

GNSS operational RNAV / RNP Procedures

Österreichisches Kuratorium
für Flugsicherheit
Wr. Neustadt
10.11.2012

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ATM TERM Graz – Austro Control

SICHERHEIT LIEGT IN DER LUFT



Abkürzungen

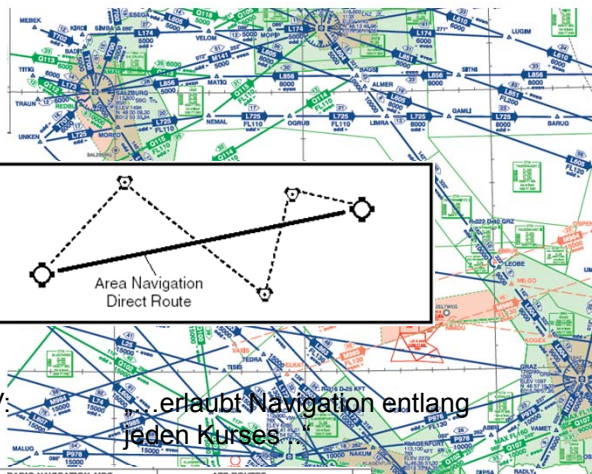
ADF, NDB, VOR, ILS, OM, GPS,
LORAN, INS, Mode C, CDI, HSI, FAF,
IAF, MAPt, HDG, ...

PBN, RNAV, BRNAV, PRNAV, RNP,
RNP 5, ADS-B, EGNOS, WAAS, SBAS,
VNAV, Baro-VNAV, LPV, LPV+, APV,
RAIM, GNSS, LAAS, DGPS, ELS, EHS,
GBAS, ABAS,

CPDLC, ADS-C, B1, Transponder E, MEDEVAC,
HAZMAT, PBN/B2B3C3S2, ...

Performance based navigation RNAV

AIR TRAFFIC MANAGEMENT



RNAV: erlaubt Navigation entlang jeden Kurses

AERODROMES	RADIO NAVIGATION AIDS	ATS ROUTES
<ul style="list-style-type: none"> ✈ Airport for International commercial air transport ✈ Airport for International commercial air transport with military flight operation ✈ Military aerodrome 	<ul style="list-style-type: none"> VOR VOR/DME VORTAC NDB 	<ul style="list-style-type: none"> Distance between adjacent waypoints Route designator Magnetic track / reverse magnetic track FL ends Minimum enroute altitude (MEA) Normally enroute route and VORT class-reporter point Waypoint
REPORTING POINTS	ATS ROUTES	
<ul style="list-style-type: none"> ▲ Compulsory reporting point △ Reporting point on request 	<ul style="list-style-type: none"> RNAV routes NATIONAL routes CDR 	

RAM

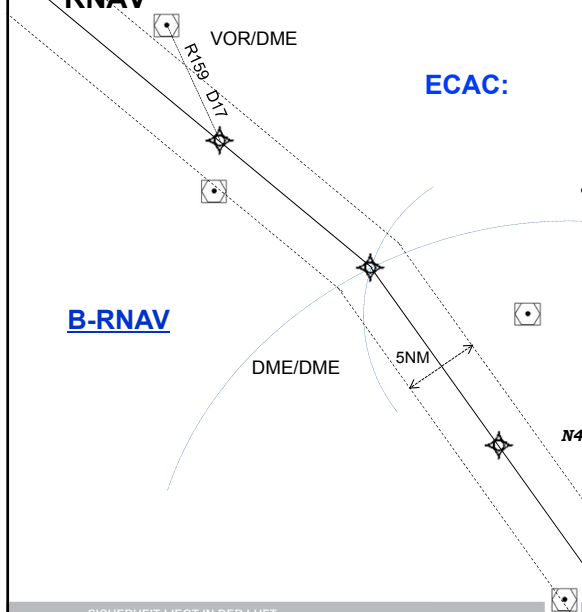
random access memory
„direkter Zugriff“-Speicher

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Performance based navigation RNAV

AIR TRAFFIC MANAGEMENT



- Ziel:
 - Navigation zu jedem Punkt
 - mit „konventioneller“ Navigationsausrüstung fliegbar
 - für die meisten Flugzeuge keine Umrüstung erforderlich

