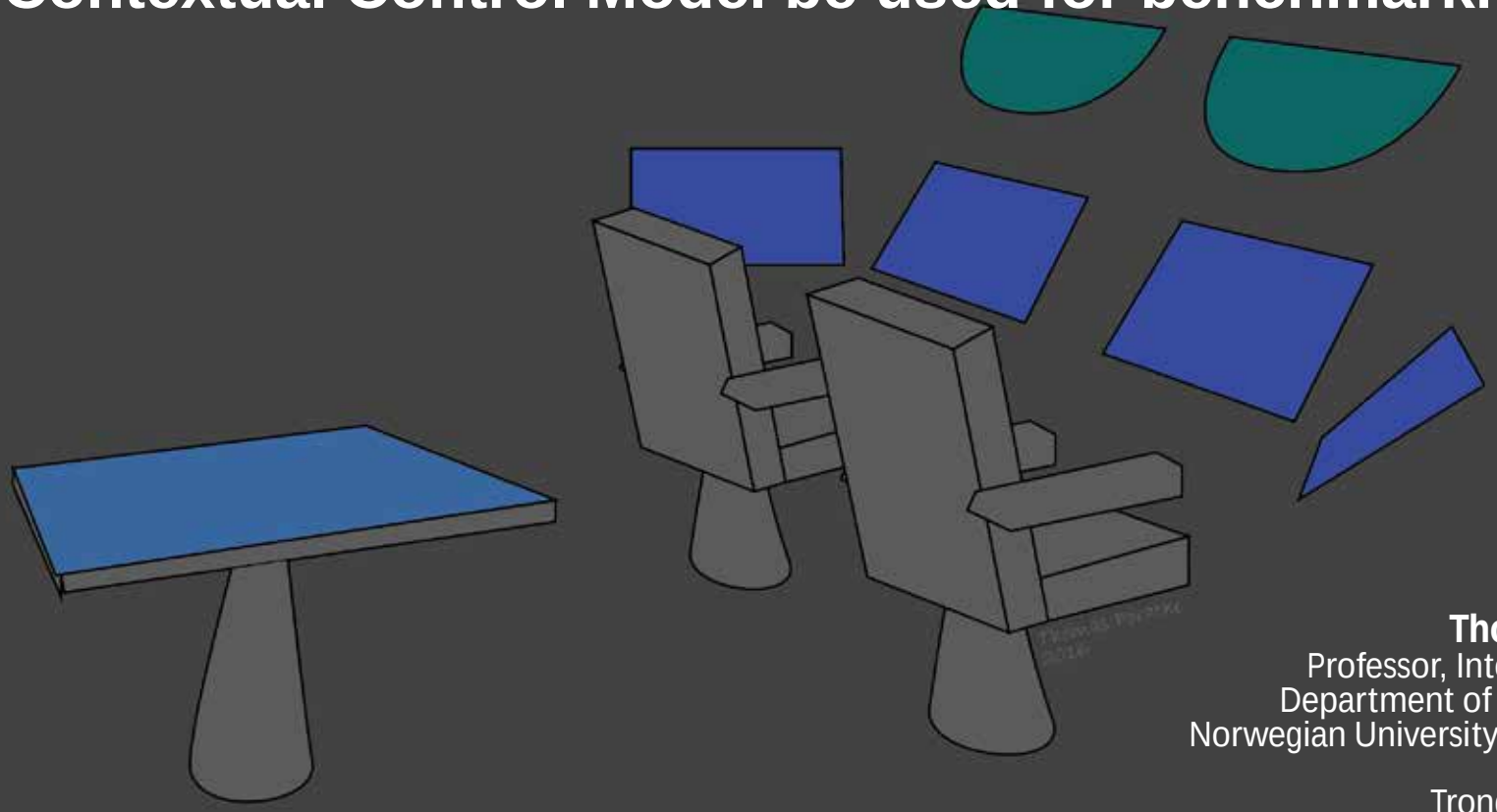
Designing HMIs for boat navigation

Can the Contextual Control Model be used for benchmarking?



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

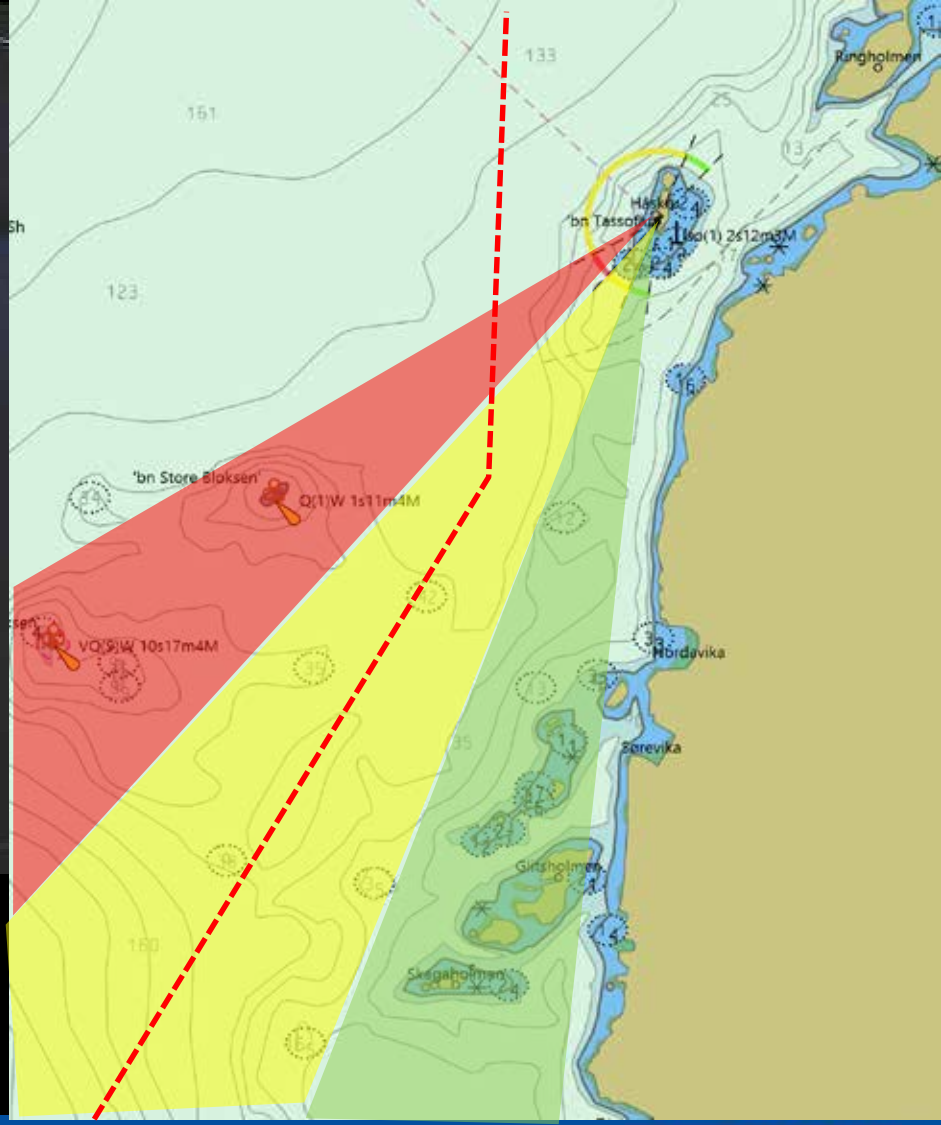
HSC Sleipner, 1999

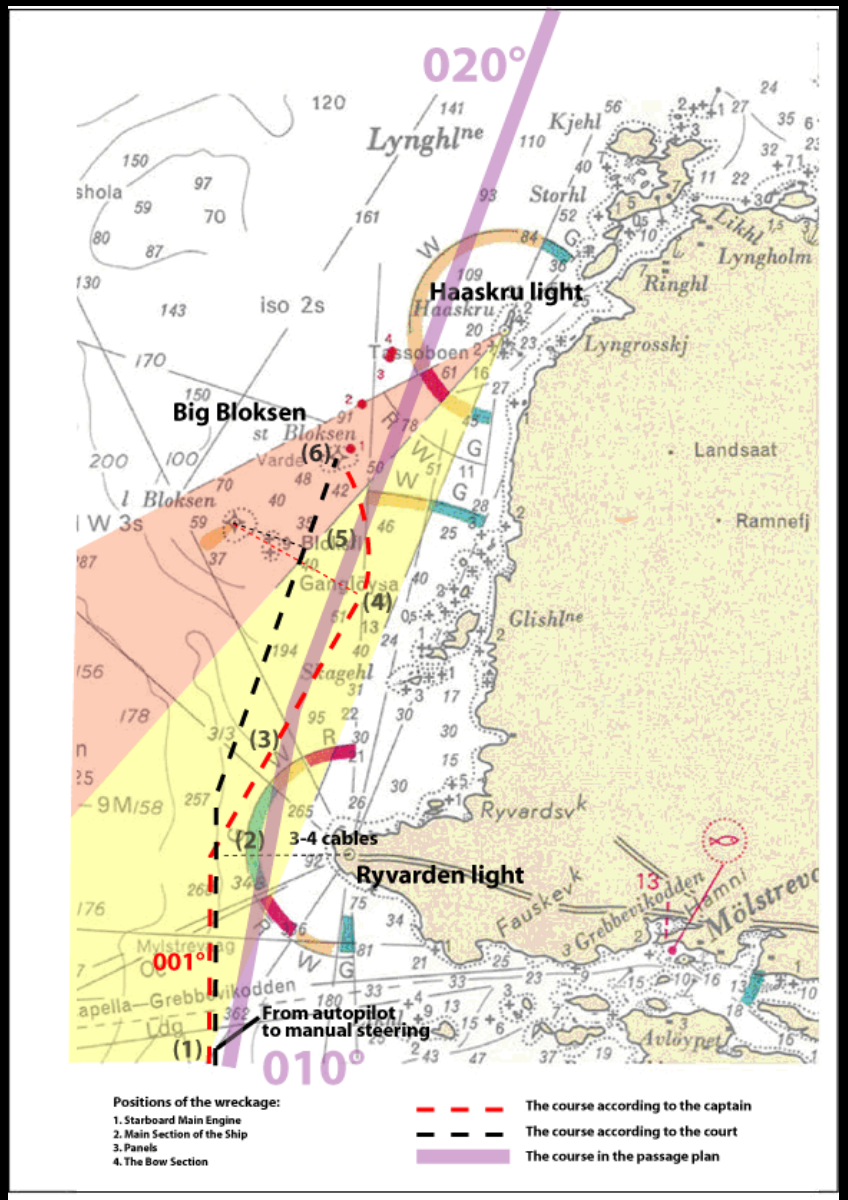
Figur 6.1 Bilde av Store Bloksen sett mot aust

Figur 6.1 Bilde av Store Bloksen sett mot øst[68]


Lille and Store Bloksen in the middle ground to the left, in the background Oksøskallen and Lyngsøy
Håskru light.
Sleipnerulykken: Skjærene i venstre bakgrunn ligger midt i skipsleden
(c) Eirik Hustvedt -HT

The identical bridge on Sleipner's sister ship Draupner




020°
Haaskru light
Big Bloksen
(6)
(5)
(4)
(3)
(2)
3-4 cables
Ryvarden light
(1)
From autopilot
to manual steering
001°
010°
Lynghlne
Kjehl
Storhl
Likhl
Lyngholm
Ringhl
Lyngrosskj
Landsaat
Ramnefj
Glishlne
Ryvardsvk
Fauskevk
Grebbevikodden
Mølstrevo
Avløypet
iso 2s
Positions of the wreckage:
1. Starboard Main Engine
2. Main Section of the Ship
3. Panels
4. The Bow Section
The course according to the captain
The course according to the court
The course in the passage plan


FLAGG

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

MSPs	Information items
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.

