | | | 1 | | | 1 | | 1 | |
| § 25.675 Stops. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.677 Trim systems. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.679 Control system gust locks. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.681 Limit load static tests. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| § 25.683 Operation tests. | 1 | | | | 1 | | 1 | | | | | 1 | | | 1 | | 1 | |
| § 25.685 Control system details. | 1 | | | | 1 | | 1 | | | | | 1 | | | 1 | | 1 | |
| § 25.689 Cable systems. | 1 | | | | 1 | | | | 1 | 1 | | | | | 1 | | 1 | |
| § 25.693 Joints. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.697 Lift and drag devices, controls. | | | 1 | | | | | | | | | | | | | | | |
| § 25.699 Lift and drag device indicator. | | | 1 | | | | | | | | | | | | | | | |
| § 25.701 Flap and slat interconnection. | | | 1 | | | | | | | | | | | | | | | |
| § 25.703 Takeoff warning system. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| *Landing Gear* | * | | * | | | | | | | | | | | | | | | |
| § 25.721 General. | 1 | | | | 1 | | | 1 | | | 1 | | | | 1 | 1 | | |
| § 25.723 Shock absorption tests. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.729 Retracting mechanism. | 1 | | | | 1 | | | | 1 | 1 | | | | | 1 | | 1 | |
| § 25.731 Wheels. | 1 | | | | 1 | | | | 1 | 1 | | | | | 1 | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | Additional Work Needed | Complete Coverage | Partial Coverage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | | | |
| § 25.733 Tires. | 1 | | | | 1 | | | | 1 | 1 | | | | | 1 | | 1 | |
| § 25.735 Brakes and braking systems. | 1 | | | | 1 | | | | 1 | 1 | | | | | 1 | | 1 | |
| § 25.737 Skis. | | | 1 | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| *Floats and Hulls* | * | | * | | | | | | | | | | | | | | | |
| § 25.751 Main float buoyancy. | | | 1 | | | | | | | | | | | | | | | |
| § 25.753 Main float design. | | | 1 | | | | | | | | | | | | | | | |
| § 25.755 Hulls. | | | 1 | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| *Personnel and Cargo Accommodations* | * | | * | | | | | | | | | | | | | | | |
| § 25.771 Pilot compartment. | | | 1 | | | | | | | | | | | | | | | |
| § 25.772 Pilot compartment doors. | | | 1 | | | | | | | | | | | | | | | |
| § 25.773 Pilot compartment view. | | | 1 | | | | | | | | | | | | | | | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | Additional Work Needed | Complete Coverage | Partial Coverage |
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| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | | | |
| § 25.775 Windshields and windows. | | | 1 | | | | | | | | | | | | | | | |
| § 25.777 Cockpit controls. | | | 1 | | | | | | | | | | | | | | | |
| § 25.779 Motion and effect of cockpit controls. | | | 1 | | | | | | | | | | | | | | | |
| § 25.781 Cockpit control knob shape. | | | 1 | | | | | | | | | | | | | | | |
| § 25.783 Fuselage doors. | | | 1 | | | | | | | | | | | | | | | |
| § 25.785 Seats, berths, safety belts, and harnesses. | | | 1 | | | | | | | | | | | | | | | |
| § 25.787 Stowage compartments. | | | 1 | | | | | | | | | | | | | | | |
| § 25.789 Retention of items of mass in passenger and crew compartments and galleys. | | | 1 | | | | | | | | | | | | | | | |
| § 25.791 Passenger information signs and placards. | | | 1 | | | | | | | | | | | | | | | |
| § 25.793 Floor surfaces. | | | 1 | | | | | | | | | | | | | | | |
| § 25.795 Security considerations. | | | 1 | | | | | | | | | | | | | | | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | Additional Work Needed | Complete Coverage | Partial Coverage |
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| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | | | |
| | * | | * | | | | | | | | | | | | | | | |
| *Emergency Provisions* | * | | * | | | | | | | | | | | | | | | |
| § 25.801 Ditching. | | | 1 | | | | | | | | | | | | | | | |
| § 25.803 Emergency evacuation. | | | 1 | | | | | | | | | | | | | | | |
| § 25.807 Emergency exits. | | | 1 | | | | | | | | | | | | | | | |
| § 25.809 Emergency exit arrangement. | | | 1 | | | | | | | | | | | | | | | |
| § 25.810 Emergency egress assist means and escape routes. | | | 1 | | | | | | | | | | | | | | | |
| § 25.811 Emergency exit marking. | | | 1 | | | | | | | | | | | | | | | |
| § 25.812 Emergency lighting. | | | 1 | | | | | | | | | | | | | | | |
| § 25.813 Emergency exit access. | | | 1 | | | | | | | | | | | | | | | |
| § 25.815 Width of aisle. | | | 1 | | | | | | | | | | | | | | | |
| § 25.817 Maximum number of seats abreast. | | | 1 | | | | | | | | | | | | | | | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | Additional Work Needed | Complete Coverage | Partial Coverage |
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| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | | | |
| § 25.819 Lower deck service compartments (including galleys). | | | 1 | | | | | | | | | | | | | | | |
| § 25.820 Lavatory doors. | | | 1 | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| *Ventilation and Heating* | * | | * | | | | | | | | | | | | | | | |
| § 25.831 Ventilation. | | | 1 | | | | | | | | | | | | | | | |
| § 25.832 Cabin ozone concentration. | | | 1 | | | | | | | | | | | | | | | |
| § 25.833 Combustion heating systems. | | | 1 | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| *Pressurization* | * | | * | | | | | | | | | | | | | | | |
| § 25.841 Pressurized cabins. | | | 1 | | | | | | | | | | | | | | | |
| § 25.843 Tests for pressurized cabins. | | | 1 | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| *Fire Protection* | * | | * | | | | | | | | | | | | | | | |
| § 25.851 Fire extinguishers. | | | 1 | | | | | | | | | | | | | | | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
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| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| § 25.853 Compartment interiors. | | | 1 | | | | | | | | | | | | | | | |
| § 25.854 Lavatory fire protection. | | | 1 | | | | | | | | | | | | | | | |
| § 25.855 Cargo or baggage compartments. | | | 1 | | | | | | | | | | | | | | | |
| § 25.856 Thermal/Acoustic insulation materials. | | | 1 | | | | | | | | | | | | | | | |
| § 25.857 Cargo compartment classification. | | | 1 | | | | | | | | | | | | | | | |
| § 25.858 Cargo or baggage compartment smoke or fire detection systems. | | | 1 | | | | | | | | | | | | | | | |
| § 25.859 Combustion heater fire protection. | | | 1 | | | | | | | | | | | | | | | |
| § 25.863 Flammable fluid fire protection. | | | 1 | | | | | | | | | | | | | | | |
| § 25.865 Fire protection of flight controls, engine mounts, and other flight structure. | | | 1 | | | | | | | | | | | | | | | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
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| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| § 25.867 Fire protection: other components. | | | 1 | | | | | | | | | | | | | | | |
| § 25.869 Fire protection: systems. | | | 1 | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| *Miscellaneous* | * | | * | | | | | | | | | | | | | | | |
| § 25.871 Leveling means. | 1 | | | | 1 | | 1 | | | | | 1 | | | 1 | | 1 | |
| § 25.875 Reinforcement near propellers. | 1 | | | | 1 | | | | 1 | 1 | | | | | 1 | | 1 | |
| § 25.899 Electrical bonding and protection against static electricity. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| **Subpart E— Powerplant** | * | | * | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| *General* | * | | * | | | | | | | | | | | | | | | |
| § 25.901 Installation. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.903 Engines. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
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| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| § 25.904 Automatic takeoff thrust control system (ATTCS). | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.905 Propellers. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.907 Propeller vibration and fatigue. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.925 Propeller clearance. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.929 Propeller deicing. | | | 1 | | | | | | | | | | | | | | | |
| § 25.933 Reversing systems. | 1 | | | | 1 | | | | 1 | | | 1 | | | 1 | | 1 | 0 |
| § 25.934 Turbojet engine thrust reverser system tests. | 1 | | | | 1 | | | | 1 | | | 1 | | | 1 | | 1 | 0 |
| § 25.937 Turbopropeller-drag limiting systems. | | | 1 | | | | | | | | | | | | | | | |
| § 25.939 Turbine engine operating characteristics. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.941 Inlet, engine, and exhaust compatibility. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.943 Negative acceleration. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
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| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| § 25.945 Thrust or power augmentation system. | 1 | | | | 1 | | 1 | | | | | 1 | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| *Fuel System* | * | | * | | | | | | | | | | | | | | | |
| § 25.951 General. | 1 | | | | 1 | | | 1 | | | 1 | | | | 1 | 1 | | |
| § 25.952 Fuel system analysis and test. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.953 Fuel system independence. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.954 Fuel system lightning protection. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.955 Fuel flow. | 1 | | | | 1 | | 1 | | | | | 1 | | | 1 | | 1 | |
| § 25.957 Flow between interconnected tanks. | 1 | | | | 1 | | 1 | | | | | 1 | | | 1 | | 1 | |
| § 25.959 Unusable fuel supply. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.961 Fuel system hot weather operation. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.963 Fuel tanks: general. | 1 | | | | 1 | | | 1 | | | 1 | | | | 1 | 1 | | |
| § 25.965 Fuel tank tests. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
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| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| § 25.967 Fuel tank installations. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.969 Fuel tank expansion space. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.971 Fuel tank sump. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.973 Fuel tank filler connection. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.975 Fuel tank vents and carburetor vapor vents. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.977 Fuel tank outlet. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.979 Pressure fueling system. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.981 Fuel tank ignition prevention. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| *Fuel System Components* | * | | * | | | | | | | | | | | | | | | |
| § 25.991 Fuel pumps. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.993 Fuel system lines and fittings. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.994 Fuel system components. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| § 25.995 Fuel valves. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.997 Fuel strainer or filter. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.999 Fuel system drains. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.1001 Fuel jettisoning system. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| *Oil System* | * | | * | | | | | | | | | | | | | | | |
| § 25.1011 General. | 1 | | | | 1 | | | 1 | | | 1 | | | | 1 | 1 | | |
| § 25.1013 Oil tanks. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1015 Oil tank tests. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1017 Oil lines and fittings. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1019 Oil strainer or filter. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1021 Oil system drains. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1023 Oil radiators. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.1025 Oil valves. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1027 Propeller feathering system. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | Additional Work Needed | Complete Coverage | Partial Coverage |
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| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | | | |
| | * | | * | | | | | | | | | | | | | | | |
| *Cooling* | * | | * | | | | | | | | | | | | | | | |
| § 25.1041 General. | 1 | | | | 1 | | | 1 | | | 1 | | | | 1 | 1 | | |
| § 25.1043 Cooling tests. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.1045 Cooling test procedures. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| *Induction System* | * | | * | | | | | | | | | | | | | | | |
| § 25.1091 Air induction. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.1093 Induction system icing protection. | | | 1 | | 1 | | 1 | | | 1 | | | | | 1 | | | |
| § 25.1101 Carburetor air preheater design. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.1103 Induction system ducts and air duct systems. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.1105 Induction system screens. | 1 | | | | 1 | | | | 1 | 1 | | | | | 1 | | 1 | |
| § 25.1107 Inter-coolers and after-coolers. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
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| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| *Exhaust System* | * | | * | | | | | | | | | | | | | | | |
| § 25.1121 General. | 1 | | | | 1 | | | 1 | | | 1 | | | | 1 | 1 | | |
| § 25.1123 Exhaust piping. | 1 | | | | 1 | | | | 1 | 1 | | | | | 1 | | 1 | |
| § 25.1125 Exhaust heat exchangers. | 1 | | | | 1 | | | | 1 | 1 | | | | | 1 | | 1 | |
| § 25.1127 Exhaust driven turbo-superchargers. | 1 | | | | 1 | | | | 1 | 1 | | | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| *Powerplant Controls and Accessories* | * | | * | | | | | | | | | | | | | | | |
| § 25.1141 Powerplant controls: general. | 1 | | | | 1 | | 1 | | | | | 1 | | | 1 | | 1 | |
| § 25.1142 Auxiliary power unit controls. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.1143 Engine controls. | 1 | | | | 1 | | 1 | | | | | 1 | | | 1 | | 1 | |
| § 25.1145 Ignition switches. | 1 | | | | 1 | | 1 | | | | | 1 | | | 1 | | 1 | |
| § 25.1147 Mixture controls. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.1149 Propeller speed and pitch controls. | 1 | | | | 1 | | 1 | | | | | 1 | | | 1 | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| § 25.1153 Propeller feathering controls. | 1 | | | | 1 | | 1 | | | | | 1 | | | 1 | | 1 | |
| § 25.1155 Reverse thrust and propeller pitch settings below the flight regime. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.1157 Carburetor air temperature controls. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1159 Supercharger controls. | 1 | | | | 1 | | 1 | | | | | 1 | | | 1 | | 1 | |
| § 25.1161 Fuel jettisoning system controls. | 1 | | | | 1 | | 1 | | | | | 1 | | | 1 | | 1 | |
| § 25.1163 Powerplant accessories. | 1 | | | | 1 | | 1 | | | | | 1 | | | 1 | | 1 | |
| § 25.1165 Engine ignition systems. | 1 | | | | 1 | | 1 | | | | | 1 | | | 1 | | 1 | |
| § 25.1167 Accessory gearboxes. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | Additional Work Needed | Complete Coverage | Partial Coverage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | | | |
| *Powerplant Fire Protection* | * | | * | | | | | | | | | | | | | | | |
| § 25.1181 Designated fire zones; regions included. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1182 Nacelle areas behind firewalls, and engine pod attaching structures containing flammable fluid lines. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1183 Flammable fluid-carrying components. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1185 Flammable fluids. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1187 Drainage and ventilation of fire zones. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1189 Shutoff means. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.1191 Firewalls. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1192 Engine accessory section diaphragm. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1193 Cowling and nacelle skin. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
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| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| § 25.1195 Fire extinguishing systems. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1197 Fire extinguishing agents. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1199 Extinguishing agent containers. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1201 Fire extinguishing system materials. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1203 Fire detector system. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.1207 Compliance. | | | 1 | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| **Subpart F—Equipment** | * | | * | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| *General* | * | | * | | | | | | | | | | | | | | | |
| § 25.1301 Function and installation. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| § 25.1303 Flight and navigation instruments. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.1305 Powerplant instruments. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.1307 Miscellaneous equipment. | 1 | | | | 1 | | 1 | | | | 1 | | | | 1 | | 1 | |
| § 25.1309 Equipment, systems, and installations. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.1310 Power source capacity and distribution. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1316 System lightning protection. | 1 | | | | 1 | | | | 1 | 1 | | | | | 1 | | 1 | |
| § 25.1317 High-intensity Radiated Fields (HIRF) Protection. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| *Instruments: Installation* | * | | * | | | | | | | | | | | | | | | |
| § 25.1321 Arrangement and visibility. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1322 Flightcrew alerting. | | | 1 | | | | | | | | | | | | | | | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| § 25.1323 Airspeed indicating system. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1325 Static pressure systems. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1326 Pitot heat indication systems. | 1 | | | | 1 | | 1 | | | 1 | | | | 1 | | | 1 | |
| § 25.1327 Magnetic direction indicator. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1329 Flight guidance system. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1331 Instruments using a power supply. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.1333 Instrument systems. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.1337 Powerplant instruments. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| *Electrical Systems and Equipment* | * | | * | | | | | | | | | | | | | | | |
| § 25.1351 General. | 1 | | | | 1 | | | 1 | | | 1 | | | | 1 | 1 | | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | Additional Work Needed | Complete Coverage | Partial Coverage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | | | |
| § 25.1353 Electrical equipment and installations. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1355 Distribution system. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1357 Circuit protective devices. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1360 Precautions against injury. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1362 Electrical supplies for emergency conditions. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1363 Electrical system tests. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1365 Electrical appliances, motors, and transformers. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| *Lights* | * | | * | | | | | | | | | | | | | | | |
| § 25.1381 Instrument lights. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1383 Landing lights. | | | 1 | | | | | | | | | | | | | | | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| § 25.1385 Position light system installation. | 1 | | | | 1 | | | 1 | | 1 | | | 1 | | | | 1 | |
| § 25.1387 Position light system dihedral angles. | 1 | | | | 1 | | | 1 | | 1 | | | 1 | | | | 1 | |
| § 25.1389 Position light distribution and intensities. | 1 | | | | 1 | | | 1 | | 1 | | | 1 | | | | 1 | |
| § 25.1391 Minimum intensities in the horizontal plane of forward and rear position lights. | 1 | | | | 1 | | | 1 | | 1 | | | 1 | | | | 1 | |
| § 25.1393 Minimum intensities in any vertical plane of forward and rear position lights. | 1 | | | | 1 | | | 1 | | 1 | | | 1 | | | | 1 | |
| § 25.1395 Maximum intensities in overlapping beams of forward and rear position lights. | 1 | | | | 1 | | | 1 | | 1 | | | 1 | | | | 1 | |
| § 25.1397 Color specifications. | 1 | | | | 1 | | | 1 | | 1 | | | 1 | | | | 1 | |
| § 25.1399 Riding light. | | | 1 | | | | | | | | | | | | | | | |

