Fundamentals of Air Traffic Control

Luboš Brim

ParaDiSe Seminar, February 25, 2008

ATC – Air Traffic Control

- The task of **ensuring safe operations** of commercial and private aircraft falls on air traffic controllers.
- Coordinating the movements of thousands of aircraft, keep them at safe distances from each other, direct them during takeoff and landing from airports, direct them around bad weather and ensure that traffic flows smoothly with minimal delays.

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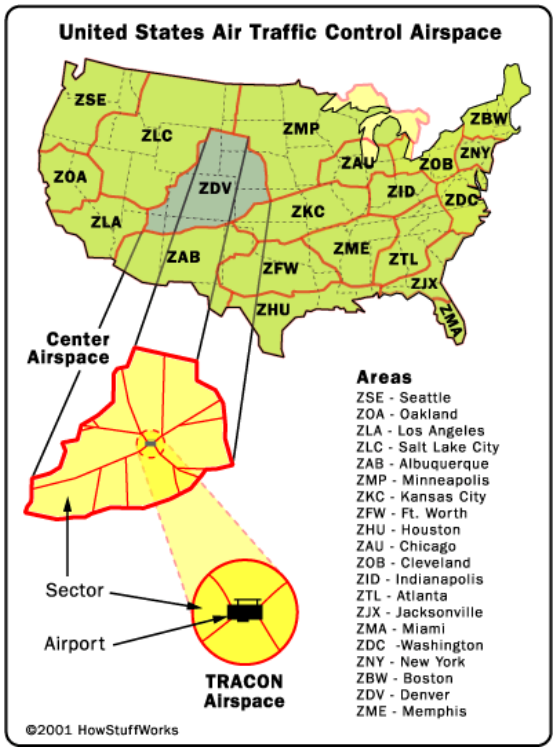
- The United States airspace is divided into 21 zones (**centers**), and each zone is divided into **sectors** .
- Within each zone are portions of airspace, about 50 miles (80.5 km) in diameter, called **TRACON** (Terminal Radar Approach CONtrol) airspaces. Within each TRACON airspace are a number of airports, each of which has its own airspace with a 5-mile (8-km) radius.



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Airspace and Air Traffic Control

The air traffic control system has been designed around these airspace divisions. The air traffic control system divisions are:

- **Air Traffic Control System Command Center (ATCSCC)** - The ATCSCC oversees all air traffic control. It also manages air traffic control within centers where there are problems (bad weather, traffic overloads, inoperative runways).
- **Air route traffic control centers (ARTCC)** - There is one ARTCC for each center. Each ARTCC manages traffic within all sectors of its center except for TRACON airspace and local-airport airspace.
- **Terminal radar approach control (TRACON)** - TRACON handles departing and approaching aircraft within its space.
- **Air traffic control tower (ATCT)** - An ATCT is located at every airport that has regularly scheduled flights. Towers handle all takeoff, landing, and ground traffic.
- **Flight service station (FSS)** - The FSS provides information (weather, route, terrain, flight plan) for private pilots flying into and out of small airports and rural areas. It assists pilots in emergencies and coordinates search-and-rescue operations for missing or overdue aircraft.

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- As an aircraft travels through a given airspace division, it is monitored by the one or more air traffic controllers responsible for that division.
- The controllers monitor this plane and give instructions to the pilot.
- As the plane leaves that airspace division and enters another, the air traffic controller passes it off to the controllers responsible for the new airspace division.

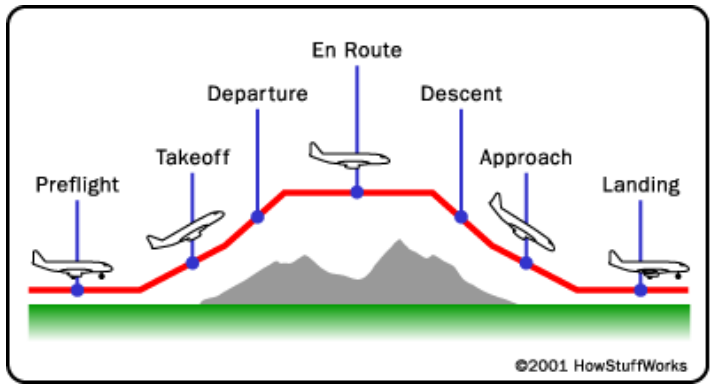
Visual & Instrument Flying

- Some pilots of small aircraft fly by vision only (**visual flight rules** , or **VFR**). These pilots are not required by the FAA to file flight plans and, except for FSS and local towers, are not serviced by the mainstream air traffic control system.
- Pilots of large commercial flights use instruments to fly (**instrument flight rules** , or **IFR**), so they can fly in all sorts of weather. They must file flight plans and are serviced by the mainstream air traffic control system.

