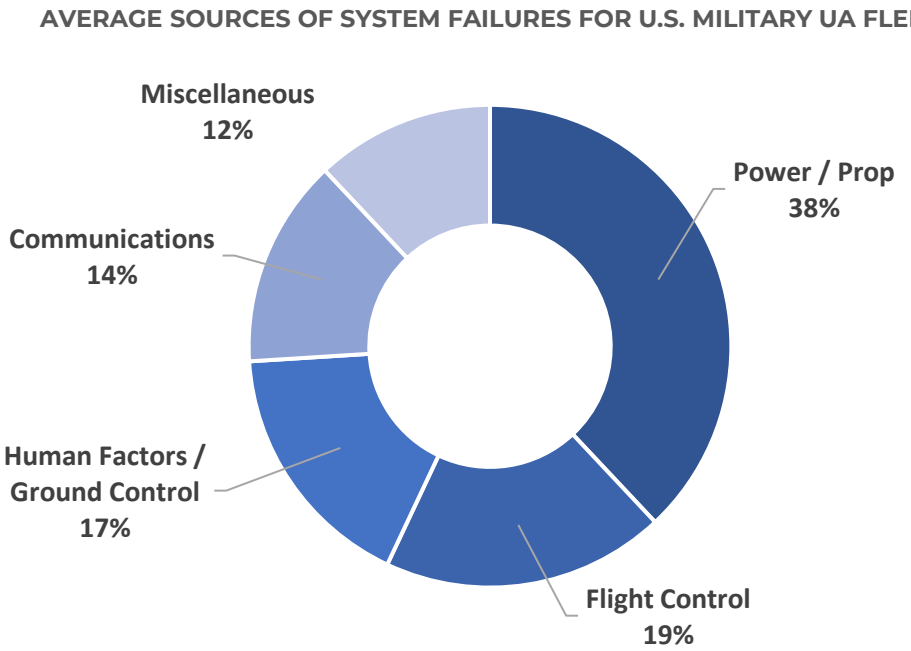
RELIABILITY SERIES 1 OF 5
DRONE CRASH CAUSES
#1 POWER / PROPULSION

In our last blog entry “Causes of UAV Loss” we explained what are the main causes of UAV losses and when they happen.

The US Department of Defense document “Unmanned Aircraft Systems Roadmap 2005-2030” uses the following definitions to categorize areas of a system failure leading to mission aborts or cancellations.



- **Power/Propulsion (P&P).** Encompasses the engine, fuel supply, transmission, propeller, electrical system, generators, and other related subsystems on board the aircraft
- **Flight Control.**
- **Human Factors/Ground Control**.
- **Communications**.
- **Miscellaneous**.

Now, let’s talk about cause #1, Power and Propulsion

Cause #1: Power and Propulsion

Power and propulsion are the most common cause of UAV crashes. A UAV engine and all subsystems in place to keep it running, are the most complex system in the UAV. The engine or motor is the only thrust source for the UAV.

An engine malfunction leads, most of the time, to losing the UAV and the payload.

Some sources of engine and propulsion failure are:

- Fuel exhaustion/starvation/mismanagement, batteries malfunction/depletion.
- Fuel contamination or wrong oil-to-fuel ratio.
- Carburetor icing.
- Fuel or power system malfunction.
- Propeller fatigue.
- Cylinder/valve failure.
- Ignition problems.
- Induction system blockages.
- Lubrication leaks
- Major internal failure
- Fatigue
- Power generation system failure

History

The first fatal airplane crash in aviation history? September 17th, 1908. On September 17th pilot Orville Wright was flying a Wright Flyer with Lt. Thomas Selfridge as a passenger, the flight trials were conducted at Fort Myer, Virginia, as part of the test required to win a contract from the U.S. Army Signal Corps.

Three or four minutes into the flight, a blade on one of the two wooden propellers split and caused the engine to shake violently. Orville shut down the engine but was unable to control the airplane. The propeller had hit a bracing wire and pulled a rear rudder from the vertical position to a horizontal position. This caused the airplane to pitch nose-down, and it could not be countered by the pilot. The Wright Flyer hit the ground hard, and both men were injured. Orville suffered a fractured leg and several broken ribs. Selfridge suffered a fractured skull and died in the hospital a few hours later.