| | Is Rule Applicable to UAV? Complete | Is Rule Applicable to UAV? No | Is Rule Applicable to UAV? Partial | DA Fleet History Applicability Complete | DA Fleet History Applicability No | DA Fleet History Applicability Partial | Flight Test Complete | Flight Test No | Flight Test Partial | Ground Test / Inspection Complete | Ground Test / Inspection No | Ground Test / Inspection Partial | Anlaysis/ Drawings Review Complete | Anlaysis/ Drawings Review No | Anlaysis/ Drawings Review Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| § 25.1401 Anticollision light system. | 1 | | | | 1 | | | 1 | | 1 | | | 1 | | | | 1 | |
| § 25.1403 Wing icing detection lights. | | | 1 | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| *Safety Equipment* | * | | * | | | | | | | | | | | | | | | |
| § 25.1411 General. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1415 Ditching equipment. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1419 Ice protection. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1421 Megaphones. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1423 Public address system. | | | 1 | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| *Miscellaneous Equipment* | * | | * | | | | | | | | | | | | | | | |
| § 25.1431 Electronic equipment. | 1 | | | | 1 | | | | 1 | 1 | | | | | 1 | | 1 | |
| § 25.1433 Vacuum systems. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.1435 Hydraulic systems. | 1 | | | | 1 | | 1 | | | 1 | | | | | 1 | | 1 | |
| § 25.1438 Pressurization and pneumatic systems. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1439 Protective breathing equipment. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1441 Oxygen equipment and supply. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1443 Minimum mass flow of supplemental oxygen. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1445 Equipment standards for the oxygen distributing system. | | | 1 | | | | | | | | | | | | | | | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | Additional Work Needed | Complete Coverage | Partial Coverage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | | | |
| § 25.1447 Equipment standards for oxygen dispensing units. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1449 Means for determining use of oxygen. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1450 Chemical oxygen generators. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1453 Protection of oxygen equipment from rupture. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1455 Draining of fluids subject to freezing. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1457 Cockpit voice recorders. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1459 Flight data recorders. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1461 Equipment containing high energy rotors. | | | 1 | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| **Subpart G—Operating Limitations and Information** | * | | * | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| § 25.1501 General. | 1 | | | | 1 | | | 1 | | 1 | | | | 1 | | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| *Operating Limitations* | * | | * | | | | | | | | | | | | | | | |
| § 25.1503 Airspeed limitations: general. | 1 | | | | 1 | | 1 | | | 1 | | | | 1 | | | 1 | |
| § 25.1505 Maximum operating limit speed. | 1 | | | | 1 | | 1 | | | 1 | | | | 1 | | | 1 | |
| § 25.1507 Maneuvering speed. | 1 | | | | 1 | | 1 | | | 1 | | | | 1 | | | 1 | |
| § 25.1511 Flap extended speed. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1513 Minimum control speed. | 1 | | | | 1 | | 1 | | | 1 | | | | 1 | | | 1 | |
| § 25.1515 Landing gear speeds. | 1 | | | | 1 | | 1 | | | 1 | | | | 1 | | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| § 25.1516 Other speed limitations. | 1 | | | | 1 | | 1 | | | 1 | | | | 1 | | | 1 | |
| § 25.1517 Rough air speed, VRA. | 1 | | | | 1 | | 1 | | | 1 | | | | 1 | | | 1 | |
| § 25.1519 Weight, center of gravity, and weight distribution. | 1 | | | | 1 | | 1 | | | 1 | | | | 1 | | | 1 | |
| § 25.1521 Powerplant limitations. | 1 | | | | 1 | | 1 | | | 1 | | | | 1 | | | 1 | |
| § 25.1522 Auxiliary power unit limitations. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1523 Minimum flight crew. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1525 Kinds of operation. | 1 | | | | 1 | | | 1 | | 1 | | | | 1 | | | 1 | |
| § 25.1527 Ambient air temperature and operating altitude. | 1 | | | | 1 | | 1 | | | 1 | | | | 1 | | | 1 | |
| § 25.1529 Instructions for Continued Airworthiness. | 1 | | | | 1 | | 1 | | | 1 | | | | 1 | | | 1 | |
| § 25.1531 Maneuvering flight load factors. | 1 | | | | 1 | | 1 | | | 1 | | | | 1 | | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| § 25.1533 Additional operating limitations. | 1 | | | | 1 | | | 1 | | 1 | | | | 1 | | | 1 | |
| § 25.1535 ETOPS approval. | | | 1 | | | | | | | | | | | | | | | |
| | * | | * | | | | | | | | | | | | | | | |
| *Markings and Placards* | * | | * | | | | | | | | | | | | | | | |
| § 25.1541 General. | 1 | | | | 1 | | | 1 | | 1 | | | | 1 | | | 1 | |
| § 25.1543 Instrument markings: general. | 1 | | | | 1 | | | 1 | | 1 | | | | 1 | | | 1 | |
| § 25.1545 Airspeed limitation information. | 1 | | | | 1 | | | 1 | | 1 | | | | 1 | | | 1 | |
| § 25.1547 Magnetic direction indicator. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1549 Powerplant and auxiliary power unit instruments. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1551 Oil quantity indication. | 1 | | | | 1 | | | 1 | | 1 | | | | 1 | | | 1 | |
| § 25.1553 Fuel quantity indicator. | 1 | | | | 1 | | | 1 | | 1 | | | | 1 | | | 1 | |
| § 25.1555 Control markings. | | | 1 | | | | | | | | | | | | | | | |

