Identification of Gross Polluting Ships (IGPS) using Airborne Measurements

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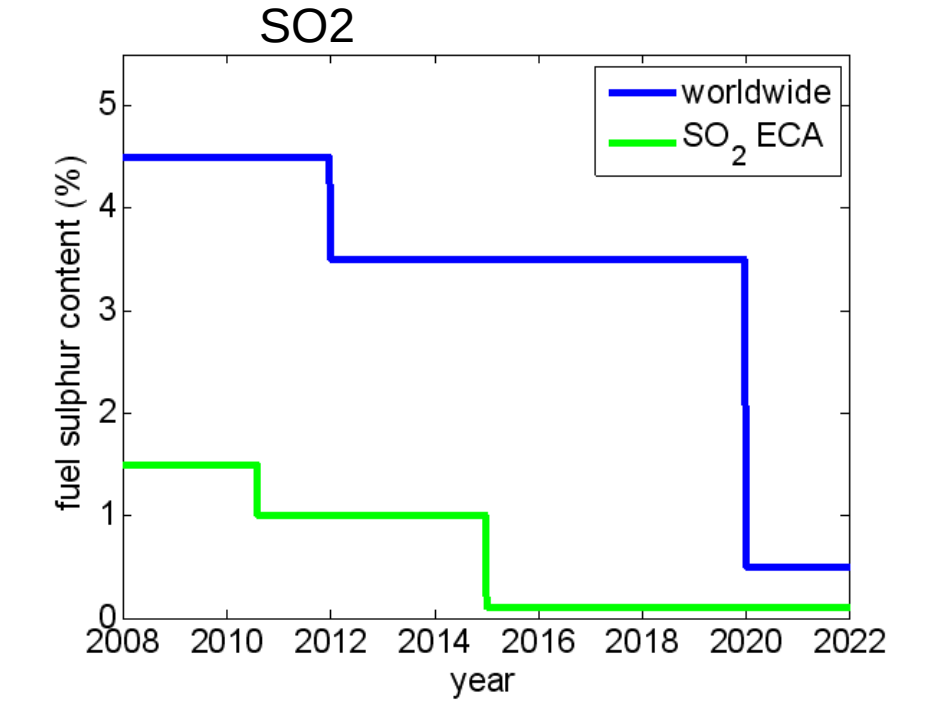
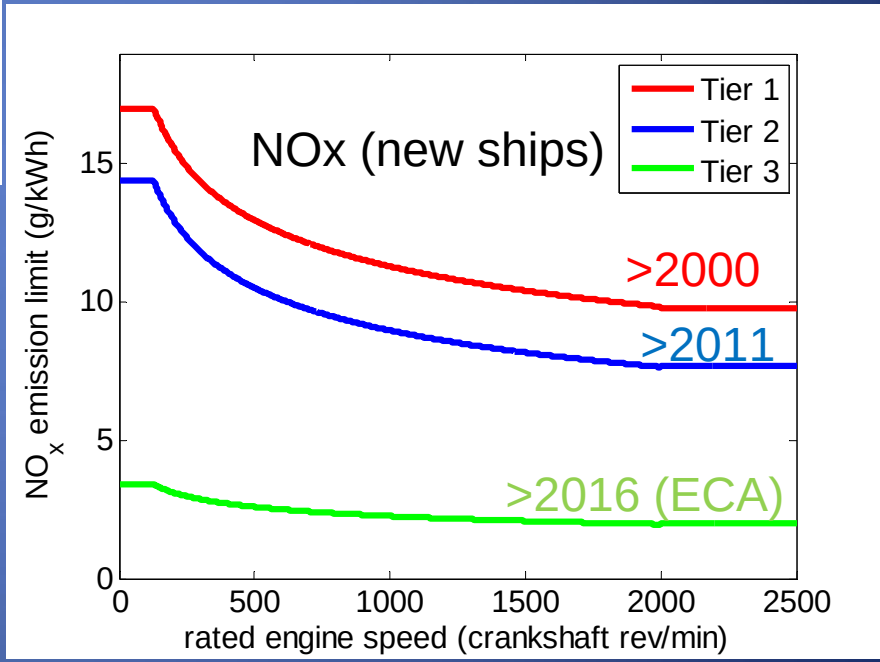
Optical remote sensing group (10 people)

- **Methods for gas emissions:**
  - **Fugitive emissions (VOC), (Mobile solar FTIR)**
  - ***SO_2 and NO_x from shipping***
  - **CH_4 from landfills (waste deposits)**
  - **NH_3 from farming**
- **Atmospheric research NDACC:**
  - **Stratospheric studies by solar FTIR of O_3 and reservoir species (chlorine, nitrogen and fluorine) (Harestua solar observatory Norway (NDACC network)**
  - **Climate gases, column measurements of CH_4, CO, ethane, N_2O**
  - **Megacities (vehicle emissions, CO column)**
- **Volcanoes, NOVAC:**
  - **Optical flux measurements of SO_2, BrO (HCl, HF) on 20 volcanoes**

