

skyguide



GPS with RAIM or EGNOS?

The difference for (mountainous) helicopter operations

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Motivation for Dedicated Helicopter Procedures

Swiss GNSS LFN network:

- › Mandate from the Swiss Air Force and REGA (Swiss HEMS operator)
- › Vision of all weather operations
- › Fly as low as possible (helicopters usually do not have de-icing capabilities)
- › Easiest way of cloud-breaking procedure

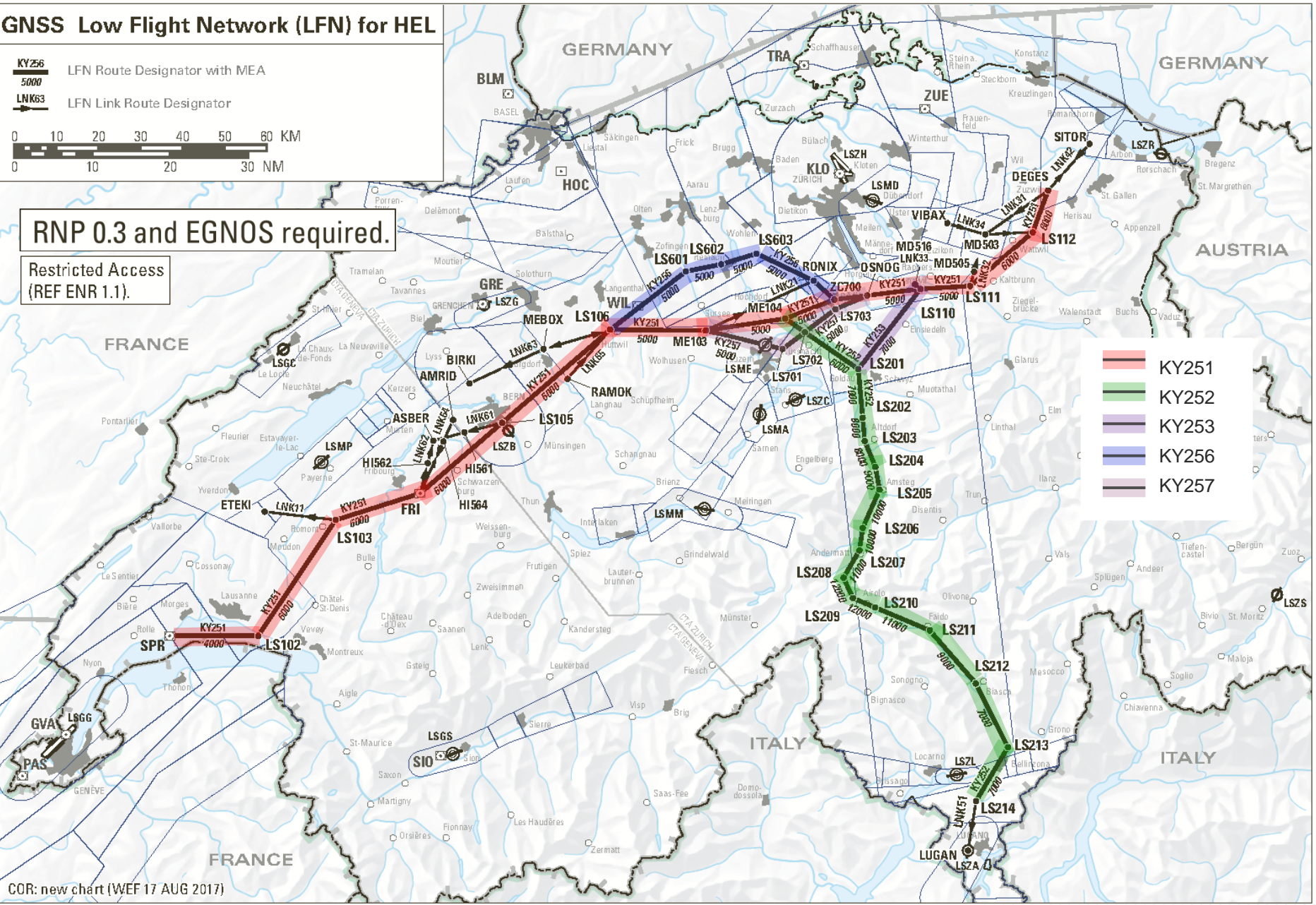
GNSS Low Flight Network (LFN) for HEL

KY256 LFN Route Designator with MEA
5000
LNK63 LFN Link Route Designator



RNP 0.3 and EGNOS required.

Restricted Access
 (REF ENR 1.1).