Flight Profile

Every commercial airline flight follows a typical profile:

1. **Preflight** -This portion of the flight starts on the ground and includes flight checks, push-back from the gate and taxi to the runway.
2. **Takeoff** - The pilot powers up the aircraft and speeds down the runway.
3. **Departure** - The plane lifts off the ground and climbs to a cruising altitude.
4. **En route** - The aircraft travels through one or more center airspaces and nears the destination airport.
5. **Descent** - The pilot descends and maneuvers the aircraft to the destination airport.
6. **Approach** - The pilot aligns the aircraft with the designated landing runway.
7. **Landing** - The aircraft lands on the designated runway, taxis to the destination gate and parks at the terminal.



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ATIS - Automated Terminal Information Service

- ATIS provides pilots with current airfield and weather information.
- These recordings provide information such as the present winds, altimeter settings, active runways, airfield hazards or any other pertinent airfield information relative to the safety of flight.
- Each recording is normally updated hourly, however, at times of rapidly changing weather conditions the recording may be updated as often as necessary.
- Each recording is identified by a **phonetic letter** which changes with each updated broadcast.
- Pilots are required to check the current ATIS prior to their initial contact with ATC.

ATIS - Automated Terminal Information Service

- This serves as notice to the controller that the pilot has received the latest ATIS information and is aware of current conditions.
- With technology such as ACARS, equipped aircraft often receive the current ATIS information automatically via datalink.
- Another standard with ATIS recordings is the use of TVGS or Text to Voice Generating System. This system compiles data for the ATIS broadcast and automatically generates a synthesized voice recording of the information. The following is an example of an ATIS broadcast as monitored on 120.825 MHz from Toronto International Airport:

> This is Toronto Int'l Airport information ALPHA, Toronto weather at 2100 Zulu, 5,000 scattered, visibility 25, temperature 24, dewpoint 12, wind 280 degrees at 6 knots, altimeter 3020. The IFR approach is ILS runway 24 right, tower frequency 118.35 and ILS runway 23 tower frequency 118.7. Departure runways are 24 right and 23. Inform Toronto ATC on initial contact that you have received information ALPHA.

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All IFR pilots must file a **flight plan** at least 30 minutes prior to pushing back from the gate. Pilot reviews the weather along the intended route, maps the route and files the plan. The flight plan includes:

- Airline name and flight number
- Type of aircraft and equipment
- Intended airspeed and cruising altitude
- Route of flight (departure airport, centers that will be crossed and destination airport)

Pilot transmits this data to the tower.

FAA Flight Plan

1. Type	2. Aircraft Ident	3. Aircraft Type / Special Equipment	4. True Airspeed (KTS)	5. Departure Point	6. Departure Time		7. Cruising Altitude
					Proposed (Z)	Actual (Z)	
[X] VFR	N12345	500A/A	172	KAST	23:00Z		12000 feet
[ ] IFR							
[ ] DVFR							