New IMO regulation



2011 EU: 0.1% S, ships at berth, >2 hours stay



2016 :Retrofitting for ships built 1990-2000, if a cost effective upgrade available to become same as 2000 standard

Activities related to shipping

- IGPS project (national funding, 2007-2010)
  - Pilot study aimed at testing technique for remote *Identification of Gross Polluting Ships* for enforcement of new IMO regulation. Measurements with Swedish Coast Guard (SCG) CASA airplane.
- North sea project (EU & Belgian Env direct, Sep 2009)
  - IGPS system applied from a Dolphin helicopter (NHV) in North sea
- IGPS-plius project (national funding , 2009-2012)
  - Development of the IGPS system to an automatic system
  - Permanent installation in SCG airplane , DASH 8, 300
- BSR Innoship project (EU Intereg, 2010-2013)
  - BSR InnoShip - Baltic Sea cooperation for reducing ship and port emissions; includes Helicopter measurements in St Petersburg

Platforms

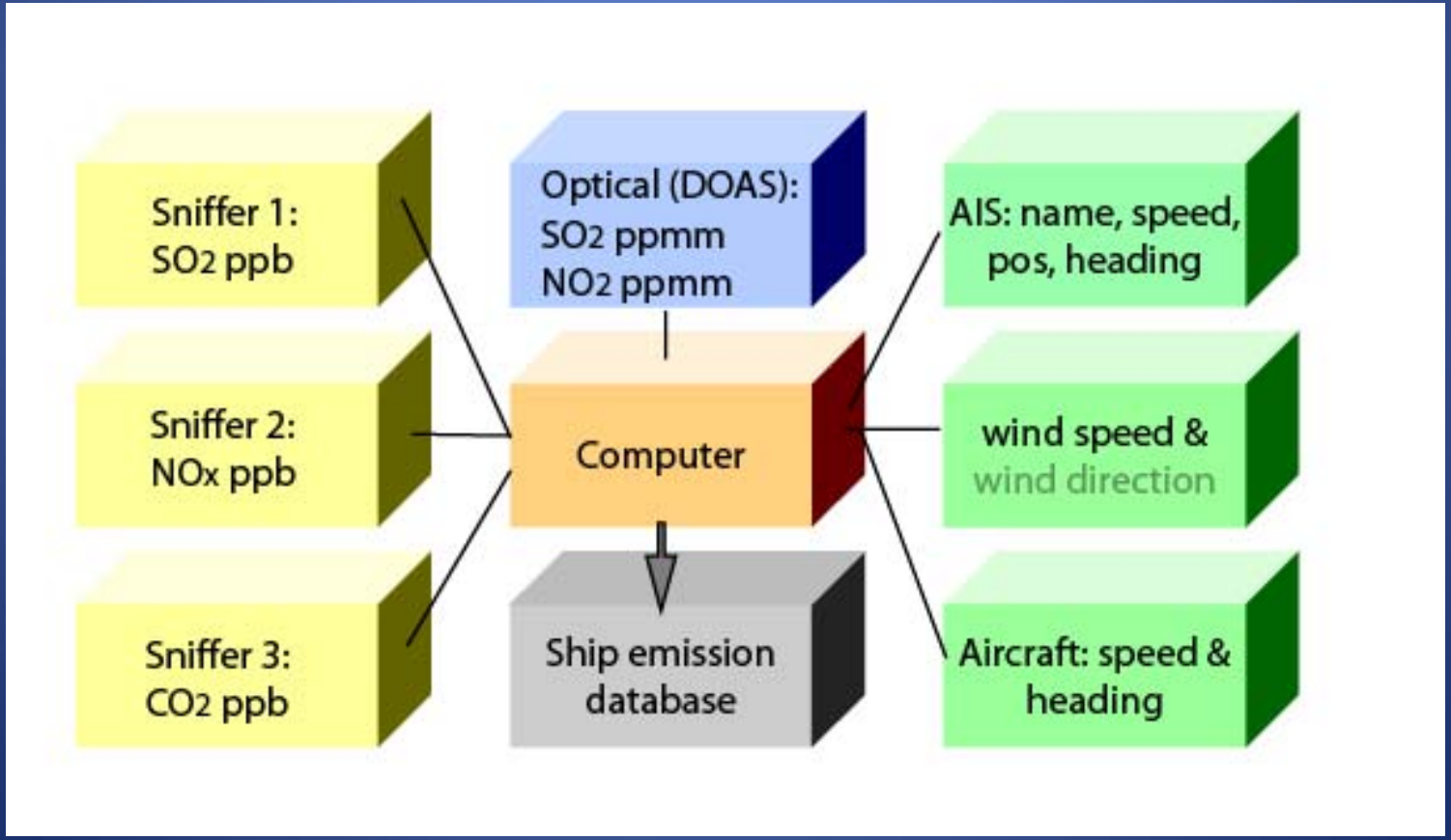
CASA airplane (Swedish Coast Guard)
Test measurements 2007/2008

