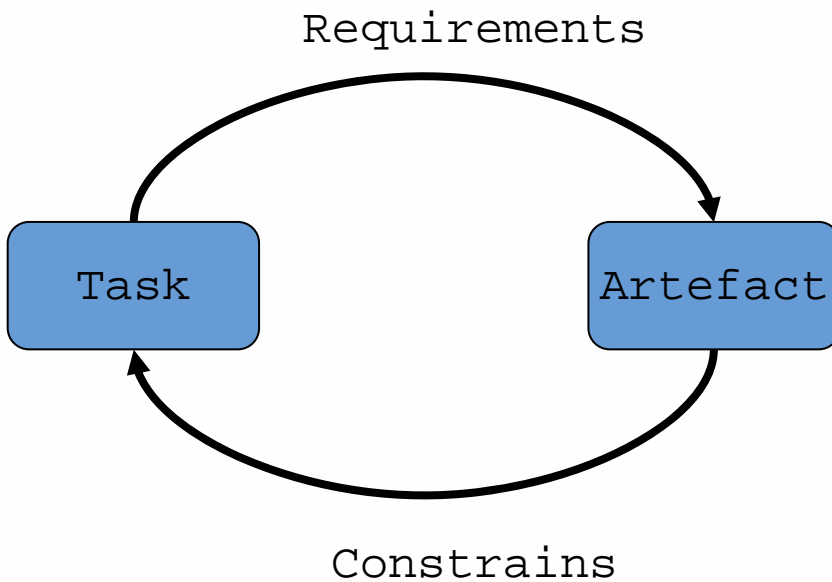




# Psychology and product innovation: Radical innovations in human-technology systems

Associate professor Thomas Hoff  
Department of psychology  
University of Oslo

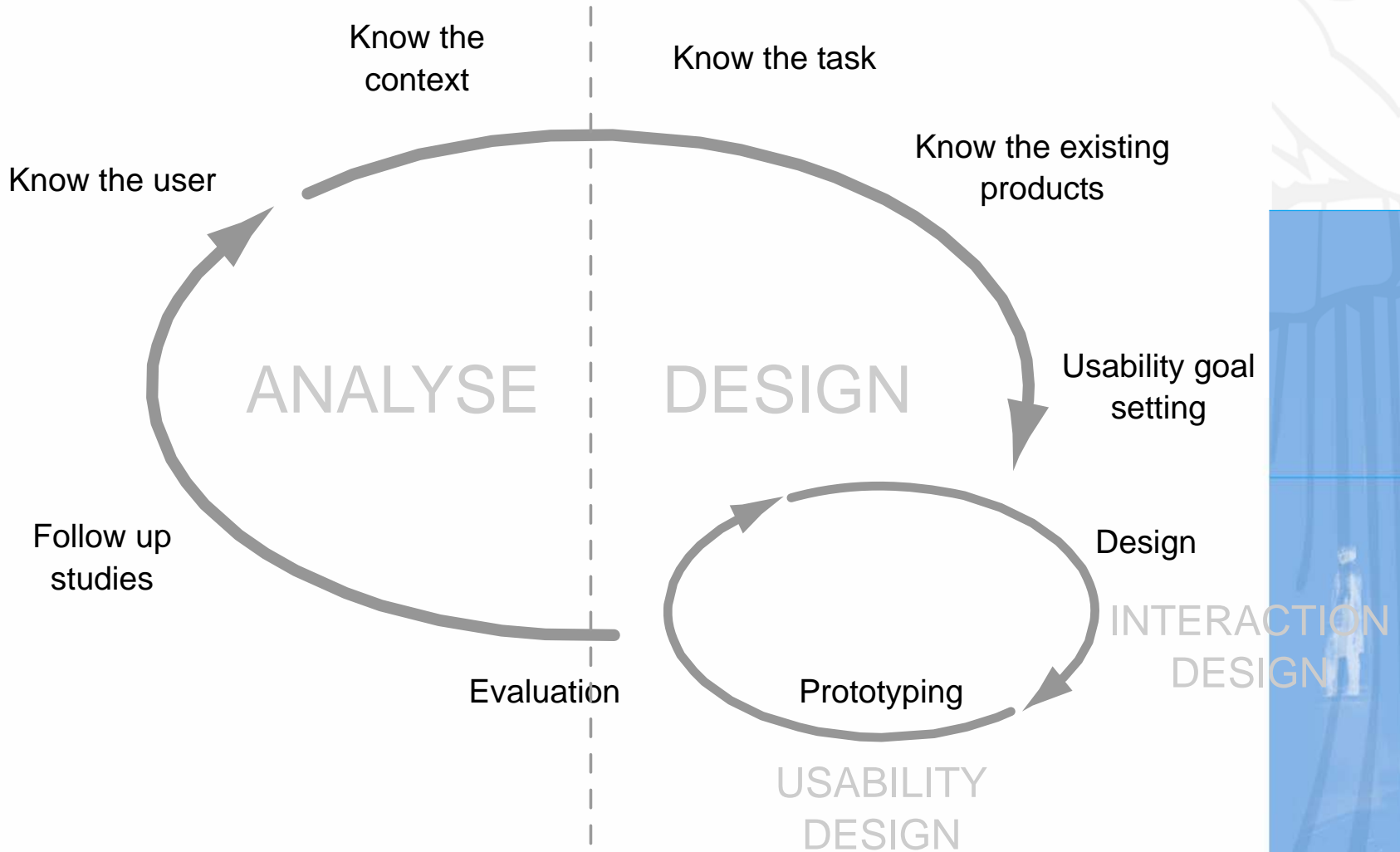
- From evaluating existing systems versus anticipating and active shaping of new forms of work practice



# COGNITIVE ENGINEERING



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# Research on human-technology systems

## 1) Control situation in High Speed Crafts

Bjørkli, C. A., Øvergård, K. I., Røed, B. K. and Hoff, T. (2007). "Control Situations in high speed craft operation." *Cognition Technology and Work* 9(2): 67-80.