Despite the crash, and the first passenger death in an airplane, the Army was significantly impressed with the Wright Flyer and allowed the brothers to complete the trials the following year. They were awarded the contract. Because of the crash, the first Army pilots were required to wear helmets similar to early football helmets to minimize the chance of a head injury like the one that killed Selfridge. Full article at: https://www.wired.com/2010/09/0917selfridge-first-us-air-fatality/

Here are some examples of crashes due to flight control issues

Oct 28, 2018 US Air Force MQ-9 Reaper Mid-flight Paktika, Afghanistan

Taliban posts photos of MQ-9 Reaper they claim to have shot down; the US says it simply crashed.

An unmanned aircraft suffered a malfunction and crashed in Afghanistan in late October, U.S. military officials say. It then wound up in Taliban propaganda photos, where militants claimed they shot down the drone.

Several pictures surfaced on Taliban channels over the past week, allegedly showing the wreckage of an armed U.S. Air Force MQ-9 Reaper drone with large trucks in the background. The serial number is legible on the aircraft wreckage, and what appears to be AGM-114 Hellfire missiles are laid out in a row beside the debris. The drone was supporting NATO's Resolute Support advise and assist mission in Afghanistan when it went down in the southeastern portion of the country last month.

"An MQ-9 unmanned aerial system crashed on Oct. 28 at approximately 1:30 a.m. in Paktika province due to engine failure. The UAS was destroyed that evening to prevent the capture of sensitive equipment," U.S. Army Maj. Bariki Mallya, a Resolute Support spokesperson, told Air Force Times.

The MQ-9 is predominately an armed hunter-killer drone, however, the aircraft is also capable of surveillance and intelligence collection. Mallya did not respond to questions about the authenticity of the pictures, whether there were concerns that sensitive equipment could have been captured or how the aircraft was destroyed.

However, standard procedure would prescribe an airstrike on the downed drone to prevent enemy capture of sensitive equipment, which includes the drone's sensor, cameras, and munitions, according to a former Air Force pilot who flew both the MQ-1 Predator and MQ-9 Reaper drones. "The approved solution would be to put a 500 or 2,000 [pound bomb] on it after it goes down," he said.

The four-bladed propeller among the wreckage indicates the aircraft was likely the extended-range version of the Reaper. The pictures were posted by a social media user who appeared to be a Taliban supporter, according to Bill Roggio, a senior fellow at the Foundation for the Defense of Democracies and editor of the Long War Journal.

"Often these are Taliban supporters that take the pics, then they may or may not get picked up by [Voice of Jihad] or the [Taliban] spokesmen," Roggio said. "Lots of times they wind up in the Arabic or Pashtun sites but not English."

In late October, before the pictures surfaced, the Taliban claimed on their official website that a "pilot-less spy plane was trying to gather intelligence when it was brought down in Gomal district of Paktika province," which is considered contested territory between the U.S.-backed Afghan government and the militants.

The former Reaper and Predator pilot said that the U.S. explanation made a lot more sense given the wreckage and known Taliban capabilities over the 17-year-long war in Afghanistan. "One blade is bent so that's probably where it hit the ground, whereas another blade is perfectly straight on the part of the propeller that didn't hit the ground," the pilot noted. "So my guess is the engine had stopped, otherwise maybe all of the blades would have been bent in the same direction if it was still rotating."

"The other thing I noticed is there are a lot of pieces, so it probably was a high-speed impact to maximize the destruction of the equipment," the pilot added.