Dolphin helicopter, rented by Belgian Environmental directorate, Rotterdam 2009

DASH 300 airplane (Swedish Coast Guard);
Installation of automatic system 2011

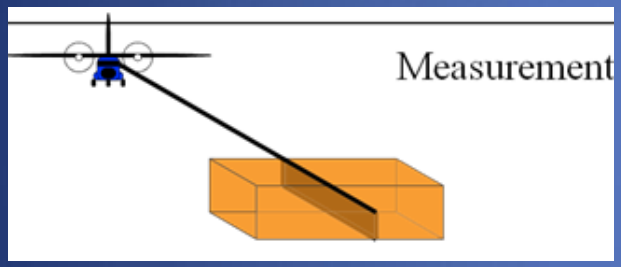
IGPS system

A) Optical measurements of SO_2 and NO_2 (kg/s) from analysis of reflected skylight on the ocean combined with wind and ship speed
B) Sniffer measurements of SO_2, NO_x, CO_2 (emission/kg fuel)
C) Measurements conducted from an airplane, boat or from shore.



IGPS surveillance method

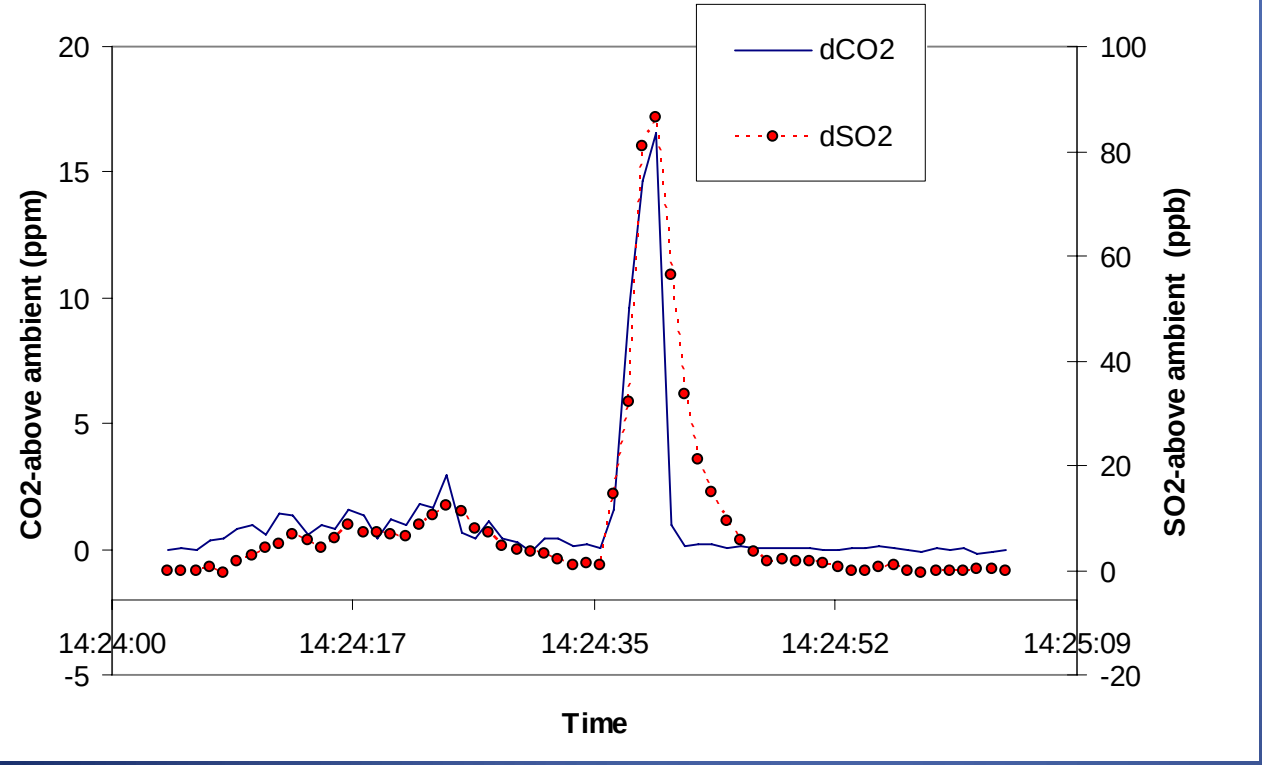
Fly over ships and conduct optical flux measurement, (altitude 300 – 600 m)



For high emitters fly through the fluegases and conduct sniffer measurements (altitude 50-300 m) to obtain emission factors (kg/fuel)