N452603 E0183315

Keine Datenbank erforderlich
Datenspeicherung von 4 Waypoints ausreichend

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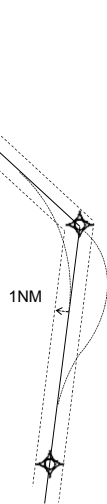
Performance based navigation RNAV

AIR TRAFFIC MANAGEMENT



ECAC: ± 1NM
in Terminalbereichen

P-RNAV



- Ziel:
 - Verdichtung von IFR-Flugwegen in „TMA“
- aber:
 - nicht mehr mit jeder Navigationsausrüstung fliegbar
 - Höhere Anforderungen an Equipment (z.B. FMS)

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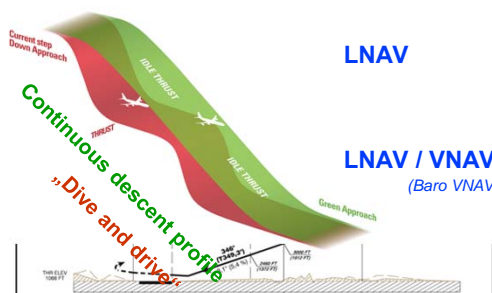
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Performance based navigation RNAV/RNP Approaches

AIR TRAFFIC MANAGEMENT



RNAV GNSS



LNAV

lateral guidance navigation

MDA: → **LNAV Minimum**

LNAV / VNAV (Baro VNAV)

LNAV with vertical guidance

DA: → **LNAV/VNAV Minimum**

APV

Approaches with vertical guidance

MISSED APPROACH: CLIMB STRAIGHT AHEAD TO 3500 FT MSL AND HOLD
Note: Missed Approach Turn limited to 180 KT IAS maximum

OCA (OCH) IN FT	A	B	C	D	WG015 to RW35 - DISTANCE 5,7 NM
LNAV	1500 (412)				120 180 160 180
LNAV/VNAV	1400 (312)				
DIST in NM to RW35	2	3	4	5	
ALTITUDE (HEIGHT) (FT)	1000 (1000)	1400 (1400)	1700 (1700)	1700 (1700)	
WG015 - RW35 MIN - SEC	4:17	3:25	2:51	2:27	2:08 1:54
Rate of descent (ft/min)	430	540	650	760	870 980

LLZ precision with vert. guidance

DA: → **LPV Minimum**

AIRAC AMDT 125 / 8 MAR 2012

Austro Control GmbH

LOWG AD 2.21-6-4

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Performance based navigation RNAV/RNP

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Definition des Luftraumes

Performance		ECAC		ICAO
En-Route	± 5 NM	B-RNAV	=	RNAV5
Terminal	± 1 NM	P-RNAV	≈	RNAV1

Endanflüge: RNAV GNSS

LNAV LNAV/VNAV

„Curved Apch“: RNP „AR“

Authorization required



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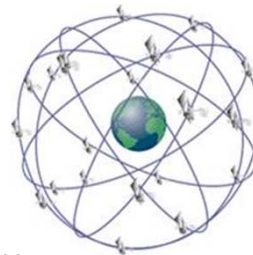
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Performance based navigation GNSS → SBAS

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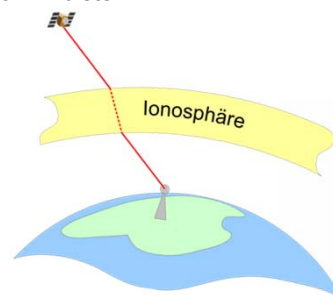
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Warum reicht GPS für Precision Approaches nicht aus?



Schwankende Genauigkeit und Abhängigkeit von Anbieter

- Ionisationsgrad der Ionosphäre
- Ausfallsabhängigkeit
- US-Verteidigungsministerium



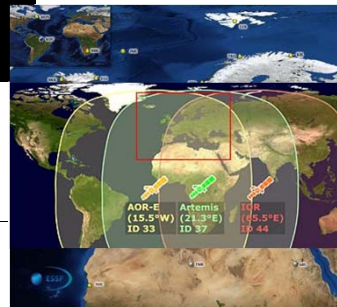
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Performance based navigation GNSS → SBAS

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Space based Augmentation Systems SBAS