8. Route of Flight

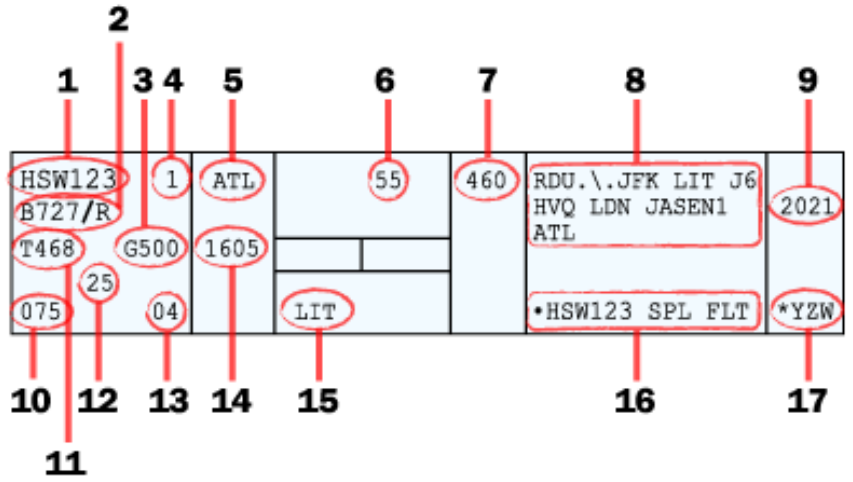
AST V27 WHEEL

9. Destination (Name of Airport and City)	10. Est. Time Enroute		11. Remarks
	Hours	Minutes	
KACV	01	48	

12. Fuel on Board		13. Alternate Airport	14. Pilot Name, Address, Telephone Number & Aircraft Home Base	15. Number Aboard
Hours	Minutes		Capt Elrey Jeppesen - 55 Inverness Drive East Englewood CO 80112 - 303-799-9090 - KUAO	
00	00		17. Destination Contact/Telephone (Optional)	1

16. Color of Aircraft	CLOSE VFR FLIGHT PLAN WITH		FSS ON ARRIVAL
white/brown			

In the tower, a controller called a **flight data person** reviews the weather and flight-plan information and enters the flight plan into the FAA host computer. The computer generates a **flight progress strip** that will be passed from controller to controller throughout your flight. The flight progress strip contains all of the necessary data for tracking the plane during its flight and is constantly updated.



1. Aircraft call sign.
2. Type of aircraft/type of equipment.
3. Actual speed across ground.
4. Number of amendments to original flight plan.
5. The previous fix. This denotes where the aircraft has been.
6. Time aircraft is estimated to cross LIT.
7. The altitude at which the aircraft is flying. This is measured in feet. Multiply this number by 100 to give the altitude.
8. Flight route. This must show departure and destination points. This can be abbreviated before entering your facility airspace.
9. Individual beacon code assigned to each aircraft
10. Computer generated number for identification within this facility.
11. Filed true air speed
12. The sector number. This identifies in which sector the aircraft is flying.
13. The strip number. The number of strips printed for this flight in this center.
14. Time aircraft crossed previous fix.
15. Coordination fix for this strip.
16. Remarks area (The only place where free text can be entered)
17. Coordination symbol to adjacent ATC facility.

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Preflight

- Once the flight plan has been approved, the flight data person gives clearance to the pilot (**clearance delivery**) and passes the strip to the **ground controller** in the tower.

AC

Clearance, it's Speedbird 177, gate 22, 747-400 with information Delta, request start-up.

ATC - clearance

Speedbird 177 cleared start for Kennedy, Compton two golf departure, squawk five three four two. Call one two one decimal nine for pushback.

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- The ground controller is responsible for all ground traffic, which includes aircraft taxiing from the gates to takeoff runways and from landing runways to the gates. When the ground controller determines that it is safe, he or she directs the pilot to push the plane back from the gate (airline personnel operate the tugs that actually push the aircraft back and direct the plane out of the gate area).

AC

Ground, Speedbird 177, gate 22, request pushback.

ATC - ground

Speedbird 177, clear to push to face East.

AC

Speedbird 177, request taxi instructions.

ATC - ground

Speedbird 177, clear taxi to runway 27 left via November Bravo. Call tower one one eight decimal five.

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- As your plane taxis to the runway, the ground controller watches all of the airport's taxiways and uses ground radar to track all of the aircraft (especially useful in bad weather), ensuring that your plane does not cross an active runway or interfere with ground vehicles. The ground controller talks with your pilot by radio and gives him instructions, such as which way to taxi and which runway to go to for takeoff.
- Once your plane reaches the designated takeoff runway, the ground controller passes the strip to the **local controller - tower** .
- The local controller in the tower watches the skies above the airfield and uses surface radar to track aircraft. He or she is responsible for maintaining safe distances between planes as they take off.

- The local controller gives your pilot final clearance for takeoff when it is deemed safe, and provides the new radio frequency for the departure controller.

AC

Tower, Speedbird 177 is with you.

ATC - tower

Speedbird 177, after the departing of Air India line up and hold two seven left.

ATC - tower

Speedbird 177, cleared for take-off. Wind two five zero at fifteen.

- Once clearance is given, the pilot must decide if it is safe to take off. If it is safe, he accelerates the plane down the runway.

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Departure

- As you leave the ground, the local controller hands the plane off electronically to the **departure controller** at the TRACON facility that services the departure airport, but still monitors the plane until it is 5 miles from the airport.

ATC - tower

Speedbird 177, call departure one two three decimal nine.

- The pilot now talks with the departure controller.

