Vectoring

This article describes the use of vectoring by air traffic controllers to manage the traffic flow and resolve conflicts. It is **focused on the en-route phase** and describes the general principles, typical uses and associated risks. The article also gives some advice about the practical use of the vectoring method. Note that the advice is based mostly on good practices and experience, and is in no way intended to replace or supersede local procedures and instructions.

Description

The goal of vectoring is to have the aircraft achieve and maintain the desired track. When an aircraft is given its initial vector diverting it from a previously assigned route, the pilot must be informed about the reason for the deviation (e.g. due to traffic, for sequencing, etc.).

General restrictions:

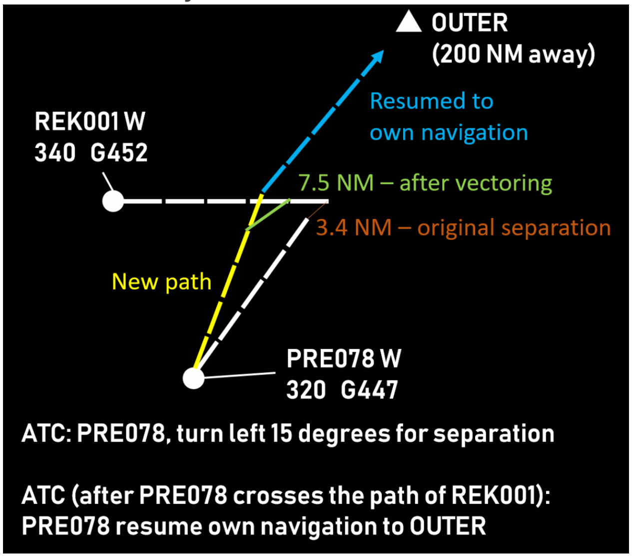
- Aircraft must not be vectored closer than a **half of the separation minimum (i.e. closer than 2.5 NM if the separation minimum is 5 NM) or 2.5NM, whichever is higher,** from the limit of the airspace which the controller is responsible for, unless otherwise specified in local arrangements.
- Controlled flights are not to be vectored into uncontrolled airspace, except in the case of emergency or in order to circumnavigate adverse weather (in which case the pilot should be informed), or at the specific request of the pilot.
- When vectoring or giving a direct route to an IFR flight takes the aircraft off an ATS route, the clearance should take into account the prescribed obstacle clearance.

After vectoring, the controller must instruct the pilot to resume own navigation, giving them the aircraft’s position if necessary.

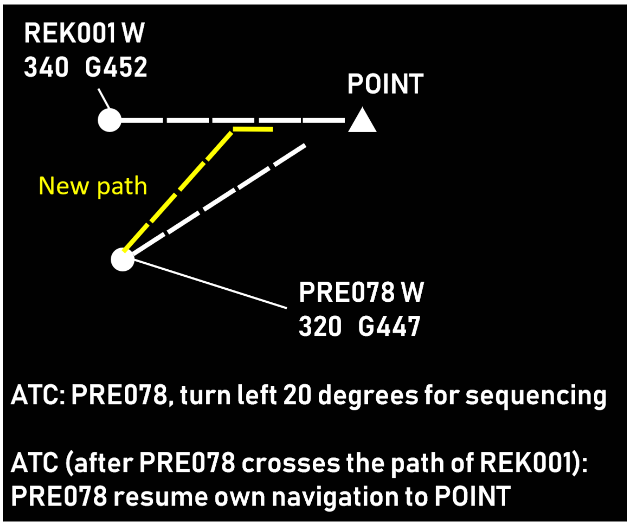
Typical uses

- **Flight Identification** - while not common in e.g. European airspace, this is one of the few methods for identification available when only primary radar is used.
- **Navigation assistance** - if due to equipment malfunction other navigation means (e.g. GNSS, INS, RNAV) are not available vectoring remains an option. This can also be useful for strayed VFR flights if the pilot has lost orientation.
- **Special use area (SUA) bypassing** - if for whatever reason a flight is approaching a SUA (prohibited, restricted, danger, temporary segregated, etc.) and flying above or below it is not feasible then vectoring may be used to guide the aircraft around it.