## 2) Redesigning maritime navigation equipment

Bjørkli, C. A., Røed, B. K., Bjelland, H. V., Gould, K. S. and Hoff, T. (2007). "Activity theory as a supportive framework in design of navigation equipment." Activites: Revue Electronique 4(1): 179-187.

## 3) Redesigning the audio systems for personal cars

Bjelland, H. V., Hoff, T., Bjørkli, C. A. and Øvergård, K. I. (2007). "Design of Invehicle Audio Systems." Design Journal 10(1): 24-24.



Cato Alexander Bjørkli · Kjell Ivar Overgård  
Bjarte Knappen Røed · Thomas Hoff

## Control situations in high-speed craft operation

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**Abstract** The control situation framework presented by Petersen (Cogn Technol Work 6(4):266–274, 2004) is elaborated upon in the context of military high-speed craft navigation. An observational study was done on a military navigational exercise in Indre Folda, a stretch of particularly demanding confined waters in Norway. The concept of control strategies is presented as a term related to how navigators choose to take out the control possibilities present in the system. Control actions are viewed as actions that fix the control demands and control possibilities over longer time-scales. Control strategies are different from control actions in that they continuously alter the control demands and control possibilities through its execution.

**Keywords** Control situations · Human–technology systems · High-speed crafts · Dynamic adaptation · Navigation · Maneuvering

### 1 Introduction

High-speed craft (HSC) offers special challenges to operation and service in maritime transport. This class of ships has top speeds of minimum 25 knot, and the construction is lightweight. The characteristic features of

HSC are the combination of high speeds and their operation in closed waters. These features are particularly observable in HSCs in military settings. Military fast patrol boats (FPB) have the same attributes as HSCs, but the military context further accentuates the challenges of safe and efficient operation. Military vessels operate across a wide range of contexts and conditions given the great variety of tasks. For example, military vessels must be able to sail into unknown waters and have the ability to quickly change the navigation plans, and this is in contrast to commercial vessels sailing fairly predefined routes and known regions. The issues of maneuvering and navigation thus become key areas of performance when considering operation of HSCs in military service. Further, the flexibility and expertise to fulfill the task of military naval presence in designated regions calls for the ship and crew to perform to the limits of their capabilities, thus constituting a rich and informative field of study for the dynamics of complex man–technology systems.

Generally, the issue of safety and efficiency in maritime transport depends on the maneuverability of the ships. Maneuverability refers to the ability to maintain and change speed (e.g. accelerate, hold, and decelerate) and course (e.g. keep and alter a straight line course). These abilities are instantiated in physical components for the production of longitudinal force (e.g. propellers) and rotational force (e.g. rudder). The reciprocal interaction of the shape of the hull together with the physical components gives rise to the course stability and steering qualities of a ship.

This article aims to investigate safety and efficiency in design and modeling of complex human–technology systems as observed in the maritime transport domain, and especially HSCs in military service. We will discuss the control situation framework offered by Petersen (2004) that addresses issues connected to the capacity of physical components in relation to their interaction with the immediate context. The control situation framework will be discussed and applied to the HSC domain by outlining how control situations will differ from the

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*Fast patrol boat - Hawk class vessels*

