Atmosphere Control International

TPG

ANALOX Military Systems

Holistic Atmosphere Management System (HAMS)

Outline

Existing atmosphere control (Manual)
Future atmosphere control (HAMS)
Factors to consider
Available technology
- Analox Atmosphere analyser
- ACI Electrolyser O2 generator, CO2 scrubber

Challenges to integration
Development route map
Next steps

Existing Atmosphere Control

4 hour maintenance

H2 dump

Water → Electrolyser → Oxygen

Multi-gas Atmosphere Analyser

Manual adjust

Interaction

CO2 → Scrubber → CO2 dump

Other gases → Burner → water, CO2 + contaminants

Atmosphere control equipment

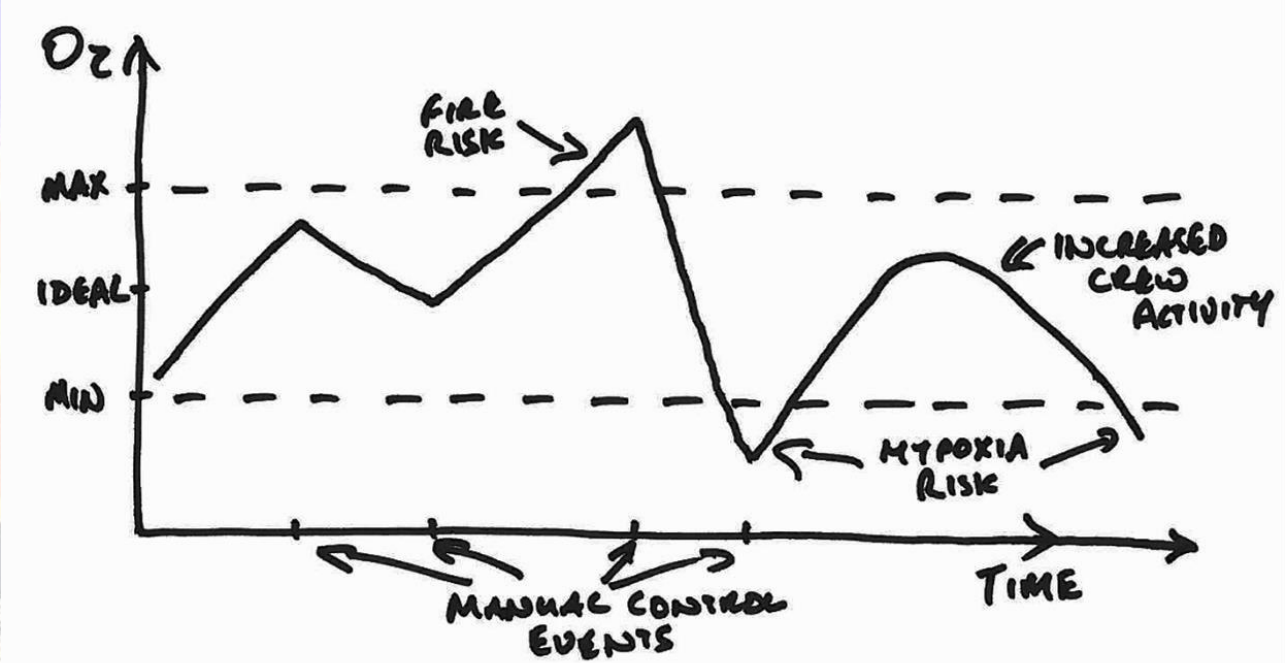
Available technology

ACI oxygen generation and carbon dioxide removal equipment plus

- Oxygen control - measurement used by a control algorithm to regulate oxygen generation so that the level is maintained at a setpoint
- Electrolyser
- Carbon Dioxide scrubber - Active warning, to ensure the carbon dioxide production matches the oxygen generation.
- Carbon Dioxide purity measurement to protect life of gas management system and warn users to take remedial actions. Possibly requires measurement of specific impurities (e.g. freon refrigerants etc.)

Problems with existing approach

- Control is not continuous
  - relies on regular manual checks
  - System can compound problems during emergencies if crew unavailable to adjust.
  - Boat compromised if it goes wrong.
- Requires highly trained personnel to manage
  - They are the predictive algorithm



Factors to consider

Critical factors which may impact on automated control include;

- volume of the boat (timing of O2 generation)
- number of crew (breathing oxygen & producing carbon dioxide)
- adequate mixing of air on boat
- location of control sensors - what's a 'representative' sample & where to draw it from.

Potential to use average readings from Submarine Atmosphere Analyser and compare these to the local O2 & CO2 safety sensors on control system in the event they disagree wildly - use O2 & CO2 safety sensors, to ensure enriched O2 atmosphere does not pose a fire risk

- Activity levels - can these be adequately predicted? Do they need to be predicted if there is good plant availability?

Need to know when the automated system is going out of limits & manual control is required? Red, amber, green based reporting system.