- KY251
- KY252
- KY253
- KY256
- KY257

COR: new chart (WEF 17 AUG 2017)

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GNSS LFN Facts

- › Navigation Specification: RNP 0.3
- › Airspace: mainly E, C, D
- › Limited to REGA (Swiss HEMS operator) and SAF (Swiss Air Force)
- › EGNOS required
- › GNSS is the sole means of navigation
- › Surveillance coverage usually available

GNSS LFN Prediction NOTAM

- › ICAO PBN manual, Part C, Chapter 7 (Implementing RNP 0.3):
 - not dependent on the availability of SBAS
 - required to have the means to predict GNSS fault detection (e.g. RAIM) unless the navigation equipment can make use of SBAS augmentation
 - in that case, the operator is required to check SBAS NOTAM
- › EGNOS NOTAM provided by ESSP-SAS and distributed by skyguide
- › Example:

EGNOS IS NOT AVAILABLE FOR HEL LOW-FLIGHT ROUTE KY251

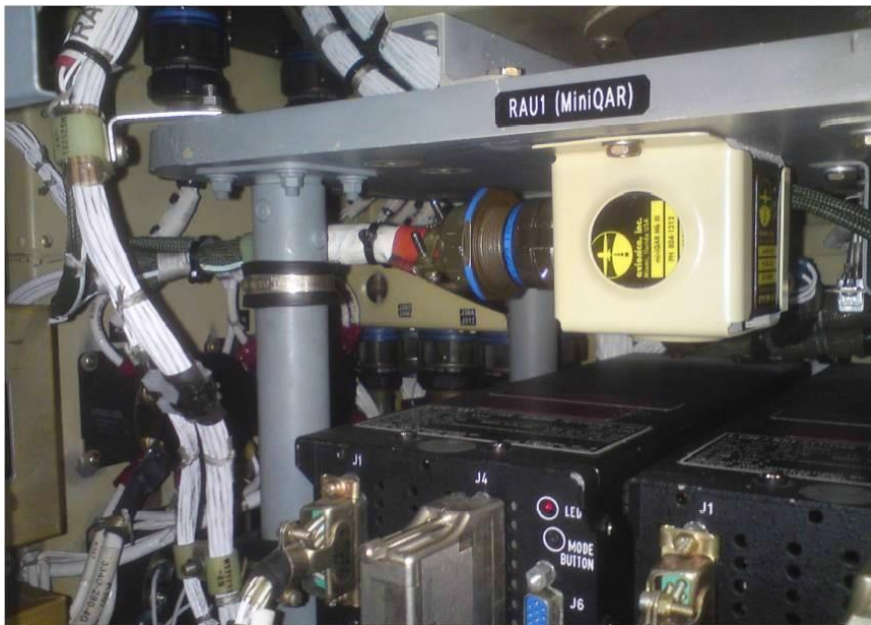
Ground Monitoring: RAIM and EGNOS Performance

- › Skyguide facility close to Zürich
- › Avionics GPS/RAIM receiver: CMC CMA-3024
- › Avionics GPS/SBAS receivers: CMC CMA-5024 and RC GPS-4000S

[m]	GPS / RAIM (CMC CMA-3024)		GPS / EGNOS (CMC CMA-5024)		GPS / EGNOS (RC GPS-4000S)	
	2015	2016	2015	2016	2015	2016
Accuracy horizontal (95%)	2.43	1.98	1.20	1.16	1.04	0.98
Accuracy vertical (95%)	4.69	4.70	2.09	2.15	1.37	1.35
HPL (99%)	445.25	412.17	12.97	11.83	13.66	12.48
VPL (99%)	(733.96)	(547.42)	19.51	18.27	19.74	18.42

