# Collect and Map it all: The Artifact Map, a Tool for Complex Context Analysis

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**ABSTRACT**
We have developed the Artifact Map as a tool for context analysis. In a first step, this tool supports and structures the early process of „hunting for stories“ by collecting, describing and mapping all artifacts on a floor map as an anchor. Subsequently, this visible, tangible surrogate paper context is collaboratively extended and used in interviews. Doing so, users are aided in making tacit knowledge explicit, analyzing and reflecting creatively about all aspects of their workaday world. Preparing and working with the Artifact map helps to immerse quickly in a complex context, to find interesting research and design questions, and to establish a common language. Collaborative, social and work processes are jointly sketched on the map, later visually informing further design. Preparing and working with the Artifact Map is both a structured analysis process and an exploratory ethnographic method, with potential to reveal hidden issues that a normal rapid analysis would not disclose. This paper describes the preparation, use, and method in detail. We also report on our results using the Artifact Map to improve our understanding of the context of a vessel traffic center.

**Author Keywords**
Contextual inquiry, Context Analysis, Tangible Mapping, Artifact Map, Ethnography, Vessel Traffic Control Center.

**ACM Classification Keywords**
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

**INTRODUCTION**
Understanding context in a complex work environment can be challenging, especially when substantial expert knowledge, a large amount of information and many artifacts are involved. Causalities may be hidden and redundancies might serve legit purposes. Especially in contexts that involve cooperation, vast experience and expert knowledge, large parts of user knowledge may be tacit. We encountered a fairly complex working environment with our client, a vessel traffic center (VTC). Vessel traffic centers control the movements of shipping on busy waterways. Our task was to generally “look at” the VTC’s work on all levels and give recommendations on how to better support the nautical officers in their work, in order to develop the “VTC of the future”. This could include technical, spatial, organizational and ergonomic recommendations. We were guided by Participatory IT-Design methods [3], but we needed to look further. This eventually led to the development of the Artifact Map presented in this paper.

Similar to air traffic control centers (ATC) for planes [e.g. 1,12], the VTC guides vessels through a port, ensuring the overall nautical safety and smooth flow of traffic on the waterways. This demanding task is performed by a team of nautical officers, who are trained experts in their field. In busy times they are under considerable cognitive strain. They use a plethora of artifacts to gather the information they need. If their workload increases, as is expected, they will need better tools to support them, and they may need to change parts of their work organization.

“Ensuring traffic safety” is a classical *wicked problem* [15]: a system that is sufficiently complex that the causal chains are hidden, involving a number of stakeholders with conflicting goals involved, and solutions that cannot be tested. Any solution found cannot be completely “right”, only “better”, and, since human beings are involved, there is no trial-and-error possible, as every try counts and changes the situation. To us, analyzing and designing for the VTC proved a *wicked problem* in itself, especially given the broad assignment for our project team together with a tight time frame. We encountered the same situation as Mackey [12] with ATCs: the users had already rejected several solutions, because they failed to meet both the informational and also the interactional needs of the nautical officers. (For instance, we found a general aversion towards keyboard and mouse because they produced cognitive friction and slowed the work).

Ethnographers in the field of technical development cooperation have developed a toolkit of methods, known as *Participatory Learning and Action* (PLA, [4,14]), which is optimized to allow diverse local experts to participate as creative analysts of their own workaday world. They participate as equal partners in an interdisciplinary team made up from local experts along with whichever discipline is needed for the technical side of the project, plus people from the social sciences. To overcome the substantial


NordiCHI '12, October 14-17, 2012 Copenhagen, Denmark

differences in background and culture, PLA methods (for a detailed description see [14]) often rely on tangible manifestations or visualizations as a focus of discussion as well as common visual language established by the team. This way, a greater sense of ownership of the information and the project is likely to emerge in the local experts.

Like many PLA methods, our artifact map is a visual, tangible method that is both a tool for analysis and a catalyst for discussion leading to development of creative new solutions by an interdisciplinary team. Once created, the map also helps to communicate findings to external stakeholders such as technical experts or decision makers. Solutions developed in such a highly participatory way are also more likely to find approval from future users.

In the remainder of this paper, we introduce the context of our work, the VTC. We then describe our methodological framework and discuss the challenges that we have met. Then, we delineate the preparation of the Artifact Map and its use, explaining why and in which way it helped us to make the requirements of this context analysis more tangible. We conclude with a discussion of the various aspects of our method.

## CONTEXT – THE VESSEL TRAFFIC CENTER

Our work was conducted in the context of a vessel traffic center, regulating traffic within a port. To our knowledge, this is the first reported study in this context. The VTC maintains the land-based radar chain, provides vessels with information on current traffic, conditions in the port, weather, moorings and so on, and advises and directs captains from the VTC. To achieve this, the VTC is staffed with teams of nautical officers, who work in shifts.