ATC

Departure, Speedbird 177, passing one thousand three hundred on Compton two romeo.

- Once the plane takes off, the pilot activates a **transponder** device inside the aircraft.
- The transponder detects incoming radar signals and broadcasts an amplified, encoded radio signal in the direction of the detected radar wave.
- The transponder signal provides the controller with your aircraft's flight number, altitude, airspeed and destination.
- A blip representing the airplane appears on the controller's radar screen with this information beside it. The controller can now follow your pla

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Departure

- The departure controller is located in the TRACON facility, which may have several airports within its airspace (50-mile/80-km radius).
- He or she uses radar to monitor the aircraft and must maintain safe distances between ascending aircraft.
- The departure controller gives instructions to your pilot (heading, speed, rate of ascent) to follow regular ascent corridors through the TRACON airspace (**Standard Instrument Departures - SID**).

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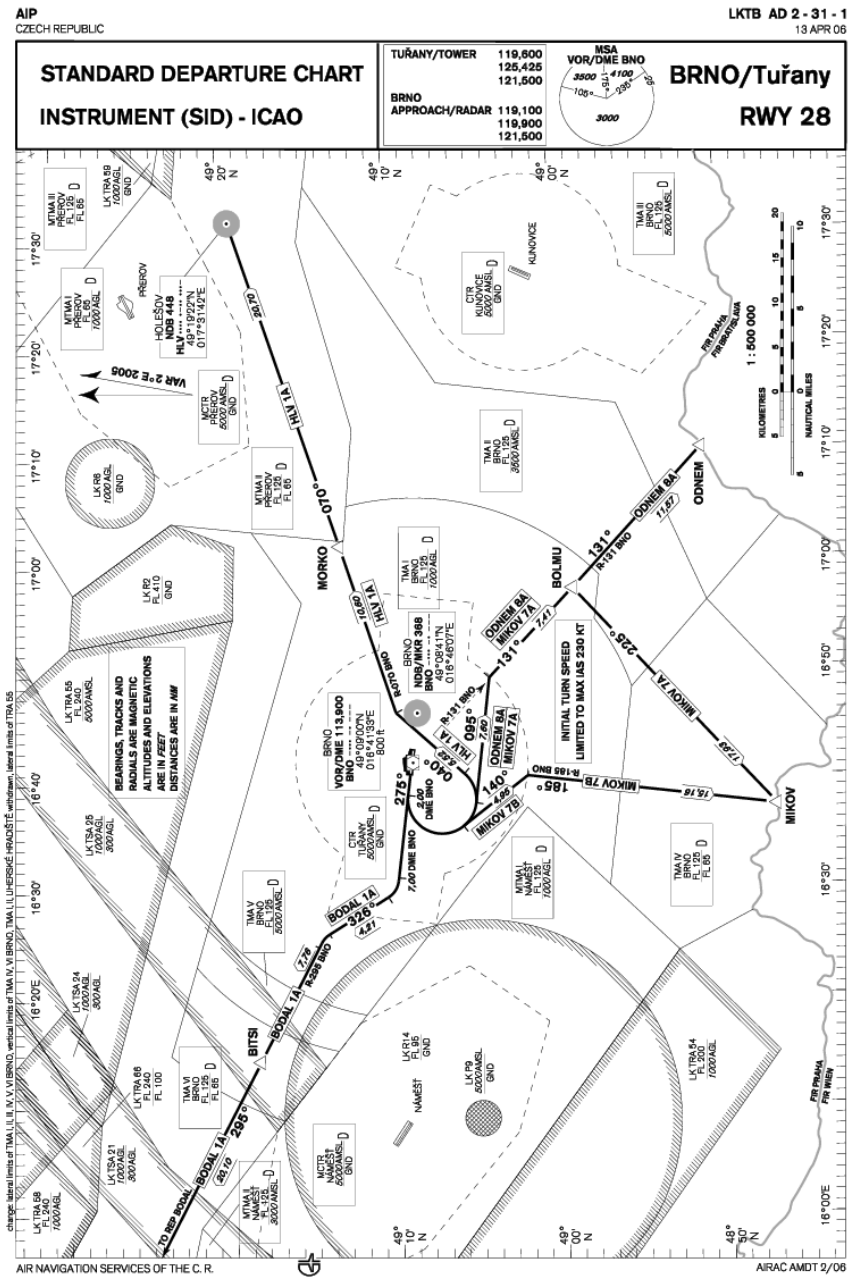
Departure - SID



Departure

- The departure controller monitors your flight during ascent to the en route portion.
- When your plane leaves TRACON airspace, the departure controller passes your plane off to the **center controller** (ARTCC controller).