Augmentation: Anreicherung, Steigerung

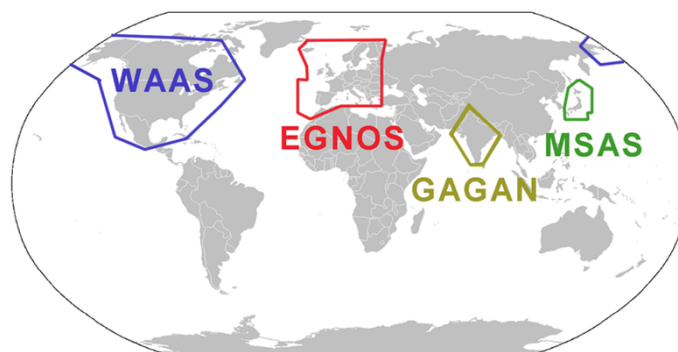
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Performance based navigation SBAS

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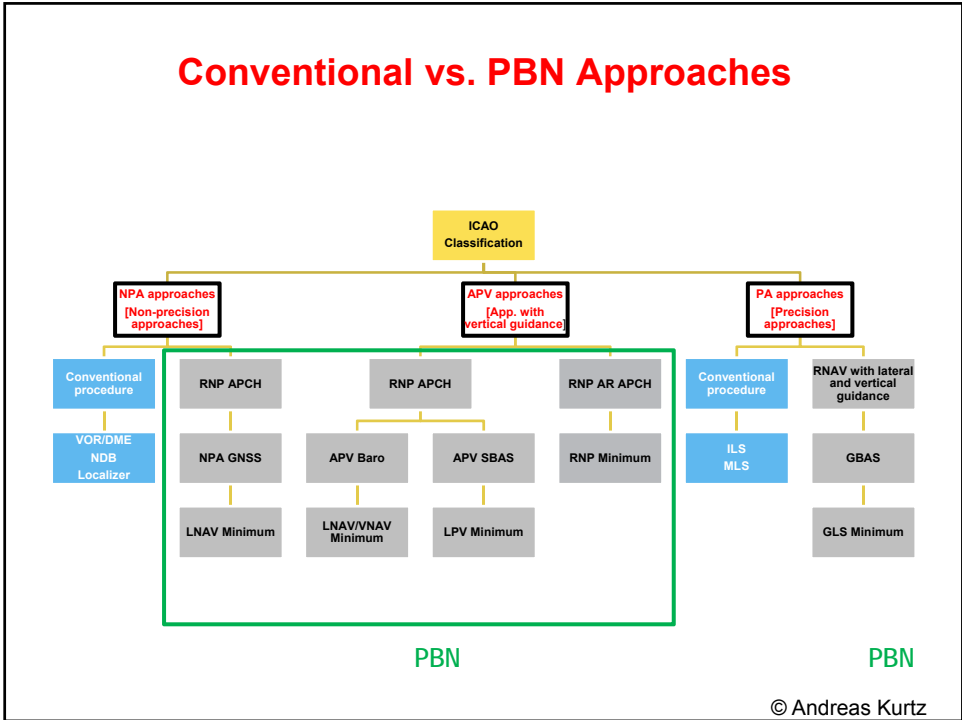


- | | | |
|-----------|-------------------|--|
| Europa: | EGNOS | European Geostationary Navigation overlay system |
| USA: | WAAS | Wide Area Augmentation System |
| Japan: | MSAS | Multi-Functional Satellite Augmentation System |
| Indien: | GAGAN | GPS and Geo Augmented Navigation |
| Russland: | <i>in Planung</i> | |

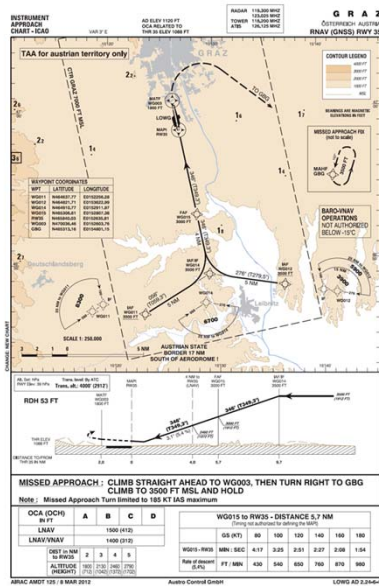
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Conventional vs. PBN Approaches