Like other studies of control centers (Hughes et al. [8], Bentley et al. [1], Mackay et al. [12], Suchman et al. [18] for airports), we found the work to be highly complex, dealing with tremendous amounts of information, relying on experienced and knowledgeable experts, and conducted by teams working closely together. However, the VTC turned out to be different in some respects. First, the nautical officers deal with many different external stakeholders with whom regular communication and collaboration must be maintained. Some, like the terminal operators or the pilots, are part of the *distributed cognition* (Hutchins [9]), necessary to coordinate the ships. Others, like the operators of construction sites or other government agencies, only either give or require information. Secondly, they deal with a broader timeframe. A given planning situation ranges over a 12-24-hour time frame, thus dealing with a lot of uncertainties. Thirdly, a large amount of the information required is obtained via fax, email or telephone and administration involves numerous paper files and binders. Fourthly, the situation in the port is generally more *complex*. Nautical officers need to overlook and keep a current mental model of *the whole* port and adjacent territories, which since it's a river port also covers over 70 relevant miles downriver to the sea. Their knowledge encompasses not only all current and expected ships but also potential planning problems with them. In the background, they also contribute nautical knowledge gleaned from decades at sea. They know all static information about the port, down to the water depth in every single mooring. Additionally, they must keep up to date on dynamic factors like tide, weather, obstacles and hazards. The demanding task of regulating traffic requires them to filter large amounts of incoming current information, deciding what to ignore and what could lead to trouble. This includes listening to up to four channels of radio while monitoring a ship's progress on a specialized IT-tool and keeping an eye on the radar and the weather. But it also requires them to be experts in stakeholder management and sometimes even in conflict mediation.

This takes not only vast expert knowledge, but also long, in-situ training in order to learn how to *read this particular scene* (Suchman et al. [18]) in order to know what to do and how to make quick and competent decisions. The nautical officers rely on teamwork in long-established, well-practiced teams sharing a specialized *expert vision* (Goodwin [7]) and have well-developed "gut feelings" for problems. As described by Goodwin, they share *coding schemes*, they *highlight* important pieces of information, and produce and share *material representations*.

These experts do excellent work, but at the cost of substantial cognitive strain. The information necessary for conducting their task must currently be obtained from a plethora of artifacts scattered over two offices. If the workload were to increase, which the port authority expects, better support will be necessary to allow them to do the same work with less load.

## METHODOLOGY FOR COMPLEX CONTEXT ANALYSIS

Our task and challenge was to explore the work of the current VTC to find strengths, weaknesses, and potentials and, then, to give design recommendations for the "VTC of the Future". This encompassed all levels, including the technical, spatial, organizational and ergonomic. There was even a chance to influence the design of a new building and office. So we needed methods and concepts with which to grasp the *wicked problem* of the VTC, encompassing actors, tasks, rooms, processes and work equipment artifacts, as well as social factors like communication, awareness, teamwork and networks. There are several authors in the area of user-centered software design who describe analysis techniques for identifying requirements, for example Rosson and Carroll [16], Beyer and Holtzblatt [1], Mayhew [12], and Bødker et al. [3].

We selected Participatory IT-Design [3] as our main methodological guideline for the analysis phase, complemented by the modeling of exemplary business processes (eGPM) [5]. These models were useful in the beginning to gain a broad overview of the main tasks of the work and how they are typically structured. At the same time, we conducted several interviews with actors in

different roles. To reach members of the staff that were not on our project team, we started a "Christmas wish campaign". We provided a decorated box, pens and paper and some inspirational printed images and collages. We sent personal letters to all shift personnel inviting them to share their wishes, visions, ideas and suggested solutions for the VTC of the future. These wish lists were later included in our analysis.

To capture the highly situated nature of the VTC's work, we used the Locales Framework (Fitzpatrick [6]) as a conceptual guideline. The locale is a concept that further elaborates place (social space, drawing on the work of Giddens [10], for the HCI community Harrison and Dourish [11]), using amongst others Strauss' Theory of Action [17]. To deal with the wicked problem of design, Fitzpatrick suggests taking several perspectives in the research. The basic view on the locale and its social world is to look at the people, artifacts and spaces, as well as the structures and institutions involved. This is complemented by various *individual views* on this situation at different times. Dynamics of the workplace are partly characterized as *trajectories*, which includes following people, artifacts or processes throughout the work environment. Especially relevant for considering future changes are the current practices, how they achieve *awareness* of each other's work and how they communicate their own. Taking into account the inherently situated nature of work, then, helps understanding the wicked problem of computer supported cooperative work, allowing a situated solution to evolve.

Using the classical methods as a start, such as document analysis, different types of interviews, thinking aloud and observation, or the exemplary business process modeling (eGPM [5]), we were able to collect a great deal of data.

Some questions, however, were hard to answer with these methods. Specifically in answering 'what parts and arrangements are supporting and what parts are impeding the workflow', we faced the challenge on how to quickly make those judgments. We found the concept of the *locale* and *place* a very useful guideline, but were unsure how to collect the data in a structured way. Fitzpatrick specifies in great detail *what* data should be collected, but not precisely *how to* collect it [6].

Also, we encountered some challenges in our context with our selected methods. In this complex environment, mere observation cannot provide enough information about invisible cognitive processes crucial for a lot of essential tasks. Observation was sometimes problematic. For example, some staff felt uncomfortable being silently observed while working. This prevented us using video for later analysis, as proposed by Suchman [18]. In situ interviews were insufficient because a large number of artifacts were used, whose use and meaning were hard to appreciate from interview data alone, when described out of context. Interviews were, in any case, problematic in this work environment that is characterized by close teamwork, constant interruptions and a high level of noise. In order to overcome these limitations and to support the participation of experts we developed the Artifact Map.

## THE ARTIFACT MAP AS TOOL FOR ANALYSIS

For the Artifact Map, we combined a *localization map* with a *rich glossary* (see Figure 1). Each artifact from the working environment is represented by one entry in a rich glossary. Such an entry consists of a photo of the artifact, its label, a brief text explaining the artifact and its use, and a consecutive number as the ID of the artifact. This ID connects the explanation of the artifact in the rich glossary with its location marked in the localization map - a plan of the working environment.