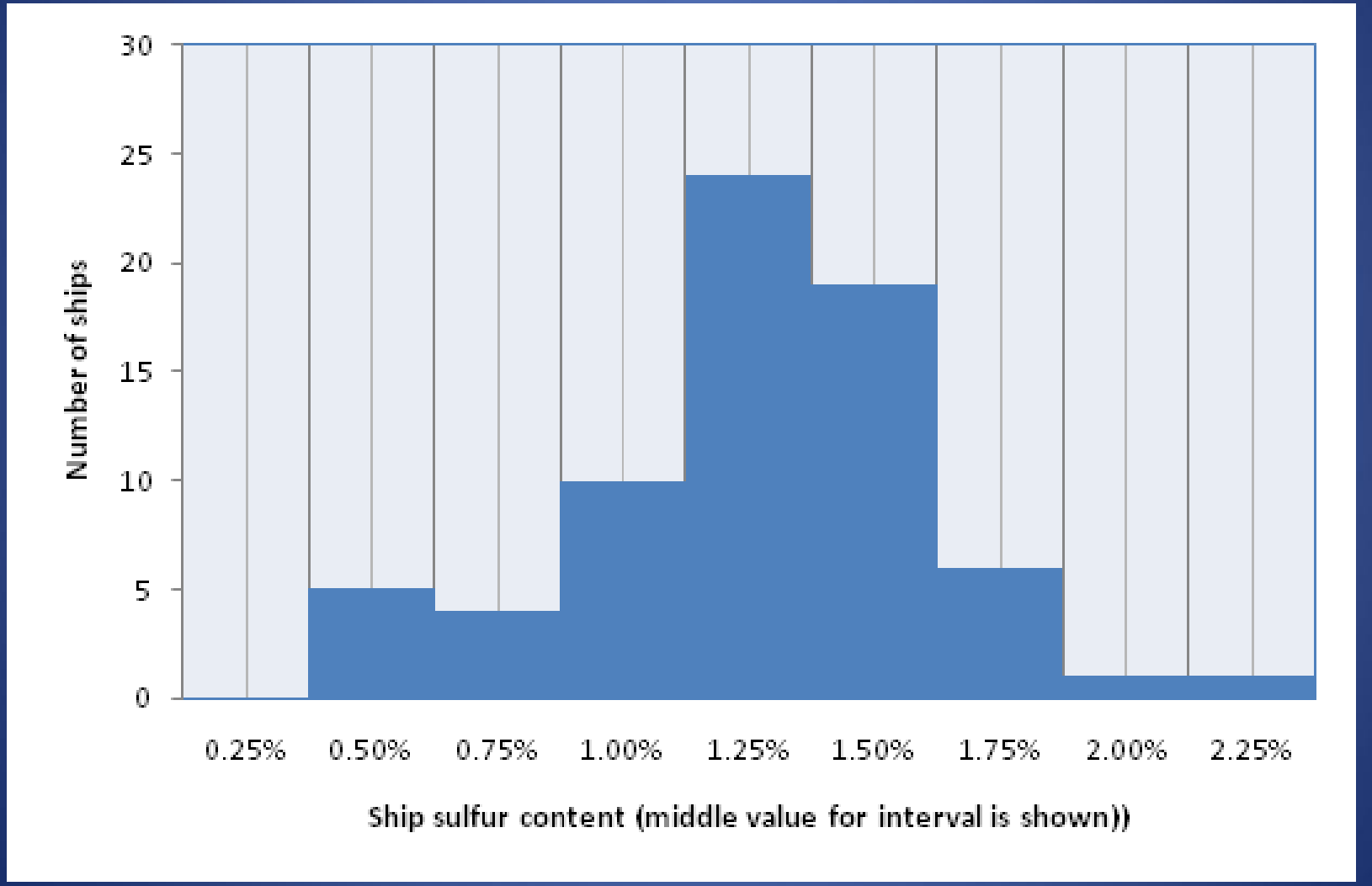
Example of sniffer measurement:

Mixing ratios of SO_2 and CO_2 in the fluegas of an oil tanker (Knock Sheen) measured between Sweden and Denmark. The SO_2/CO_2 ratio in the plume indicates a sulfur fuel concentration of 1.9%.

