

A CO₂ versus noise trade-off study for the evaluation of current air traffic departure procedures A case study at Gothenburg Landvetter Airport

Debbie Mitchell
& Henrik Ekstrand
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Outline

- Motivation for study
- Green departures
- Overview of turn-related speed constraints
- Case study: Gothenburg Landvetter Airport
- Speed constraints on TOPLA 1M SID
- Speed constraint scenarios modelled
- Data and aircraft performance/noise modelling
- Results – CO₂ versus noise trade-off study
- Conclusions
- Possible solutions for removal of SID speed constraints

Motivation

SESAR target 10%  CO₂ via ATM improvements by 2020



Historically emphasis on reducing noise exposure around airports.



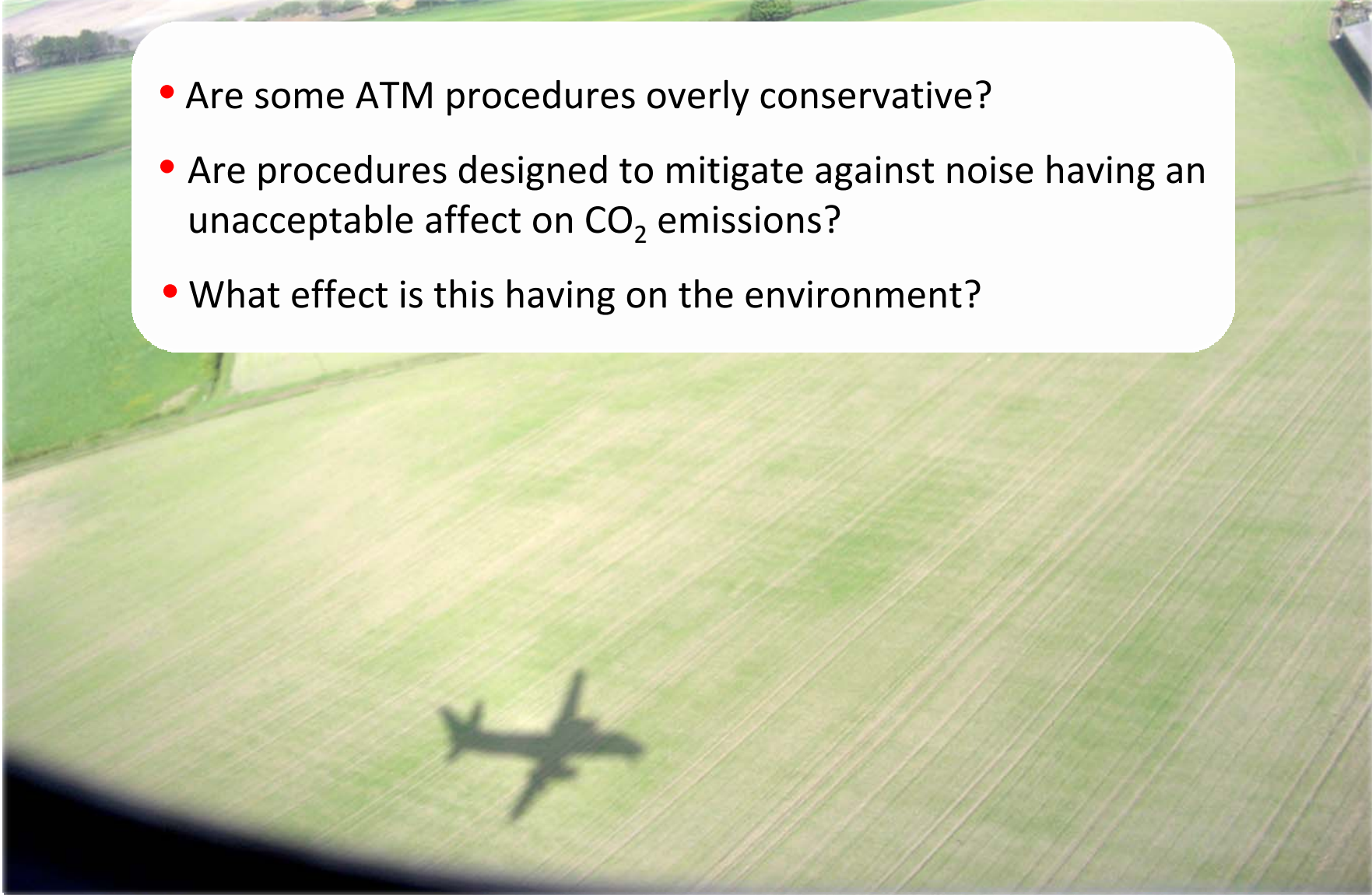
Potential for substantial fuel savings



Procedures based on old aircraft types



Issues

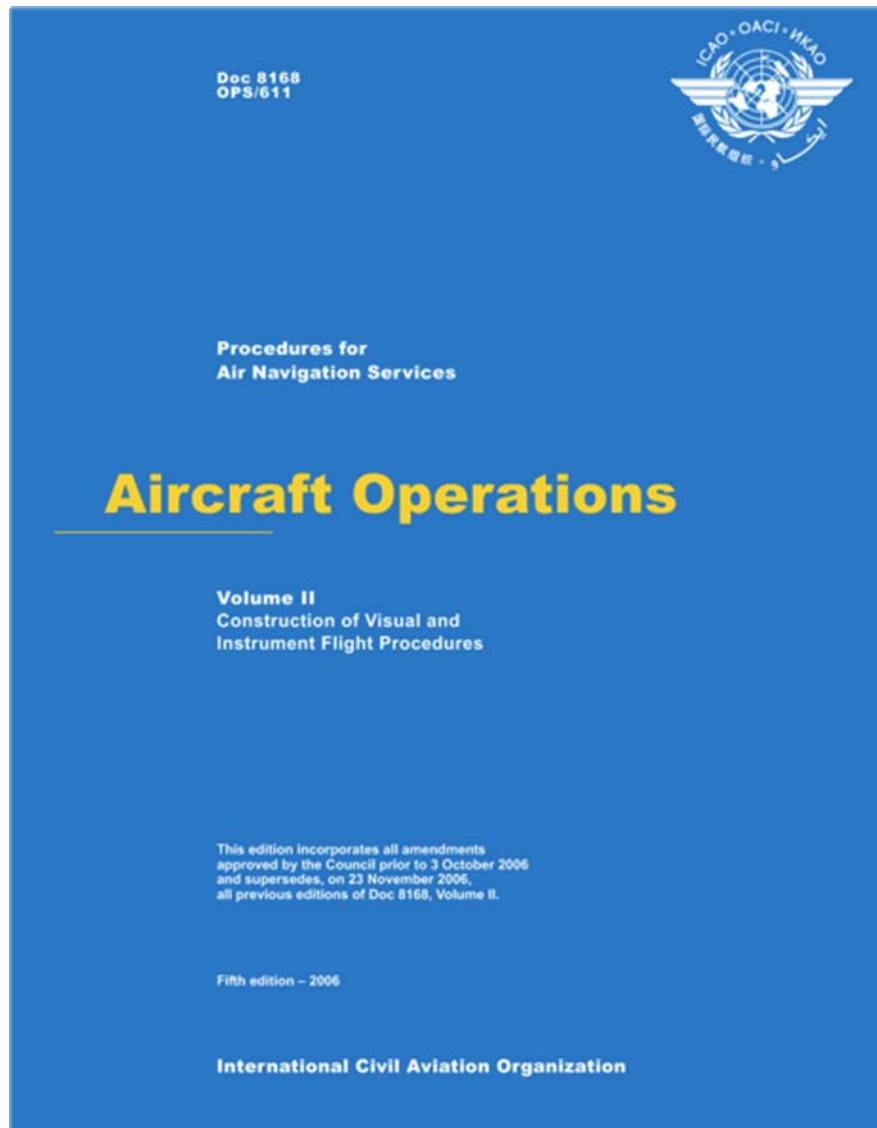
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- Are some ATM procedures overly conservative?
 - Are procedures designed to mitigate against noise having an unacceptable affect on CO₂ emissions?
 - What effect is this having on the environment?

What constitutes a 'green departure'?



- Continuous climb departures.
- Direct routing (effective ATC coordination).
- Variable SID deviation altitudes.
- Minimum take-off thrust and reduced climb thrust.
- Low thrust cutback altitude.
- Green speed.
- Optimise use of PANS-OPS Doc. 8168.