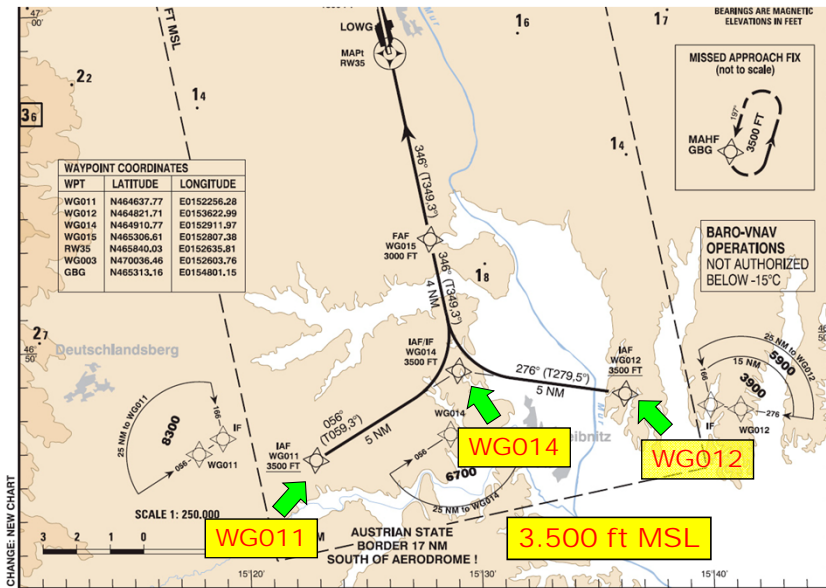


Graz: RNAV – Approach RWY 35:



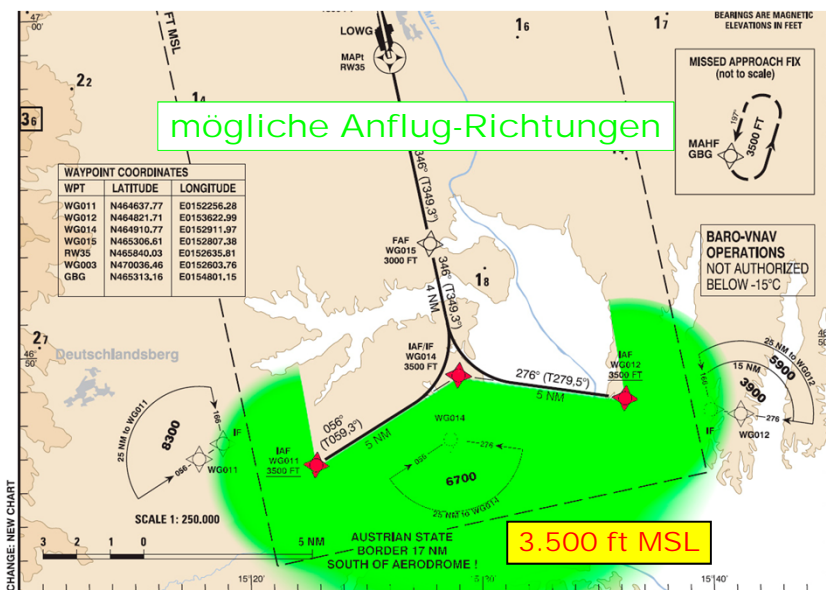
- kein Holding-Fix
- nicht an STARs angebunden
- kann nicht „own-navigation“ geflogen (=begonnen) werden

Graz: RNAV – Approach RWY 35:



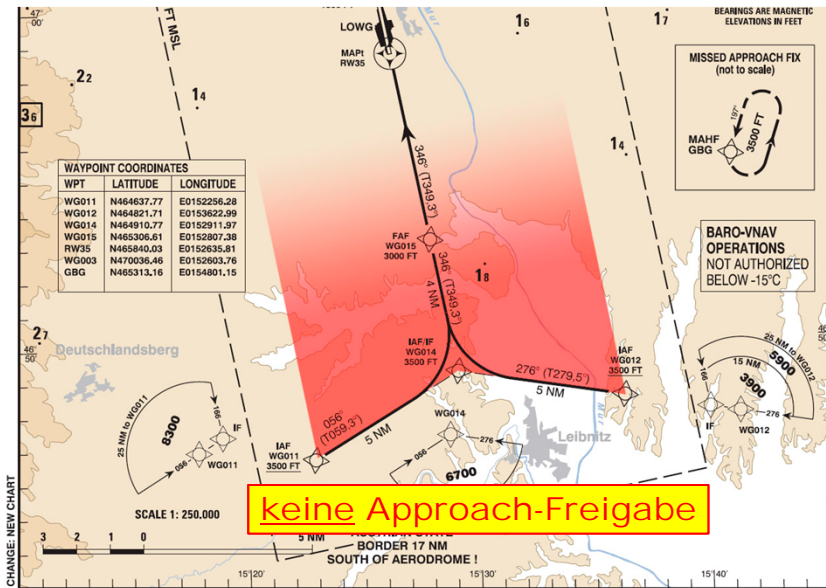
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Graz: RNAV – Approach RWY 35:

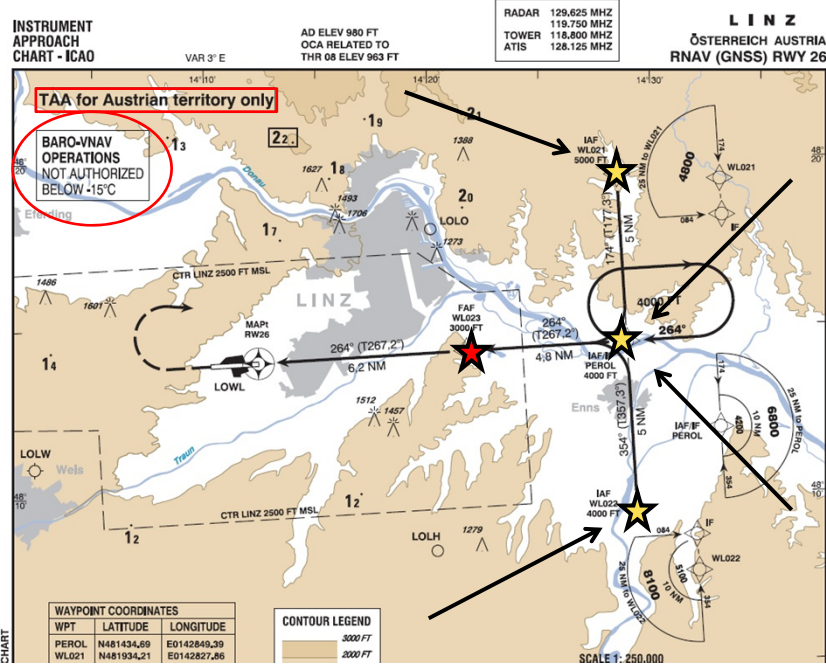


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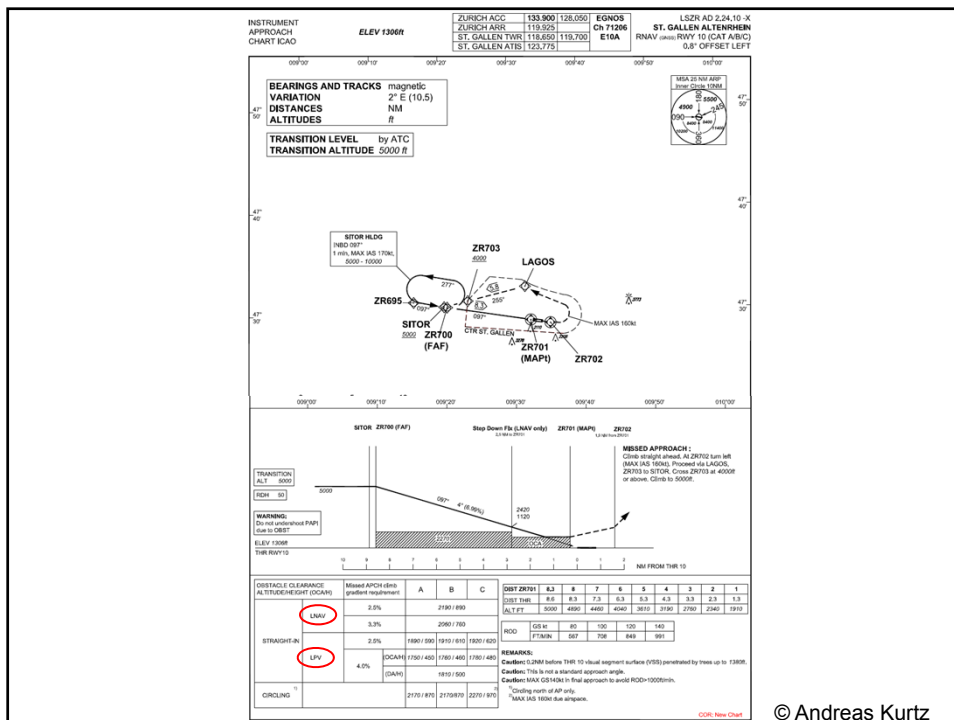
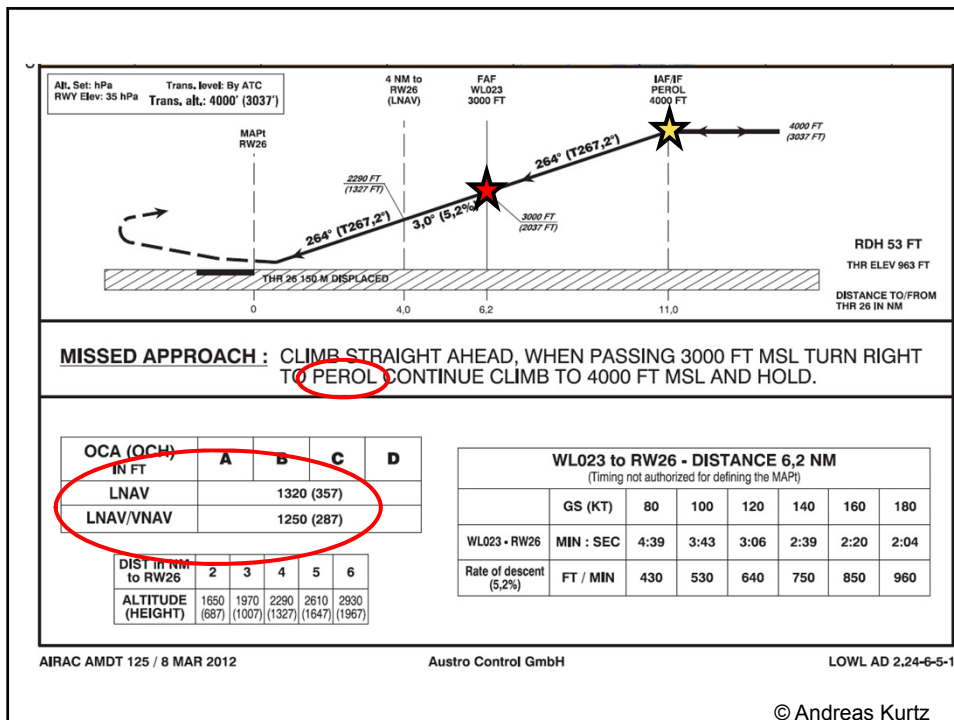