The Artifact Map makes the context of the work available outside the actual work situation. It does so in a concrete, situated and nearly complete way, thereby encompassing three aspects: An overview over the working environment, the spatial arrangement of the artifacts within this environment, and a detailed view of every single artifact. This thick description gives us the freedom to work on different models of the work situation, for example, models about processes, cooperation, frequency-of-use and so on, even though not being present in the specific situations.

We used the resulting Artifact Map for further interviews about the work and context, visualizing the results in various kinds of diagrams, and thereby, creating a rich situated context description on a map: quasi a *locale map*.


**Figure 1: Artifact Map consisting of a rich glossary entry of each artifact plus a marker of its location on a map (center)**

## PREPARING THE ARTIFACT MAP

In the following we describe our main activities in the analysis phase including the preparation of the artifact map (see Figure 2 for an overview).

Before starting to create our Artifact Map, we tried to acquire the best possible initial understanding of tasks and context using standard methods. We visited the VTC, carried out document analysis, and conducted initial general interviews about the work tasks of the nautical officers. For these tasks, we did an exemplary modeling of work processes using eGPMs [5], to gain an idea of the frequently complex steps involved in them. eGPMs are an IT supported, scenario-based method to jointly discuss and visualize work processes during an interview and proved very useful for an overview. With these methods we gained initial understanding of the work environment and the core processes and tasks. This was important in order for us to understand details from later observations and interviews.

### Observation and In Situ Questioning

Based on our initial understanding, an Artifact Map was prepared (see steps in Figure 2). The first step was drafting a raw sketch of the office floor plan with the relevant furniture. Then, a photo of every artifact was taken and its location was marked on the sketch. This data collection was accompanied by short in situ questions, as needed, in order to understand the general intent and usage of any particular artifact. We call these 'in situ questions' in contrast to 'in situ interviews' to denote their short and informal nature. These brief interventions cause less disturbance to the workflow, and should feel more like a visitor or co-worker asking a question.

Personal preferences and individual usages of artifacts are not the major focus of interest at this stage. They come into play at a later stage when using the Artifact Map in interviews or for later visualization of particular aspects of work (see next section). This procedure, of first gathering the general intent and usage of artifacts, then later studying the individual differences, is well founded in working environments where most artifacts are shared rather than personal. We call an artifact *shared,* if several people or a group uses the same object, e.g. a shift schedule on a pin board or a medical record of a patient, while a *personal* artifact is mainly used by one person, e.g. a personal password list stored in an individual's office desk drawer. Shared artifacts are, for example, common in work environments that require shift work since most artifacts are used by all shifts. Shared artifacts are typically connected with shared intent and usage, which facilitates successful cooperation. It is therefore especially appropriate to concentrate on the shared understanding and usage of artifacts first, and explore personal differences later.

In the course of preparing the Artifact Map, the use of every artifact is detailed. This has several advantages. First, an almost complete list of all tasks and work processes is generated, often enriched by anecdotes, preferences and other interesting details prompted by the question and the prop. By doing this, even tasks that are not prominent and that might otherwise be overlooked, are identified, since they are associated with an artifact. Secondly, one can detect artifacts that have become superfluous. And finally, the researcher gets a chance to participate in the working

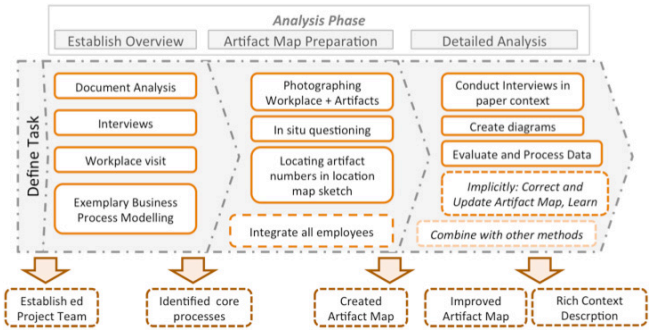


**Figure 2: Analysis phase including Artifact Map preparation and subsequent usage in interviews and for diagrams.**

environment for an extended period of time, gaining observational data without disturbing people, while he or she is waiting for someone to answer a question. This whole process provides valuable insights for possible research questions that one did not know or realize were important in advance. The *perspectives* proposed by Fitzpatrick [6] can provide structure and direction as to where to look for inspiration for interesting questions. Since the researcher has a clearly delineated task, his or her presence at the workplace and the observation of work practices is perceived by staff as far less disturbing.

Due to its nondiscriminatory approach, this method can be described as an ethnographic method, opening the researchers mind to the hitherto unknown. It additionally provides a structured process aiding the researcher in getting from open data collection to relevant findings grounded in the data.

### From Data to the Artifact Map

We had first amassed detailed notes including answers to our in situ questions as well as all kinds of observations. To achieve a rich glossary, this heap of information was processed into glossary entries with two hidden byproducts - a *commented rich glossary* and *encyclopedic entries*. The research team used the latter two only internally. To make sense of the data "heap", we found it advisable to first create the rich glossary in a rough form, making an entry with photo and number for each artifact and putting all information concerning this artifact into its entry. Later, we sifted through each entry and separated one short, neutral description of the artifact and its use, distilled from all sorts of comments, likes or dislikes, and individual differences in use. Just a photo, number and description are extracted for use in the Artifact Map. The commented rich glossary holds the original data about all artifacts. It holds all collected details about the artifacts and its use and stories and subsequently supports all further ethnographic data analysis.

