Optimising runway capacity

Ensuring a competitive future for Europe’s busiest airports
Optimizing runway capacity

**Introduction**

In September of 2015, Eurocontrol made a seven-year forecast of flight movements, predicting a continuous growth of IFR movements, as seen in Figure 1. Eurocontrol also collects information directly from airports to calculate effective annual capacity figures. They predict that over the next 7 years, the capacity of the entire aviation system is expected to increase by 5.6%. They conclude that constraints at airports will prevent these airports from accommodating flight demand by 2021. Therefore, changes in the current situation are necessary. This factsheet focuses on the possibilities for airports to cope with the predicted demand.

Amsterdam’s Schiphol Airport in the Netherlands serves as a good example. During peak hours, traffic demand is at Schiphol’s maximum capacity. Schiphol therefore needs to grow to keep its market share and to accommodate the increasing number of aircraft movements at the airport. However, its growth is limited by internal and external factors. Noise and environmental regulations mean that the airport cannot build another runway. External safety regulations, meteorological conditions, airport capacity (active runway combinations are limited because some runways intersect) and airspace capacity also play a role. However, the airport could use its current runways more efficiently.

The question is: *How can airports optimize runway capacity while taking into account meteorological conditions and safety requirements?*
What is runway capacity?

Runway capacity is defined as the number of aircraft movements that can be safely operated as determined by aeronautical authorities. This is usually stated as the total number of landings and take-offs per hour. Runway capacity depends on issues such as runway availability, the number and layout of exits (taxiways connected to the runway), operational procedures and meteorological conditions such as wind speed and direction, and visibility.

For example, the VEM (Veiligheid, Efficiency en Milieu) performance standard from the LVNL (Luchtverkeersleiding Nederland), written in 2015, displays the runway and ground capacity for the most preferred 2+1 runway combinations during inbound (Figure 2) and outbound (Figure 3) peak modes respectively. These capacities apply between 06:30 and 22:30.

Schiphol’s current peak hour capacity is already high. How can this capacity be increased to accommodate growth in the number of aircraft movements? The answer may lie in the construction of high-speed exits, time-based separation, a re-categorization of wake turbulence categories, or the use of other navigation systems.

Figure 2: Runway capacity in numbers of movements per hour and per 10 minutes for the two most preferred inbound peak mode runway combinations. Reprinted from VEM performance standard, by LVNL, 2015.
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\[ 9 = \text{for crosswind less than 20 knots} \]

### Runway capacity

<table>
<thead>
<tr>
<th>Runway Combination</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good visibility, inside ULP</td>
</tr>
<tr>
<td>06L / 36L+16C¹</td>
<td>hour: 30 / 35+35 10 min: 7 / 6+4</td>
</tr>
<tr>
<td>18R / 36R+18F¹</td>
<td>hour: 30 / 35+37 10 min: 7 / 7+7</td>
</tr>
</tbody>
</table>

Figure 3: Runway capacity in number of movements per hour and per 10 minutes for the two most preferred outbound peak mode runway combinations. Reprinted from VEM performance standard, by LVNL, 2015.

High speed exits reduce runway occupancy time

A key indicator for runway capacity is Runway Occupancy Time (ROT). During the arrival of an aircraft, ROT is defined as the time interval between the aircraft crossing the threshold of the runway and the tail of the aircraft leaving the runway. Runway capacity is often limited by ROT because only one aircraft is allowed to use the runway at any given time. The leading aircraft must first vacate the runway before the trailing aircraft is allowed to cross the threshold.

ROT can be reduced through the use of high-speed exits. These exits are not perpendicular to the runway, but instead use a smaller angle allowing aircraft to vacate sooner and at higher speeds, reducing ROT.

### Time-based separation, rediscovered

To explain the concept of time-based separation (TBS) some basic information about aircraft separation is needed. This information can be divided into why aircraft need to be separated in the first place and what the current legislation states.

**Why do aircraft need to be separated?**

The most obvious reason for separating aircraft, of course, is to prevent collisions. The European Aviation Safety Agency (EASA) has made it mandatory to provide air traffic control service to all aerodrome traffic at controlled aerodromes (SERA.8001). In SERA.8001, EASA defines a controlled aerodrome as: “...an aerodrome at which air traffic control service is provided to aerodrome traffic regardless whether or not a control zone exists,” (p. L 281/5). It defines air traffic control service as “…a service provided for the purpose of:

1. Preventing collisions:
   - Between aircraft; and
   - On the manoeuvring area between aircraft and obstructions; and
2. Expediting and maintaining an orderly flow of air traffic,” (p. L 281/4).