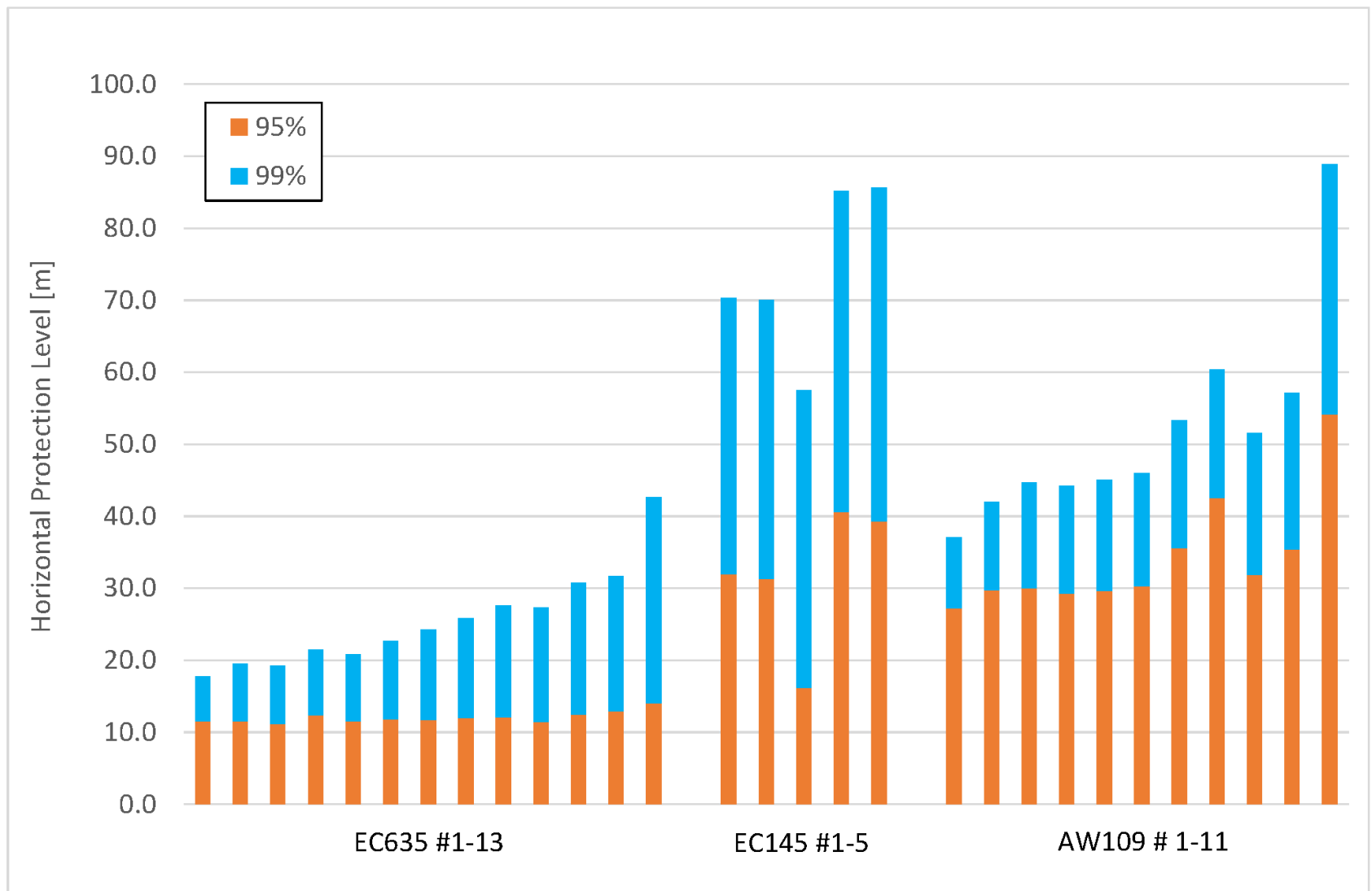
EGNOS Performance during Flights

- › Project Helicopter Recording Random Flights (HRRF)
- › 18 EC635, 6 EC145 and 11 AW109 helicopters equipped with recording unit (mQAR)
- › Recording of GPS (position and range domain), FMS and AHRS data



