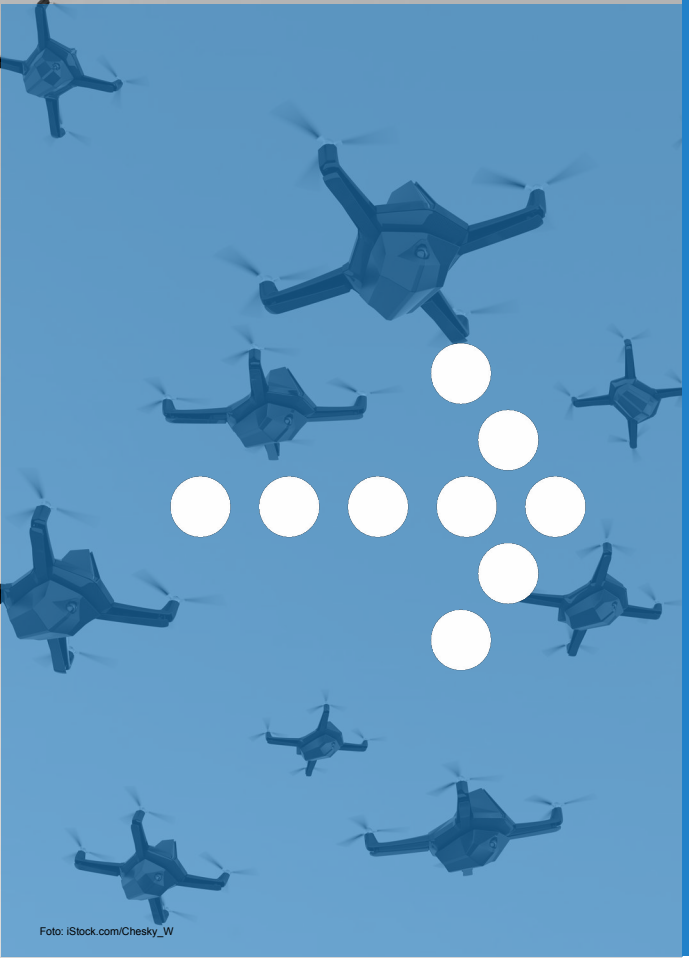
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On the challenges of research

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Challenges in research – and how to simplify

- What are the challenges to be simplified?
  - Identify the future military problem
  - Explaining the need for future knowledge to military users
  - Making scientist focus on the right problem

Why research?

- To develop new knowledge – the basis for engineering
- Curiosity driven or problem driven
- To understand why, and how, things work
- To understand the limitations, why things not work
- Research is never without a goal, but the result is often a suprise

On autonomy/automation

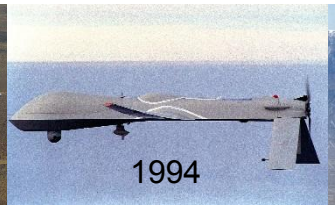
- Automation is generic from an engineering point of view but very context specific from an application point of view
  - Model the specific environment and context
- Human factors important to autonomous systems
  - The cognitive load different from using manned systems
- Operational use – identify the added value
  - Find the possible weaknesses
  - Find the workarounds

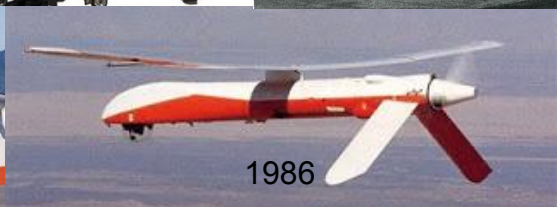
Challenges – not always trivial to foresee

- Challenges are not always where expected
  - From a control point of view rail traffic is trivial (one dimensional), automobile slightly more complex in 2D, and aircraft control in 3 dimensions most complex. Rail turns out to be very difficult to automate safely, and aircraft least difficult.
- GNSS-free navigation – different requirements for different applications, no generic solution

The future military problem – the future war?

- UAV research since 40+ years
  - Did it play out as expected?
- Problems are context and environment dependent
- Automation
  - Generic from engineering perspective
  - Environment and context specific





Why research – Fight tonight!

- Why not just innovation?
- Innovation needs knowledge, future knowledge
- ”Technology exists!”
  - But solutions are context dependent
  - AUV:s
    - Archipelago – compare Sweden’s and Finland’s fractal obstacle ridden coast line with deep water coast
    - Fishing nets – hard to detect, fatal for smaller AUV:s

Autonomy research

- Autonomy functions
  - Enabling technologies (e.g. navigation and communication)
  - Systems autonomy, vehicle control, safety critical functions
  - Mission autonomy, mission-type tactics, breaking down missions into automatable subtasks
- HAT/MUMT/Operator – System interaction and integration
- Legal and ethical questions

- Operational efficiency – assessment of combat effect

Research on AUV

Applications

- Mapping
- Mine search
- Mine hunting
- Surveillance

Research topics

- Navigation
- Efficient vehicle control for low signature, low detection and low energy consumption
- Energy systems for underwater vehicles
- Trajectory and path planning minimizing signatures and maximizing information
- Design of collaborative heterogeneous and homogenous fleets

Some AUV challenges

- Detailed model of the UW-environment
- Collaborative behaviour
  - In communication denied environment
  - Swarming UW-robotics, i.e. with communication
  - Precise navigation
- Fault detection and fault handling/emergency recovery

Liability, obligations and responsibilities

- Beyond international law and regulations
  - National interpretations of international law
  - (Safety)standards express the intention of regulations in technical detail, domain dependent
  - Domains have developed differently
    - Aircraft control software vs. air traffic control software
    - Automotive industry vs. other safety critical industries
- Complex interdependencies
  - International law, national law and stakeholder interests

How to make scientists stay tuned?

- Focus on research questions – keep future in sight
- Find the interesting questions in the less exciting topics
- Broad research teams
  - Work simultaneously on effects, and counter effects
- Work on the hard problems

In conclusion

- Unmanned and autonomous systems are not new
  - New situations and new contexts still requires new knowledge
- Research requires experiments – not only demonstrations
  - Collaborate and share experimental data
- Fight tonight, but prepare for tomorrow
  - What is the next under researched threat? Swarms of attack AUV:s?