ATC - departure

Speedbird 177, turn right heading two nine five. Call London one three three six with the heading.

- Every time your plane gets passed between controllers, an updated flight progress slip gets printed and distributed to the new controller.

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En Route and Descent

- Once your plane has left TRACON airspace, it enters a sector of the ARTCC airspace, where it is monitored by at least two air traffic controllers.
- The radar associate controller receives the flight-plan information anywhere from five to 30 minutes prior to your plane entering that sector.
- The associate controller works with the radar controller in charge of that sector.
- The radar controller is in charge of all air-to-ground communication, maintains safe separation of aircraft within the sector and coordinates activities with other sectors and/or centers.
- The controllers must monitor the airspace at high altitude (above 24,000 ft/7320 m) and low altitude (below 24,000 ft).
- The center controllers provide your pilot with updated weather and air-traffic information. They also give directions to your pilot regarding such aspects as speed and altitude to maintain a safe separation between aircraft within their sector. They monitor your plane until it leaves their sector. Then they pass it off to another sector's controller.

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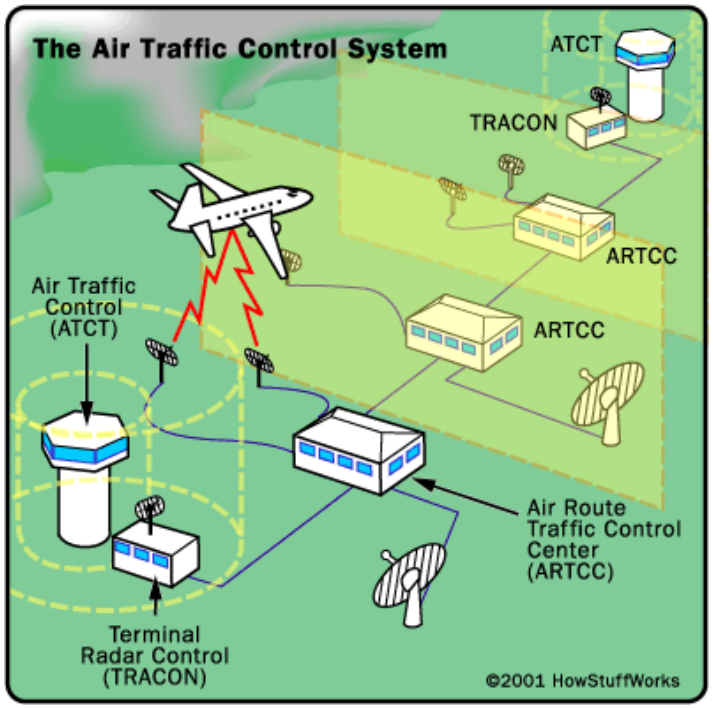

Safe Separation

- Safe vertical separation between aircraft is considered to be 1,000 ft (305 m) at altitudes below 29,000 ft (8845 m) and 2,000 ft (610 m) at altitudes above that.
- When aircraft are at the same altitude, safe horizontal separation is considered to be 5 miles (8 km).

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En Route and Descent

AC

London, Speedbird 177, good afternnon. We‘re out of six thousand for level one two zero, heading two nine five.

ATC - center

Speedbird 177, maintain heading two nine five, recleared level one eight zero.

...

AC

London, Speedbird 177, now level three one zero.

ATC - center

Speedbird 177, level three one zero, call Shannon one three five decimal six.

AC

Shannon, Speedbird 177, now level three one zero.

ATC - center

Speedbird 177, level three one zero, call Shannon one three five decimal six.

En Route and Descent

- The plane gets passed from sector to sector and center to center.
- In each sector, center controllers give radio instructions to the pilots.
- The path of your plane may have to be changed from the original flight plan to move around bad weather or avoid a congested sector. The pilots may request a change in altitude to avoid or reduce turbulence. This back and forth between pilots and center controllers continues until about 150 miles (241 km) from destination.
- At this point, the center controller directs all planes to move from high altitudes to low altitudes and merges the descending aircraft into a single file line toward the airport. The controller gives instructions to the pilot, such as changes in heading, speed and altitude, to place your plane in line with these other aircraft.
- Depending on traffic conditions, the controller may have to place the plane into a **holding pattern**, which is a standard route around each airport, where you wait until the airport can handle your arrival. The controller continues to give directions to the pilot until your plane is within TRACON airspace.