Therefore, at controlled aerodromes the air traffic control service ensures aircraft separation.

A less obvious reason to separate aircraft is wake vortex turbulence. Wake vortex turbulence is defined as turbulence that is generated by the passage of an aircraft in flight. It is generated from the point at which the nose landing gear of an aircraft leaves the ground upon take-off and ceases to be generated when the nose landing gear touches the ground during landing. It can be dangerous to fly within the wake turbulence of an aircraft. According to ICAO Doc 9426, wake turbulence causes three basic effects: induced roll (Figure 2, www.myairlineflight.com, 2014), loss of height or rate of climb, and possible structural stress. Therefore, the second reason to separate aircraft is to ensure a safe flight without wake turbulence dangers.
What is the current legislation on aircraft separation?

Because EASA made it mandatory to provide separation, it also created separation rules. EASA states in PART- SERA.8010 Separation minima: “The selection of separation minima for application within a given portion of airspace shall be made by the air navigation service provider (ANSP) responsible for the provision of air traffic services and approved by the competent authority concerned.” This means that the airport’s ANSP can create their own separation rules as long as they are approved by the ‘competent authority concerned’. In the Netherlands, the ANSP for civil traffic is the ‘Luchtverkeersleiding Nederland’ (LVNL). The competent authority is ‘Inspectie Leefomgeving en Transport’.

Collision avoidance separation

The LVNL based its rules on ICAO Doc 4444 (PANS-ATM). ICAO states in chapter 7.10.1 of Doc 4444 for arriving aircraft that:

“A landing aircraft will not normally be permitted to cross the runway threshold on its final approach until the preceding departing aircraft has crossed the end of the runway-in-use, or has started a turn, or until all preceding landing aircraft are clear of the runway-in-use,” (p.7-15).

This reflects the previously-addressed issue of limiting ROT. For departing aircraft, ICAO Doc 4444 chapter 7.9.2 states that: “A departing aircraft will not normally be permitted to commence take-off until the preceding departing aircraft has crossed the end of the runway-in-use or has started a turn or until all preceding landing aircraft are clear of the runway-in-use,” (p. 7-14).

But the runway separation minima between aircraft using the same runway may be reduced in certain situations, as described in ICAO Doc 4444 chapter 7.11. The conclusion of these rules is that ‘collision avoidance separation’ may be reduced at the airport’s own discretion in certain situations, such as visual separation. However, ‘wake turbulence avoidance separation’ still needs to be taken into account.

When Air Traffic Control (ATC) separates the IFR flight from other flights with the aid of radar, ICAO Doc 4444 chapter 8.7.3 prescribes a minimum separation of 5.0 nautical miles (9.3 km). This may be reduced at the discretion of the appropriate Air Traffic Services (ATS) authority to 3 nautical miles (5.6 km) or even 2.5 nautical miles (4.6 km) when the conditions described in ICAO Doc 4444 chapter 8.7.3.2b are met. One of these conditions is that the average ROT must not exceed 50 seconds. At Schiphol, the LVNL uses the approach separation rules as displayed in Figure 5 (LVNL, n.d).
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Figure 5: Approach separation rules from LVNL. Reprinted from Luchtverkeersleiding Nederland website, by LVNL, n.d., retrieved from https://www.lvnl.nl/over-ons/veiligheid/separatie-van-vliegtuigen.html

Wake turbulence avoidance separation

Wake turbulence avoidance separation also needs to be taken into account. Wake turbulence categories are defined in ICAO Doc 4444 chapter 4.9 as: “HEAVY (H) – all aircraft types of 136,000 kg or more; MEDIUM (M) – aircraft types less than 136,000 kg but more than 7,000 kg; and LIGHT (L) – aircraft types of 7,000 kg or less”(p. 4-11). Then Airbus made the Airbus A380, with a maximum take-off mass of approximately 560,000 kg. ICAO had to investigate whether these three wake turbulence categories were sufficient. After conducting investigations and writing state letters, ICAO created a guideline in 2008 recommending a new category. Because the vortices generated by the A380 are more substantial than those of other aircraft in the HEAVY wake turbulence category, as SUPER category was introduced for A380 aircraft.

