

# Separation

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# Radar separation

## General

**Radar separation** describes a minimum horizontal and vertical distance that must exist between two aircraft in the air.

As safety is the greatest asset in aviation, care must always be taken to ensure that separation is maintained at all times.

Radar separation is **maintained** when between two aircraft **either** the horizontal distance **or** the vertical distance exists (or of course both).

When two aircraft have **neither** the minimum horizontal **nor** the vertical distance, this is called a **loss of separation (LoS)**. A loss of separation caused by the controller will always result in a failure in the exam.

Radar separation is used wherever air traffic control has radar equipment available to check separation. In Germany, all Approach and Center stations have this equipment and so radar separation is used throughout Germany. The tower controllers at international airports (EDDx) also have a radar screen for separation, so radar separation must also be ensured in the tower area for approaches and departures.

There is a [separate guide](#) detailing radar separation explicitly for **tower controllers**.

## Need for separation

Whether two aircraft must be radar-separated depends on the respective airspace and the applicable flight rules.

The following table provides an overview of the separation obligation:

		controlled			uncontrolled
		C	D	E	G
IFR	separation	to IFR/VFR	to IFR/SVFR*	to IFR	procedural
	traffic info	not req	VFR	VFR if poss	if poss
	speed limit	M.99	250 kts	250 kts	250 kts
	on freq	mandatory	mandatory	mandatory	recommended
	clearance	required	required	required	not req
VFR	separation	to IFR	SVFR* to IFR	none	none
	traffic info	VFR	IFR/VFR	if poss	if poss
	speed limit	250 kts below FL100	250 kts	250 kts	250 kts
	on freq	mandatory	mandatory	nighttime	nighttime
	clearance	required	required	not req	not req

\*) SVFR in CTRs only

In other words, there is obligatory radar separation between:

- (all flights in airspace A and B - does not exist in Germany)
- IFR to IFR in airspace C, D and E
- IFR to VFR and vice versa in airspace C
- Special VFR to IFR in the control zone

## Vertical separation

The following vertical separation must be applied between two aircraft subject to separation:

Level	Vertical separation	Remarks
FL410 - UNL	2000 FT	
FL290 - FL410	2000 FT	during CVSM (exception)
	1000 FT	during <a href="#">RVSM</a> (standard)
GND - FL245	1000 FT	

This regulation applies to aircraft flying at altitudes as well as at flight levels. Important further information can be found in the corresponding [altimetry article](#).

Vertical separation must not be used on **final approach**, horizontal separation only is applied here.

## Horizontal separation

The following horizontal separation must be applied between two aircraft subject to separation:

Level	Horizontal separation	Remarks	
FL245 - UNL	5 NM		
GND - FL245	3 NM		
Final approach within 10 NM	2,5 NM	<b>ONLY</b> if specified and approved by SOPs!	

The horizontal separation is always measured as a direct line **between centers of targets**.

**Formation flights** must be separated to other traffic with **1 NM** more than the required minimum distance.

**Two formation** flights must be separated with **2 NM** more than the required minimum distance to each other.

If the required **wake turbulence separation** is higher than the above values, it must be given priority, so that the higher value always applies.

# Wake turbulence separation

Wake turbulence: yet another abstract new term. [This video](#) explains what wake vortices are and how they arise.

And what do air traffic controllers have to do with it? We have to make sure that accidents like the one shown in the video in New York don't happen again. There are minimum separation values for this depending on the maximum take-off mass of the aircraft and we as controllers need to make sure these separation distances are maintained at all times.

## When must wake turbulence separation be applied?

Wake turbulence separation is used in areas where wake turbulence is expected.

