NCSR 4/WP.4   Annex 2:
Draft guidelines for shipborne Position, Navigation and Timing (PNT) data processing

E. Engler et.al.
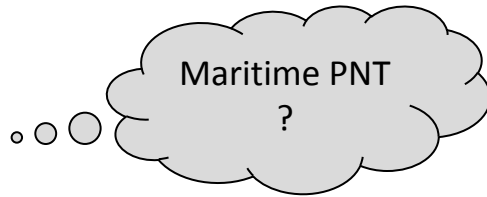
Wissen für Morgen

DLR

Purpose (1)
Improved PNT Data Provision

Maritime PNT
?

Sanders (NL)

E-navigation strategy:

- **Solution 3:**
  Improved reliability, resilience and integrity of bridge equipment and navigation information
- **RCO 5:**
  Improved reliability and resilience of onboard PNT information

Demand on PNT data:

- **Position (P)**
  horizontal, vertical, 3-dimensional, absolute, relative
- **Navigation (N)**
  SOG, COG, heading, rate of turn, and …..
- **Timing (T)**
  date (dd:mm:yy), time (hh:mm:ss)

Purpose (2)

Improved PNT Data Provision

Reliability

> Reliability is the ability of a system to <u>perform its required functions without interruptions</u> under specified conditions for a certain period of time.

Integrity

> Ability to provide users with warnings within a specified time when the system (or data) should not be used for navigation. <u>(criteria?)</u>

Resilience

> Resilience is the ability of a system <u>to detect and compensate external and internal disturbances, malfunction and breakdowns</u> in parts of the system <u>without loss of functionalities</u> and preferably <u>without degradation of their performance</u>.

Purpose (3)

Improved PNT Data Provision - Examples

Reliability

positioning 99.8%/30 days

➢ *no position: ~86 min*

accuracy<10m (95%)

➢ *HPE>10m :   ~2156 min (~1.5 day)*

Integrity

test criteria: (HPE <) estimated HPE < HAL (25m)
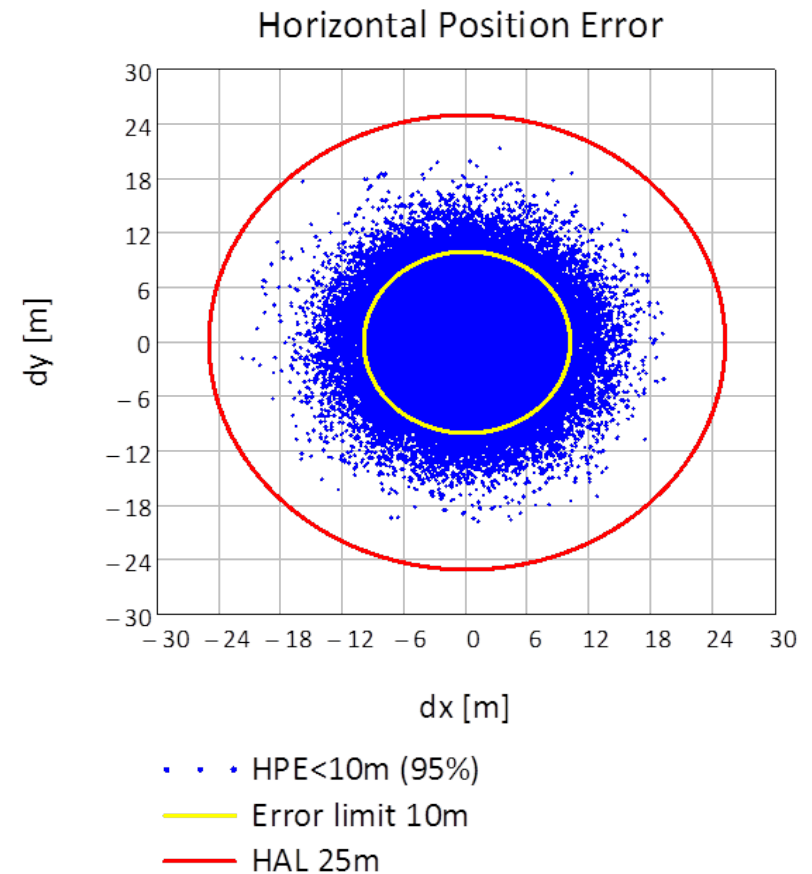
➢ *nominal: HPE < HAL (100%)*

faulty test result (10^{-5} / 3h)

