Danmarks Tekniske Universitet

DTU Skylab
- where it begins

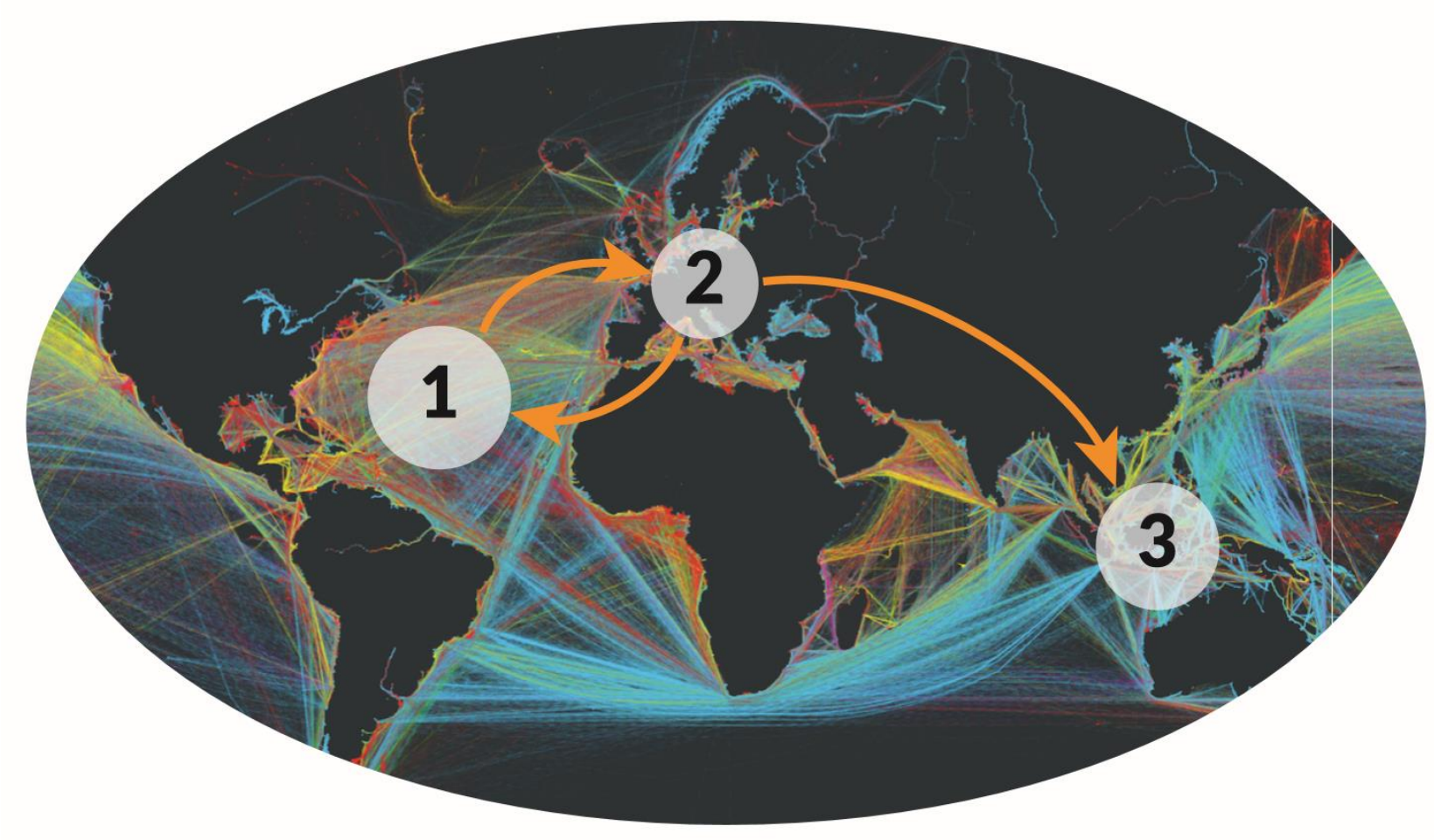
SOx Emissions Innovation Challenge

Three elements for an even playingfield

- Hannelore, Jens, Lina & Rasmus

Agenda

- Overview
- The Three Elements
  1. Measuring SOx
  2. Data Analysis
  3. Soot Sample
- Next Steps



Who we are

Jens Moll

Mathematical Modelling

DTU Compute

Hannelore Peeters

Environmental Technology

KULeuven Bioscience engineering

Lina Christensen

Naval Architecture

DTU Mechanical Engineering

Rasmus Korslund

Engineering Design and Applied Mechanics

DTU Mechanical Engineering

Bunker fuel

- Lubrication and bunker fuel tells about sulphur content
- Requires cooperation and monitoring in all ports

Storage and combustion on-board

- Tamperproof solution
- Hard to do spot check at high seas
- Traces left in the engine and stack

