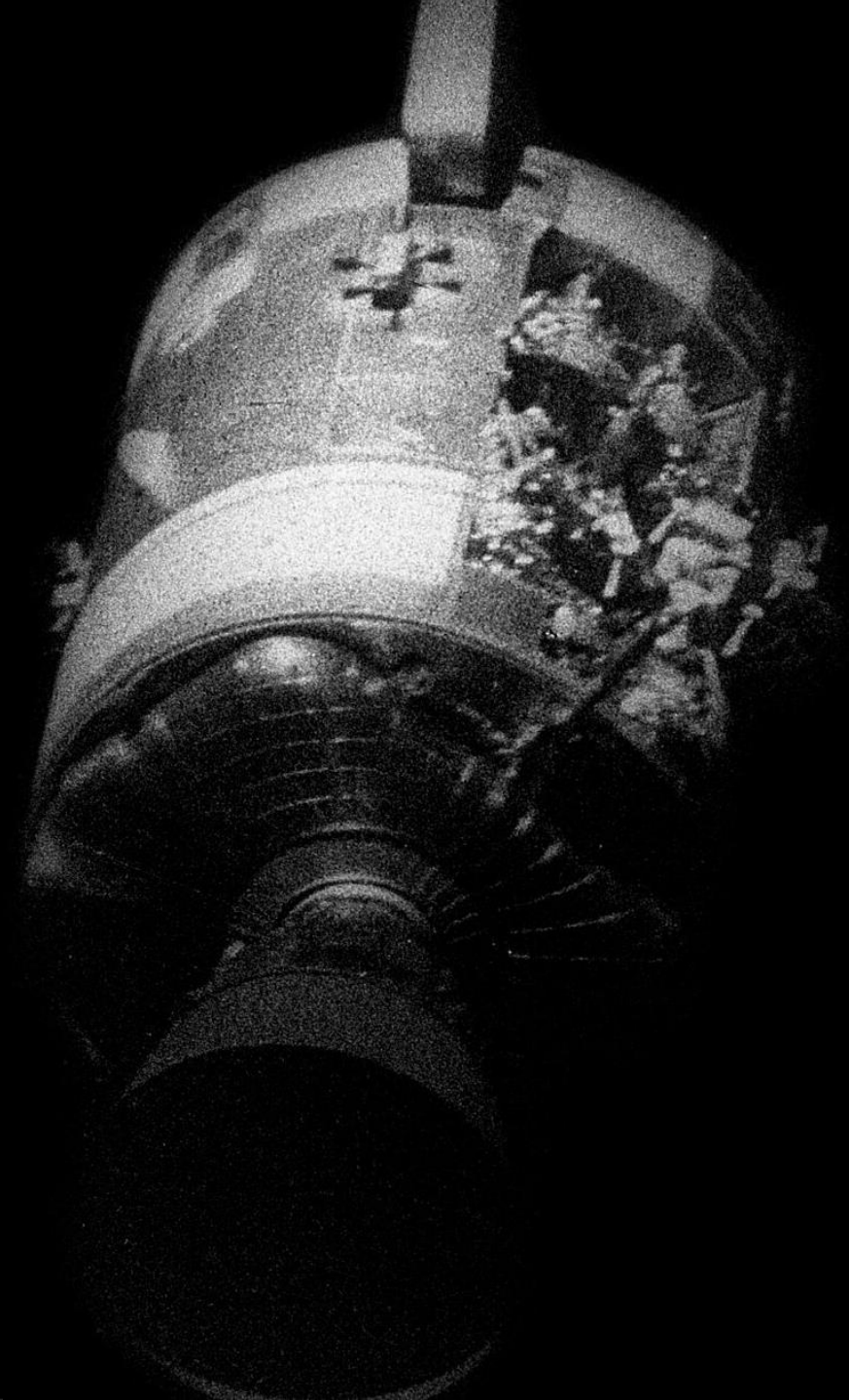
IT-Operations aspects of submarine and surface ship design