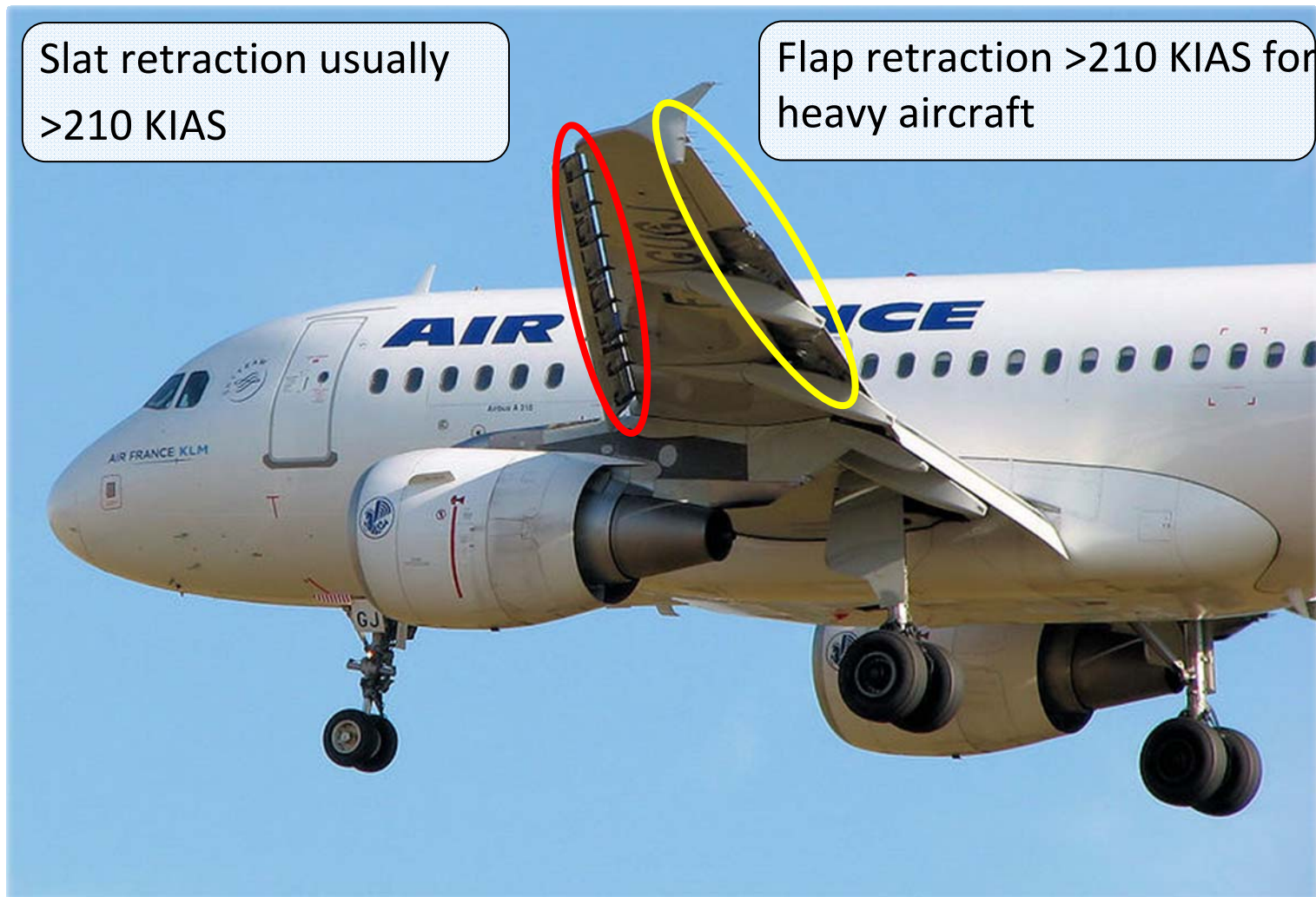
Turn-related speed constraints



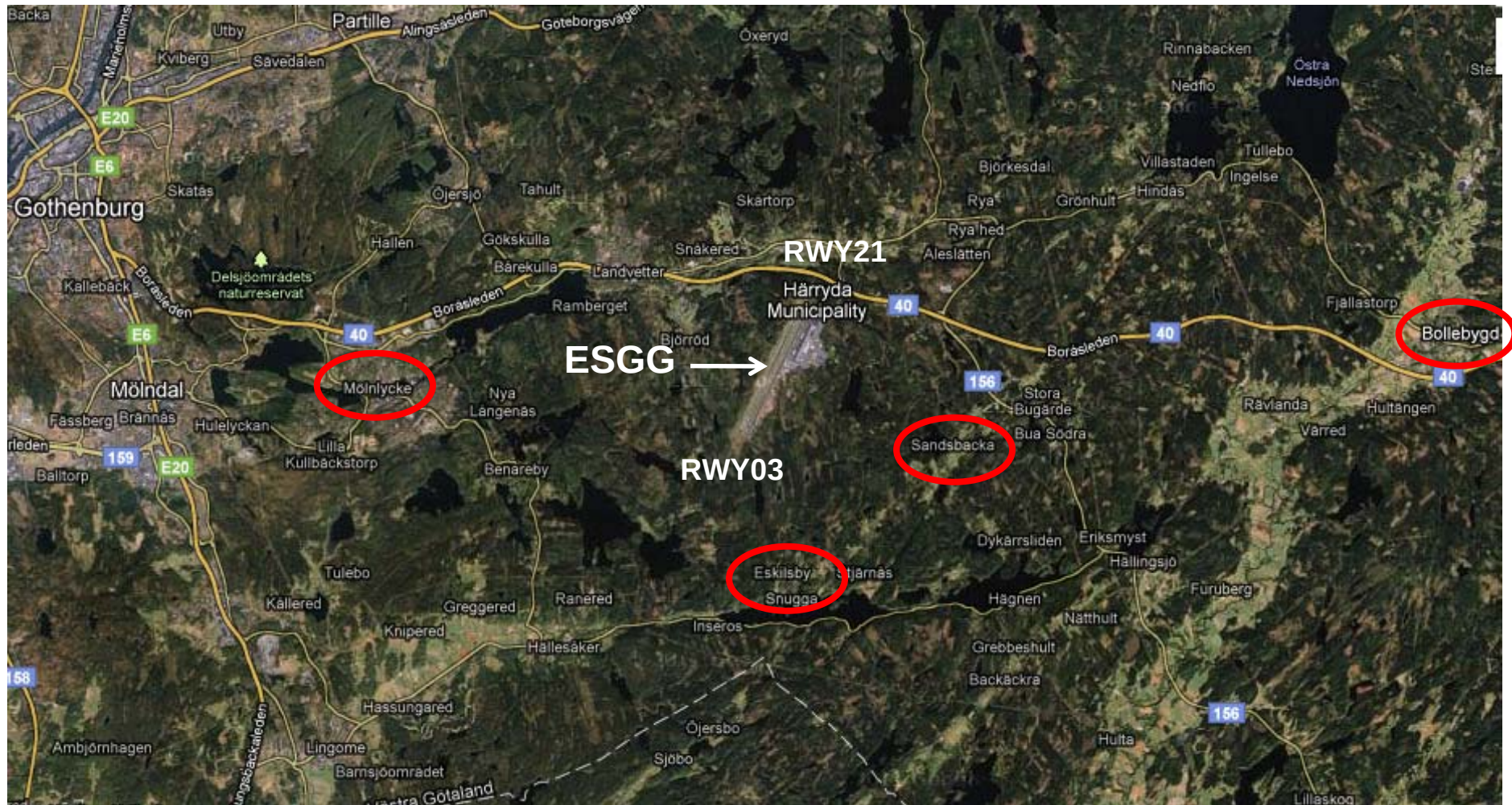
- Track change of turn
- Altitude
- Assumed met conditions
- Max. allowed aircraft bank angle