Courtesy of VBS and REGA

Horizontal Protection Level



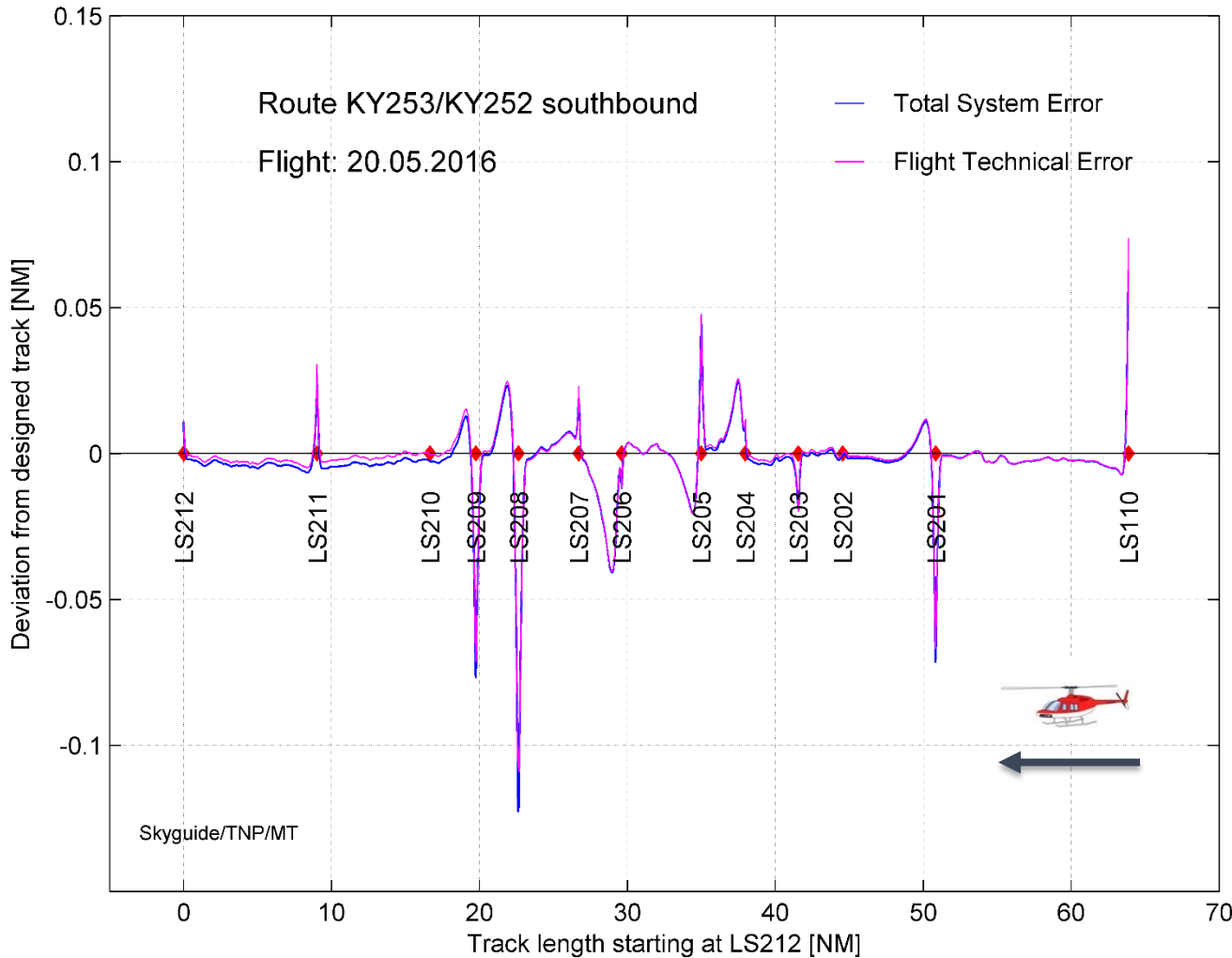
Summary Protection Level Analysis

[m]	99% HPL	99% VPL	Flight Hours
EC635	24.9	38.4	7353 h
EC145	72.4	109.7	2276 h
AW109	52.1	82.0	2555 h

Reminder: Summary from ground monitoring

[m]	GPS / RAIM (CMC CMA-3024)		GPS / EGNOS (CMC CMA-5024)		GPS / EGNOS (RC GPS-4000S)	
	2015	2016	2015	2016	2015	2016
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GNSS LFN Trajectory Analyses



Total system error analysis of 14 flights:

- considering whole flight (including fly-by waypoints):

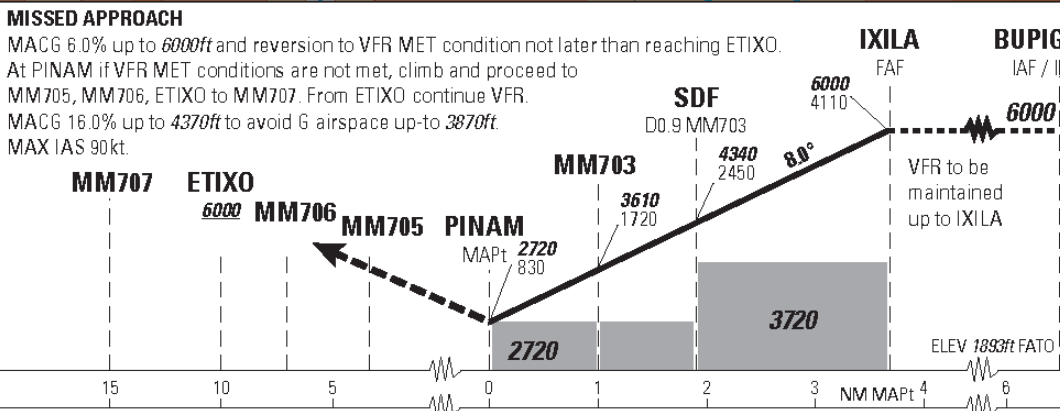
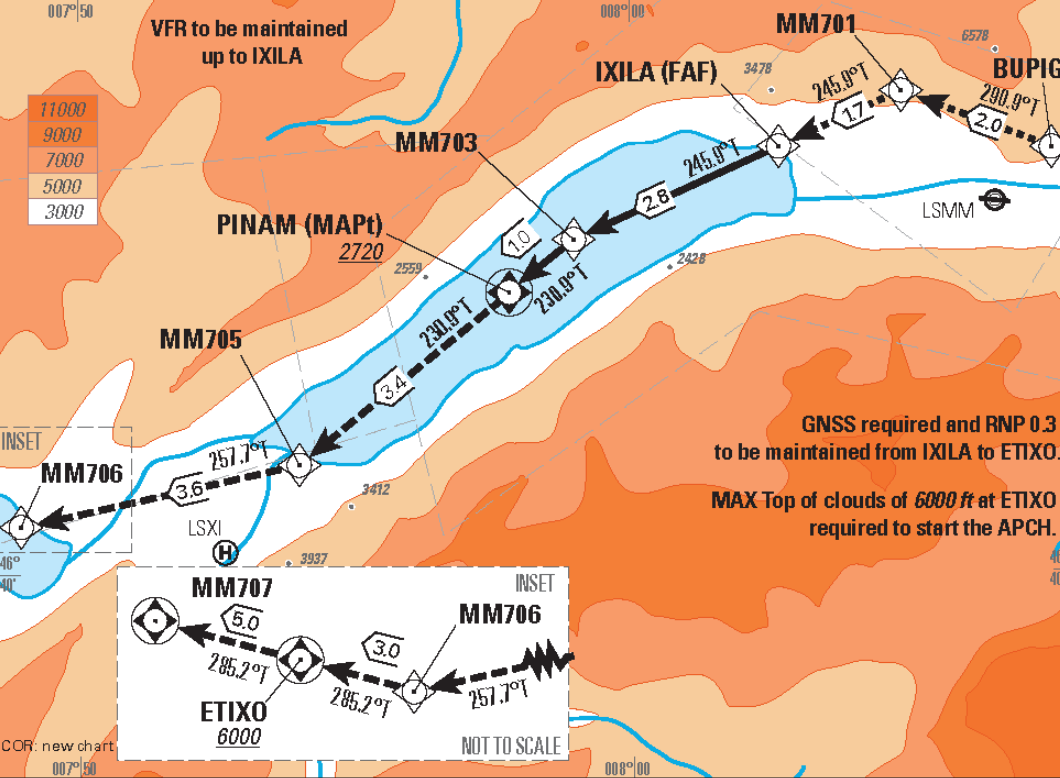
~ 315 m (0.170 NM)