➢ *1 of 96.000 rest results (10Hz)*

Resilience

tbd: position or PNT with/without integrity monitoring

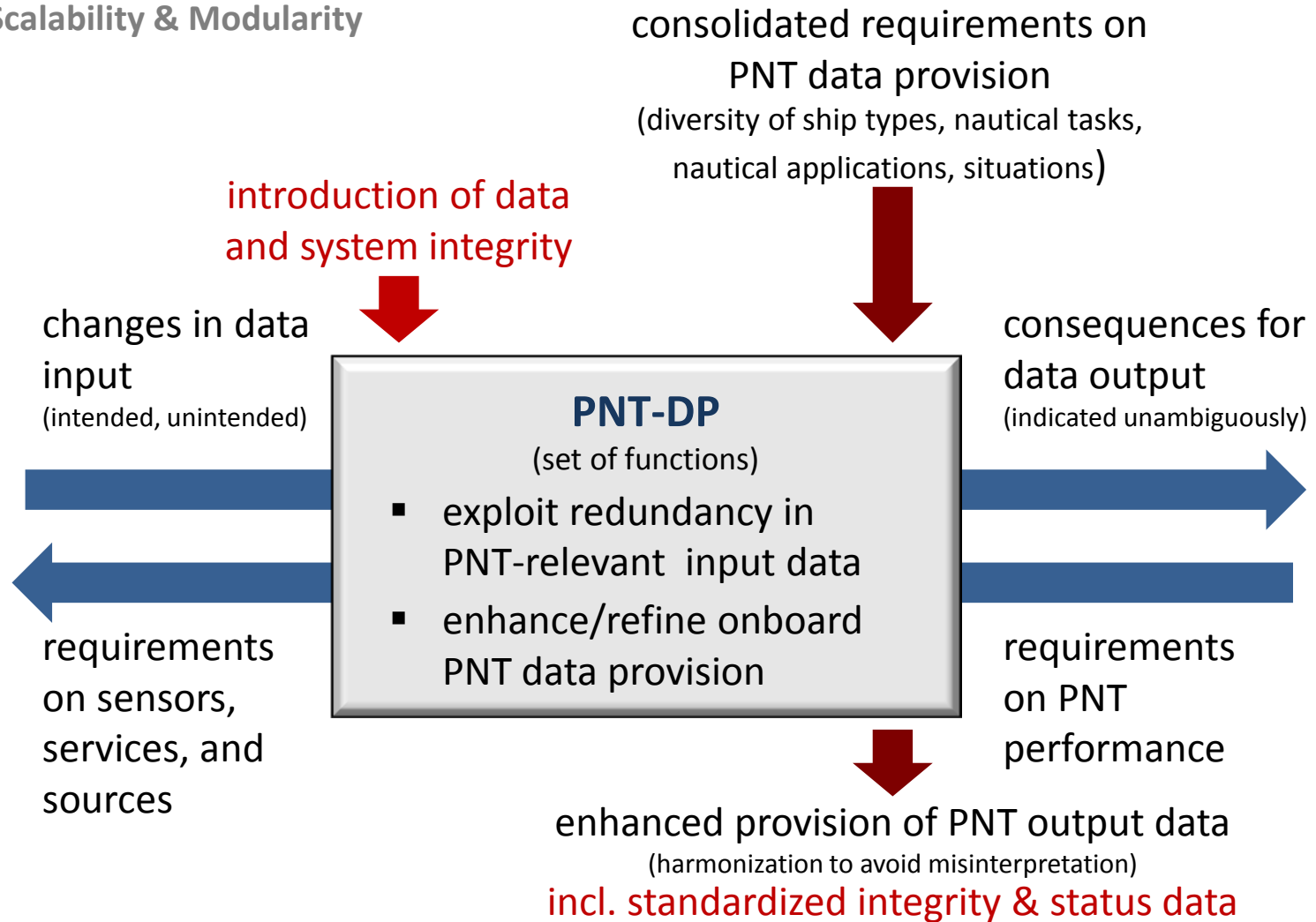*tbd:* in relation to supported accuracy/integrity level

Horizontal Position Error

• • • HPE<10m (95%)

— Error limit 10m

— HAL 25m

PNT relevant systems, services, sensors & sources
Overview
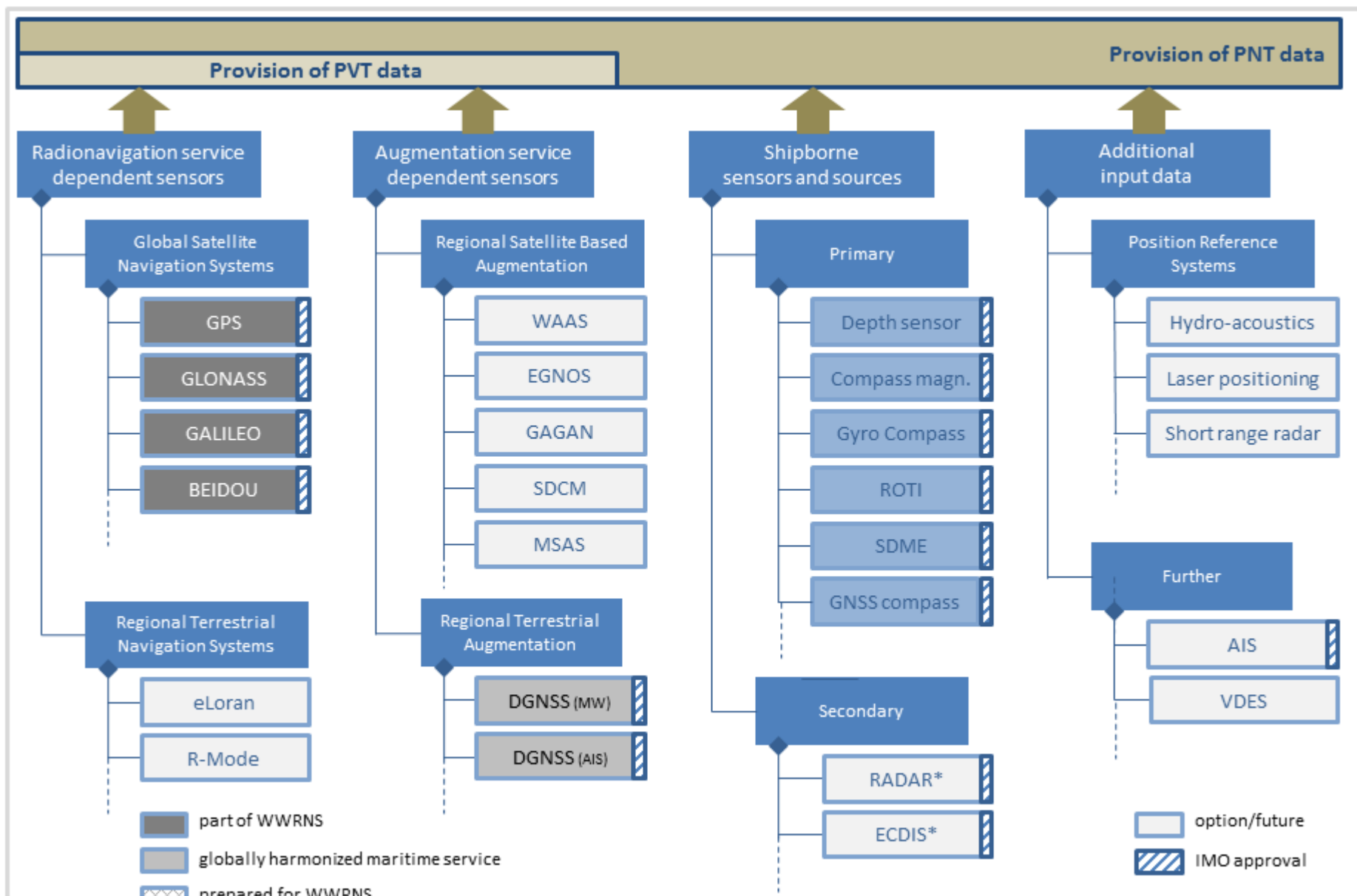
Challenge (1)

