Does Aerial Refuelling have something to offer Commercial Air Transport?

Introduction

The aim of this article is to stimulate debate on the practicalities of introducing air to air refuelling to mainstream commercial aviation.

Certain aspects like the history will only be dealt with in brief as the subject is dealt with in a number of excellent books. The article contains some bold statements as a means to stimulate debate.

Vision and Mission

In 1990 Boeing delivered two B747 aircraft to the USAF designated VC-25. Principal differences between the VC-25 and the standard aircraft are the interior, the specialist communications, front and rear air stairs and the capability for aerial refuelling.

The VC-25 first flew as Air Force One on September 6 1990 and has been in extensive use since then employing aerial refuelling to allow operation from short airports while retaining almost unlimited range and endurance.

Using the same proven technology and techniques would allow an airliner to depart London with a full compliment of passengers and freight and fly non stop to Sydney. It could take off using de rated thrust, climb quickly to best cruising altitude and use aerial refuelling to achieve a direct flight.

I also believe an Air Freight Company could coordinate its operations so that medium haul tanker freighters routinely use aerial refuelling to extend the reach and payload of its own and other companies long range freighters.

For extended commercial use current public private finance initiatives must be extended so that current military tanker assets will be available to sell fuel to commercial flights.

A Brief History

According to the US Centennial of Flight Commission aerial refuelling was discussed as long ago as 1917 by a Russian pilot who subsequently moved to the USA and became an engineer in the War Department. He applied and received the first patent for air to air refuelling in 1921.

During the 1920s and onwards a number of pilots established duration flying records. In July 1930 the record was 647.5 hours in the Curtiss Robin Monoplane “Greater St Louis” nearly 27 days in the air!

By 1934 Alan Cobham had established the firm Flight Refuelling Limited to manufacture equipment that enabled aerial refuelling to be used routinely. Cobham thought aerial refuelling would have great advantages for commercial aviation.

Sir Alan did not anticipate the considerable technological advantages that would subsequently occur in war and peace to allow military and civil aircraft to carry greater payloads faster and further.

The mission extension that aerial refuelling offered military aircraft, especially smaller fighter bombers, plus the strategic issues surrounding the Cold War and the delivery of Nuclear Weapons ensured that aerial refuelling was widely adopted.

How does it Work?

This brief explanation is extracted in part from "Range Unlimited" a history of aerial refuelling. For the purpose of this paper I will only refer to refuelling using the boom method because of the much higher delivery rates possible and the relatively simpler task for the receiver aircraft of having to fly in close formation while a boom operator ensures contact.

The preparation for aerial refuelling starts with the planning and coordination of the rendezvous point. The geographical area used may be a designated piece of reserved airspace (see UK Charts) or a remote area outside controlled airspace.

For an enroute rendezvous the tanker and receiver both plan to arrive at the same point, at the same time, with a thousand feet separating the two aircraft. Aids to achieving this include radar (ATC and on board), TCAS, Air to Air TACAN, enhanced vision systems, FLIR, night sights etc.

For a point parallel rendezvous the tanker arrives some minutes prior to the receiver and flies a hold. Once the receiver arrives the tanker manoeuvres to roll out in front of the receiver with a thousand feet altitude difference.

There is much more detail to the planning of this initial rendezvous that can be found elsewhere. The receiver aircraft has to close to the pre contact position, approximately 30 feet behind the tanker and slightly below.

There is a lot of skill involved in achieving this smoothly, quickly and safely and work would have to be done on the use of autopilot modes and auto throttle use etc. The receiver pilot uses lights on the bottom of the tanker to gauge his position and altitude relative to the tanker. Once in position the boom operator extends a fly by wire boom nozzle into the receptacle of the receiver (there is a universal receptacle design for commonality).

Once in contact the refueller turns on the appropriate pumps to ensure transfer at between 3 and 4 tonnes per minute depending on equipment.

Turbulence?

Aerial refuelling is routinely continued in conditions of light turbulence because it affects both aircraft equally causing them to move up and down together.

Breakaway!

Any time an unsafe condition is observed by any crew member on either aircraft a "breakaway" is called. The tanker pilot advances his power levers; the boom operator moves the boom clear of the receiver. The receiver pilot reduces power to idle and descends to 1,000 feet below the tanker. Once clear the breakaway can be terminated and the aircraft rejoin.

