

# SmartSea GA MSP Toolbox Workshop

Planning the marine space – implications for support systems and data needs. What is the use of a scientist and scientific data?

*Ari Jolma, SYKE Marine Research Centre*

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The idea is to work (surf) through a spatial design process (after Carl Steinitz: A Framework for Geodesign). The goal of the exercise is to get some understanding of how information technologies and we scientists could/can help in the MSP process taking place in Finland (and elsewhere). The exercise attempts to simulate how a planner might come to the conclusion that she needs something from a scientist (i.e., this tries to not to start the thinking from what the scientist has that might be useful for the planner).

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The workshop agenda:

(20 min, all together) Demonstration and hands-on (username/password required in some parts, registration requires help from the workshop organizer) building a simple rule-based model & other features of the toolbox.

(35 min, group work) Simulation of a spatial planning project, 3 cases / in parallel independent study of the toolbox.

(5 min) Establish the motivation and build up the case for something to be done.

(15 min) Plan the study: understand how the changes are made to come about and prepare to support it.

(15 min) Carry out the study: prepare the material for the decision makers and others involved.

(3 x 10 + 5 min, all together) Wrap-up of cases & toolbox features

For the group work. Form 3 groups per topic with 3 to 4 people per group. The group work comprises 3 main steps and each step comprises 6 steps (the same 6 steps are repeated 3 times). Divide the work so that first each person in the group thinks about the main step from a different point of view (different step).

**Topics:** In the following X is a specific use of marine space. Please select one for your examination:

Energy production,

Aquaculture,

Turism, or

Something Else

Similarly, in the following S is a marine space (and the land area, which is interconnected to it). Please select one for your examination:

Gulf of Bothnia (Finnish or both Finnish and Swedish parts)

Bothnian Bay (Finnish or both Finnish and Swedish parts)

Kvarken (Finnish or both Finnish and Swedish parts)

Bothnian Sea (Finnish or both Finnish and Swedish parts)

Archipelago Sea (Finnish or both Finnish and Swedish parts)

# The design process after Carl Steinitz

## 1 The first iteration. WHY is there a need to look into X in S?

If you do not have an answer quickly, then you should think/discuss/write down an action point describing how the question could be answered.

1.1 How would you define X in S? What is the current situation of X in S? Think about physical, ecological, economic, and social situation.

1.2 What is going on regarding X in S? Again, think about physical, ecological, economic, and social situation. Think about links between these.

1.3 Is the area attractive for X in S? Why? Why not? By whom? Is X developing or declining in S? In what ways? What are the current physical, ecological, economic, and social problems related to X in S? Are the problems tied to some location?

1.4 How do you see the future of X in S (if things go on as usual)? Is X developing or declining in S? What are the driving factors?

1.5 Regarding your answers to the previous questions: what will be the consequences? Are they beneficial or harmful? To whom? Are they serious? Is the current development sustainable or will it lead to irreversible changes?

1.6 What do you think would be the value of "looking into X in S"? Raising public interest? Economic profit? Improved scientific knowledge? Who do you think has interest in X in S? What are their positions on the issue? Are the positions in conflict? Does law or something else set restrictions on how to look into X in S?

## **2 The second iteration. Assuming you have convinced those that will fund the study, to actually fund it, HOW should you proceed with it?**

2.1 How will the decisions that affect how the marine space is used, be made? Who will make them? What do they need to know to make informed decisions? What are the things that they base their decisions on? How much do science, cultural norms, law, profit to be made, social issues, ecology matter in the decision making? Are there implementation related issues like cost and choice of technology? How much does communication matter?

2.2 Assuming that some decisions are made there will be changes to the use of the marine space. The changes will have an impact. What are the most important impacts? How will the impacts be assessed by the different interest groups? Will some impacts be assessed by law or regulations – and if yes, how complex will that be? How certain are the impacts? How will you propose to assess the impacts.

2.3 Who defines the thinking behind the changes that will be proposed? "The thinking" means assumptions and requirements. How are the assumptions and requirements formulated? How many scenarios are needed? How are the changes defined? Do they involve time horizon? What is the spatial and temporal scale of the changes? How will the changes be defined: what are the roles of manual design, simulation models, optimization?

2.4 How are the impacts and things related to anticipated changes measured? Be as concrete as possible, think about units, accuracy Think about key concepts and measures (indicators) related physical, ecological, economic, and social situation. What are the spatial and temporal aspects of the measures?