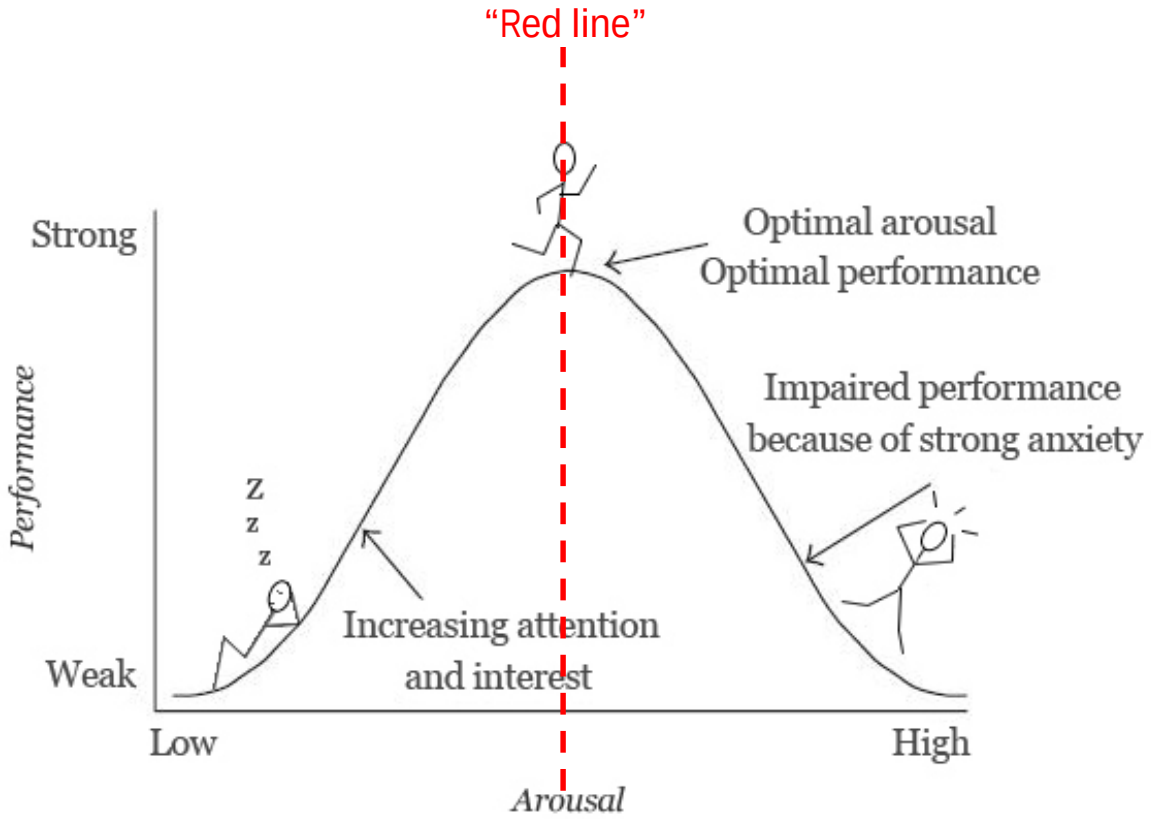
... and 11+ more...

Integrated Navigation System (INS)

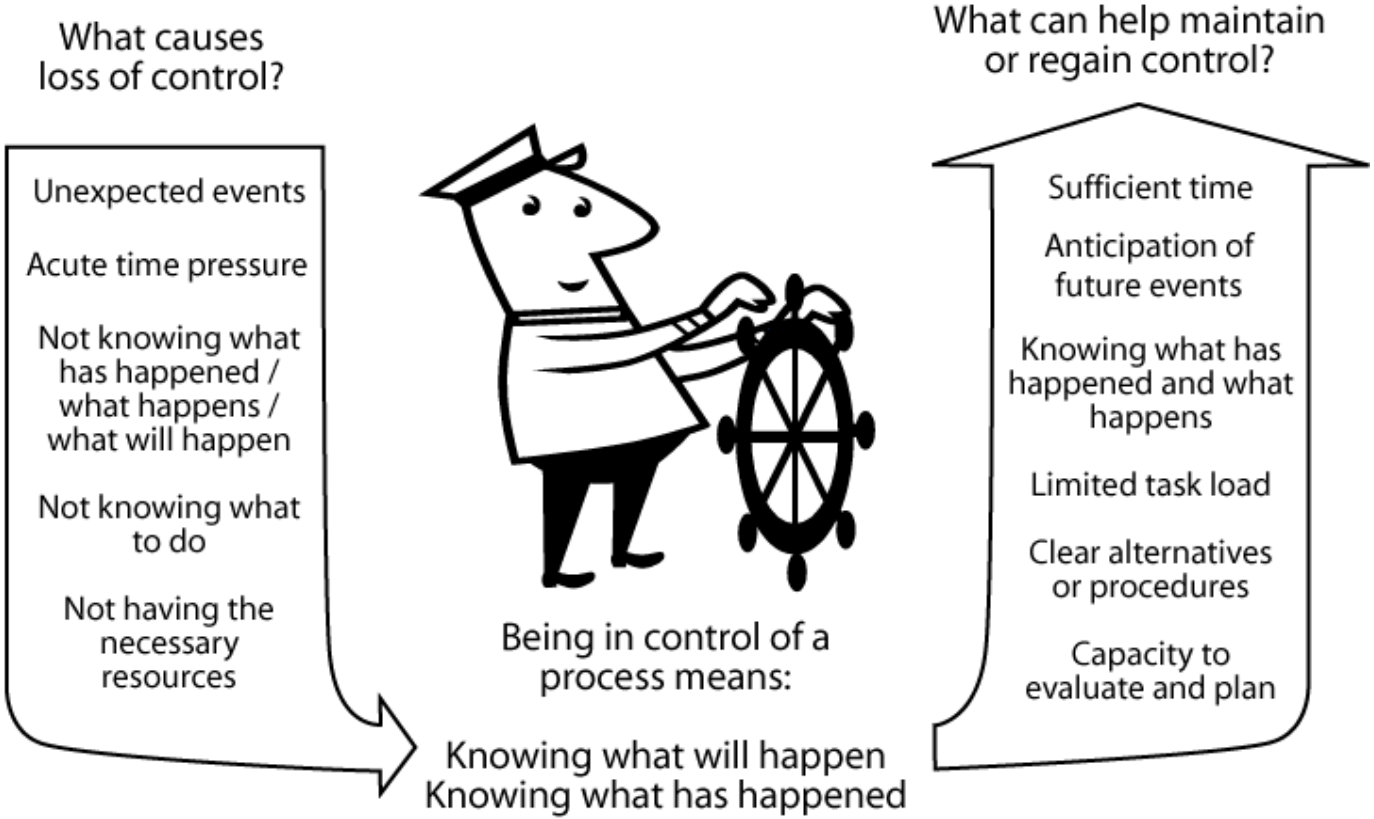
M/V Kong Harlad

Worst case

Unintegrated
Stand Alone
ECDIS



The Yerkes–Dodson law



Determinants of control, adapted from Hollnagel & Woods (2005) Joint Cognitive Systems: Foundations of Cognitive Systems Engineering, CRC Press. p. 75.

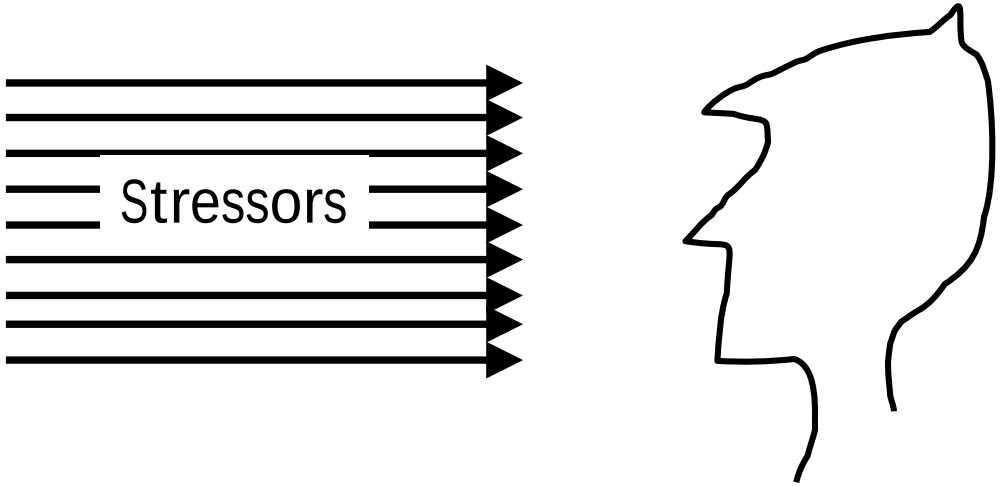
The deviation-amplifying loop (Maruyama, 1963)

Low predictability — more time is needed to make sense of what is going on and decide on the proper control actions

Inadequate time — not possible to develop an adequate understanding of what is going on. (Control actions more likely to fail.)

Maruyama, M. (1963). The second cybernetics: Deviation-amplifying mututal processes. *American Scientist, 55*, 164-179

Stress Component Effects (passing the “Red line”)



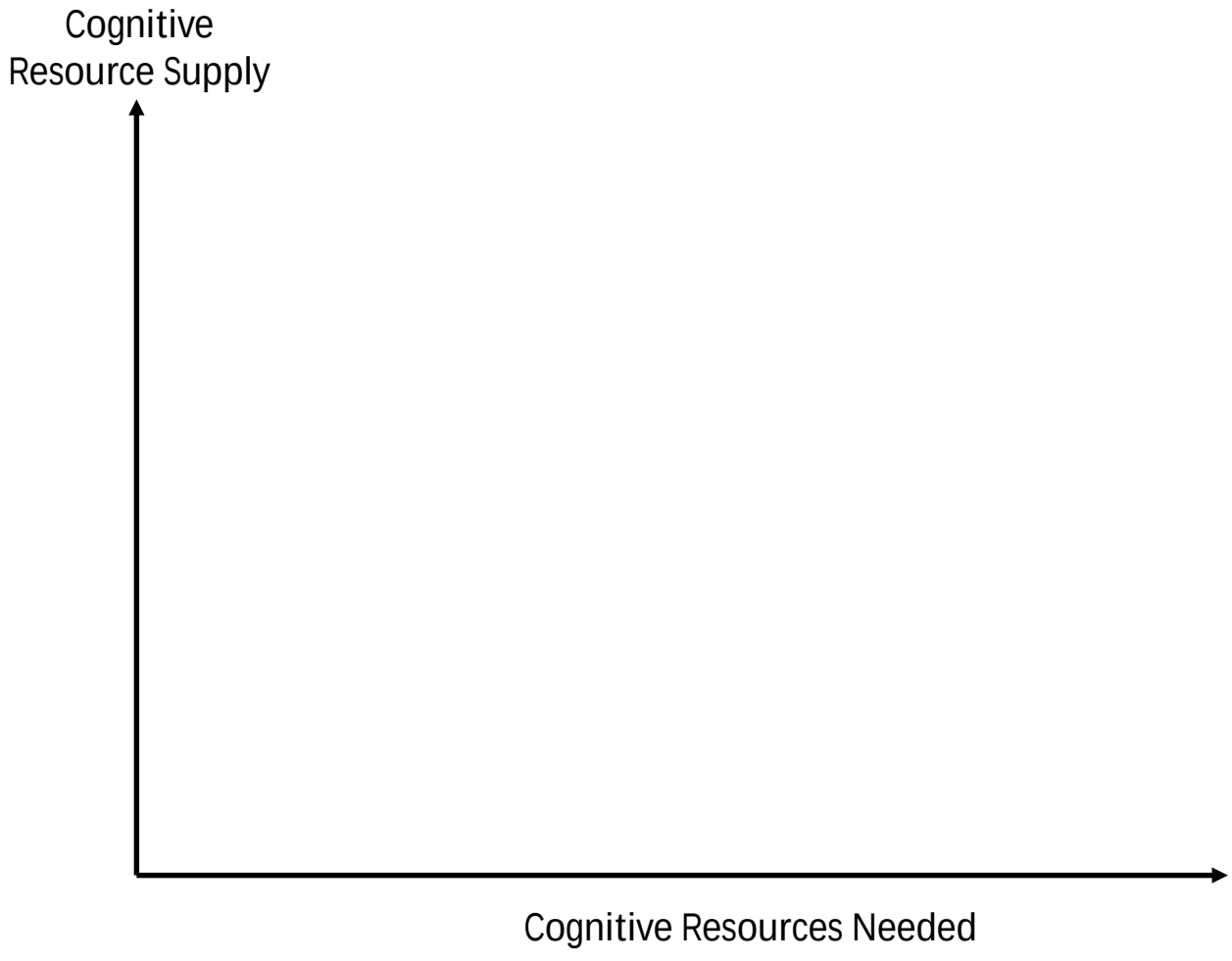
- Selective attention (”tunnelling”)
- Working memory loss
- Preservation (confirmation bias)
- Coping