| | Is Rule Applicable to UAV? Complete | Is Rule Applicable to UAV? No | Is Rule Applicable to UAV? Partial | DA Fleet History Applicability Complete | DA Fleet History Applicability No | DA Fleet History Applicability Partial | Flight Test Complete | Flight Test No | Flight Test Partial | Ground Test / Inspection Complete | Ground Test / Inspection No | Ground Test / Inspection Partial | Anlaysis/ Drawings Review Complete | Anlaysis/ Drawings Review No | Anlaysis/ Drawings Review Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| § 25.1557 Miscellaneous markings and placards. | 1 | | | | 1 | | | 1 | | 1 | | | | 1 | | | 1 | |
| § 25.1561 Safety equipment. | | | 1 | | | | | | | | | | | | | | | |
| § 25.1563 Airspeed placard. | 1 | | | | 1 | | | 1 | | 1 | | | | 1 | | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |
| *Airplane Flight Manual* | * | | * | | | | | | | | | | | | | | | |
| § 25.1581 General. | 1 | | | | 1 | | | 1 | | 1 | | | | 1 | | | 1 | |
| § 25.1583 Operating limitations. | 1 | | | | 1 | | | 1 | | 1 | | | | 1 | | | 1 | |
| § 25.1585 Operating procedures. | 1 | | | | 1 | | | 1 | | 1 | | | | 1 | | | 1 | |
| § 25.1587 Performance information. | 1 | | | | 1 | | | 1 | | 1 | | | | 1 | | | 1 | |
| | * | | * | | | | | | | | | | | | | | | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| **Subpart H—Electrical Wiring Interconnection Systems (EWIS)** | * * | | * * | | | | | | | | | | | | | | | |
| § 25.1701 Definition. | 1 | | | | 1 | | | 1 | | | 1 | | | 1 | | 0 | 1 | |
| § 25.1703 Function and installation: EWIS. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1705 Systems and functions: EWIS. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1707 System separation: EWIS. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1709 System safety: EWIS. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1711 Component identification: EWIS. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1713 Fire protection: EWIS. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1715 Electrical bonding and protection against static electricity: EWIS. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| § 25.1717 Circuit protective devices: EWIS. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1719 Accessibility provisions: EWIS. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1721 Protection of EWIS. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1723 Flammable fluid fire protection: EWIS. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1725 Powerplants: EWIS. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1727 Flammable fluid shutoff means: EWIS. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1729 Instructions for Continued Airworthiness: EWIS. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1731 Powerplant and APU fire detector system: EWIS. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |
| § 25.1733 Fire detector systems, general: EWIS. | 1 | | | | 1 | | | 1 | | 1 | | | | | 1 | | 1 | |

| | Is Rule Applicable to UAV? | | | DA Fleet History Applicability | | | Flight Test | | | Ground Test / Inspection | | | Anlaysis/ Drawings Review | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Complete | No | Partial | Additional Work Needed | Complete Coverage | Partial Coverage |
| TOTAL | **282** | **0** | **115** | **1** | **279** | **2** | **151** | **116** | **15** | **172** | **83** | **27** | **19** | **28** | **235** | **13** | **263** | **5** |
| | 71.0% | 0.0% | 29.0% | 0.4% | 98.9% | 0.7% | 53.5% | 41.1% | 5.3% | 61.0% | 29.4% | 9.6% | 6.7% | 9.9% | 83.3% | 4.6% | 93.6% | 1.8% |

Table A.1 – Assessment of Part 25 Applicability to UAS and Sufficiency of Compliance Means