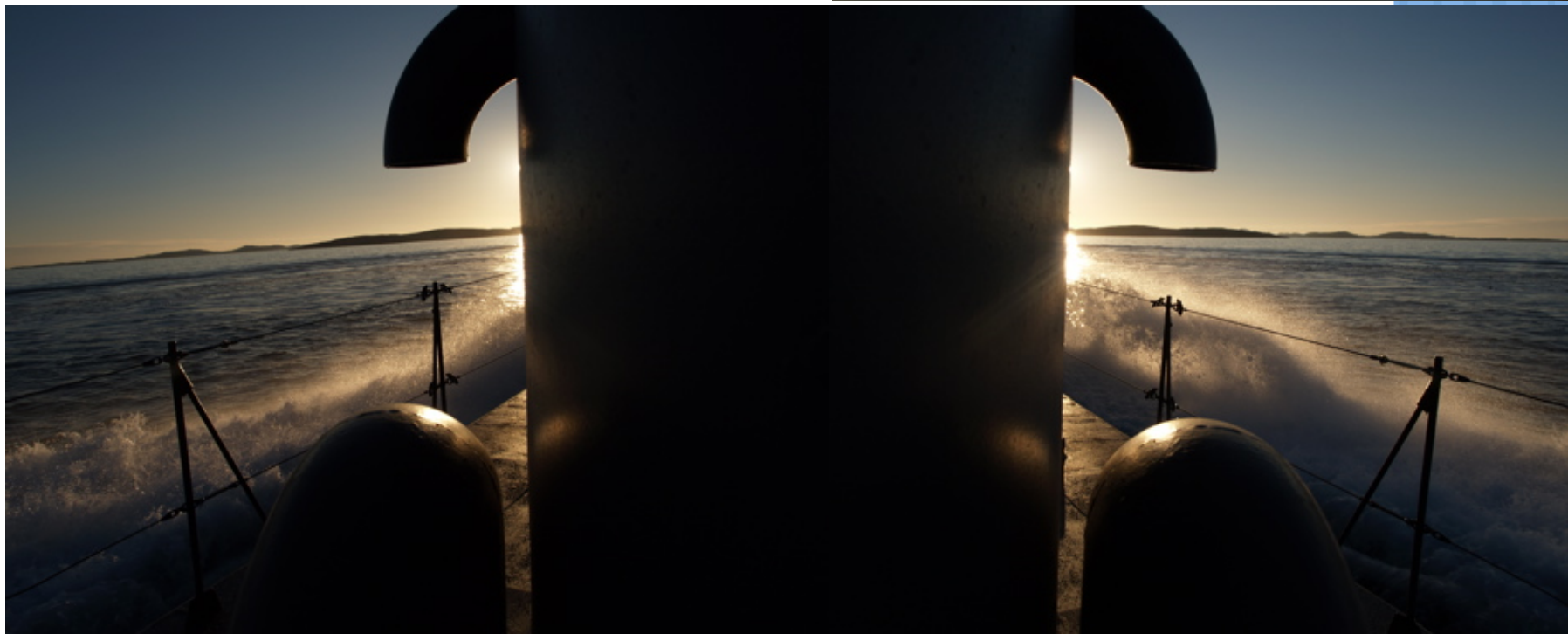
*Length: 36,5 meters*

*Weight: 150 tonnes*

*Maximum speed: 32 knots*

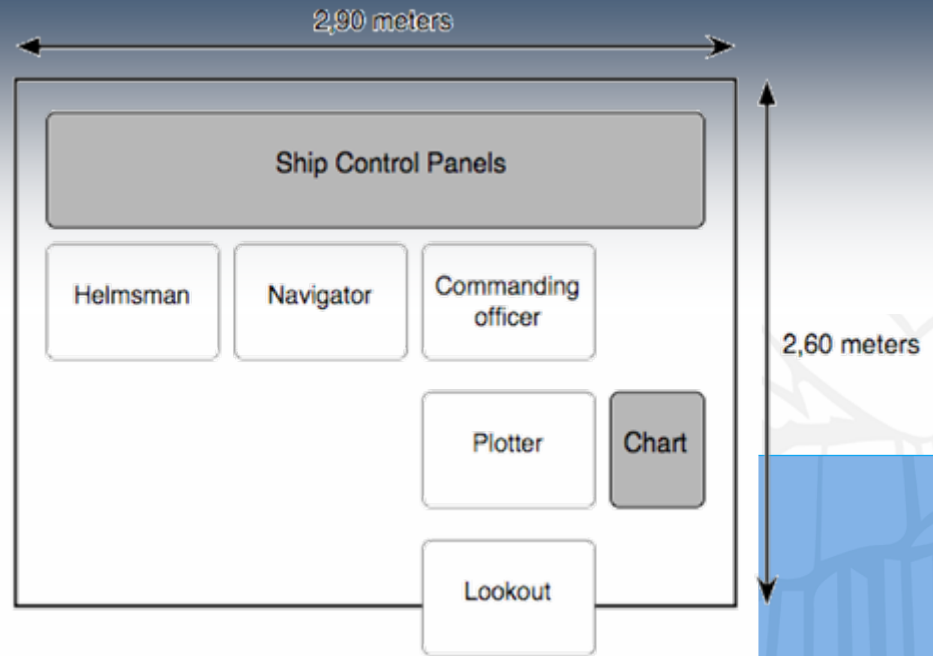
*Effect: Two diesel engines of 3600 hp each*

*Capacity: 15 crewmembers*



Navigation:  
Knowing where you are  
and where to go next

Manoeuvring:  
Steering the ship in  
accordance to navigation  
and immediate surroundings



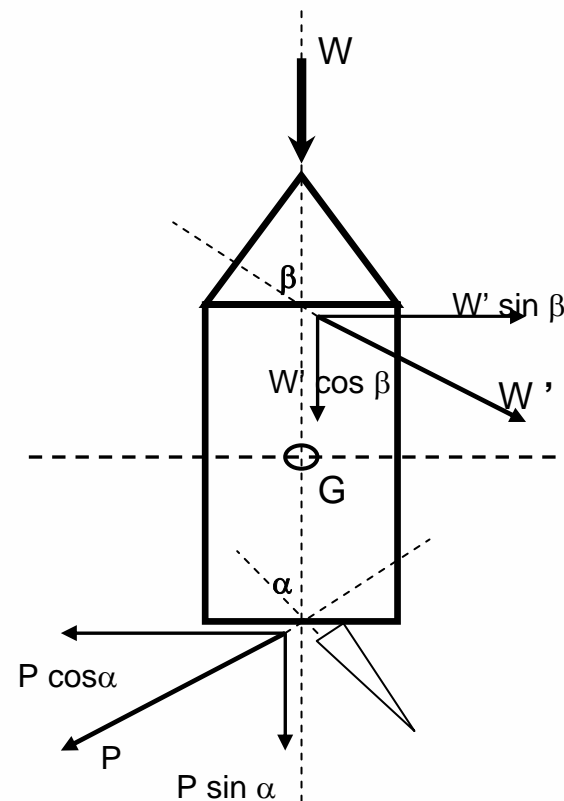
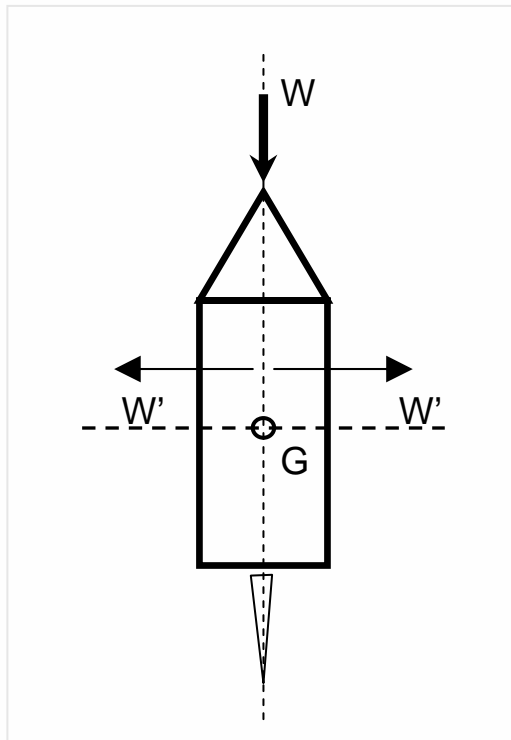