- **Conflict solving (opposite)** - if a level change is not possible for some reason (e.g. aircraft unable to climb, conflicting traffic at other levels, need for coordination with other sector, etc.) vectoring can be a very efficient way to solve the situation. A relatively small change of heading is often enough to achieve the desired separation.
- **Conflict solving (crossing)** - vectoring is a very effective method for solving crossing conflicts if a level change is not preferable and there is not enough time to perform speed control. In most cases, the aircraft that comes second to the intersection point of the two tracks is instructed to turn in the direction of the first one ("aiming for the other traffic"). This manoeuvre effectively puts the second (or slower) aircraft well beind the first (faster) one. After the crossing is complete, the vectored aircraft may be resumed to point that would compensate for the deviation and the extended flight path, thus gaining both safety and efficiency.



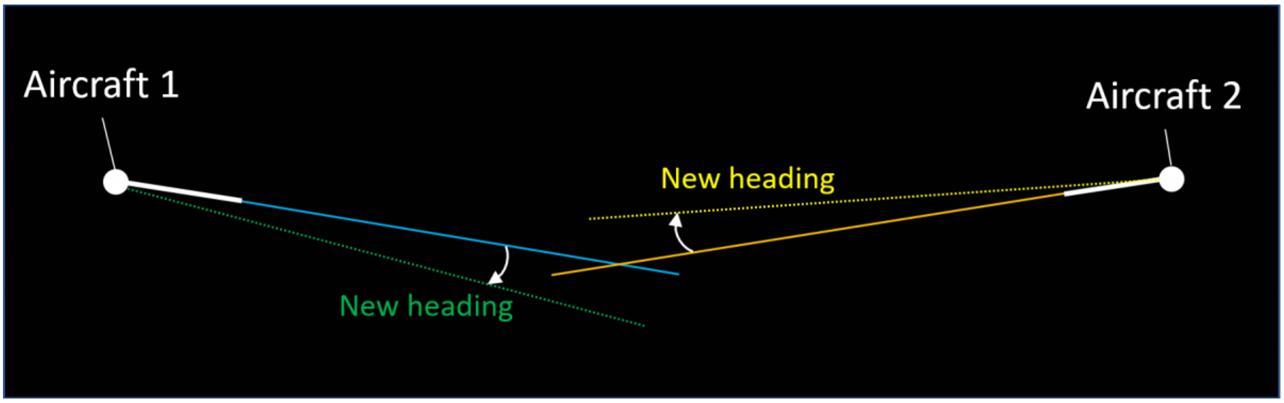
- **Sequencing** - often combined with speed control, vectoring is an effective method to achieve the desired distance before reaching the boundary with the next ATS sector or unit. The application is similar to the crossing scenario, the difference being that after the desired separation is achieved the aircraft being vectored remains behind the one that is ahead.



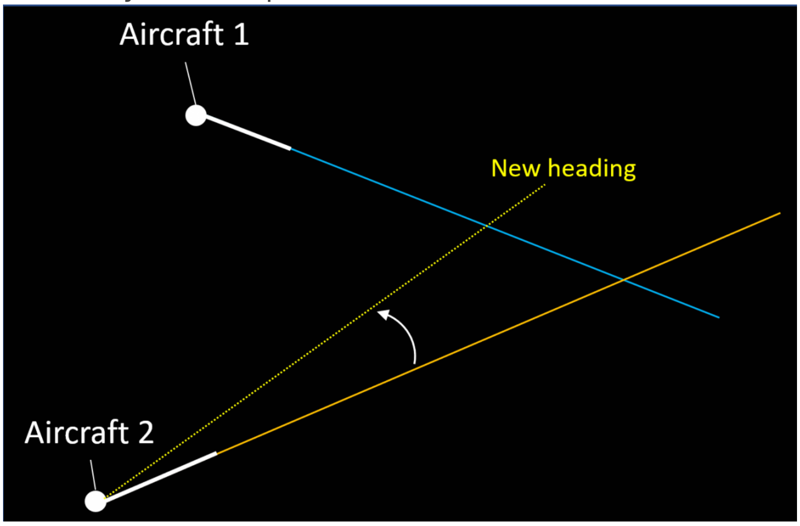
Choosing the aircraft

When vectoring is chosen as a means to solve a conflict, the first task of the controller is to decide which aircraft will have to change its heading. Generally, there are three situations:

