737 airport planning manual


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AIRPORT PLANNING MANUAL

PART 3

GUIDELINES FOR CONSULTANT/CONSTRUCTION SERVICES

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Safety regulations require aircraft to carry fuel beyond the minimum needed to fly from origin to destination, allowing for unforeseen circumstances or for diversion to another airport if the planned destination becomes unavailable. Furthermore, under the supervision of air traffic control, aircraft flying in controlled airspace must follow predetermined routes known as airways at least where they have been defined, even if such routes are not as economical as a more direct flight. Within these airways, aircraft must maintain flight levels, specified altitudes usually separated vertically by 1,000 or 2,000 ft 300 or 610 m, depending on the route being flown and the direction of travel. When aircraft with only two engines are flying long distances across oceans, deserts, or other areas with no airports, they have to satisfy additional ETOPS safety rules to ensure they can reach some emergency airport if one engine fails.These regulations vary by country but more and more countries require their airline operators to employ such personnel.Aircraft must also carry some reserve fuel to allow for unforeseen circumstances, such as an inaccurate weather forecast, or air traffic control requiring an aircraft to fly at a lowerthanoptimal altitude due to congestion, or the addition of lastminute passengers whose weight was not accounted for when the flight plan was prepared. The way in which reserve fuel is determined varies greatly, depending on airline and locality. The most common methods areThe alternate airport is for use in case the destination airport becomes unusable while the flight is in progress due to weather conditions, a strike, a crash, terrorist activity, etc.. This means that when the aircraft gets near the destination airport, it must still have enough alternate fuel and alternate reserve available to fly on to the alternate airport.

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Since the aircraft is not expected at the alternate airport, it must also have enough holding fuel to circle for a while typically 30 minutes near the alternate airport while a landing slot is found. United States domestic flights are not required to have sufficient fuel to proceed to an alternate airport when the weather at the destination is forecast to be better than 2,000foot 610 m ceilings and 3 statute miles of visibility; however, the 45minute reserve at normal cruising speed still applies.In some cases the destination airport may be so remote e.g., a Pacific island that there is no feasible alternate airport; in such a situation an airline may instead include enough fuel to circle for 2 hours near the destination, in the hope that the airport will become available again within that time.Subject to safety requirements, commercial airlines generally wish to minimise costs by appropriate choice of route, speed, and height.A commercial airline makes its money by charging to carry payload. This includes the zero fuel weight and all required fuel. This is the ramp weight minus any fuel used for taxiing. Major airports may have runways that are about 2 miles 3 km long, so merely taxiing from the terminal to the end of the runway might consume up to a ton of fuel. After taxiing, the pilot lines up the aircraft with the runway and puts the brakes on. On receiving takeoff clearance, the pilot throttles up the engines and releases the brakes to start accelerating along the runway in preparation for taking off. Few flight planning systems calculate the actual takeoff weight; instead, the fuel used for taking off is counted as part of the fuel used for climbing up to the normal cruise height. This is the brake release weight minus the trip fuel burned. It includes the zero fuel weight, unusable fuel, and all alternate, holding, and reserve fuel. The applicable rules are known as ETOPS ExTended range OPerationS.

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The particular units used may vary by aircraft, airline, and location across a flight.Aviation charts always show distances as rounded to the nearest nautical mile, and these are the distances that are shown on a flight plan. Flight planning systems may need to use the unrounded values in their internal calculations for improved accuracy.When fuel is measured by weight, the specific gravity of the fuel used is taken into account when checking tank capacity.In this particular case the flight crew managed to glide to a nearby runway and land safely the runway was one of two at a former airport then being used as a dragstrip .This can cause some interesting rounding problems, especially when subtotals are involved.The heights quoted here are thus the nominal heights under standard conditions of temperature and pressure rather than the actual heights. All aircraft operating on flight levels calibrate altimeters to the same standard setting regardless of the actual sea level pressure, so little risk of collision arises. When cruising at higher altitudes aircraft adopt flight levels FLs. Flight levels are altitudes corrected and calibrated against the International Standard Atmosphere ISA. These are expressed as a threefigure group e.g., FL320 is 32,000 ft 9,800 m ISA.The vertical separation between aircraft is either 300 metres or 600 metres about 1.6% less than 1,000 or 2,000 feet.Since then there has been a phased introduction around the world of reduced vertical separation minimum RVSM. This cuts the vertical separation to 1,000 feet 300 m between flight levels 290 and 410 the exact limits vary slightly from place to place. Since most jet aircraft operate between these heights, this measure effectively doubles the available airway capacity.Many airlines request that weights be rounded to a multiple of 10 or 100 units. Great care is needed when rounding to ensure that physical constraints are not exceeded.