# 1) Control situation in High Speed Crafts

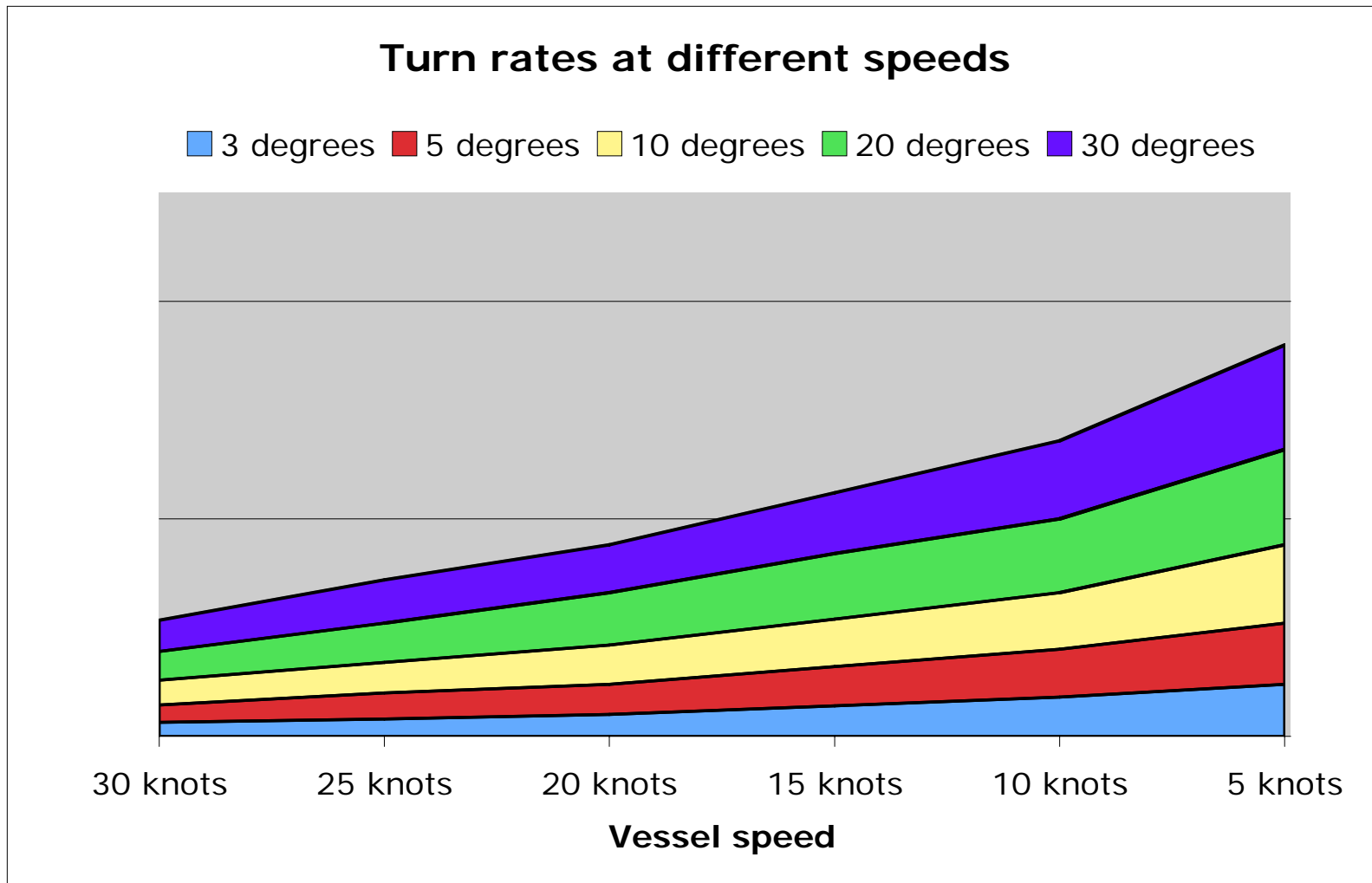
- A ship class specifies formal capabilities that the crew applies to solve the formal instructions of safe and efficient operations.
- The technological constitution sets limits for what the ship can do, setting up a space of possibilities (capabilities and demands)
- The crew members apply control strategies to to find the balance between optimizing efficiency (taking risk) or idealizing safety (going slow).

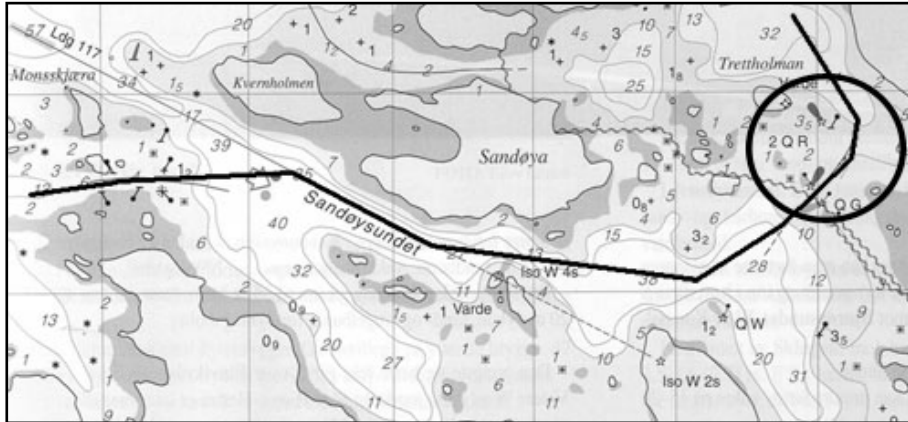
## 1) Control situation in High Speed Crafts

Formal maneuvering capabilities are specified in standard hydrodynamics and fluidmechanics