Airspeed and Altitude?

This depends on the type of receiver and the amount of fuel transferred but I have heard of refuelling taking place anywhere from a 1,000 to nearly 40,000 feet. The commercial advantage is that the receiver aircraft may only have to descend 5-10,000 feet from optimum cruise to take on fuel.

The penalty for an enroute rendezvous could be very small, perhaps a tonne of fuel and a few minutes lost while extending an aircrafts range.

Some Drivers for Commercial Aviation to Adopt Aerial Refuelling.

Political

Since the end of the cold war commercial aviation has been granted access to air space over Russia, China and other countries that have significantly reduced flight times.

These expeditious routings rely on international co operation and goodwill between some markedly different political systems. Unfortunately, the current political climate between Russia and America has deteriorated.

This is a complex issue, partly due to a more hard-line approach from Russia and their concern over the building of an American missile defence system in Europe. Russia has just re introduced long range bomber patrols after 15 years of inactivity.

There is also some friction between the USA and China over exchange rates and the global economy. At the time of writing global stock markets are suffering extreme volatility.

Further deterioration in the relationship between Russia, China and the West might result in sanctions. There is a small risk, difficult to quantify, that such sanctions might see

some flag carriers having to return to the longer routes used 20 plus years ago and this would have a significant commercial impact.

Brand Enhancement

Returning to the vision statement, the first airline to run a non stop service between London and Sydney would receive a considerable amount of global publicity and have a unique selling point over its rivals.

Notwithstanding the risks involved, previous technological advances like auto land capability and the introduction of a supersonic airliner did have significant brand benefits for the airlines who led the way.

Technological

The aerospace industry has produced some ground breaking aircraft but within current limits we still do not have an aircraft with the absolute and range and payload that the market would like. Current technological improvements like retro fitting winglets on a B767 might increase range by 325miles.

The B787 promises much and will apparently be able to fly considerable distances with a reasonable payload. But, even using very advanced composite structures, better aerodynamic design and more efficient engines we cannot fly direct from Europe to Australasia with substantial commercial loads.

Economic

Many aircraft depart airfields with reduced payloads because of performance constraints. Sometimes freight or passengers are left behind, sometimes tech stops occur because of unfavourable headwinds and holding at destination. Many long range flights are planned with reduced payloads to remain safe and viable.

Aerial refuelling would allow such a performance constrained flights to easily uplift 30 tonnes of fuel en route. How much further would your aircraft type fly if you could add that much fuel in the cruise?

According to information on the web, Global Air Tanker Service states that they can deliver fuel for $8.5 per gallon (roughly $2,800 tonne).

I believe the cost could be much reduced if the tanker aircraft was also carrying a commercial payload and some supportive data is provided later in the article.

Assuming that costs can be reduced, on some routes, relatively small amounts of fuel transferred in the cruise would be sufficient to avoid a tech stop or improve payload such that the benefit would justify fuel at say $2,000 tonne.

Environmental

Direct flights with full aircraft would lower the relative environmental impact. This assumes we can routinely coordinate flights such that the fuel is quickly and efficiently transferred and that the tanker is also carrying a commercial load.

The Market

Some business passengers and freight movers will pay a premium for a direct long haul flight.

Safety, Training, Insurance, Regulation and Certification

Safety

Difficult to provide absolute proofs for a technique that has remained exclusively military for so long. One could claim that aerial refuelling between large aircraft using the Boom method is comparatively safer than a commercial airliner flying a non precision approach.

Some examples of the level of tanker activity include Vietnam from 1965 until cessation which accounted for 195,000 sorties, 814,000 refuellings and almost 9 Billion pounds of fuel off-loaded.

Desert Storm statistics for the KC 135A/R/Q include 9,897 sorties, 27,390 refuelling and the transfer of 353 million pounds of fuel.

If aerial refuelling is considered safe enough for Air Force One should we not at least consider it safe enough for commercial consideration?

Training

Many commercial pilots have experience of aerial refuelling. Some military reserve pilots are remaining current and only a relatively small number of pilots in an airline would require training.

