Vectoring

General

Vectoring is achieved by instructing aircraft to maintain a heading that will result in it following a desired ground track. It is one of the most effective techniques to establish and maintain horizontal separation between traffic and is far more effective than speed control in doing so, producing the desired result much more quickly. However, it results in a larger increase in controller as compared to other methods.

When aircraft are placed on a vector, they must be informed of the reason for the vector, and the expected point where they are expected to re-join the flight planned route.

The procedures laid down in 5.2 shall apply when aircraft are under radar vectors.

Use of vectoring

Navigation assistance

Should aircraft navigational equipment fail, or ground navigational aids are unavailable, vectoring may be used to provide navigational assistance to aircraft.

This may also be used to provide navigational assistance to VFR aircraft should they become lost.

Circumnavigating airspace

If aircraft is approaching special use airspace such as danger, restricted and prohibited areas and a climb or descent is unfeasible, aircraft may be vectored around the airspace.

Conflict prevention

In situations where there is adequate separation between aircraft projected to cross each other at the same level, but it is only slightly above separation minima, aircraft may be instructed to “MAINTAIN PRESENT HEADING”.

This technique of “locking” the heading ensures that the minimum separation will be maintained between aircraft, and the aircraft will not make any turns such as to follow an airway or terminal procedure.

Conflict solving

If a level change is not possible, or practical, aircraft may be issued a heading change in order to ensure horizontal separation minima is maintained. In most cases, only a relatively small change in heading is required to achieve the desired result. This results in a minimal change to the aircraft's total flight distance and therefore to its fuel consumption.

After the conflict has been solved and separation is assured aircraft may be instructed to resume their own navigation.

Sequencing

Aircraft may be sequenced to a sector boundary point using a combination of speeds and vectors. The objective of sequencing is to establish and maintain a minimum separation between the leading and following aircraft.

Vectoring geometry

Conflict geometry

Crossing point

The crossing point is the point where the projected flight paths between two aircraft are expected to cross. It is fairly easy to determine the crossing point as it is only dependent on the projected tracks of two aircraft and is unaffected by speed and wind.

Closest point of approach (CPA)

The minimum distance between two aircraft at the time they pass each other is known as the closest point of approach (CPA). In general, the separation between two aircraft continues to reduce after the first aircraft crosses the track of the second aircraft until reaching the CPA.

CPA is dependent on the angle of the trajectories of the two aircraft and their projected ground speed and therefore the time taken to reach the crossing point. For this reason, it is more complex to calculate than crossing point as it requires the use of trigonometry.

Closest point of approach is displayed on the radar screen along the projected path of an aircraft and is color coded yellow. A red color code indicates that the CPA is below the required separation minima. It should be noted, however that this is an instantaneous prediction and may not necessarily be accurate if aircraft vertical and horizontal speed change and should therefore be used with caution.

Determining CPA

- A crossing angle of 90 degrees means separation will be reduced by 30% between crossing point and CPA. As a result, a separation of 7.2 NM at the crossing point is required to ensure 5 NM separation at CPA.

- A crossing angle of 60 degrees means separation will be reduced by 20% between crossing point and CPA. As a result, a separation of 6.3 NM at the crossing point is required to ensure 5 NM separation at the CPA.
- A crossing angle of 60 degrees means separation will be reduced by 10% between crossing point and CPA. As a result, a separation of 5.6 NM is required at the crossing point to ensure 5 NM separation at the CPA.
- A crossing angle of 120 degrees means separation will be reduced by 50% between the crossing point and the CPA. As a result, a separation of 10 NM is required at the crossing point to ensure 5 NM separation at the CPA.
- A crossing angle of 150 degrees means separation will be reduced by 75% between the crossing point and CPA. As a result, a separation of 20 NM is required at the crossing point to ensure 5 NM separation at the CPA.

Selecting the aircraft

Vectoring both aircraft

This is the most commonly used method to solve conflicts on reciprocal tracks. Although it increases controller workload, as multiple transmissions need to be made to different aircraft, it has less of an impact on each aircraft’s trajectory resulting in a minimal increase in distance flown. For this technique to work, both aircraft need to alter course in the same direction (e.g., both turn mright).

Vectoring the aircraft behind

This method is used when two aircraft are maintaining altitude and one is overtaking the other. The aircraft further from the crossing point is given a vector to increase separation. This is much more effective than vectoring the aircraft closer to the crossing point.

