CANVAS AS A DESIGN TOOL OF AN AUTONOMOUS OPERATION FOR THE DETECTION OF A WASTE WATER PLUME

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A goal is to solve the right tasks in the best way => Autonomy in it self is not a goal

Autonomy: When? What? How?

- Autonomy not only on "vehicle level"

- To which degree should ….
  - … an operation be made autonomous?
  - … system functions be made autonomous?

- Autonomy at different "dimensions"

- …and with different stakeholders: Decision maker, operator and developer
- …and throughout the timeline of operations

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What is SEATONOMY?

SEA TONOMY

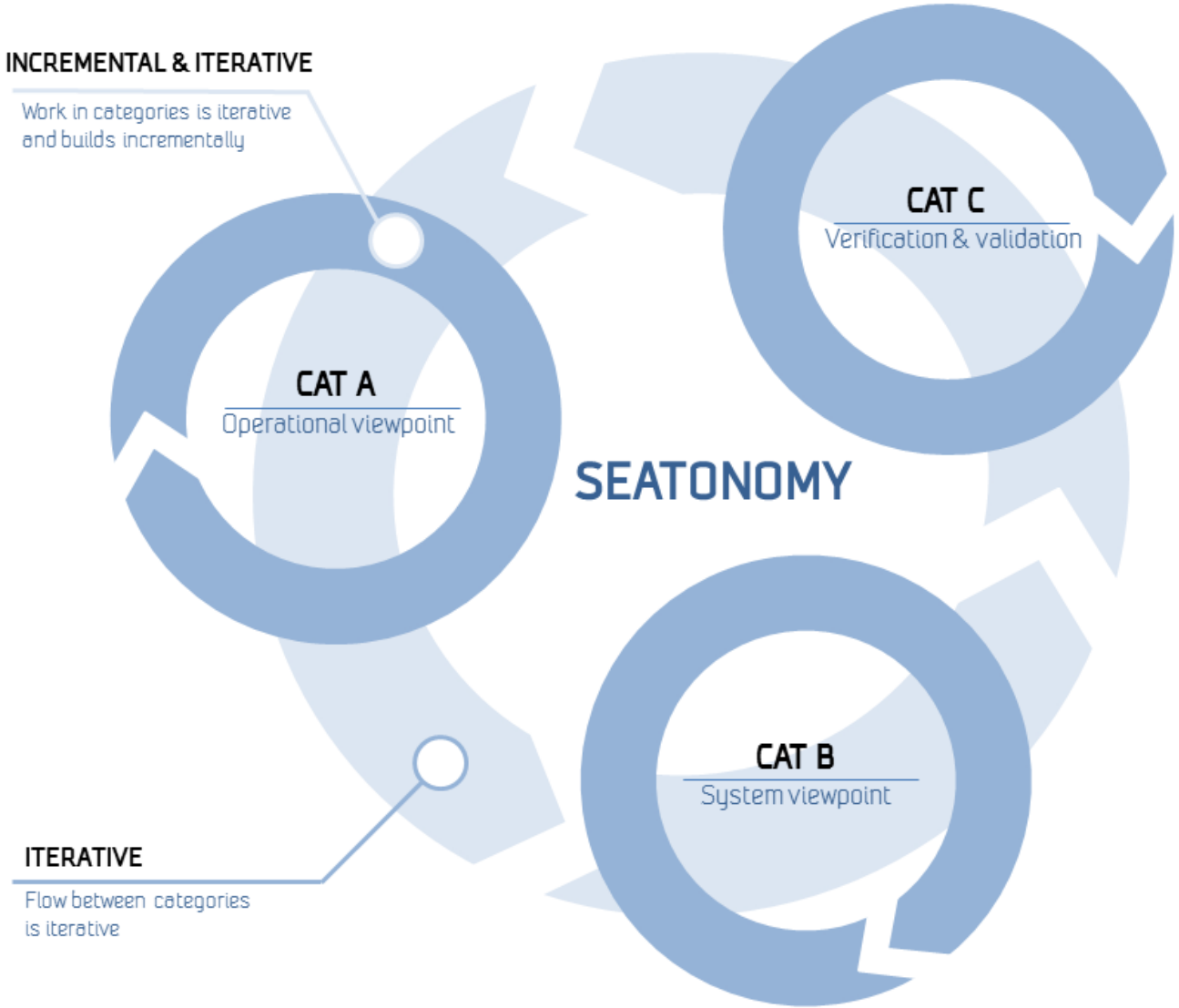
Safer, less expensive and more robust autonomous operations