Graz: RNAV – Approach RWY 35:

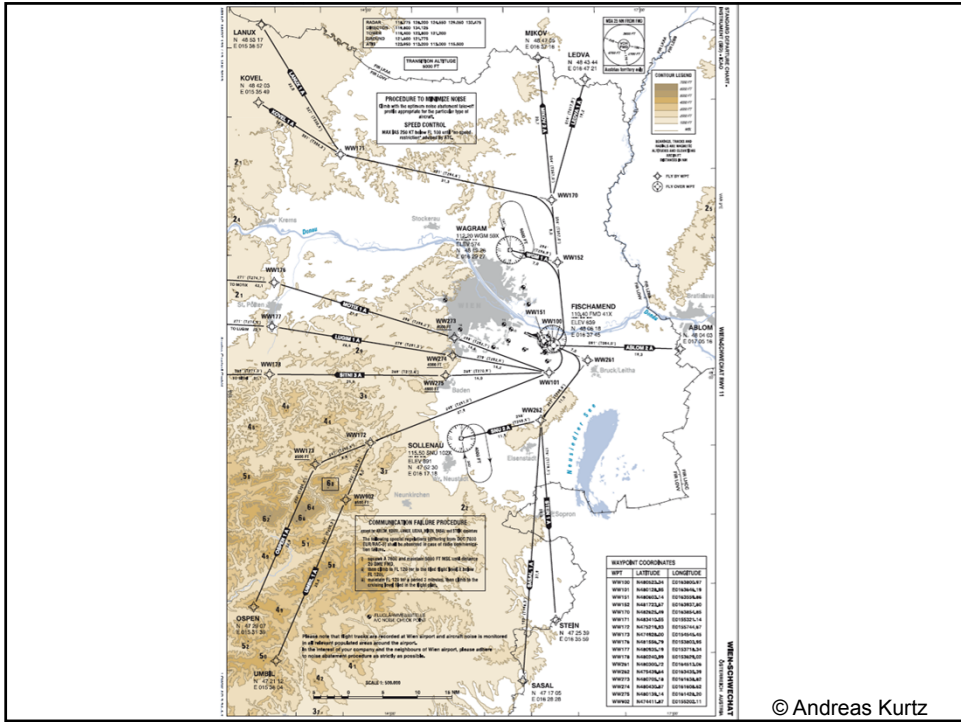


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Streckennavigation B-RNAV, P-RNAV