Mikael Lindberg,

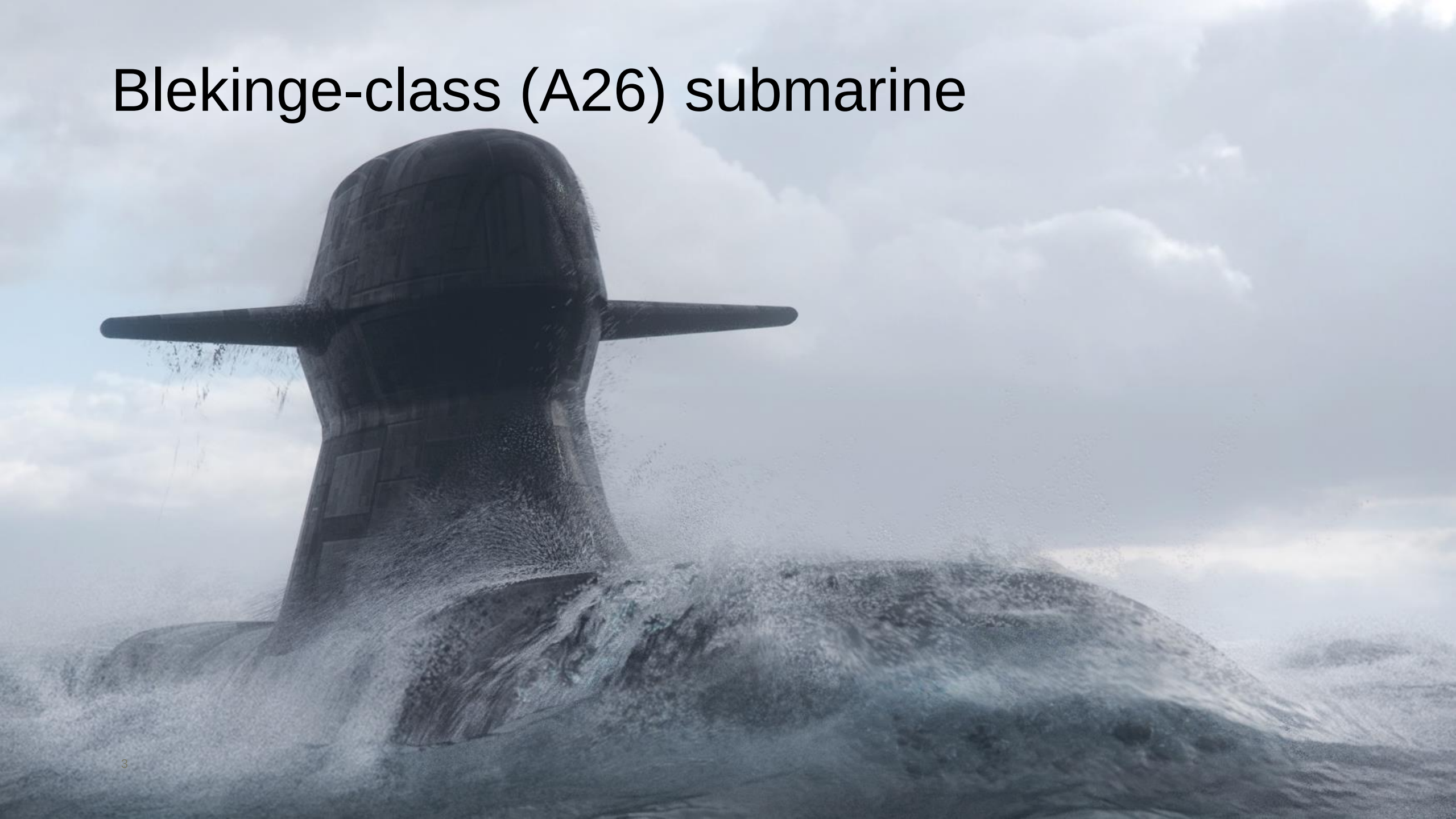
OBSITA

”Huston, we’ve had a problem.”