PNT - Scalability & Modularity

consolidated requirements on
PNT data provision
(diversity of ship types, nautical tasks,
nautical applications, situations)

introduction of data
and system integrity

changes in data
input
(intended, unintended)

consequences for
data output
(indicated unambiguously)

PNT-DP
(set of functions)

- exploit redundancy in
  PNT-relevant input data
- enhance/refine onboard
  PNT data provision

requirements
on sensors,
services, and
sources

requirements
on PNT
performance

enhanced provision of PNT output data
(harmonization to avoid misinterpretation)
incl. standardized integrity & status data
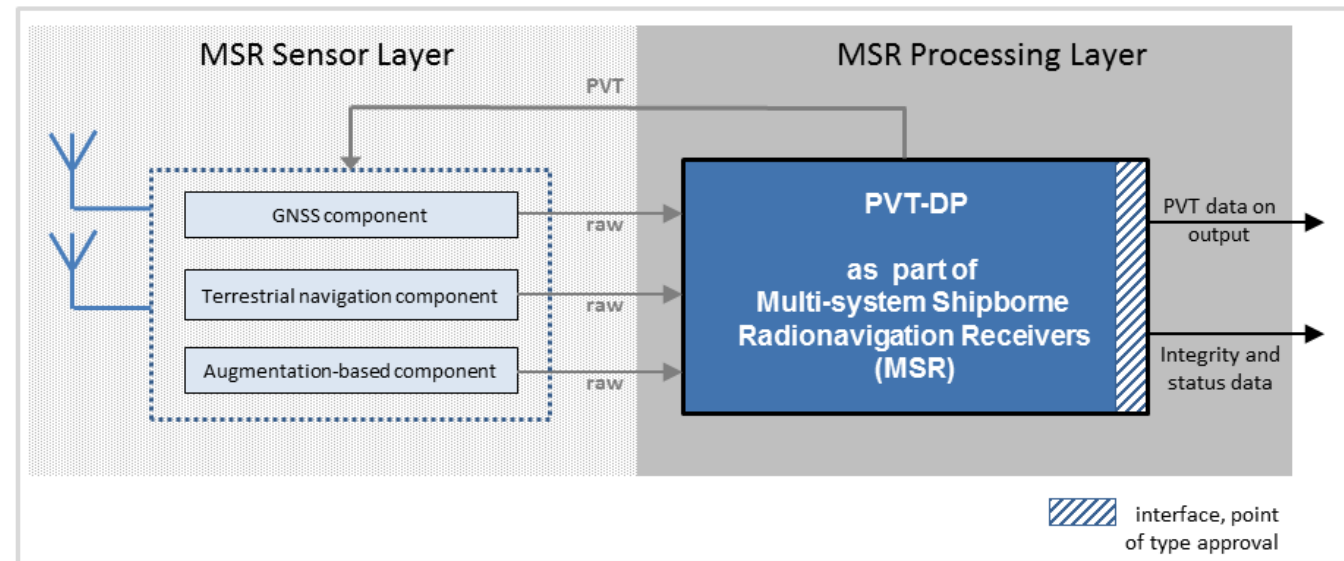
DLR

Challenge (2)