Full article at: https://www.airforcetimes.com/news/your-air-force/2018/11/09/taliban-posts-photos-of-mq-9-reaper-they-claim-to-have-shot-down-us-says-it-simply-crashed/

July 5, 2016 US Air Force MQ-9 Reaper Mid-flight (Mechanical failure) Syria

EXECUTIVE SUMMARY
UNITED STATES AIR FORCE
ABBREVIATED AIRCRAFT ACCIDENT INVESTIGATION
MQ-9A, T/N 12-4177
UNDISCLOSED LOCATION
5 JULY 2016

On 5 July 2016, at 0408 Zulu (Z) time, an MQ-9A, tail number 12-4177, assigned to the 27th Special Operations Wing at Cannon Air Force Base (AFB), New Mexico, and deployed to an undisclosed location, crashed in an open area. While flying with the autopilot engaged, the aircraft experienced an uncommanded loss of thrust followed by an uncommanded descent. The Mishap Crew (MC), which consisted of two mishap pilots (MP1 & MP2) and one mishap sensor operator (MSO), were unable to regain normal engine control, but were able to guide the aircraft to a controlled crash, away from any persons, animals, cultivated plants, or manmade objects. The impact destroyed the MA with modifications, resulting in a loss valued at $15,922,806. There were no fatalities or damage to private property.

The Abbreviated Accident Investigation Board President found by a preponderance of the evidence the cause of the mishap to be an unrecoverable failure of the on-engine fuel control unit which resulted in insufficient thrust to maintain flight under any circumstance. Further, the board was able to rule out other malfunctions, anomalies, or defects of the command/control datalink, fuel, aircraft, or ground control station and any encounter with adverse weather, foreign object, or hostile fire.

Full report:
https://www.airforcemag.com/PDF/AircraftAccidentReports/Documents/2017/070516_MQ9A_Cannon.pdf

Nov 18, 2015 US Air Force MQ-9 Reaper Take-off phase (engine failure) Afghanistan

EXECUTIVE SUMMARY
UNITED STATES AIR FORCE
ABBREVIATED AIRCRAFT ACCIDENT INVESTIGATION
MQ-9A, T/N 08-4044
AFGHANISTAN
18 November 2015

On 18 November 2015, at approximately 2338 Zulu (Z) an MQ-9A, tail number 08-4044, assigned to the 27th Special Operations Wing at Cannon Air Force Base (AFB), and deployed to Kandahar International Airport, crashed in an open field near the base after declaring an in-flight emergency (IFE) shortly after take-off. The Launch and Recovery Element mishap crew (MC), consisting of one mishap pilot (MP) and one mishap sensor operator (MSO), noticed high oil pressure, rising exhaust gas temperature, and fluctuating torque immediately upon take-off. The MC reported the IFE and attempted a recovery to the runway; however, complete engine failure occurred on the crosswind leg at approximately 500 feet above ground level. The mishap aircraft (MA) glided to a crash landing as the crew attempted to circle around to land. The impact destroyed MA, four missiles, and one bomb, resulting in a loss valued at $14,391,950. There were no fatalities or damage to private property.

The Abbreviated Accident Investigation Board President found by a preponderance of the evidence the cause of the mishap to be a compressor bearing failure that led to engine loss. The Board President determined that the lack of an audible warning to indicate the high oil pressure associated with the bearing failure and the mishap crew's task saturation significantly contributed to the mishap.

Full report at:
https://www.airforcemag.com/PDF/AircraftAccidentReports/Documents/2017/111815_MQ9-A_Kandahar.pdf

Reference Library:

We have found very illustrative the following documents or web pages:

US Department of Defense: Unmanned Aircraft Systems Roadmap 2005-2030.
Although old, this document shows an in-depth understanding of how drones started to become a core element in military operations, the implications of UAV reliability, the regulatory framework, and the future of UAV development. The full document can be found at:
https://irp.fas.org/program/collect/uav_roadmap2005.pdf

Drone Wars UK: Accidents Will Happen
Drone Wars published a dataset of just over 250 large military drone crashes that have taken place over the past decade (2009-2018). You can find the links and document here:
https://dronewars.net/2019/06/09/accidents-will-happen-a-dataset-of-military-drone-crashes/

Dedrone: Worldwide Drone Incidents
This page keeps a log of all reported drone-related incidents worldwide, from a small drone invading airport airspace to a drone trying to deliver drugs and phones into a prison yard. Here is the info:
https://www.dedrone.com/resources/incidents/all

George Slensky: Analysis of UAV Military Aircraft Mishaps
Mr. Slensky analyses the main causes of US military aircraft both, manned and unmanned.
https://www.researchgate.net/publication/327135551_Analysis_of_UAV_Military_Aircraft_Mishaps