Cognitive Task Load Analysis
Specification and assessment of critical scenarios

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TNO Human Factors
Human Factors Envisioning High-demand Situations

decompose task

task decomposition

specify BAS

BAS

specify CAS

human task, interface and support

specify events

events

specify scenarios

scenarios

specify BAS

Task-Set Classes

Task-Set Instances

task or process

data
Task Decomposition and Allocation

Abstraction Level

Activity

Managing Emergencies

Task

Restore propulsion engine

Determine cause

Replace cooling circuit

Fire fighting

Ventilation crashstop

Announce fire alarm

Action

task set 1

task set 2
Human Factors Envisioning High-demand Situations

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Task decomposition
specify BAS

specify events

events

specify CAS

human task, interface and support

Task-Set Instances

task or process

data
<table>
<thead>
<tr>
<th>Event category</th>
<th>Basic event</th>
<th>Example event</th>
<th>Example consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extern</td>
<td>Weather</td>
<td>…</td>
<td>Storm approaching</td>
</tr>
<tr>
<td>Sea state</td>
<td>Current</td>
<td>…</td>
<td>…</td>
</tr>
<tr>
<td>Traffic</td>
<td>Vessel passing ahead</td>
<td>…</td>
<td>Vessel approaching from port gives way.</td>
</tr>
<tr>
<td></td>
<td>Vessel gives way</td>
<td>Vessel approaching from port changes to collision course</td>
<td>A collision occurs</td>
</tr>
<tr>
<td>Intern</td>
<td>Cargo</td>
<td>Gas-leak</td>
<td>Release of toxic fumes</td>
</tr>
<tr>
<td>System Failure</td>
<td>Propulsion</td>
<td>Engine shutdown</td>
<td>A temperature rise caused the engine to automatically shutdown</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Max. temp.</td>
<td>Engine temperature exceeds set point</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Max. level.</td>
<td>…</td>
</tr>
<tr>
<td>Collision Avoidance</td>
<td>…</td>
<td>Collision avoidance sensor malfunction</td>
<td>A collision occurs</td>
</tr>
<tr>
<td>Navigation</td>
<td>…</td>
<td>Ship off course</td>
<td>Ship can’t arrive at ETA</td>
</tr>
<tr>
<td>Electric</td>
<td>Short circuit</td>
<td>Short circuit in cooling pump</td>
<td>Malfunctioning cooling circuit of the engine</td>
</tr>
<tr>
<td>Fire</td>
<td>Fire in the engine room</td>
<td>Engine speed is limited</td>
<td></td>
</tr>
</tbody>
</table>
Method

- decompose task
- task decomposition
- specify BAS
- specify events
- BAS
- specify CAS
- human task, interface and support
- specify scenarios
- scenarios

Task-Set Classes

Task-Set Instances

class: task or process
data
**Initial state**  
Ship is en route to Hamburg; there are two operators present on the bridge.

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Location</th>
<th>Details</th>
<th>Consequences</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.54</td>
<td>Short circuit</td>
<td>Cooling- pump of engine in engine room</td>
<td>Short circuit causes a fire in the pump, which is located in the cooling system of the engine.</td>
<td>Cooling system will not work and the engine temperature will increase.</td>
<td>None (event is not detected by system)</td>
</tr>
<tr>
<td>22.03</td>
<td>Fire</td>
<td>Engine room</td>
<td>A pump in the engine room is on fire</td>
<td>Unknown</td>
<td>Smoke detector of Fire Control System</td>
</tr>
<tr>
<td>22.06</td>
<td>Max. temp. engine</td>
<td>Engine room</td>
<td>The temperature of the engine increased beyond the set point.</td>
<td>The engine shuts down after a period of high temperature.</td>
<td>Propulsion management system</td>
</tr>
<tr>
<td>22.08</td>
<td>Engine shutdown</td>
<td>Engine room</td>
<td>The temperature was too high for the critical period.</td>
<td>The vessel cannot maintain its current speed.</td>
<td>Propulsion management system</td>
</tr>
</tbody>
</table>
Human Factors Envisioning High-demand Situations

**Method**

- decompose task
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- specify BAS
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- events

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- scenarios

**Task-Set Classes**

**Task-Set Instances**

- task or process
- data
Compound Action Sequence

<table>
<thead>
<tr>
<th>Time (min:sec)</th>
<th>Others</th>
<th>Operator 1</th>
<th>Operator 2</th>
<th>System</th>
</tr>
</thead>
<tbody>
<tr>
<td>00:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00:15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00:45</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>01:15</td>
<td>Black smoke above ship</td>
<td>crash-stop ventilation</td>
<td>determine cause</td>
<td>Fire engine room</td>
</tr>
</tbody>
</table>

- Black smoke above ship
- Crash-stop ventilation
- Determine cause
- Guide diagnosis
- Provide procedure
Overview of specifications

Abstraction Level

Activity

Task

Action

External Triggers

Scenario
- ship to Hamburg
- two bridge operators
...

Event
- engine shutdown
- fire deck A
...

Process state
- c. circuit replaced
- ventilation on/off
...

Managing Emergencies

Restore propulsion engine

Fire fighting

Determine cause

Replace cooling circuit

Ventilation crashstop

task set 1

task set 2

Announce fire alarm
Workshop to elicit task demands: Identifying critical load factors and functions

Knowledge of plant

Operational goals & criteria

Controller knowledge

Secondary level

Information transfer

Primary level

Process Plant

sensors

actuators
Specifying task load factors

Tasks: distinguish functional and contextual elements
- Situation Awareness
- Disturbance Assessment
- Decision Making
- Direction & Control

Task Load
- Time occupied
- Level of information processing
- Task-set switches
Elicitation of bottlenecks

Indicators, such as
- expert opinions
- (near) incidents
- practitioner’s reports
- observations/analyses of task performances

Causes
- task demands do not match human capacities
- context provides the specific conditions for the appearance of this mismatch
Time-occupied bottlenecks

Possible indicators
- work overtime
- work not finished
- insufficient interim, brief rests

Causes?
- task
- context
Level of info processing bottlenecks

Possible indicators
- hardly time for concurrent actions like conversation
- extensive use of manuals, help systems, etc.
- need for advise or assistance
- occurrence of non-routine situations for which
  - the critical elements are hard to identify
  - it is not immediately clear what actions to perform

Causes?
- task
- context
Task-set switching bottlenecks

Possible indicators
- interruptions from the environment (e.g. phone calls)
- occurrences of several problems or task assignments that have to be handled “simultaneously”

Causes?
- task
- context
Workshop Envisioning High-demand Situations

- Individuals generate instances of bottlenecks for
  - task and context, and
  - the four functions and three load factors
- Each group structures the bottlenecks according to the load and functional framework
- Each group presents the results to the other groups for discussion

In the next phase, critical scenarios will be derived from the workshop results