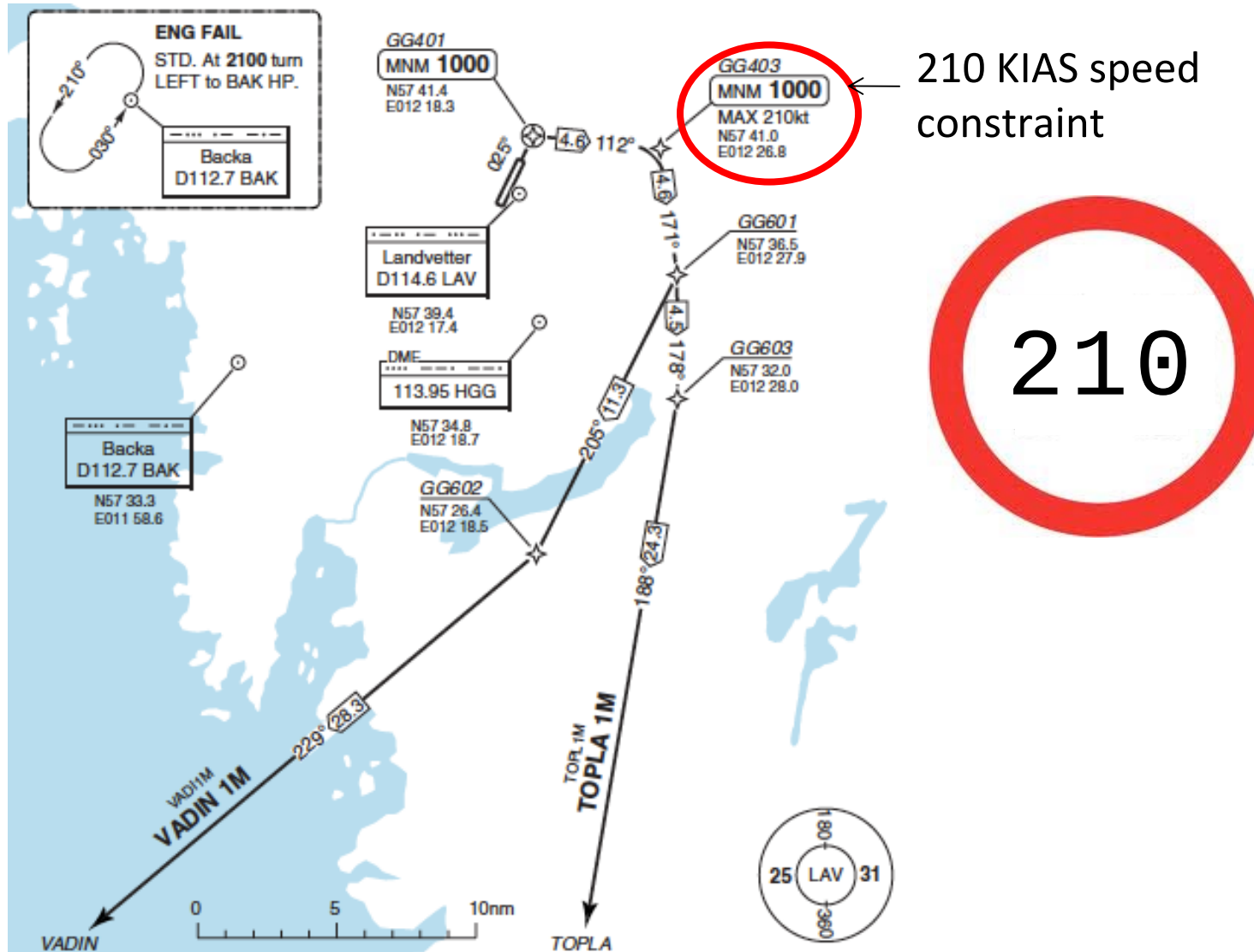
Fuel burn penalty of turn-related speed restrictions



Case study: Gothenburg Landvetter Airport (ESGG)



TOPLA 1M departure route



Speed constraint scenarios



1. 205 KIAS to 10 NM
2. 210 KIAS to 10 NM
3. 220 KIAS to 10 NM
4. 250 KIAS to Flight Level 100
5. Free Speed (no constraints)

Data

- Flight Data Recorder data from Novair.
- Novair A321 departures along TOPLA 1M SID (RWY 03).
- Take-Off Data Calculation (TODC) data.
- Meteorological data.
- Selected initial conditions for typical Winter flight.



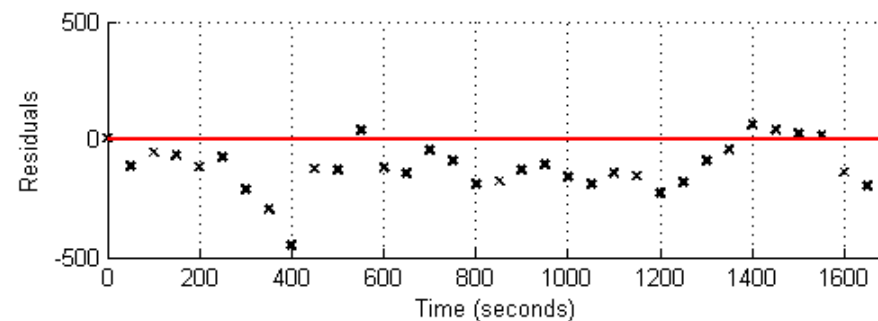
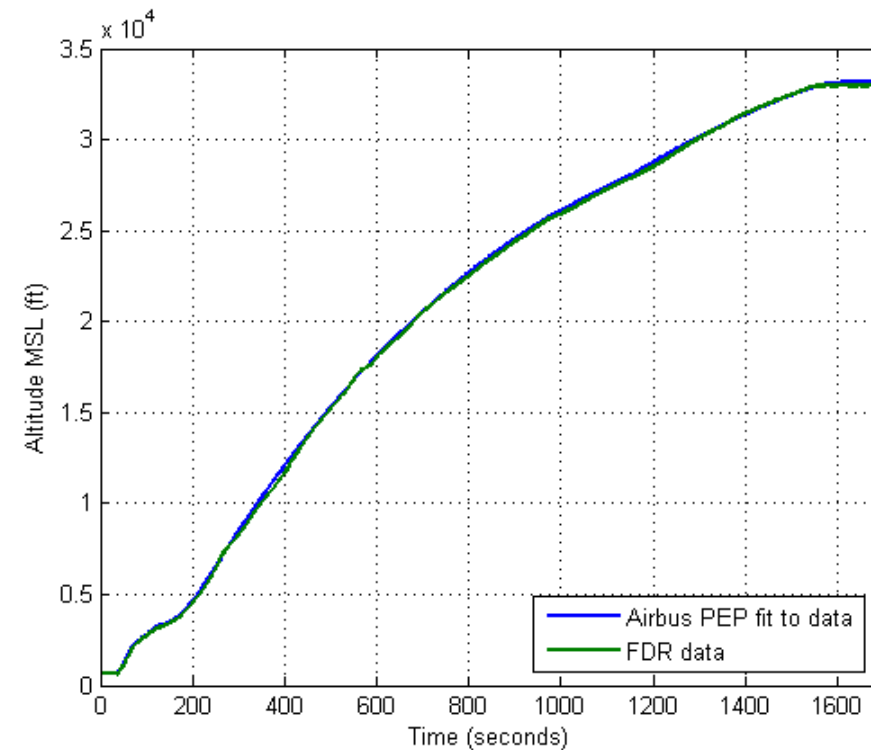
Parameter	Winter flight
Take-off mass	85,500 kg
V_{ROTATE}	168 KIAS
V_2	175 KIAS
Initial aircraft configuration	CONF 1+F
Thrust setting	TOGA
Air conditioning	Off
Engine Anti Ice	On
Outside Air Temperature	0
QNH	1008