Between aircraft with **obligatory radar separation** (see [radar separation](#)), if:

- an aircraft is directly behind a preceding aircraft at the same altitude or less than 1000ft below
- an aircraft crosses directly behind another aircraft - at its 6 o'clock position - at the same altitude or less than 1000ft below

Between aircraft in the **approach or departure phase** of flight when:

- an aircraft is directly behind a preceding aircraft at the same altitude or less than 1000ft below it
- an aircraft crosses directly behind another aircraft - at its 6 o'clock position - at the same altitude or less than 1000ft below it
- both aircraft are using the same runway or parallel runways less than 760m apart
- the aircraft use crossing or parallel runways (distance of 760m or more) and one aircraft flies through the flight path of the preceding aircraft at the same altitude or less than 1000ft below it

Wake turbulence separation does not apply to:

- approaching VFR flights
- approaching IFR flights that are performing a visual approach, have reported the preceding aircraft in sight and have been instructed to follow it and maintain their own separation

In these cases, a **wake turbulence warning (CAUTION WAKE TURBULENCE)** must be issued.

## Departure phase

A VFR flight is in the departure phase from take-off until

- reaching 1000ft above aerodrome level or
- reaching level flight or
- entering (right) downwind

## Approach phase

A VFR flight is in the approach phase when it is at or below 1000ft above aerodrome level and

- has entered the traffic pattern or part of it or
- has begun the final descent within a control zone

until landing.

A **touch-and-go** is considered an approaching aircraft until touchdown, from then on it is handled as a departing aircraft. A **low-approach** is considered to be an approaching aircraft until it crosses the runway threshold, after which it is considered to be a departing aircraft.

## Wake turbulence categories

For this purpose, aircraft are divided into four wake turbulence categories (WTC) according to their maximum take-off mass (MTOM).

WTC	MTOM
Light (L)	$MTOM \leq 7t$
Medium (M)	$7t < MTOM < 136t$
Heavy (H)	$MTOM \geq 136t$
Super (J)	A388; A225

Of course, you don't need to know how heavy each aircraft is. In addition to the aircraft type, the corresponding WTC can always be found in the flight plan.

The Boeing 757 counts as heavy in Germany despite an MTOM of less than 136 tons.

Aircraft in the "Super" category are treated as "Heavy" above flight level 100.

## Minimum separation values

Wake turbulence separation can either be distance-based or time-based. As a standard procedure, distance-based wake turbulence separation is used. However, there are also constellations in which this is not possible and in these cases time-based wake turbulence separation is used.

## Distance-based

Preceeding	Suceeding	Separation value
M	L	5 NM
H	L	6 NM
	M	5 NM
	H	4 NM
J	L	8 NM
	M	7 NM
	H	6 NM

## Time-based

With time-based wake turbulence separation, a distinction is made between the separation values of departing and approaching aircraft.

We also differentiate between a take-off from an intersection or the full runway length. Usually the values of the take-off on an intersection apply to a take-off on a crossing runway. In each case, the separation value is increased by one minute.

In contrast to distance-based wake turbulence separation there is no separation value between heavy-heavy aircraft in time-based wake turbulence separation.

## Departing aircraft

Preceeding	Suceeding	Separation value	Separation value (intersection)
M	L	2 min	3 min
H	L	2 min	3 min
	M	2 min	3 min

J	L	3 min	4 min
	M	3 min	4 min
	H	2 min	3 min

## Approaching aircraft

Preceding	Succeeding	Separation value
M	L	3min
H	L	3min
	M	2min
J	L	4min
	M	3min
	H	2min

## Examples for separation values

1. IFR departure B744 (H) behind IFR departure B744 (H) --> 4 NM
2. IFR departure C172 (L) behind IFR departure A388 (J) --> 8 NM
3. IFR approach A320 (M) behind IFR approach B753 --> 5 NM (B753 is considered H)
4. IFR approach B752 behind IFR approach B773 (H) --> 4 NM (B752 is considered H)
5. IFR approach A320 (M) behind IFR approach A320 (M) --> no wake separation needed (no value in the table for this scenario)
6. VFR approach C172 (L) behind IFR Anflug A320 (M) --> Wake turbulence warning required (for 2 minutes)
7. VFR departure C172 (L) behind IFR departure A332 (H) --> 6 NM (see table; separation required as this is a VFR departure)
8. VFR touch and go C172 (L) behind IFR departure A320 (M) --> 5 NM as soon as the C172 enters the area where wake turbulence is expected after the touch and go

Further information on wake turbulence separation can be found [here](#).



