Display of e-Navigation information
Where do we display all this new information?

Thomas Porathe
Professor, Interaction design
Department of Product design
Norwegian University of Science and Technology
Trondheim, Norway

thomas.porathe@ntnu.no
The Yerkes–Dodson law

Optimal arousal
Optimal performance

Impaired performance because of strong anxiety

Increasing attention and interest

"Red line"
Stress Component Effects (passing the “Red line”)

- Selective attention ("tunnelling")
- Working memory loss
- Preservation (confirmation bias)
- Coping

Coping techniques
- Recrute ressources ("try harder")
- Remove stressors
- Strategic adaptation (change goals)
- Do nothing
Stress Remediation

- Environmental solutions (e.g. remove noise)
- Personal solutions (e.g. training)
- Design solutions:
  - Decluttering (attention narrowing)
  - Organisation of information (unsystematic scanning)
  - Move from textual to graphic presentation (faster parallel processing)
  - Minimize need to keep info in memory
  - Compatibility between response and mental model (Ecological Interface Design)
  - Design of emergency procedures
  - Avoid arbitrary symbols
<table>
<thead>
<tr>
<th>MSPs</th>
<th>Information items</th>
</tr>
</thead>
</table>
| 1 IS | • The position, identity, intention and destination of vessels;  
• Amendments and changes in promulgated information concerning the VTS area such as boundaries, procedures, radio frequencies, reporting points;  
• The mandatory reporting of vessel traffic movements;  
• Meteorological and hydrological conditions, notices to mariners, status of aids to navigation;  
• Maneuverability limitations of vessels in the VTS area that may impose restrictions on the navigation of other vessels, or any other potential hindrances: or  
• Any information concerning the safe navigation of the vessel. |
| 2 NAS | • Risk of grounding;  
• Vessel deviating from the recommended track or sailing plan;  
• Vessel unsure of its position or unable to determine its position;  
• Vessel unsure of the route to its destination;  
• Assistance to a vessel to an anchoring position;  
• Vessel navigational or maneuvering equipment casualty;  
• Inclement conditions (e.g. low visibility, high winds);  
• Potential collision between vessels;  
• Potential collision with a fixed object or hazard;  
• Assistance to a vessel to support the unexpected incapacity of a key member of the bridge team, on the request of the master. |
| 3 TOS | • vessel movements need to be planned or prioritized to prevent congestion or dangerous situations;  
• special transports or vessels with hazardous or polluting cargo may affect the flow of other traffic and need to be organized;  
• an operating system of traffic clearances or sailing plans, or both, has been established;  
• the allocation of space needs to be organized;  
• mandatory reporting of movements in the VTS area has been established;  
• special routes should be followed;  
• speed limits should be observed;  
• the VTS observes a developing situation and deems it necessary to interact and coordinate vessel traffic;  
• nautical activities (e.g. sailing regattas) or marine works in-progress (such as dredging or submarine cable-laying) may interfere with the flow of vessel movement. |
| 4 LPS | • berthing information;  
• availability of port services;  
• shipping schedules;  
• meteorological and hydrological data. |
| 5 MSI | • National Hydrographic Offices, for navigational warnings and chart correction data;  
• National Meteorological Offices, for weather warnings and forecasts;  
• Rescue Co-ordination Centres (RCCs), for shore-to-ship distress alerts;  
• The International Ice Patrol, for Oceanic ice hazards. |

… and 11+ more…
Integrated Navigation System (INS)

M/V Kong Harlad

thomas.porathee@ntnu.no
“Back bridge” 2015

P&O North Sea Ferries’ M/V Pride of Hull

thomas.porathec@ntnu.no
Worst case
Unintegrated
Stand Alone
ECDIS
Captain Jason Ikiadis, right, and First Officer Nikos Ninios on the bridge of the Azamara Journey. (Photo Eric Wynne)  
http://thechronicleherald.ca/titanic/slideshow/83244-azamara-journey
Cognitive Resources Needed

Cognitive Resource Supply

Cognitive Resources Needed vs. Cognitive Resource Supply

Cognitive Resources Needed:
- Open Sea
- Coastal
- Confined waters
- Berthing

Cognitive Resource Supply

Cognitive Resources Needed

Cognitive Resource Supply

Workload overload
Person 1

Open Sea
Coastal
Confined waters
Berthing

Person 1 Maximum

Cognitive Resources Needed

Cognitive Resources Needed

Cognitive Resource Supply

Person 2
Maximum

Person 1
Maximum

Workload overload
Person 1

Workload overload
Person 2

Cognitive Resources Needed

Open Sea
Coastal
Military Sea
Berthing

Contextual Control Model (COCOM), Erik Hollnagel, 2005

<table>
<thead>
<tr>
<th>Control mode</th>
<th>Number of goals</th>
<th>Subjectively available time</th>
<th>Evaluation of outcome</th>
<th>Selection of action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic</td>
<td>Several</td>
<td>Abundant</td>
<td>Elaborate</td>
<td>Based on modes/predictions</td>
</tr>
<tr>
<td>Tactical</td>
<td>Several (limited)</td>
<td>Adequate</td>
<td>Detailed</td>
<td>Based on plans/experience</td>
</tr>
<tr>
<td>Opportunistic</td>
<td>One or two (competing)</td>
<td>Just adequate</td>
<td>Concrete</td>
<td>Based on habits/association</td>
</tr>
<tr>
<td>Scrambled</td>
<td>One</td>
<td>Inadequate</td>
<td>Rudimentary</td>
<td>Random</td>
</tr>
</tbody>
</table>

