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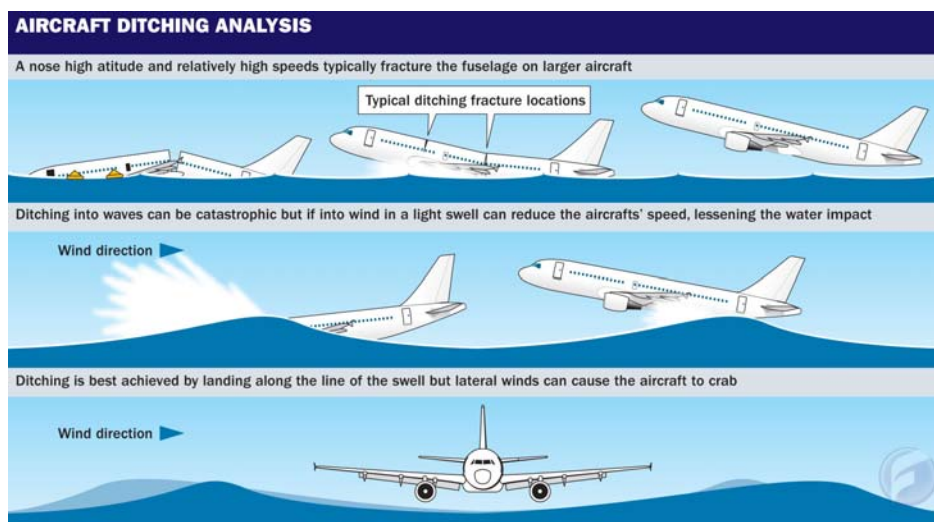
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THE CONCEPT OF DETACHABLE ENGINE PYLONS IN JET AIRLINERS

The paper provides the new conception for improvement of safety in commercial passenger flights, especially during ditching, fuel exhaustion and engine breakdown causing irreversible impossibility of re-ignition engines during the flight. This solution is designed for jet airlines with engines mounted in pylons under the wings.

In November 1996 Boeing 767-260ER, Ethiopian Airlines Flight 961 that was previously hijacked and run out of fuel crash landed in sea. Due to drag force asymmetry caused by not simultaneous contact with water surface of both engines and plunging moment of engines beyond fuselage outline the fuselage was torn apart, killing 122 people on board. You could say that engines mounted in tail section of a plane could prevent it. For sure yes. But such mounting of engines in a plane has one particular weakness namely parts of engine rotating with high rpm in case of breakdown if they separate due to centrifugal force could damage rudder steering or, what is worse, pitch steering as for example in Il-ushyn Il-62 crash in Warsaw, 1981. Another cases of ditching are: a16 January 2002, Garuda Indonesia Flight 421 (a Boeing 737) successfully ditched into the Bengawan Solo River near Yogyakarta, Java Is-

land after experiencing a twin engine flameout during heavy precipitation and hail. The pilots tried to restart the engines several times before making the decision to ditch the aircraft. Photographs taken shortly after evacuation show that the plane came to rest in knee-deep water. Of the 60 occupants, one flight attendant was killed. The survival rate was 98 %. On 2 May 1970, ALM Flight 980 (a McDonnell Douglas DC-9-33CF), ditched in mile-deep water after running out of fuel during multiple attempts to land at Princess Juliana International Airport on the island of Saint Maarten in the Netherlands Antilles under low-visibility weather. Insufficient warning to the cabin resulted in several passengers and crew still either standing or with unfastened seat belts as the aircraft struck the water. Of 63 occupants, 40 survivors were recovered by U.S. military helicopters. The survival rate was 63 %.



Aircraft ditching analysis; Source: flightglobal.com

In case of fuel exhaustion or engine failure excluding possibility of re-ignition of engines the front surface of engines causes huge drag force seriously affecting glide ratio of a plane. For example Air Canada Flight 143, a Boeing 767-200 jet, ran out of

fuel at 26,000 feet (7,920 m) altitude, about halfway through its flight from Montreal to Edmonton via Ottawa. The crew was able to glide the aircraft safely to an emergency landing at Gimli Industrial Park Airport, a former Canadian Air Force base at