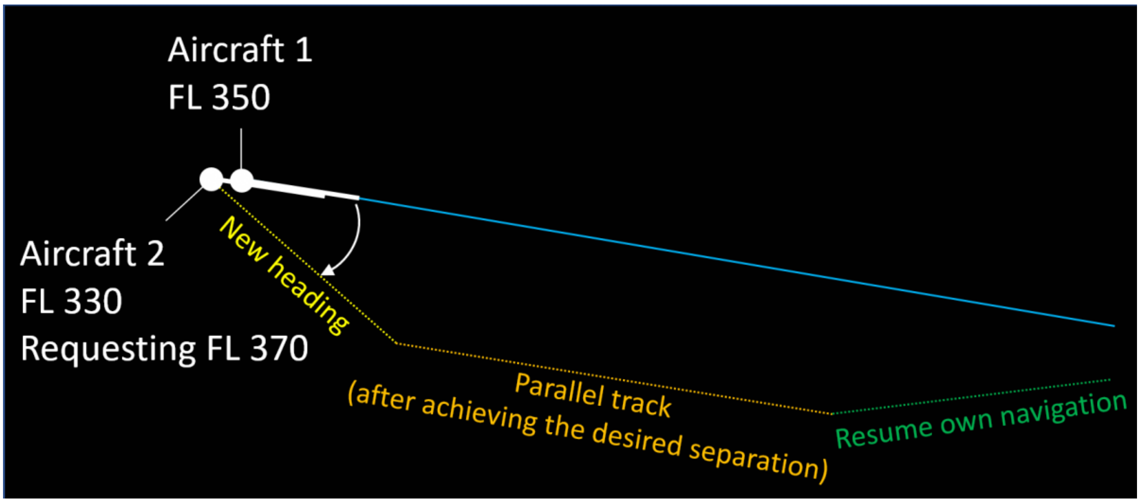
- Vector both aircraft. This is mostly used to solve conflicts of aircraft on reciprocal (opposite) tracks. This method increases the controller workload (due to having more communication exchanges on the frequency) but offers the benefit of less impact on each aircraft trajectory. Consequently, the increase of the distance flown is usually negligible. While turn direction is determined based on other factors (see next section), the general idea that both aircraft turn, and in the same direction, remains.



- Vector the aircraft that is behind. This is usually used when the two aircraft are maintaining altitude and one is considered to be overtaking the other. This is the more convenient choice from ATC perspective as well, since it requires less intervention (there is already some separation).



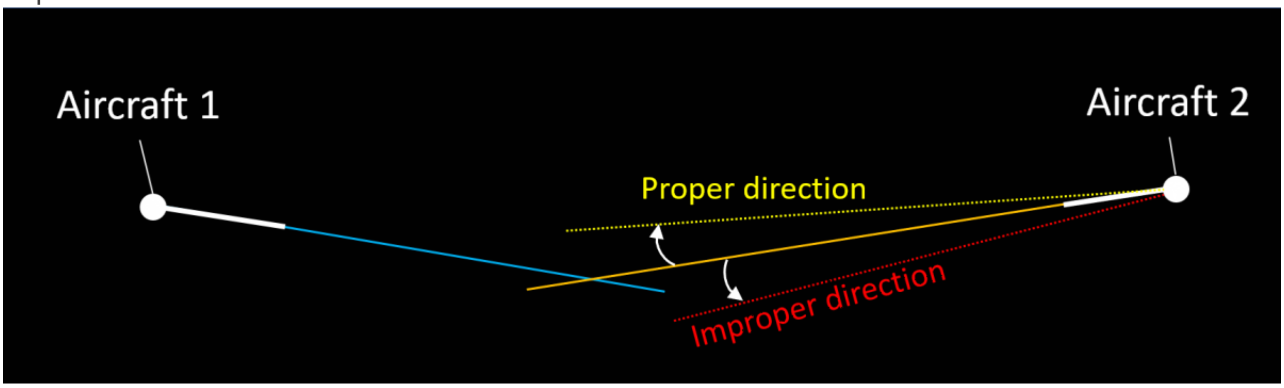
- Vector the requesting aircraft. If a pilot makes a request (usually to climb) and accommodating this request would result in insufficient separation with another aircraft, then the general choice is to vector the requester. Sometimes two vectors are used in such situations - the first one to achieve the desired separation and a second one to maintain it by flying on a parallel track.