Most commercial flights will travel from one airport to another, but private aircraft, commercial sightseeing tours, and military aircraft may do a circular or outandback trip and land at the same airport from which they took off.An airway has no physical existence, but can be thought of as a motorway in the sky. On an ordinary motorway, cars use different lanes to avoid collisions, while on an airway, aircraft fly at different flight levels to avoid collisions. One can often see planes passing directly above or below ones own. Charts showing airways are published and are usually updated every 4 weeks, coinciding with the AIRAC cycle. AIRAC Aeronautical Information Regulation and Control occurs every fourth Thursday, when every country publishes its changes, which are usually to airways.Waypoints use five letters e.g., PILOX, and those that double as nondirectional beacons use three or two TNN, WK. Airways may cross or join at a waypoint, so an aircraft can change from one airway to another at such points. A complete route between airports often uses several airways.There are two main types of waypointsSuch waypoints over land often have an associated radio beacon so that pilots can more easily check where they are. Useful named waypoints are always on one or more airways. Air traffic control require that geographic waypoints have latitudes and longitudes that are a whole number of degrees. Most of the climb portion of a flight will take place on the SID. Much of the descent portion of a flight will take place on a STAR. Unlike ordinary airways, which change infrequently, ocean tracks change twice a day, so as to take advantage of favourable winds. Flights going with the jet stream may be an hour shorter than those going against it. Ocean tracks may start and finish about 100 miles offshore at named waypoints, to which a number of airways connect.All scenarios using airways use SIDs and STARs for departure and arrival.

In some cases, political considerations may influence the choice of route e.g., aircraft from one country cannot overfly some other country.Most flights over land fall into this category. Most flights over northern oceans fall into this category. Most flights over southern oceans fall into this category. This is a relatively uncommon situation for commercial flights. Flight planning systems organise this by inserting geographic waypoints at suitable intervals. For a jet aircraft, these intervals are 10 degrees of longitude for eastbound or westbound flights and 5 degrees of latitude for northbound or southbound flights. In freeflight areas, commercial aircraft normally follow a leasttimetrack so as to use as little time and fuel as possible. A great circle route would have the shortest ground distance, but is unlikely to have the shortest air distance, due to the effect of head or tail winds. A flight planning system may have to perform significant analysis to determine a good freeflight route.This calculation is somewhat complicatedFor instance, reserve fuel is often calculated as a percentage of trip fuel, but trip fuel cannot be calculated until the total weight of the aircraft is known, and this includes the weight of the reserve fuel. The wind may provide a head or tailwind component, which in turn will increase or decrease the fuel consumption by increasing or decreasing the air distance to be flown. These forecasts are generally issued every 6 hours and cover the subsequent 36 hours. Each 6hour forecast covers the whole world using grid points located at intervals of 75 nautical miles 139 km or less. At each grid point, the wind speed, wind direction, air temperature is supplied at nine different heights between 4,500 and 55,000 feet 1,400 and 16,800 m. For 75nauticalmile 139 km intervals, linear interpolation is satisfactory.

