Approach Control

- Terminal Area (TMA) Techniques

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Procedure design

RNAV arrivals

Most RNAV STARs are “trombone” type arrivals, which allow aircraft to absorb arrival delay, and minimize the requirement for vectoring when sequencing aircraft, greatly reducing controller workload and frequency congestion during times of high traffic volume.

Aircraft are positioned on a 4 to 5-mile downwind on opposing sides of the runway, allowing aircraft to perform continuous descents, and resulting in consistent behavior when vectoring aircraft for sequencing base-to-final.

The STARs also incorporate level and speed restrictions, which assure separation from departing traffic, as well as terrain and obstacles. Although, traffic permitting, the speed restrictions may be cancelled. Level restrictions may also be cancelled in compliance with the specific procedures for the terminal area.

RNAV departures

RNAV standard SIDs, incorporating altitude and speed restrictions to assure airspace containment, separation from arriving traffic and terrain and obstacle clearance.

Allowing aircraft to follow the published reduces controller workload, but consideration must be given to the interaction between departure and arrival procedures, and appropriate climb instructions must be given.

Where airports are equipped for simultaneous instrument departures, allowing aircraft to follow the published procedure will assure separation between parallel departing aircraft.

Initial arrival sequencing

Sequencing before aircraft reach downwind

In some cases, aircraft may require vectors before reaching the downwind leg of the STAR. In these cases, an appropriate vector should be issued to the aircraft to achieve the target separation as appropriate.

In addition to vectors, aircraft may be issued direct routings from the upwind leg of the trombone to the downwind leg of the trombone, allowing more optimal sequencing of aircraft and reduced controller workload.

Rules of thumb

Controllers shall keep the following in mind when providing vectors to final. For aircraft travelling at the same speed:

- "Aiming" an aircraft well ahead of the preceding aircraft will reduce separation rapidly
- "Aiming" an aircraft at the preceding aircraft will cause the separation to increase slowly
- "Aiming" an aircraft behind the preceding aircraft will cause the separation to increase rapidly.

Base to final sequencing

Use of standard vectors

When vectoring aircraft base to final, standard headings shall always be used. This permits consistent behavior of aircraft when turning base and intercepting the final approach course, which allows the timing of the vectors to be adjusted to account for factors such as winds with a high degree of accuracy.

In general, the following standard vectors shall be used when sequencing aircraft from base to final:

- A 90-degree base vector, perpendicular to the runway course
- A 30-degree intercept vector to intercept the final approach course

Speed, turn radius and turn rate

Turn radius and turn rate of an aircraft are proportional to their airspeed and bank angle. As the bank angle and/or airspeed increases, the turn rate and turn radius of an aircraft will increase.

As most modern jet turbine aircraft autopilots are programmed to utilize a constant 25-degree bank angle, as the airspeed of an aircraft reduces, its turn rate and turn radius will increase. Controllers must have a sound understanding of this relationship, as it is particularly important during base to final sequencing.

Timing of the base turn

Assuming aircraft are travelling at the same speed, the timing of the base turn depends primarily on the distance of the downwind from the final approach course.

If an aircraft initiates a base turn abeam traffic on final, the final separation between the aircraft will be approximately one mile greater than the initial distance between the two aircraft at the time of the base turn.

For example, if the downwind leg is 4 miles from the final approach course, the separation when the following aircraft establishes will be approximately 5 miles from the leading aircraft, assuming the following aircraft initiates the base turn as the two aircraft pass abeam each other.

Allowance must also be made for the reaction time of the pilot, and autopilot response time. This generally requires the base turn to be anticipated by approximately one mile.

Using this technique, the timing of the base turn may be adjusted to account for differing wake turbulence-based radar separation requirements. Turning the aircraft earlier or later will result in a corresponding reduction or increase in separation on the final approach course, respectively.

Compression on final approach

In order to minimize the risk of a loss of separation on the final approach, a safety margin must be added to the required minimum spacing to account for a phenomenon known as “compression”.

Compression is a result of a combination of factors but is primarily due to the fact that aircraft final approach speeds are generally significantly lower (approximately 130 to 150 knots) than the speed control that is applied to the aircraft until 4 miles. In addition, variation in winds between higher and lower levels, may result in unexpected variations in aircraft ground speed, possibly causing a trailing aircraft to have a higher than anticipated closure rate towards the preceding aircraft.

In general, a buffer of approximately 1 to 1.5 miles is sufficient to account for compression. Often, this buffer may be completely eroded by the time the leading aircraft crosses the landing threshold, but its application assures that no loss of separation will occur.

However, controllers must be careful not to apply buffers that are too large, as this results in a reduction in arrival rate and, as a result, a reduction in the overall capacity of the terminal area and increases the arrival delay required during peak arrival times.

Departure sequencing

Airspeed profile

During the initial climb out, most jet turbine aircraft follow approximately the same airspeed profile. The initial climb speed immediately after take-off is typically dictated by speed restrictions on the SID, after which aircraft will accelerate to a speed of 250 knots.

Passing 10,000 ft, aircraft will accelerate to a cruise-climb speed (typically 270 to 320 knots) until approximately 30,000 ft, after which they transition to their planned cruise Mach number.

Speed control

Controllers must be aware of the expected acceleration points on the SID where the airspeed will rapidly increase. This may occasionally be undesirable and require assignment of a lower speed to maintain separation.

Conversely, aircraft may be instructed to accelerate early if separation with the leading aircraft is adequate. This allows for increased capacity of the departure procedure and minimizes the need to vector traffic off the SID to increase separation.

Vectors

In some instances, vectors may be required in order to increase separation before aircraft transition to the enroute phase. When vectoring is applied, the aircraft shall always be turned away from the leading aircraft's planned track.

The heading changes to achieve the desired separation should not exceed 30 degrees off track, as this technique results in a very rapid increase in the separation, and time must be allowed for the aircraft to carry out the heading necessary heading change maneuver.