Turn Direction

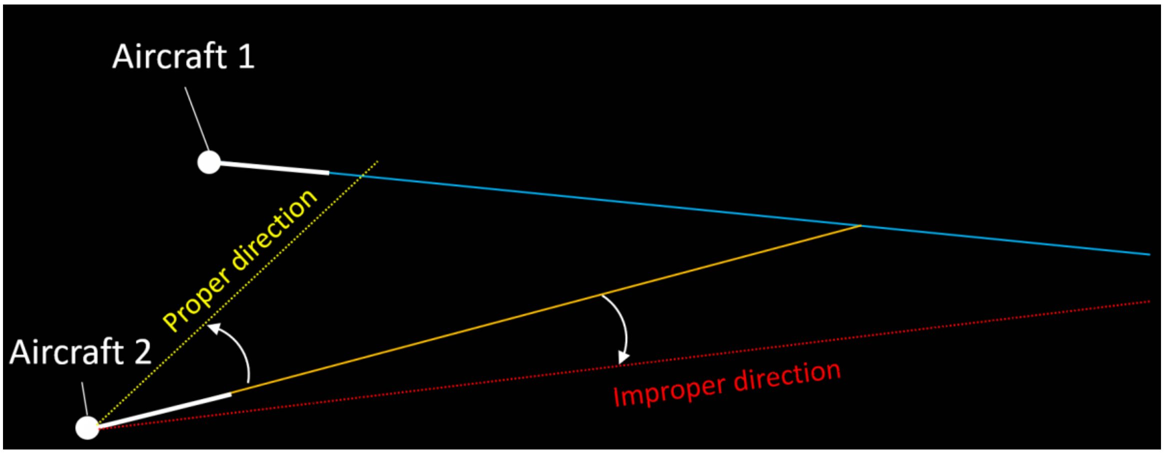
After the aircraft to be vectored has been chosen, the controller decides the direction of the turn. The following general principles are used:

- Aircraft flying on opposite tracks are turned in a direction that would increase the separation.



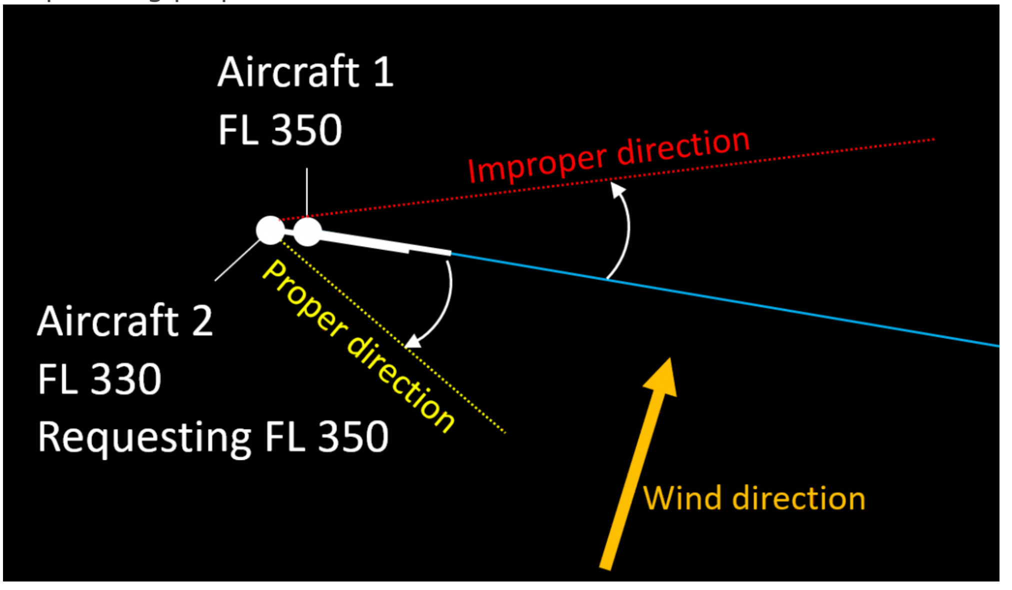
Turning Aircraft 2 slightly to the right is enough to solve the conflict while turning it to the left, even by more degrees, does not.