2.5 How will the criteria be computed? What types of models are needed? Are they complex, what are their temporal and spatial scales? How deep into future do we need to look into?

2.6 What is the study area? What subdivisions (political, natural science based, related to X, ...) of it are needed? Which data is needed? What type of data is needed? Do you need to distinguish between things? Do you need to determine if something is better the some other thing? Does the difference between values at different locations matter? Is there something else that is important in the data? What is the scale and temporality of the needed data? Do you know where/how to get the data? What will be the cost of the data? Is the data available right away or will it take a long time to get it?

### **3 The third iteration. You need to carry out the study and deliver the results. WHAT should be done regarding X in S? I.e., what are the changes that need to come about? WHERE should something be done and WHEN?**

3.1 You need the data. Do you have it? Is it in the toolbox? Take a look at

<http://msp.smartsea.fmi.fi/Starman/browser/dataset>

and

<http://msp.smartsea.fmi.fi/Starman/app> (select plan "All data")

How would you organize, describe, and visualize the data for your study?

3.2 You will need to describe and show the situation of X in S, highlighting the opportunities and risks that lie within it. You will also need to describe and show how the things related to X in S will change assuming certain decisions are made, highlighting the benefits and not forgetting the risks and adverse impacts. In the project planning you identified (did you?) the tools (process models) for this. You need to set them up now.

How would you do that?

3.3 Run the process models for past and present situation and based on that evaluate the current situation. Show and tell the results.

How do you show and tell the results? Assuming the results are in an information system, who will use it? What is the required interactivity of the user interface of the system?

3.4 Obtain the decision scenarios. You have already planned how to organize and store them and what data is included in them (have you?). They should now be usable for the process models. Run the process models for the decision scenarios. Show and tell the results.

3.5 Assess and compare the impact model results for the decision scenarios. Show and tell the results.

3.6. Obtain feedback/decision and either 1) go back to 2.1 (you have understood something very wrongly and need to make fundamental changes to your approach), 2) go back to 3.1 (your approach is ok but you need to add something to your study or make some changes to how you carried it out), or 3) take the material you have prepared and go to the authorities who make the final decision concerning X in S.

# About models in the design process

Steinitz' framework is based on six steps (the 1.1 ... 1.6; 2.6 ... 2.1; and 3.1 ... 3.6 above), which each involve a model (and thus modeling). In the order of 2.1 ... 2.6:

## Decision model

Based on a defined set of alternative courses of action, pick one.

## Impact model

What are the metrics (indexes, indicators, etc) related to changes and situations, and how are they valued by different people.

## Change model

What does a course of action (the proposed change) include. (Why?, How?, When?, and Where?)

## Evaluation model

How should a situation be assessed? (physical, ecological, economic, and social situation; attractiveness, vulnerability, risk, resilience, sustainability, etc)

## Process model

Based on a selected course of action, compute the impacts of it. A process model describes how things affect each other.

## Representation model

How does the study area need to be described (with data) to fulfill the requirements of the above five models.

For a planner, the change model is perhaps the most important. Steinitz lists eight approaches to develop it, and one that combines different approaches:

Anticipatory – the designer hero makes one or more plans based on his or her experience

Participatory – a group of planners work together and come up with one or more plans

Sequential – the plan is constructed from parts, which each solve one issue by a simplest and most likely solution

Constraining – the plan is constructed from parts, where the issues are tackled in their order of importance (or at least bad solutions are tried to avoid)

Combinatorial – the plan is constructed by studying the combinations, where issues of approximately similar importance are solved

Rule-based – the plans is constructed by devising formal (spatial) rules that, when applied, guide the planning

Optimized – the plan is constructed by solving a mathematical model that is built in an attempt to capture the requirements, decision criteria, and constraints

Agent-based – the plan is constructed with the help of an agent-based simulation model of the studied area, subject, and actors

Mixed – the plan is constructed by combining results from subprojects applying two or more approaches mentioned above

# The toolbox

## Database of datasets

Data access in the toolbox is based on the famous GDAL FOSS4G translator library, which supports currently 226 geospatial data formats. Some formats are based on files, some on databases, and some on internet services. The analytical engine of the toolbox uses raster data, which requires conversion from vector to raster. Second, the data may also need to be reprojected to the map projection used by the engine. Third, some modeling methods need discretized data. All of these conversions can be done on-the-fly as data is used.