Coping techniques

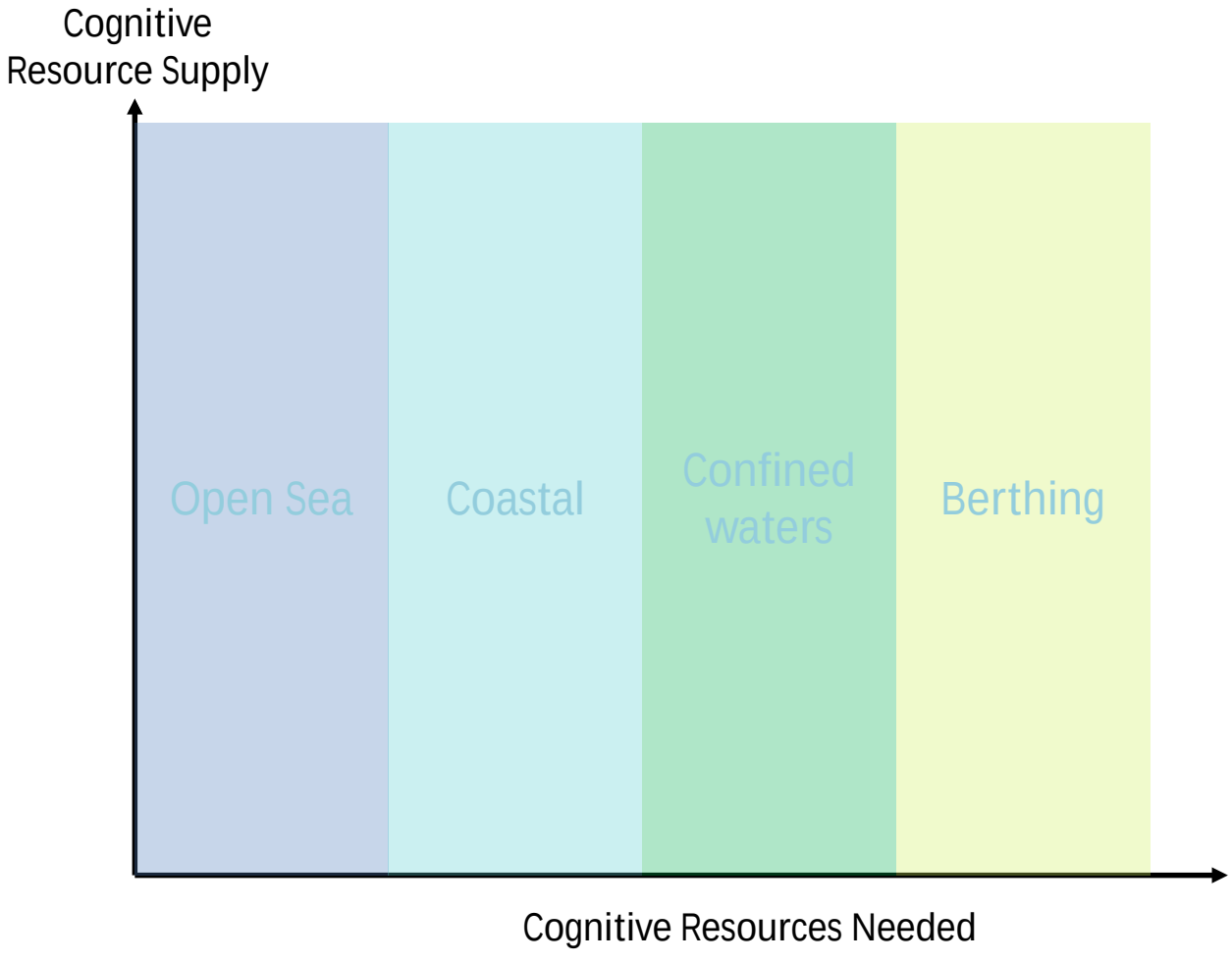
- Recrute ressources (”try harder”)
- Remove stressors
- Strategic adaptation (change goals)
- Do nothing

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 (“knowledge in the world”)
  - Compatibility between response and mental model (Ecological Interface Design)
  - Design of emergency procedures
  - Avoid arbitrary symbols



Christopher D. Wickens, Justin G. Hollands, Raja Parasuraman, & Simon Banbury. (2012). “Engineering Psychology & Human Performance (4th Edition)”. Pearsons. p. 348



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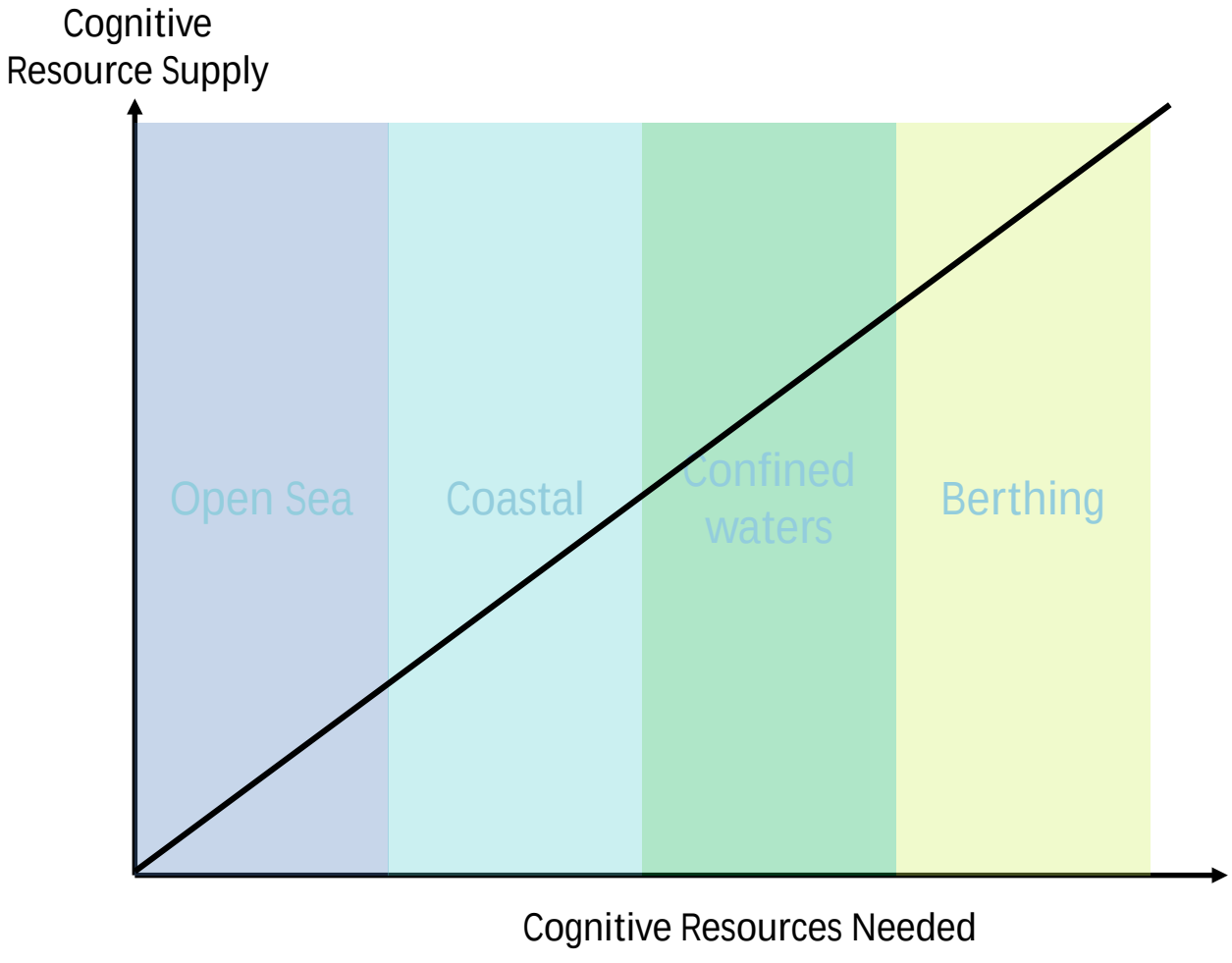

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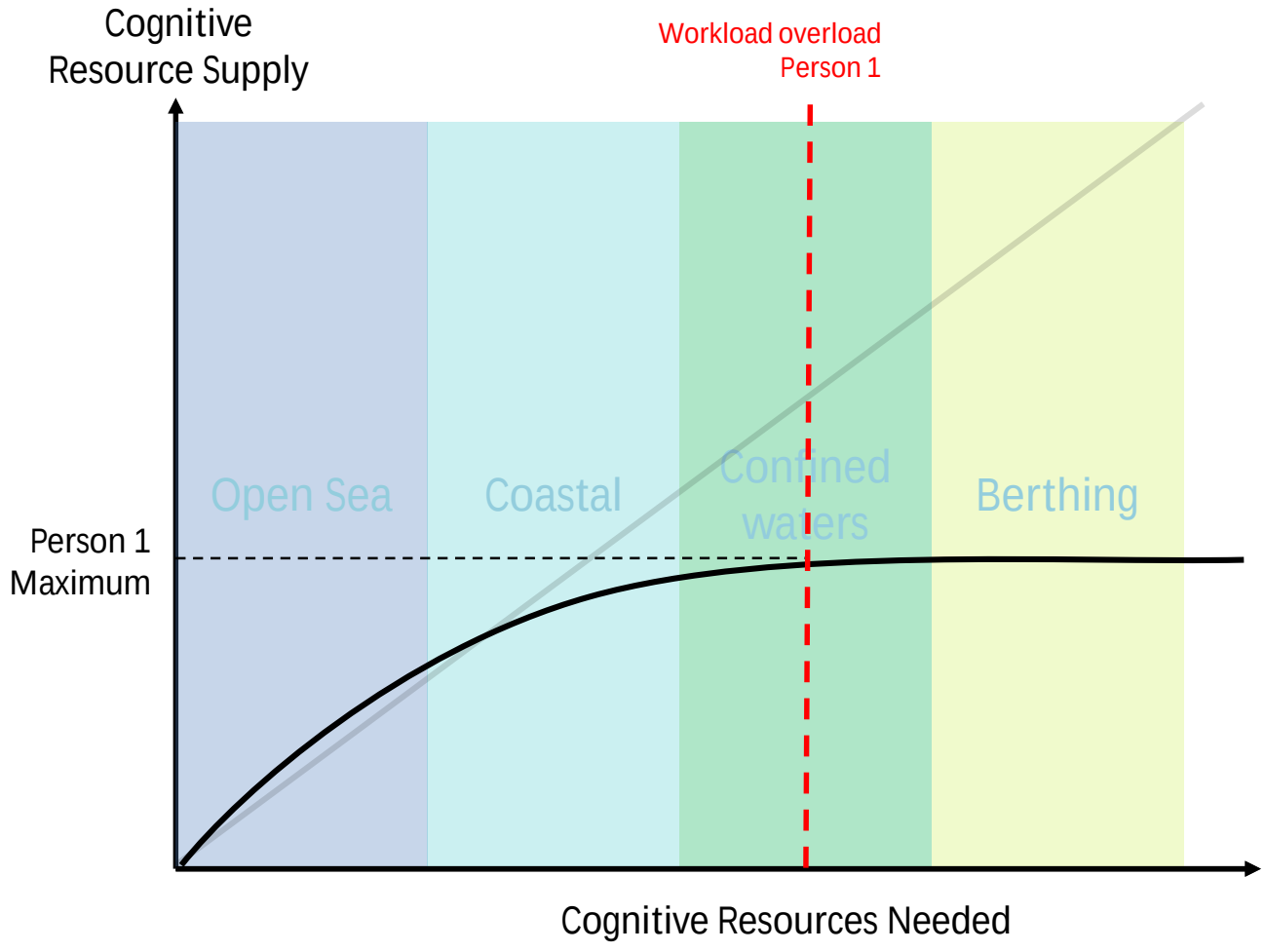

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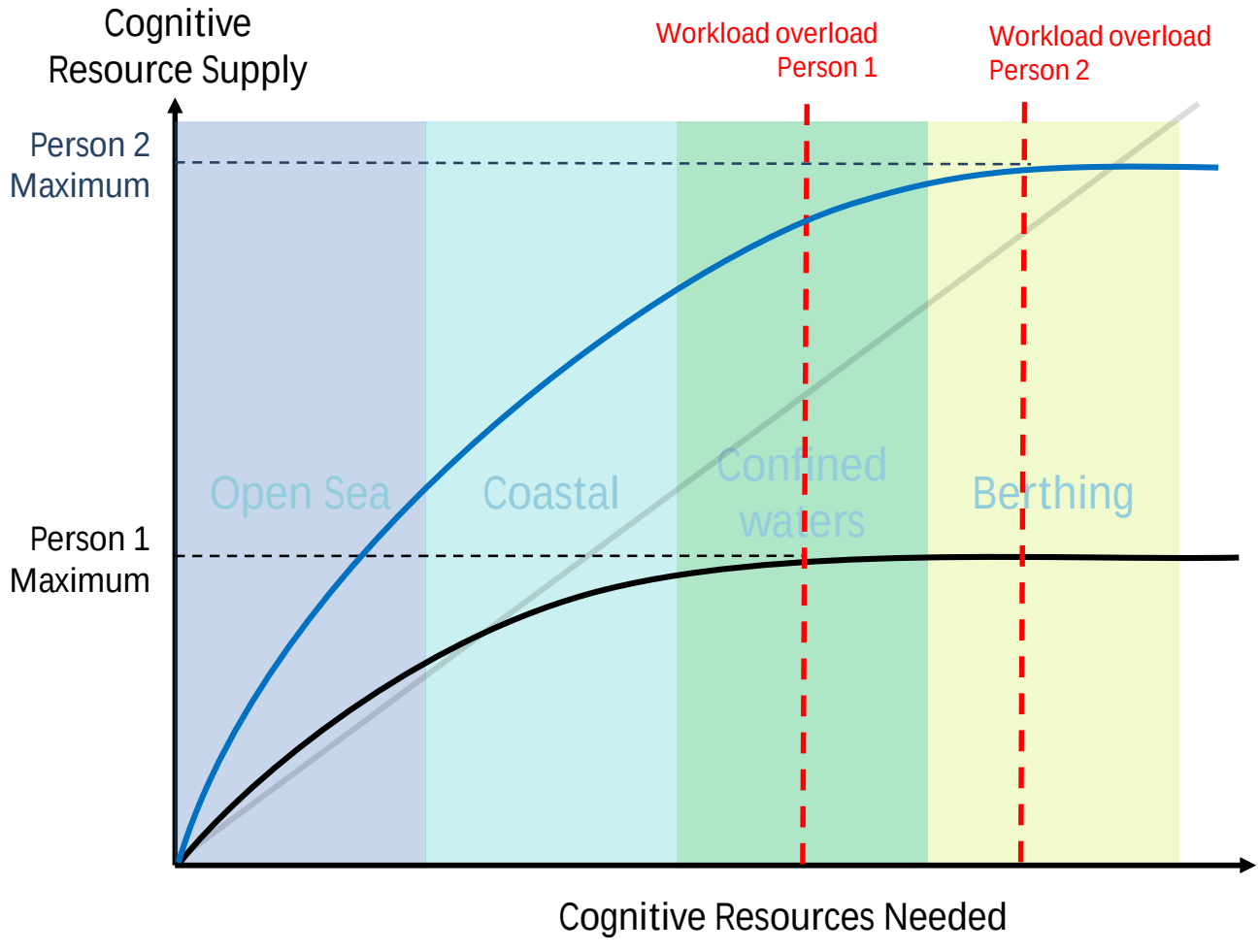