Vectoring the aircraft requesting a level change

If accommodating a climb or descent request would cause and aircraft to pass through the level of another and subsequently result in insufficient separation between them, the aircraft requesting the level change is usually the one that is given the vector.

This is usually done in three steps, first a vector is given to establish lateral separation between the two aircraft, followed by a vector to parallel the track, while at the same time accommodating the climb request. Once the aircraft has passed through the level of the other with sufficient vertical separation, a direct routing is given to the requesting aircraft to re-establish it on the planned track.

More complex situations

In more complex situations where the aforementioned techniques would not necessarily, generally controllers should follow the principle of requiring minimal intervention to achieve the desired result.

Turn direction

Aircraft on reciprocal tracks

Aircraft on opposing tracks should be vectored in the direction that would increase separation

Aircraft on crossing tracks

The aircraft further away from the crossing point should be “aimed” at the current position of the aircraft closer to the crossing point. This results in the distance from the crossing point of the leading aircraft to be reduced significantly, where the distance from the crossing point of the second aircraft is only marginally reduced. This method causes the second aircraft to pass behind the first.

For example, if the aircraft further from the crossing point has traffic on the left-hand side, it should be turned to the left to “aim” it towards the crossing traffic. Although it may seem counter-intuitive, this method will increase the separation between the aircraft.

Aircraft on the same track requesting a level change

The requesting aircraft should be turned into the wind, which will result in a reduction in its ground speed, resulting in a larger rate of increase of separation and placing the aircraft being vectored further behind. A sufficiently strong wind can be much more effective than speed control in managing an aircraft’s speed.

Consideration of the planned track

When aircraft are being vectored, due consideration must also be given to the planned flight paths of the aircraft such that the vector does not result in a significant increase in the track miles flown by the aircraft. In this case, aircraft may be issued a direct routing to “cut the corner”, which will have the same effect as a vector in that direction.

Airspace consideration

The dimensions of the airspace must also be considered when issuing vectors to aircraft. Aircraft shall not be vectored closer than 2.5 NM to the boundary of the airspace that a controller is responsible for, as this may require other actions such as coordination and further conflict solving.

Crossing angle

After the direction of turn is selected, the extent of the heading change must be determined. The crossing angle is crucial as it determines:

- The increase of separation after vectoring
- The separation reduction between the crossing point and the CPA The general impact of the crossing angle is as follows:
- Right angle (crossing) tracks allows the 1-in-60 rule to be used
- Acute angle (similar) tracks lead to:

    - Less separation gained be vectoring as opposed to other options. This scenario may sometimes require a heading change of 20 degrees or more, and if wind conditions are unfavorable, it may require an even greater turn.
    - In combination with vectoring to reduce the number and magnitude of heading changes required
- Obtuse angle (reciprocal) tracks lead to:
    - Greater separation reduction after the crossing point
    - More separation gained by vectoring. A small turn of 5 to 10 degrees is often enough to achieve the desired separation.

Associated risks

Forgetting that an aircraft has been issued a vector

This has a negative impact on flight efficiency and may also “surprise” the next controller if the airway or arrival procedure makes a sharp turn at the transfer point and the aircraft does not.

To mitigate this risk, the aircraft tag is marked before handoff to the next controller when the aircraft is placed under radar vectors.

Miscalculation of wind impact

If a controller attempts to sequence an aircraft behind another and by turning but instructs the aircraft to turn so the tailwind increases, the maneuver may have no effect as the tailwinds increases the aircraft’s speed effectively reducing the expected benefit from vectoring.

In addition, the wind speed and direction may be different at different levels and may vary significantly. Consequently, the headwind/tailwind/crosswind component will also vary, affecting the desired result. For example, the drift angle may be different at different levels, resulting in aircraft flying on converging tracks despite flying parallel headings.

This may be mitigated by assigning slightly diverging headings to aircraft being vectored.

Miscalculation of aircraft performance

Generally climbing aircraft increase their ground speed and descending aircraft will reduce their ground speed. The speed at cruise level may be up to twice as high as the speed at lower altitudes.

To mitigate this risk, controllers must always have an awareness of the performance characteristics that are altered by changes in altitude.

Rules of thumb

- Turn radius in NM = Ground speed in knots / 100

Revision #1
Created 11 October 2024 02:02:28 by Ali

Updated 27 January 2025 04:21:12 by Ali