Gimli, Manitoba. So called “Gimli Glider” managed to glide safely to an airfield however part of the facility had been converted to a race track complex, now known as Gimli Motorsports Park. It includes a road race course, a go kart track, and a dragstrip. Furthermore, a CASC amateur sports car race was underway that day and the area around the decommissioned runway was full of cars and campers. Only due to lucky coincidence nobody of the 61 passengers were seriously hurt. The glide ratio was approximately 12:1. Without huge surfaces of engines giving enormous drag force the glide ratio would be much greater, giving the pilot possibility of glide flight to an airport equipped with facilities like fire fighting brigades and medical care. But not every gliding flight ended so luckily Avianca Flight 52 was a regularly scheduled flight from Bogotá to New York via Medellín, Colombia. On Thursday, January 25, 1990, the aircraft performing this flight, a Boeing 707-321B registered as HK-2016, crashed into the village of Cove Neck, Long Island, New York after running out of fuel. Eight of the nine crew members and 65 of the 149 passengers on board were killed.

The third case is when one engine breaks down and causes drag asymmetry that should be compensated by appropriate rudder deflection.

The another reason for using our invention is engine fire which would likely expand endangering the whole structure of an aircraft.

Concept description:

The solution for this problems is detachable engine pylons which after being detached could fall freely on the parachute to the surface of land. In centre of gravity of the engine pylon would be mounted a tray with component similar to available the market readymade product Ballistic Recovery System (United States Patent 4607814). The largest and most capable parachutes from BRS were originally certified on Cirrus Design’s SR20 aircraft, which was certified in October 1998 as the first aircraft to have a whole-airframe parachute system installed as standard equipment. The SR22 has a slightly different design. The canopy is deployed by a solid fuel rocket motor with manual activation. Deployment occurs within one second and canopy inflation follows rapidly. The canopy is attached to the airframe via 15,000 pound (6,800 kg) and Kevlar Bridles. The Cirrus Maximum Gross Weight is about 1542 kg and the mass of the Boeing 737 engine is about 1950 kg. So that after slight redesign BRS made for Cirrus could serve for safe bringing down engine pylon without causing any harm to people on the land



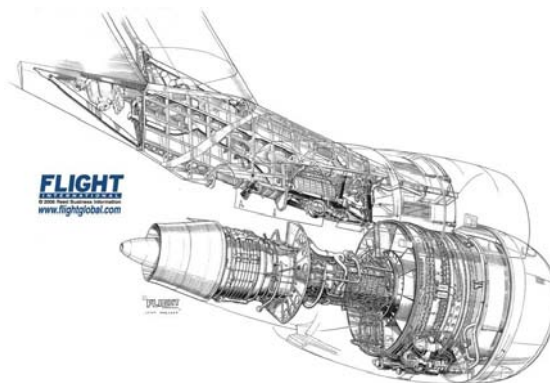
Ballistic Recovery System for light aircraft; Source: sportflyingshop.com

The engine is suspended to an aircraft’s wing by bolts in which there would be an explosive material with an igniter attached to it that would break the bolt or, alternatively, bolts might be connected with the structure by a simple mechanical lock that could be open in case of an activation of the system. This is the captain who is responsible for deployment of the system. There should be appropriate checklist and procedures regulating under which circumstances the deployment would be reasonable such as because using the system would be irreversible. After deploying igniter the bolts will burn or melt causing disconnection engine pylon forced by net force

of gravity and drag force. After appropriate period of time providing safety distance from a plane the BRS equivalent would be deployed. Engine pylon would be brought down in one piece on the Earth surface so that it could be examined by air incident investigators. The cables that link engine and engine aggregates with a plane should have fittings that could be easily disconnected and fuel line as well as cables which transport liquid medium should be fitted with ball valves that would prevent possibility of leakage in case of disconnection. The cables should be screened from wing/pylon attach points by incombustible bulkheads due to prevent fire during system

activation. In further research it should be taken into account how system deployment would affect flight for example if we got rid of one pylon would it cause with the spin tendency or such a sudden loss of weight of an aircraft would lead to uncontrollable change in horizontal and longitudinal balance or stress in the wing-fuselage connection, as we can observe in firefighting planes during the waterdrop. The operation of the system is calculated for detachment of the engines only in straight and level flight, so that forces of gravity and drag make them separate straight down in the configuration not threatening the wings. The construction of an engine pylon should be designed in the way that enables using an easy-breaking material in the place, where the BRS is mounted, as in case it is fired the parachute may exit the pylon and open freely. The BRS tray must be connected with the engine by belts encircling the engine inside the pylon structure in such way that the whole unit can fall horizontally. Belts have to be high-temperature resistant to prevent them from melting or losing their strength in a hot environment of a working engine. The time between the drop of the engine and BRS ignition should be long enough to let the pylon lose its progressive speed.