# Runway separation

# Runway separation

Runway management is the main task of every tower controller. Without a runway, an airport obviously makes no sense. Not only do we have to use our runway as efficiently as possible in order to fully utilize the airport's capacity, but we also have to protect it accordingly, as the critical flight phases of take-off and landing take place there. Runway separation was introduced for this purpose. But what actually is runway separation? It's actually quite simple:

**The runway may only ever be occupied by one user at a time.**

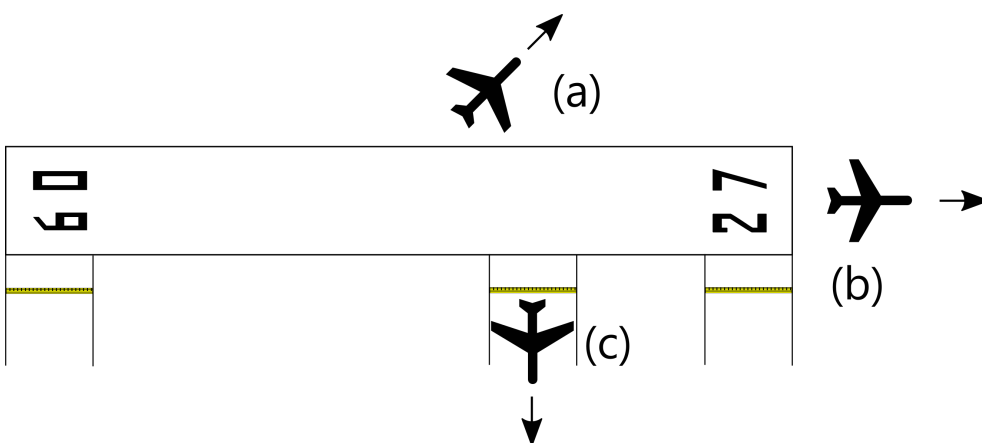
Now we just have to deal with a few more questions to clearly define the concept.

Who is considered a runway user?

- Landing aircraft (i.e. aircraft with active landing clearance)
- Aircraft taking off (i.e. aircraft with active take-off clearance)
- Vehicles on the runway e.g. inspecting the runway (not implemented on Vatsim)

How long is a user considered to be an active user of a runway and when is the runway free again for the next user?

- For aircraft taking off: The runway can be used again as soon as the departing aircraft has either
  - overflowed the end of the runway (image b) or
  - vacated the runway to the side (picture a)
- For landing aircraft: The runway can be used again as soon as the aircraft has vacated the runway (image c). The runway is considered abandoned as soon as all parts of the aircraft have rolled over the stop bar of the CAT1 holding point.



An aircraft that is cleared for line-up (i.e. taxiing onto the runway, but without take-off clearance) does not count as a runway user. A line-up clearance can therefore be given in the following cases, even though the runway is still occupied according to the above criteria:

- After a landing aircraft has passed the point at which the waiting aircraft will taxi onto the runway
- After a departing aircraft has passed the point at which the waiting aircraft will taxi onto the runway

The procedure described on this page is also called “**full**” runway separation. Does this mean that there is a “half” runway separation, too? Not quite, but almost. There is also “**reduced**” runway separation (RRS), which is taught in the specific tower textbooks. A brief teaser: with reduced runway separation, under certain conditions the runway may be used more efficiently.

# Intersecting runways

Many airports have intersecting runways either to compensate for prevailing weather conditions or to increase efficiency due to a lack of space. In Germany, Hamburg and Cologne are particularly well known for their intersecting runways.

As always, there are rules and regulations that must be observed when using the two runways simultaneously.

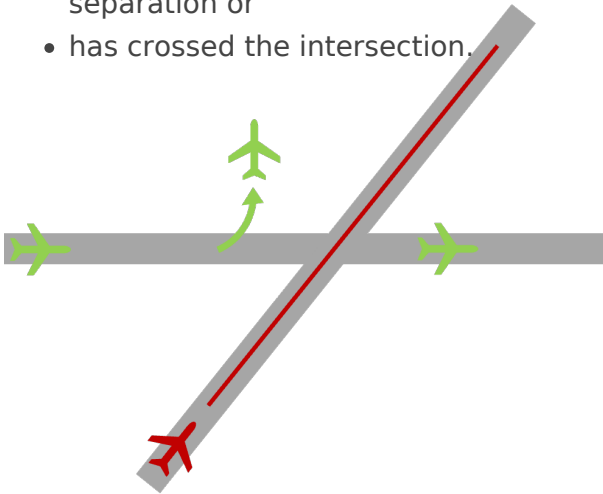
In this chapter, we will consider all possible combinations for using the runways.