In addition to information that is clearly related to artifacts, we had collected extra, unrelated observations and insights. Some of these insights may concern more than one artifact. These necessitate another type of glossary entry which we call encyclopedic entry. If, for example, a workflow has been observed involving five artifacts and characteristic patterns of how awareness is achieved, it is described in as much detail as possible, including any photos and quotes. When writing these notes, further questions and preliminary interpretations may arise and are included in the document. Pros, cons, perceived problems and ideas for solutions from researchers and interviewees find their place here and are updated regularly, as further information is gathered. As the notes become detailed, patterns soon start to emerge and one can refer to older observations to help to answer newly appearing questions. This process helps towards answering research questions in a structured way; at the same time producing a valuable body of information that will be of help in later stages of the design process.

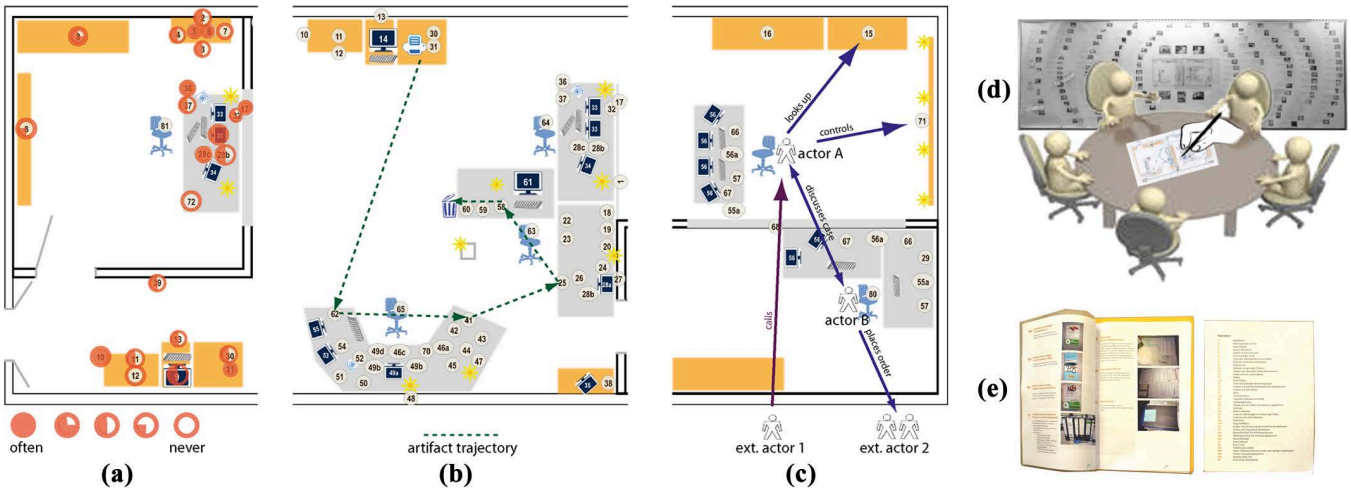


**Figure 3: Localization map with: (a) frequency of use-, (b) trajectory- and (c) situated cooperation diagram, i.e. three different locale perspective maps. (d) The Artifact Map creating a quasi in situ context in an interview. Wall poster version in the VTC, width 11,5 ft (e) the 'transportable' Artifact Map: a rich glossary booklet and index replace the poster.**

## USING THE ARTIFACT MAP

In this section we illustrate, how we used the Artifact Map as a new interview technique and how we applied it as a tool for visualization and modeling (see Figure 2).

### Application as an Interviewing Technique

The Artifact Map proved to be especially effective when used in interviews. Doing so, it is possible to talk about work as if in the workaday environment by using the visible, tangible *surrogate context* on paper. The conversation gets very practical, detailed and thus situated, giving the researcher access to data otherwise unobtainable outside the workplace environment. Since details about the work environment can easily be referenced by pointing at them, conversation becomes quick, unambiguous and clear.

It is possible to work with either a large poster or with a smaller version (see Figure 3 (d) and (e)). There, we used a printed localization map, with the rich glossary as a booklet and a list of all labels with their respective numbers.

With this surrogate paper context, a double benefit is obtained: Interviewees "zoom in" the context and the answers are given in great detail because every artifact can be referred to. Since the whole context is right there in front of everybody, the eye can wander across it, and interesting and relevant associations are stimulated. At the same time, interviewees easily "zoom out" of the context, which is especially useful for people, who have worked in this context for a very long time. Zooming out gives the opportunity to reflect on their daily work from a distance, adopting a bird's eye view of their work environment and processes. The mind can let go of habitual patterns and acquire a fresh view on the daily routine.

### The Artifact Map as a Tool for Visualizing and Modeling

Beyond benefiting from the artifact map as a surrogate context, we utilized it in interviews to work out and visualize interview contents. Interviewers and work experts thereby create a shared image of, and a common language about the topics. Procedures, cooperation or other issues can be visualized and made concrete via locating them as diagrams on the localization map, either on a printout or on transparent film, so that various diagrams can be combined later on. Of these visualizations, we will describe three types of diagrams in the following sections: frequency-of-use-diagrams, trajectory-diagrams, and situated-cooperation-diagrams. All are set onto the localization map, using it as background.