Christopher D. Wickens, Justin G. Hollands, Raja Parasuraman, & Simon Banbury. (2012). “Engineering Psychology & Human Performance (4th Edition)”. Pearsons. p. 348

Control characterises the orderliness of performance and the way in which competence is applied

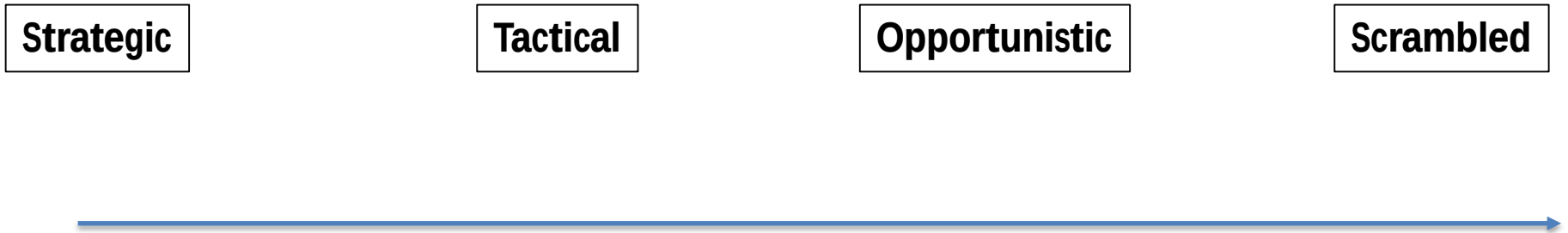
Control

Full control
Completely deterministic performance

No Control

Hollnagel, E & Woods, D.D. (2005). *Joint Cognitive Systems: Foundations of Cognitive Systems Engineering*. CRC Press

Contextual Control Model (COCOM), Erik Hollnagel, 2005



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

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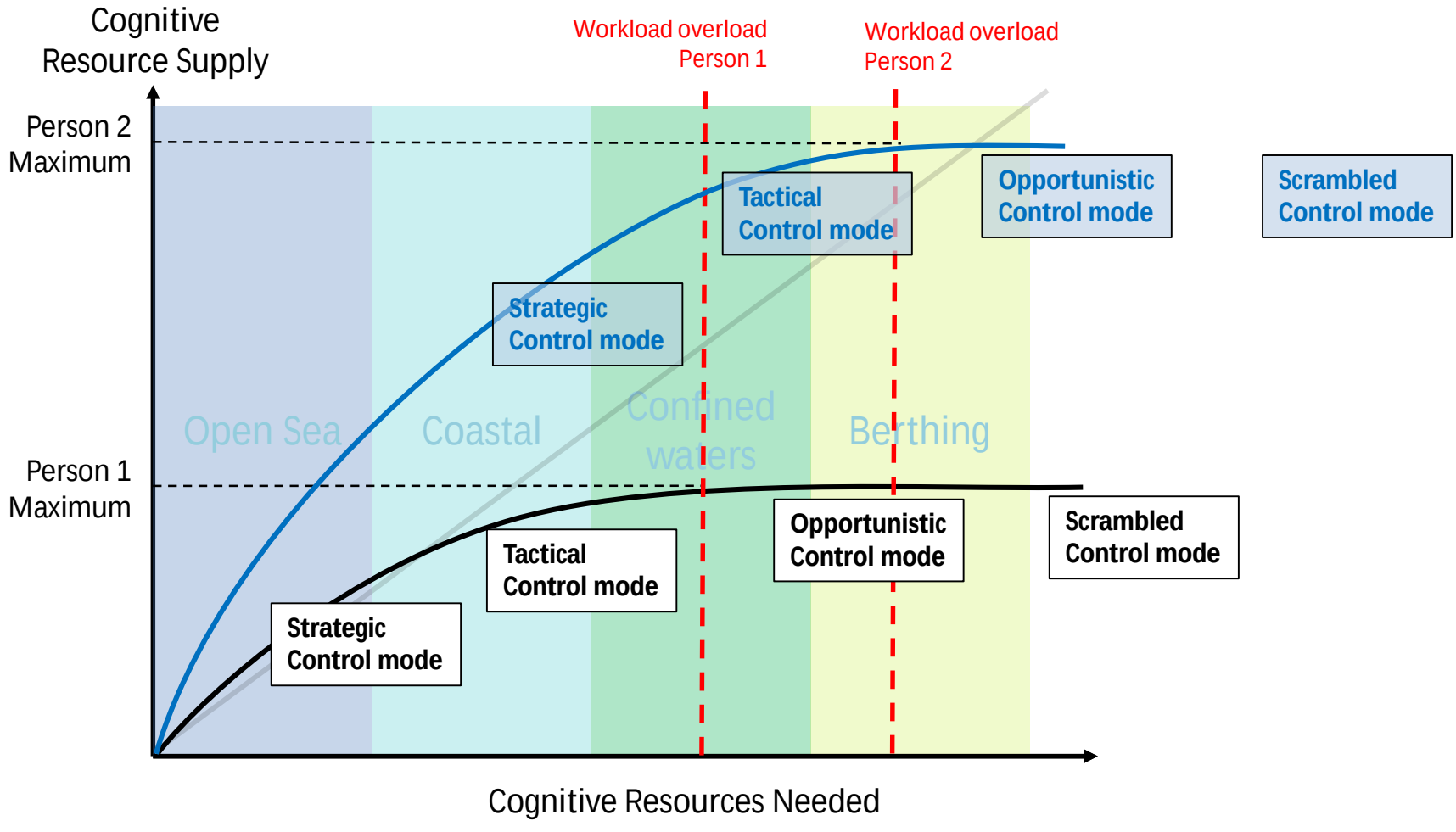

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“Back bridge”
2015

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

Contextual Control Model (COCOM), Erik Hollnagel, 2005

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Integrated Navigation System (INS)

M/V Kong Harlad

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MV Rena, N.Z. 2011

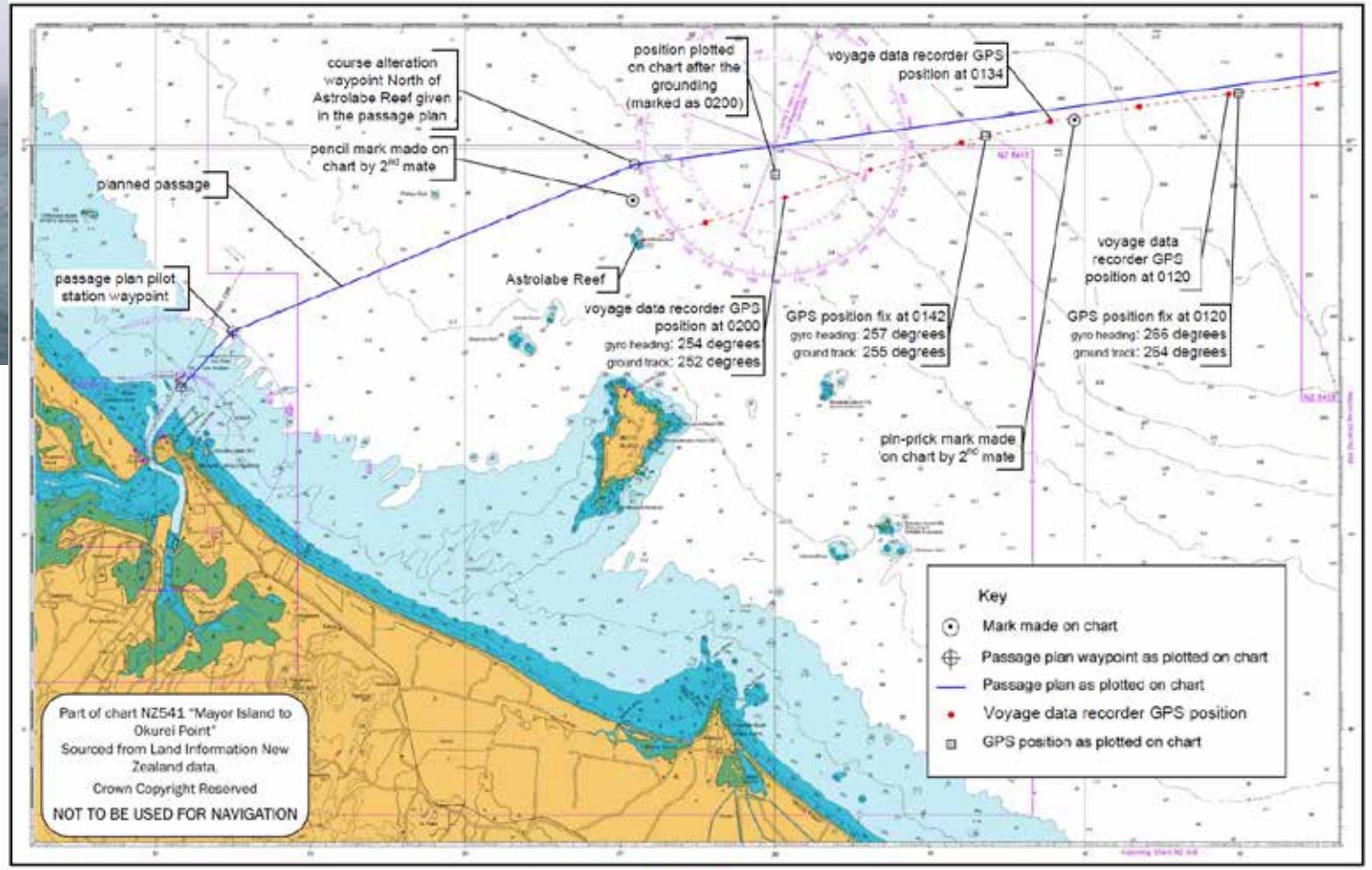

Figure 3
Part of chart NZ541 showing passage plan (course line), plotted positions and voyage data recorder GPS positions on approach to Tauranga

MV Rena, N.Z. 2011

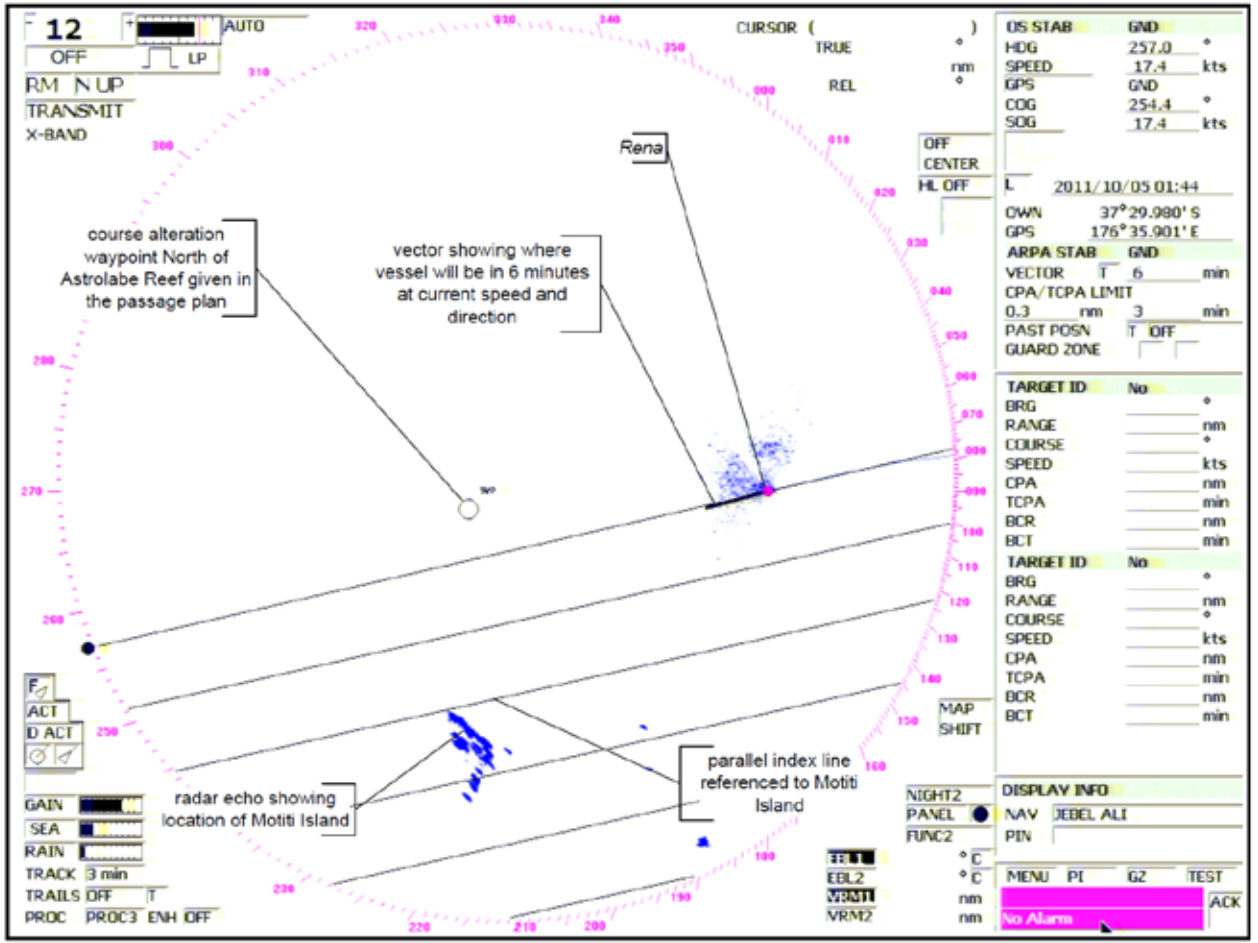

Figure 4
Annotated screenshot of the *Rena*'s radar (colour reversed for clarity)