## Departure - Departure

In the case of two departures on intersecting runways, the second aircraft may only begin the take-off run if one of the following conditions is met:

The other aircraft is taking off and

- has taken off and has initiated a turn that excludes the possibility of undercutting the separation or
- has crossed the intersection.

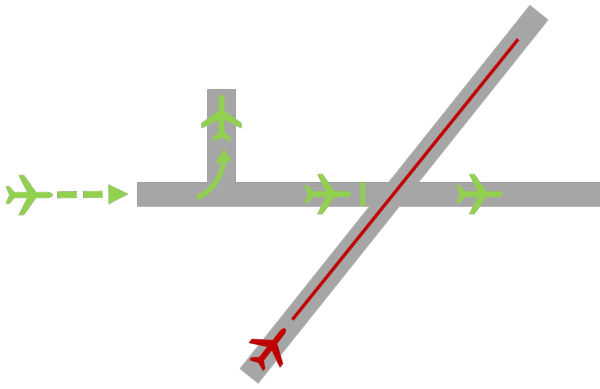


## Arrival - Departure

The situation is different if we have a preceding inbound, in which case the second aircraft on the intersecting runway may only begin the take-off run if one of the following conditions is met:

The other aircraft lands and

- has left the runway or
- has been instructed to stop before the intersection and has completed the landing roll or
- has crossed the intersection.

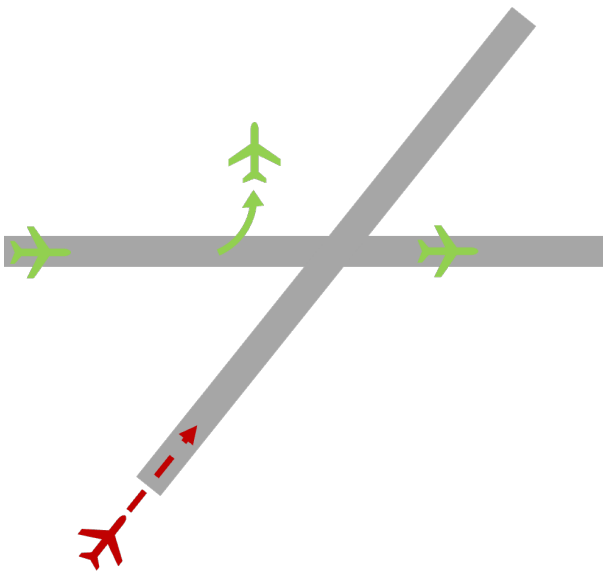


## Abflug - Anflug

Bei einem abfliegenden Luftfahrzeug gefolgt von einem anfliegenden Luftfahrzeug auf der kreuzenden Piste, darf das folgende Luftfahrzeug den Anfang der Piste erst überfliegen, wenn eine der folgenden Bedingungen gegeben ist::

Das andere Luftfahrzeug startet und

- hat abgehoben und eine Kurve eingeleitet, die eine Staffelungsunterschreitung ausschließt  
oder
- hat die Kreuzung überquert.



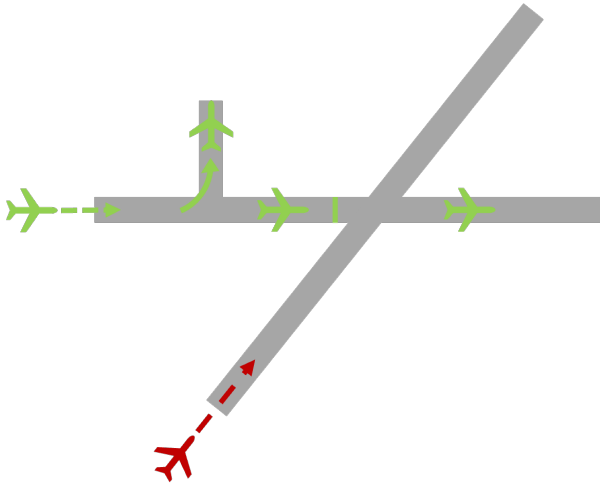
## Arrival - Arrival

The last possibility is a landing aircraft followed by another landing aircraft on the intersecting runway. The following aircraft may only fly over the runway threshold if one of the following conditions is met:

