

Viability of Unmanned Aircraft Replacing Cargo Aircraft Pilots

Ryan Blakeney

Embry-Riddle Aeronautical University

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Abstract

The purpose of this research is to determine the viability of unmanned aircraft assuming the role of cargo aircraft for transporting packages and goods globally. Unmanned aircraft are becoming the latest in ground breaking technology for aviation. The first phase of this research is to determine if unmanned aircraft would be able to replace conventional cargo aircraft due to their large size. We compare current technology with tested technology to realize limitation in unmanned aviation. The final phase involves determining if the unmanned aircraft would be able to fly autonomously using predetermined routes and altitudes with manned aircraft while sharing the same airspace. By identifying these limitations, we will allow for the introduction of unmanned aviation in the cargo aircraft realm. This will open the door to expanding the unmanned system's role in creating more efficient and safe operations where human error has had devastating costs.

Keywords: unmanned aviation, manned, aircraft, limitations, cargo aircraft

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With the growing technology of unmanned aircraft systems, it is time to start looking into replacing conventional manned aircraft with these unmanned systems. This paper will compare the utilization of manned systems versus unmanned systems to see how unmanned systems in aircraft cargo operations would be beneficial. "In a recent survey of airline pilots, those operating Boeing 777s reported that they spent just seven minutes manually piloting their planes in a typical flight. Pilots operating Airbus planes spent half that time." (Markoff, 2015) The groundwork for replacing pilots has already started and is being used by those pilots today. Replacing pilots would allow for a more automated approach to moving cargo from one place to another.

Instead of having two pilots per aircraft who are limited by laws regulating their lifestyles and day, we could have one operator watch up to three aircraft at once as they move across the globe. "Most Scientists believe that pilot should have the opportunity for 8 hours of sleep in a rest

period. The current regulations do not ensure the opportunity for this amount of sleep. Pilots have filed reports with the National Aeronautics and Space Administration's Aviation Safety Reporting System that also documents the effects that work patterns have on pilot fatigue and performance." (Goode, 2003) Unmanned cargo aircraft would also allow for more aircraft thus more cargo to be transported at once due to no crew limitations.

Using automated aircraft can streamline traffic which can save on fuel which saves money and the environment. "The cost of delays to the airlines - mostly extra crew time and fuel - was over \$800 million. Because of delays airlines used an additional 700 million gallons of fuel over 8% of their total consumption for that year." (Levin, 1980) This also removes human error from allowing the aircraft to do things they shouldn't be doing during the flight from start to finish. This is because the aircraft would be able to fly preplanned routes and get to their destinations in one shot from start to finish with minimal changes from a human operator from afar.

Based on how the semi-autonomous Global Hawk operates, I predicted that cargo aircraft can outfit with unmanned systems to fly around the world without pilots. I believe with recent breakthroughs in UAV technology, we can replace the human factor in the transportation of cargo. Replacing humans in cargo aircraft is highly utilized by the United States military today. This allows for an aircraft to fly into harm's way without causing any danger to the pilot. This also reduces stress and physical limitations of the crew when the aircraft is flying, since most of these unmanned aircraft fly for 24 hours or longer at a time.

Another option that unmanned aircraft currently employ with the military is the ability to have preplanned routes throughout the flight. The aircraft can takeoff and immediately start following the preplanned routes and altitudes to get to its destination. With these preplanned routes, we are able to have the aircraft takeoff autonomously and fly the entire mission without human control. If we can remove the pilots from the aircraft and have it fly the preplanned route, it would allow for 100% predictability for the airspace controllers as the cargo aircraft travel through their territory.

Automated systems also keep the fuel usage to a minimum. The autonomy of the throttle to maintain its airspeed and altitude removed the pilots from making human judgement errors in computing the power required in all phases of flight. This would drastically improve the fuel efficiency of the aircraft by small percentages. These small percentages over time will accumulate and equate to large amounts of fuel saved." Virgin Atlantic estimates that shaving even a single pound off all the planes in their fleet would save them 14,000 gallons of fuel per year."