Emission in high seas

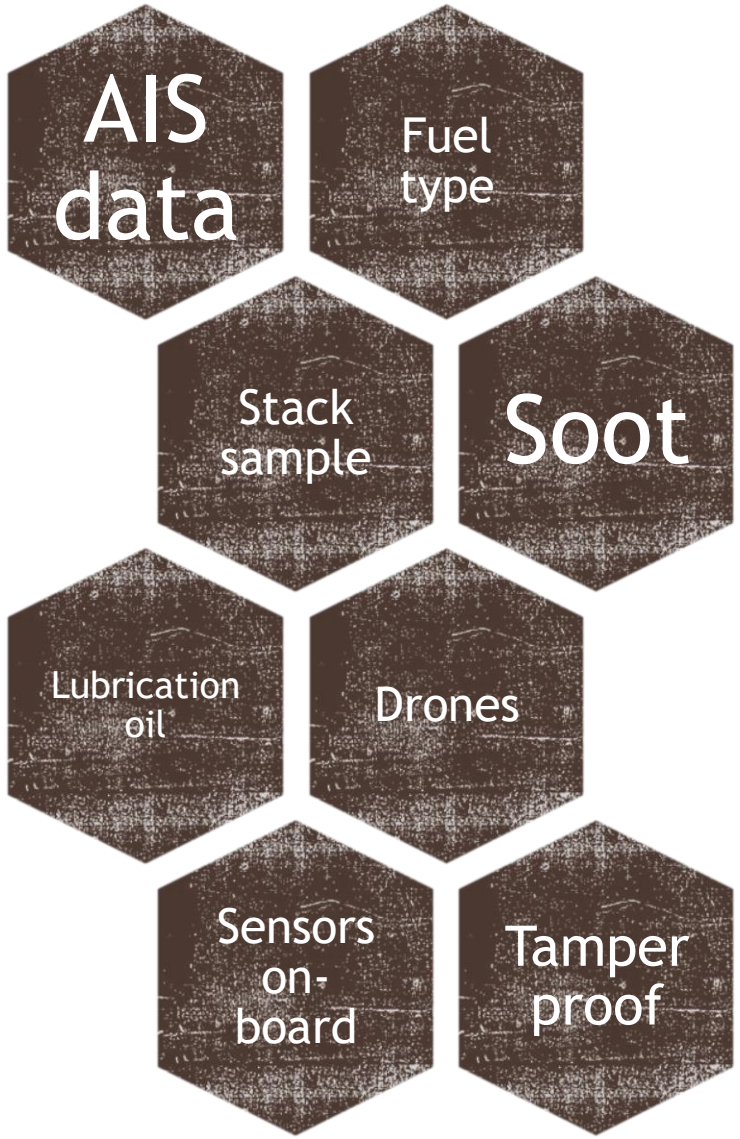
- Monitor directly in high seas
- International waters.
- Regulation concerned with emission not fuel type.

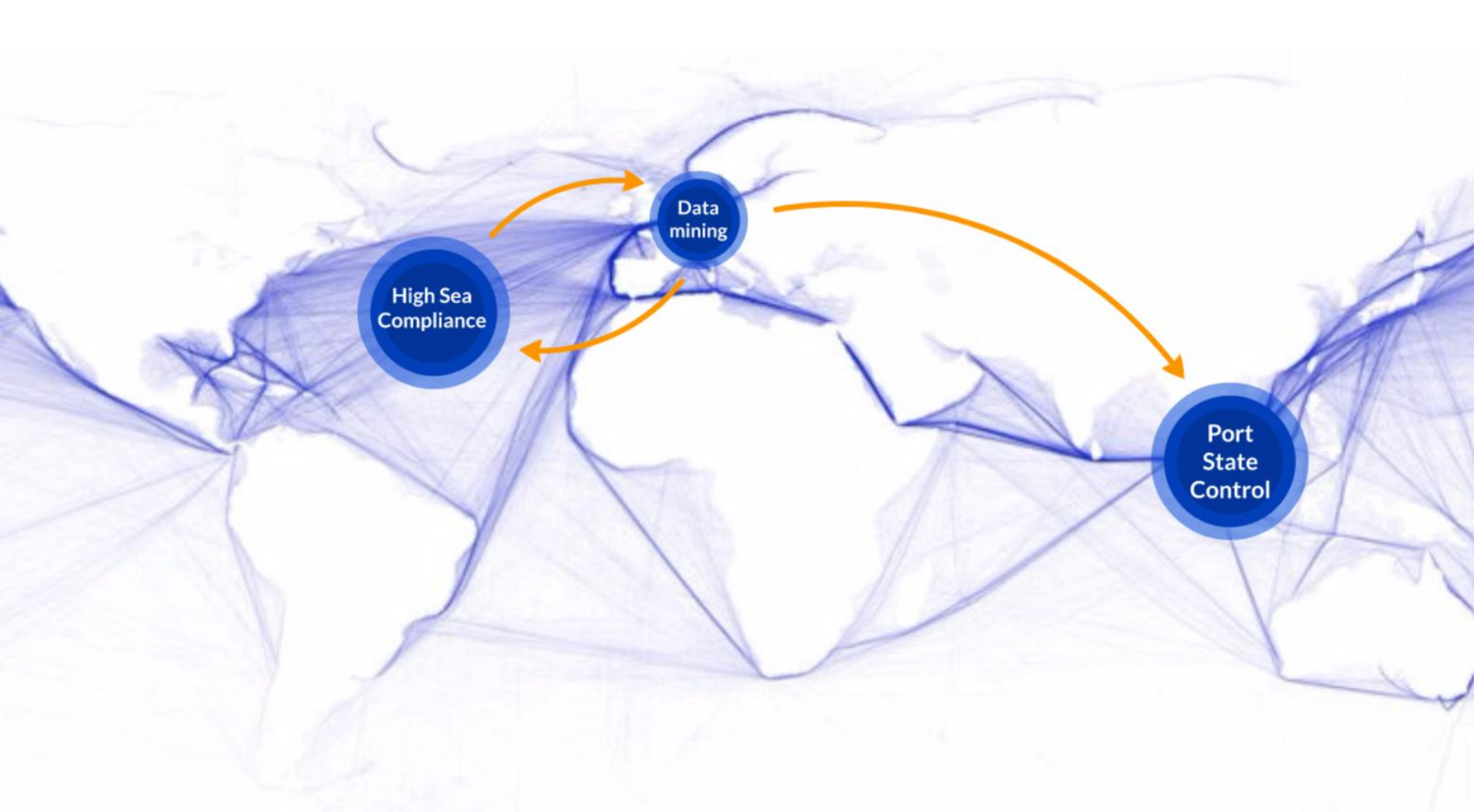
Combine elements enough to get a functional solution