The other aircraft is landing and

- has left the runway or

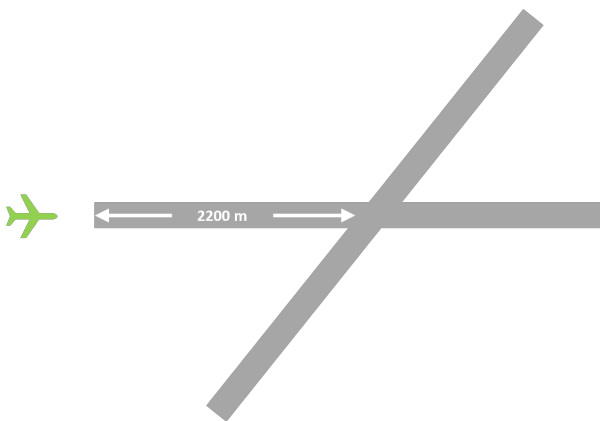
- has been instructed to stop before the intersection and has completed the landing roll or
- has crossed the intersection.



## Simultaneous use of intersecting runways

The simultaneous use of intersecting runways may only be authorized for two landing aircraft under the following conditions:

- One of the intersecting runways has an available distance between threshold and intersection of at least 2200 meters.
- An aircraft with a maximum take-off weight of up to 2000 kg lands on this runway.



All of the following conditions must additionally be met:

- VMC
- The braking action is not negatively affected.
- Both aircraft have been informed of the simultaneous landings.
- The aircraft landing on the 2200m runway has been instructed to stop before the intersection.

# Reduced runway separation (RRS)

Reduced runway separation is not a mandatory part of S1 training.

## Requirements

ATCOs can only use Reduced Runway Separation if the following aspects are fulfilled:




- The tailwind component on the ground must not exceed 5 knots
- Ground visibility must be equal to or greater than 5 kilometers
- The main cloud base must be at 1000ft AGL or higher
- Wake turbulence separation must be maintained at all times
- The braking effect on the runway must not be significantly impaired by precipitation
  - On Vatsim, the braking effect is considered to be significantly impaired by precipitation: snow (SN), snow grains (SG), ice grains (PL), hail (GR) and rime (GS) - in other words, all precipitation except rain (RA) and drizzle (DZ)
- The following aircraft in the RRS sequence must receive traffic information about the preceding traffic

## Aircraft categories

For the Reduced Runway Separation procedure, aircraft have been divided into three categories.

These three categories are:

CAT 1	CAT 2	CAT 3
Single-engine propeller-driven aircraft with a maximum take-off weight of up to 2 tons.	Single-engine propeller-driven aircraft with a maximum take-off weight greater than 2 tons but less than 7 tons.  Twin-engine propeller-driven aircraft with a maximum take-off weight of less than 7 tons.	All other aircraft

		
<p>The following registrations apply in Germany:</p> <ul style="list-style-type: none"> <li>• D-<b>E</b></li> <li>• D-<b>K</b></li> <li>• D-<b>M</b></li> </ul>	<p>The following registrations apply in Germany:</p> <ul style="list-style-type: none"> <li>• D-<b>C</b> (up to 7 tons)</li> <li>• D-<b>F</b></li> <li>• D-<b>G</b></li> <li>• D-<b>I</b></li> </ul>	<p>The following registrations apply in Germany:</p> <ul style="list-style-type: none"> <li>• D-<b>C</b> (over 7 tons)</li> <li>• D-<b>B</b></li> <li>• D-<b>A</b></li> </ul>
Examples: C152, C172, P28A, A210, DA40, DR40, DV20, SR22	Examples: DA62, PA34, TBM9, BE58, B350	Examples: AT75, DH8D, C25C, CRJ9, B738, A359

## Possible constellations

There are four different possible constellations of these categories on a runway. We will now look at these step by step with a focus on Reduced Runway Separation.