Background

Manned Major International Cargo Carrier Operations

Major international cargo carriers utilize a hub and spoke system when flying cargo from one location to another. The high activity airports are called hubs and the low activity airports are called spokes. “A duty is a working day of a crew that consists of a sequence of flights and is subject to FAA and company rules. Among other rules, there is a minimum and maximum connection time between two consecutive flights in the duty.” (Klabjan, 2002) Before these duties can be accomplished by the pilots, they must first have crew rest which in most cases is 12 hours. The duty day for each pilot varies, however most organizations abide by a 12-hour duty day and add supplemental crew if the flight will be longer.

The two pilots on the aircraft will fly the flight planned route that has been filed by their base of operations. They will make decisions in the flight to deviate or work around different obstacles such as weather or restricted airspace. The pilots will then arrive at the destination airfield and land the aircraft. Once they taxi in, the maintenance personnel will tow the jet to the appropriate location and unload the cargo. Depending on the length of the flight or the distance flown, the crew may be finished for the day. This means for the aircraft to turn to another flight will require a whole new crew to do everything that the previous crew did in the opposite direction. When these crews are flying, they will be using pilot judgement and experience to get the jet in the best location with the best settings to get from point A to point B.

Unmanned Aircraft Operations Utilized by The United States Air Force

Unmanned operations are currently the most requested assets in the middle east. The unmanned aircraft are able to take off and fly for over 24 hours without refueling and land without putting a pilot in danger. The Air Force utilizes what it calls “Remote Split Operations.” This means that an operator is forward deployed to launch and recover aircraft at their hub. Once the aircraft is airborne, the mission pilot will connect to the aircraft via a satellite link and fly the aircraft throughout the mission. While the aircraft is airborne, the mission pilot will switch out with other pilots when they need a break or when they hit their duty day.

Having the ability to swap pilots in mid-flight allows the aircraft to fly for extended periods of time unheard of in the manned world. “In 2014, an RQ-4 Block 40 flew a 34.3-hour flight, setting the endurance record for longest unrefueled flight by a U.S. Air Force aircraft.” (Air Force, n.d.) During the 34.3-hour flight, the global hawk crews swapped out multiple pilots to keep the aircraft aloft all while continuing their mission seamlessly. This allows for extremely long distance flights without concerns about the aircrew limiting their ability to travel.

When the pilots arrive to fly, they have received the appropriate amount of crew rest. They will get updates on where the aircraft is and any maintenance issues on the aircraft. They will then step to the mission control element and take over from the pilot that is currently flying. At any time during their flight, if they need a break or if they get sick, they can be relieved by a standby pilot. This allows extreme flexibility in scheduling and operations for unmanned aircraft. Once the pilot reaches their duty day of 12 hours, they can proceed home and get crew rest to then arrive back to work again to fly the same aircraft that they flew the day prior. There are many instances where a pilot will take an aircraft off the ground and get it on-station. They will go home and come back to work to continue flying this aircraft and maybe return it to base to land.

Mixed Information On Manned and Unmanned Pros and Cons

Both manned and unmanned pilots require crew rest. Current FAA regulations state “The allowable length of a flight duty period depends on when the pilot’s day begins and the number of flight segments he or she is expected to fly, and ranges from 9-14 hours for single crew operations. The flight duty period begins when a flight crew member is required to report for duty, with the intention of conducting a flight and ends when the aircraft is parked after the last flight.” (FAA, 2011) “The FAA limits flight time – when the plane is moving under its own power before, during or after flight – to eight or nine hours depending on the start time of the pilot’s entire flight duty period.” (FAA, 2011) The Air Force regulations state “Crew rest is compulsory for aircrew members prior to performing any duties involving aircraft operations and is a minimum of 12 non-duty hours before the Flight Duty Period (FDP) begins (T-2). Crew rest is free time and includes time for meals, transportation, and rest. This time must include an opportunity for at least 8 hours of uninterrupted sleep. Crew rest period cannot begin until after the completion of official duties” (USAF, 2016)

When manned cargo aircraft fly, they require two pilots to man the controls and they fly the flight plan route that is given to them by their base of operations. When unmanned pilots fly, they only require one pilot for the duration of the flight and they can have the aircraft follow set parameters autonomously to achieve their predetermined flight performance. The cargo pilots must use pilot experience to keep the performance of the aircraft in check. The unmanned pilots allow for the computers to run algorithms and decide how to manipulate the controls and throttle to get the best performance during the flight.