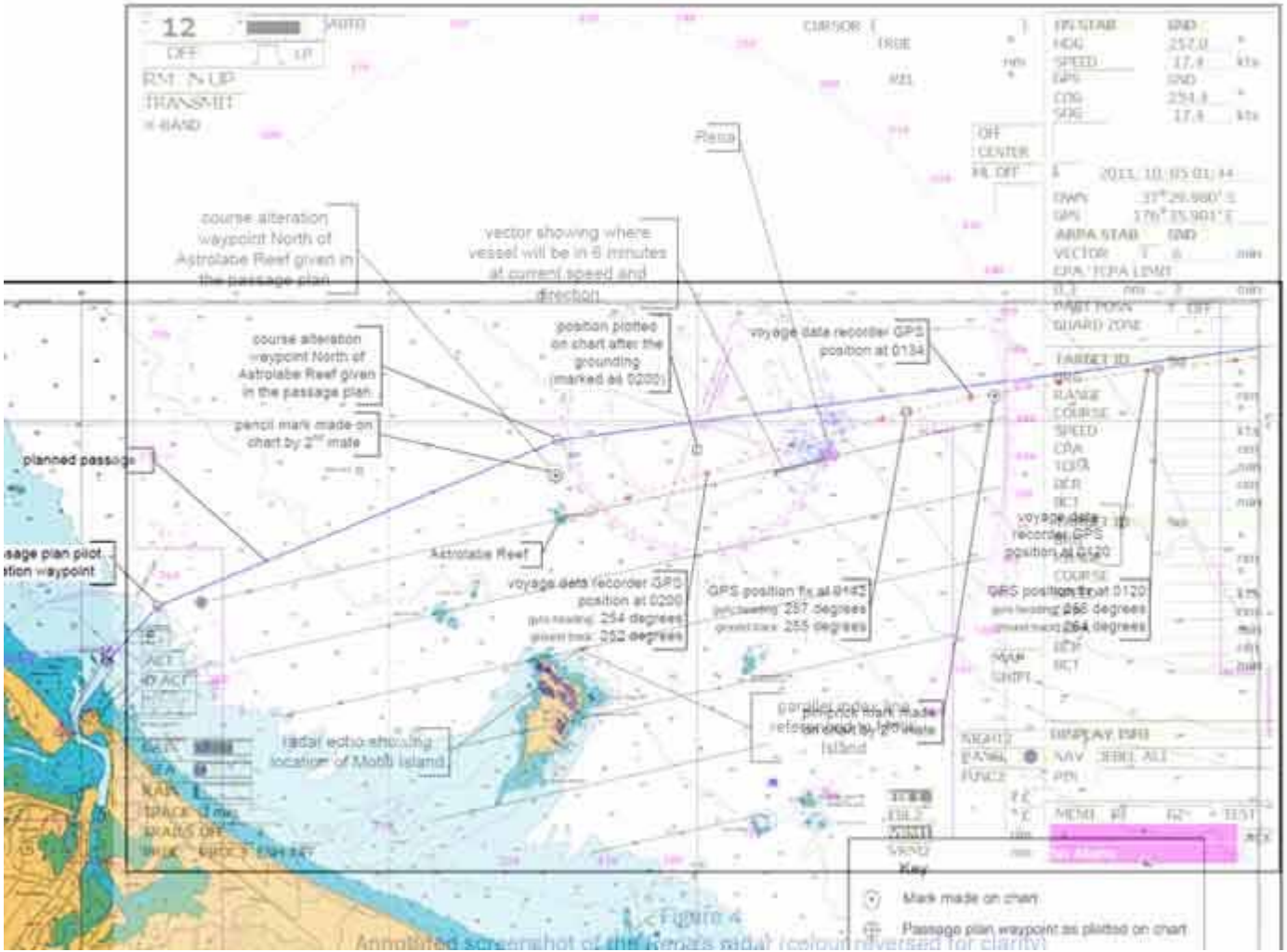

Figure 4
Annotated screenshot of the Kelvin radar (colour reversed for clarity)

Contextual Control Model (COCOM)

(Erik Hollnagel, 2005)

Control mode	Number of goals	Subjectively available time	Evaluation of outcome	Selection of action
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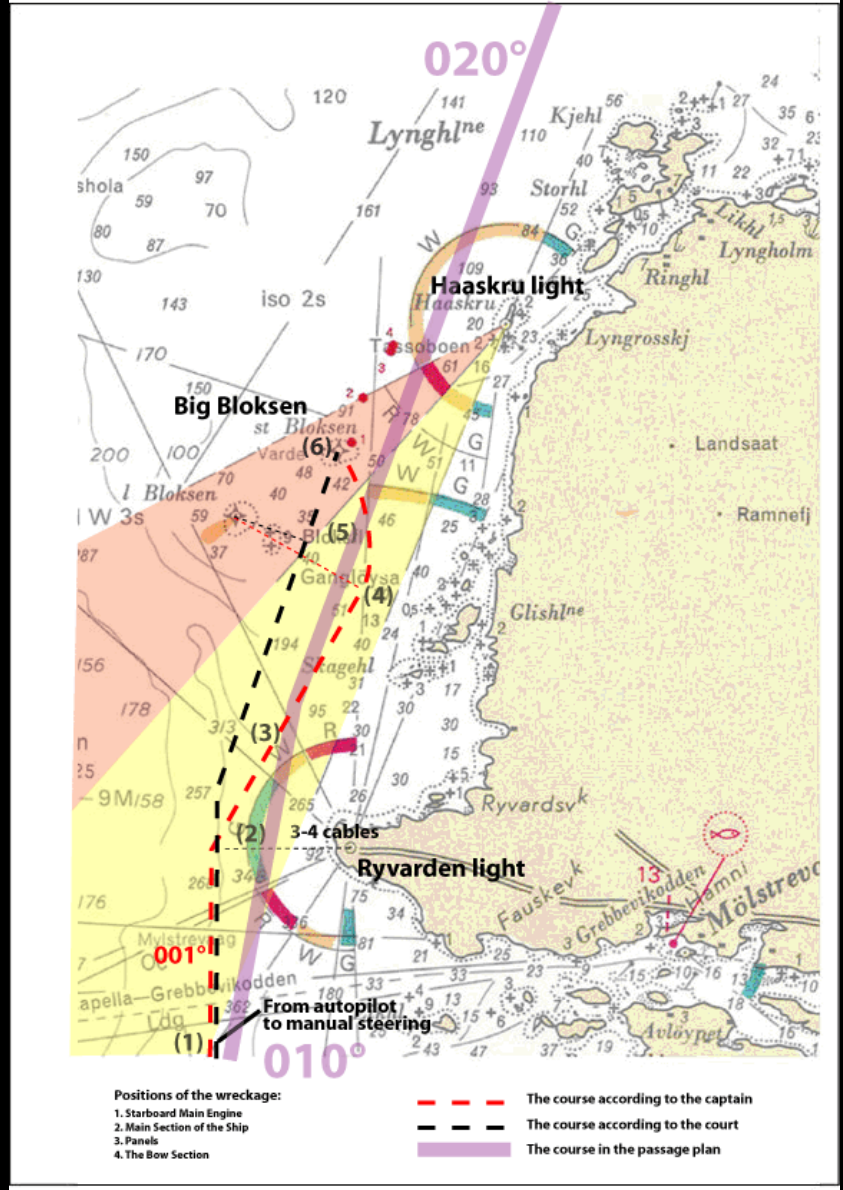
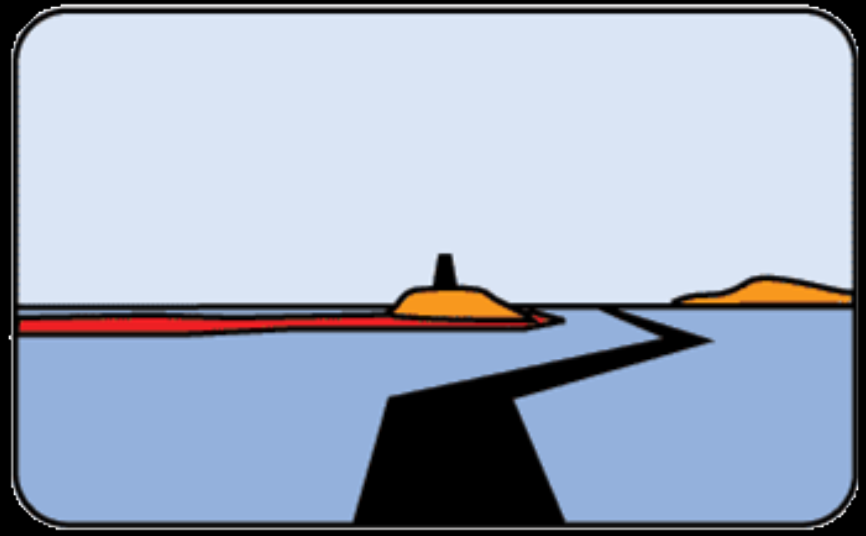
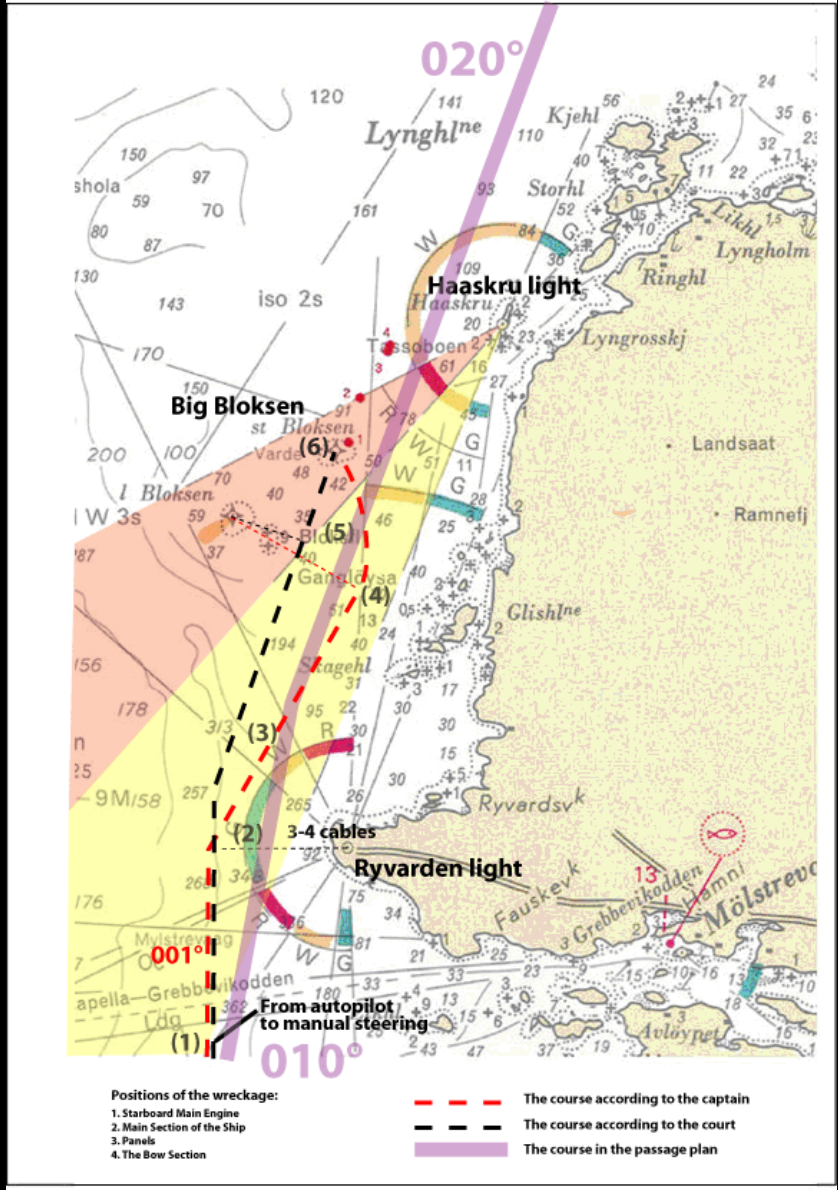