- A structured approach for design, development and validation of autonomous functionality

Focus areas

- Methodology and tools for designing autonomous marine operations
- Principles for finding the right degree of autonomy / human-machine interaction

The seatonony workflow



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Autonomous Job Analysis

- Is based on the principles used in HTA which is considered "best known task analysis technique".
- The AJA method
  - Aids the design of autonomous marine operations by uncovering the overall operational modes and design challenges as well as needs and limitations related to autonomous behavior by breaking down operations into sub-operations and tasks and analyzing these individually.
- The method facilitates a common understanding between all different stakeholders

Autonomous Job Analysis

The Autonomous Job Analysis consists of the following steps:

1) Describe the main goal of the operation

2) Divide into sub-operations based on e.g. sequence, parallel behavior or choices

3) Answer the list of AJA questions

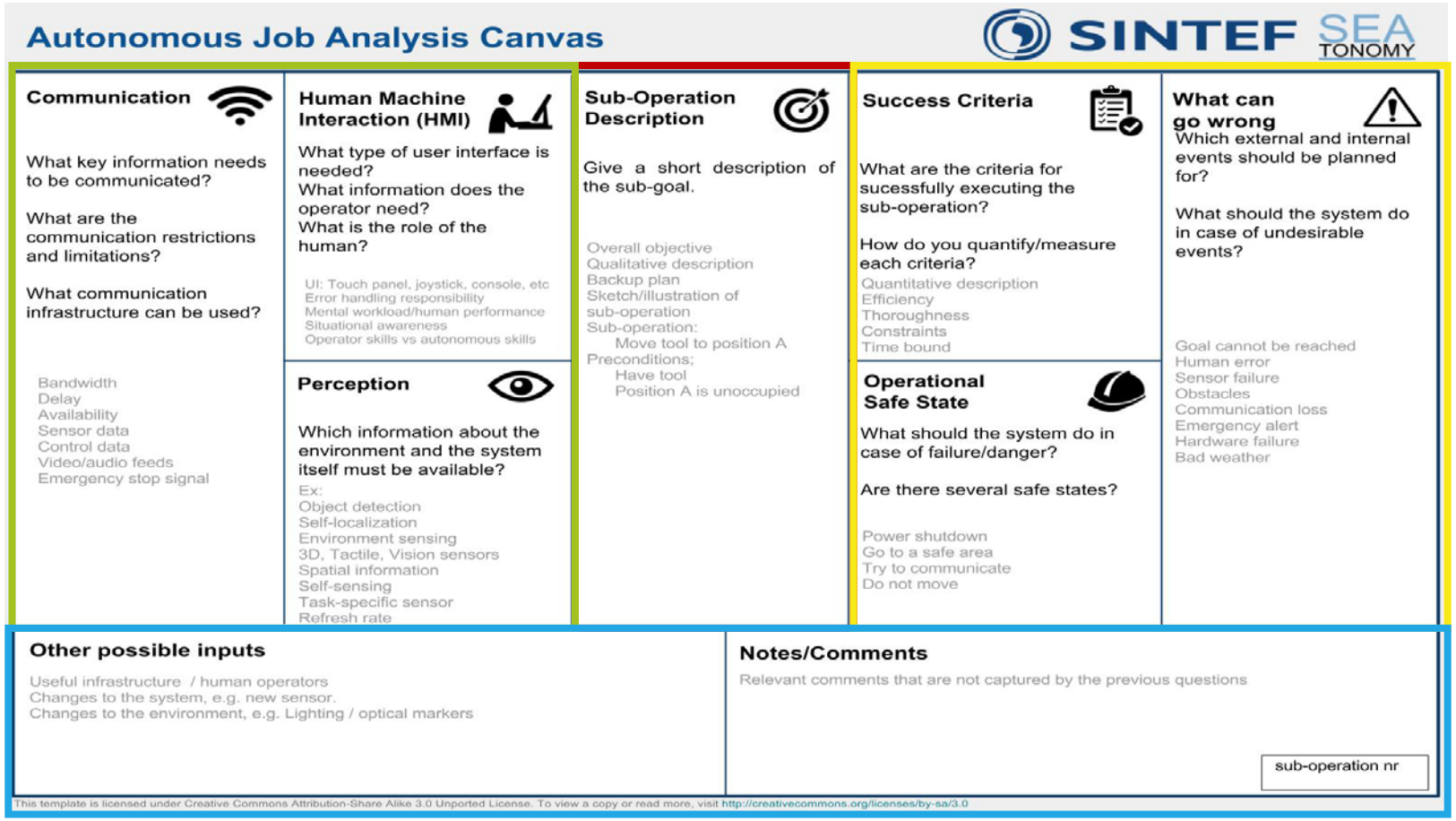
4) For each sub-operation, go to step 2) and repeat until the sub-operations become trivial tasks.