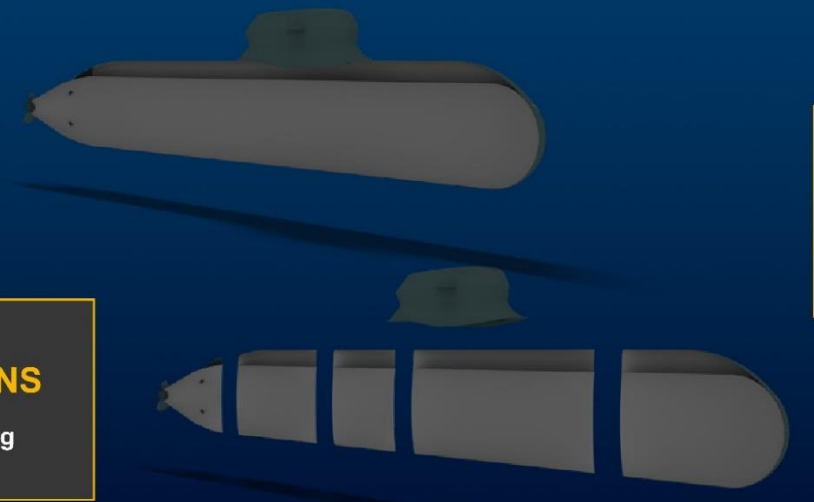
Jim Lovell, Apollo 13 mission commander

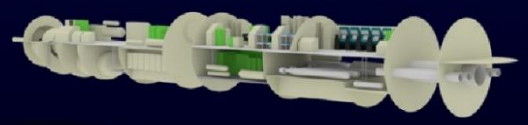


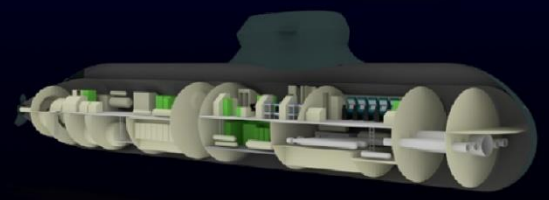
Blekinge-class (A26) submarine



The anatomy of a modern submarine







900
TONNES
High-grade Swedish steel

5 SUPER SECTIONS
For swift handling in production

2 MAIN PLATFORMS
To hold critical systems

140
SYSTEMS
For survival, performance and combat

> 400,000
COMPONENTS
Not to mention the nuts and bolts

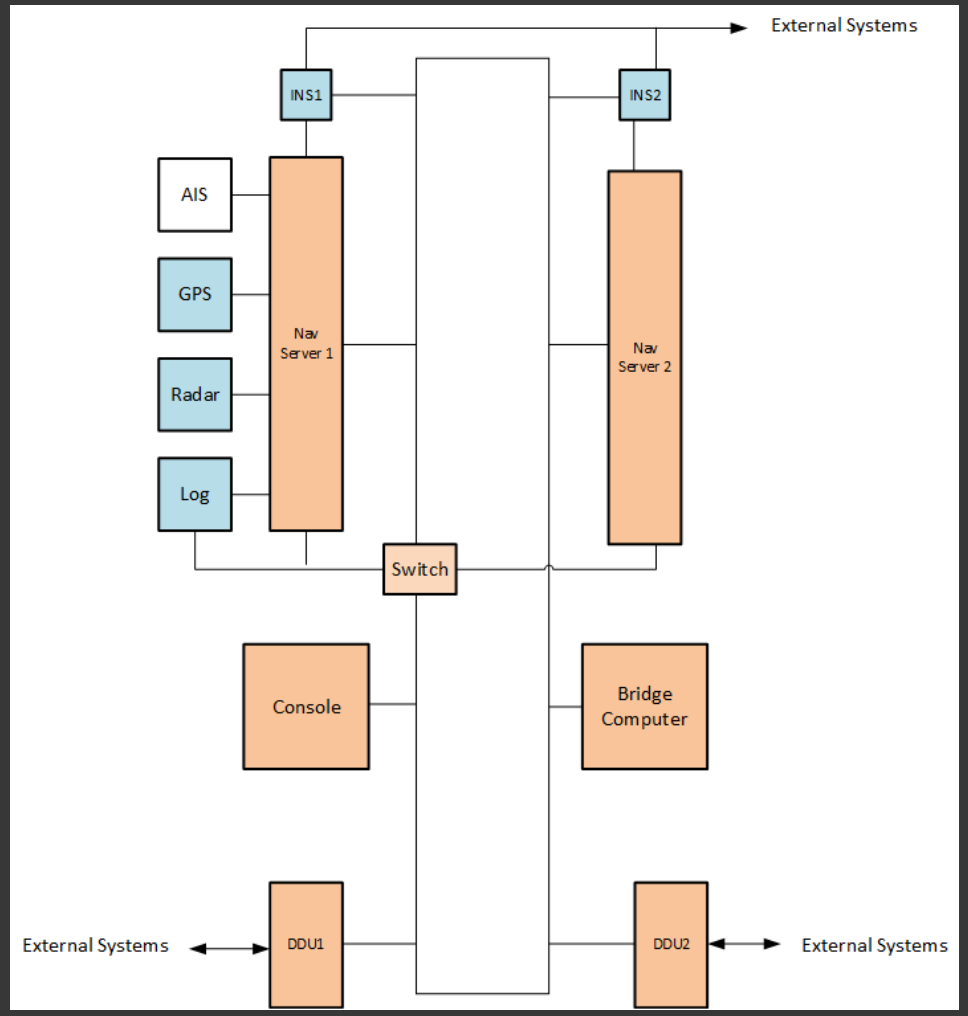
100 KM
CABLES
Communication command and power