020°
Haaskru light
Big Bloksen
(6)
(5)
(4)
(3)
(2)
3-4 cables
Ryvarden light
001°
From autopilot
to manual steering
(1)
010°
Lynghlne
Kjehl
Storhl
Ringhl
Lyngholm
Haaskru
Tassoboen
Lyngrosskj
Landsaat
Ramnefj
Glishlne
Ryvardsvk
Fauskevk
Grebbevikodden
Mölstrevo
Avløypet
iso 2s
Positions of the wreckage:
1. Starboard Main Engine
2. Main Section of the Ship
3. Panels
4. The Bow Section
The course according to the captain
The course according to the court
The course in the passage plan



Porathe, 2006

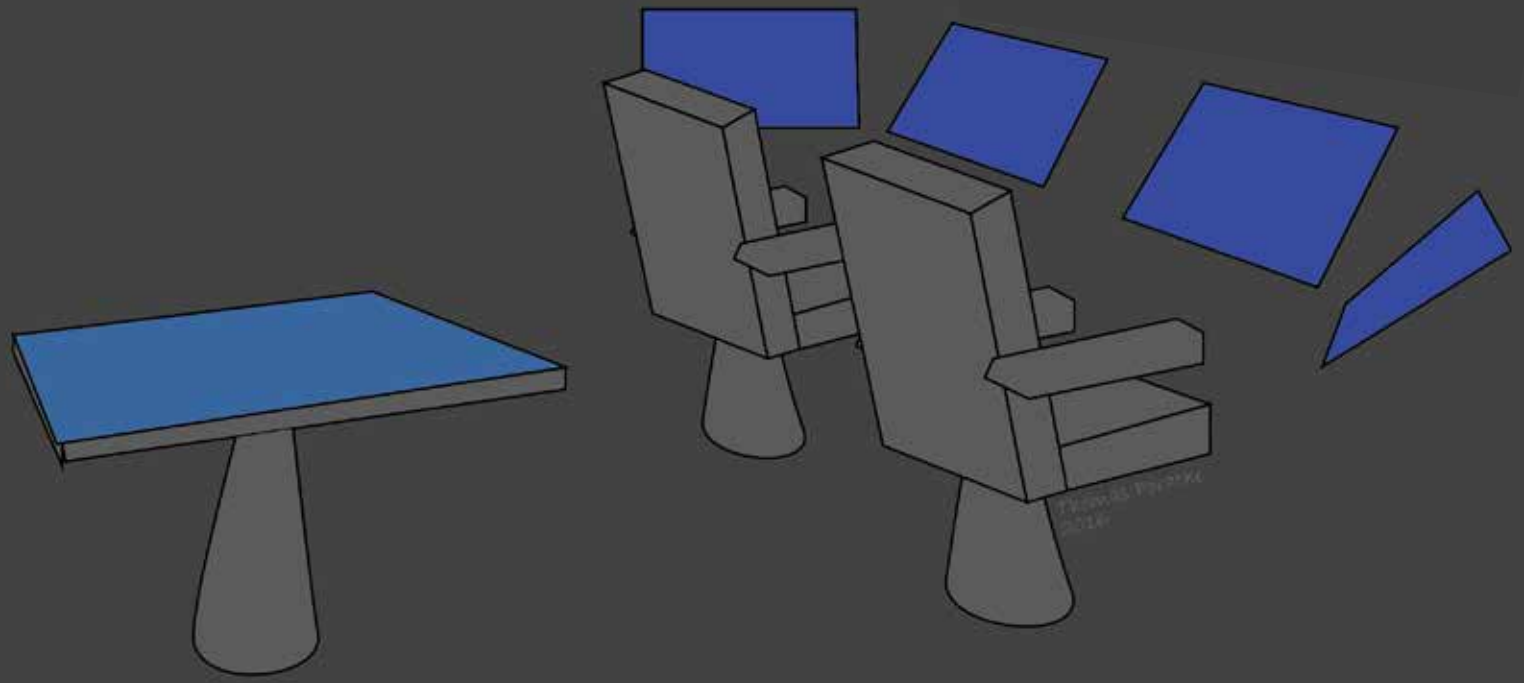
Egocentric 3D chart view
(in conning display or as HUD/HMD)



Porathe, T. (2006). 3-D Nautical Charts and Safe Navigation. Dissertation: Malardalen University Press

https://www.flickr.com/photos/rolls-royceplc/15354513854/in/set-72157647334399764/

Where do we display the new e-Navigation information?

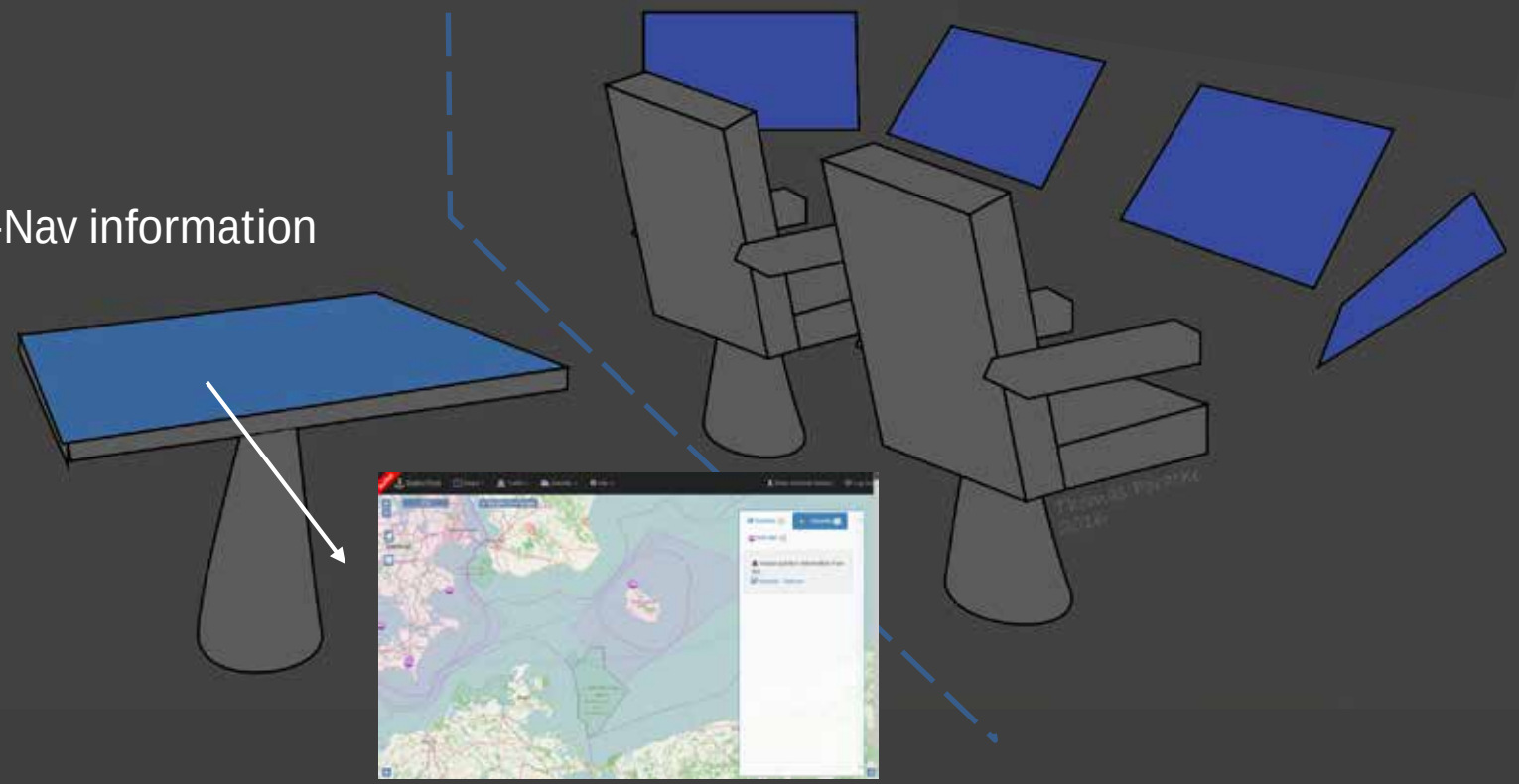


Strategic navigation

”Back bridge”

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

Most e-Nav information



Electronic chart tables
OSMOS project

Focus group with captains
Chalmers 2013

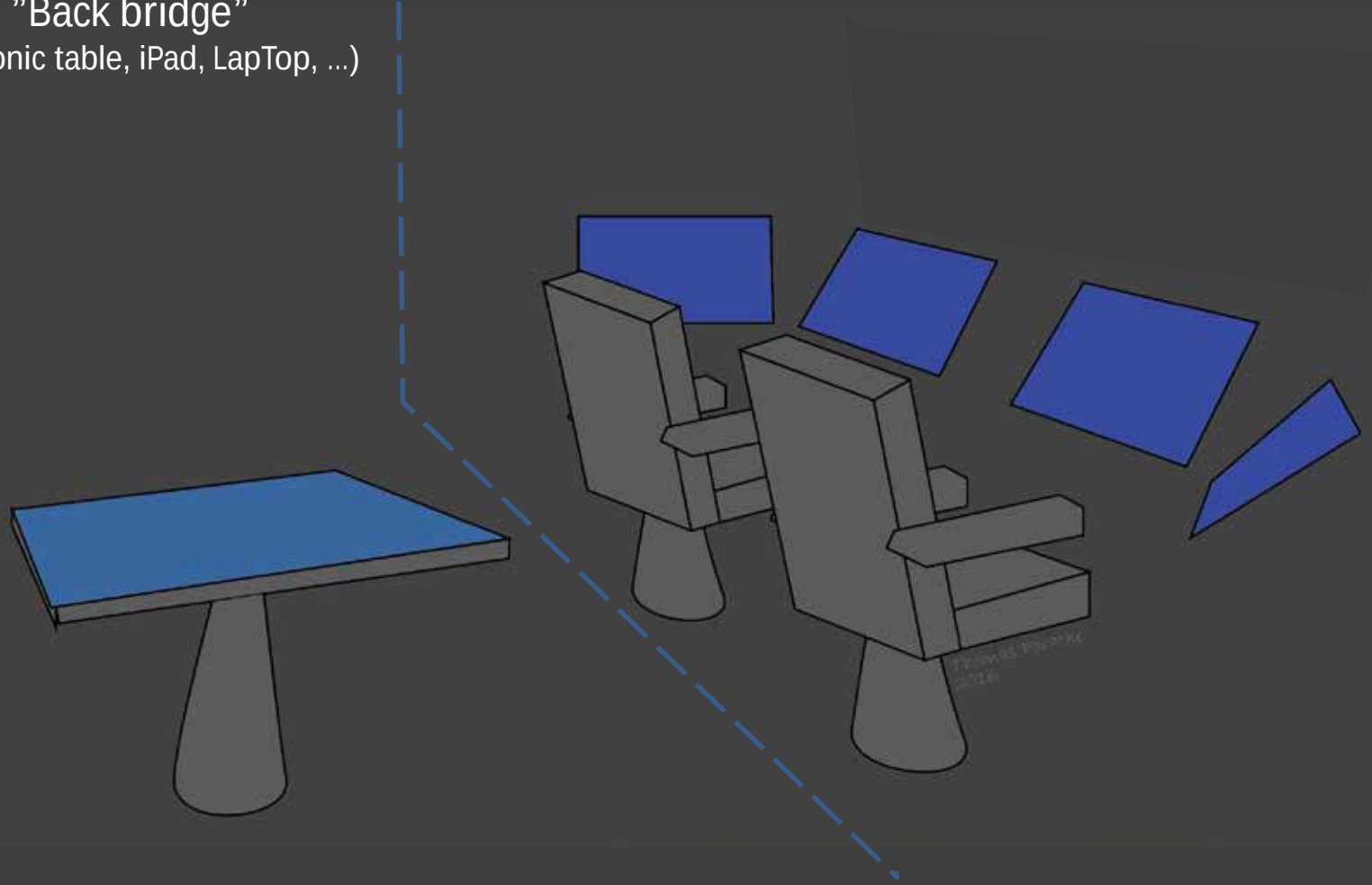
thomas.porathe@ntnu.no

NTNU

Strategic navigation

”Back bridge”

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



Strategic navigation

"Back bridge"