### Departure behind departure

- The following departure receives traffic information about the leading departure.
- If all other criteria are met, the second departure may be cleared for take-off as soon as the first departure has taken off and is a defined distance away from the second departure. The distance is specified by the LFZ-KATs (aircraft categories):

Preceding	Succeeding	Requirement
CAT 1 / CAT 2	CAT 1	airborne and at a distance of 600m
CAT 1 / CAT 2	CAT 2	airborne and at a distance of 1500m
CAT 3	all	airborne and at a distance of 2400m

- As soon as the second departure has taken off, any applicable separation must exist.
- Example of application: First departure is a DV20 IFR, second departure a BE58 VFR. No separation must be established between the two aircraft in D(CTR), only wake turbulence separation, as the VFR is a departure. However, since light behind light does not require wake turbulence separation, I only have to consider the runway separation. Without Reduced Runway Separation, I would have to hold back the take-off clearance until the DV20 has flown over the end of the runway. Using RRS, I can now clear the following take-



off as soon as the DV20 has taken off and is 1500 m away from the BE58. This means I can use the runway more effectively and have more capacity.

## Arrival behind arrival

- The second approach receives traffic information about the approach ahead.
- If all other criteria are met, the second approach may be cleared for landing as soon as the first approach has landed and is a defined distance away from the threshold. Additionally, the first approach must continue moving and leave the runway without backtracking. Because the landing clearance is explicitly clearance to overfly the runway threshold, it must of course be issued before the threshold is crossed. If the criteria are not (yet) fulfilled, a missed approach must be instructed. The distance is specified by the LFZ-KATs (aircraft categories):

Preceding	Succeeding	Clearance before	Requirement
CAT 1 / CAT 2	CAT 1	aircraft crosses runway threshold	vacating runway and at least 600m from threshold
CAT 1 / CAT 2	CAT 2		vacating runway and at least 1500m from threshold
CAT 3	all		vacating runway and at least 2400m from threshold

This situation may seem somewhat strange, as a landing clearance is issued even though there is another pilot still on the runway. However, if the distances are maintained, this is actually legal and is practiced in reality.

## Arrival behind departure

- The approach receives traffic information about departure.
- If all other criteria are met, the approach may receive landing clearance as soon as the departure has taken off and is a defined distance away from the threshold. Because the landing clearance is explicitly clearance to overfly the runway threshold, it must of course be issued before the threshold is crossed. If the criteria are not (yet) fulfilled, a missed approach must be instructed. The distance is specified by the LFZ-KATs (aircraft categories):

Preceding	Succeeding	Clearance before	Requirement
CAT 1 / CAT 2	CAT 1	aircraft crosses runway threshold	airborne and at least 600m from threshold

CAT 1 / CAT 2	CAT 2	airborne and at least 1500m from threshold
CAT 3	all	airborne and at least 2400m from threshold

## Departure behind arrival

Reduced runway separation **may not be used** in this constellation.

## Phraseology examples

German	English
G: VERKEHR C172 FLIEGT *VON PISTE 25* AB	G: TRAFFIC C172 DEPARTING *ON RUNWAY 25*
G: VERKEHR A320 IST *AUF PISTE 25* GELANDET	G: TRAFFIC A320 LANDED *ON RUNWAY 25*
G: VERKEHR PA34 LANDET *AUF PISTE 25*	G: TRAFFIC PA34 LANDING *ON RUNWAY 25*