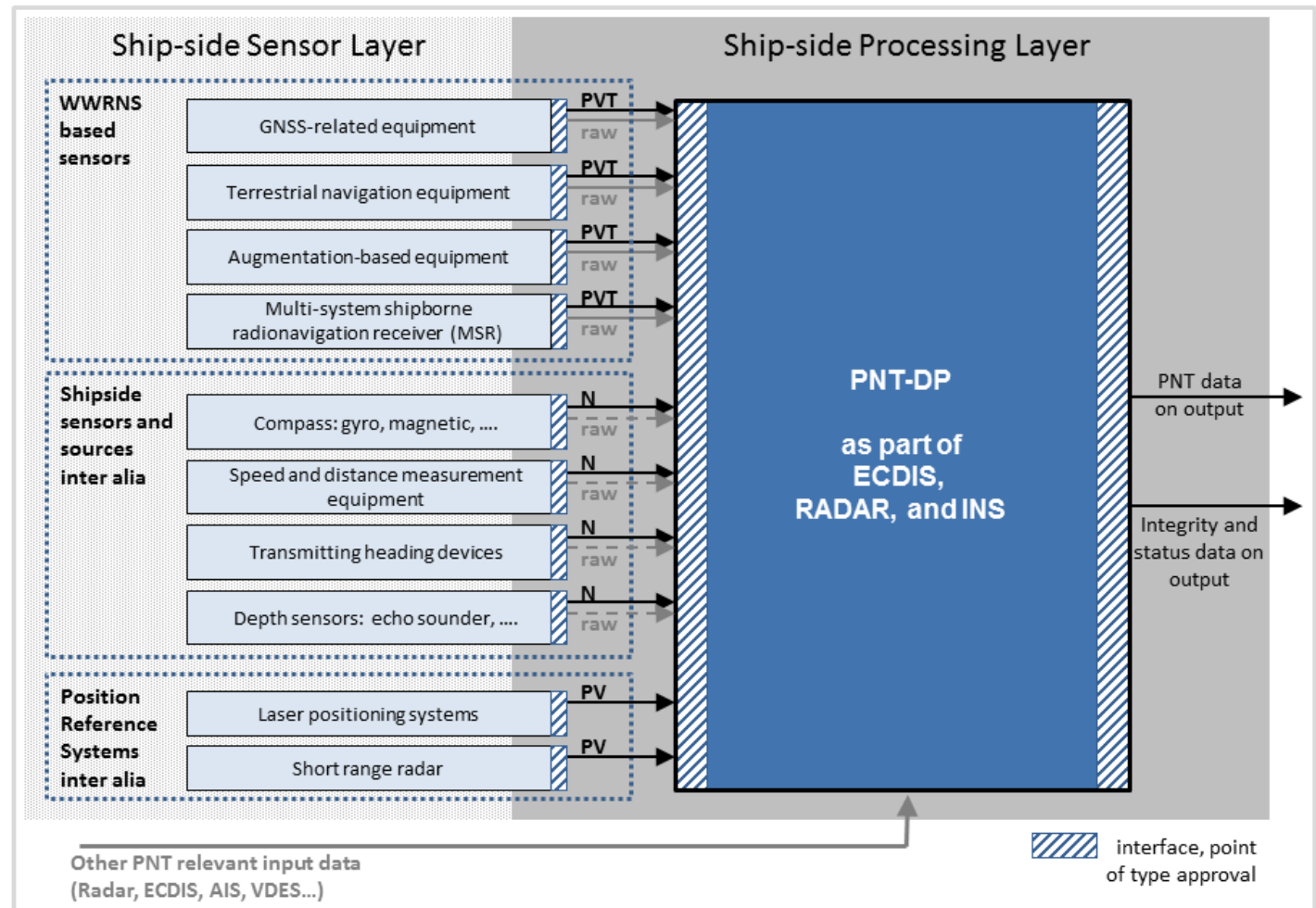## PNT - Scalability & Modularity

**PNT-DP
of
MSR
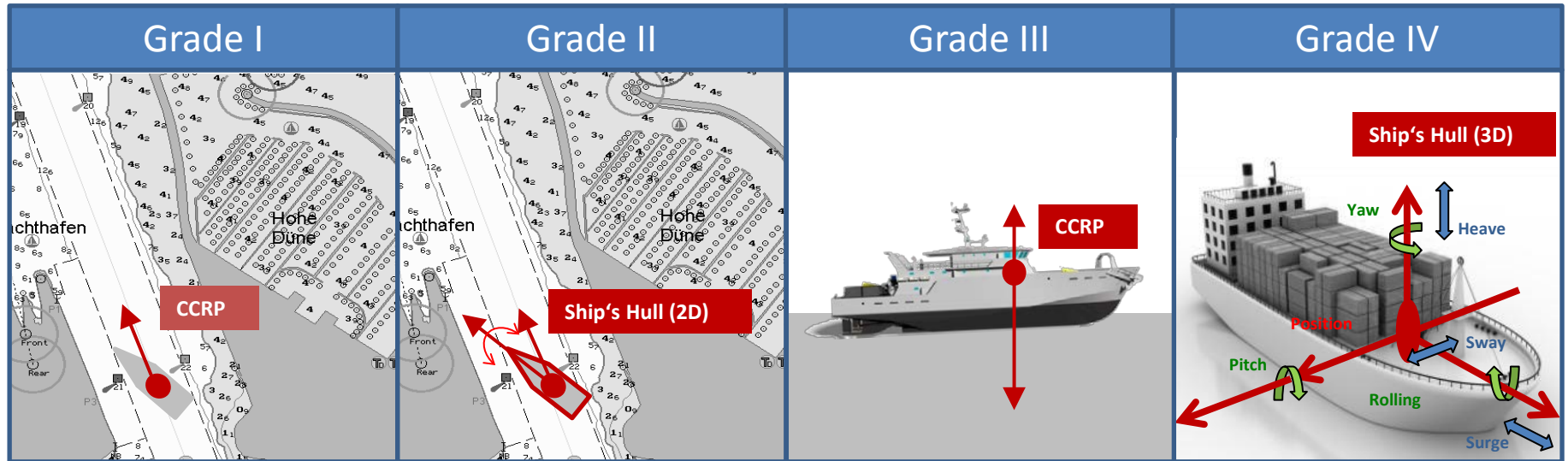receivers**

Challenge (3)

PNT - Scalability & Modularity

PNT-DP of multi-sensor systems (ECDIS, RADAR, INS)

Performance Specification (1)

Data Amount and Types

PVT data:
- Latitude and Longitude
- SOG and COG
- Time

Horizontal PNT data:
PVT data +
- Heading and ROT
- STW and CTW

Extended PNT data:
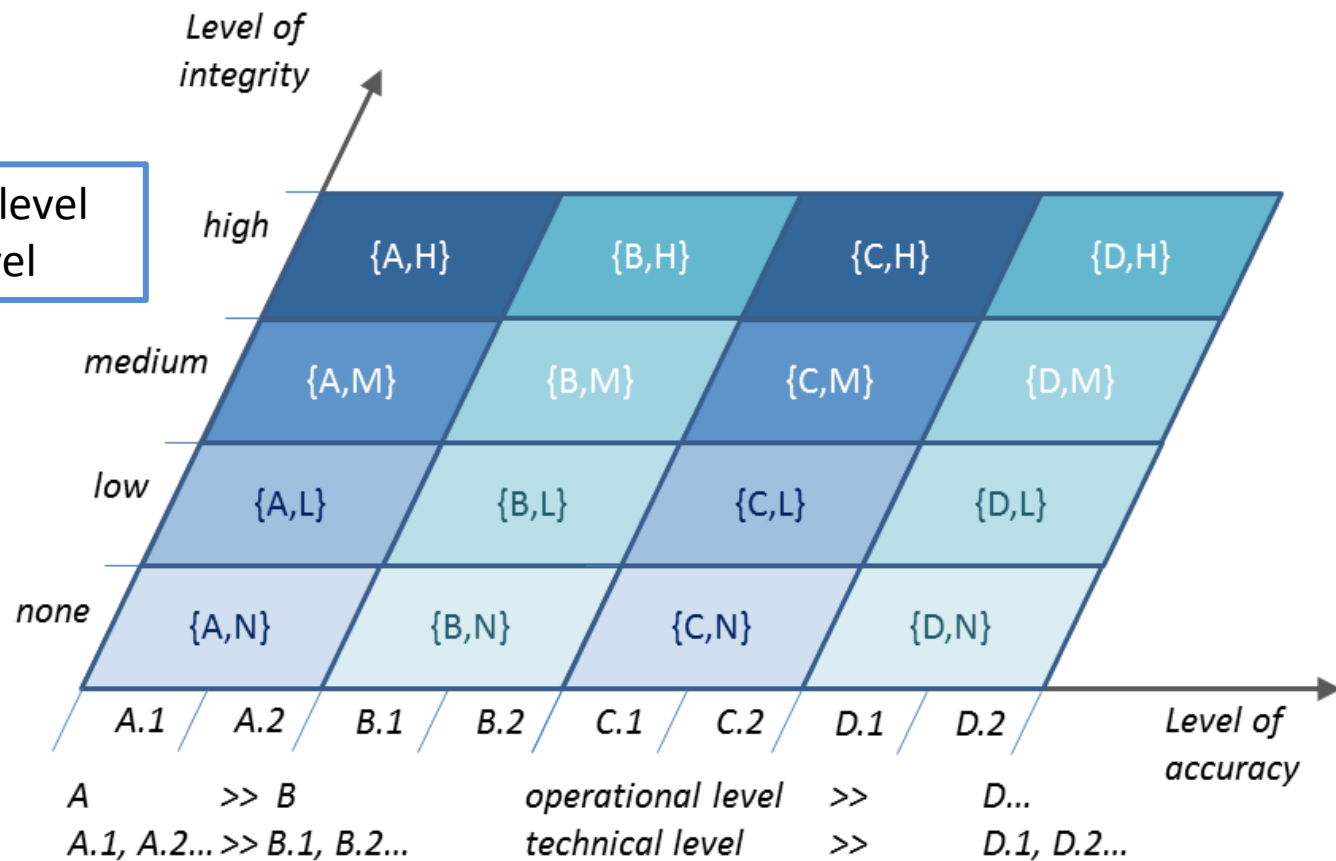Horizontal PNT data +
- Altitude
- Depth