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	B-RNAV	P-RNAV
Track keeping accuracy (RNP)	<ul style="list-style-type: none"> ± 5 NM (----- for at least 95% of flight time -----) 	<ul style="list-style-type: none"> ± 1 NM
Signal inputs	<ul style="list-style-type: none"> VOR/DME; DME/DME; GNSS; IRS 	<ul style="list-style-type: none"> IRS only for limited time only
Onboard database	<ul style="list-style-type: none"> Database not required Programmed routes (e.g. Transition routes, SIDs) not required Pilot defined waypoints are approved Minimum storage capability: 4 waypoints 	<ul style="list-style-type: none"> Database required Programmed routes required Pilot defined waypoints are not approved Minimum storage capability: sufficient to store all required waypoints and routes for intended TMA-procedure
Phase of flight	<ul style="list-style-type: none"> Enroute Connection to TMA Within TMA only above MSA 	<ul style="list-style-type: none"> Enroute Connection to TMA Within TMA also below MSA Connection to Final Approach (Final Approach waypoint/fix) but not for Final Approach itself

EU JAA TGL 2
FAA AC 90-97

EU JAA TGL 10
FAA AC 90-96

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Performance based navigation

AIR TRAFFIC MANAGEMENT



VOR, NDB, ...
Nav. bzw. Anflug



RNAV5, RNP0.3, ... -
Airspace bzw. Apch

Sensor based
Navigation



Performance based
Navigation

SICHERHEIT LIEGT IN DER LUFT

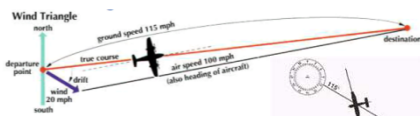
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Die Navigation im Rückblick – im Ausblick

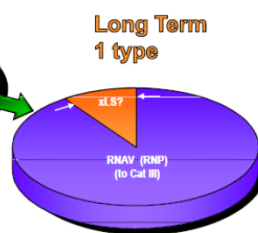
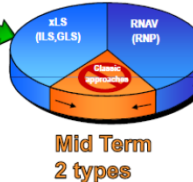


► Koppelnavigation – Dead Reckoning or Point to Point

► Highway in the Sky



ILS
MLS
NDB
VOR
DME
...



PBN
RNAV
RNP

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RAIM

Mit sofortiger Wirkung wird von der EUROCONTROL unter dem Projektnamen AUGUR ein „RAIM Prediction Tool“ (**RAIM=Receiver Autonomous Integrity Monitoring**) angeboten.
Dieses Tool dient zur Integritätsprüfung der eintreffenden GPS-Signale.

Aus diesem Tool heraus erhalten wir spezielle NOTAM's welche sich auf Einschränkungen hinsichtlich der Nutzbarkeit von GNSS-Services beziehen. Es sind dies Warnungen (oft im Voraus) vor „ungünstigen“ Satellitenkonstellationen, atmosphärischen Störungen (z.B. Sonnenwinde), Satellitenwartungen oder –umschaltungen und dergleichen.

Die aufgelieferten NOTAM's kommen bei uns in das zweimal täglich aufgelieferte NOTAM-BULLETIN für LOWG und könnten z.B. wie folgt aussehen:

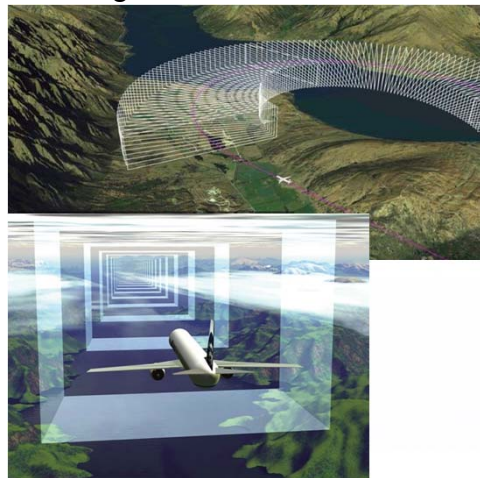
- Q) LOVV/QGAAU//NBO/A/000/999/4659N01526E005
- A) LOWG
- B) 1202062126
- C) 1202081819
- D) 06 2126-2306 07 0132-0220 1251-1341 1759-1823 2122-2302
08 0127-0216 1246-1337 1754-1819
- E) NOTAMPN 0001/12
GPS RAIM IS NOT AVAILABLE FOR LNAV AND LNAV/VNAV

Performance based navigation RNP

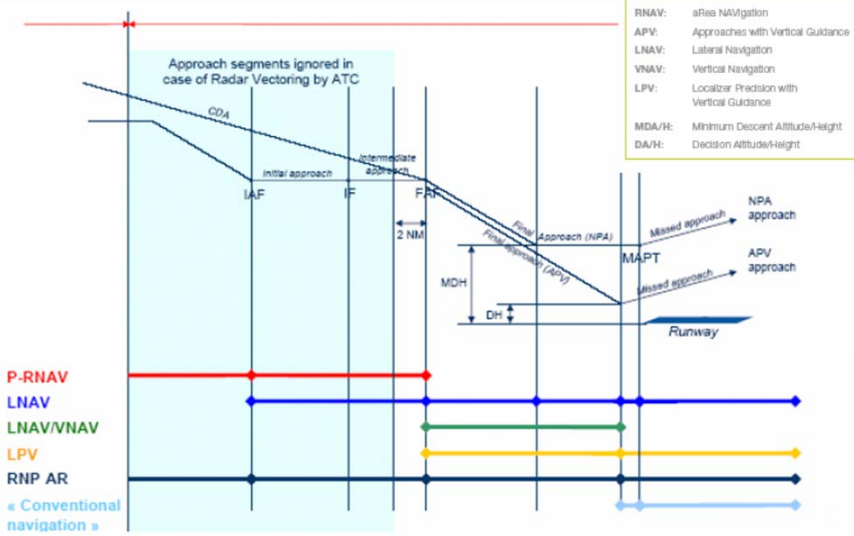
RNP Verfahren bedingen

wiederholbare und vorhersagbare
Flugwege
→ „repeatable and predictable tracks“

AKTIVE Positionskorrektur des LFZ
→ „on board monitoring and alerting“



Anflugverfahren RNP APCH



ARINC CODING - "TRANSLATION" OF PROCEDURE INTO FMS DATA BASE

PATH AND TERMINATOR		
Example Path	Diagram	Description
IF		Figure 1: Initial Fix or TF Leg. Defines a database fix as a given in space.
TF		Figure 2: Track to a Fix or TF Leg. Defines a great circle track over ground between two known database fixes.
CF		Figure 3: Course to a Fix or CF Leg. Defines a specified course to a specific database fix.
DF		Figure 4: Direct to a Fix or DF Leg. Defines an unspecified track starting from an unspecified position using from a database fix to a specific database fix. Note: See also Table 1.3. Leg Sequencing for other uses of the DF Leg.
FA		Figure 5: Fix to an Altitude or FA Leg. Defines a specified track over ground from a database fix to a specified altitude or an unspecified position.
FC		Figure 6: Track from a Fix to a Distance or FC Leg. Defines a specified track over ground from a database fix for a specific distance.



NEW ENHANCED FMS FUNCTIONALITY...

- Modern FMS provide capability to perform ARINC 424 RF transitions
- The aircraft follows during turn a prescribed track around a centre waypoint with the same accuracy as during straight flight by adjusting the bank angle of the aircraft to allow for changes of speed and wind

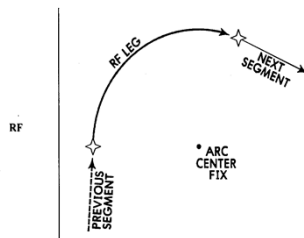


Figure 13: Constant Radius Arc or RF Leg. Defines a constant radius turn between two database fixes, lines tangent to the arc and a center fix.

Note: While the arc initial point, arc ending point and arc centerpoint are all available as database fixes, implementation of this leg type may not require them to be available as fixes.