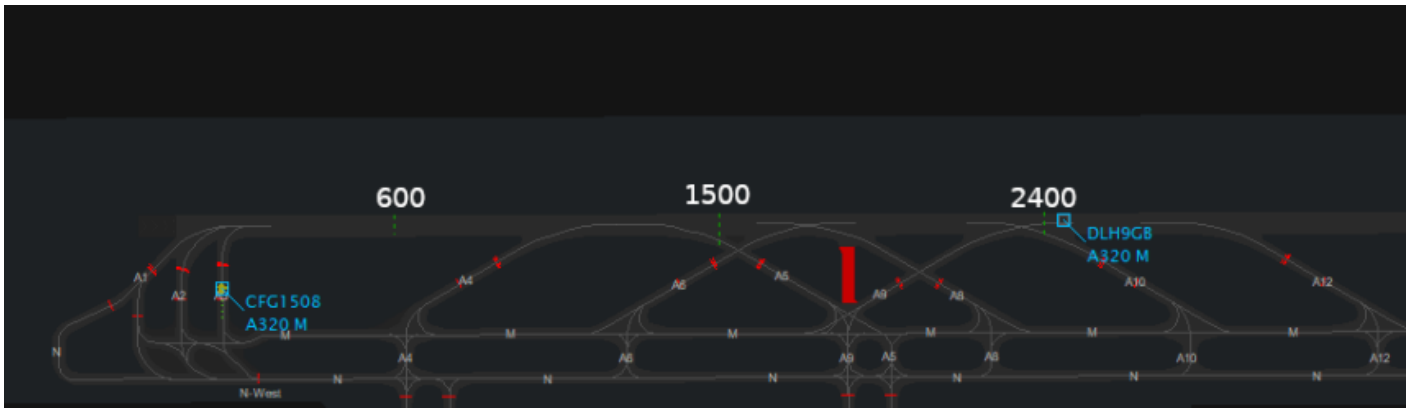
## Miscellaneous and example

### Example of the procedure

We issue a take-off clearance, the next approach is on a 3NM final. In this situation full runway separation is not so likely, so we give traffic information to the landing traffic about the departing traffic. As soon as this is done and the meteorological conditions are suitable, we can apply RRS. The traffic info can read: "DLH414, TRAFFIC A320 DEPARTING RUNWAY 26R". Theoretically, the traffic information can also be given when the aircraft is cleared to land. However, as RRS is quite tight, it is advisable to give the traffic information as early as possible so you only have the landing clearance left to give and can keep it brief and concise later. As soon as the departing traffic has taken off and passed the prescribed distance from the runway threshold, the landing clearance can be given: "DLH414 WIND 170 DEGREES 6 KNOTS RUNWAY 26R CLEARED TO LAND".

### Marker in the sector file

Of course, you do not have to estimate the distances in meters. Depending on the runway direction selected in Euroscope, you will find green markers on the runway (design may vary depending on the FIR). These describe the distances for the various combinations of aircraft CATs from the start of the runway. The first marker is at 600m and the following ones at 1500m and 2400m. The picture shows an example of these markings for runway 08L in Munich. The representation may differ depending on the FIR.



## Article about Reduced Runway Separation

Anyone interested in the topic of RRS beyond the content mentioned above will find an interesting article on the subject in an issue of “Flugleiter”, the magazine of the air traffic controllers’ union. It can be found from page 48 onwards.

[Flugleiter 04/22](#)

# Visual separation

Visual separation refers to two possibilities of separation used in different cases. There is **visual separation in the vicinity of aerodromes** (relevant for the tower controller, depending on the situation possibly also for the approach controller) and there is the **delegation of separation to the pilot during descent or climb** (relevant for the approach controller).

## Visual separation in the vicinity of aerodromes

The specified radar separation (not the wake turbulence separation or runway separation!) between two aircraft may be reduced in the vicinity of the aerodrome if:

1. adequate separation can be maintained by the tower controller, provided that he can see both aircraft continuously and gives traffic information to at least one aircraft or
2. both pilots have sight of each other and report that they can maintain adequate separation, or
3. if one aircraft is following the other, the pilot of the following aircraft reports that he can see the front aircraft and can maintain adequate separation.

The terms “vicinity of the aerodrome” and “adequate separation” are not defined in detail. Therefore, this procedure should be used sensibly. Examples are a swing-over in Frankfurt from the 25L to the 25C if a pilot is simultaneously approaching the 25R in parallel or the avoidance of a missed approach if there is a risk of falling below the minimum separation.