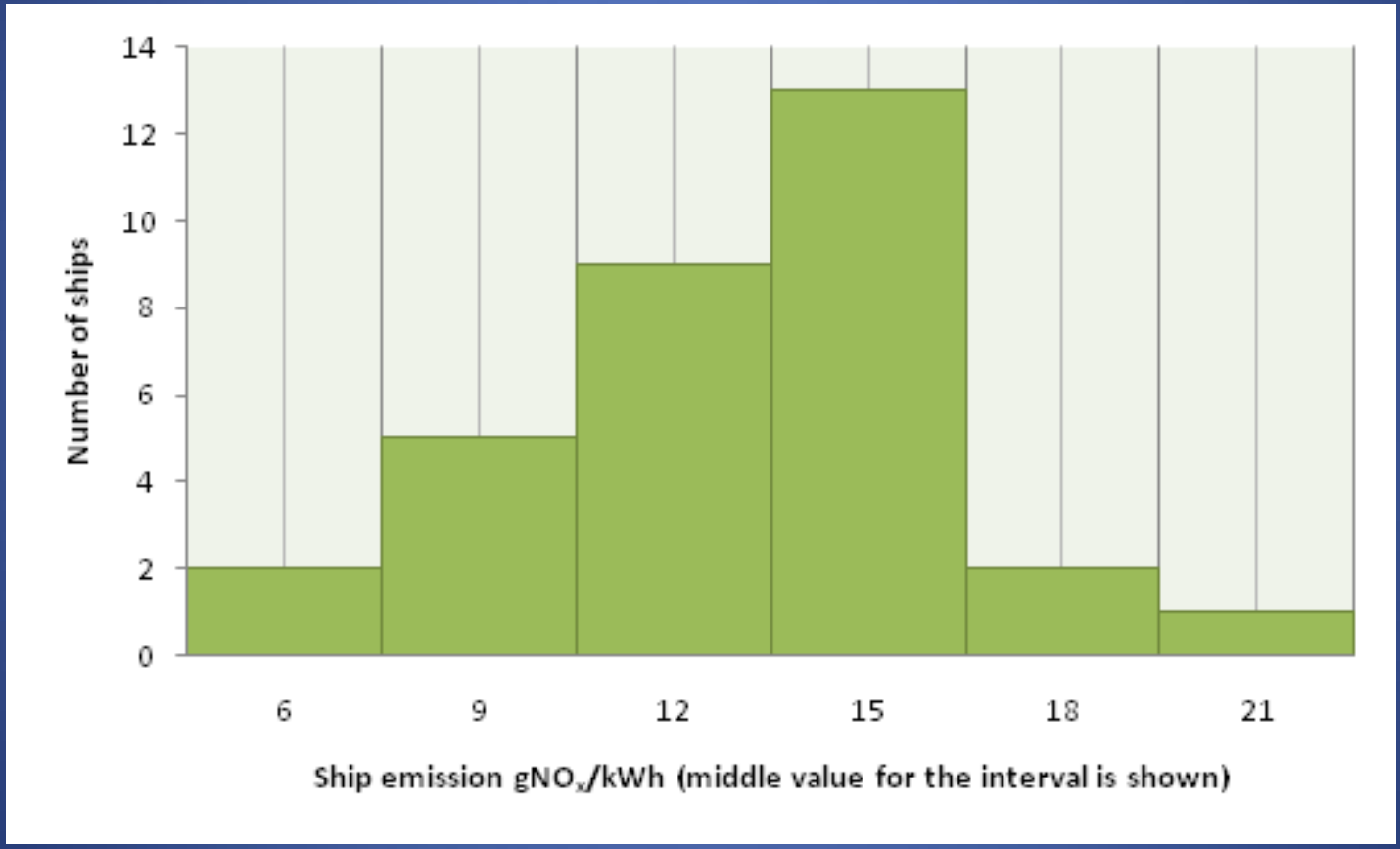


$S_{fuel}\ \% = SO_2/CO_2 * Mass\_sulfur/Mass\_carbon * C\_content = SO_2/CO_2 * 2.32$

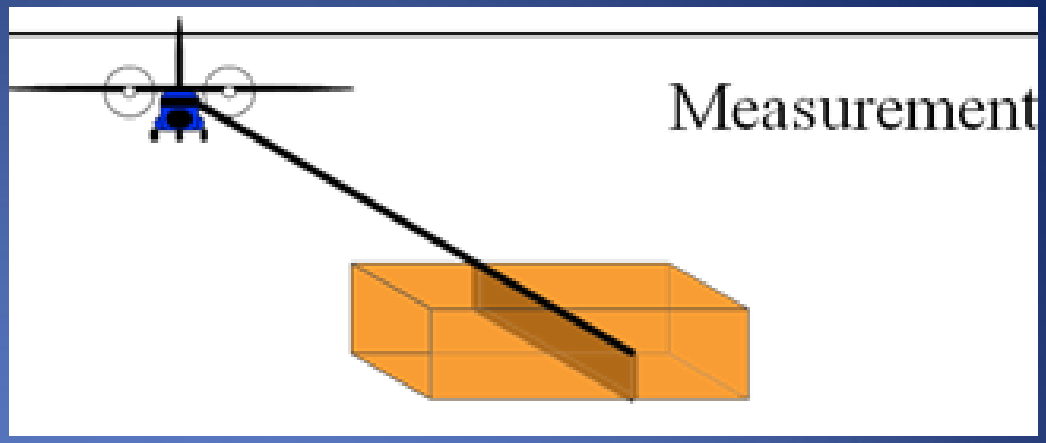
S% in ship fuel obtained from measurements in the Baltic sea 2008