Can Unmanned Aircraft Be as Large as Cargo Aircraft

When looking into the size possibilities for unmanned aircraft, there may be an immediate no as the answer. The reason for this is because most people are aware of small quadcopters that are flown in neighborhoods or in someone’s backyard. These are simply small to make it easier for hobbyist to fly at their leisure, wherever they feel like flying that day. If we look to NASA we

would find a whole different story. In 1984 NASA flew a Boeing 720 into a controlled impact demonstration to test a fuel additive. “An obsolete Boeing 720 four-engine airliner was obtained from the Federal Aviation Administration for the project, which would conclude with an intentional crash-landing of the remotely piloted aircraft into several steel structures set up on the bed of Rogers Dry Lake at Edwards Air Force Base to breach the fuel tanks in the wings.” (Dunbar, 2015) The large aircraft was flown around for a few hours to double check its remote control systems and was then flown into the test.

The United States Air Force currently employs the RQ-4 Global Hawk. This aircraft has a wingspan of 130.9 feet. It has the ability to fly 100% autonomously without pilot intervention. These aircraft demonstrate that even in 1984, we have been able to remotely fly large aircraft that have the ability to transport cargo. The Global Hawk shows that technology has advanced enough to allow for autonomous operations. Every single day, these large aircraft maneuver through weather and get to their destination without incident. They land on their own while being monitored by the pilot.

The technology to allow this to happen also has the ability for one pilot to monitor up to three aircraft at a time. If we take two pilots out of three aircraft and replace the six pilots with one pilot. We will save on fuel and crew limitations over the course of time. With these examples I am positive that with current technology, we can fly large cargo aircraft remotely without pilots onboard.

Limitations of Unmanned Aircraft

Limitations for unmanned aircraft spread across the spectrum. There are instances in different areas of interest that effect operations of these UAS (Unmanned Aircraft Systems). One of those areas is operations in the NAS (National Airspace System). Due to HR. 658 that congress signed into bill in 2012, no unmanned aircraft can fly in the NAS without a Certificate of Authorization. These waivers are difficult to obtain due to the nature of the NAS and the hesitation of the FAA to trust unmanned aircraft.

There have been many strides in this area but the big picture for unmanned aircraft is that they cannot make and new plans quickly. The routes and destinations that any unmanned aircraft flying through the NAS want to go, are required to be vetted and signed off by the FAA. This process would make is difficult for cargo aircraft wanting to fly to an alternate airport if one of their main spoke airports is shut down due to maintenance or an accident that may have shut down the runway.

Another limitation that would affect unmanned cargo aircraft is bandwidth. To fly unmanned aircraft, you require a type of command and control link to the aircraft to maintain control and telemetry. This is the system that allows the pilots to monitor the aircrafts location and performance during the flight while also talking on the radios as if they were actually there. Without bandwidth, the unmanned aircraft will not be able to fly. This will become a larger issue over time as the companies that adopt these systems utilize them. The more aircraft that are operating at a time, the more connections that would be required over satellite. Without these connections, the aircraft will be unable to be controlled by their ground operators. If we cannot control or monitor these aircraft, we would not be able to intervene in certain situations such as an emergency.

Are The Limitations Worth it

With these limitations outlined, we must ask ourselves if it is worth converting the current cargo aircraft fleet from manned to unmanned. By having pilots onboard, we are required to adhere to the crew rest and flight duty period requirements of the two individuals flying the aircraft. If we are utilizing an unmanned system, we would only have to worry about the crew rest and flight duty period of one pilot over one or more aircraft.

By having two pilots onboard we will not have to worry about bandwidth concerns for having command control links to the aircraft. The two pilots would fly the aircraft like normal and would not cause any traffic on the spectrum when determining how to allocate usage over the satellite. This would also save money as satellite usage is expensive and over the course of a flight with multiple aircraft, it can add up to an expensive bill over time. This can be avoided by simply having the aircraft fly autonomous without an operator watching the system, however this would be further into the future when technology would allow the aircraft to deviate on its own based on a logic system tied into weather radar and the traffic avoidance system.

By removing the pilots from the aircraft, we remove the operator's ability to physically monitor the jet. Physically being with the aircraft allows the pilots to have a larger situational awareness than someone who is monitoring from thousands of miles away. "Situation awareness is formally defined as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future"" (Endsley, 1999) In aviation, situational awareness is one of the most important aspects of flying safely for yourself and those around you. Removing the pilots from the aircraft will greatly decrease the situational awareness of the operator to the point where they may not notice small changes in the flight of the aircraft in case something is going wrong.