### Phraseology example: Own Separation - Final

G: DLH123, traffic, A320, 2 o'clock, report in sight and able for own separation

A: DLH123, traffic in sight and able

G: DLH123, cleared visual approach runway 25C, in case of missed approach, climb on runway track to 5.000 feet, maintain own separation to mentioned traffic

# Delegation of separation during climb or descent

Under certain conditions, the responsibility of maintaining separation between two flights requiring separation may be delegated to the pilot. The conditions are:

- Daytime
- Below FL100
- Airspace E or D
- VMC
- Only during climb or descent
- Both pilots involved agree to the procedure

## Funkbeispiel Own Separation - CLB/DES

G: DLH123, REPORT FLIGHT CONDITIONS AND LEVEL

A: DLH123, VMC, FL80

G: DLH123, TRAFFIC IS PA42, 1 O'CLOCK 5 MILES SAME DIRECTION, 1000 FEET BELOW, REPORT IN SIGHT

A: DLH123, TRAFFIC IN SIGHT

G: DLH123, ADVISE ABLE TO MAINTAIN OWN SEPARATION UNTIL PASSING FL60

A: DLH123, AFFIRM

G: DEHHH, TRAFFIC 7 O'CLOCK 5 MILES AIRBUS 320 HAS YOU IN SIGHT. MAY HE DESCEND THROUGH YOUR LEVEL MAINTAINING OWN SEPARATION

A2: DEHHH, AFFIRM

G: DLH123, DESCEND 5000 FEET QNH1013, MAINTAIN OWN SEPARATION AND VMC UNTIL PASSING FL60

A: DLH123, DESCENDING 5000 FEET QNH1013, MAINTAINING OWN SEPARATION AND VMC UNTIL PASSING FL60

G: DLH123, DEHHH, CLEAR OF TRAFFIC

# Procedural separation

With procedural separation, two aircraft can fall below the 3 NM required for radar separation under certain circumstances .

Procedural separation is used in the following examples:

## Independent parallel approaches (IPA)

In Frankfurt, Munich and Berlin, under certain conditions so-called **independent parallel approaches** (IPA) are possible. This means that two aircraft may approach the respective north and south runway in parallel. At this point, they have neither 3 NM nor 1,000 feet of separation. Nevertheless, the procedure is legal, as both aircraft are on non-overlapping flight paths. As the aircraft come relatively close to each other at comparatively high speeds, certain **conditions** must be met. These include the following:

- Both aircraft must perform a precision approach (ILS or GLS)
- Both aircraft must be established on the LOC **before** falling below 3 NM or 1,000 feet
- An NTZ (non-transgression zone) must be displayed on the radar - if an aircraft enters this zone, the parallel aircraft must go around
- A controller must monitor compliance with the procedure for each runway
- There must be no meteorological conditions that could cause aircraft to deviate from their track (e.g. thunderstorms)

Details and exceptions can be found in the SOPs of the respective airports.

## Dependent parallel approaches (DPA)

In addition to independent parallel approaches, there are also **dependent parallel approaches** (DPA). Here, too, two aircraft may fly with less than 3 NM separation, but not completely parallel. In Frankfurt, for example, 1.5 NM must still be maintained between the aircraft. The requirements for this are less strict than for IPAs.

Details can be found in the SOPs of the respective airports.

## Independent parallel departures

In Berlin and Munich, there are departure routes with non-intersecting flight paths and obstacle protection areas which are far enough apart to use the departure routes simultaneously. This is why they are referred to as **independent parallel departures**. Here too, the aircraft come closer to each other than 3 NM and/or 1,000 feet. As with independent parallel approaches, the controllers must strictly monitor compliance with the routes in order to be able to react immediately with traffic information and avoidance instructions in the event of a deviation.

Details can be found in the SOPs of the respective airports.

## Geographical separation

At certain airfields, special VFR aircraft are considered separated to IFR if they are located above a geographically defined point (e.g. a roundabout, a highway intersection, a sports facility, etc.). Even then, the distance may be less than 3 NM. This procedure is often only permitted for certain SVFR pilots (e.g. police and rescue helicopters).

The use of geographical separation on Vatsim must be explicitly regulated in the SOPs, otherwise it is not permitted.