The ADF format used 300nauticalmile 560 km intervals; this interval was large enough to miss some storms completely, so calculations using ADFpredicted weather were often not as accurate as those that can be produced using GRIBpredicted weather. Each interwaypoint portion of an airway may have different rules as to which flight levels may be used. Total aircraft weight at any point determines the highest flight level which can be used. Cruising at a higher flight level generally requires less fuel than at a lower flight level, but extra climb fuel may be needed to get up to the higher flight level it is this extra climb fuel and the different fuel consumption rate that cause discontinuities. Due to stress on the wheels and undercarriage when landing, the maximum safe landing weight may be considerably less than the maximum safe brakerelease weight. In such cases, an aircraft that encounters some emergency and has to land immediately after taking off may have to circle for a while to use up fuel, or else jettison some fuel, or else land immediately and risk having the undercarriage collapse. On some occasions, commercial flight planning systems find that an impossible flight plan has been requested. The aircraft cannot possibly reach the intended destination, even with no cargo or passengers, since the fuel tanks are not big enough to hold the amount of fuel needed; it would appear that some airlines are overoptimistic at times, perhaps hoping for a very strong tailwind. Note that a large aircraft, such as a jumbo jet, may burn up to 80 tons of fuel on a 10hour flight, so there is a substantial weight change during the flight. Instead of trying to predict the fuel load not yet burned, a flight planning system can handle this situation by working backward along the route, starting at the alternate, going back to the destination, and then going back waypoint by waypoint to the origin.

Several possibly many iterations are usually required, either to calculate interdependent values such as reserve fuel and trip fuel, or to cope with situations where some physical constraint has been exceeded. In the latter case it is usually necessary to reduce the payload less cargo or fewer passengers. Some flight planning systems use elaborate systems of approximate equations to simultaneously estimate all the changes required; this can greatly reduce the number of iterations needed.Hence a flight planning system can calculate alternate holding fuel on the basis that the final aircraft weight is the zero fuel weight. Since the aircraft is circling while holding, there is no need to take wind into account for this or any other holding calculation. A flight planning system can then work back along the route, calculating the trip fuel and reserve fuel one waypoint at a time, with the fuel required for each interwaypoint segment forming part of the aircraft weight for the next segment to be calculated. Problems mean that either the aircraft weight must be reduced in some way or the calculation must be abandoned. Calculation can then proceed forward along the route, waypoint by waypoint. On reaching the destination, the actual trip fuel can be compared with the estimated trip fuel, a better estimate made, and the calculation repeated as required.There are three main factors that contribute to the costSuch local optimisation can be done on a waypointbywaypoint basis.To cope with such requirements, a flight planning system must be capable of nonlocal altitude optimisation by simultaneously taking a number of waypoints into account, along with the fuel costs for any short climbs that may be required.Many situations have tens or even hundreds of possible routes, and there are some situations with over 25,000 possible routes e.g., London to New York with freeflight below the track system.

The amount of calculation required to produce an accurate flight plan is so substantial that it is not feasible to examine every possible route in detail. A flight planning system must have some fast way of cutting the number of possibilities down to a manageable number before undertaking a detailed analysis.Techniques known variously as reclear, redispatch, or decision point procedure have been developed, which can greatly reduce the amount of reserve fuel needed while still maintaining all required safety standards.The final destination airport is where the flight is really going to, while the initial destination airport is where the flight will divert to if more fuel is used than expected during the early part of the flight. The waypoint at which the decision is made as to which destination to go to is called the reclear fix or decision point. On reaching this waypoint, the flight crew make a comparison between actual and predicted fuel burn and check how much reserve fuel is available. If there is sufficient reserve fuel, then the flight can continue to the final destination airport; otherwise the aircraft must divert to the initial destination airport.Under normal circumstances, little if any of the reserve fuel is actually used, so when the aircraft reaches the reclear fix it still has almost all the original reserve fuel on board, which is enough to cover the flight from the reclear fix to the final destination. These numbers apply only to the specific type of aircraft considered, for a specific reserve percentage, and take no account of the effect of weather. The fuel savings due to reclear depend on three factorsThis position cannot be determined theoretically since there are no exact equations for trip fuel and reserve fuel. Even if it could be determined exactly, there may not be a waypoint at the right place.