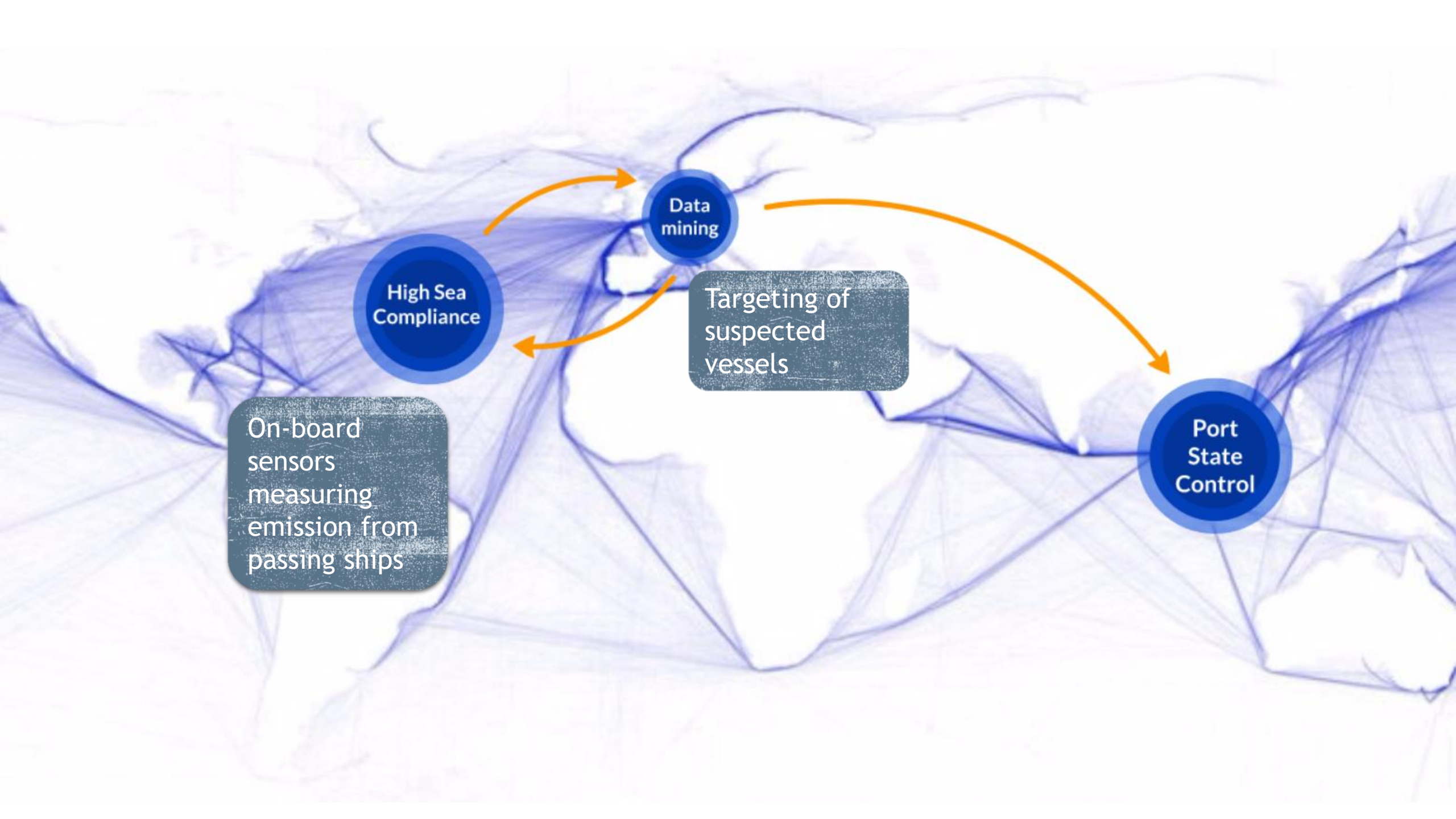
Make solution tamper proof OR remove incentive to tamper with it