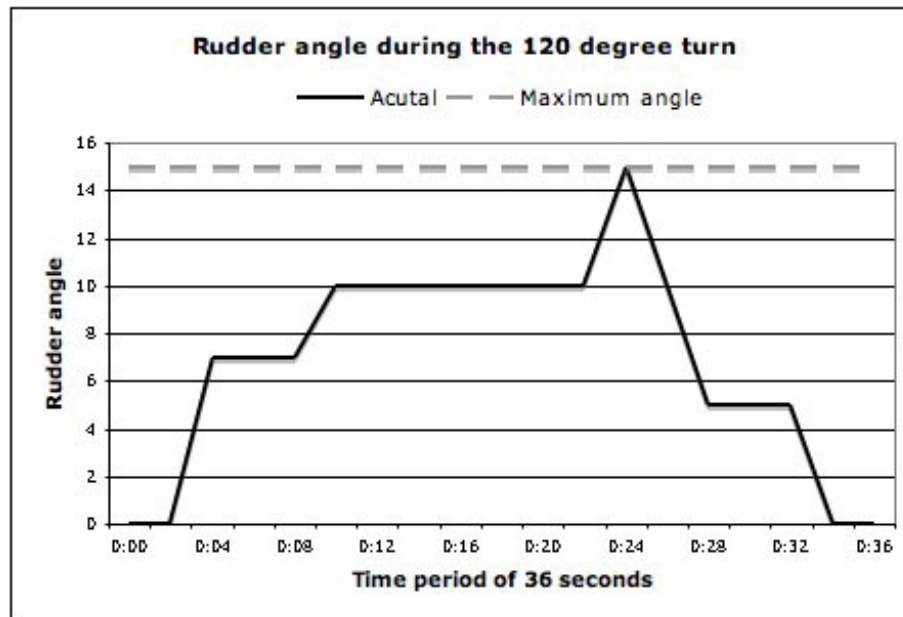


# 1) Control situation in High Speed Crafts



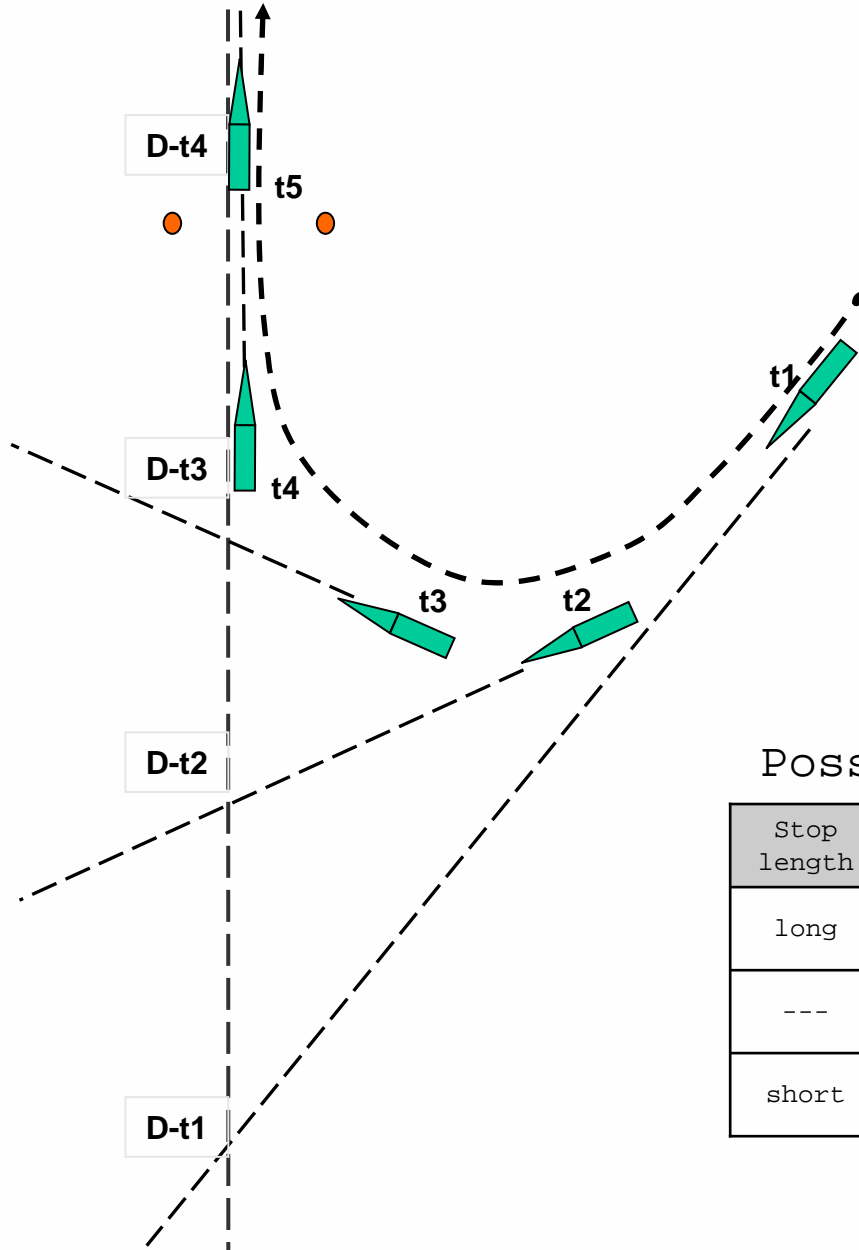


Excerpt from sea chart:  
Indre Folla region,  
the 120 degree Turn



HTO performance:  
Actual rudder angles  
during the 120  
degree turn

# Control situation in High Speed Crafts



SITUATION (S-n)

Time-n	Deg(D-n)	Heading	Position	Speed
t1	d1	x1	y1	z1
t2	d2	x2	y2	z2
t3	d3	x3	y3	z3
t4	d4	x4	y4	z4
t5	d5	x5	y5	z5

Possibilities

Requirements

Stop length	Speed Change	Turn rate	Situation	Speed	Heading	Position
long	slow	low	S-1	high	sharp	far
---	---	---	S-n	---	---	---
short	quick	high	S-2	low	soft	close

## Skjold class

The Hawk class is being phased out, and the new Skjold class will replace Hawk vessels

*"The bridge is equipped with all modern electronic navigation equipment"*

*"Everything is controlled by automation and advanced data networks"*

Air Cushion Surface  
Effect Ship

Weight: 260 tonnes

Speed: 60 knots

Effect: 16.000 HP

Crew: 2 navigators



## Activity theory as a supportive framework in design of navigation equipment

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### ABSTRACT

This study reports on the use of Activity Theory as a supportive framework in a design process. Crews on Fast Patrol Boats in the Royal Norwegian Navy were observed during high-speed navigation in coastal waters. The unit of analysis was the navigation team of five persons in their work. Activity was regarded as situated actions shaped by tools, objects and constraints. The framework of Activity Theory was used to form a design language that encompassed the aspects relevant to design and navigation. Based on the findings, a prototype of a automated steering system was built. We suggest that in design process, Activity Theory moves the focus from the technical qualities of artefacts towards how artefacts are used as tools to mediate activity.