AJA Table formulation

The output is a structured description and breakdown of the operation where each sub-operation is individually analyzed based on technological and operational constraints uncovered at the AJA meeting.

ID	Name	Description
1	Description of sub-operation and corresponding goal	Give a short description of the sub-operation, focusing on the goal without too much technical detail. Achievement of the goal should contribute to the achievement of a goal at a higher level, and eventually the main goal of the operation.
2	Communication	Communication flow: What key information needs to be communicated? Communication restrictions: What are the limitations?
3	Perception	Which information about the environment and the system itself must be available?
4	Success Criteria	List design criteria which specify whether the sub-operation has been achieved. This can for instance be performance specifications related to accuracy or time.
5	What can go wrong?	Is there anything that can prevent the sub-operation from being successfully accomplished? Be specific about what characterizes abnormal behavior.
6	What is the operational safe state?	Define what state or mode should the system should go to, in order maintain the safety of the operation in a best possible way.

AJA Canvas



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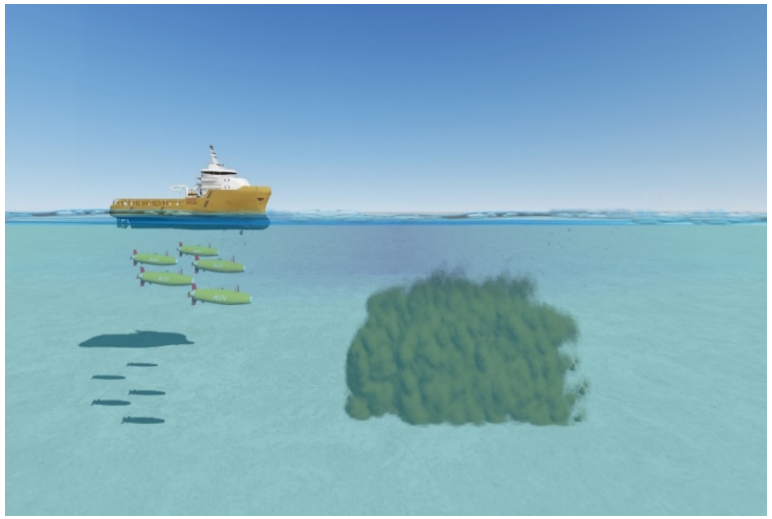
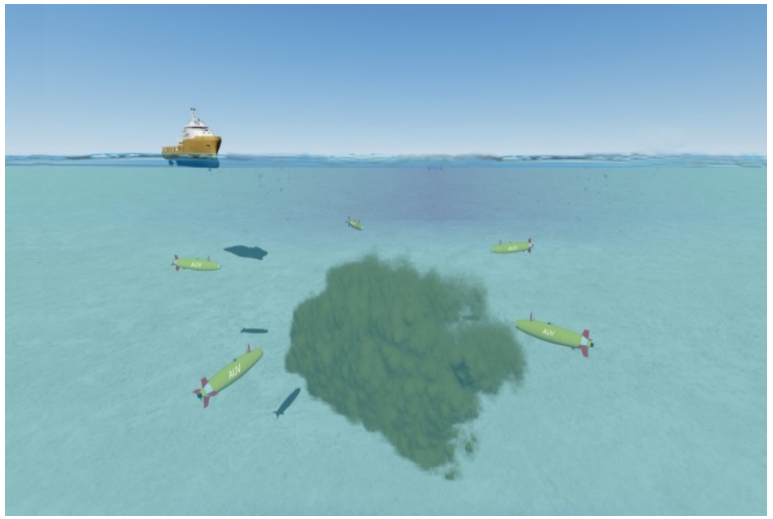
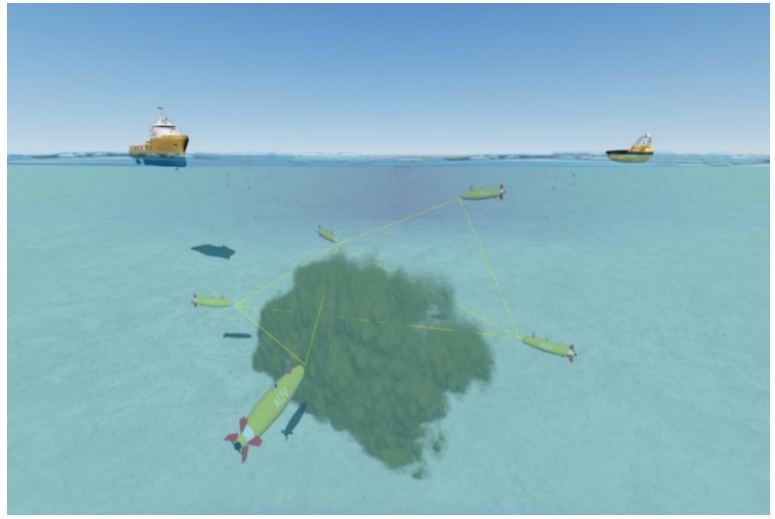
Requirements Table