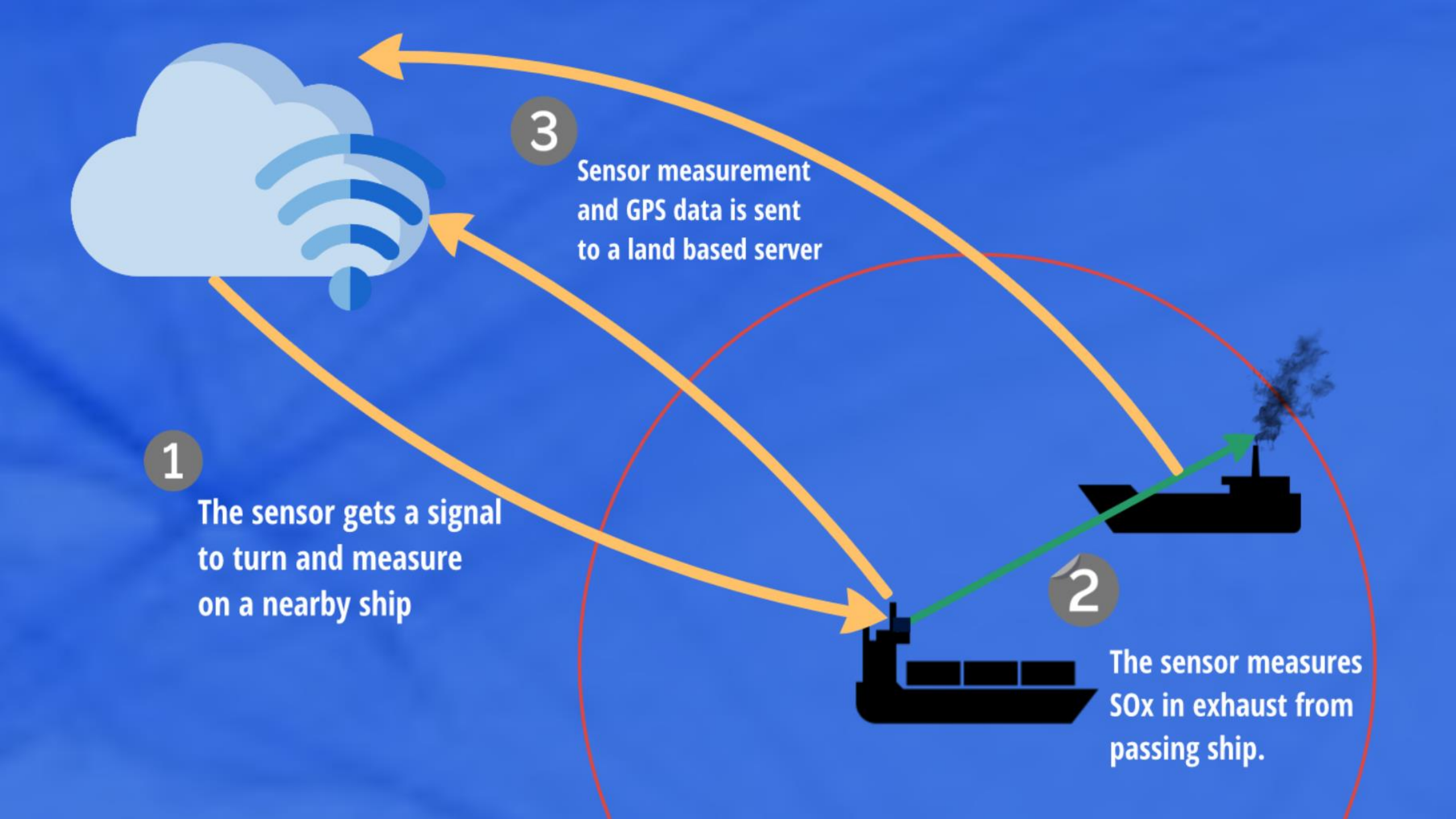
Solution should be applicable world wide and work in high seas