The military operating procedures that have matured over 50plus years could be adopted for commercial use.

Insurance

The industry was able to obtain cover for previous technological advances like auto land and super sonic flight. It should be able to persuade brokers to support aerial refuelling and they may already do so where the “military tanker” is actually owned and run by a commercial company.

Regulation

On the basis of the very good safety record aerial refuelling has achieved with the military over the past 30 years. I believe a case could be put, with safeguards that would persuade them to allow its limited use in commercial aviation.

Certification

Not an area on which I have much knowledge but a number of existing civilian types have been converted by aircraft manufacturers for use as Multi Role Tankers for the military. On that basis I will assume civilian certification is achievable.

An American company Omega Air developed the FAA's first certified civil tanker aircraft based on a B707.

The Tanker Market and a brief examination of Types

The Market

The USAF operates some 500 tanker aircraft. Since WW2 Boeing has produced 2,000 tanker airframes and we are in the midst of a competition for a USAF replacement aircraft. The market for tanker/freighter aircraft is large.

Synergies

Other Air Forces have fewer numbers than the Americans but assets are based in some very useful positions including the UK, Alaska, California, Australia, Qatar and Japan to same but a few.

If more commercial providers/contractors were allowed to employ tanker freighters for joint civil military use this would significantly reduce the cost per gallon of aerial refuelling.

A310 MRTT Multi-Role Tanker Transport, Europe

The Airbus Industrie A310 MRTT is a wide-bodied multi-role tanker transport aircraft derived from the Airbus A310-300 civil passenger and transport aircraft.

It is powered by either General Electric CF6-80C2 or Pratt and Whitney PW 4152 engines. The A310 MRTT is capable of being readily converted to the following roles: air-to-air refueling tanker, all-cargo transporter, medical evacuation aircraft, and an all-passenger transporter or combination of VIP, passenger and cargo transporter.

Four A310 MRTT aircraft are in service with the German Air Force. The first took its maiden flight in December 2003 and was delivered in October 2004. The A310 were already in service with the German AF as transports and aircraft conversion for in-flight refueling was carried out by Airbus Deutschland and Lufthansa Technik.

For the air-to-air refueling (tanker) role, the aircraft is equipped with five centre fuel tanks or Additional Centre Tanks (ACT). The total fuel capacity is up to 96,920l (25,605USgl), which corresponds to 77,500kg (171,000lb).

In an all-cargo transport role, the maximum non-fuel payload is 37t (81,600lb). For the troop transport role, the aircraft can provide up to 214 seats. In a combined cargo / troop transport, 12 pallets and 54 troops can be carried.

Cockpit

The multi-role tanker transport is operated by a flight crew of three for all missions relating to Air-to-Air Refueling (AAR): two pilots and the AAR operator. The AAR operator station is located in the cockpit just behind the captain. The two pilots have direct access to the majority of the information and controls concerning the AAR operational and safety aspects.

Tanker Systems

The MRTT is capable of transferring 33t of fuel during a 3,000nm trail operation or 40t of fuel at 1,000nm with two hours on station. Fuel transfer during air-to-air refueling is achieved by using the aircraft's centre tank as a collector tank. The fuel management system and the centre of gravity computer ensure automatic tank sequencing, centre of gravity control and engine fuel feed control.

A flying boom system can be installed, which is capable of transferring fuel at a rate of 1,200USgl/min.

Avionics

The tanker aircraft is equipped with the avionics systems installed in the A310-300 civil aircraft to ensure the operation of the tanker under civil air traffic control. The military avionics systems installed on the tanker are the V/UHF system, an IFF system and an AIR TACAN.

The avionics suite can include a Global Positioning System (GPS), satellite communications, an Aircraft Communications Addressing and Reporting System (ACARS) and a Traffic Collision Avoidance System (TCAS).

The KC-30 Tanker or Airbus A330

The KC-30 Tanker Aircraft is a derivative of the multi-role tanker that already has been selected for service in the air forces of Australia and the United Kingdom. The KC-30 offers full operational flexibility for cargo, passengers and aeromedical evacuation.

The KC-30 is derived from the A330 widebody twin-engine passenger jet, which has earned its reputation as the commercial airliner of choice for leading carriers worldwide.