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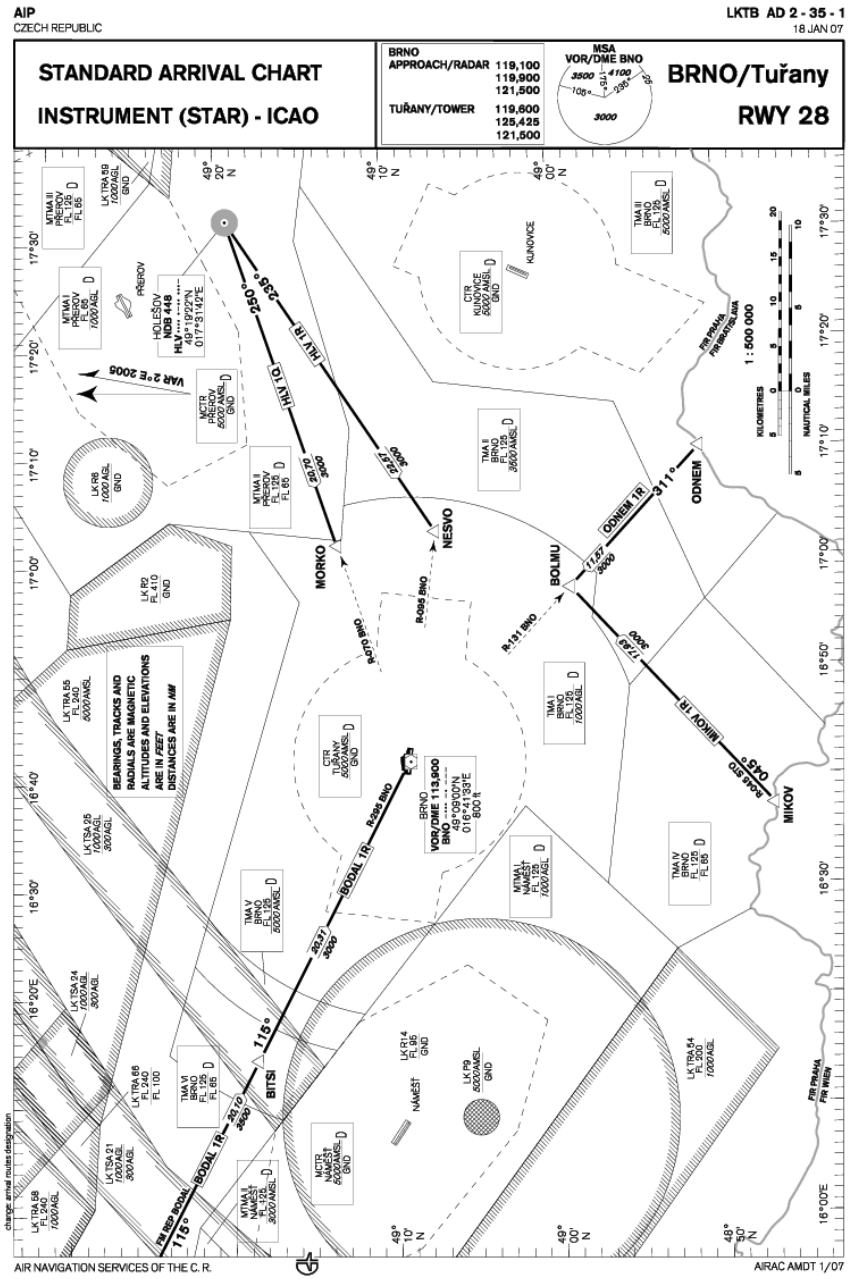
Approach

- When the descending plane is 50 miles from the airport, it is within TRACON airspace.
- An **approach controller** directs your pilot to adjust the aircraft's heading, speed and altitude to line up and prepare to land along standard approach corridors (**Standard Terminal Arrival Route**).
- The pilot then aligns your plane with the runway. When at 10 miles (16 km) from the runway, the approach controller passes your plane off to the local controller in the airport tower.

Approach - STAR



Approach

AC

New York Approach, Speedbird 177 heavy, just levelling twelve thousand.

ATC - approach

Speedbird 177 heavy, maintain twelve thousand.

...