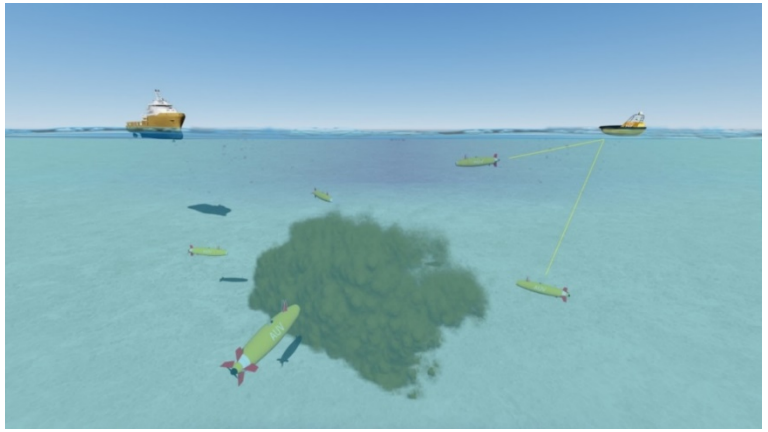
- "Requirements table" can be used as an extra input to the next development stage
- It can be made by carefully analyzing the AJA-tables and write these requirements in an agreed upon format
- AT an early stage it is best to focus on functional requirements