Appendix B: Summary Data – AFSC – All Classes

| | LL | RP | HL | RE | === | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2000** | **1** | **3** | **3** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **2001** | **0.5** | **0** | **4** | **6.5** | **1** | **3** | **2** | **1** | **1** | **0** | **0** | **0** | **0** |
| **2002** | **1.0** | **1** | **2** | **11** | **0** | **6** | **3** | **1** | **1** | **0** | **0** | **0** | **1** |
| **2003** | **0** | **1** | **1** | **10** | **3** | **4** | **4** | **0** | **1** | **1** | **0** | **0** | **0** |
| **2004** | **0** | **2** | **3** | **8** | **2** | **5** | **3** | **0** | **0** | **0** | **2** | **0** | **0** |
| **2005** | **1** | **2** | **4** | **12** | **1** | **7** | **5** | **0** | **0** | **0** | **0** | **0** | **0** |
| **2006** | **1** | **4** | **2** | **13** | **2** | **9** | **2** | **2** | **0** | **0** | **0** | **0** | **0** |
| **2007** | **2** | **2** | **4** | **13** | **0** | **9** | **1** | **2** | **0** | **1** | **0** | **1** | **1** |
| **2008** | **3** | **10** | **11** | **25** | **0** | **18** | **5** | **0** | **0** | **2** | **1** | **1** | **5** |
| **2009** | **3** | **10** | **9** | **35** | **0** | **23** | **4** | **6** | **1** | **1** | **2** | **1** | **5** |
| **SUM** | **12.5** | **35** | **43** | **133.5** | **9** | **84** | **29** | **12** | **4** | **5** | **5** | **3** | **12** |
| **4.9%** | **13.8%** | **17.0%** | **52.8%** | **3.6%** | **33.2%** | **11.5%** | **4.7%** | **1.6%** | **2.0%** | **2.0%** | **1.2%** | **4.7%** | **4.9%** |

**Remote** **47.2%** **Non-Remote** **49.4%**

Table B.1 – Fleet Cause Mishap Frequency – All Classes – AFSC

| | LL | RP | HL | RE | === | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 1 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2001 | 1.5 | 3 | 7 | 6.5 | 1 | 3 | 2 | 1 | 1 | 0 | 0 | 0 | 0 |
| 2002 | 2.5 | 4 | 9 | 17.5 | 1 | 9 | 5 | 2 | 2 | 0 | 0 | 0 | 1 |
| 2003 | 2.5 | 5 | 10 | 27.5 | 4 | 13 | 9 | 2 | 3 | 1 | 0 | 0 | 1 |
| 2004 | 2.5 | 7 | 13 | 35.5 | 6 | 18 | 12 | 2 | 3 | 1 | 2 | 0 | 1 |
| 2005 | 3.5 | 9 | 17 | 47.5 | 7 | 25 | 17 | 2 | 3 | 1 | 2 | 0 | 1 |
| 2006 | 4.5 | 13 | 19 | 60.5 | 9 | 34 | 19 | 4 | 3 | 1 | 2 | 0 | 1 |
| 2007 | 6.5 | 15 | 23 | 73.5 | 9 | 43 | 20 | 6 | 3 | 2 | 2 | 1 | 2 |
| 2008 | 9.5 | 25 | 34 | 98.5 | 9 | 61 | 25 | 6 | 3 | 4 | 3 | 2 | 7 |
| 2009 | 12.5 | 35 | 43 | 133.5 | 9 | 84 | 29 | 12 | 4 | 5 | 5 | 3 | 12 |

Table B.2 – Fleet Cause Accrued Mishaps – All Classes – AFSC

| | LL | RP | HL | RE | === | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2001 | 1.9E-04 | 3.7E-04 | 8.7E-04 | 8.0E-04 | 1.2E-04 | 3.7E-04 | 2.5E-04 | 1.2E-04 | 1.2E-04 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2002 | 8.6E-05 | 1.4E-04 | 3.1E-04 | 6.0E-04 | 3.4E-05 | 3.1E-04 | 1.7E-04 | 6.9E-05 | 6.9E-05 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 3.4E-05 |
| 2003 | 4.9E-05 | 9.9E-05 | 2.0E-04 | 5.4E-04 | 7.9E-05 | 2.6E-04 | 1.8E-04 | 4.0E-05 | 5.9E-05 | 2.0E-05 | 0.0E+00 | 0.0E+00 | 2.0E-05 |
| 2004 | 3.0E-05 | 8.3E-05 | 1.5E-04 | 4.2E-04 | 7.1E-05 | 2.1E-04 | 1.4E-04 | 2.4E-05 | 3.6E-05 | 1.2E-05 | 2.4E-05 | 0.0E+00 | 1.2E-05 |
| 2005 | 2.7E-05 | 6.9E-05 | 1.3E-04 | 3.6E-04 | 5.4E-05 | 1.9E-04 | 1.3E-04 | 1.5E-05 | 2.3E-05 | 7.7E-06 | 1.5E-05 | 0.0E+00 | 7.7E-06 |
| 2006 | 2.3E-05 | 6.7E-05 | 9.8E-05 | 3.1E-04 | 4.6E-05 | 1.7E-04 | 9.8E-05 | 2.1E-05 | 1.5E-05 | 5.1E-06 | 1.0E-05 | 0.0E+00 | 5.1E-06 |
| 2007 | 2.3E-05 | 5.2E-05 | 8.0E-05 | 2.6E-04 | 3.1E-05 | 1.5E-04 | 7.0E-05 | 2.1E-05 | 1.0E-05 | 7.0E-06 | 7.0E-06 | 3.5E-06 | 7.0E-06 |
| 2008 | 2.1E-05 | 5.5E-05 | 7.5E-05 | 2.2E-04 | 2.0E-05 | 1.3E-04 | 5.5E-05 | 1.3E-05 | 6.6E-06 | 8.8E-06 | 6.6E-06 | 4.4E-06 | 1.5E-05 |
| 2009 | 1.9E-05 | 5.2E-05 | 6.4E-05 | 2.0E-04 | 1.3E-05 | 1.2E-04 | 4.3E-05 | 1.8E-05 | 5.9E-06 | 7.4E-06 | 7.4E-06 | 4.4E-06 | 1.8E-05 |

Table B.3 – Fleet Cause Accrued Mishap Rate – All Classes – AFSC

| | RQ-1 /MQ-1 | MQ-9 | RQ-4 | SUM |
|---|---|---|---|---|
| 2001 | 7,571 | 30 | 486 | 8,087 |
| 2002 | 19,313 | 191 | 1,566 | 21,070 |
| 2003 | 20,507 | 100 | 779 | 21,386 |
| 2004 | 31,383 | 767 | 1,375 | 33,525 |
| 2005 | 41,024 | 2,373 | 2,841 | 46,238 |
| 2006 | 57,798 | 3,180 | 3,214 | 64,192 |
| 2007 | 79,193 | 6,872 | 5,631 | 91,696 |
| 2008 | 147,980 | 13,490 | 7,894 | 169,364 |
| 2009 | 186,010 | 26,072 | 7,810 | 219,892 |

Table B.4 – Vehicle Flight Hours – All Classes – AFSC

| | RQ-1/ MQ-1 | MQ-9 | RQ-4 | SUM |
|---|---|---|---|---|
| 2001 | 7,571 | 30 | 486 | 8,087 |
| 2002 | 26,884 | 221 | 2,052 | 29,157 |
| 2003 | 47,391 | 321 | 2831 | 50,543 |
| 2004 | 78,774 | 1088 | 4,206 | 84,068 |
| 2005 | 119,798 | 3,461 | 7,047 | 130,306 |
| 2006 | 177,596 | 6,641 | 10,261 | 194,498 |
| 2007 | 256,789 | 13,513 | 15,892 | 286,194 |
| 2008 | 404,769 | 27,003 | 23,786 | 455,558 |
| 2009 | 590,779 | 53,075 | 31,596 | 675,450 |

Table B.5 – Vehicle Accrued Flight Hours – All Classes – AFSC

| | GCS | MQ-1 | MQ-9 | RQ-1 | RQ-4 | SUM |
|---|---|---|---|---|---|---|
| 2000 | 0 | 0 | 0 | 6 | 1 | 13 |
| 2001 | 0 | 1 | 0 | 11 | 0 | 12 |
| 2002 | 0 | 2 | 0 | 12 | 2 | 16 |
| 2003 | 0 | 1 | 1 | 12 | 1 | 15 |
| 2004 | 0 | 12 | 0 | 4 | 1 | 17 |
| 2005 | 0 | 15 | 1 | 0 | 4 | 20 |
| 2006 | 1 | 16 | 3 | 0 | 2 | 22 |
| 2007 | 0 | 18 | 4 | 0 | 1 | 23 |
| 2008 | 2 | 42 | 11 | 0 | 1 | 56 |
| 2009 | 0 | 47 | 14 | 0 | 4 | 65 |
| SUM | 3 | 154 | 34 | 45 | 17 | 253 |