- considering straight segments only:

~ 15 m (0.008 NM)

Approach Procedure Example Meiringen

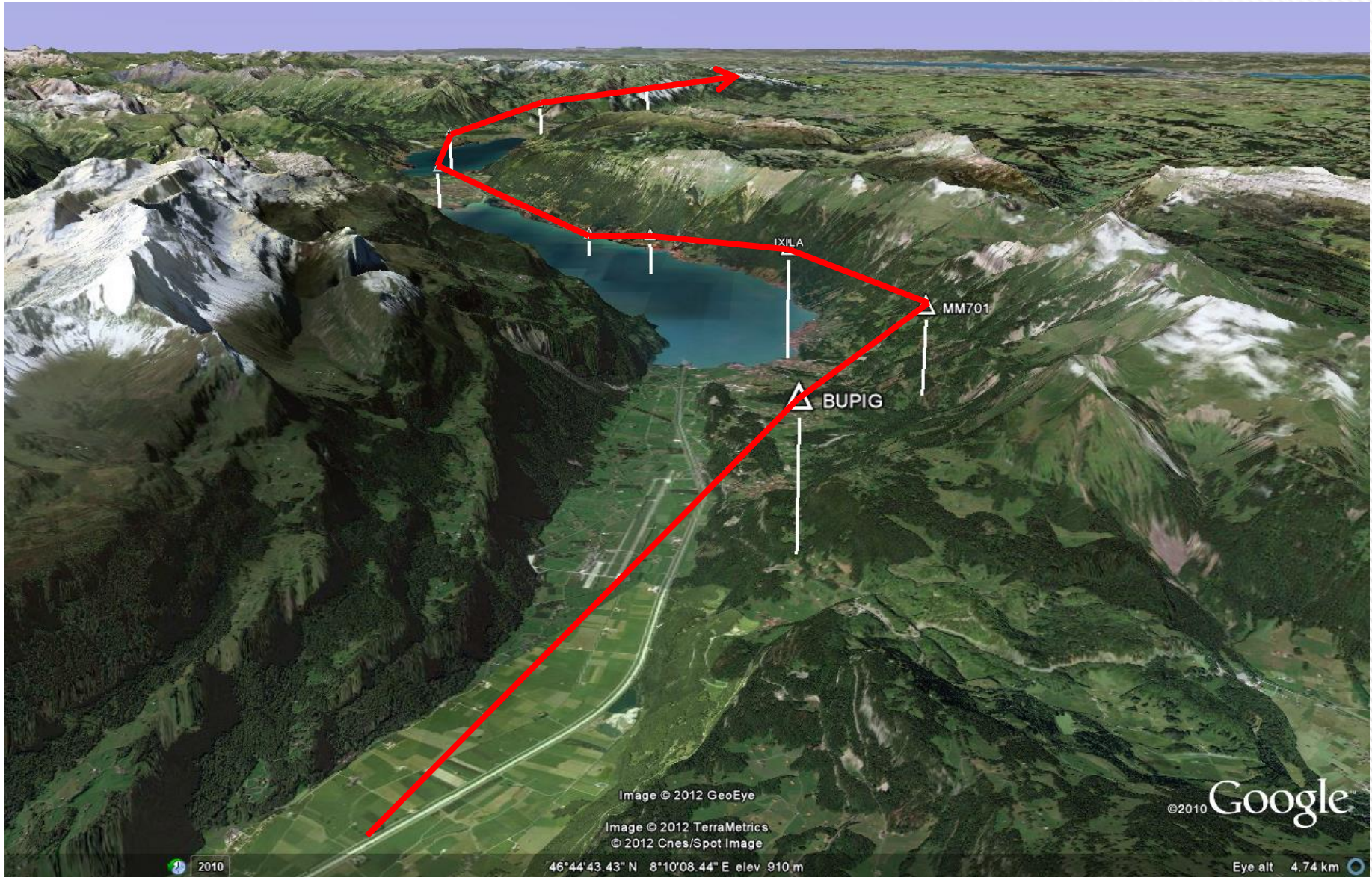
- › Cloud-breaking procedure
- › RNP 0.3 requirement
- › Two turns in the approach
- › Two turns in the missed approach
- › GNSS is sole means of navigation
- › LNAV minima only