Full PNT data:
Extended PNT data +
- Heave, sway*, and surge*
- Yaw*, pitch, and roll

Performance Specification (2)

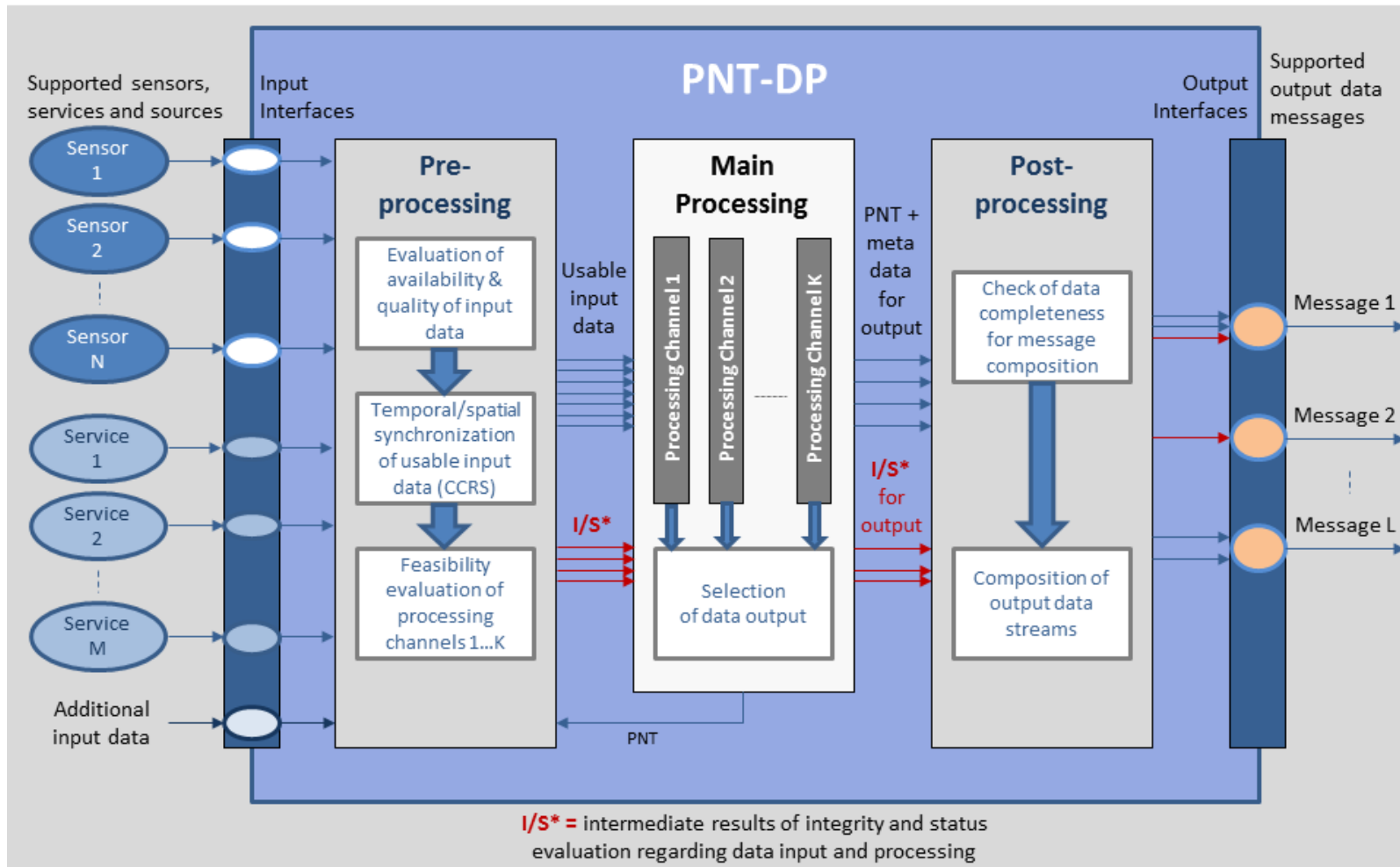**Accuracy**

Performance Specification (3)
Integrity

- None: Unavailable integrity evaluation;

- Low: Integrity as result of plausibility and consistency checks;

- Medium: Integrity as results of consistency checks of data with uncorrelated error parts as far as   possible;