### KEYWORDS

Activity theory, design, ships, navigation

## 1.- Introduction

A team working on the ship's bridge navigates the ship by cooperation and operation of advanced equipment in order to proceed safely. A ship is here considered a dynamic system as it is heavily influenced by environmental factors such as weather, wind, and visibility conditions.

During the last 10 years automated systems has largely been utilized in operations of ships. Despite the complexity of modern ships, the design of the bridge layout and navigation artefacts is traditionally not subject to any explicit design process. Safe operations are established through the fulfilment of technical and functional demands stated by classification societies and international organizations.

Technology driven design narrows the designers' focus to technical features of the single artefact, rather than focusing on its actual use. By using Activity Theory (AT), we wanted to expand focus to describe how artefacts have more than technical and formal qualities. This study will investigate how such an approach can shape design.

Design approaches commonly emphasize the need to understand the context in which products are to be used. However, these approaches are primarily ways to identify and organize steps in a design process, rather than research-based theoretical frameworks that guide in how to describe context of use. Support from AT may augment design approaches by providing tools for understanding the meaning and implication of the context.

In a design process, AT intends to bridge the gap between descriptions of work and the design of artefacts. This is a large step that can be taken as two smaller steps. First, AT can be used to give a description of work. Second, AT can contribute to a *design language*, which represent those aspects of work that matter to design (Beyer, & Holzblatt, 1998). This paper primarily concerns the latter aspect, but the forming of a design language is based on a more comprehensive AT study of navigation

# Redesign of maritime navigation equipment

Electronic map

Soundscape

Ship autopilot

## Vibration Ecdis Concept

The Kongsberg Maritime Design Section | Human Factors Research Ltd

### Background

When planning a route on the ECDIS, the navigator operates a virtual list for positioning different waypoints. Waypoints are then combined into a sailing route. When route planning is finished, the ECDIS can evaluate the route and notify if any sailing on the route is feasible. During evaluation, feedback from the ECDIS to the navigator is given as text or warnings.

The "Vibration ECDIS" spans up two new aspects on the ECDIS: (1) give the navigator real-time feedback, and (2) enriched feedback.

### Design

The prototype of the "Vibration ECDIS" consists of a Kongsberg Maritime ECDIS run on a laptop PC and a haptic mouse. The connected mouse has programmable vibration functions, which is felt through the hand of the user. This type of feedback gives the user a richer experience than just text, without being intrusive (like sound feedback would be).

For demonstration, the mouse was programmed to vibrate each time the line between two waypoints touched or passed over land. The vibration indicates that the navigator is about to make a plan that can lead to grounding. The vibration gives real-time information and demonstrates the inseparable connection between potential dangers and feedback. In contrast, ECDIS provides feedback during the evaluation process, which usually would take place at a later time.

The "Vibration ECDIS" prevents the navigator from overlooking small, but important details in the electronic chart. The feedback is given directly to the body of operator, and there is no need to identify and read text.

### Further interaction designs

Further work can reveal if the "Vibration ECDIS" can be connected to the ECDIS route evaluation criteria for providing true time feedback on the route planning.

Use of different vibration envelopes can be used to represent different types of feedback, e.g. one type of vibration for to sharp turns, another vibration for passing shallow areas.

### Point of contact

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## The Soundscape Concept

The Kongsberg Maritime Design Section | Human Factors Research Ltd

### Background

Sound is an important information source on the bridge. Motor sounds, jolting from the crew and hammering from parts of the boat tell the navigator much about the situation. But in bridge interaction design, the use of sound has mostly been limited to one single alarm beep which is used for all kinds of alarms. This leads to confusion, annoyance and eventually loss of attention.

A soundscape can be described as three-dimensional (1) frequency (tone height), volume and complexity stretches out a room where sounds can be placed. The existing alarm beeps are situated in the exact same place in this room, and are therefore overiding each other instead of making use of the full potential. Sounds also have a wide range of other qualities based on overtones. An instrument has full, rich overtones and are therefore very comfortable to listen to. On the other hand, a sinus beep has no overtones, and easily becomes annoying.

### Design

Our concept demonstrates a change of course on a Skjold bridge, and is made as an MP3 file. The gyrocompass has been equipped with a tic for each 0.5 degree of course change, like in older fast patrol boats. In order to support mode awareness when using steering automation, the tic has some important properties:

In manual mode, the sound is "organic" in order to signal that the mode is done manually, by a human.

In auto mode, the sound is more technical in order to discreetly make the operator aware of the mode change in track mode, the tic changes to an unmistakably electronic sound.

On mode changes, the bridge gives a pleasant, short and fast melody played on a

rhodes piano. The three tones are put in rising order when entering a higher mode of automation and vice versa.

Soundscape is all about making subtle changes in an environment where attention is an extremely scarce resource. It can dramatically ease the learning curve for new recruits, as well as support experienced users in high workload situations.

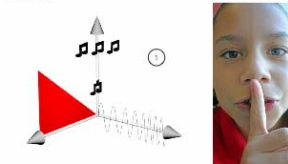
**Further development:**  
Explore the possibilities in alarm differentiation. Directions, spreading out the sound sources. Experiment with ambient and intrusive sounds.