Removing pilots from the aircraft also reduces weight that is being carried on the aircraft. When looking at fuel savings over the course of time, even small reductions in weight increases fuel efficiency. “American Airlines claims that by switching from paper to iPads, they will save 1.2 million dollars in fuel over the course of a year.” (Allain, 2012) The average bag of aircraft flight manuals that are carried by pilots weighs approximately 35 pounds. By replacing these with two 1.5 pound iPads, the airlines were able to save 1.2 million dollars. If that much fuel can be saved by removed 32 pounds from each flight, imagine remove two grown adults from each flight. The average weight of a human is 180 pounds. By removing 360 pounds from each aircraft for a full year would save large amount of gas being burned. This would not only save money but the environment.

Strategy to Implement Unmanned Systems into Cargo Aircraft

To implement unmanned systems into cargo aircraft I would recommend starting with a small fleet of smaller aircraft. I believe using a small fleet of smaller jets will allow the company to understand the risks and see what limitations would come from the small fleet. This would allow them to see how the limitations would affect larger aircraft and larger fleets. I believe over time the company would do well in investing into either more safety mechanism in the aircraft or investing into more satellite coverage for their routes of flight.

By removing the pilots, it will be more difficult for an autonomous aircraft to deviate when necessary for weather or other traffic. This will need to be immediately addressed in the unmanned aircraft because this will make these aircraft unsafe without someone or something monitoring its progress. Having pilots onboard eliminates these two risks but since they will not be onboard, it will be up to the manufacturer or the operators to ensure safe operations of the aircraft.

Another strategy that should be implemented is canned flight routes. Since most cargo companies fly to the same airports every single day, this should not be an issue. By having canned flight routes, we can preset the unmanned aircraft to fly the same route, altitude, and airspeed every single day. One thing that the FAA really wants out of unmanned aircraft flying in the NAS is predictability. If they know where the aircraft is going to be at any given time, it allows for them to work other aircraft around them or even deviate the unmanned aircraft themselves in time of need. This will also allow a streamlined process with the unmanned systems. You could have all the jets either take off at the same time or have them staggered so that they may start their engines 20 minutes apart. This would allow for equal spacing between them and allow them to taxi and takeoff without being concerned about conflicting with other unmanned aircraft.

To initially start the testing for this system, I would recommend they begin with installing the system on current aircraft and letting the system fly with pilots onboard. They would be available at all times to act in case something was to go wrong. By doing this, the operators will be able to test the systems and allow them to make mistakes early so that normal operating procedures can be established. Over time we can remove one pilot from the aircraft and simply have one pilot monitor while the operator from the base of operations flies the aircraft. As these test progress and more advances are made in the decisions on how to further implement the system, the pilot can be removed. This would allow for 100% unmanned flight in the cargo aircraft enterprise. By removing the pilots, we will have taken steps in the future of having an automated system allowing us to transport goods and services more safely and economically around the globe.

Conclusions

Based on the research for this idea, I believe that having unmanned cargo aircraft is the future. We have proven that the technology has existed for many years to fly large aircraft by remote control. With recent technology and current systems utilized by the United State Air Force, we already have the architecture built to begin testing and implementing these systems. By having the pilots on board the aircraft, we limit our ability to fly further for longer with cargo. If we take the human factor out of the equation, it allows us to plan moving goods and services based on the needs of the company and not the limitations of the crew.

By removing the pilots, we have shown that the weight reduction will save money over the course of time with a large fleet of aircraft. By reducing the weight, we give more weight options to carry more goods, or to save in fuel. The fuel savings from small amounts of weight, would help compensate for the expenses required to operate the aircraft from long distances. Removing the pilots would also reduce overall situational awareness of the operator, however this can be overcome by having a constant connection to the aircraft or implementing see and avoid systems on the aircraft to allow it to deviate when required for the safety of flight.

Having preset canned flight plans would allow for the aircraft to be 100% predictable in the NAS. This would make it easier to acquire permission from the FAA to fly when and where we need to, to move goods and services. This would also help in keeping the skies in a more highway like fashion to keep from overcrowding or overloading certain air traffic control areas.

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