10,000
UNIQUE PIPES
Oxygen, fuel, water sewage and more

> 25
Crew members
Living and working together for several weeks at a time.

Submarine System Operations

- **Heterogenous**
  - most systems are best of breed 3rd party
  - range from single computer embedded systems to small datacenter
- High degree of **interdependancy**
- Typically multiple **levels of redundancy**
- Small crew 2-3 technical officers
  - **limited training, limited experience**

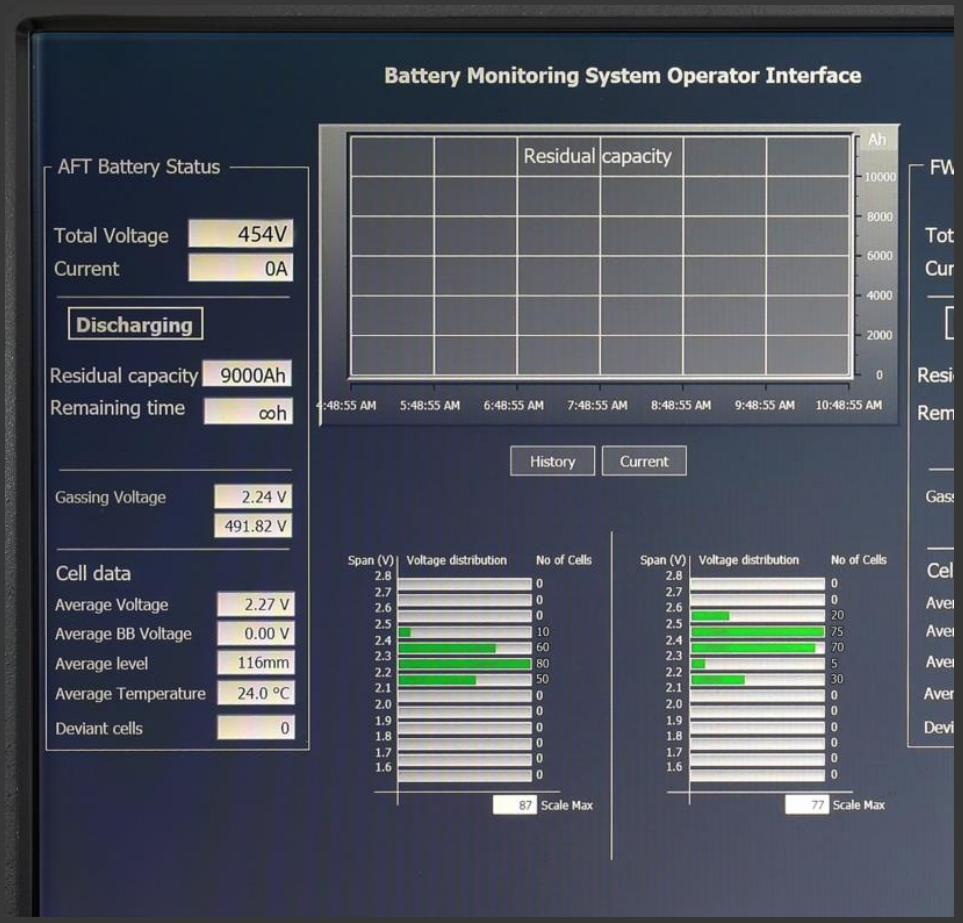


Simplified view of the NAV system

System Monitoring and Diagnostics

- Many hard lessons from Gotland-class sub and Visby-class corvette
- Towards unified monitoring and diagnostics
- System subcontractors very secretive

- Problems **very suited for machine learning** approaches
- Many ideas can be ported over from autonomy work