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Gyro compass



## The Slider Concept

The Kongsberg Maritime Design Section | Human Factors Research Ltd

### Background

On modern ships automatic steering systems are used to steer ships very accurate and decrease the workload for the navigator. However, automatic steering of a ship can cause problems and accidents. Automation is a powerful player and can cause confusion about who is actually in control of the ship and what modes that are used for steering. A challenge in design is to make the system clearly show what mode it is in.

### Design

"The Slider" arranges the steering positions for ships. The concept is based on a semi-transparent, physical cover sliding over the unused functions, letting the operator change more consciously between steering modes.

"The Slider" builds on the existing Kongsberg Maritime AP2000.

Our concept is used by the navigator to steer the ship in (1) manual mode or (2) autopilot mode or in (3) auto track mode. The design of "The Slider" demonstrates how a system clearly can present the mode in use for steering to all crew members on the bridge.

The three steering modes have their own specific panel. The highest degree of automation (auto track) is located above the medium degree of automation (autopilot). Controls for manual steering is located lowest down. This is a concrete representation of the navigator "high and low degree of automation" where the degree of automation correspond to the physical location of interfaces.

The moveable surface, a curtain, can be operated in 3 positions. When the curtain is completely down, only controls for manual steering are available. When the curtain is mid position the controls for manual steering and autopilot are available. When the curtain is fully open, panel for all three steering modes are available.

Lowering the slider from fully open to mid position takes the ship from auto track to autopilot steering. Closing the slider fully initiates manual steering. Manual operation of the joystick will take the ship to manual steering no matter previously active mode.

**Further interface developments**  
For further development, "The Slider" can be combined with other types of rich feedback to the navigator. Use of sound representations can support mode information.

The joystick can be motorised and move according to rudder angles. This will visualise how the automation steers the ship.

The operator panels can be further developed to present ecological information.

### Point of Contact

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The Slider



Full automation



Auto track mode

Auto pilot mode

Manual steering



Kongsberg Maritime AP2000



# A CASE STUDY OF A TOUCH-BASED INTERFACE FOR IN-CAR AUDIO SYSTEMS

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**KEYWORDS:** Touch-based interaction, multimodal interfaces, traffic safety

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**C**urrent in-car audio systems are part of a demanding driver-vehicle interaction that is responsible for a high number of traffic accidents. This paper addresses this issue and describes some common problems regarding current in-car audio systems. A project is presented which was initiated to explore alternative interfaces using touch-based interaction, resulting in a working prototype, tested on 25 people. The prototype demonstrates how the focus on touch interaction and the change of position and interface controls, without the use of any expensive or advanced technology, can significantly alter the drivers' operation of the in-car audio system. The results are encouraging.

## INTRODUCTION

Since the introduction of radios in cars in the early 1920s, the in-car audio system has evolved and been supplemented with other sources of media, like the cassette and the compact disc. Today even other sources like MP3-players, digital radio and memory cards are added. In addition to the original on/off, tuning and volume regulations, modern systems enable the user to adjust the quality and physical balance of the sound. They also present a vast amount of extra

functions for the radio as well as other media. The developments in in-car audio systems are part of a general, substantial increase in the complexity of the driver-vehicle interface (Burnett, 2001). Even though it is shown that the in-car audio system is an important cause of traffic accidents (Kobe, 2000; Stutts *et al.*, 2001), it is unlikely that consumers will welcome a move towards less functionality, as the features of the audio system have become an expected part of modern cars. In fact, as other audio media, like portable devices

## Redesigning audio systems

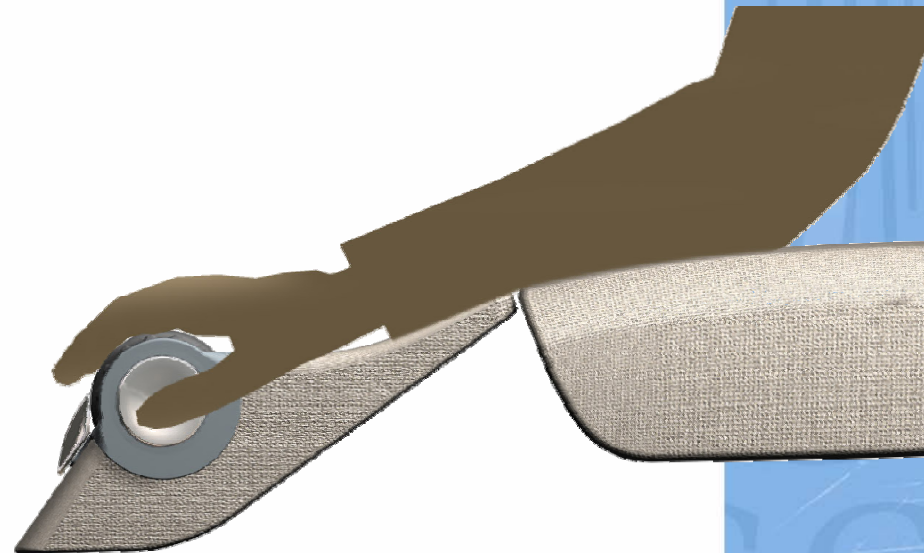
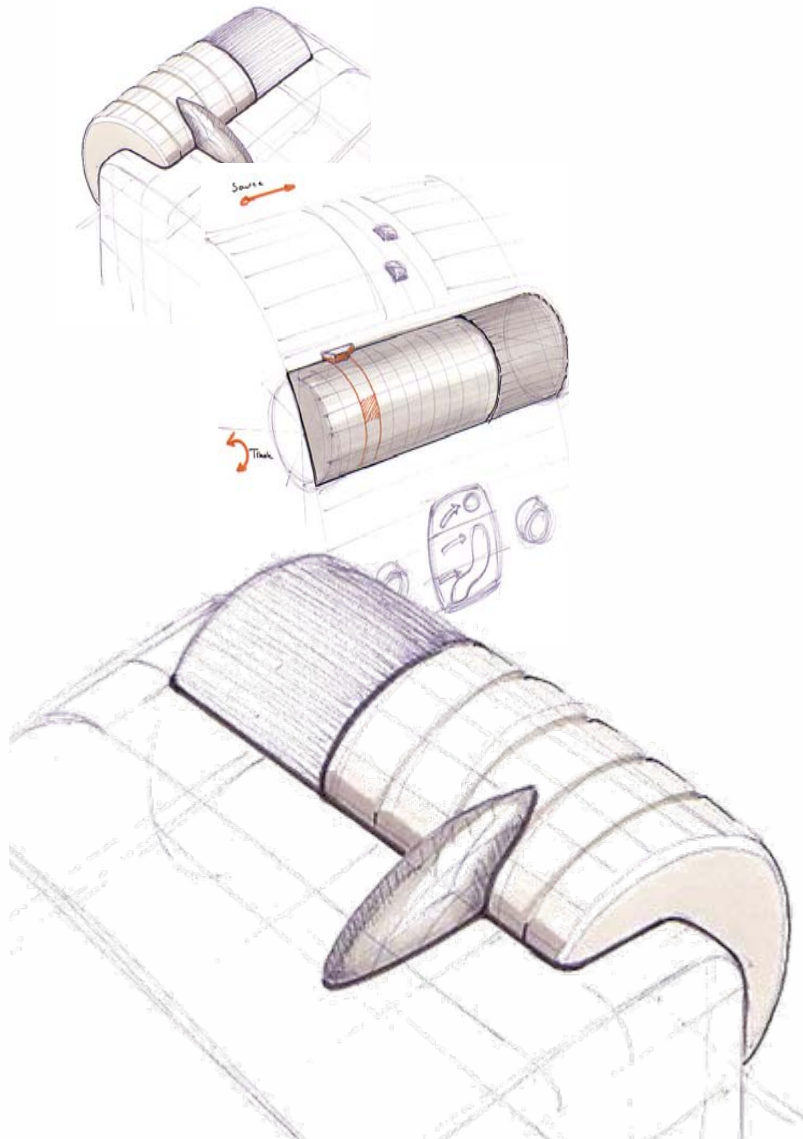
- Digitalization and streaming technology enables immaterial access to audio in personal vehicles.
- Current designs are minor modifications of the first models of car stereos, playing vinyl records and radio.