Table B.6 – Vehicle Mishaps – All Classes – AFSC

| | RQ-1/ MQ-1 | MQ-9 | RQ-4 |
|---|---|---|---|
| 2001 | 18 | 0 | 1 |
| 2002 | 32 | 0 | 3 |
| 2003 | 45 | 1 | 4 |
| 2004 | 61 | 1 | 5 |
| 2005 | 76 | 2 | 9 |
| 2006 | 92 | 5 | 11 |
| 2007 | 110 | 9 | 12 |
| 2008 | 152 | 20 | 13 |
| 2009 | 199 | 34 | 17 |

Table B.7 – Vehicle Accured Mishaps – All Classes – AFSC

| | A | B | C | D | E |
|---|---|---|---|---|---|
| 2000 | 2 | 1 | 3 | 0 | 1 |
| 2001 | 4 | 1 | 4 | 0 | 3 |
| 2002 | 9 | 0 | 5 | 0 | 2 |
| 2003 | 2 | 0 | 3 | 0 | 10 |
| 2004 | 6 | 0 | 4 | 0 | 7 |
| 2005 | 10 | 2 | 2 | 0 | 6 |
| 2006 | 7 | 0 | 4 | 0 | 11 |
| 2007 | 8 | 0 | 3 | 0 | 12 |
| 2008 | 13 | 3 | 18 | 0 | 22 |
| 2009 | 18 | 4 | 15 | 0 | 28 |
| SUM | 79 | 11 | 61 | 0 | 102 |

Table B.8 – Class Mishaps – AFSC

| | RQ-1 / MQ-1 | MQ-9 | RQ-4 |
|---|---|---|---|
| 2000 | 5 | 0 | 0 |
| 2001 | 13 | 0 | 0 |
| 2002 | 20 | 0 | 0 |
| 2003 | 31 | 1 | 1 |
| 2004 | 41 | 1 | 2 |
| 2005 | 46 | 2 | 6 |
| 2006 | 57 | 3 | 8 |
| 2007 | 68 | 6 | 9 |
| 2008 | 100 | 14 | 10 |
| 2009 | 134 | 24 | 13 |

Table B.10 – Vehicle Accrued Mishaps – Classes B-E – AFSC

| | RQ-1 / MQ-1 | MQ-9 | RQ-4 |
|---|---|---|---|
| 2000 | 5 | 0 | 0 |
| 2001 | 8 | 0 | 0 |
| 2002 | 7 | 0 | 0 |
| 2003 | 11 | 1 | 1 |
| 2004 | 10 | 0 | 1 |
| 2005 | 5 | 1 | 4 |
| 2006 | 11 | 1 | 2 |
| 2007 | 11 | 3 | 1 |
| 2008 | 32 | 8 | 1 |
| 2009 | 34 | 10 | 3 |
| SUM | 134 | 24 | 13 |

Table B.9 – Vehicle Mishaps – Classes B-E – AFSC

| | RQ-1 /MQ-1 | MQ-9 | RQ-4 |
|---|---|---|---|
| 2001 | 2.4E-03 | 0.0E+00 | 2.1E-03 |
| 2002 | 1.2E-03 | 0.0E+00 | 1.5E-03 |
| 2003 | 9.5E-04 | 3.1E-03 | 1.4E-03 |
| 2004 | 7.7E-04 | 9.2E-04 | 1.2E-03 |
| 2005 | 6.3E-04 | 5.8E-04 | 1.3E-03 |
| 2006 | 5.2E-04 | 7.5E-04 | 1.1E-03 |
| 2007 | 4.3E-04 | 6.7E-04 | 7.6E-04 |
| 2008 | 3.8E-04 | 7.4E-04 | 5.5E-04 |
| 2009 | 3.4E-04 | 6.4E-04 | 5.4E-04 |

Table B.11 – Vehicle Accrued Mishap Rate – All Classes – AFSC

| | RQ-1 / MQ-1 | MQ-9 | RQ-4 |
|---|---|---|---|
| **2001** | **1.7E-03** | **0.0E+00** | **0.0E+00** |
| **2002** | **1.0E-03** | **0.0E+00** | **0.0E+00** |
| **2003** | **1.5E-03** | **1.0E-02** | **1.3E-03** |
| **2004** | **1.3E-03** | **1.3E-03** | **1.5E-03** |
| **2005** | **1.1E-03** | **8.4E-04** | **2.1E-03** |
| **2006** | **9.9E-04** | **9.4E-04** | **2.5E-03** |
| **2007** | **8.6E-04** | **8.7E-04** | **1.6E-03** |
| **2008** | **6.8E-04** | **1.0E-03** | **1.3E-03** |
| **2009** | **7.2E-04** | **9.2E-04** | **1.7E-03** |

Table B.12 – Vehicle Accrued Mishaps Rates – Classes B-E – AFSC

| | LL | RP | HL | RE | === | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2000** | 1 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2001** | 0.5 | 0 | 4 | 6.5 | 1 | 3 | 2 | 1 | 1 | 0 | 0 | 0 | 0 |
| **2002** | 1.0 | 0 | 2 | 10 | 0 | 5 | 3 | 1 | 1 | 0 | 0 | 0 | 1 |
| **2003** | 0 | 1 | 0 | 9 | 3 | 3 | 4 | 0 | 1 | 1 | 0 | 0 | 0 |
| **2004** | 0 | 2 | 3 | 7 | 2 | 5 | 2 | 0 | 0 | 0 | 2 | 0 | 0 |
| **2005** | 1 | 2 | 2 | 9 | 1 | 4 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2006** | 1 | 2 | 1 | 10 | 2 | 8 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| **2007** | 2 | 0 | 3 | 12 | 0 | 8 | 1 | 2 | 0 | 1 | 0 | 0 | 1 |
| **2008** | 2 | 9 | 5 | 22 | 0 | 15 | 5 | 0 | 0 | 2 | 1 | 0 | 3 |
| **2009** | 2 | 7 | 7 | 25 | 0 | 19 | 3 | 2 | 0 | 1 | 2 | 1 | 3 |
| **SUM** | 10.5 | 25 | 30 | 110.5 | 9 | 70 | 26 | 7 | 3 | 5 | 5 | 1 | 8 |
| | 5.3% | 12.6% | 15.1% | 55.5% | 4.5% | 35.2% | 13.1% | 3.5% | 1.5% | 2.5% | 2.5% | 0.5% | 4.0% |
| | | | **Remote** | 46.0% | | **Non-Remote** | 49.7% | | | | | | |

Table B.13 – RQ-1 / MQ-1 Cause Mishap Frequency – All Classes – AFSC

| | LL | RP | HL | RE | === | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2000** | 1 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2001** | 1.5 | 2 | 7 | 6.5 | 1 | 3 | 2 | 1 | 1 | 0 | 0 | 0 | 0 |
| **2002** | 2.5 | 2 | 9 | 16.5 | 1 | 8 | 5 | 2 | 2 | 0 | 0 | 0 | 1 |
| **2003** | 2.5 | 3 | 9 | 25.5 | 4 | 11 | 9 | 2 | 3 | 1 | 0 | 0 | 1 |
| **2004** | 2.5 | 5 | 12 | 32.5 | 6 | 16 | 11 | 2 | 3 | 1 | 2 | 0 | 1 |
| **2005** | 3.5 | 7 | 14 | 41.5 | 7 | 20 | 16 | 2 | 3 | 1 | 2 | 0 | 1 |
| **2006** | 4.5 | 9 | 15 | 51.5 | 9 | 28 | 17 | 3 | 3 | 1 | 2 | 0 | 1 |
| **2007** | 6.5 | 9 | 18 | 63.5 | 9 | 36 | 18 | 5 | 3 | 2 | 2 | 0 | 2 |
| **2008** | 8.5 | 18 | 23 | 85.5 | 9 | 51 | 23 | 5 | 3 | 4 | 3 | 0 | 5 |
| **2009** | 10.5 | 25 | 30 | 110.5 | 9 | 70 | 26 | 7 | 3 | 5 | 5 | 1 | 8 |