When data is used in planning it is important to know the metadata and the provenance of the data. Metadata represents the properties of the data. Provenance is a part of metadata, specifically, it describes how the data was created. The provenance is especially important for data that is a result of scientific research and is used in planning.

Metadata of geospatial data is usually served by specialized services, which can be based on Catalogue Service standards. For an example of a searchable data catalogue see <http://www.paikkatietohakemisto.fi>. Finding useful data for a planning task at hand can be problematic.

The dataset access in the toolbox is arranged by a database (see for example <http://msp.smartsea.fmi.fi/Starman/browser/dataset>). Data is organized into a structure, which usually starts from a description that broadly covers a source of data and not a concrete dataset. That data source then leads to subsets or derivative datasets, which in turn can lead to other subsets and derivative datasets.

**Example 1:** Yearly max wave height data from FMI. This data is natively in a NetCDF file. One NetCDF file may contain several datasets and the yearly max wave height is only one in this file.

<http://msp.smartsea.fmi.fi/Starman/browser/dataset:118/parts:119>

This data is in latitude, longitude coordinate system (set in the database as EPSG 4326) and is internally reprojected for the toolbox (either EPSG 3857 or 3067).

View: <http://msp.smartsea.fmi.fi/Starman/app> (Plan: testailua, Data: Yearly wave max height)

Assuming we have a Bayesian network, which needs this data discretized, we have created a derivative dataset from this, which separates areas of wave height < 3 m, 3 – 7 m, and > 7 m.

<http://msp.smartsea.fmi.fi/Starman/browser/dataset:118/parts:119/derivatives:120>

View as above, Data: Yearly wave max height discretized.

**Example 2:** EMODnet maintains and also serves many datasets, for example extrapolated chlorophyll data from EEA Waterbase.

<https://msp.smartsea.fmi.fi/Starman/auth/browser/dataset:121/parts:122>

You can view this data as above. But, this data is served as WMS, i.e., maps and thus the information is encoded into colors. The decoding is not a straight-forward task and not yet supported by the toolbox. Thus the colors in the view are not meaningful. Note also the slowness of the data, which is because the toolbox needs to first download the data from the EMODnet server.

**Example 3:** Select and show the dataset 'Natura erityiset'. Choose from **Explain site** 'Point', and click on one of the green areas. Below the 'Point' you will get a code, which is a link. Clicking the link opens a page describing the selected Natura site in a new browser tab.

## The analytical tool

The analytical tool is a raster-based spatial computer aimed at computing spatial attributes relevant to uses of marine space. Computing is rule-based (see below). Uses are defined in the database

[http://msp.smartsea.fmi.fi/Starman/browser/use\\_class](http://msp.smartsea.fmi.fi/Starman/browser/use_class)

A use class is (currently) defined by the activities it produces (and activities are considered here only from the point of view of environmental impacts it causes). From activities we can deduce environmental pressures, and from pressures environmental impacts, and from environmental impacts the (environmental) suitability of a plan utilizing specific uses. The spatial attributes

[http://msp.smartsea.fmi.fi/Starman/browser/layer\\_class](http://msp.smartsea.fmi.fi/Starman/browser/layer_class)

are (currently) just tags. However, 'impact' layers are linked to 'allocation' layers and a 'computation method' in an aim to develop impact modeling.

**Example:** Open the plan 'Vesiviljelyn sijainninhjous', open use 'Fish farming' and select 'Suitability'.

<http://msp.smartsea.fmi.fi/Starman/app>

You will see a spatial coverage computed using exclusive rules, which shows the area deemed suitable for new fish farming development. The computation works by starting from 'yes' everywhere in the planning area, and then by applying the various excluding rules, shown in the panel below. In this model there are two types of rules: boolean and threshold. A rule is boolean if the dataset in the rule has only two values, for example a location is or is not a protected area. Threshold rules work on ordinal datasets, i.e., the values at different locations can be compared to each other with operators  $<$ ,  $\leq$ ,  $>$ , and  $\geq$ .

You can see the effect of each rule if you click them on and off from the checkbox. You can also see the effect of changing the threshold by clicking on the rule and changing the threshold in the dialog box.