This is beneficial because it minimises the reserve fuel needed between reclear fix and initial destination, and hence maximises the amount of reserve fuel available at the reclear fix. In busy airspace with a number of competing aircraft, the optimum routes and preferred altitudes may be oversubscribed. This problem can be worse in busy periods, such as when everyone wants to arrive at an airport as soon as it opens for the day. If all the aircraft file optimal flight plans then to avoid overloading, air traffic control may refuse permission for some of the flight plans or delay the allocated takeoff slots. This might involve requesting a higher flight level than in the plan or asking for a more direct routing. If the controller does not immediately agree, it may be possible to rerequest occasionally until they relent. Alternatively, if there has been any bad weather reported in the area, a pilot might request a climb or turn to avoid weather.The captain has to make sure that there will be enough fuel on board for the trip and sufficient reserve fuel for unforeseen circumstances. Weight and centre of gravity must remain within their limits during the whole flight. The captain must prepare an alternate flight plan for when landing at the original destination is not possible.A flight planning system may produce summaries for, say, the next 4 best routes, showing zero fuel weight and total fuel for each possibility. A flight planning system can analyse each possibility and select whichever is best for this particular flight. The total weight of passengers and cargo might not be known at the time the flight plan is prepared. To allow for these situations a flight planning system may produce summaries showing how much fuel would be needed if the aircraft is a little lighter or heavier, or if it is flying higher or lower than planned. These summaries allow flight dispatchers and pilots to check if there is enough reserve fuel to cope with a different scenario.

The rules depend on how much fuel is to be loaded, and there may be different sets of rules for different total amounts of fuel. A flight planning system may follow these rules and produce a report showing how much fuel is to be loaded into each tank. A flight planning system can work out how much extra fuel can profitably be carried. Note that discontinuities due to changes in flight levels can mean that a difference of as little as 100 kg one passenger with luggage in zero fuel weight or tankering fuel can make the difference between profit and loss. A flight planning system can produce a new flight plan for the new route from the diversion point and transmit it to the aircraft, including a check that there will be enough fuel for the revised flight. Such refuelling is a process rather than instantaneous. Some flight planning systems can allow for the change in fuel and show the effect on each aircraft involved. By using this site, you agree to the Terms of Use and Privacy Policy. Developed to supplement the Boeing 727 on short and thin routes, the twinjet retains the 707 fuselage crosssection and nose with two underwing turbofans. Envisioned in 1964, the initial 737100 made its first flight in April 1967 and entered service in February 1968 with Lufthansa. The lengthened 737200 entered service in April 1968. It evolved through four generations, offering several variants for 85 to 215 passengers.It was the highestselling commercial aircraft until being surpassed by the competing Airbus A320 family in October 2019, but maintaining the record in total deliveries. The 737 MAX, designed to compete with the A320neo was grounded worldwide in March 2019 following two fatal crashes. After system improvement required by FAA, the aircraft had completed a series of recertification test flights aim for ungrounding in the midyear 2020.

African airline orders kept the production running until the 1978 US Airline Deregulation Act, which improved demand for sixabreast narrowbody aircraft.Assembly commenced on premises adjacent to Boeing Field now officially named King County International Airport because the factory at Renton was filled to capacity with the production of the 707 and 727.This model featured a 134 in 87 in 340 cm 221 cm freight door just behind the cockpit, and a strengthened floor with rollers, which allowed for palletized cargo.These were later divided into what has become known as the four generations of the 737These are divided into four generations but all are based on the same basic design.It is forbidden to operate without the caps, because they are linked to the ground speed sensor that interfaces with the antiskid brake system.The original design was too small to require this, and adding a fuel dump system to the later, larger variants would have incurred a large weight penalty. Depending upon the nature of the emergency, 737s either circle to burn off fuel or land overweight.The 737 Classic series featured CFM56 high bypass turbofan engines, which yielded significant gains in fuel economy and a reduction in noise over the JT8D low bypass engines used on the 737 Original series 100 and 200, but also posed an engineering challenge given the low ground clearance of the 737 aircraft family.This sidemounted gearbox gives the engine a somewhat rounded triangular shape. Because the engine is close to the ground, 737300s and later models are more prone to engine foreign object damage FOD. The improved, higher pressure ratio CFM567 turbofan engine on the 737 Next Generation is 7% more fuelefficient than the previous CFM563 on the 737 Classic with the same bypass ratio.In the event of total hydraulic system failure or double engine failure, they will automatically and seamlessly revert to control via servo tab.

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