Table B.14 – RQ-1 / MQ-1 Cause Accrued Mishaps – All Classes – AFSC

| | LL | RP | HL | RE | === | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2001 | 2.0E-04 | 2.6E-04 | 9.2E-04 | 8.6E-04 | 1.3E-04 | 4.0E-04 | 2.6E-04 | 1.3E-04 | 1.3E-04 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2002 | 9.3E-05 | 7.4E-05 | 3.3E-04 | 6.1E-04 | 3.7E-05 | 3.0E-04 | 1.9E-04 | 7.4E-05 | 7.4E-05 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 3.7E-05 |
| 2003 | 5.3E-05 | 6.3E-05 | 1.9E-04 | 5.4E-04 | 8.4E-05 | 2.3E-04 | 1.9E-04 | 4.2E-05 | 6.3E-05 | 2.1E-05 | 0.0E+00 | 0.0E+00 | 2.1E-05 |
| 2004 | 3.2E-05 | 6.3E-05 | 1.5E-04 | 4.1E-04 | 7.6E-05 | 2.0E-04 | 1.4E-04 | 2.5E-05 | 3.8E-05 | 1.3E-05 | 2.5E-05 | 0.0E+00 | 1.3E-05 |
| 2005 | 2.9E-05 | 5.8E-05 | 1.2E-04 | 3.5E-04 | 5.8E-05 | 1.7E-04 | 1.3E-04 | 1.7E-05 | 2.5E-05 | 8.3E-06 | 1.7E-05 | 0.0E+00 | 8.3E-06 |
| 2006 | 2.5E-05 | 5.1E-05 | 8.4E-05 | 2.9E-04 | 5.1E-05 | 1.6E-04 | 9.6E-05 | 1.7E-05 | 1.7E-05 | 5.6E-06 | 1.1E-05 | 0.0E+00 | 5.6E-06 |
| 2007 | 2.5E-05 | 3.5E-05 | 7.0E-05 | 2.5E-04 | 3.5E-05 | 1.4E-04 | 7.0E-05 | 1.9E-05 | 1.2E-05 | 7.8E-06 | 7.8E-06 | 0.0E+00 | 7.8E-06 |
| 2008 | 2.1E-05 | 4.4E-05 | 5.7E-05 | 2.1E-04 | 2.2E-05 | 1.3E-04 | 5.7E-05 | 1.2E-05 | 7.4E-06 | 9.9E-06 | 7.4E-06 | 0.0E+00 | 1.2E-05 |
| 2009 | 1.8E-05 | 4.2E-05 | 5.1E-05 | 1.9E-04 | 1.5E-05 | 1.2E-04 | 4.4E-05 | 1.2E-05 | 5.1E-06 | 8.5E-06 | 8.5E-06 | 1.7E-06 | 1.4E-05 |

Table B.15 – RQ-1 / MQ-1 Cause Accrued Mishap Rate – All Classes – AFSC

| | LL | RP | HL | RE | ===== | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2000** | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2001** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2002** | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2003** | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2004** | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2005** | 0 | 0 | 1 | 3 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2006** | 0 | 0 | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2007** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| **2008** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2009** | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 |
| **SUM** | 1 | 3 | 1 | 11 | 0 | 6 | 2 | 2 | 1 | 0 | 0 | 1 | 0 |
| | 5.9% | 17.6% | 5.9% | 64.7% | 0.0% | 35.3% | 11.8% | 11.8% | 5.9% | 0.0% | 0.0% | 5.9% | 0.0% |
| | | | Remote | 41.2% | | Non-Remote | 8.8% | | | | | | |

Table B.16 – RQ-4 Cause Mishap Frequency – All Classes – AFSC

| | LL | RP | HL | RE | === | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2000** | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2001** | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2002** | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2003** | 0 | 2 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2004** | 0 | 2 | 0 | 3 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2005** | 0 | 2 | 1 | 6 | 0 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2006** | 0 | 2 | 1 | 8 | 0 | 6 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2007** | 0 | 2 | 1 | 8 | 0 | 6 | 2 | 0 | 0 | 0 | 0 | 1 | 0 |
| **2008** | 1 | 2 | 1 | 8 | 0 | 6 | 2 | 0 | 0 | 0 | 0 | 1 | 0 |
| **2009** | 1 | 3 | 1 | 11 | 0 | 6 | 2 | 2 | 1 | 0 | 0 | 1 | 0 |

Table B.17 – RQ-4 Cause Accrued Mishaps – All Classes – AFSC

| | LL | RP | HL | RE | ===== | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2001 | 0.0E+00 | 3.3E-02 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2002 | 0.0E+00 | 9.0E-03 | 0.0E+00 | 4.5E-03 | 0.0E+00 | 4.5E-03 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2003 | 0.0E+00 | 6.2E-03 | 0.0E+00 | 6.2E-03 | 0.0E+00 | 6.2E-03 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2004 | 0.0E+00 | 1.8E-03 | 0.0E+00 | 2.8E-03 | 0.0E+00 | 1.8E-03 | 9.2E-04 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2005 | 0.0E+00 | 5.8E-04 | 2.9E-04 | 1.7E-03 | 0.0E+00 | 1.4E-03 | 2.9E-04 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2006 | 0.0E+00 | 3.0E-04 | 1.5E-04 | 1.2E-03 | 0.0E+00 | 9.0E-04 | 3.0E-04 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2007 | 0.0E+00 | 1.5E-04 | 7.4E-05 | 5.9E-04 | 0.0E+00 | 4.4E-04 | 1.5E-04 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 7.4E-05 | 0.0E+00 |
| 2008 | 3.7E-05 | 7.4E-05 | 3.7E-05 | 3.0E-04 | 0.0E+00 | 2.2E-04 | 7.4E-05 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 3.7E-05 | 0.0E+00 |
| 2009 | 1.9E-05 | 5.7E-05 | 1.9E-05 | 2.1E-04 | 0.0E+00 | 1.1E-04 | 3.8E-05 | 3.8E-05 | 1.9E-05 | 0.0E+00 | 0.0E+00 | 1.9E-05 | 0.0E+00 |

Table B.18 – RQ-4 Cause Accrued Mishap Rate – All Classes – AFSC

| | LL | RP | HL | RE | ===== | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2000** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2001** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2002** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2003** | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2004** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2005** | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2006** | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2007** | 0 | 2 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2008** | 0 | 1 | 6 | 3 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| **2009** | 1 | 2 | 2 | 7 | 0 | 4 | 1 | 2 | 0 | 0 | 0 | 0 | 2 |
| **SUM** | 1 | 7 | 12 | 11 | 0 | 8 | 1 | 2 | 0 | 0 | 0 | 0 | 3 |
| | 2.9% | 20.6% | 35.3% | 32.4% | 0.0% | 23.5% | 2.9% | 5.9% | 0.0% | 0.0% | 0.0% | 0.0% | 8.8% |
| | | | Remote | 61.8% | | Non-Remote | 38.2% | | | | | | |

Table B.19 – MQ-9 Cause Mishap Frequency – All Classes – AFSC

| | LL | RP | HL | RE | === | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2000** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2001** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2002** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2003** | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2004** | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2005** | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2006** | 0 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2007** | 0 | 4 | 4 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2008** | 0 | 5 | 10 | 4 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| **2009** | 1 | 7 | 12 | 11 | 0 | 8 | 1 | 2 | 0 | 0 | 0 | 0 | 3 |

Table B.20 – MQ-9 Cause Accrued Mishaps – All Classes – AFSC

| | LL | RP | HL | RE | ===== | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2001 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2002 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2003 | 0.0E+00 | 0.0E+00 | 3.1E-03 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2004 | 0.0E+00 | 0.0E+00 | 9.2E-04 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2005 | 0.0E+00 | 0.0E+00 | 5.8E-04 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2006 | 0.0E+00 | 3.0E-04 | 4.5E-04 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2007 | 0.0E+00 | 3.0E-04 | 3.0E-04 | 7.4E-05 | 0.0E+00 | 7.4E-05 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2008 | 0.0E+00 | 1.9E-04 | 3.7E-04 | 1.5E-04 | 0.0E+00 | 1.5E-04 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 3.7E-05 |
| 2009 | 1.9E-05 | 1.3E-04 | 2.3E-04 | 2.1E-04 | 0.0E+00 | 1.5E-04 | 1.9E-05 | 3.8E-05 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 5.7E-05 |

Table B.21 – MQ-9 Accrued Cause Mishaps – All Classes – AFSC

Appendix C: Summary Data – AFSC – Class A

| | LL | RP | HL | RE | ===== | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2001 | 0.0 | 0 | 1 | 3.0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 1.0 | 1 | 1 | 5 | 0 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| 2003 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2004 | 0 | 2 | 0 | 4 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2005 | 1 | 1 | 2 | 6 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2006 | 1 | 1 | 2 | 3 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 2007 | 1 | 0 | 2 | 5 | 0 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 2008 | 1 | 1 | 5 | 6 | 0 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2009 | 2 | 2 | 3 | 11 | 0 | 7 | 2 | 2 | 0 | 0 | 0 | 0 | 0 |
| SUM | 8 | 10 | 16 | 44 | 0 | 27 | 11 | 6 | 0 | 0 | 0 | 0 | 1 |
| missing | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 10.1% | 12.7% | 20.3% | 55.7% | 0.0% | 34.2% | 13.9% | 7.6% | 0.0% | 0.0% | 0.0% | 0.0% | 1.3% |