According to ICAO Doc 4444 chapter 8.7.3.4, the wake turbulence separation as shown in Figure 4 and Figure 5 are applied when:

a) an aircraft is operating directly behind another aircraft at the same altitude or less than 300 m (1000 ft) below; or

b) both aircraft using the same runway, or parallel runways separated by less than 760 m (2500 ft); or

c) an aircraft is crossing behind another aircraft, at the same altitude or less than 300 m (1000 ft) below (p. 8-17).

ICAO describes in Doc 4444 chapter 5.8 that when the aerodrome controller uses non-radar separation, an IFR arrival/departure must be separated from other aircraft with time-based wake turbulence separation. The following rules apply for arriving aircraft: A MEDIUM aircraft behind a HEAVY aircraft needs a separation of 2 minutes. A LIGHT aircraft behind a HEAVY or MEDIUM aircraft needs a separation of 3 minutes. One minute must be added for an aircraft following an A380.
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For departing aircraft, a minimum separation of 2 minutes should be applied between a LIGHT or MEDIUM aircraft taking off behind a HEAVY aircraft or a LIGHT aircraft taking off behind a MEDIUM aircraft. A minimum separation of 3 minutes should be applied for a LIGHT or MEDIUM aircraft and 2 minutes for a non-A380-800 HEAVY aircraft taking off behind an A380-800 aircraft. One exception applies for departures from intermediate parts of the same runway. Then, a minimum separation of 3 minutes is needed for a configuration with LIGHT, MEDIUM and HEAVY aircraft. A separation minimum of 4 minutes should be applied for a LIGHT or MEDIUM aircraft when taking off behind an A380-800 aircraft.

Time-based separation?

Time-based separation (TBS) already exists but it is only used when aircraft are not separated by the use of radar. This is probably because it is less accurate in contrast to distance-based separation (DBS). DBS can be visualized on a radar screen or a similar device. TBS limits may therefore preferably be translated into DBS minima. There is one disadvantage of separation DBS: when an aircraft is on final approach and the headwind component increases, the groundspeed drops. This results in a reduced landing rate, which leads to increased airborne holdings and delays. TBS does not suffer from wind influences.

The influences of the weather

The ICAO introduced the current aircraft separation standards in the 1970’s. These standards are based on the worst meteorological conditions. In normal conditions, runway capacity can be increased.

NATS, the English ANSP, conducted research and together with Lockheed-Martin and developed a system that provides air traffic controllers with time-based separation indicators on their radar. Lockheed-Martin also developed a system called LIDAR (Light Detection And Ranging) to measure wake vortex behaviour. LIDAR is a system that uses lasers instead of traditional radio waves. Lasers are excellent for determining wake vortex turbulence at airports. Laser pulses are sent through the atmosphere measuring wind speed by using Doppler-induced frequency shift on the backscattered laser light. However, to understand the behaviour of wake vortex turbulence, which is necessary for time-based separation, an algorithm must be used to extract wind speed and air direction.

This LIDAR system, together with the time-based separation system, has been installed at London Heathrow airport. Experiments with the LIDAR system showed that if the headwind component increases, the wake vortex decays faster and therefore the separation between aircraft can be reduced. With this input, the time-based separation system dynamically adjusts the separation between arrivals to maintain time separation equivalent to distance separation with a headwind of 5-7 knots. Therefore, this system eliminates the disadvantages of the ‘simple time-based separation’ – not being able to make the separation visible. It also provides another advantage, in that it adapts to the current weather situation.

Another system used to measure wake turbulence behaviour is the X-band RADAR system. This system uses ‘normal’ radar wave technology to detect wake vortex turbulence. When a vortex occurs, radar waves return to the system as a consequence of Rayleigh scattering. Then the circulation of the wake vortex, which determines its strength, is calculated with the use of Doppler frequencies.