ATC - approach

Speedbird 177 heavy, recleared nine thousand. Leave Rober heading two five zero. When level nine thousand, speed two ten knots.

...

ATC - approach

Speedbird 177 heavy, turn left two four zero, descend now to two thousand, cleared ILS two two left, minimum speed one sixty till the outer marker. Call tower one nineteen one when established.

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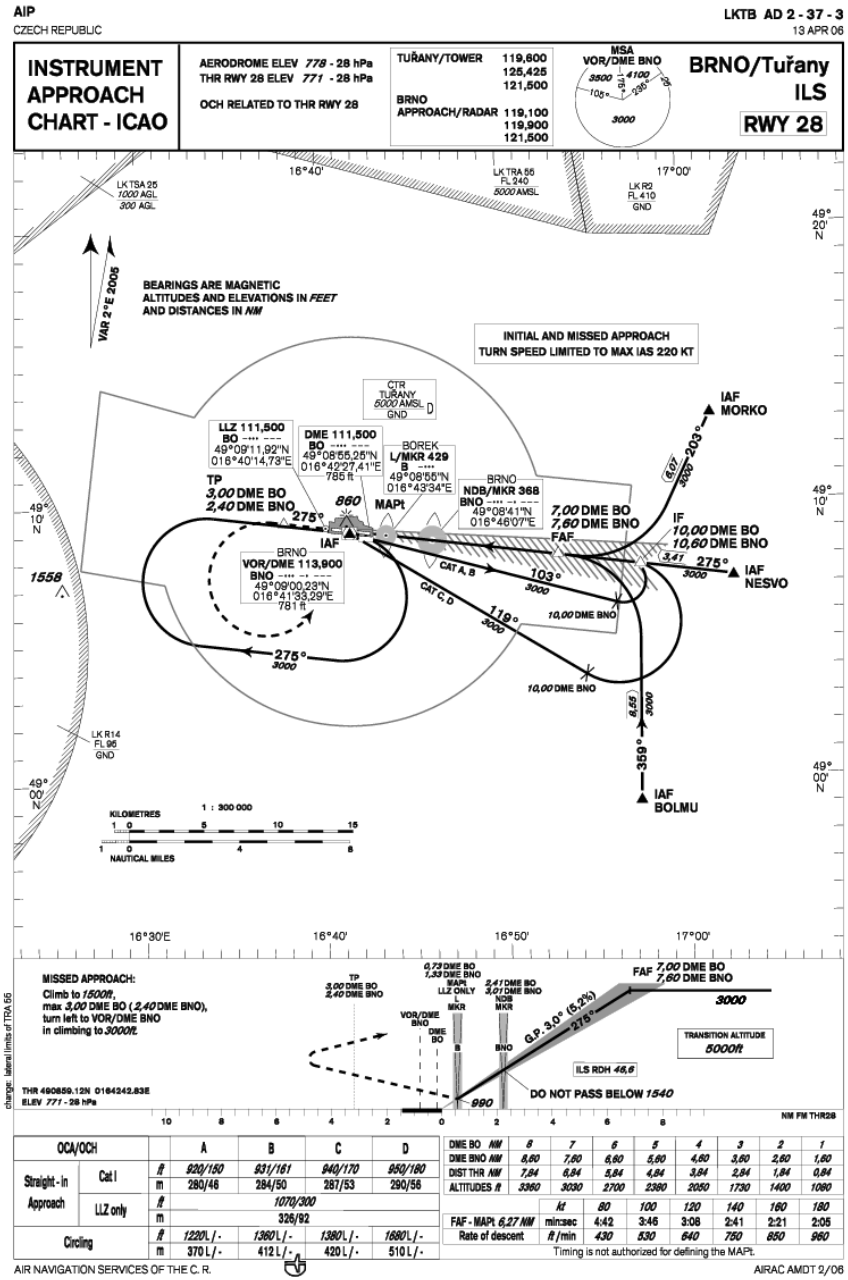
Landing

- The local controller in the airport tower checks the runways and the skies above the runways with binoculars and surface radar (local and ground controllers are the only controllers licensed to use visual information in performing their duties).
- When the local controller determines that it is safe, he or she gives your pilot clearance to land.
- The local controller also updates weather conditions for your pilot and monitors the spacing between your plane and other landing aircraft.
- Once you've landed, the local controller directs your plane to an exit taxiway, tells your pilot the new radio frequency for the ground controller and passes your plane off to the ground controller.
- The ground controller watches the runways and taxiways and uses ground radar information to ensure that your taxiing aircraft does not cross active runways or interfere with ground vehicles. He or she directs your plane to the appropriate terminal gate. Ground personnel from the airline use hand signals to assist your pilot in parking the airplane at the gate.