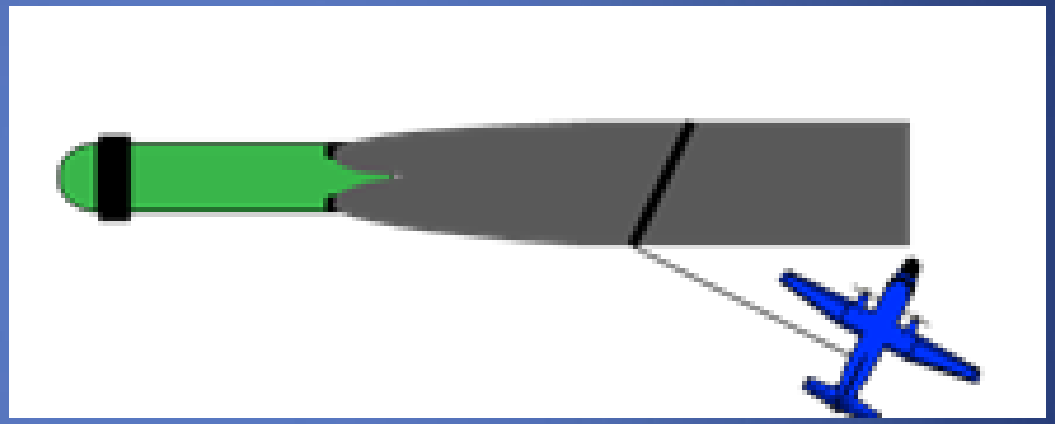


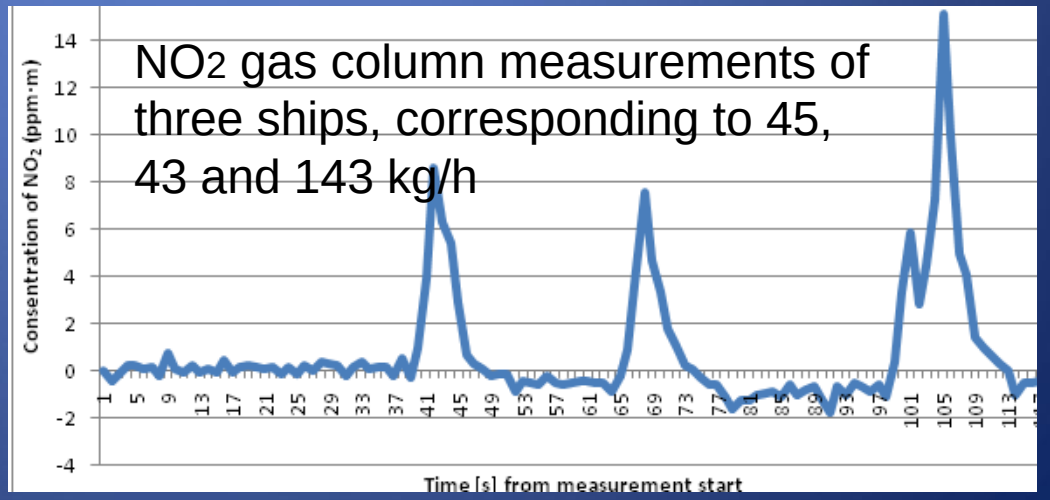
NO_x from ships obtained with airborne sniffer measurements in the Baltic sea 2008