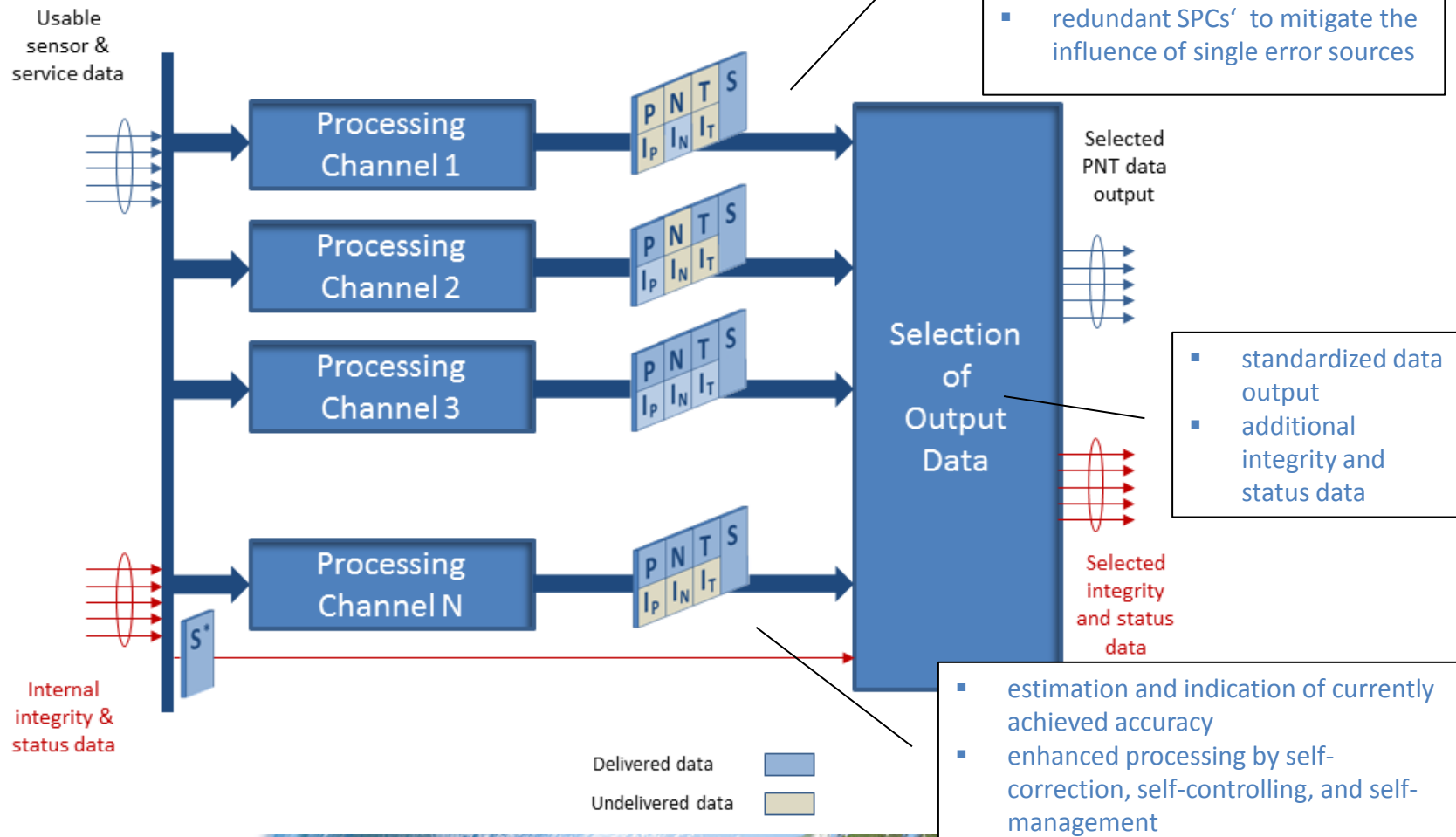- High: Integrity based on estimated accuracy (PL).

Generic Architecture

Exploitation of redundancy in PNT-relevant database

View on Main Processing

Modularity: Concept of Single Processing Chains

- a SPC provides some or all output data with its specific accuracy and integrity level;
- several SPCs to complete PNT output data or to meet other accuracy and integrity level (e.g. fall-back solutions);
- redundant SPCs' to mitigate the influence of single error sources

- standardized data output
- additional integrity and status data

- estimation and indication of currently achieved accuracy
- enhanced processing by self-correction, self-controlling, and self-management