Aircraft performance modelling

- **Operational Flight Performance (OFP)** tool in Airbus Performance Engineers Program (**PEP**).
- Replicate actual flights based on manufacturer's data.

Aircraft PEP model validation

- Ensured PEP climb profile in good agreement with the FDR data.
- Made deviations in PEP by changing speed constraints.



Aircraft noise modelling

- Airbus Noise Level (NLC) tool.
- Noise calculations based on manufacturer's Noise Power Distance tables.
- Assume microphone location 1.2 m above ground level (ICAO Annex 16) and directly under flight path.
- Maximum A-Weighted Audible Noise (LA_{max}) metric used for analysis (metric used in Sweden).

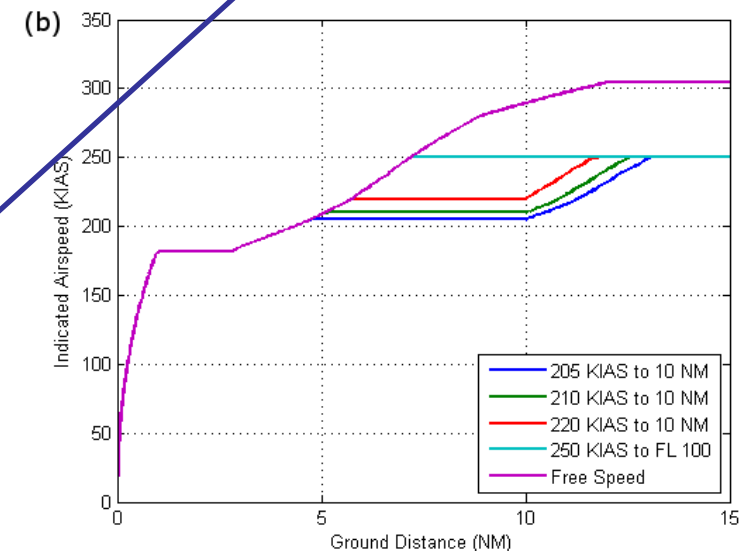
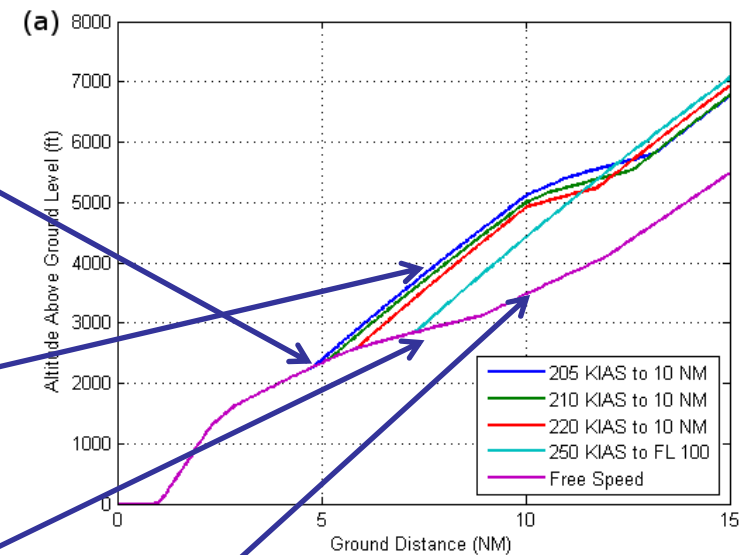