- "Aiming" at the first aircraft's current position. The crossing point is moved in such a way that the distance from the first aircraft is reduced significantly while the distance from the second one is reduced marginally. This results in the second aircraft passing further behind.



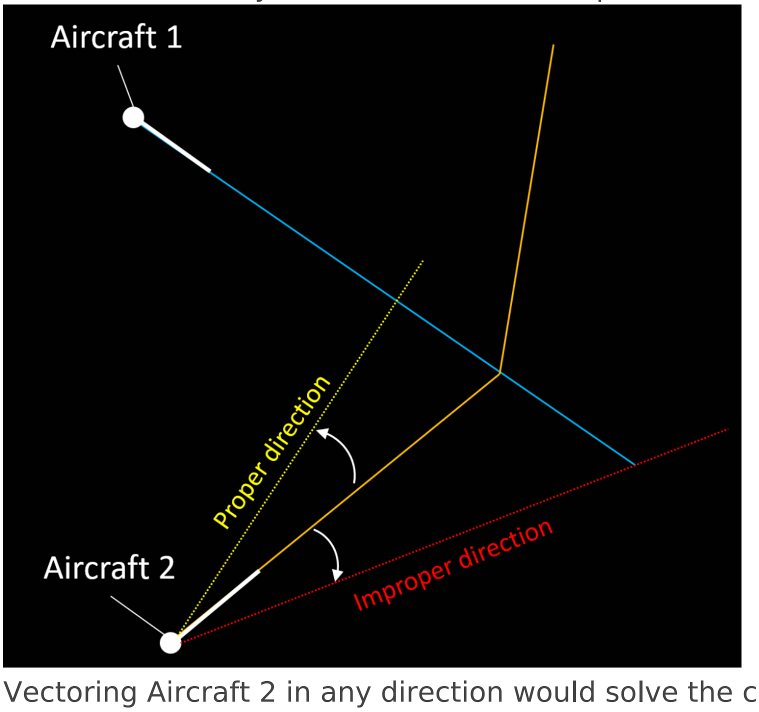
Turning Aircraft 2 to the left solves the conflict by placing it behing Aircraft 1. A vector to the right, while prolonging the time to the conflict, does not solve it.

- Turning an aircraft against the wind. This reduces the ground speed, effectively placing the aircraft being vectored further behind. In some situations, if the wind is strong enough, vectoring against the wind can be much more effective than speed control for sequencing purposes.



Turning Aircraft 2 to the right allows it to safely climb to FL 350. Due to the speed reduction caused by the wind Aircraft 2 can be sequenced behind Aircraft 1.

- Turning in a direction that is in line with the flight planned trajectory is preferable. Thus when the aircraft resumes own navigation its overall flight distance will be only marginally increased and may even be reduced (compared to the flight planned).



Vectoring Aircraft 2 in any direction would solve the conflict but the left turn would not cause a delay.

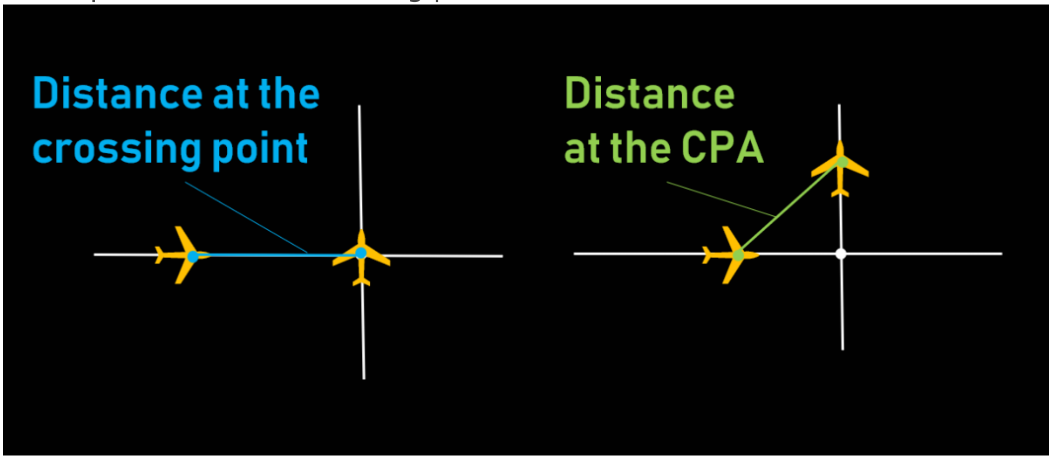
- Turning away from other traffic, special use areas and sector boundaries when practicable. Otherwise additional controller actions may be necessary (e.g. coordination, solving other conflicts, etc.).