Table C.1 – Fleet Cause Mishap Frequency – Class A – AFSC

| | LL | RP | HL | RE | === | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2000** | **1** | **1** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **2001** | **1** | **1** | **1** | **3** | **0** | **1** | **1** | **1** | **0** | **0** | **0** | **0** | **0** |
| **2002** | **2** | **2** | **2** | **8** | **0** | **4** | **2** | **2** | **0** | **0** | **0** | **0** | **1** |
| **2003** | **2** | **3** | **2** | **9** | **0** | **5** | **2** | **2** | **0** | **0** | **0** | **0** | **1** |
| **2004** | **2** | **5** | **2** | **13** | **0** | **7** | **4** | **2** | **0** | **0** | **0** | **0** | **1** |
| **2005** | **3** | **6** | **4** | **19** | **0** | **10** | **7** | **2** | **0** | **0** | **0** | **0** | **1** |
| **2006** | **4** | **7** | **6** | **22** | **0** | **12** | **7** | **3** | **0** | **0** | **0** | **0** | **1** |
| **2007** | **5** | **7** | **8** | **27** | **0** | **16** | **7** | **4** | **0** | **0** | **0** | **0** | **1** |
| **2008** | **6** | **8** | **13** | **33** | **0** | **20** | **9** | **4** | **0** | **0** | **0** | **0** | **1** |
| **2009** | **8** | **10** | **16** | **44** | **0** | **27** | **11** | **6** | **0** | **0** | **0** | **0** | **1** |

Table C.2 – Fleet Cause Accrued Mishaps – Class A – AFSC

| | LL | RP | HL | RE | ===== | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2001** | **1.2E-04** | **1.2E-04** | **1.2E-04** | **3.7E-04** | **0.0E+00** | **1.2E-04** | **1.2E-04** | **1.2E-04** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** |
| **2002** | **6.9E-05** | **6.9E-05** | **6.9E-05** | **2.7E-04** | **0.0E+00** | **1.4E-04** | **6.9E-05** | **6.9E-05** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **3.4E-05** |
| **2003** | **4.0E-05** | **5.9E-05** | **4.0E-05** | **1.8E-04** | **0.0E+00** | **9.9E-05** | **4.0E-05** | **4.0E-05** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **2.0E-05** |
| **2004** | **2.4E-05** | **5.9E-05** | **2.4E-05** | **1.5E-04** | **0.0E+00** | **8.3E-05** | **4.8E-05** | **2.4E-05** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **1.2E-05** |
| **2005** | **2.3E-05** | **4.6E-05** | **3.1E-05** | **1.5E-04** | **0.0E+00** | **7.7E-05** | **5.4E-05** | **1.5E-05** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **7.7E-06** |
| **2006** | **2.1E-05** | **3.6E-05** | **3.1E-05** | **1.1E-04** | **0.0E+00** | **6.2E-05** | **3.6E-05** | **1.5E-05** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **5.1E-06** |
| **2007** | **1.7E-05** | **2.4E-05** | **2.8E-05** | **9.4E-05** | **0.0E+00** | **5.6E-05** | **2.4E-05** | **1.4E-05** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **3.5E-06** |
| **2008** | **1.3E-05** | **1.8E-05** | **2.9E-05** | **7.2E-05** | **0.0E+00** | **4.4E-05** | **2.0E-05** | **8.8E-06** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **2.2E-06** |
| **2009** | **1.2E-05** | **1.5E-05** | **2.4E-05** | **6.5E-05** | **0.0E+00** | **4.0E-05** | **1.6E-05** | **8.9E-06** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **1.5E-06** |

Table C.3 – Fleet Cause Accrued Mishap Rate – Class A – AFSC

| | GCS | MQ-1 | MQ-9 | RQ-1 | RQ-4 | MQ-1/ RQ-1 |
|---|---|---|---|---|---|---|
| 2000 | 0 | 0 | 0 | 1 | 1 | 1 |
| 2001 | 0 | 1 | 0 | 3 | 0 | 4 |
| 2002 | 0 | 2 | 0 | 5 | 2 | 7 |
| 2003 | 0 | 0 | 0 | 2 | 0 | 2 |
| 2004 | 0 | 5 | 0 | 1 | 0 | 6 |
| 2005 | 0 | 10 | 0 | 0 | 0 | 10 |
| 2006 | 0 | 5 | 2 | 0 | 0 | 5 |
| 2007 | 0 | 7 | 1 | 0 | 0 | 7 |
| 2008 | 0 | 10 | 3 | 0 | 0 | 10 |
| 2009 | 0 | 13 | 4 | 0 | 1 | 13 |
| SUM | 0 | 53 | 10 | 12 | 4 | 65 |

Table C.4 – Vehicle Mishap Frequency – Class A – AFSC

| | RQ-1/ MQ-1 | MQ-9 | RQ-4 |
|---|---|---|---|
| 2001 | 6.6E-04 | 0.0E+00 | 2.1E-03 |
| 2002 | 4.5E-04 | 0.0E+00 | 1.5E-03 |
| 2003 | 3.0E-04 | 0.0E+00 | 1.1E-03 |
| 2004 | 2.5E-04 | 0.0E+00 | 7.1E-04 |
| 2005 | 2.5E-04 | 0.0E+00 | 4.3E-04 |
| 2006 | 2.0E-04 | 3.0E-04 | 2.9E-04 |
| 2007 | 1.6E-04 | 2.2E-04 | 1.9E-04 |
| 2008 | 1.3E-04 | 2.2E-04 | 1.3E-04 |
| 2009 | 1.1E-04 | 1.9E-04 | 1.3E-04 |

Table C.6 – Vehicle Mishap Rate – Class A – AFSC

| | RQ-1/ MQ-1 | MQ-9 | RQ-4 |
|---|---|---|---|
| 2000 | 1 | 0 | 1 |
| 2001 | 5 | 0 | 1 |
| 2002 | 12 | 0 | 3 |
| 2003 | 14 | 0 | 3 |
| 2004 | 20 | 0 | 3 |
| 2005 | 30 | 0 | 3 |
| 2006 | 35 | 2 | 3 |
| 2007 | 42 | 3 | 3 |
| 2008 | 52 | 6 | 3 |
| 2009 | 65 | 10 | 4 |

Table C.5 – Vehicle Accrude Mishaps – Class A – AFSC

|  | LL | RP | HL | RE | ===== | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2001 | 0 | 0 | 1 | 3 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 1 | 0 | 1 | 4 | 0 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| 2003 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2004 | 0 | 2 | 0 | 4 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2005 | 1 | 1 | 2 | 6 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2006 | 1 | 0 | 1 | 3 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 2007 | 1 | 0 | 1 | 5 | 0 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 2008 | 1 | 1 | 2 | 6 | 0 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2009 | 1 | 1 | 2 | 9 | 0 | 5 | 2 | 2 | 0 | 0 | 0 | 0 | 0 |
| SUM | 7 | 6 | 10 | 41 | 0 | 24 | 11 | 6 | 0 | 0 | 0 | 0 | 1 |
|  | 10.8% | 9.2% | 15.4% | 63.1% | 0.0% | 36.9% | 16.9% | 9.2% | 0.0% | 0.0% | 0.0% | 0.0% | 1.5% |
|  |  |  | Remote | 52.3% |  | Non-Remote | 47.7% |  |  |  |  |  |  |

Table C.7 – RQ-1 / MQ-1 Cause Mishap Frequency – Class A – AFSC

|  | LL | RP | HL | RE | === | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2001 | 1 | 0 | 1 | 3 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 2 | 0 | 2 | 7 | 0 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 1 |
| 2003 | 2 | 1 | 2 | 8 | 0 | 4 | 2 | 2 | 0 | 0 | 0 | 0 | 1 |
| 2004 | 2 | 3 | 2 | 12 | 0 | 6 | 4 | 2 | 0 | 0 | 0 | 0 | 1 |
| 2005 | 3 | 4 | 4 | 18 | 0 | 9 | 7 | 2 | 0 | 0 | 0 | 0 | 1 |
| 2006 | 4 | 4 | 5 | 21 | 0 | 11 | 7 | 3 | 0 | 0 | 0 | 0 | 1 |
| 2007 | 5 | 4 | 6 | 26 | 0 | 15 | 7 | 4 | 0 | 0 | 0 | 0 | 1 |
| 2008 | 6 | 5 | 8 | 32 | 0 | 19 | 9 | 4 | 0 | 0 | 0 | 0 | 1 |
| 2009 | 7 | 6 | 10 | 41 | 0 | 24 | 11 | 6 | 0 | 0 | 0 | 0 | 1 |