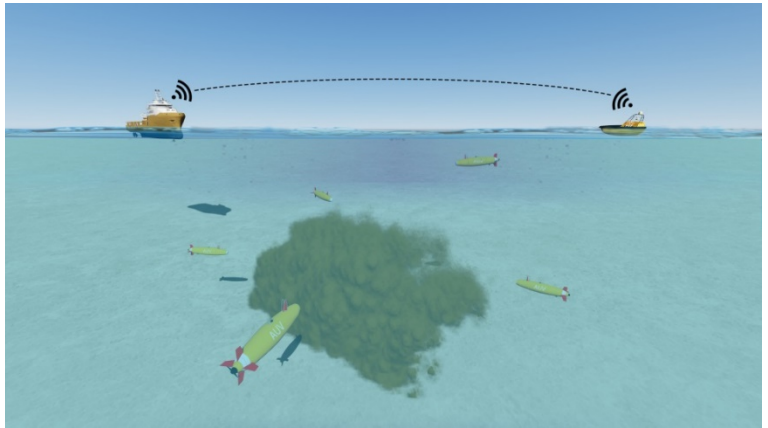
Use case scenario











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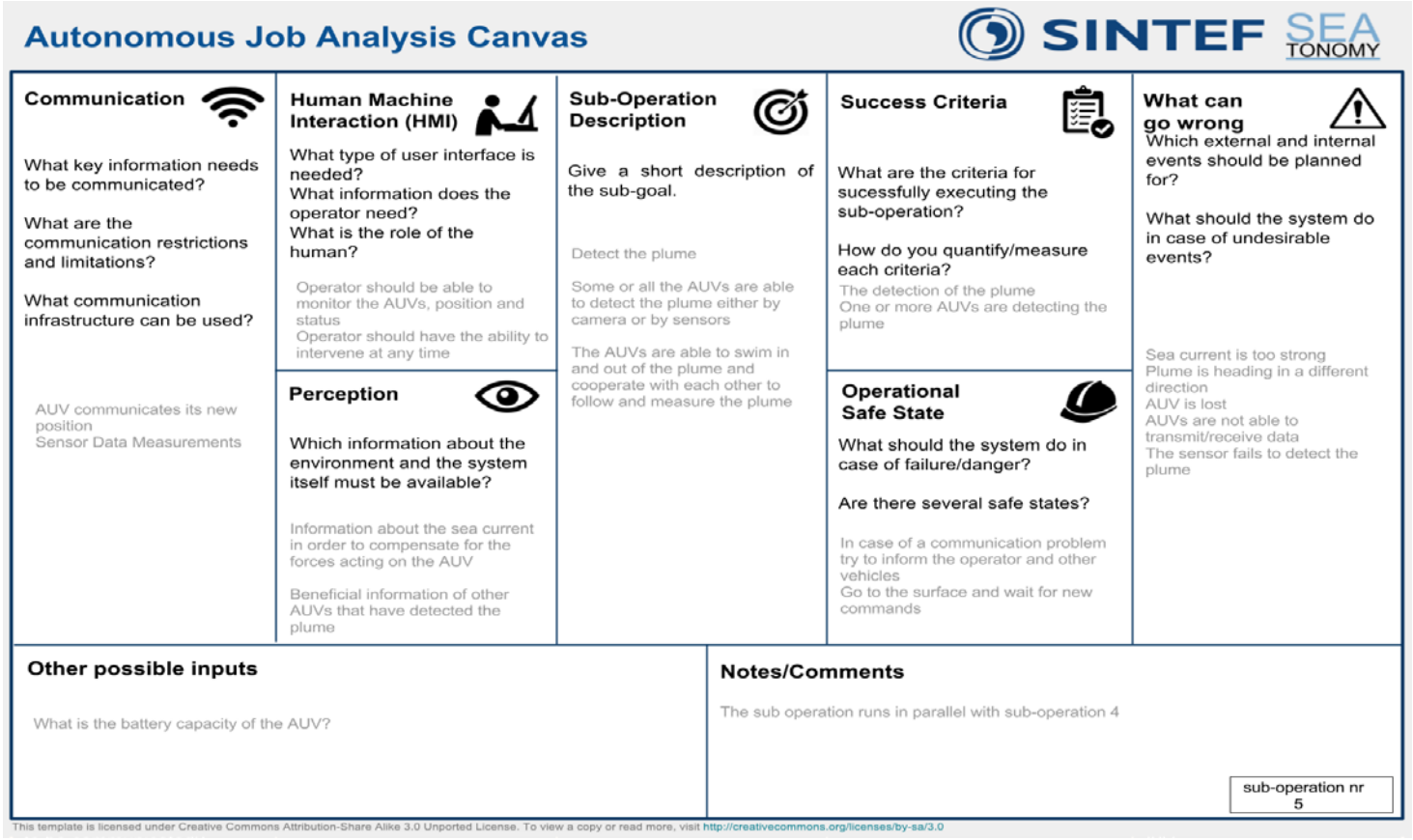
AJA Table Snapshot for the given storyboard

5	Description of sub-operation	Detect the plume
	Communication	AUV communicates its new position and the sensor data measurements at regular intervals so the operator is able to supervise the movement.
	Perception	Beneficial information about sea-current in order to compensate for the forces acting on the AUV. Beneficial information of other AUVs that have detected the plume is critical in that case.
	Success criteria	The sensor detects whether the AUV is inside the plume or not.
	What can go wrong?	The sea current is too strong for the AUV to follow its trajectory. The plume is heading in a different direction compared to initial expectations. The AUV is lost. AUVs are not able to transmit/receive data. The sensor fails to detect the plume.
	What is the operational safe-state?	If there is a communication problem try to inform the operator and other vehicles, otherwise autonomously go to the surface and wait for new commands.
	HMI	Operator should be able to monitor the AUVs all the time, position and status. Operator should have the ability to intervene at any time (abort or change mode).
	Other premises/requirements	What is the battery capacity of the AUV?
	Notes/comments	This sub-operation runs in parallel with sub-operation 4.

AJA Canvas snapshot for the given storyboard



Autonomous Job Analysis Canvas

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Communication

What key information needs to be communicated?

What are the communication restrictions and limitations?

What communication infrastructure can be used?

AUV communicates its new position
Sensor Data Measurements

Human Machine Interaction (HMI)

What type of user interface is needed?
What information does the operator need?
What is the role of the human?

Operator should be able to monitor the AUVs, position and status
Operator should have the ability to intervene at any time

Perception

Which information about the environment and the system itself must be available?

Information about the sea current in order to compensate for the forces acting on the AUV

Beneficial information of other AUVs that have detected the plume

Sub-Operation Description

Give a short description of the sub-goal.