Characteristics that make the A330 a bestseller include: a large existing fuel capacity in the wings; an advanced digital cockpit with fly-by-wire controls for excellent handling qualities and low crew workload; a fuselage cross-section maximized for both passenger and cargo payloads and underfloor holds that are sized to accommodate NATO standard 463L pallets, bulk cargo and side-by-side LD-3 containers.

As a derivative of a modern commercial jetliner early in its operational prime, the KC-30's advantages also include low life cycle costs, continued manufacturer upgrades and improvements, and a guaranteed supply of spare parts for decades to come.

The U.K. government has selected the AirTanker industry group and it's A330 MRTT (Multi-Role Tanker Transport) as the preferred bidder for its Future Strategic Tanker Aircraft requirement.

The Royal Australian Air Force signed a contract in December 2004 to acquire five A330 MRTTs. Deliveries of the Australian aircraft are scheduled to begin in 2008, with the A330 MRTT entering operational service in 2009 following operational test and evaluation by the RAAF.

KC 767 Advanced Tanker

The first 767 tanker was based around the well known commercial model and initial sales were made to Italy and Japan. Boeing is proposing to base the KC 767 on a new civil configuration called the 767 200 Long Range Freighter (LRF).

A recent article in Flight suggests that Boeing hopes to revive the 767 production line for extended military and civil sales.

The KC 767 will have a Max Take Off Weight of more than 400,000lbs and a Max Fuel Capacity in excess of 200,000lbs. It features mission flexibility, all digital flight deck and an advanced and highly reliable boom refueling system.

The configuration of a commercial 767 for the tanker transport role involves the installation of additional pumps and auxiliary fuel tanks together with the fuel distribution lines below the floor of the main cabin, leaving the main cabin free for cargo, passenger or both cargo and passenger transportation. The concept allows simultaneous refueling and airlift operations or successive refueling and airlift missions.

The KC 10 Extender

A modified DC 10, the KC 10A entered service with the UASF in 1981 but retains 88% commonality with the original model. Its prime mission is as an aerial refueling it can combine the tasks of a tanker and cargo aircraft. An advanced fly by wire boom can transfer fuel at 1100 gals per minute.

Vital statistics include a range of about 4,400 miles with 76,560kg of cargo and 75 passengers. It has a combined fuel capacity of 160,200kg.

KDC10 Global Air Services

The US Company Evergreen International Aviation and Omega Air, based in Dublin, have formed the joint company Global Airtanker Service LLC, based in Oregon. The company is carrying out modification and upgrade work on a commercially proven airliner, the DC-10 from Japan Airlines, to manufacture the KDC-10 which is equipped with hose and drogue and centreline boom refueling systems.

Global Airtanker Service plans to modify up to 15 DC-10-40 aircraft (an extended range version of the DC10) which were previously owned and operated by Japan Air Lines and have been purchased by Global Airtanker.

The KDC-10 tanker aircraft will be dual use with the capability to carry freight or passengers. The aircraft can carry 247,000lb of fuel for refueling plus up to 100,000lb of freight or passenger payload. An alternative payload configuration includes an additional fuselage fuel tank which gives a maximum 345,000lb fuel payload.

Global Airtanker estimates that the fuel offload capability at a range of 1,500 nautical miles is 235,000lb fuel offload for the KDC10 with wing pods, HDU and optional tanks.

The KDC-10 tanker aircraft is available in cargo and passenger configurations. The main deck can be fitted for 277 mixed class passenger seats in a twin aisle configuration (22 six-abreast first class passenger seats and 255 nine-abreast economy class passenger seats).

Conclusion

- **Aerial refueling is relatively safe.**

- **We live in changing times and the political situation might see airspace sanctions applied to some airlines that would significantly increase journey times and reduce payloads.**

- **Conventional technology has not yet produced a commercial aircraft that can travel non stop with a full pay load from one side of the globe to the other**

- **A range of commercial aircraft is now available that can carry a useful payload and transfer fuel en route. These aircraft can be made from new or modified into multi role tanker transport aircraft.**

- **Joint civil military contractors could reduce the cost of fuel delivered by this technique.**

- **Sufficient commercial pilots have the skill and experience to carry out aerial refueling.**