#### *Frequency of Use Diagram*

This diagram shows, how often a person uses each artifact on the map and also serves a purpose in a special type of interview. After defining a legend for degrees of "felt frequency" with the interviewee, we asked how often they subjectively estimated they used each artifact on the map, marking the answer visible (see Figure 3 (a)). In the same way, we documented frequency of cooperation with several persons in different roles. As well as investigating "felt frequencies", the interview facilitates corrections, annotations and anecdotes to amend the rich glossary. People bring up personal opinions and stories about artifacts. From the insights we have established, we can then ask the right questions, to draw out and explore personal styles of use.

Frequency-of-use-diagrams aid design. They indicate important artifacts and frequently used routes in the workplace. Using those as a basis, it is possible to draw conclusions on a very detailed level about where artifacts could be better placed. For example, artifact 72 in Figure 3 (a) on the right side of the table is never used, but sits in a prominent place. If consistently indicated by all users, this might e.g. indicate potential for a spatial rearrangement. The diagrams might also themselves indicate individual styles, if interviews are done with several people occupying the same role. The knowledge about individual styles is of large importance for a successful change management, if work processes are changed or systems are re-designed.

*Trajectory Diagram*

Our artifact map is especially suited to depict movement paths of people or artifacts either within a work process or a unit of time. This would be a visualization of Fitzpatrick's [6, p. 121ff] *interaction trajectories.*

Figure 3 (b) shows for instance, how we marked the path of an artifact through the work environment. If this is done during an interview, the description of work processes becomes extremely situated and precise. In further analysis it is possible to use several of these trajectory diagrams to draw conclusions about badly placed artifacts or even parts of work processes that can be optimized. Especially when an artifact is used by several roles, these diagrams can help in finding the most appropriate location for it.

*Situated Cooperation Diagram*

We used a derivate of the exemplary modeling of work processes (eGPM [5]) to represent cooperation and work processes. The original version of eGPM gives a good overview of workflows, but disregards the workplace environment. It is also purposefully selective, not all artifacts used are also modeled, and achieved this by incorporating the eGPM onto the localization map, merging the two. The center of attention in this type of diagram is the user or actor (Figure 3 (c)). Cooperation of actors and different types of use of artifacts can be represented with different types of lines, for instance:

- Physical movement, e.g. "goes to the printer",
- Haptic use of an artifact, e.g. "uses the keyboard",
- Visual use, e.g. "looks at the pinboard",
- Acoustic use, e.g. "hears buzzer",
- Direct cooperation, e.g. "talks to colleague"
- Cooperation via media, e.g. talking on the phone

This provides yet another perspective on the complex workaday world. Looking at cooperation and workflow situated in their context and with special regard of artifacts used, it is possible to draw conclusions as to where artifacts can be better placed and, most importantly, gaps in the technical support show up.

*Working with Diagrams on the Localization Map*

The simplest possibility to use the Artifact Map is to bring a printout of the localization map, a legend for all numbers and the rich glossary as a booklet. Arranging the rich glossary and the localization map on a poster is great for group interviews because an even larger number of participants can easily use it together. The advantage of this larger version is that all artifacts with their details are available at one glance. While talking, the gaze can wander, and see something relevant to the question, triggering further relevant answers.

Answers are arranged in a special format – via a diagram drawn together on the localization map. Meanwhile, a team member takes notes to capture any verbal discussion contributing to the final diagram. Later an encyclopedia entry is made to reflect it.

Drawing a picture *together* with actors, instead of interviewers just taking verbal notes of their own, is of vital importance. The flexible symbolic language of the various diagrams produced on the localization map help interviewees to bridge the gap between their non-verbal implicit knowledge and the verbal explanation they are asked to give. Conveniently, this process co-produces a record for future reference.

All those pieces together eventually produce a multi-faceted *locale map*. The Artifact Map with diagrams, rich glossary and comments provides general information about the context. The text and the diagrams allow different perspectives depending on the research questions.

Of course other methods complement the Artifact Map. P*ersonas* for example, are useful to picture the social context. Non-localized eGPMs provide an additional perspective on the process component. Other methods can potentially be combined with the artifact map, providing a more complete or pertinent version of the context.

## THE ARTIFACT MAP IN THE VESSEL TRAFFIC CENTER

During our research project in the VTC, one Artifact Map was created, showing two offices, where two small teams work with a large number of artifacts. One office is responsible for planning for future traffic in the port. The other office is responsible for guiding the current traffic by communicating with moving vessels mostly by radio. The final Artifact Map contains the spatial layout of the two offices and a rich glossary of 169 entries. The poster version in Figure 3 has a height of about 5ft (1.5m) and spans 11.5ft (3.5m).

We gathered data in both offices at the same time. In each office, one researcher spent approximately 16 hours collecting data. That included photographing all artifacts, locating them in a sketch (that would later become the localization map), taking notes of explanations of artifacts, and, if possible, observing their use. Subsequently, data was reviewed, amended, edited and finally converted into a large poster version. The poster was presented at a workshop and, even at that stage, a lively discussion began about several artifacts and their use. Corrections and amendments were added with post-its. We put up the Artifact Map poster along with post-its and pens in the VTC directly after the workshop. In this way, all employees had a chance to further inspect it and make comments, even if they had missed the workshop.