Real-world tests were performed to evaluate the potential of the system. The performance of X-band RADAR was tested at Paris Orly airport (2006, 2007) and at Paris Charles de Gaulle airport (2007). In 2012, another test at Paris Charles de Gaulle was performed (part of the Single European Sky ATM Research program). Both tests proved that X-band RADAR is complementary for detecting wake vortex turbulence. This capability is not restricted to clear air conditions, but applies to all weather conditions (e.g. light to heavy rain, fog).
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European Wake Vortex Re-categorisation (RECAT-EU)

Eurocontrol, in consultation with its stakeholders, has developed a RECAT-EU programme and indicates that:

“during recent years, knowledge about wake vortex behaviour in the operational environment has increased thanks to recorded data and improved understanding of physical processes. It is mainly for this reason that it was possible to revise wake turbulence categorisation and corresponding separation minima to enable optimisation of airport capacity and efficiency whilst maintaining acceptable levels of safety,” (p. 7).21

The RECAT-EU program basically uses information from the LIDAR and X-band RADAR systems, and splits the HEAVY and MEDIUM ICAO category into an upper and lower subcategory. Therefore, the separation minima between the (sub) categories can be reduced. Then, as Eurocontrol mentions, “Safety benefits are also delivered for some smaller aircraft types, by increasing their separation minima and/or change of category grouping, hence reducing the risk of wake turbulence-induced accidents for the most vulnerable types,” (p. 6).21

The proposed new aircraft wake turbulence categories are displayed in Figure 8.

Figure 8: Categorisation process and criteria for assigning an existing aircraft type into RECAT-EU scheme. Reprinted from RECAT-EU document, by Eurocontrol, 2015, retrieved from https://www.eurocontrol.int/download/publication

The proposed new aircraft wake turbulence separations are displayed in Figure 9 and Figure 10.
According to Eurocontrol, ATS can immediately expect benefits from the deployment of this program. They specifically mention the following benefits:

- “The runway throughput benefits can reach 5% or more during peak periods depending on individual airport traffic mix.
- For an equivalent throughput, RECAT-EU also allows a reduction of the overall flight time for an arrival or departure sequence of traffic, and this is beneficial to the whole traffic sequence. This may offer more flexibility for the air traffic controllers to manage the traffic.
- RECAT-EU will also enable more rapid recovery from adverse conditions, helping to reduce the overall delay and will also enable improvements in ATFM slot compliance through the flexibility afforded by reduced departure separations.
- The gain in capacity could even increase further by 2020 due to evolution of traffic mix. Indeed, the benefits are expected to further increase over time as the overall fleet mix is forecasted to evolve towards larger aircraft, a mitigation for the lack of runway capacity foreseen in Eurocontrol’s 2013 ‘Challenges to Growth’ study,” (p.19).

The implementation of this program does not require the deployment of new technologies, but it does require minor updates, adaptations to the approach and tower traffic surveillance display, and the publication of new applicable minima. Air traffic controllers must also be trained with regard to the new categories and the flight crew must be made aware of the change.21

A Microwave Landing System and a Ground-Based Augmentation System can improve runway capacity

Another interesting technological development concerns precision approach technology. Precision approach technology guides aircraft towards the runway in both horizontal and vertical directions. The
Instrument Landing System (ILS), which uses two radio beams to provide the pilots with vertical and horizontal guidance, is currently the most used approach system. However, the ILS has some disadvantages.

The most important disadvantage is that the radio beams for horizontal and vertical guidance are fixed and narrow. There is also a critical sensitive area to prevent vehicles and aircraft from interfering with the ILS signal during ILS operations (only in low visibility). As a result, aircraft have to be sequenced and adequately separated into the range of the radio beams, which can cause landing delays. This does not help when optimizing runway capacity.

The Microwave Landing System (MLS) was designed to replace the ILS with an advanced precision approach system that would overcome these disadvantages. The MLS radio beams have a large cover area and the signals cannot be disturbed by other vehicles. This means that the critically sensitive area plays no role, thereby improving runway capacity during low visibility conditions. The aircraft have a larger area to intercept the radio beams, which is helpful when separating aircraft (it delivers greater flexibility). Implementing MLS therefore provides an opportunity to optimize runway capacity.

Another technological development designed to replace the ILS is the Ground-Based Augmentation System (GBAS). The GBAS augments GPS to provide precise navigation service for the airport and surrounding airspace with the use of a Very High Frequency (VHF) data link. Several operational GBAS are located in the USA, Germany, Australia, Spain, Switzerland and Russia. The navigation and approach operation can be used within 23 nautical miles of the GBAS reference. In practice, this results in an approach guidance of 20 nautical miles. The benefit of the GBAS is that – contrary to ILS and MLS – a single system can support multiple runways/approaches at an airport. Another benefit is that the GBAS eliminates the critical sensitive area, just like the MLS, and provides accuracy up to one metre in both vertical and horizontal directions. Finally, the GBAS uses less of the radio frequency spectrum. However, there are some downsides to the current version of the GBAS.