Associated Risks

- Forgetting that an aircraft is being vectored. This has a negative impact on flight efficiency but may also "surprise" the next ATS sector or unit, especially if the airway makes a sharp turn at the transfer of control point and the aircraft does not.
- Miscalculation of wind impact (level flight). If a controller tries to sequence an aircraft after another one by vectoring but instructs it to turn so that the tailwind component increses, then the manoeuvre may have no effect (the tailwind will increase the aircraft's speed effectively reducing the expected benefit from vectoring).
- Miscalculation of wind impact (climbing and descending aircraft). Wind may be different at different levels. Even if the direction is somewhat the same, the windspeed can vary significantly. Consequently the headwind/tailwind/crosswind component will also vary and this may impact the desired result. For example, the drifting angle at different levels may be different if the windspeed (and therefore the crosswind component) increases with height. This may lead to parralel tracks becoming converging. A common mitigation for this is to assign a parallel or slightly diverging heading to the aircraft being vectored.
- Miscalculation of aircraft performance (climbing and descending aircraft). Generally, climbing aircraft increase their groundspeed and descending aircraft reduce it. The speed at cruising level can be twice that at e.g. FL 150. If this is not taken into account properly, the result may be loss of separation.

Things to consider

- **Crossing point.** In most cases vectoring is used to solve crossing conflicts. It is usually most efficient to turn the aircraft that would reach the crossing point later and in the direction of the other aircraft, i.e. if the conflicting traffic is to the left, then the turn should also be to the left. The manoeuvre effectively places the aircraft being vectored behind the other one. If for some reason the first aircraft needs to be vectored, this would require a much larger deviation.
- **Closest Point of Approach (CPA).** This is the moment when the distance between the two aircraft reaches its minimum. It should be noted that in general, the separation between aircraft continues to reduce for some time even after the first aircraft to reach the crossing point has crossed the track of the second one. The difference between the separation when the first aircraft reaches the crossing point and the moment of CPA depends on the conflict geometry. For example, if the tracks cross at right angle and both aircraft fly at the same ground speed then the separation at the CPA will be about 70% of the separation at the crossing point.



- **The sooner, the better.** An instruction given well in advance will have (almost) no impact on flight efficiency while solving the situation safely. For example, even a 5 degree heading change would result in about 6 miles displacement to the left/right after 10 minutes. On the other hand, if the conflict is happening after 3-4 minutes, the deviation may need to be 20 degrees or even more in some situations.
- **Wind direction and speed.** Generally, it is advisable to take advantage of the wind e.g. by turning the second aircraft into the wind to reduce its speed. This may reduce the necessary time an aircraft has to fly on a heading and generally help in resolving the situation faster.
- **Aircraft speeds.** Vectoring the faster aircraft would result in more spacing after the same amount of time.
- **Limitations**, e.g. during weather avoidance vectoring may not be a feasible method for conflict solving.
- Track crossing angle. An acute crossing angle means a larger deviation would be necessary to reach the desired separation (compared to a right angle). Generally, the bigger the angle of crossing, the smaller the necessary vector (0 degrees meaning the same direction and 180 - opposite).
- **Turn direction.** If the instruction "*turn left/right heading [ABC]*" is used **and** the present heading is unknown then the manoeuvre performed may surprise the controller (e.g. if the heading is 360 then "Turn left heading 005" would result in the aircraft making an orbit instead of a small turn to the left).
- **Misunderstanding.** Sometimes it is possible for the flightcrew to confuse instructions like "Turn left 10 degrees" and "Turn left heading 010".

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