Optical measurements to obtain the gasflux in kg/s



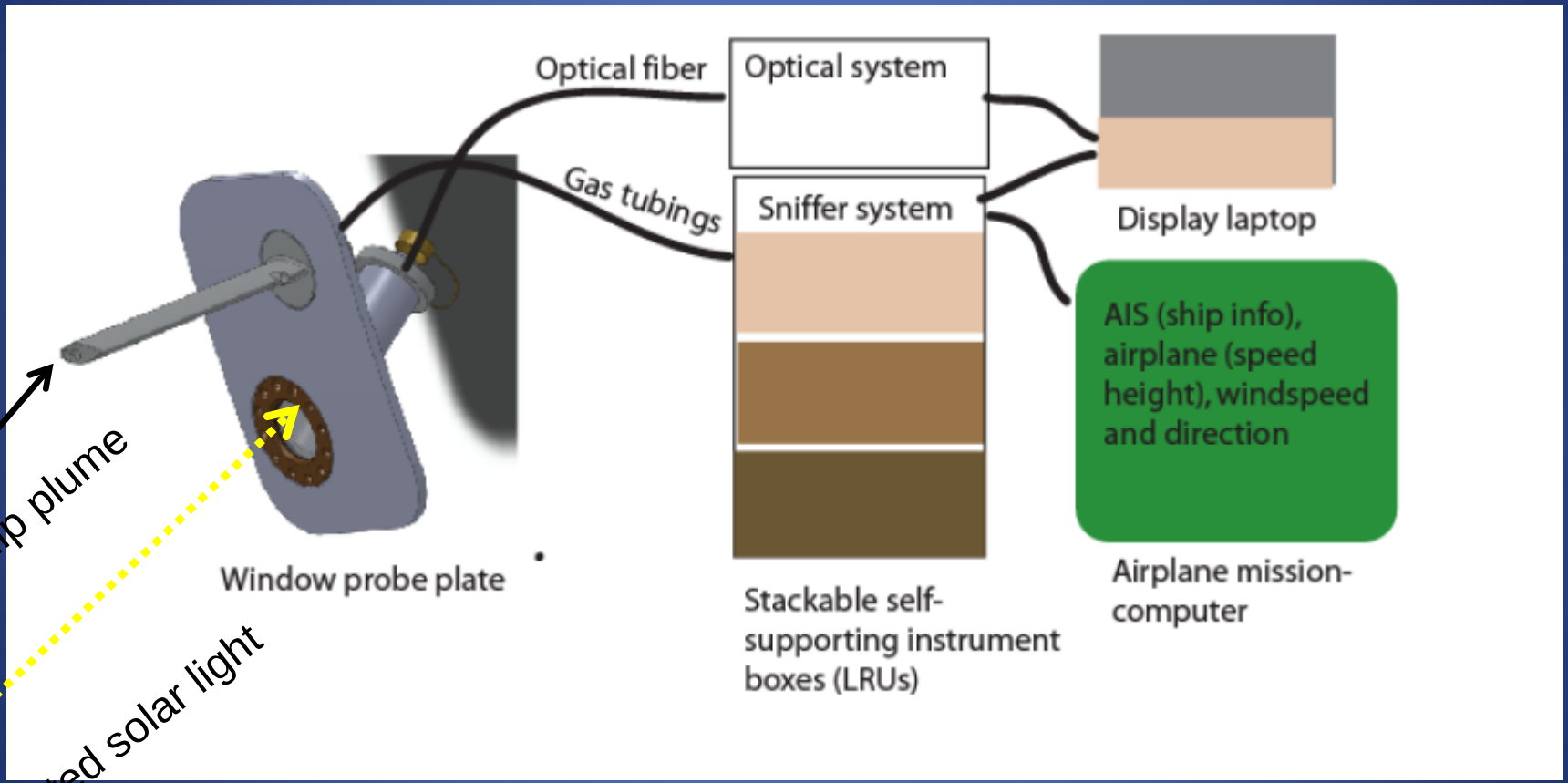




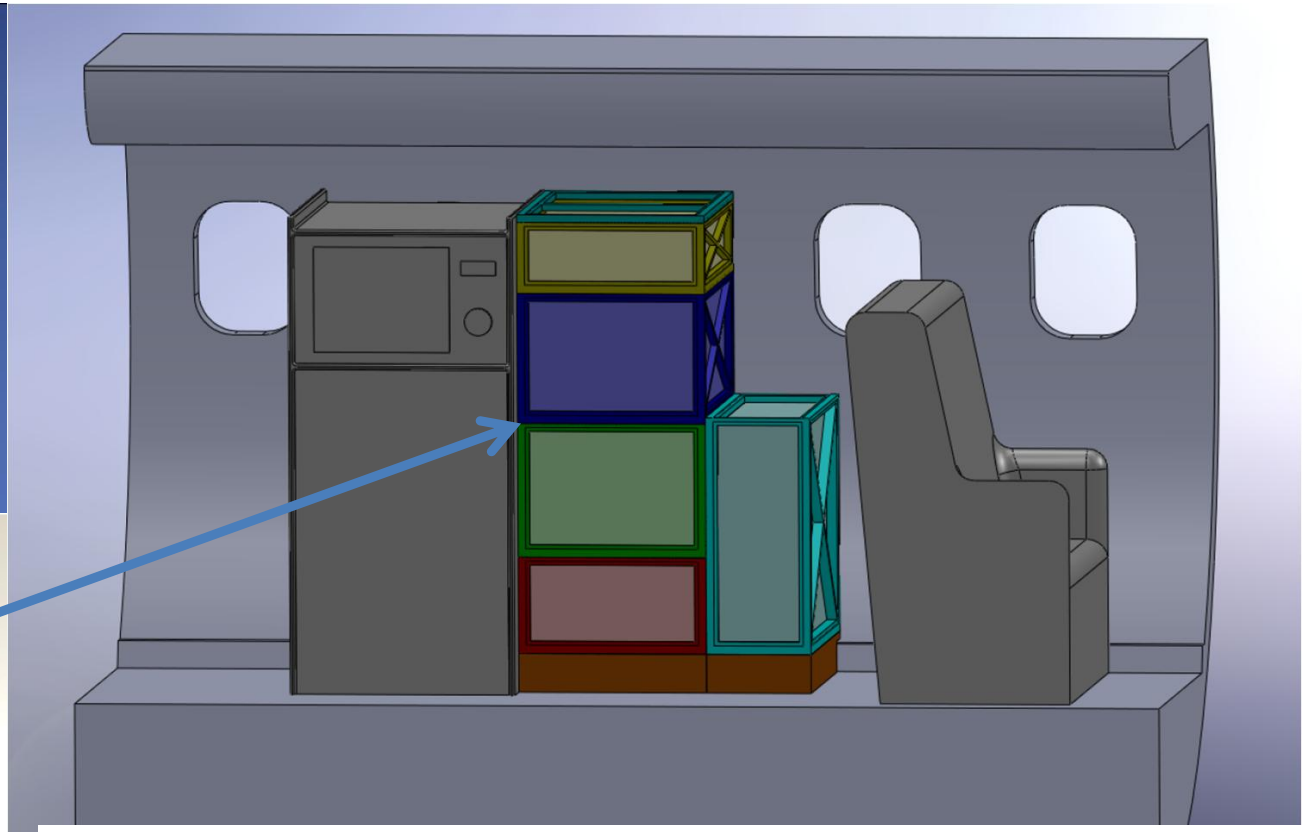
IGPS plius (2009-2012)