The GBAS can only be used in CAT-I conditions (decision height not lower than 200 feet with either a visibility of not less than 800 metres or a runway visual range not less than 550 metres on a runway with a touchdown zone and centreline lighting). When conditions worsen, the GBAS cannot be used and the ILS or MLS needs to be used. The Federal Aviation Administration (FAA) focuses on validations standards for a GBAS approach service that covers the CAT-III minima, which results in a useable GBAS in low visibility conditions. It is expected that this system (GAST-D) will be available in 2018.

Discussion

The main question asked at the beginning of this document was: How can airports optimize runway capacity while taking into account meteorological conditions and safety requirements? We have discussed five options.

High-speed exits are a possibility to reduce the ROT. However, this is not an option for every airport. For example, Amsterdam's Schiphol Airport already has high-speed exits on all but one runway, so the advantages gained through this solution would be very small.

Time-based separation is designed to increase runway capacity. However, this only makes a difference under the right meteorological conditions. In low visibility, air traffic controllers and ground controllers will be at their maximum capacity. If time-based separation is used in these conditions, controllers may possibly have more aircraft than they can safely deal with. TBS should first be tested with caution, as it may not be the best solution under all conditions. Furthermore, it also requires the installation of systems necessary to visualize the separation limits, requiring ATC training.
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The RECAT programme sounds very promising, although it should be noted that the developer of the programme itself forecast the results. Once the solution is simulated to analyse the safety effects, and if EASA approves it, implementation will move forward quickly, as there are few changes to be made.

MLS has been mentioned as a technology that can possibly increase runway capacity. MLS has some advantages for the airport and the surrounding community. However, aircraft modifications are required as not every aircraft is equipped with MLS. For MLS to be as effective as possible at Amsterdam Airport Schiphol, every runway and aircraft must have the proper equipment for the MLS. This can be costly for the airport and operators, and is likely to be an unpopular solution.

The MLS is not the only system that has been developed to increase runway capacity. The GBAS augments the existing GPS signal by broadcasting a differential correction signal using VHF, which is transmitted by a GBAS transmitter. However, this system can only be used under CAT-I conditions. This means that the system, in today’s state, can never be a standalone landing system, and a secondary system (such as ILS or MLS) must be installed alongside the GBAS to provide sufficient landing guidance in all weather conditions.

Some of the new procedures, such as RECAT-EU, are hard to implement. Currently, aircraft are lined up on the runway in the sequence in which they approach, and controllers have to take into account three aircraft wake turbulence categories. For RECAT-EU to be effective, aircraft must be lined up in a sequence that provides the minimum total time interval between landings. To do this, some aircraft must hold and other must be expedited. This will increase controller workload, raise complexity and congest the TMA even more.

Before one of these possible solutions can be implemented, a VEM (Veiligheid, Efficiency en Milieu) analysis is needed. This analysis requires specific information to which the authors of this fact sheet have limited or no access.

Overall conclusion

All of the techniques and procedures described in this fact sheet are, in some way, possible solutions for the problem of insufficient runway capacity. The high-speed exits could ensure a smaller ROT, whereby an aircraft might be allowed to have less distance between it and the aircraft ahead.

When using time-based separation, aircraft separation limits can be dynamically adjusted, related to the current weather. This can be done due to the fact that a strong headwind will result in quicker wake vortex dissipation. In order to achieve this time-based separation, new technology must be used, such as X-band RADAR and LIDAR radar systems in combination with algorithms to calculate the strength of the actual vortices.

Legislation states that separation is necessary to prevent collisions between aircraft and to expedite and maintain an orderly flow of air traffic. It also makes clear the fact that aircraft must be separated at certain distances as a result of wake vortices. By creating more aircraft categories, as is done in the RECAT-EU program, wake turbulence categories are tied to the size of the aircraft, which prevents unnecessary separation.