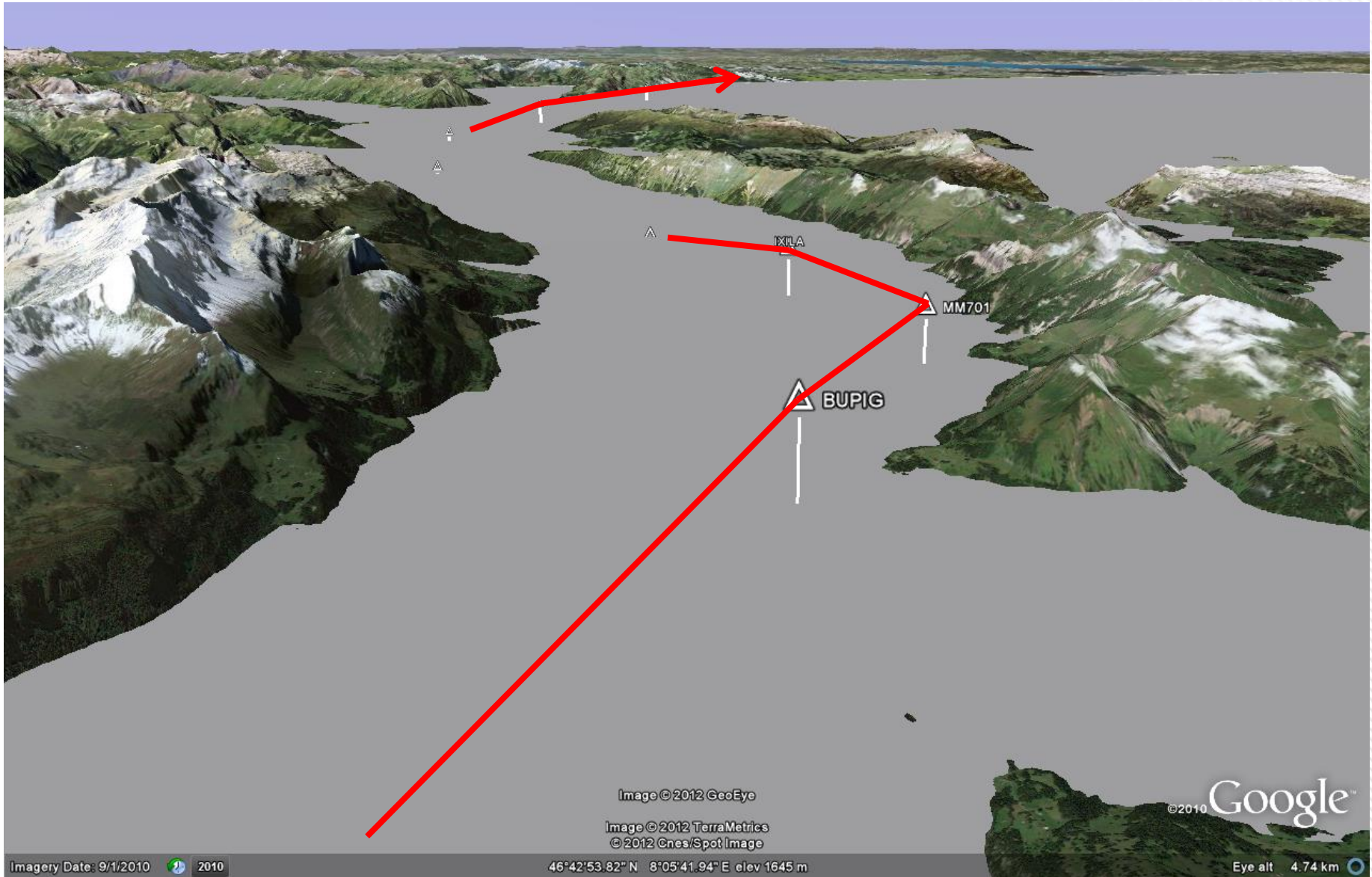
CATEGORY	H
Obstacle clearance altitude/height (OCA/H)	2720
Minimum descent altitude/height (MDA/H)	830
VIS	1500 m

Dist to MM703	Crossing Altitude		
	ISA	ISA-10	ISA-20
2.8	6000	6220	6450
2	5320	5520	5720
0.9	4380	4540	4710
MM703	3610	3740	3880
PINAM	2720	2820	2930