- If have multiple sensors & a voting system - warning if it goes to vote
- warning if disagree with main submarine atmosphere monitoring system
- Requirements for monitoring - O2 partial pressure levels for life support (183 - 223mbar) / 18-22%

HAMS what will it look like?

Daily maintenance

H2 dump

Water → Electrolyser → Oxygen

Multi-gas Atmosphere Analyser → Control algorithm

Interaction

Safety CO2 sensor

CO2 → Scrubber → CO2 dump

Safety O2 sensor

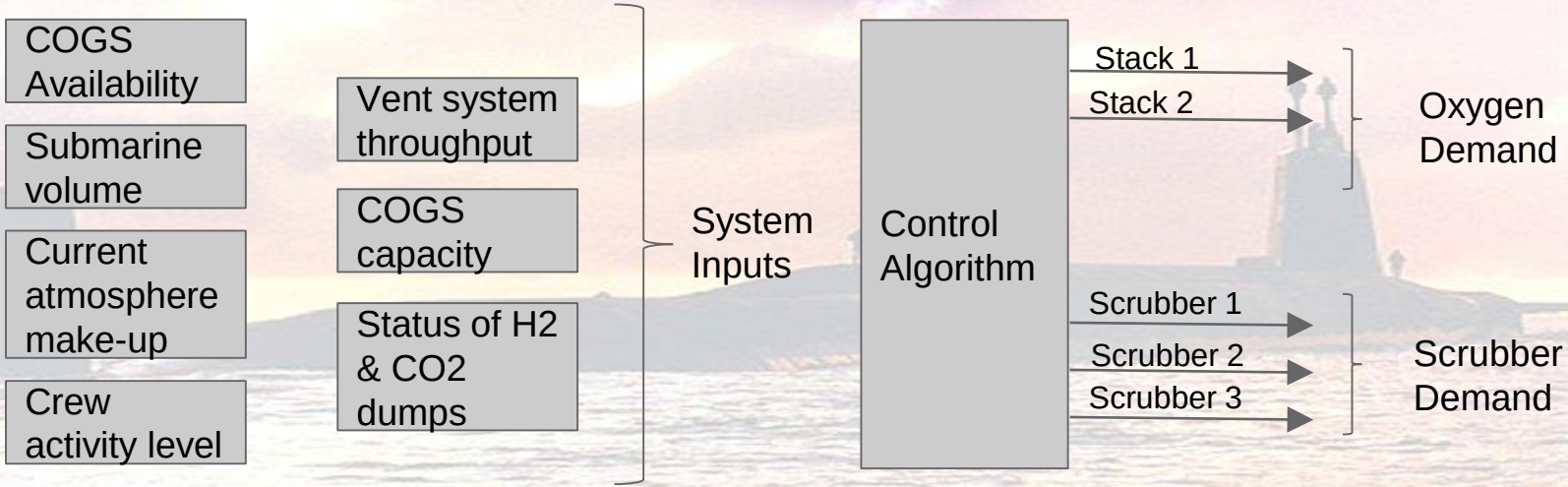
Other gases → Burner → water, CO2 & contaminants

Process automation

The automatic control proposed can be considered to be a process.

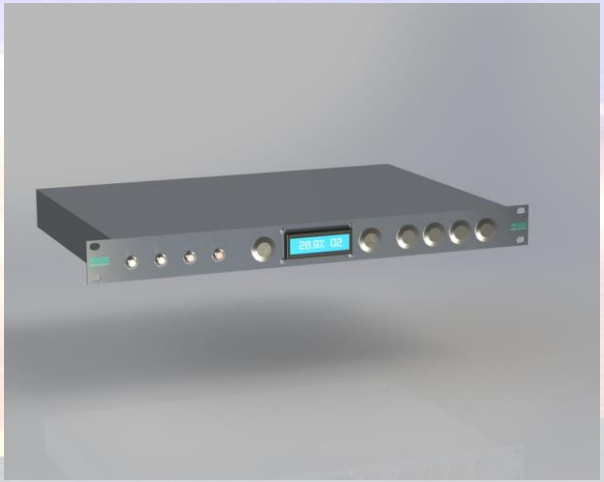
Similar process automation is common in the chemical industry and commercial diving.

The automation needs to be customised to the application and environment.



Atmosphere monitoring equipment

Atmosphere Analyser
> 20 gases analysed
- Configurable alarms



SIL O_2 analyser
- High %VOLO_2 alarm
- Low ppO_2 alarm

SIL CO_2 analyser
- High ppCO_2 alarm
- Low ppO_2 alarm

Safety case

O2 generation is highly safety critical, an automated control system will require a safety case.

Caveat: The safety case will be dependent on the nature of the boat….

In our experience an automatic control system like HAMS is typically required to be at least SIL2

Advantages and limitations

Advantages:

- Reduced crew workload
- Increased system reliability
- Better control of the atmosphere
- Increased safety
- One less thing to worry about

Limitations:

- Safety case will require careful thought
- Loss of true manual control

The next steps

We’re interested in feedback and for customers to decide whether to progress to a feasibility study.