The MLS is designed as a replacement for the ILS. The MLS provides a large radio beam coverage and the signal cannot be disturbed by other vehicles. This means that the aircraft will have a larger area to intercept the radio beams for guidance to the runway. MLS also has some disadvantages. The largest disadvantage is cost – for the airport and for the operator. Finally, the GBAS was designed to use GPS in an aviation-related manner. A GBAS transmitter augments the GPS signal, which is located near the runway. Unfortunately, the use of GBAS is currently limited to CAT-I conditions and
Optimizing runway capacity therefore it cannot be used as stand-alone equipment for precision approaches.

With the exception of the high-speed exits, all of these techniques and procedures are still under development or in testing stages at other airports. They also currently deviate from ICAO standards. Before the LVNL and Amsterdam’s Schiphol Airport will consider these solutions, they will need to see a VEM analysis.

The authors of this fact sheet cannot currently conduct this analysis. But we hope that some of these solutions will turn out to be helpful. If nothing changes, Amsterdam Airport Schiphol will face capacity-related problems in the future.
Glossary

- **Airborne holdings**: Aircraft that are flying in circles in the vicinity of an airport because of delays.
- **Aircraft separation**: The space between two aircraft.
- **ANSP**: Air Navigation Service Provider.
- **ATC**: Air Traffic Control.
- **ATFM**: Air Traffic Flow Management.
- **ATS**: Air Traffic Services.
- **DBS**: Distance-Based Separation.
- **EASA**: EASA is an Agency of the European Union. As a Community Agency, EASA is a body governed by European public law; it is distinct from the Community Institutions (Council, Parliament, Commission, etc.) and has its own legal personality. EASA was set up by a Council and Parliament regulation (Regulation (EC) 1592/2002 repealed by Regulation (EC) No 216/2008 and amended by Regulation (EC) 1108/2009) and was given specific regulatory and executive tasks in the field of civil aviation safety and environmental protection (EASA, 2013).
- **Eurocontrol**: EUROCONTROL, the European Organisation for the Safety of Air Navigation, is an intergovernmental Organisation with 41 Member States, committed to building, together with its partners, a Single European Sky that will deliver the air traffic management performance required for the twenty-first century and beyond.
- **FAA**: Federal Aviation Administration. American aviation authority with the mission to provide the safest, most efficient aerospace system in the world.
- **Flight crew**: Personnel who operate the aircraft while in flight.
- **Groundspeed**: Speed of the aircraft with respect to the ground.
- **Headwind component**: Component of the wind which blows against the direction of travel.
- **ICAO**: The International Civil Aviation Organization (ICAO) is a UN specialized agency, established by States in 1944 to manage the administration and governance of the Convention on International Civil Aviation (Chicago Convention) (ICAO, n.d.)
- **IFR**: Instrument Flight Rules. IFR flight depends upon flying by reference to instruments in the flight deck, and navigation is accomplished by reference to electronic signals.
- **Induced roll**: Purposely-induced rolling movement of an aircraft.
- **Peak hours**: A regular period of heavy traffic.
- **ROT**: Runway Occupancy Time.
- **TBS**: Time-Based Separation.
- **Threshold of the runway**: The runway thresholds are markings that denote the beginning and end of the designated space for landing and takeoff under non-emergency conditions.

References


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Image references (top to bottom, left to right)

Front page:

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Dutch Summary

Verwachtingen van Eurocontrol voorspellen een voortdurende groei van het vliegverkeer. Als het vliegverkeer groeit zoals verwacht dan zullen de luchthavens deze omvang van het verkeer niet meer aankunnen in 2021.
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Groeimogelijkheden voor luchthavens, zoals Amsterdam Airport Schiphol, zijn beperkt. Echter, een manier om te groeien is het toenemen van de baancapaciteit. Er zijn verschillende mogelijkheden om dit te doen.

Ten eerste: laat vliegtuigen de baan sneller verlaten na landing en verlaag daarmee de runway occupancy time. Bij sommige weersomstandigheden kan de capaciteit ook vergroot worden door te separeren op basis van tijd. Daarnaast kunnen er meer wake turbulence categories gebruikt worden. Ook het gebruik van microwave landing systems en ground based augmentation systems kunnen de baancapaciteit verhogen omdat er meer vliegtuigen tegelijk gebruik van kunnen maken. Als de situatie op Schiphol niet verandert, zullen er in de toekomst capaciteit gerelateerde problemen optreden. Sommige van de hier genoemde technologieën en procedures kunnen een uitkomst bieden bij zulke problemen.

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