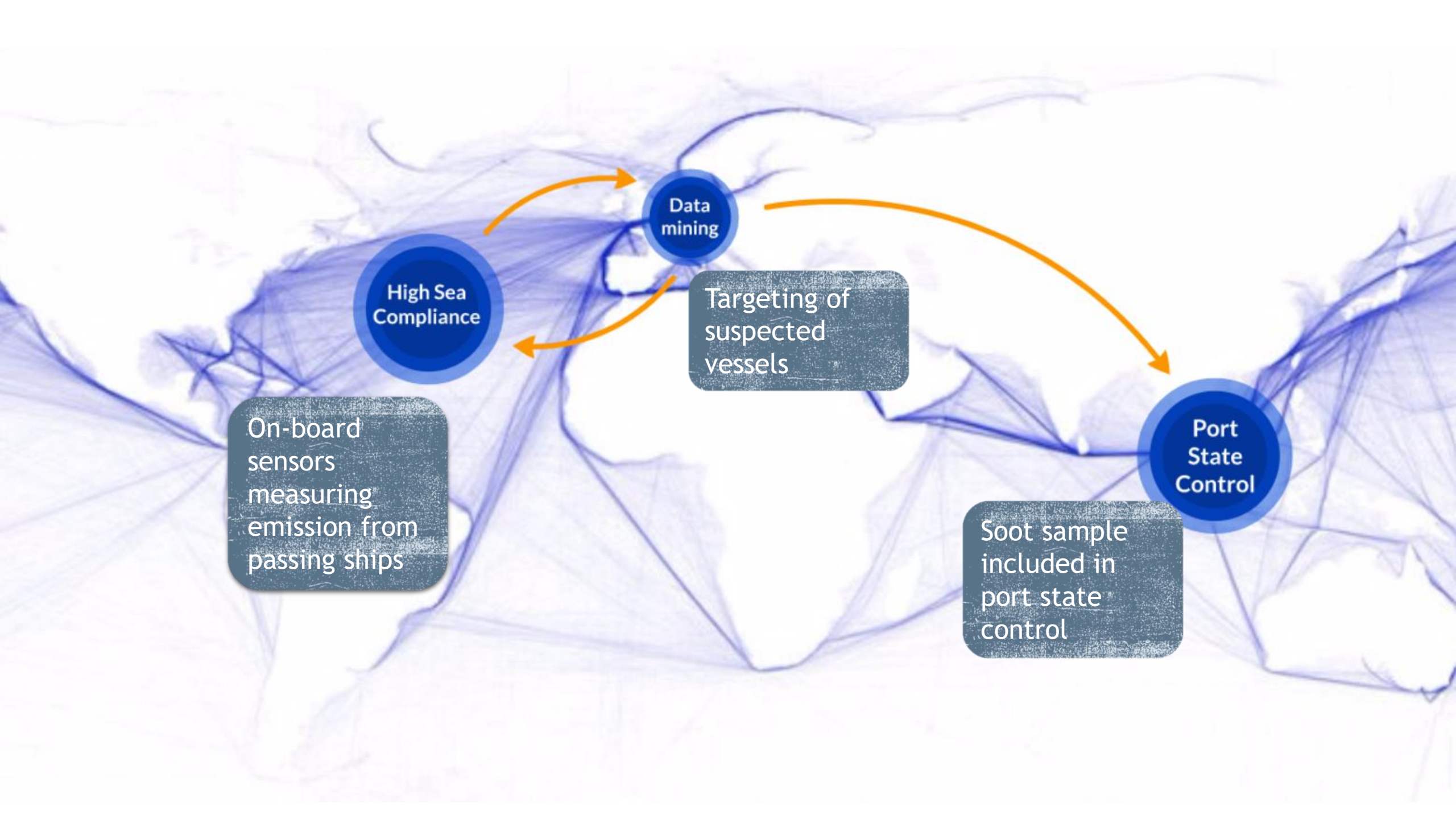
Limiting cost




Data mining
High Sea Compliance
Port State Control


Data mining
High Sea Compliance
Targeting of suspected vessels
On-board sensors measuring emission from passing ships
Port State Control


3
Sensor measurement and GPS data is sent to a land based server
1
The sensor gets a signal to turn and measure on a nearby ship
2
The sensor measures SOx in exhaust from passing ship.


Data mining
High Sea Compliance
Port State Control
Targeting of suspected vessels
On-board sensors measuring emission from passing ships
Soot sample included in port state control

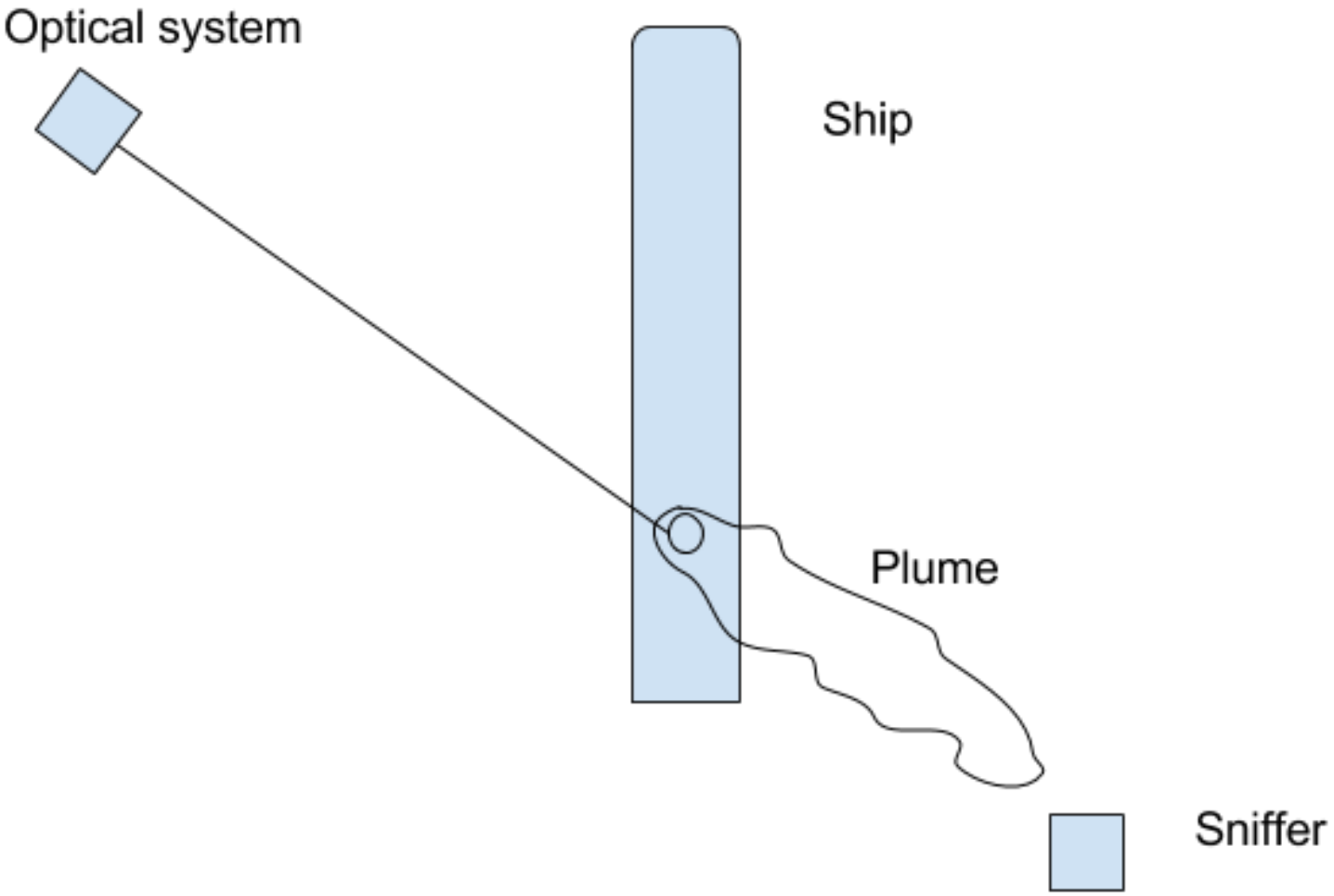
Key points

- Solution is a combination of known technologies
- Designed to gradually narrow down the pool of vessels that should be investigated for non compliance
- Little incentive to tamper with the solution
  - Counter productive
  - Difficult due to multiple measurements