View on Main Processing
Modularity: Controlled Output Selection

Integrity level „M" and „H" is based on evaluated data accuracy .
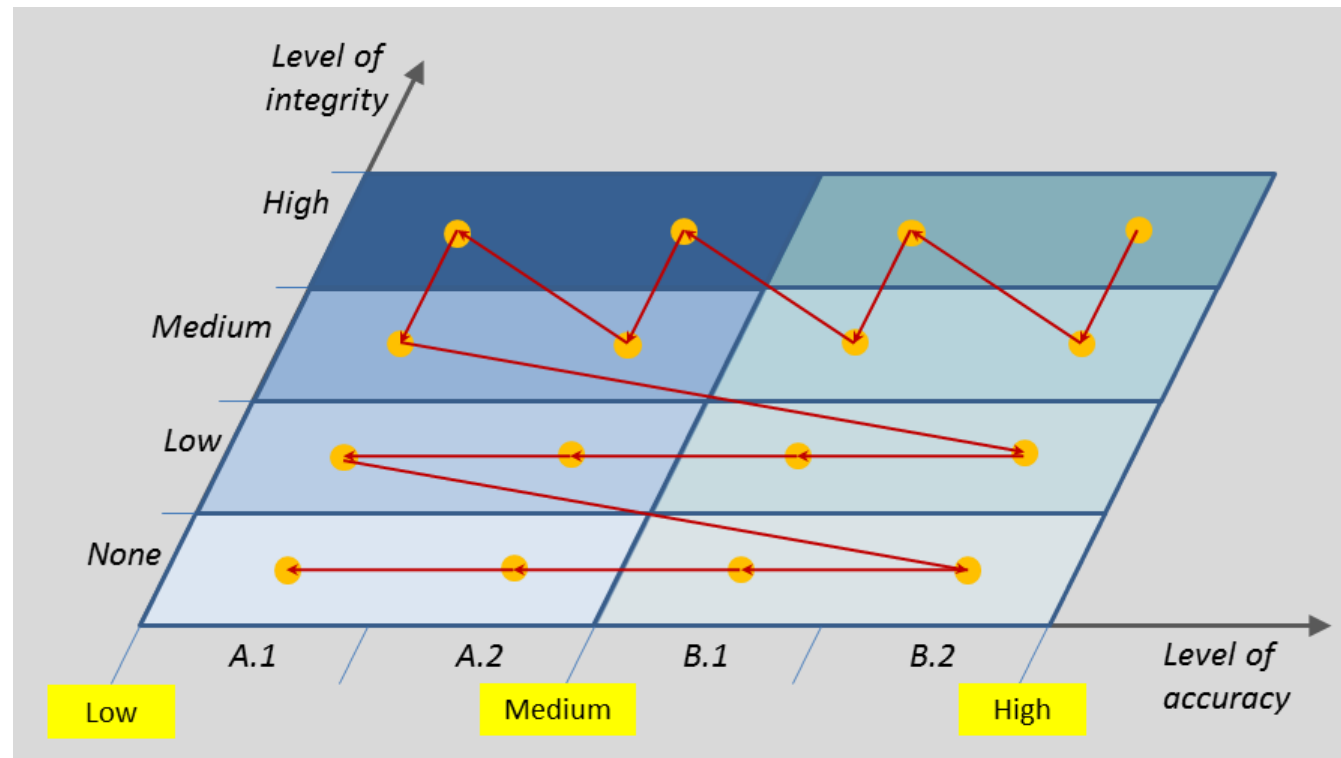
View on Main Processing
Modularity: Controlled Output Selection

The application decides ultimately about the current usability of PNT data based on supported accuracy level and evaluated integrity.

	Latitude	Longitude	SOG	COG	Time	Heading	ROT	CTW	STW	Altitude	Depth	Pitch	Roll	Heave
Monitoring	x	x	x	x	x									
Ocean	A,N	A,N	tbd	tbd	tbd									
Coast	B,N	B,N	tbd	tbd	tbd									
...														
Automated Control	x	x	x	x	x	x	x	x	x					
Ocean	A,L	A,L	tbd	tbd	tbd	tbd	tbd	tbd	tbd					
Coast	B,L	B,L	tbd	tbd	tbd	tbd	tbd	tbd	tbd					
Port	C,M	C,M	C,M	C,M	C,M	C,M	C,M	C,M	C,M					
Docking	D,H	D,H	D,H	D,H	D,H	D,H	D,H	tbd	tbd					
3D-Stabilization	x	x			x	x	x			x	x	x	x	x
tbd	tbd	tbd			tbd	tbd	tbd			tbd	tbd	tbd	tbd	tbd

Application Grade: I, II, III, IV

Nautical Application

x — need of individual PNT data types
A, B,C.... — accuracy level
N, L, M.... — integrity level in relation to required accuracy level
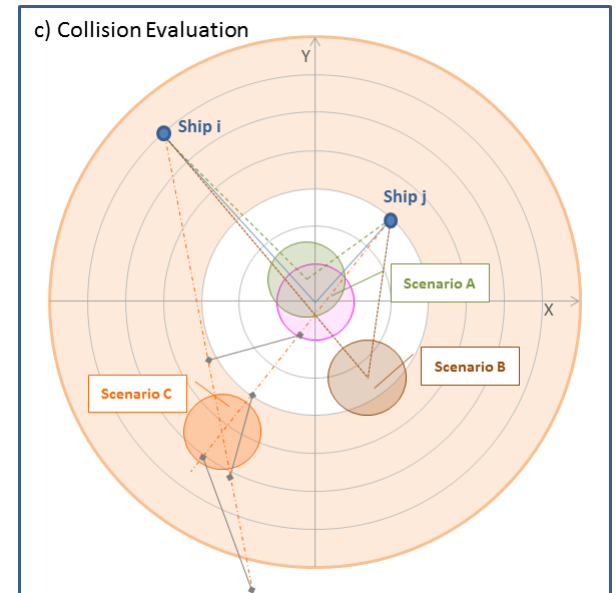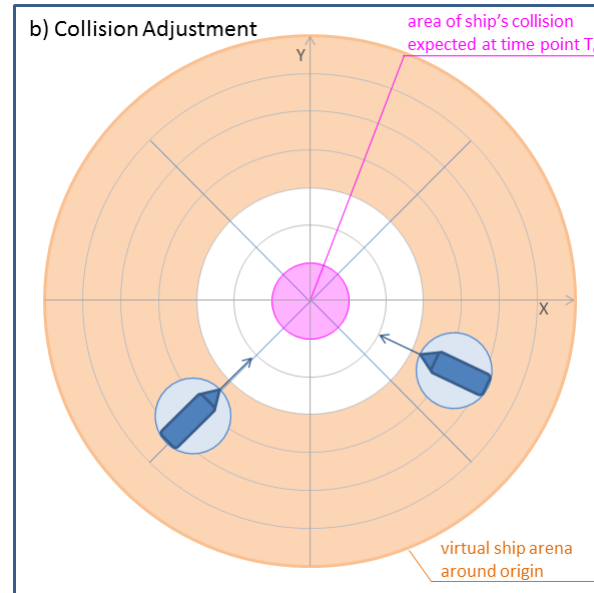tbd — to be defined

Performance Requirement (1)

Task and/or application driven specification

Case studies may harmonize and concretize requirements on accuracy.