# Redesigning audio systems

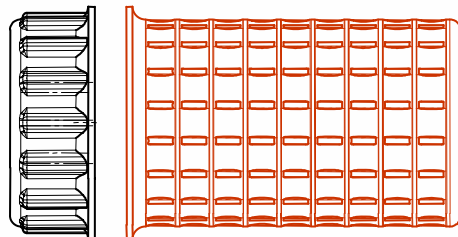
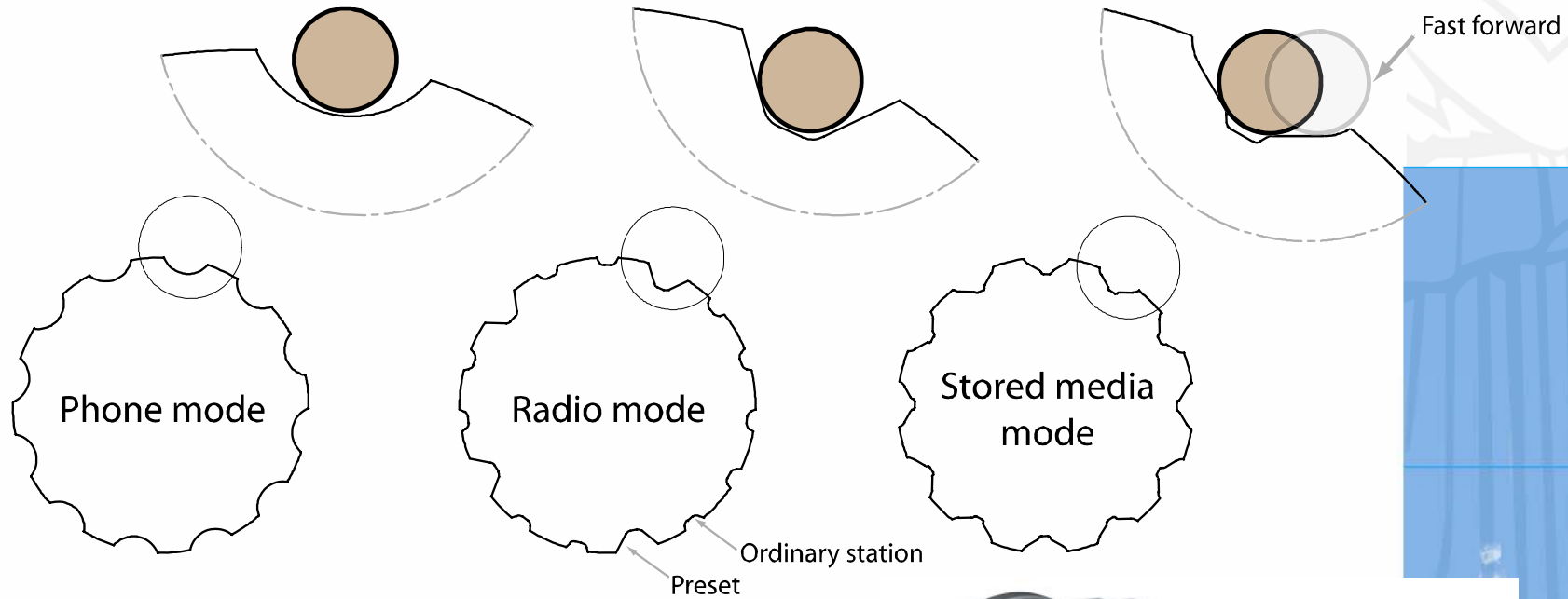


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# Redesigning audio systems



# Redesigning audio systems



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# Psychology and product innovation: Radical innovations in human-technology systems

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Department of psychology  
University of Oslo



Thank you for your attention