Data analysis



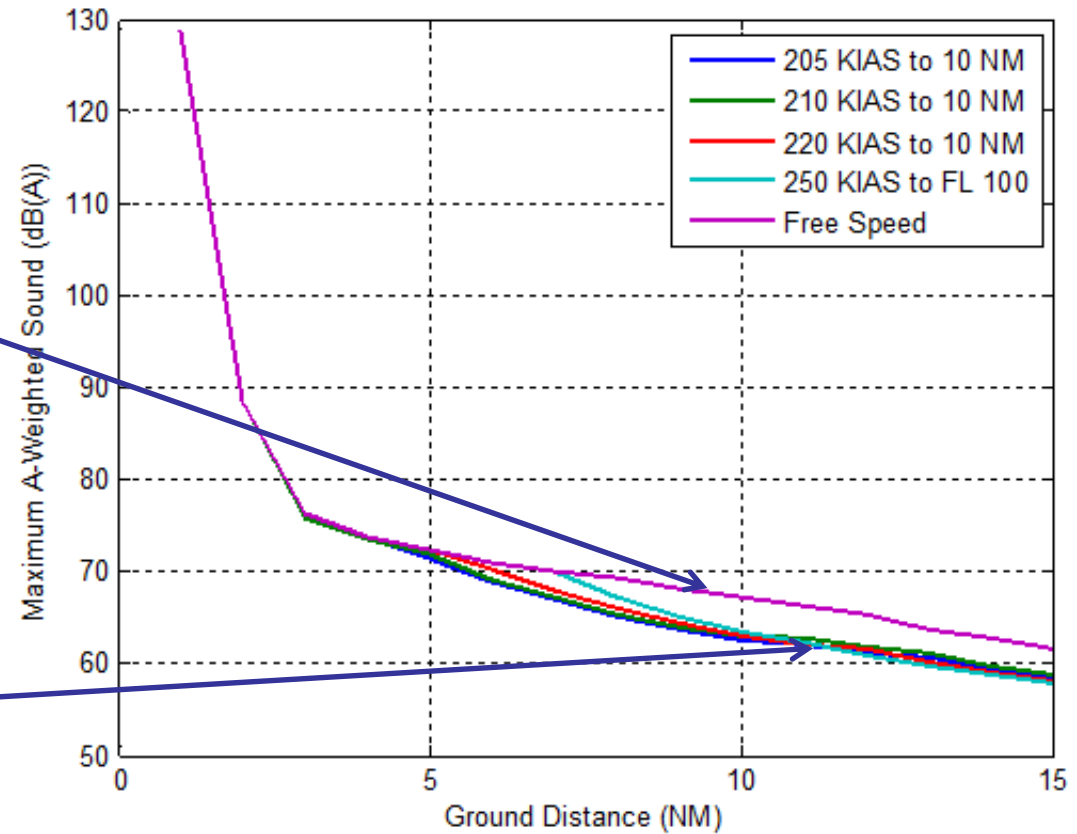
Speed Constraint Scenarios - Results

- Climb profiles consistent until 5 NM and 2300 ft AGL.
- 205 KIAS scenario has highest altitude between 5 NM and 12 NM.
- 250 KIAS and Free Speed scenarios identical until 7 NM and 2800 ft AGL.
- Free Speed profile has lowest climb angle during initial climb phase.

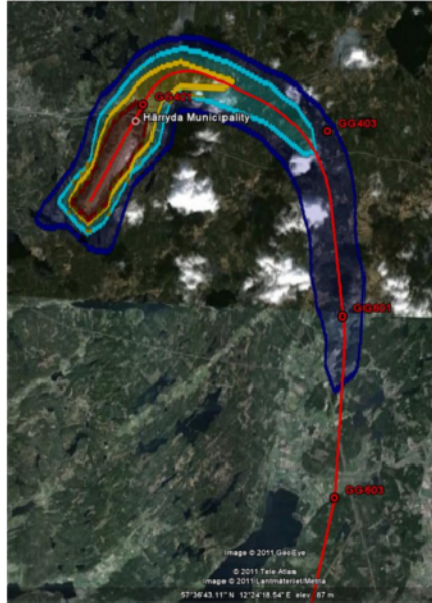


Speed Constraint Scenarios - Results

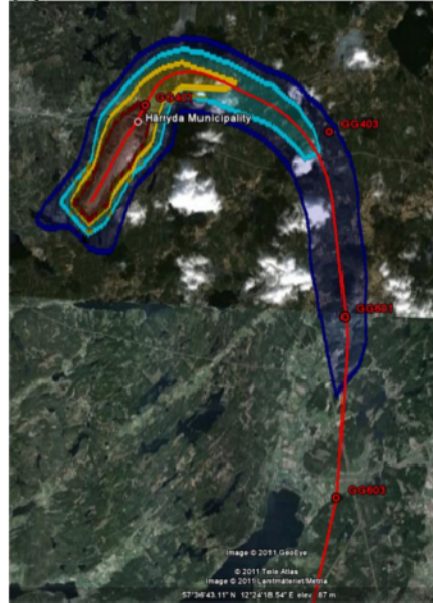
- Distances >7 NM Free Speed scenario generates highest LA_{max} .
- Explained by climb profile of aircraft.
- Similar noise profiles for remaining 4 scenarios above 10 NM ground distance.



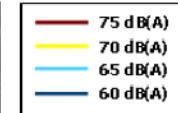
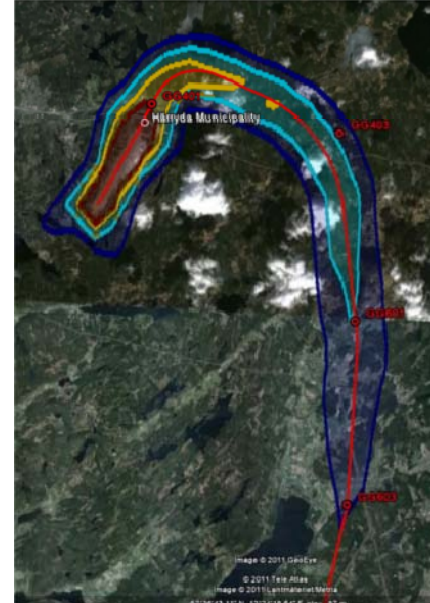
(a) 205 KIAS to 10 NM