Measuring SOx

Measuring SOx

- Difference between Optical sensors and Sniffing systems



Current optical systems

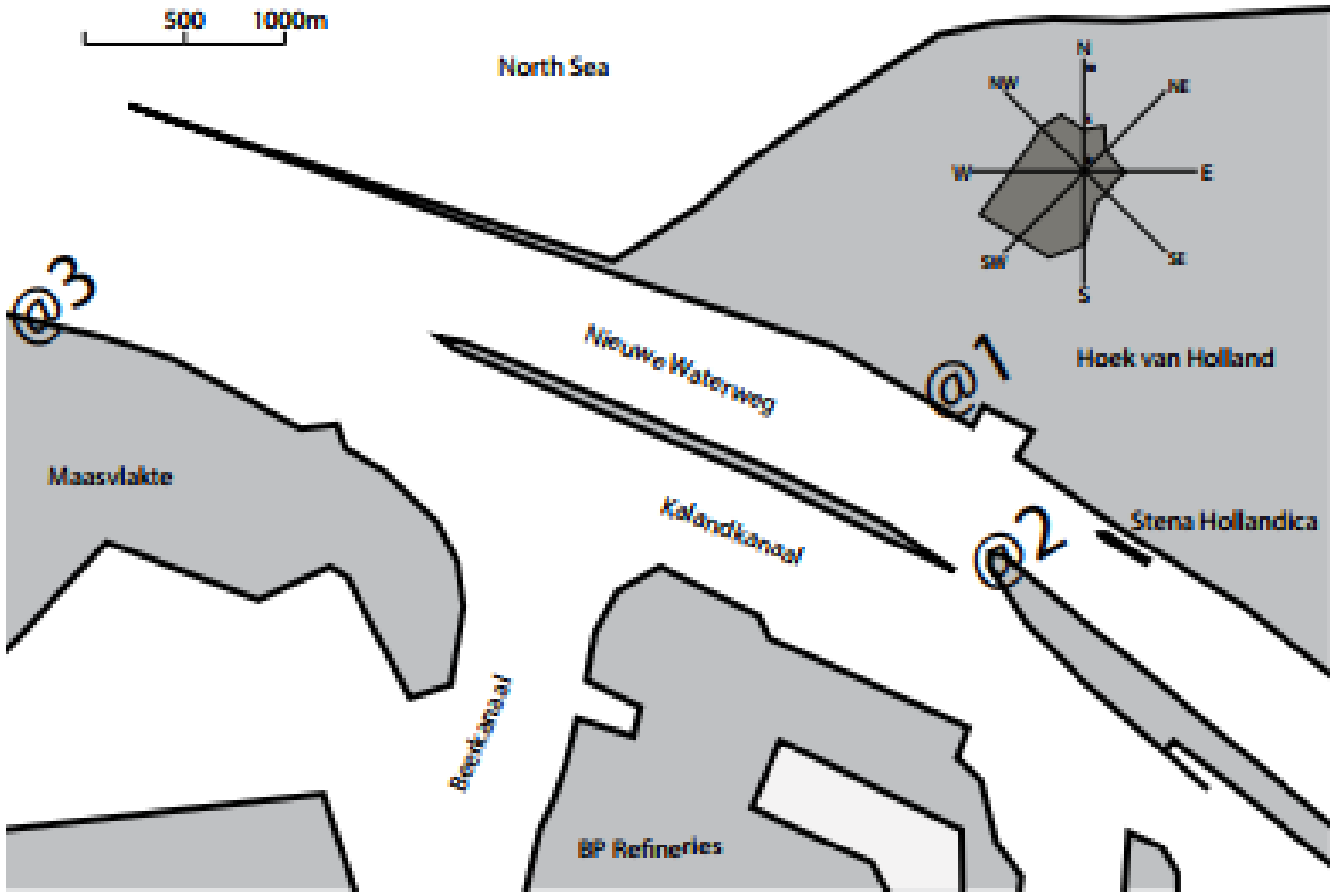
- DOAS
  - Spectrometer either mounted on ship or helicopter
  - When based on ship it looks ”up” at the plume
- LIDAR
  - Two laser pulses with different wavelength.
  - One is absorbed by the plume
- UV-CAM
  - Photosensors, with a focus on UV (280-320 nm) can estimate SOx