Detect the plume

Some or all the AUVs are able to detect the plume either by camera or by sensors

The AUVs are able to swim in and out of the plume and cooperate with each other to follow and measure the plume

Success Criteria

What are the criteria for sucessfully executing the sub-operation?

How do you quantify/measure each criteria?

The detection of the plume
One or more AUVs are detecting the plume

Operational Safe State

What should the system do in case of failure/danger?

Are there several safe states?

In case of a communication problem try to inform the operator and other vehicles
Go to the surface and wait for new commands

What can go wrong

Which external and internal events should be planned for?

What should the system do in case of undesirable events?

Sea current is too strong
Plume is heading in a different direction
AUV is lost
AUVs are not able to transmit/receive data
The sensor fails to detect the plume

Other possible inputs

What is the battery capacity of the AUV?

Notes/Comments

The sub operation runs in parallel with sub-operation 4

sub-operation nr 5

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Thank you!

For further analysis and questions please contact Marialena Vagia

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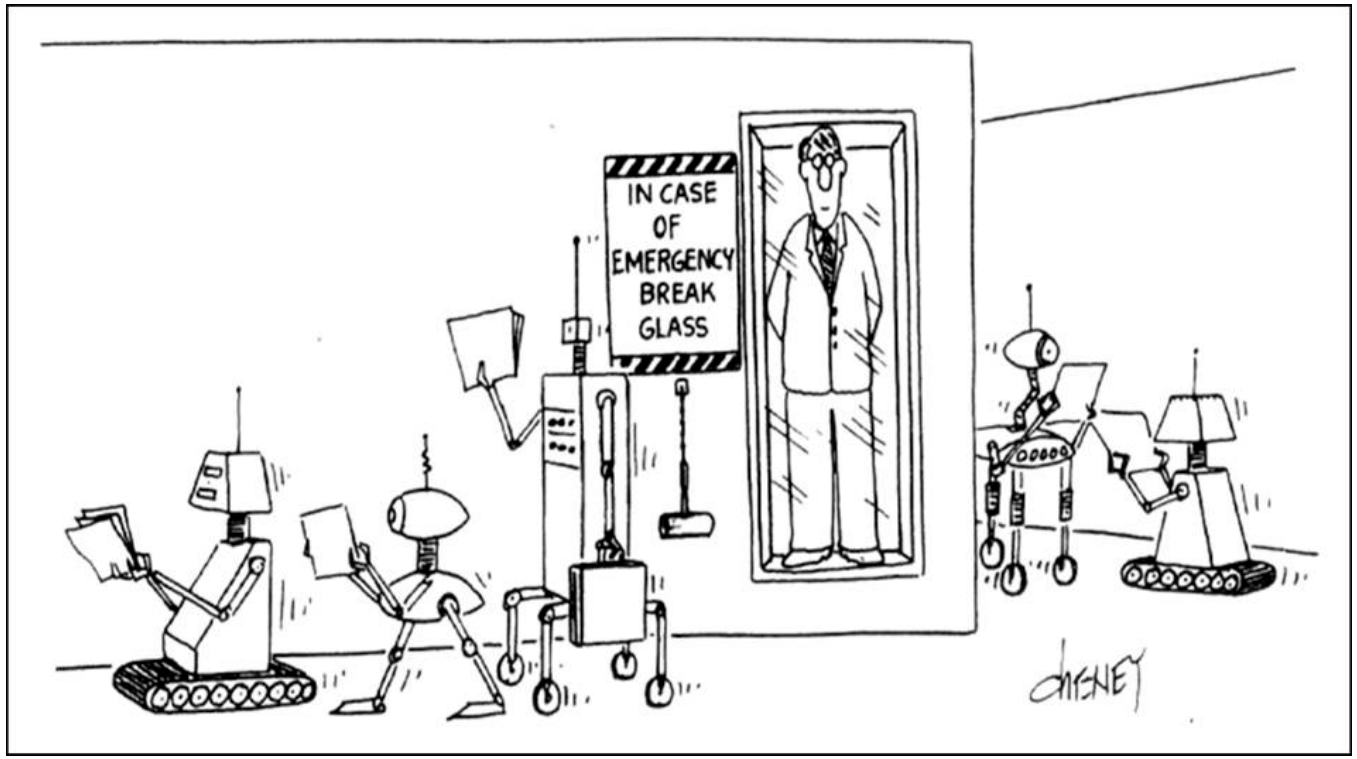

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Teknologi for et bedre samfunn

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