Example: None detection of collision risks (case C) by inaccurate PNT data.

b) Collision Adjustment

area of ship's collision expected at time point T_c

virtual ship arena around origin

c) Collision Evaluation

Ship i

Ship j

Scenario A

Scenario B

Scenario C

Performance Requirement (2)
Task and/or application driven specification

Consideration of single error sources:

- ❑ σ_{Pos} should be smaller than 27m (see Figure),
- ❑ σ_{SOG} should be smaller than 0.09 knots,
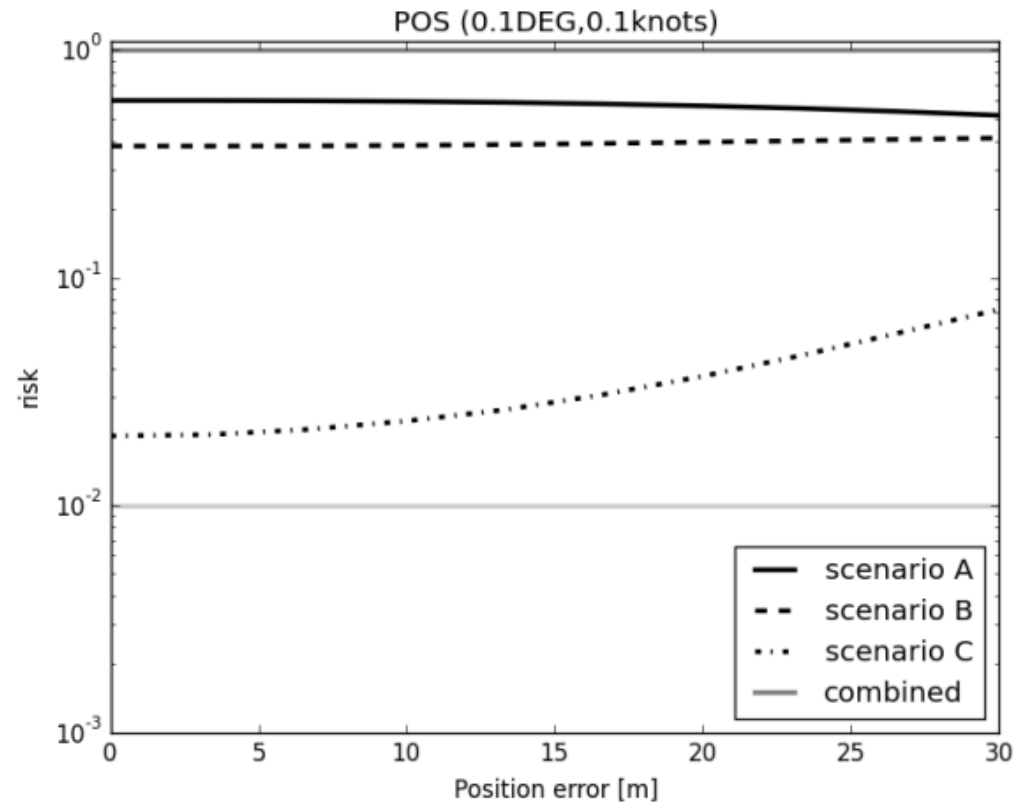- ❑ σ_{COG} should be smaller than 0.25 DEG,
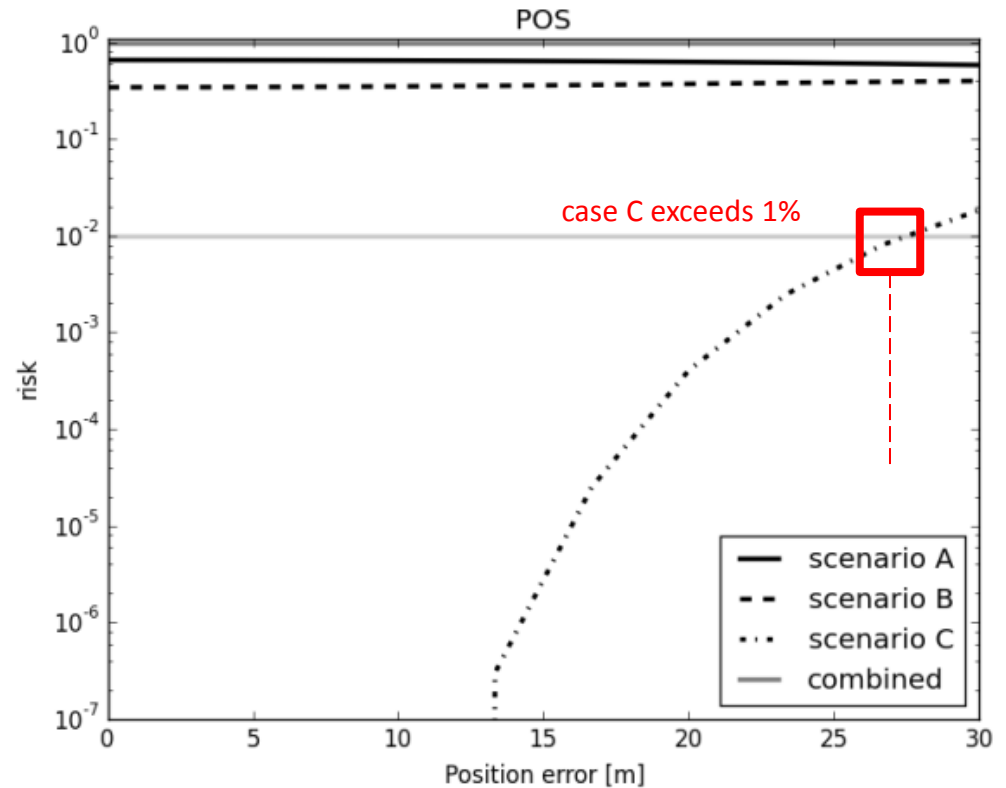
Performance Requirement (3)

Task and/or application driven specification

Consideration of single error
sources:

❑ σ_{Pos} should be smaller than
27m (see Figure),

❑ σ_{SOG} should be smaller than
0.09 knots,

❑ σ_{COG} should be smaller than
0.25 DEG,

In the case of the combined error it
is not possible to keep the
probability of occurrence of
scenario C below 1% !

POS (0.1DEG,0.1knots)

scenario A
scenario B
scenario C
combined

risk

Position error [m]

Thanks for your attention !