Using the revised version, we, together with the users, produced frequency-of-use-diagrams for different roles and trajectories - as well as situated-cooperation-diagrams for several questions. Some of those questions had been raised during the preparation of the Artifact Map. During initial interviews we used the large poster version (Figure 3 (d)) displayed on a wall for an overview and to stimulate discussion. Later, we switched to a large printout of the localization map along with a numbered key list and the rich glossary as a reference booklet for artifact details, if

needed, as shown in see Figure 3 (e). This was possible, as we all increased our familiarity with the method and context and needed less reference to details of artifacts.

All diagrams from interviews were drawn by hand on a localization map, 12x16inch (30x40 cm), mostly on transparent sheets. This allowed later easy combination and comparison of different diagrams.

This method of creating diagrams has proved very effective in the VTC. Each artifact was already "there", represented by its number and located in its "normal" position. So everyone knew what someone else was talking about without further discussion as soon as the artifact, role or space was referenced on the map via pointing to it. This made interviews effective and efficient, leaving more time and attention for the actual question. Additionally, since all interviews were documented by a diagram, a shared context for the answer to that question was created. This proved very helpful when later adding any details to that answer or for presenting information to outside stakeholders.

## FROM ANALYSIS TO DESIGN

At the end of the first phase of our project, we ended up with rich contextual data from many sources. Based on that, we developed hypotheses as to what were the most pressing problems and what resources had to be preserved during future changes. Here, the various maps aided by providing and easily accessible visual overview and anchor for all the interviews and findings. We also formally explored strength and weaknesses, collected and prioritized all our obervations and formed hypotheses. We then tested and refined our hypotheses in participatory workshops, often using the Artifact Map as a common focus, until we reached a consensus on needs and requirements. The results were presented to decision makers, who then elected a few *focus areas* for work on initial design solutions (see Figure 4 for the general design process).

The Artifact Map as a tool for analysis helped us identify several problems elected as *focus areas*, i.e. information on hazards and construction sites in the harbour; and 'a better way to keep up to date on the weather'. When doing *locale maps* for the main work processes, we realized that updating weather information involved a quest and the use

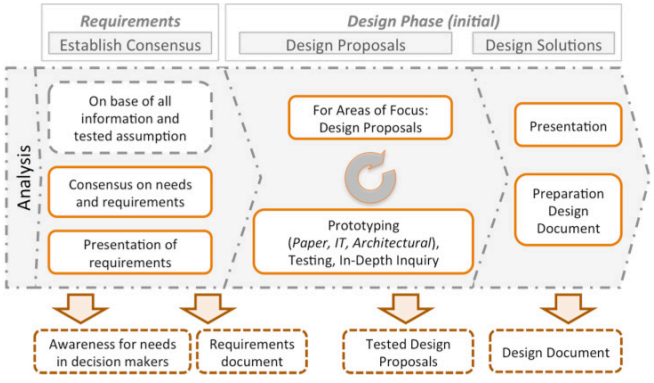


**Figure 4: From Analysis to Design**

of many artifacts, some electronic and some paper, scattered across the office. For hazards and construction work in the harbor, the situation was even worse. It was necessary for users to hunt for pieces of the puzzle across the office, with their colleagues and sometimes via phone or radio. These tedious tasks did not provoke comment from the nautical officers, as they had become so used to them. The Artifact Map made transparent a work process that we would not have thought of asking about, nor they of complaining about. These areas of focus came as a surprise to the clients and us, but were obvious, once identified.

Another *area of focus* was to give recommendations for the architecture and ergonomics of the VTC of the future. This required us to maintain a focus on the situated quality of the work, and was one of the main reason to develop the Artifact Map. Thanks to our *locale maps* we could make those recommendations. We did not only analyze the work but also how much space it would need, how close this space needed to be to other relevant spaces, how often the tasks were conducted and so on.

It is notable that it would have been compelling to stick with the most prominent paper-based artifact of the office as an area of improvement, the paper strips used to symbolize the ships while inside the territory. Like air traffic controllers in the studies cited above, the nautical officers had intricate ways of interacting with their strips, annotating them, sorting them according to the status of the ship, and arranging and rearranging them to literally keep "in touch" with current traffic. In the initial interviews, they appeared often both as an object of love and of hate, and much attention was spent upon whether or not to replace them. Similar to Mackey [12], we came to the conclusion that they were a part of the nautical officer's work that was fit for purpose and did not need now digital replacement.

Our questions also focused on why some tools in the past had been rejected. The main reason was that although tools provided information, they were inadequate as to the kind of information or *presentation of it* and in the affordance for *interaction* with the tool. For instance, the nautical officers working the radio preferred to use seven paper artifacts that were accessible to them at one glance, rather than to use the mouse to look one of them up with a click, because that presented too much cognitive friction. They were open to change, but it had to be of the right kind.

To briefly describe the further design process: we made working design proposals for the three areas of focus. In order to do this, we created a paper prototype and design documents for a weather-and-tide tool, and an actual software prototype of a tool to manage information on construction work and hazards in the harbor. To propose adequate *presentation* and *interaction*, we researched current state-of-the-art hardware and I/O-options in order to present the nautical officers with a range of diverse solutions to fit their needs. Once we had identified possible candidates, we tested our solutions for all *areas of focus* by

creating an architectural model of a possible future *localization map*, complete with hardware and furniture, and we discussed our proposals on the basis of this model.

In design workshops with our clients, we worked in a very tangible and situated way (see Figure 5). For example, we used the exact size of a monitor cut from paper and pinned on boards, to give staff an idea of how their office and desk might look. Since we had access to a VR lab, we mocked-up an electronic wall using the lab's projection wall. We also had the construction site prototype run on a multi-touch digital tabletop, which met with general approval.