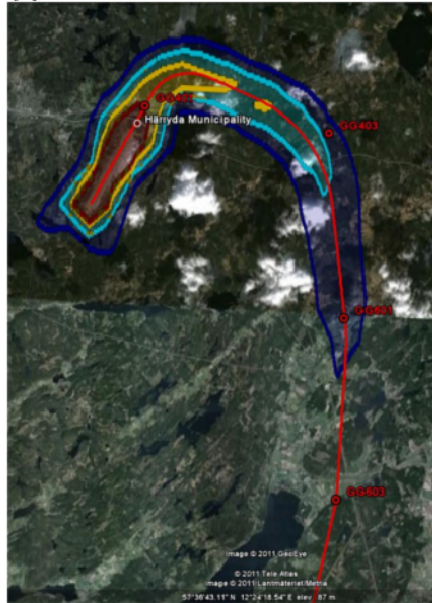
(b) 210 KIAS to 10 NM



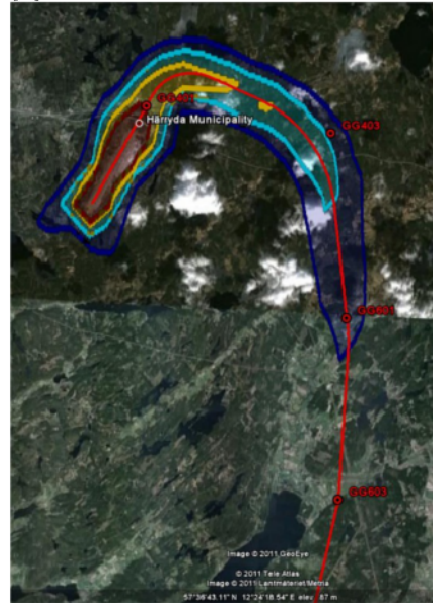
(c) Free Speed



(d) 220 KIAS to 10 NM

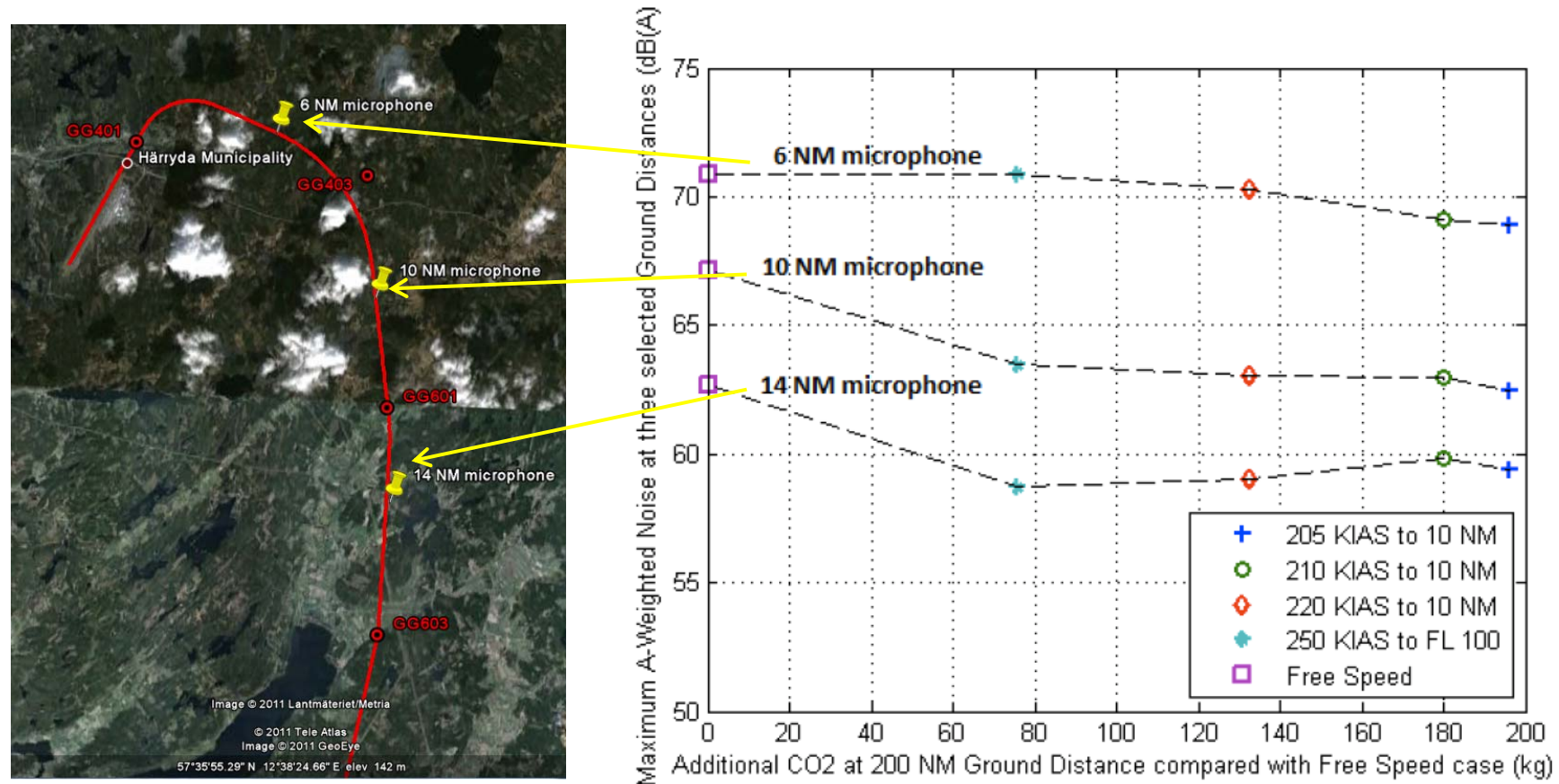


(e) 250 KIAS to FL 100



Speed restriction scenario	Surface area of LA _{max} noise contour (km ²)			
	75 dB(A)	70 dB(A)	65 dB(A)	60 dB(A)
205 KIAS to 10 NM	7.07	14.38	31.30	75.20
210 KIAS to 10 NM	7.07	14.34	31.46	75.45
220 KIAS to 10 NM	7.07	14.51	34.26	74.77
250 KIAS to FL 100	7.07	14.42	35.54	73.60
Free Speed	7.07	14.42	41.69	93.32

CO₂ vs. Noise Trade-Off Analysis – Results



- Potential for CO₂ savings of **~180 kg** per flight if remove 210 KIAS and 250 KIAS speed constraints on LABAN 1M SID (~60 kg fuel).
- Increase in noise ranging between 2 dB(A) – 5 dB(A) during initial climb depending on position along flight path.