Landing - ILS


AIP
CZECH REPUBLIC
LKTB AD 2 - 37 - 3
13 APR 06
INSTRUMENT APPROACH CHART - ICAO
AERODROME ELEV 778 - 28 hPa
THR RWY 28 ELEV 771 - 28 hPa
OCH RELATED TO THR RWY 28
TUŘANY/TOWER 119,800 125,425 121,500
BRNO APPROACH/RADAR 119,100 119,900 121,500
MSA VOR/DME BNO
BRNO/Tuřany ILS
RWY 28
BEARINGS ARE MAGNETIC
ALTITUDES AND ELEVATIONS IN FEET
AND DISTANCES IN NM
VAR 2°E 2005
INITIAL AND MISSED APPROACH
TURN SPEED LIMITED TO MAX IAS 220 KT
CTR TUŘANY 5000 AMSL GND D
LLZ 111,500 BO 49°09'11,92"N 016°40'14,73"E
DME 111,500 BO 49°08'55,25"N 016°42'27,41"E 785 ft
BOREK L/MKR 429 B 49°08'55,25"N 016°43'34"E
BRNO NDB/MKR 368 BNO 49°08'41"N 016°46'07"E
TP 3,00 DME BO 2,40 DME BNO
MAPt
IAF MORKO
IF 10,00 DME BO 10,60 DME BNO
IAF NESVO
FAF 7,00 DME BO 7,60 DME BNO
IAF BOLMU
BRNO VOR/DME 113,900 BNO 49°09'00,23"N 016°41'33,29"E 781 ft
CAT A, B
CAT C, D
LK TSA 25 1000 AGL 300 AGL
LK TRA 55 FL 240 5000 AMSL
LK R9 FL 410 GND
LK R14 FL 96 GND
KILOMETRES
NAUTICAL MILES
MISSED APPROACH:
Climb to 1500ft, max 3,00 DME BO (2,40 DME BNO), turn left to VOR/DME BNO in climbing to 3000ft.
THR 490859.12N 0164242.83E
ELEV 771 - 28 hPa
ILS RDH 46,6
DO NOT PASS BELOW 1540
G.P. 3.0° (5.2%)
TRANSITION ALTITUDE 5000ft
NM FM THR28
OCA/OCH
Straight - in Approach Cat I
LLZ only
Circling
A B C D
ft m
920/150 931/161 940/170 950/180
280/46 284/50 287/53 290/56
1070/300
326/92
1220 L/- 1360 L/- 1380 L/- 1680 L/-
370 L/- 412 L/- 420 L/- 510 L/-
DME BO NM 8 7 6 5 4 3 2 1
DME BNO NM 8,60 7,60 6,60 5,60 4,60 3,60 2,60 1,60
DIST THR NM 7,84 6,84 5,84 4,84 3,84 2,84 1,84 0,84
ALTITUDES ft 3360 3030 2700 2380 2050 1730 1400 1080
kt 80 100 120 140 160 180
FAF - MAPt 6,27 NM min:sec 4:42 3:46 3:08 2:41 2:21 2:05
Rate of descent ft/min 430 530 640 750 850 960
Timing is not authorized for defining the MAPt.
AIR NAVIGATION SERVICES OF THE C. R.
AIRAC AMDT 2/06

Landing

AC

Tower, Speedbird 177 heavy, established ILS two two left.

ATC - tower

Speedbird 177 heavy, continue approach. Call me at the marker.

...

AC

Speedbird 177 heavy, outer marker inbound.

ATC - tower

Speedbird 177 heavy, cleared to land, wind one eight zero at 20 knots. Runway is wet - braking action reported as good.

...

ATC - tower

Speedbird 177 heavy, proceed right zulu, left golf, hold short two two right. Contact ground on one two one decimal nine.

Miscellaneous

- Squawk codes:
  - 7700 – emergency code
  - 7600 – radio failure
  - 7500 – hi-jack code
- Airport Codes – EGLL (ICAO), LHR (IATA); LKTB a BRQ
- Airline Codes – BAW - British Airways; registration codes - G-BNLO Boeing 747 of British Airways named City of Dundee
- TCAS – Traffic Alert and Collision Avoidance System
- Reporting Points

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