Current projects

- Great Belt Bridge

Current projects

- Great Belt Bridge
- Port of Rotterdam



Current projects

- Great Belt Bridge
- Port of Rotterdam
- Göteborg

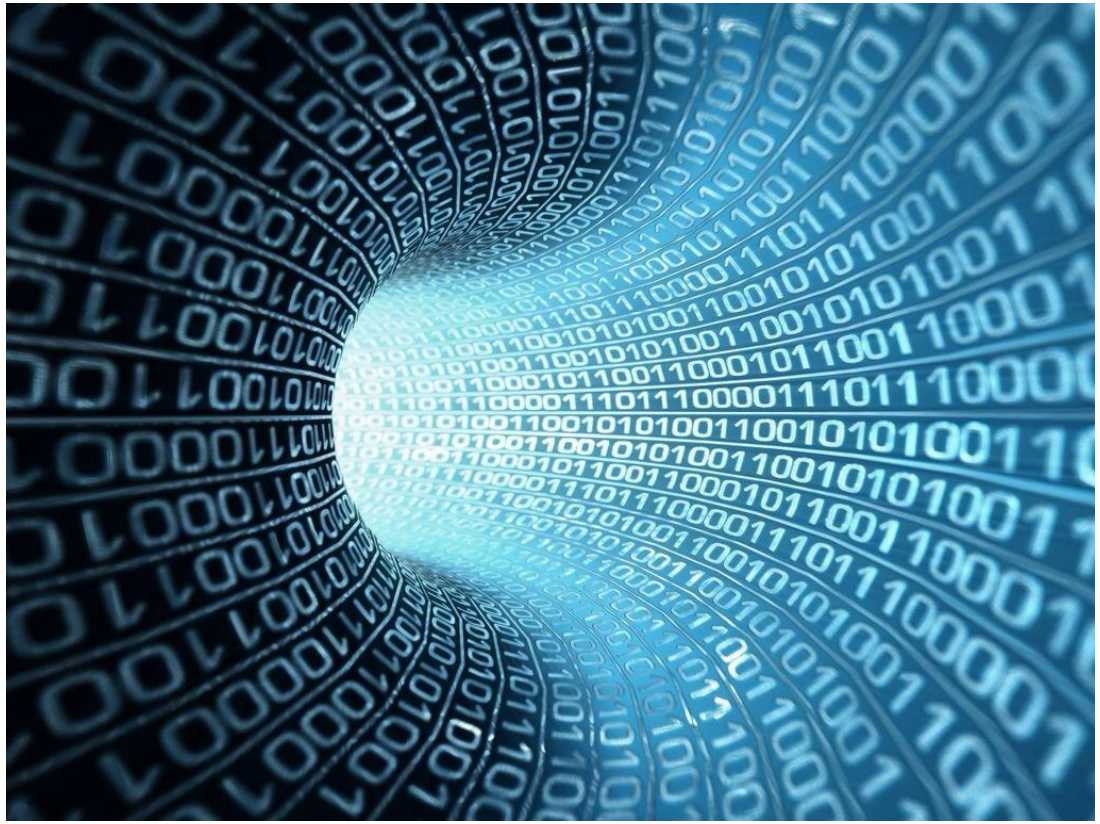
Challenges

- Range
- Accuracy (Optical systems = Absolute SOx, not relative to air)
- Stabilization

Data Analysis

Data Analysis

- Measuring SOx
  - Accuracy not essential, but of course beneficial
- Identify non-compliant vessels