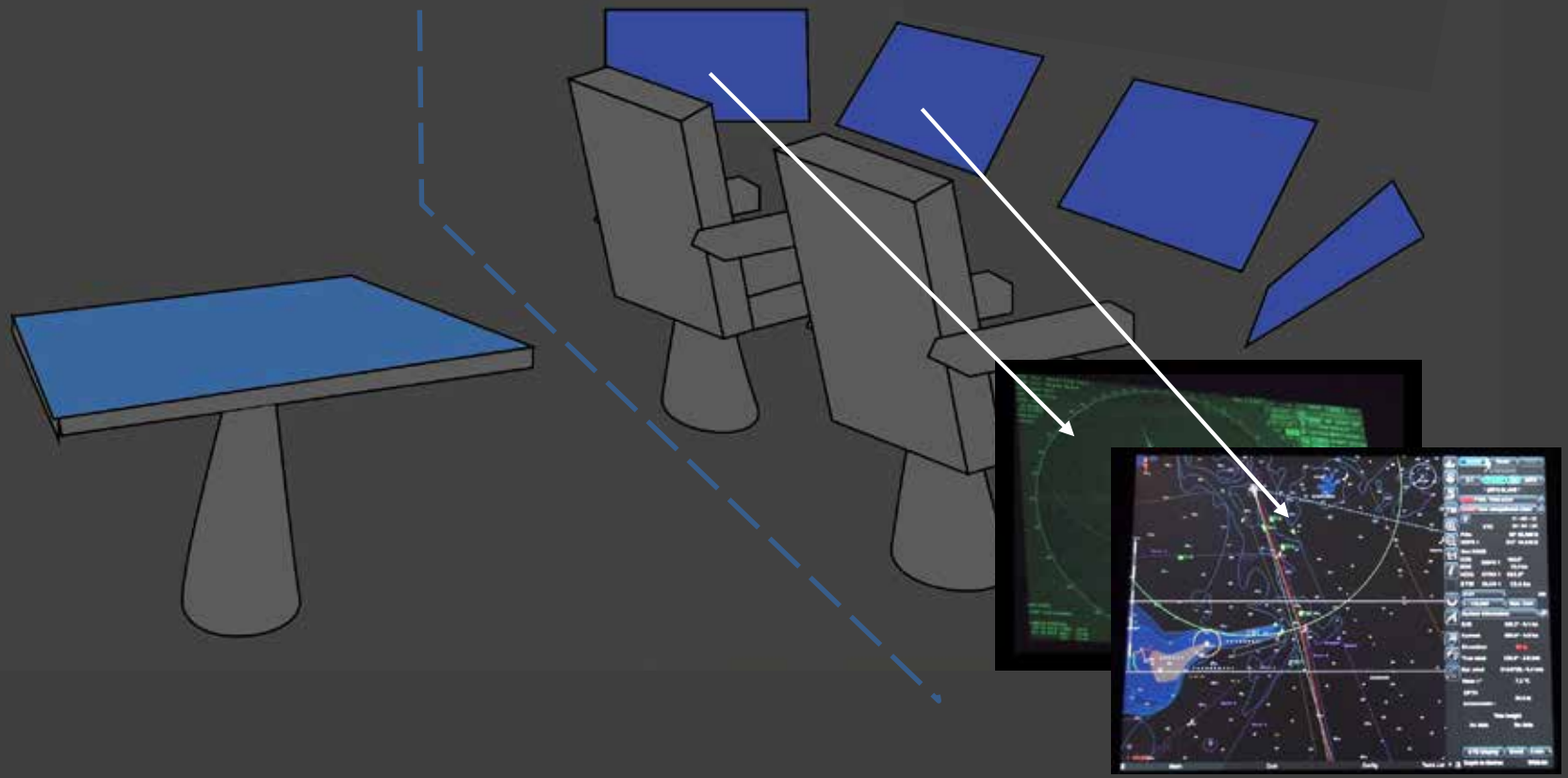
(Electronic table, iPad, LapTop, ...)

Tactical navigation

"Front bridge"

(INS)

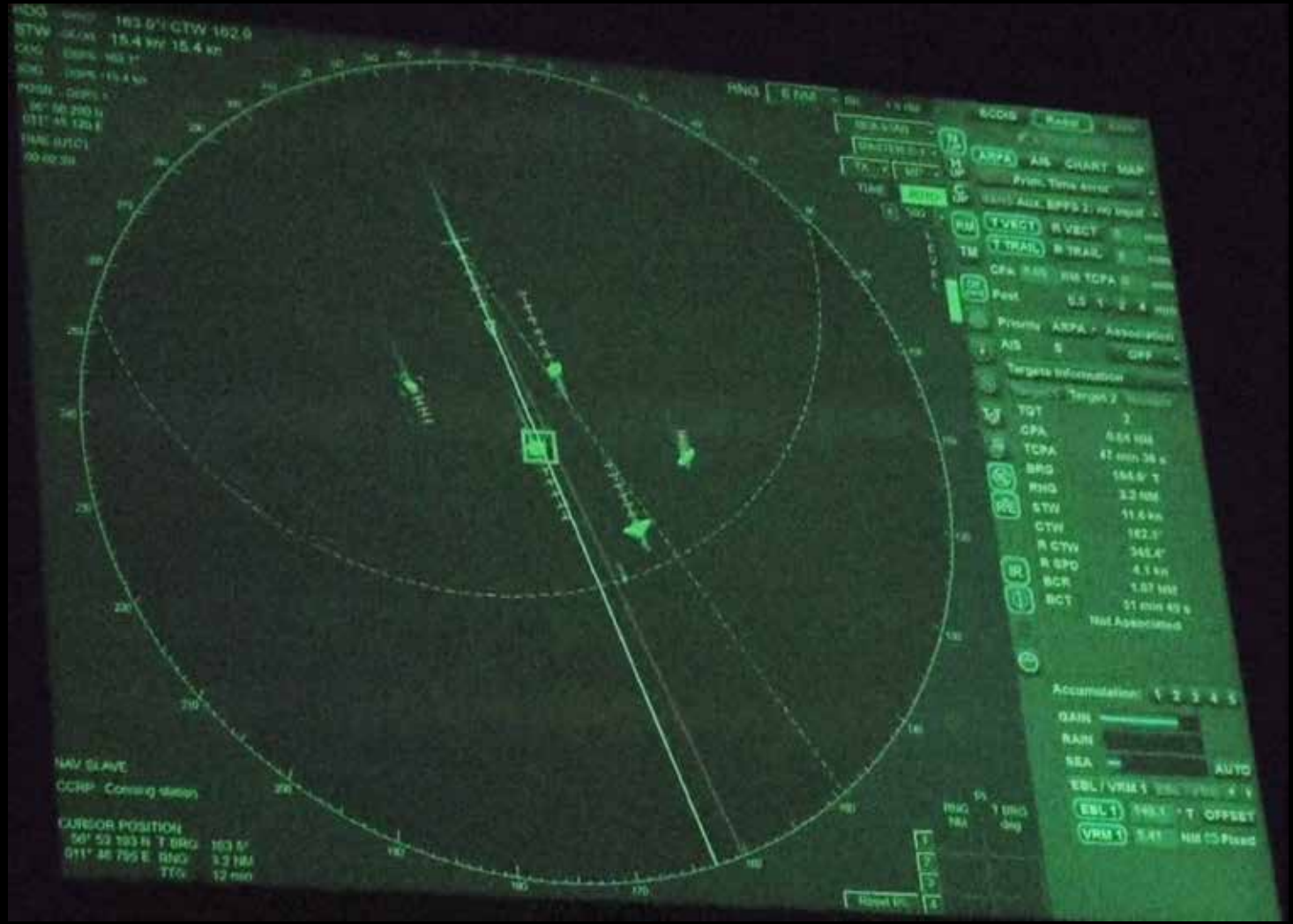
Certain e-Nav information



ECDIS

Radar


Radar
X-1
Overlay
AIS
ARPA
* (BR1) SLAVE *
Prim. Time error
CHART Non navigational chart
11 - 05 - 12
UTC
10 : 01 : 03
Prim
56° 56.586 N
DGPS 1
011° 44.548 E
Sec: NONE
COG
DGPS 1
182.8°
SOG
15.4 kn
HDG
GYRO 1
183.0°
STW
DLOG 1
15.4 kn
d101
CM
1 : 150,000
Man. Corr.
System information
Drift
328.3° - 0.1 kn
Current
000.0° - 0.0 kn
Bf.contour
30 m
True wind
223.0° - 2.6 m/s
Rel. wind
014.0°(S) - 9.4 m/s
Water t °
7.2 °C
DPTH
34.4 m
ECHOSOUNDER 1
Tide height
No data
No data
BTD Display
Event
3 min
Main
Dual
Config
Tasks List
Depth in Metres
WGS-84


ARPA
AIS
CHART
MAP
T VECT
R VECT
T TRAIL
R TRAIL
TQT
CPA
TCPA
BRG
RNG
STW
GTW
R GTW
R SPD
BCR
BCT
Not Associated
GAIN
RAIN
SEA
AUTO
EBL 1
VRM 1
OFFSET
NAV SLAVE
CURSOR POSITION

Strategic navigation

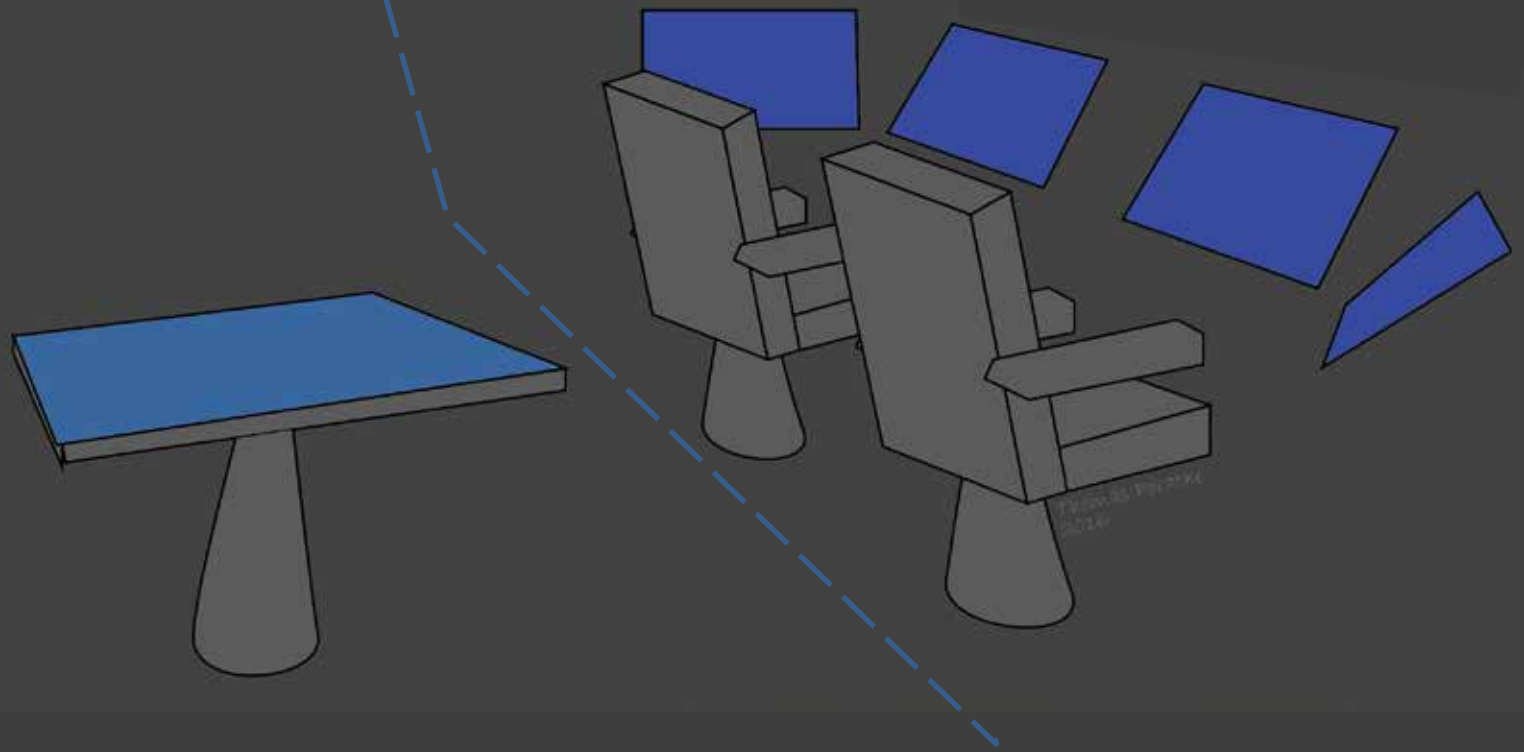
”Back bridge”

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

Tactical navigation

”Front bridge”

(INS)



Strategic navigation

”Back bridge”