Table C.8 – RQ-1 / MQ-1 Cause Accrued Mishaps – Class A – AFSC

| | LL | RP | HL | RE | ===== | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2001 | 1.3E-04 | 0.0E+00 | 1.3E-04 | 4.0E-04 | 0.0E+00 | 1.3E-04 | 1.3E-04 | 1.3E-04 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2002 | 7.4E-05 | 0.0E+00 | 7.4E-05 | 2.6E-04 | 0.0E+00 | 1.1E-04 | 7.4E-05 | 7.4E-05 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 3.7E-05 |
| 2003 | 4.2E-05 | 2.1E-05 | 4.2E-05 | 1.7E-04 | 0.0E+00 | 8.4E-05 | 4.2E-05 | 4.2E-05 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 2.1E-05 |
| 2004 | 2.5E-05 | 3.8E-05 | 2.5E-05 | 1.5E-04 | 0.0E+00 | 7.6E-05 | 5.1E-05 | 2.5E-05 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 1.3E-05 |
| 2005 | 2.5E-05 | 3.3E-05 | 3.3E-05 | 1.5E-04 | 0.0E+00 | 7.5E-05 | 5.8E-05 | 1.7E-05 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 8.3E-06 |
| 2006 | 2.3E-05 | 2.3E-05 | 2.8E-05 | 1.2E-04 | 0.0E+00 | 6.2E-05 | 3.9E-05 | 1.7E-05 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 5.6E-06 |
| 2007 | 1.9E-05 | 1.6E-05 | 2.3E-05 | 1.0E-04 | 0.0E+00 | 5.8E-05 | 2.7E-05 | 1.6E-05 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 3.9E-06 |
| 2008 | 1.5E-05 | 1.2E-05 | 2.0E-05 | 7.9E-05 | 0.0E+00 | 4.7E-05 | 2.2E-05 | 9.9E-06 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 2.5E-06 |
| 2009 | 1.2E-05 | 1.0E-05 | 1.7E-05 | 6.9E-05 | 0.0E+00 | 4.1E-05 | 1.9E-05 | 1.0E-05 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 1.7E-06 |

Table C.9 – RQ-1 / MQ-1 Cause Accrued Mishap Rate – Class A – AFSC

| | LL | RP | HL | RE - PWP | ===== | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2004 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2005 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2006 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2007 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2008 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2009 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SUM | 0 | 3 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 0.0% | 75.0% | 0.0% | 25.0% | 0.0% | 25.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | Remote | 75.0% | | Non-Remote | 25.0% | | | | | | |

Table C.10 – RQ-4 Cause Mishap Frequency – Class A – AFSC

| | LL | RP | HL | RE | === | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2001 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2003 | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2004 | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2005 | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2006 | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2007 | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2008 | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2009 | 0 | 3 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table C.11 – RQ-4 Cause Accrued Mishaps – Class A - AFSC

| | LL | RP | HL | RE | ===== | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2001** | **0.0E+00** | **2.1E-03** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** |
| **2002** | **0.0E+00** | **9.7E-04** | **0.0E+00** | **4.9E-04** | **0.0E+00** | **4.9E-04** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** |
| **2003** | **0.0E+00** | **7.1E-04** | **0.0E+00** | **3.5E-04** | **0.0E+00** | **3.5E-04** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** |
| **2004** | **0.0E+00** | **4.8E-04** | **0.0E+00** | **2.4E-04** | **0.0E+00** | **2.4E-04** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** |
| **2005** | **0.0E+00** | **2.8E-04** | **0.0E+00** | **1.4E-04** | **0.0E+00** | **1.4E-04** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** |
| **2006** | **0.0E+00** | **1.9E-04** | **0.0E+00** | **9.7E-05** | **0.0E+00** | **9.7E-05** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** |
| **2007** | **0.0E+00** | **1.3E-04** | **0.0E+00** | **6.3E-05** | **0.0E+00** | **6.3E-05** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** |
| **2008** | **0.0E+00** | **8.4E-05** | **0.0E+00** | **4.2E-05** | **0.0E+00** | **4.2E-05** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** |
| **2009** | **0.0E+00** | **9.5E-05** | **0.0E+00** | **3.2E-05** | **0.0E+00** | **3.2E-05** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** | **0.0E+00** |

Table C.12 – RQ-4 Cause Accrued Mishap Rate – Class A - AFSC

| | LL | RP | HL | RE - PWP | ===== | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2004 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2005 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2006 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2007 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2008 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2009 | 1 | 0 | 1 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SUM | 1 | 1 | 6 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 10% | 10% | 60% | 20% | 0% | 20% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| | | | Remote | 80.0% | | Non-Remote | 20.0% | | | | | | |

Table C.13 – MQ-9 Cause Mishap Frequency – Class A - AFSC

| | LL | RP | HL | RE | === | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2001 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2004 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2005 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2006 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2007 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2008 | 0 | 1 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2009 | 1 | 1 | 6 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table C.14 – MQ-9 Cause Accrued Mishaps – Class A – AFSC

| | LL | RP | HL | RE | === | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2001 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2002 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2003 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2004 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2005 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2006 | 0.0E+00 | 1.5E-04 | 1.5E-04 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2007 | 0.0E+00 | 7.4E-05 | 1.5E-04 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2008 | 0.0E+00 | 3.7E-05 | 1.9E-04 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| 2009 | 1.9E-05 | 1.9E-05 | 1.1E-04 | 3.8E-05 | 0.0E+00 | 3.8E-05 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |

Table C.15 – MQ-9 Cause Accrued Mishap Rate – Class A – AFSC

Appendix D: Summary Data – AIB – Class A

| | LL | RP | HL | RE | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 0 | 0 | 0 | 3 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2001 | 0 | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 1 | 0 | 1 | 4 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| 2003 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2004 | 0 | 0 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 2005 | 0 | 0 | 1 | 3 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| 2006 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 2007 | 0 | 0 | 1 | 4 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 2008 | 0 | 0 | 0 | 8 | 2 | 0 | 6 | 0 | 0 | 0 | 0 | 0 |
| 2009 | 1 | 0 | 0 | 7 | 4 | 0 | 3 | 0 | 0 | 0 | 2 | 1 |
| SUM | 4 | 0 | 6 | 34 | 15 | 7 | 11 | 0 | 1 | 1 | 5 | 1 |
| | 8% | 0% | 12% | 67% | 29% | 14% | 22% | 0% | 2% | 2% | 10% | 2% |
| | | | Remote | 33% | Non-Remote | 67% | | | | | | |

Table D.1 – Fleet Cause Mishap Frequency – Class A - AIB

| | LL | RP | HL | RE | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2000** | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2001** | 0 | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2002** | 1 | 0 | 1 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| **2003** | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **2004** | 0 | 0 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| **2005** | 0 | 0 | 1 | 3 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| **2006** | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| **2007** | 0 | 0 | 1 | 4 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| **2008** | 1 | 0 | 0 | 8 | 2 | 0 | 6 | 0 | 0 | 0 | 0 | 0 |
| **2009** | 3 | 0 | 0 | 7 | 4 | 0 | 3 | 0 | 0 | 0 | 1 | 1 |
| **SUM** | 7 | 0 | 5 | 31 | 14 | 6 | 11 | 0 | 0 | 1 | 4 | 1 |
| | 15% | 0% | 11% | 67% | 30% | 13% | 24% | 0% | 0% | 2% | 9% | 2% |

**Remote 39% Non-Remote 67%**

Table D.2 – MQ-1/ RQ-1 – Cause Mishap Frequency – Class A – AIB

| | LL | RP | HL | RE | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2000** | **0** | **0** | **0** | **1** | **0** | **1** | **0** | **0** | **0** | **0** | **0** | **0** |
| **2001** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **2002** | **0** | **0** | **0** | **2** | **1** | **0** | **0** | **0** | **1** | **0** | **0** | **0** |
| **2003** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **2004** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **2005** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **2006** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **2007** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **2008** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **2009** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **SUM** | **0** | **0** | **0** | **3** | **1** | **1** | **0** | **0** | **1** | **0** | **0** | **0** |
| | **0%** | **0%** | **0%** | **100%** | **33%** | **33%** | **0%** | **0%** | **33%** | **0%** | **0%** | **0%** |
| | | | **Remote** | **33%** | **Non-Remote** | **67%** | | | | | | |

Table D.3 – RQ-4 – Cause Mishap Frequency – Class A – AIB

| | LL | RP | HL | RE | PWP | AP | EE | HD | STR | ME | PE | ENV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2000** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **2001** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **2002** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **2003** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **2004** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **2005** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **2006** | **0** | **0** | **1** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **2007** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **2008** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| **2009** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **1** | **0** |
| **SUM** | **0** | **0** | **1** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **1** | **0** |
| | **0%** | **0%** | **50%** | **0%** | **0%** | **0%** | **0%** | **0%** | **0%** | **0%** | **50%** | **0%** |

**Remote 50% Non-Remote 50%**

Table D.4 – MQ-9 – Cause Mishap Frequency – Class A – AIB