Contextual Control Model (COCOM), Erik Hollnagel, 2005

<table>
<thead>
<tr>
<th>Control mode</th>
<th>Number of goals</th>
<th>Subjectively available time</th>
<th>Evaluation of outcome</th>
<th>Selection of action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic</td>
<td>Several</td>
<td>Abundant</td>
<td>Elaborate</td>
<td>Based on modes/predictions</td>
</tr>
<tr>
<td>Tactical</td>
<td>Several (limited)</td>
<td>Adequate</td>
<td>Detailed</td>
<td>Based on plans/experience</td>
</tr>
<tr>
<td>Opportunistic</td>
<td>One or two (competing)</td>
<td>Just adequate</td>
<td>Concrete</td>
<td>Based on habits/association</td>
</tr>
<tr>
<td>Scrambled</td>
<td>One</td>
<td>Inadequate</td>
<td>Rudimentary</td>
<td>Random</td>
</tr>
</tbody>
</table>

Figure 3
Part of chart NZ541 showing passage plan (course line), plotted positions and voyage data recorder GPS positions on approach to Tauranga
Figure 4
Annotated screenshot of the Rena’s radar (colour reversed for clarity)
thomas.porathe@ntnu.no
## Contextual Control Model (COCOM)

(Erik Hollnagel, 2005)

<table>
<thead>
<tr>
<th>Control mode</th>
<th>Number of goals</th>
<th>Subjectively available time</th>
<th>Evaluation of outcome</th>
<th>Selection of action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic</td>
<td>Several</td>
<td>Abundant</td>
<td>Elaborate</td>
<td>Based on modes/predictions</td>
</tr>
<tr>
<td>Tactical</td>
<td>Several (limited)</td>
<td>Adequate</td>
<td>Detailed</td>
<td>Based on plans/experience</td>
</tr>
<tr>
<td><strong>Opportunistic</strong></td>
<td>One or two (competing)</td>
<td>Just adequate</td>
<td>Concrete</td>
<td>Based on habits/association</td>
</tr>
<tr>
<td>Scrambled</td>
<td>One</td>
<td>Inadequate</td>
<td>Rudimentary</td>
<td>Random</td>
</tr>
</tbody>
</table>

## Contextual Control Model (COCOM)

(Erik Hollnagel, 2005)

<table>
<thead>
<tr>
<th>Control mode</th>
<th>Number of goals</th>
<th>Subjectively available time</th>
<th>Evaluation of outcome</th>
<th>Selection of action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic</td>
<td>Several</td>
<td>Abundant</td>
<td>Elaborate</td>
<td>Based on modes/predictions</td>
</tr>
<tr>
<td>Tactical</td>
<td>Several (limited)</td>
<td>Adequate</td>
<td>Detailed</td>
<td>Based on plans/experience</td>
</tr>
<tr>
<td>Opportunistic</td>
<td>One or two (competing)</td>
<td>Just adequate</td>
<td>Concrete</td>
<td>Based on habits/association</td>
</tr>
<tr>
<td>Scrambled</td>
<td>One</td>
<td>Inadequate</td>
<td>Rudimentary</td>
<td>Random</td>
</tr>
</tbody>
</table>

HSC Sleipner, 1999
The identical bridge on Sleipner’s sister ship Draupner
Display of e-Navigation information

Where do we display all this new information?
Strategic navigation
”Back bridge”
(Electronic table, iPad, LapTop, ...)

Most e-Nav information
Electronic chart tables
OSMOS project
Focus group with captains
Chalmers 2013

thomas.porathe@ntnu.no
Strategic navigation

“Back bridge”

(Electronic table, iPad, Laptop, …)
**Strategic navigation**

"Back bridge"

(Electronic table, iPad, LapTop, ...)

**Tactical navigation**

"Front bridge"

(INS)

Certain e-Nav information
ECDIS

Radar
Strategic navigation
“Back bridge”
(Electronic table, iPad, LapTop, ...)

Tactical navigation
“Front bridge”
(INS)
Strategic navigation
"Back bridge"
(Electronic table, iPad, Laptop, …)

Tactical navigation
"Front bridge"
(INS)

Opportunistic navigation
One fused simplified display
(Head-up ECDIS with radar overlay)
Strategic navigation
“Back bridge”
(Electronic table, iPad, LapTop, …)

Tactical navigation
“Front bridge”
(INS)

Opportunistic navigation
One fused simplified display
(Head-up ECDIS with radar overlay)

Scrambled navigation
(Conning, HUD, HMD, …)
Strategic navigation
"Back bridge"
(Electronic table, iPad, LapTop, ...)

Tactical navigation
"Front bridge"
(INS)

Opportunistic navigation
One fused simplified display
(Head-up ECDIS with radar overlay)

Scrambled navigation
(Conning, HUD, HMD, ...)

N
Strategic navigation
"Back bridge"
(Electronic table, iPad, LapTop, …)

Tactical navigation
"Front bridge"
(INS)

Opportunistic navigation
One fused simplified display
(Head-up ECDIS with radar overlay)

Scrambled navigation
(Conning, HUD, HMD, …)

Most e-Nav information

Some e-Nav information

Some carefully selected e-Nav information