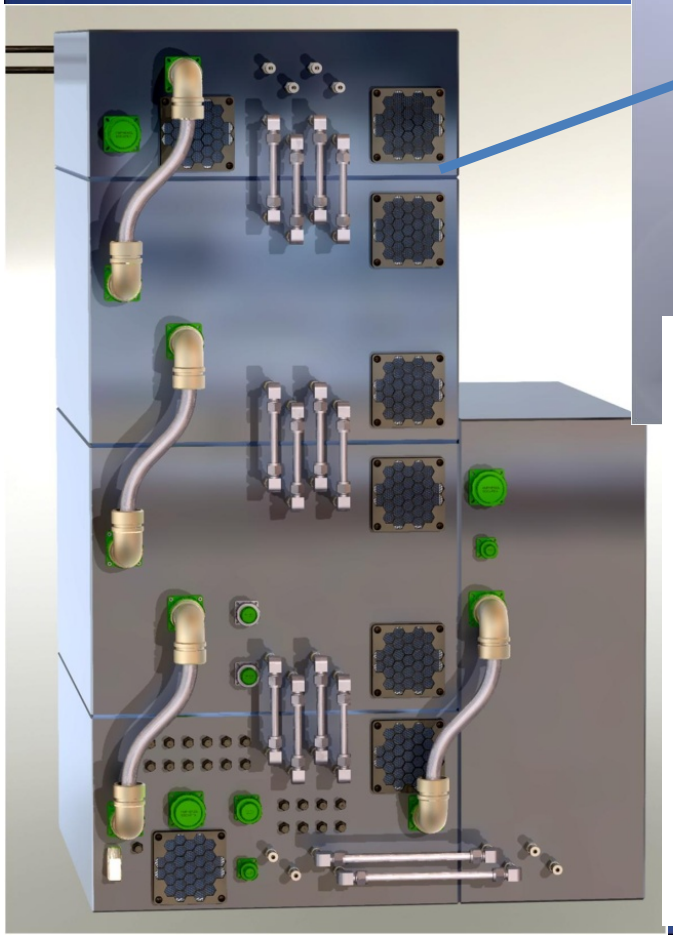
- Implement a permanent automatic measurement system, for fluegas measurements in the DASH 8-300 airplanes of the Swedish coast guard, 2011.
- Implement a system for automatic operation at a stationary measurement station, in 2010.
- Control the shiptraffick along the coasts of Sweden and put ship data will in a database. (Put ambient measurements into IAGOS database)
- Continue to develop and quality assure the technique (*IAGOS*)
- Promote the technique internationally, implement on other coast guard airplanes (*IAGOS*).
- (Work for a continuation of the project after 2012)

Overview of system



The IGPS system in the cabin of the DASH 8-300 from SCG





Instrument denotation	Measured species	Measurement range	Precision	Response time
Thermo Scientific 43i-TLE	SO_2	0 – 1,000 ppb	< 1 ppb	< 2s
Thermo Scientific 42i-TL	NO_x	0 – 1,000 ppb	< 1 ppb	< 2s
Picarro/ LGR/LICOR (pending)	CO_2 CH_4 H_2O	300 – 700 ppm 300 – 2,600 ppm 0 – 2.5%	< 100 ppbv < 1 ppbv < 100 ppmv	< 1 s < 1 s N/A
Andor SR-163 with Detector Newton DU920N	SO_2	N/A*	N/A*	N/A*
PCASP (pending)	Aerosol number/size	0.1-10 µm		