At the end of this iterative phase, we summarized the design solutions and presented them to the decision makers. Thanks to the participative development of those solutions, they were immediately and fully approved.

## DISCUSSION

In our work for the VTC, we faced the challenge of how exactly to gather and present the data necessary to understand the particular *wicked problem* we were dealing with. Since we had to analyze the work on many levels as detailed in the *Locales Framework* [6], and especially when dealing with the spatial aspects of work, current methods were not sufficient. Some of the classic methods disregard the space within which the work takes place, so they are not helpful when detailed situated results need to be obtained and documented (i.E.: Bødker et al. [3], Mayhew [12], Breitling et al. [5]). Beyer and Holtzblatt describe five types of models that allow conceptualizing central aspects of the workaday world [1]. These work models capture similar information as our artifact map. The *artifact model* describes details about important artifacts and the *physical model* documents spatial circumstances including some artifacts. These two come closest to the Artifact Map. *Sequence model* and *flow model* capture information about work processes. In our approach similar information is visualized in Situated Cooperation Diagrams as well as encyclopedia entries.

In contrast to these work models we demand to capture **all** artifacts in the Artifact Map. This prerequisite has four major advantages. Firstly, one cannot know in advance which artifacts will turn out to be important for future improvements. In our case, for example, the related artifacts have never been mentioned in interviews. This way it is made sure that all are considered. Secondly, each artifact is a trigger for use stories, social stories and connected information. In this, the process of creating the artifact map is a byline or surrogate in the pursuit to foster the telling of all tacit information. Third, the task to document all artifacts allows the person preparing the map to become invisible during a normal workday, the immersion necessary for any participant observation. Fourth, in the case that complex work and many artifacts need to be understood, this approach provides a valuable structuring of the extensive analysis process.

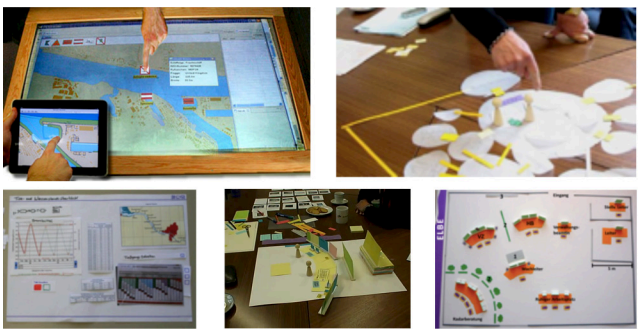

**Figure 5: Design Models and Prototyping**

### The Problem of Abstraction

Abstraction, while being a necessary part of research, always requires leaving details out. Which details is up to the judgment of the researcher in accordance with criteria that he or she needs to determine in advance. This requires that the researcher already *knows* what is important. In a context such as ours, where work relies heavily on expert knowledge, situated action and a complex mental model, this is impossible. Knowing what is important is not the prerequisite, it *is* the research.

The Artifact Map, while not being a panacea to this problem, provided help in how to tackle it, when used in tandem with domain experts. By starting from the workspace and the artifacts and then building up, it is ensured that researchers start with a *complete* overview of "the work", even the parts that are routine or easily forgotten, since every task involves a location to do it in and artifacts to do it with. As shown in our example, people tend to forget or omit parts of their work and those can be hooks for solutions.

The process of creating the Artifact Map initially provided a rich body of ethnographic data. As in any ethnographic enquiry, the researchers spend a large amount of time just "hanging out" in the context, and can develop a general feeling for it. Researchers also found the Artifact Map helpful in acquiring membership, perhaps also because the map made abstract everyday work tangible and visible and helped appreciation of just how hard and complex it really is. This phase of comprehensive appraisal provided insights into the right questions to ask.

### Digging It Out: Making Tacit Knowledge Explicit

The Artifact Map, once created, also served as a context in which to answer questions together. A lot of the expert knowledge of the nautical officers was tacit, and when asking some questions in normal interviewing situation we received short and generic answers. In-situ interviews might have provided a solution, but may have impeded cooperation and disturbed the current workflow. The Artifact Map served as a surrogate paper context and triggered long, detailed answers and numerous anecdotes. We refined our questions and explored answers together with the nautical officers, who reported that seeing their workplace in the Artifact Map "from above" made them see it with fresh eyes. In open discussions, our questions which were sometimes instructive ("what do you do? why do you

do things this way?"), sometimes hypothetical ("what if you had …?") were either answered with good justification for maintaining the status quo or with new creative ideas.

We found that visual and tangible methods including our diagrams take the *mutual learning process* advocated in the participatory approaches one step further, giving the users themselves tools how to *express* what they *already know*, and making their *tacit* knowledge *explicit.*

### Situated Work Processes

In our example, document analysis showed that the job descriptions of the nautical officers were at the same time results-oriented and surprisingly vague. The official documents state clearly, what *results* the nautical officers in charge need to achieve, but leave it to the individual *how* exactly to achieve them. This is also due to the nature of the work. Important tasks involve highly responsible *decisions* which require expert knowledge, experience and an adequate mental model of the current situation. Along with their responsibility, the nautical officers in charge get flexibility to do whatever *they* find necessary in order to make those decisions.