## Modeling by rules

The rule-based planning approach is supported by the toolbox. In the toolbox one can currently construct layers using three types of rules:

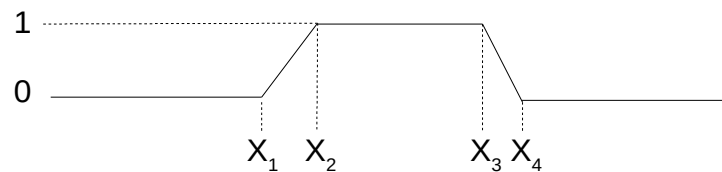


exclusive (and inclusive)

Each rule excludes (or includes) a spatial unit from the result based on a logical predicate of type "A Operator X", where A is an attribute, Operator is a mathematical comparison (<, ==, etc), and X is a value. Rules are executed sequentially and the resulting value is 0 or 1.

"boxcar"

Each rule produces a real number between 0 and weight (or weight and 0 if weight is negative) based on a linear shape function that is defined by four values ( $X_1 \dots X_4$ ,  $X_1 \leq X_2 \leq X_3 \leq X_4$ ) (the shape function can also be inverted and run from 1 to 0 to 1). The values from individual rules are summed.



Bayesian network

The value of the resulting layer is obtained as the probability of a state of a node in the network (thus its value is a real number between 0 and 1). Attributes are linked to other nodes in the network (thus they need to be discrete and the discretization must match the discretization (states) of the nodes).

## Modeling example

Creating models requires logging in into the app, so log in. Models are created using dialog boxes, which are opened as context menus (clicking the mouse right button) from Plan, uses, and layers. (This is not very usable and all menus will be moved to a main menu, which will open from the hamburger button but that has not yet been done.) As a visual hint the elements with menus are shown with a dashed box around the element.

From context menu of **Plan** select 'Add..' and give a name to your new plan. (In fact, *plan* may be a bit misleading title here, a better one might be *analysis*)

The initial set up of a plan is currently an empty Data and Ecosystem with only 'Coastal fish'. The Data section will contain the datasets that are used in the rules, and extra datasets, which you can add using the context menu of Data.

Again, from the **Plan** menu add a use. You are given a predefined set of use classes. Select the one that you're interested in. (For demonstration, I will select Offshore wind farms). The use appears into the layer panel but it does not contain any layers yet.

From the context menu of 'Offshore wind farms' (or whatever use class you selected) select 'Add layer...'. You now need to define the layer class, which is just a tag, the rule system, and the color

palette. If you select 'Bayesian network' you would need to select a network from a list of available networks (currently only one), and a node and the state to use as the value for the layer. Note that inclusive, multiplicative, and additive rule systems probably do not work currently. (For demonstration, I will select suitability, exclusive, and blue)

The 'Suitability' layer appears into the 'Offshore wind farms'. The layer can be clicked on and off from the checkbox, its information can be set on and off by clicking the text, and the transparency of the layer can be adjusted from the slider. Click the layer on and you will see that the whole planning area is marked as 'Käypä alue' (suitable) with the blue color.

From the context menu of 'Suitability' select 'Add rule...'. In the dialog box there is a list of datasets and, depending of the type of the dataset, an operator menu, or an operator menu and a widget to define a threshold value. I will first add a rule based on 'Etäisyys asutukseen' (distance to residential buildings). I want to exclude areas that are closer than 5 km to residential buildings, thus I select '<' and 5000 (the unit is m) in the slider (or the text box). The suitability layer is immediately updated and clearly the areas near the shores are excluded. I will add the second rule based on the depth of the sea to exclude areas that are more than 50 m deep. The dataset is 'Syvyysmalli', the operator is '>=' and the threshold is 50,1 – 60 m. Now most of the areas that are far from the coast are excluded. As the third rule I add areas where the yearly max wave height is more than 5 m. The dataset is 'Yearly wave max height', operator is '>=', and threshold is 5 m.

I can't do it yet, but the next step in my imaginary wind farm planning study would be to take this result to the planning tool which is described next.

## The planning tool

The planning tool is a recent introduction to the toolbox, thus it is only at the stage of an idea. The idea is that once you have an understanding of what the uses of the marine space are and how you want to assess them you need a tool with which you can try out plans. Two useful features of such a tool would probably be a possibility to compare two plans and feedback on the performance of the plans. The URL of the planning tool is

<https://msp.smartsea.fmi.fi/Starman/auth/planner-app/index.html>

The data from the planning tool can be fed into the analytical tool, for an example see the dataset 'Planning data' in Plan 'All data' and

<http://msp.smartsea.fmi.fi/Starman/browser/dataset:123>

Viewing datasets or results from the analytical tool in the planning tool is not yet implemented.