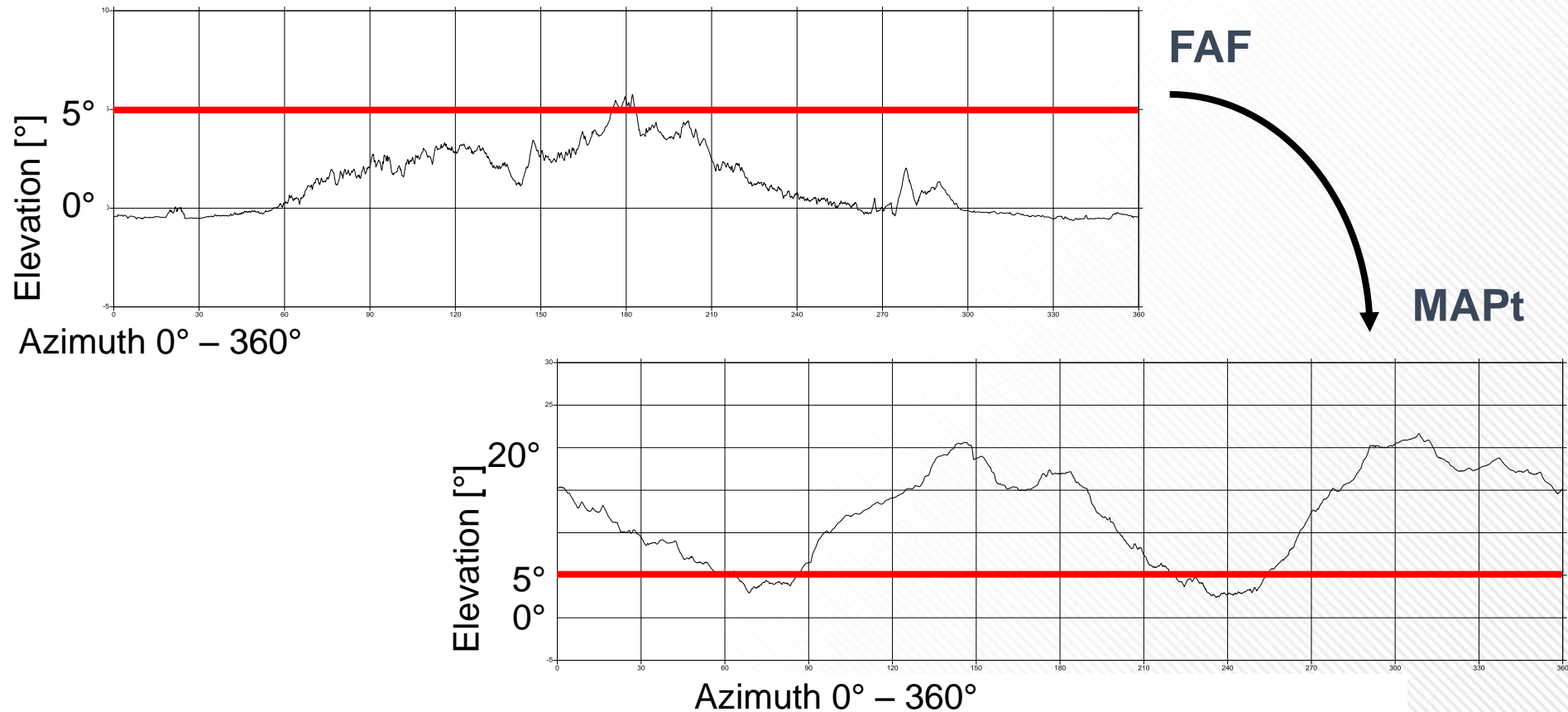
Meiringen Approach



Meiringen Approach



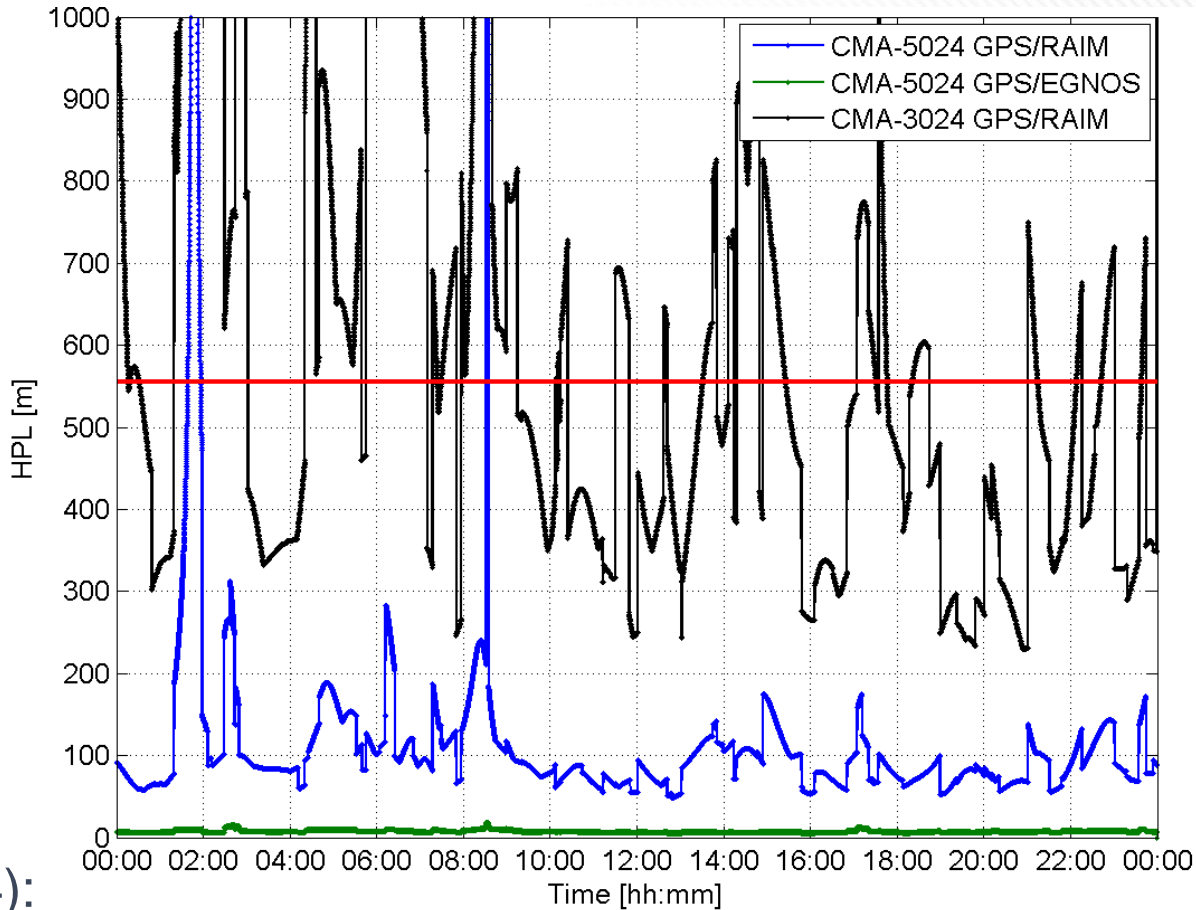
Terrain Masking FAF and MAPt



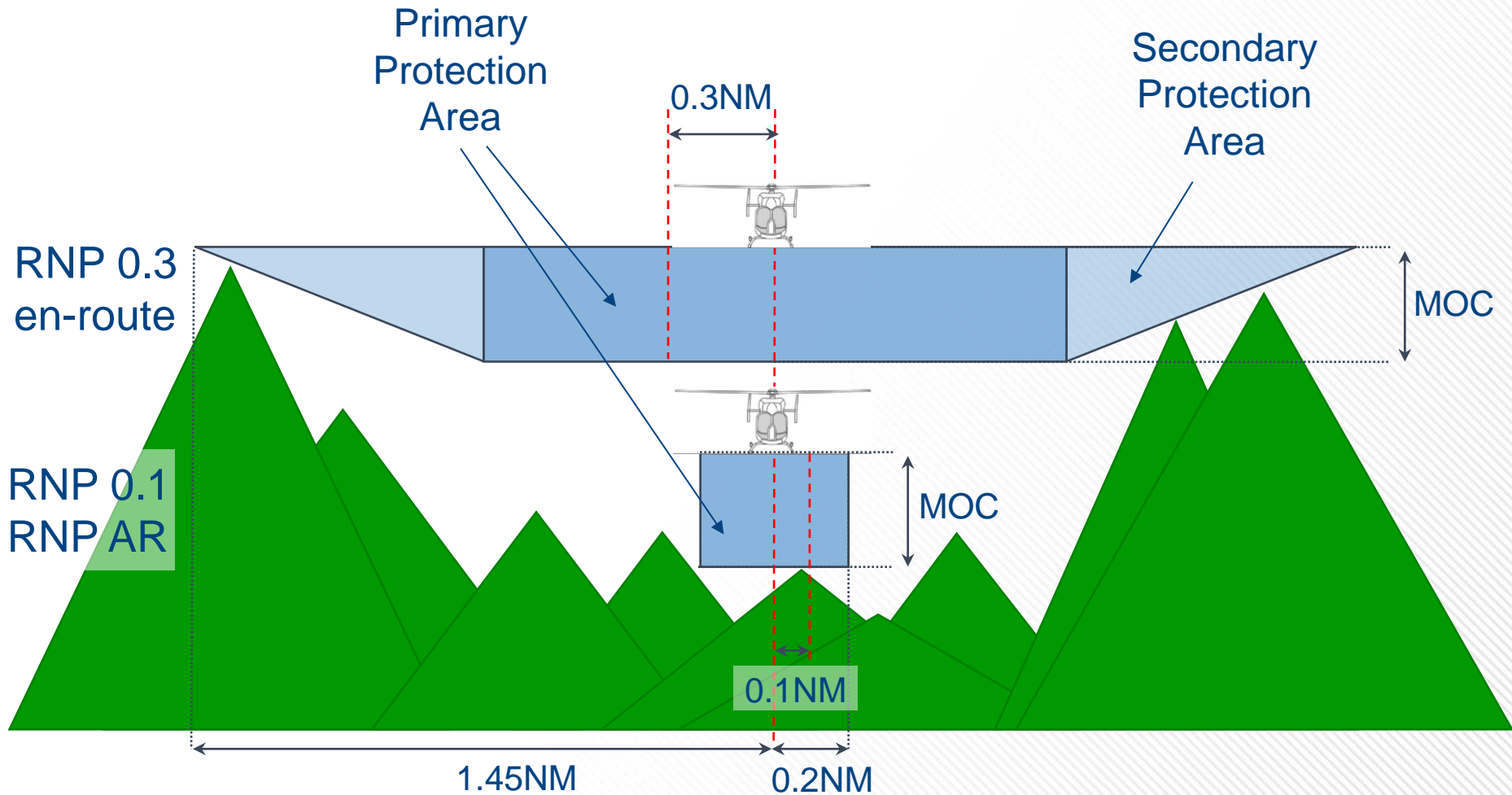
- › Prediction RAIM by aircraft commenced before the approach
- › Terrain changing significantly during the approach

Performance Simulation of Avionics GPS Receivers

- › IFEN-NavX-NCS GNSS signal generator
- › worst case location (MAPt)
- › during 24 hour
- › 30 satellites GPS constellation
- › Availability with:
 - GPS/RAIM (CMC-3024, not SA-aware): 56.5%
 - GPS/RAIM (CMA-5024): 98.5%
 - GPS/EGNOS (CMA-5024): 100%



Outlook: Procedure Design in Mountainous Areas



GPS with RAIM or EGNOS?

What makes the difference!

- › Availability of EGNOS significantly higher
- › Much better robustness with EGNOS
- › This is especially important when:
 - GNSS is the sole means of navigation
 - coming closer to the ground
 - the GPS satellite constellation is decreasing

EGNOS is the favorite solution for rotorcraft operations (not only in mountainous environment)

Questions ?

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