This means, the individual nautical officers, but also the different groups, use *different processes* – depending on the situation as well as personal preferences – to obtain the information necessary to build and update their very own mental model. Some prefer visual representation of data, others need to read descriptions and some developed a seemingly supernatural ability to parse through vast amounts of acoustic input from radio channels. This is an extreme case of what Suchman [19] described as the difference between *plans* and *situated actions*. Instead of acting upon one big plan that can be described step by step, like a business process, a person has many optional little plans at their command, and employs them reacting to the conditions at hand in their particular situation. Modeling exemplary business processes can thus not provide a sufficient understanding for creating better solutions – because the processes necessary to make those informed decisions are by nature not exemplary, but situated.

This presents a problem when new technical solutions are to be designed. CSCW presents the special challenge that since tools are used cooperatively, individualization by one person might present the others with cognitive strain and standardization of certain features is important [12]. The balance between the necessary degrees of individual freedom and the necessary standardization is a delicate process upon which the efficiency of the "VTC of the Future" hinges. Since the users need to handle the resulting workload, it is the users that need to negotiate amongst themselves over these questions. The Artifact Map, in our experience, provided an appropriate tool to keep the discussion situated and precise. It helped us to moderate the often heated controversies by suggesting a "zoom in" on certain details or "zoom out" to set things into a wider perspective. We believe that this is a general advantage of providing any sort of tangible representation of the work context and is one that can stimulate a quicker and more focused development of solutions.

### Participatory Ethnography

In comparable situations, researchers use extensive video analysis to understand contexts of high complexity and intricate patterns of cooperation (e.g. [18]). After a video is taken, ethnographers transcribe and analyze the data with methods from ethnomethodology or conversation analysis [6, p.15-54]. This brings detailed and valuable results, but at tremendous costs. It is laborious, time-consuming, requires special equipment and a team of specifically trained ethnographers; that may not always be at hand.

Creating and using the Artifact Map certainly also requires competent ethnographers for full benefit, but it shares the advantages of associated PLA methods: It is quick, efficient and thus economical. By following simple tasks like gathering knowledge about artifacts, most of the context and task information is already retrieved (yet maybe, without proper ethnographic training, not correctly further processed). We have followed many of the principles of PLA, like *triangulation* – answering the same question with different methods with different people, or *optimal ignorance*, best captured in the phrase "it is better to be approximately right than precisely wrong".

Also, the domain expert users are treated as equal team members. The method is more *participatory,* as in classical ethnography, the ethnographer "carries away" the data to do the analysis somewhere else and presents the findings later. Here, at least some of the interpretation emerges in a common discourse between researchers and work experts and any remote analysis was discussed with the work experts within a short time frame. There is a focus on *learning*, since the technical experts need to learn about the workaday world and the local experts need to learn about technological possibilities (and impossibilities), in order to get into *action* and creatively develop and refine solutions.

### A Common Language

At the same time as supporting users to express themselves in a flexible, multi-faceted, multi-dimensional language the Artifact Map helps users and researchers to develop a common language. This has been described as a major problem in the design process (Fitzpatrick [6] amongst others). While a common language is established using the artifact map, it conveniently produces along the way a tangible artifact that documents shared understanding.

This makes the Artifact Map particularly useful as part of the design process. Using the Artifact Map itself, the diagrams, the rich glossary with comments and the encyclopedia, detailed, situated results of the fieldwork can be presented to developers or any other party involved. This portable format transmits a large amount of information on many levels and yet is easy to understand. Furthermore, it equips users and designers with a common language with which to discuss needs.

## SUMMARY AND CONCLUSION

The development and use of the Artifact Map proved to be very helpful to us in the participatory analysis and design project in the context of a large port VTC. In addition to core IT considerations, this project had a strong focus on general proposals for technical, spatial, organizational and ergonomic improvements for the 'VTC of the Future', a complex and cognitive demanding workplace.

We use the Artifact Map in two stages: First, we build the map, collecting all information about all artifacts, plus all additional information triggered by this process. Second, the resulting map is used as in interview method to retrieve diverse information, mapped in various forms on the localization map. With this visual, tangible and shared method, in addition to other methods from Participatory IT Design, we were able to quickly collect a lot of information about use of artifacts, processes, social relationships, space considerations and so on in a structured way. At the same time, the clients more and more accepted us as our partners in the pursuit to improve their workplace. We contribute this to the fact that results from interviews and workshops immediately became visible and users had a feeling of agency over their contributions and the overall project.

While using the Artifact Map, we found areas for improvement that we probably only identified because of the situated and tangible way the map supported our work. The areas of work that this affected dealt with various tasks that could appear as scattered and minor, but in sum composed tedious tasks involving many artifacts. The Artifact Map, through its abstracting surrogate character, provided a tool for easy reflection on the everyday work context. This, in turn, supported immediate, creative new design proposals with clients. We believe that this approach is useful for other projects, regardless of complexity, due to the methodological advantages detailed in the discussion.

With the Artifact Map we have created a tool that helps us to better understand the "wicked problem" of design and to find appropriate solutions. It is particularly helpful in a complex context where cooperation, a large number of artifacts, multiple people sharing the same tasks and expert domain knowledge need to be taken into account. Using the Artifact Map supports a truly participatory mutual learning process between researchers and users, allowing researchers to understand the context, while users are helped to make their own *tacit* knowledge *explicit,* become creative analysts of their situation and creative designers of their future workaday world. This, in turn, further aids the design process, since users are much better equipped for talking to designers about their needs in a common language established and refined during the creation and use of the Artifact Map.

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