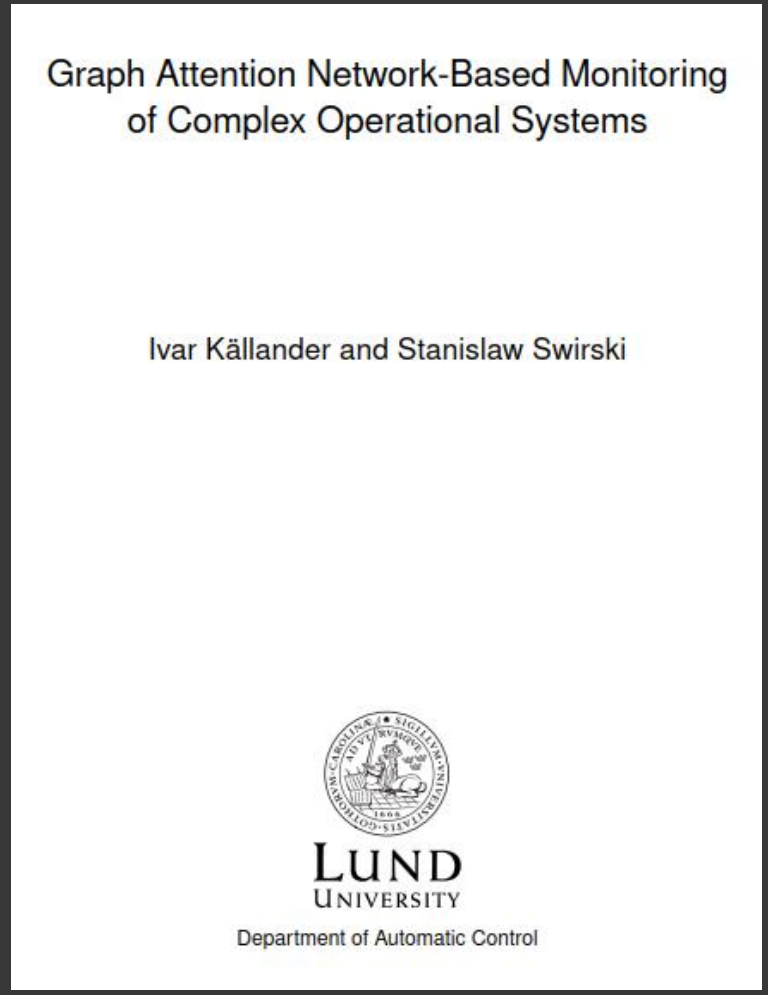


Battery monitoring system, https://nojdhselektronik.se/

SAAB TECHNOLOGIES SAAB

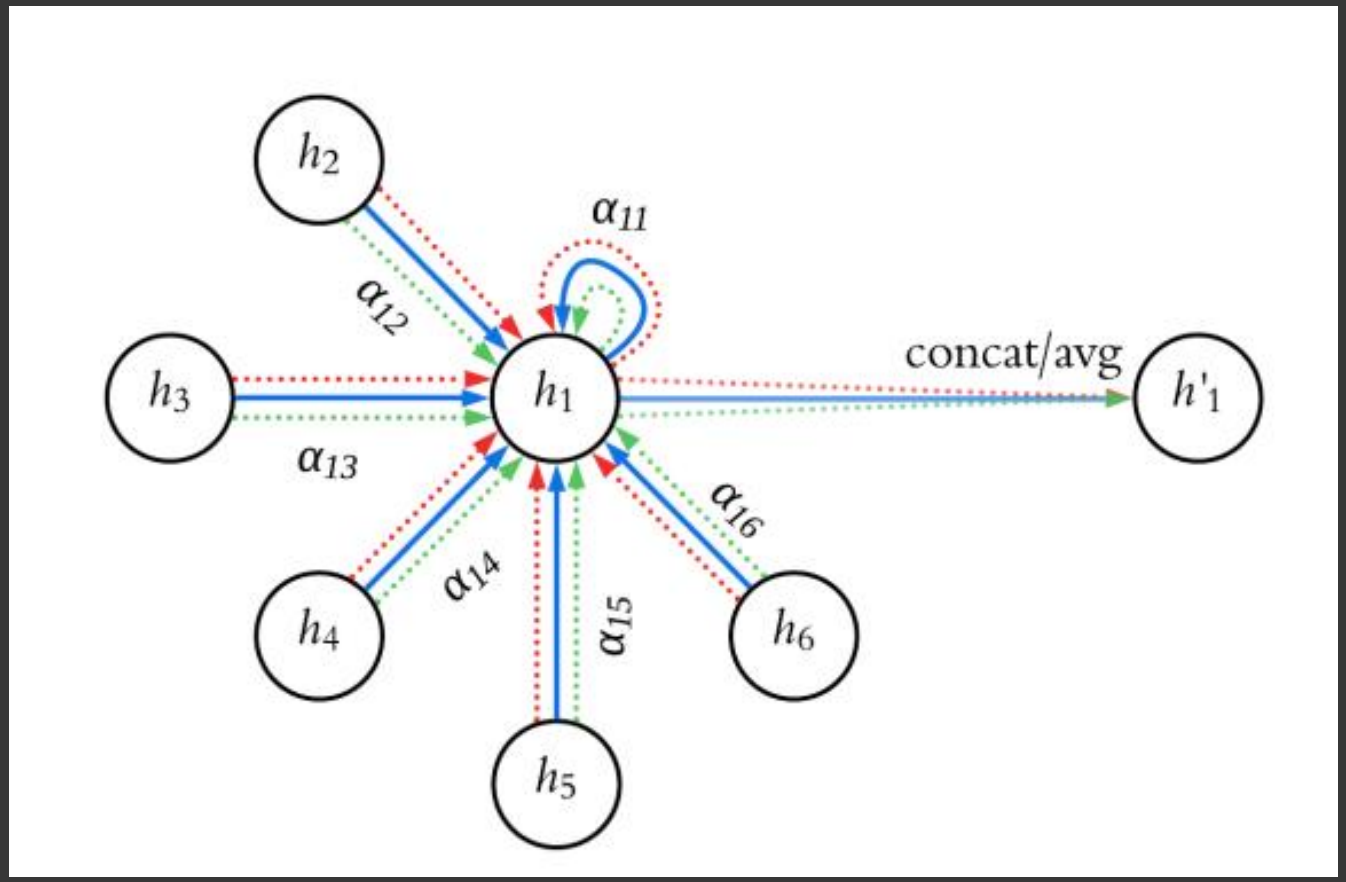
Thesis project

- **Deep learning-based anomaly detection** and classification
  - **assuming very little prior knowledge** about system
- Supported by WARA-Ops
- Work done **primarily around ship automation** system
- Data sets will be available on WARA-Ops