Speed Constraint Analysis - Conclusions

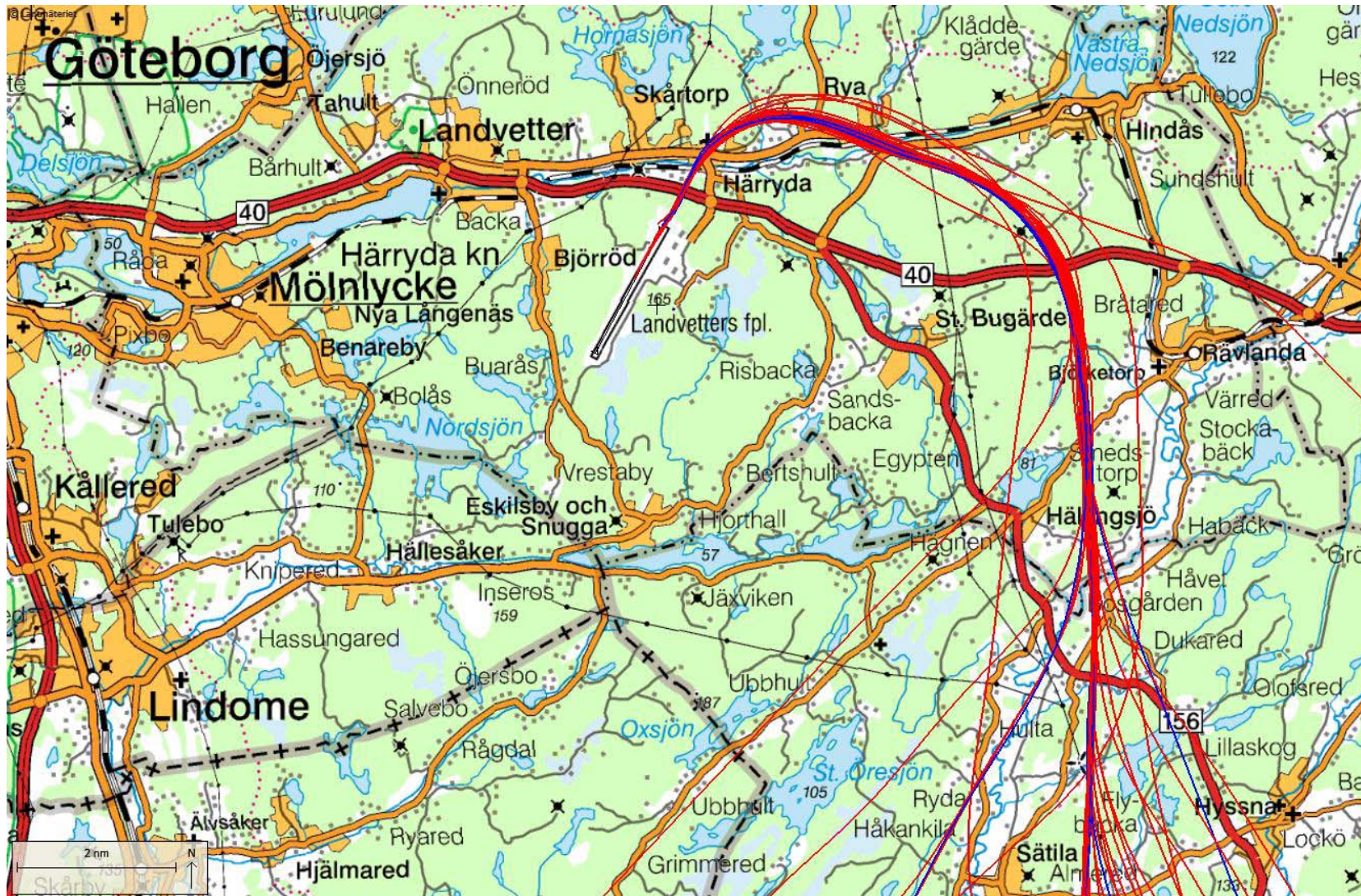
- Free Speed means aircraft stays closer to ground during initial climb – affect on noise profile.
- Does not affect noise contours above 70 dB(A), i.e. loudest noise range, but reducing speed restrictions causes increases in noise below 65 dB(A) contour level (increase in surface area of 18.12 km²).
- Potential fuel savings ~60 kg for heavy A321 winter flight and ~180 kg reduction in CO₂, but increase in noise 2 dB(A) – 5 dB(A) depending on position along flight path.
- ~3500 departures along TOPLA 1M per year **~190 tonnes** of fuel savings and **~575 tonnes** of CO₂.

Possible solutions for removal of SID speed constraints

- Remove turn-related speed constraints applied to SIDs as significant environmental benefit.
- Optimise use of PANS-OPS 8168:
 - Use of statistical wind.
 - Allow aircraft capable of banking 30° to fly turn without speed restriction (state in AIP).
 - Deviate from PANS-OPS by proving track adherence via flight trials.



Track-keeping adherence



QUESTIONS?

Email: deborah.mitchell@chalmers.se