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

Tactical navigation

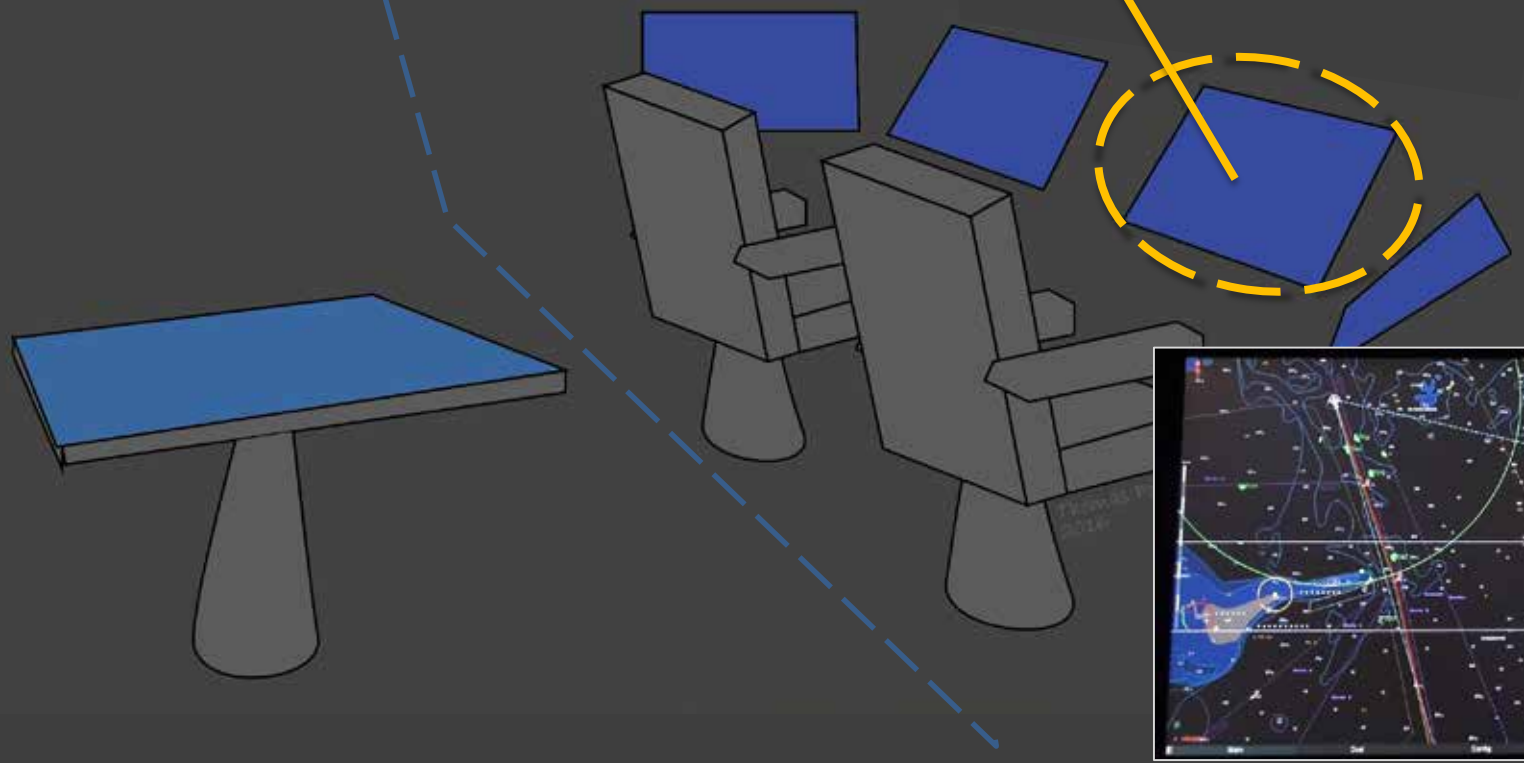
”Front bridge”

(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)

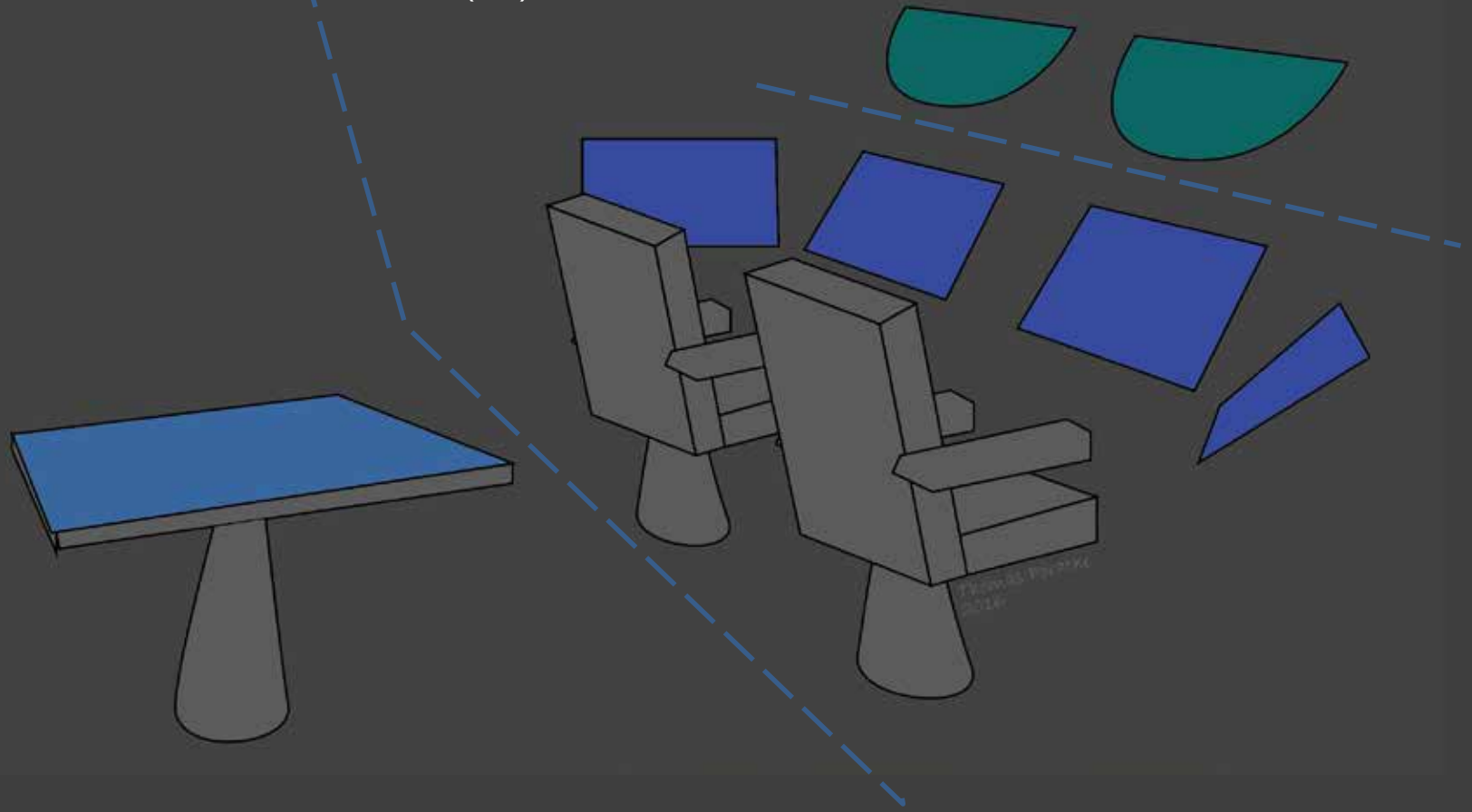
Opportunistic navigation

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

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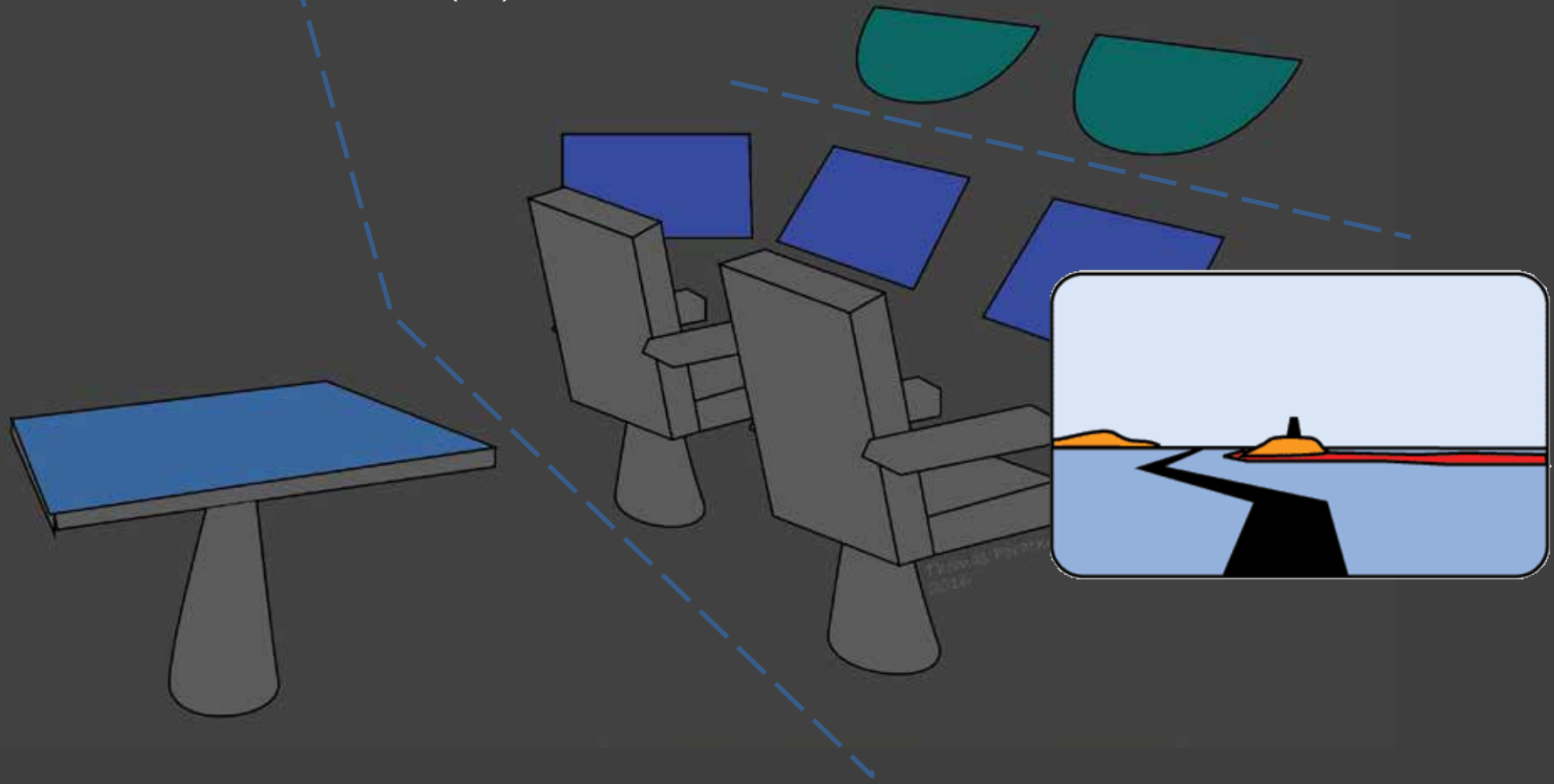

Strategic navigation

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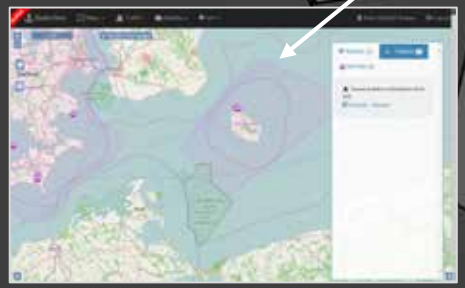
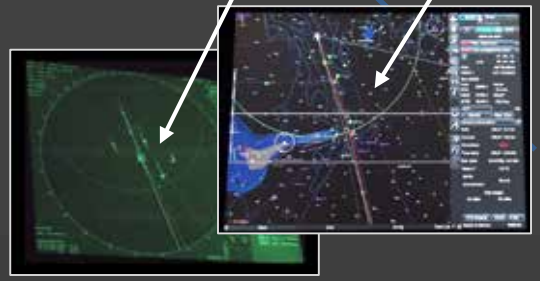


Most e-Nav information



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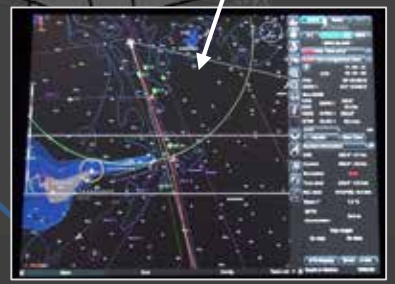
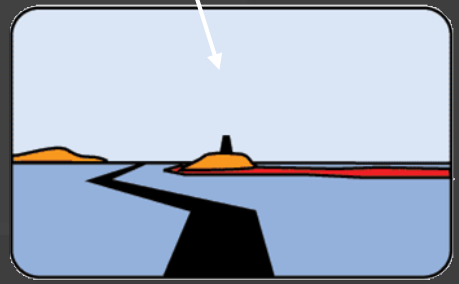


Some carefully selected e-Nav information



Benchmarking ?

”This control room/bridge/radar set is certified for work in strategic-tactical control mode”