The pylon should smoothly fit the wing surface in a way making it easy to detach the engine, so that after the system ignition there will not be any part of the pylon left, disturbing the airflow and creating the drag. Before mounting the system on an aircraft, an aerodynamic research should be made in the wind tunnel to designate the new polar speed (which shows speeds such as: optimal, economical, stall speeds and so on), as the aerodynamic characteristics would likely change a lot if engine pylons were removed. The installation shall have a variety of safety features preventing an accidental ignition, including a necessity of first officer confirmation that use of the system is essential, as well as technical protection, which would make sure that in case of e.g. electric fault the system would not be activated by itself. Of course, we are aware that circumstances in flight like those shown previously happen statistically rarely, but we think that any way of improving passengers safety seems to be well worth it especially when it is relatively cheap and technically easy to achieve, such as our one certainly is, because it is based on developments that already exist and are ready to use.



Aircraft's engine mount cross-section; Source: www.flightglobal.com

Advantages of a detachable engine pylons system:

- Relatively slight influence on the aircraft's overall mass increase;
- Increased survival factor of passengers and crew in cases of water-landing and loss of power;
- Low cost of developing, because of use of the already existing solution, yet available on the market;
- The system is designed for commercial jetliners with engines mounted in pylons under the wings, which are the majority of the market at the time.

Disadvantages of a detachable engine pylons system:

- Irreversibility (once used, the plane cannot be brought back to its initial configuration);
- Threat of accidental activation;
- Possibility of harming people on the ground damaging buildings;
- Use of the systems is limited only to planes with jet engines mounted under the wing;
- There is a possibility that the pylon after detachment and landing on the ground might not be found, which would make it impossible to examine by the team of air crash investigators.

After engines rejection all on-board systems essential to continue the flight, such as power to support steering or instruments could be powered by the Ram Air Turbine (RAT) or the Auxiliary Power Unit (APU) if the fuel supply is suitable.

After the crew's initiation, the system should work entirely by itself and start all of its systems automatically in a proper preset sequence (igniters, pause for detachment and braking, detonation of BRS), which would reduce pilots' workload and let them focus on finding the solution for an emergency situation they would experience.

When creating the procedures the possibility of a too hasty and unconsidered use of the system need to be excluded, as there is a possibility that engines which previously had failed or had lost power would recover and be back in use during the flight, as it have happened quite a few times in history already, like in June 1982 when British Airways flight no. 9 Boeing 747 flew into a cloud of a volcanic ash above Indonesia resulting in the failure of all four engines. The reason for the failure was not immediately apparent to the crew or ground control. The aircraft was diverted to Jakarta in the hope that enough engines could be restarted to allow it to land there. The aircraft was able to glide far enough to exit the ash cloud, and all engines were restarted (although one failed again soon after), allowing the aircraft to land safely at Halim Perdanakusuma, Jakarta's airport.

We must take under consideration that after rejecting its engines, a jetliner turns into a huge glider, which requires very good flying skills and a wise tactic of height management from the pilots, so it should become an inherent part of pilots' training (especially on flight simulators that would make it possible to check

how the crew handles the aircraft in such situations) after the system's implementation.

It might also be considered to automatically start the system under some circumstances, like sudden and irreversible damage of an engine, for example in case of a birdstrike, which occur on relatively low altitude giving pilot very little time to act. Such solution would save a few valuable seconds during which the crew would have to do a checklist and engines detach procedure. Of course, the automatic detach shall only be possible above a determined height letting the BRS to inflate and decrease the vertical speed of the pylon to a level which would let it land softly and not threaten people on the ground.

Conclusion:

In conclusion, our project is, as far, only theoretical and presents just an idea which we think might be worth to consider for use in civil aeronautical industry. But after proper calculations and expanded research we believe that detachable engine pylons can be used in practice with very good results. Of course to be completely sure we would need and access to professional laboratory facilities, such as wind tunnel and special computer programs to get complete data.

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