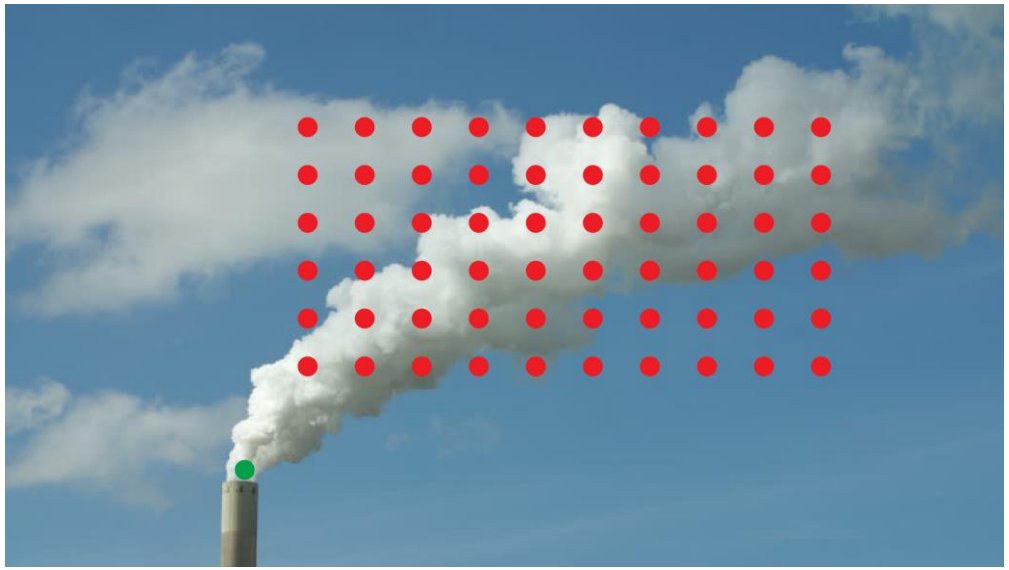
Laser Measurements

Pros

- Speed
- Range

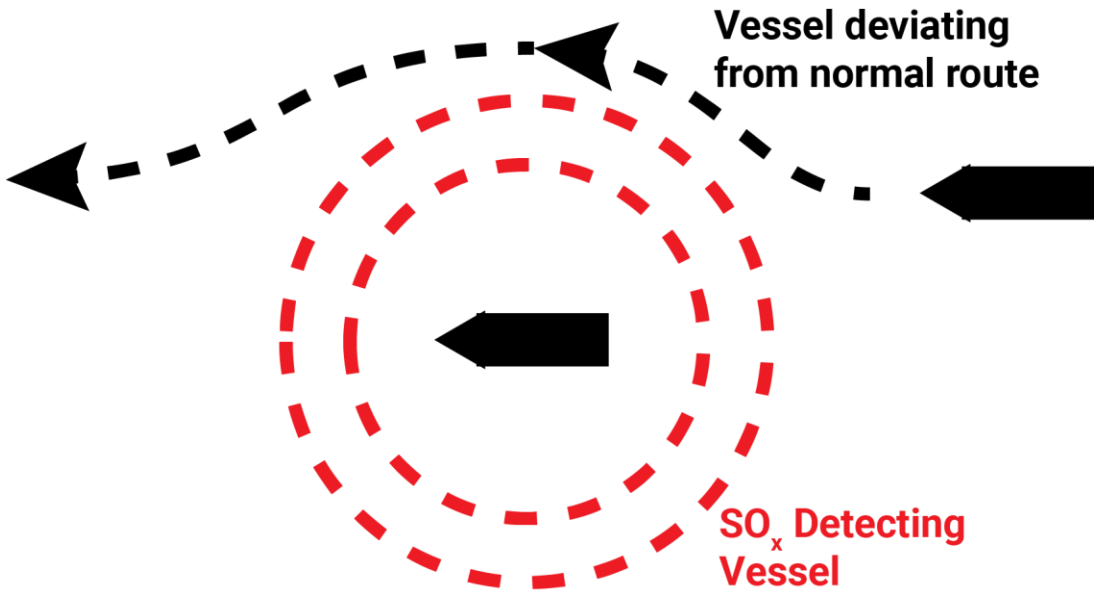
Cons

- Only measures SOx



Which Vessels to Target

1. High SOx Emissions
2. Undetected Vessels
3. Detection Avoidance



Targeted Port Control

Targeted Port Control

- Specific: non-compliant and suspicious ships
- Extention of port control:
  - Soot sample from stack
  - Heat resistant sampler
  - Chemical analysis

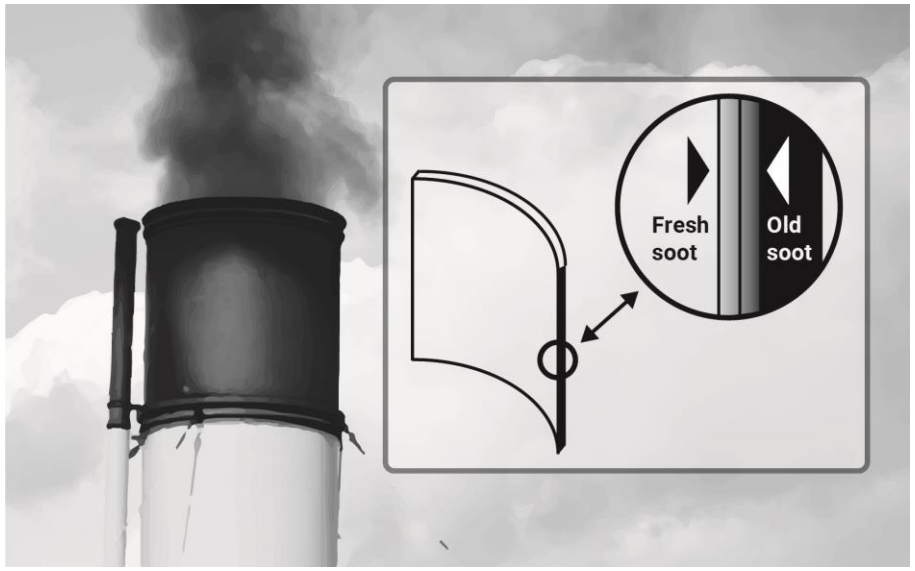
Soot

- SOx in exhaust gas deposits on PM
- PM deposits in stack

  Relationship SO_2 concentration/adsorption: OK

⇨ Relationship soot deposition: ?

  Back calculation: ?



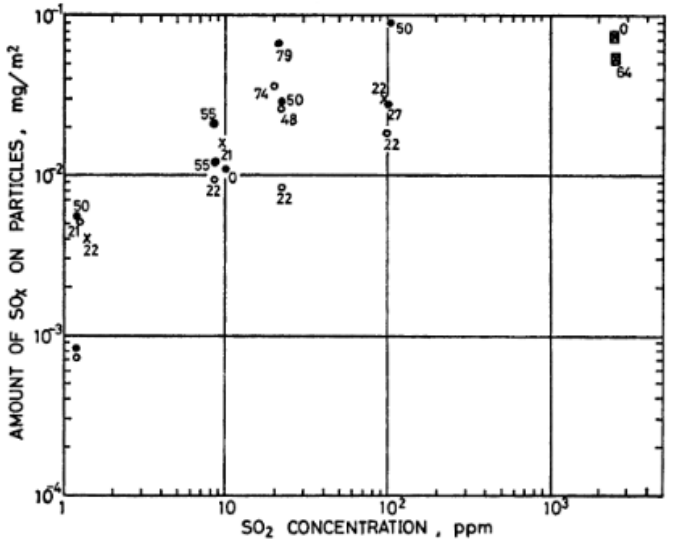


Fig. 6 SO_X adsorption as a function of SO_2 concentration
○; coal combustion fly ash, ●; coal combustion soot,
×; oil combustion fly ash, ⊗; Liberti et al.,
⊠; Tartarrelli et al.
The number presents relative humidity

(Murao et al.,1983)

Sampling

- Heat resistant sampler

  ~ Vulcano sampler

⇨ No need to stop engine

  + : Time and money saving

Analysing

- Standard oil/fuel analyser ?

  e.g. SpectrOil®, MiniLab® (Spectro Scientific)

  + : portable, in situ analysis

  fast

  - : solid (soot) vs fluid (oil)

- Lab analysis - spectroscopy

  e.g.: ICP-MS, IR, ….

  + : established methods

  - : slower

Portable oil analysis kit (Spectro Scientific)

ICP-MS (Analytical West, Inc.)

Conclusions & Prospect

Cost Guestimate

One-time costs

- Laser: 50,000 DKK
- Stabilisation: 50,000 DKK
- Installation: 50,000 DKK
- Port receiver: 20,000 DKK

Total cost of equipping entire Maersk

Line fleet of 605 vessels and 343 ports:

98 mio DKK

Annual cost

- Maintenance: ?
- Data center: ?

What is next?

- Assess viability
  - Passing distance and frequency
  - Estimate SOx contents without CO_2 measurements
- Develop soot test
- Partner up!
  - Ports
  - Insurance
  - Tech

Thank you, questions?