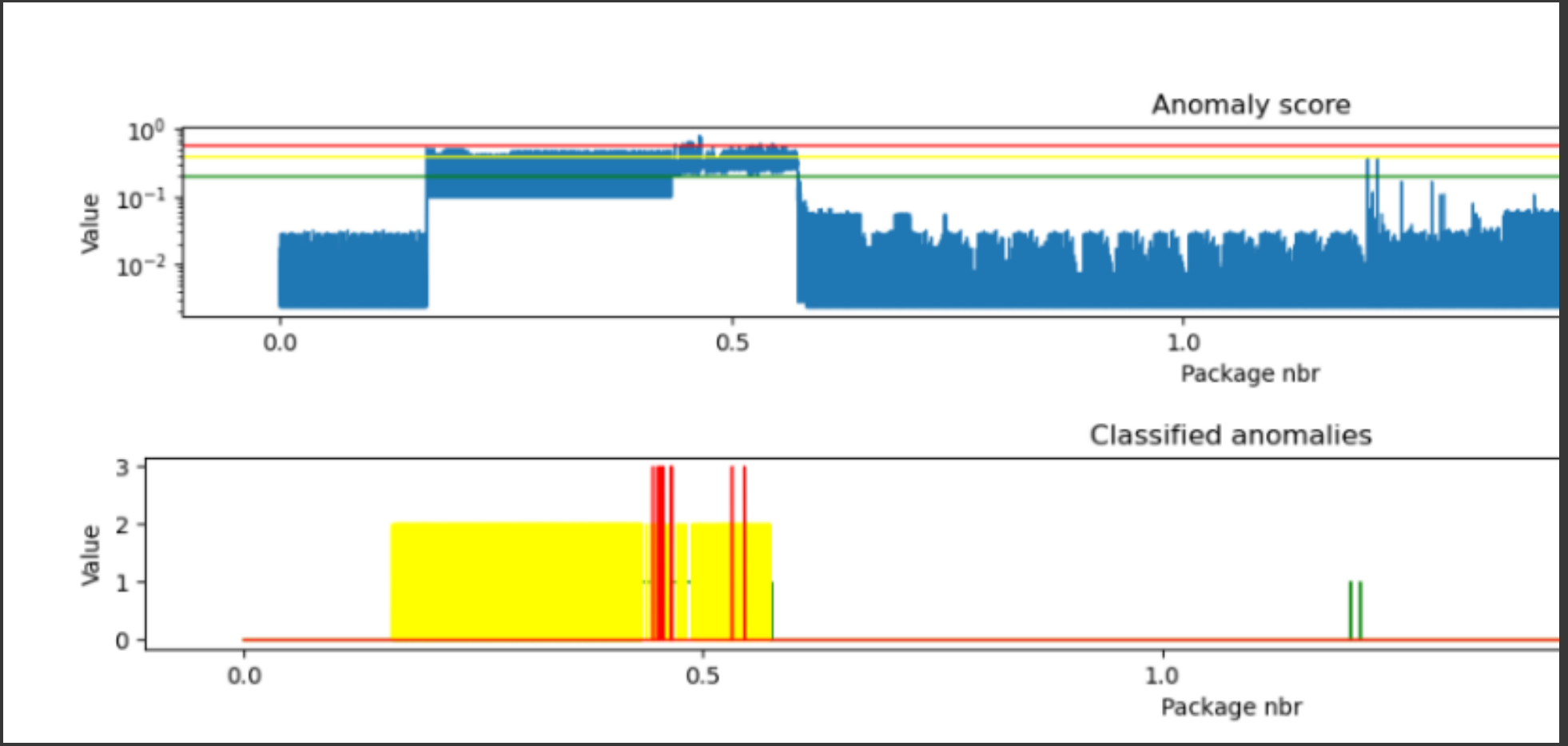


Graph Attention Networks

- Veličković, Petar, et al. "Graph attention networks." *arXiv preprint arXiv:1710.10903* (2017).
  - https://github.com/PetarV-/GAT
- Zhao, Hang, et al. "Multivariate time-series anomaly detection via graph attention network." 2020 IEEE International Conference on Data Mining (ICDM). IEEE, 2020.
  - https://github.com/ML4ITS/mtad-gat-pytorch
- The central idea is to **learn the graph structure** of the system generating the data
  - often unknown to us due to 3rd party secrecy



Thesis project (cont'd) – node death detection

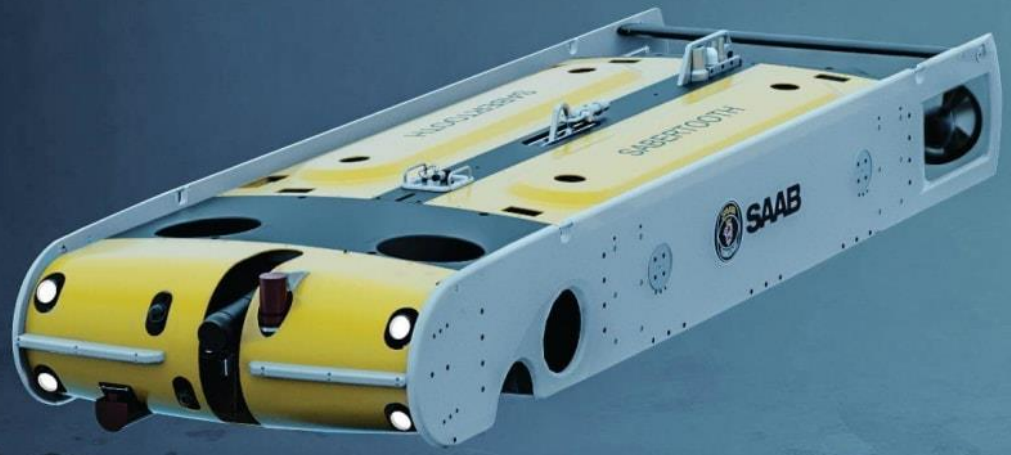


Thesis work (cont'd)

- Approach seems promising but **more and better data is needed**
- Ideas around **diagnostics never got much time**
- Other concurrent projects include
  - Alarm HMI
  - Load prediction for network segments
  - LLM-based documentation searches

Seabed operations are expanding

- Seabed installations are key for infrastructure
- Communication limitations force autonomy



Thank you!