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Feasibility Study of Automated Process of Ship Navigation and A Framework of Action Planning System (APS)

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Outline

1. Autonomous Ship – NYK's Motivation

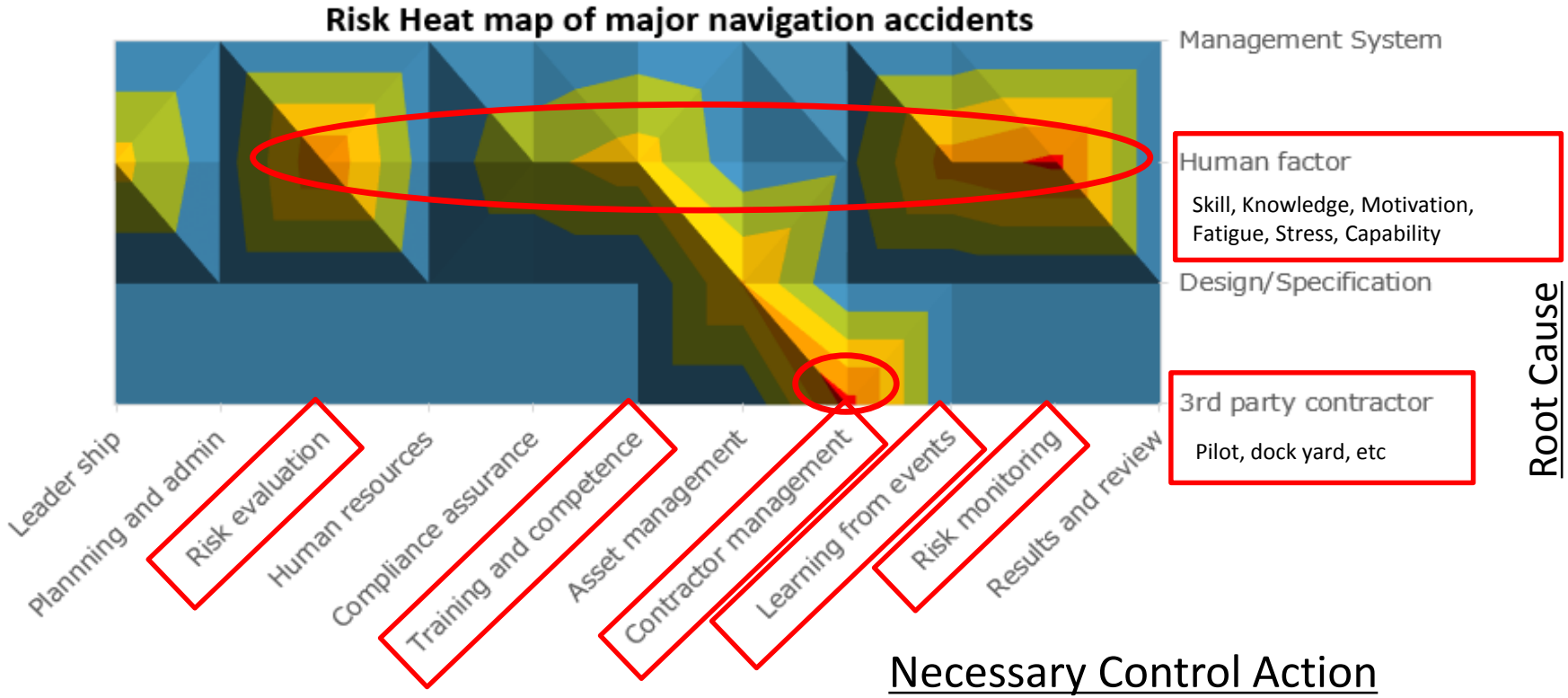
2. Feasibility Study of Autonomous Ship (Deep Sea Vessel)

3. A Framework of Action Planning System (APS)

4. Summary

1. Autonomous Ship – NYK's Motivation

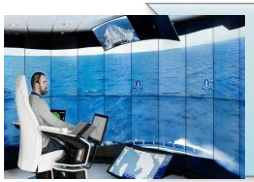
Approaching to Human Factor



Obviously human factor is the key to reduce accident

2. Feasibility Study of Autonomous Ship (Deep Sea Vessel)

Level of Autonomous Navigation for Economic Evaluation

Level of Autonomous Navigation	Information Acquisition	Analysis	Planning	Approval
 1.Current	Seafarer Onboard Equipment	Seafarer	Seafarer	Seafarer
 2. Manned Autonomous	Onboard Equipment Seafarer	Onboard Equipment Seafarer	Onboard Equipment Seafarer	Seafarer
 3. Remote	Onboard Equipment	Onboard Equipment	Onboard Equipment	Remote Operator
 4. Unmanned Autonomous	Onboard Equipment	Onboard Equipment	Onboard Equipment	Onboard Equipment

Quote:

1. Yara International ASA, The first ever zero emission autonomous ship, March 14, 2018, https://www.yara.com/knowledge-grows/game-changer-for-the-environment/
2. Rolls-Royce plc, AHEAD OF THE PACK, https://www.rolls-royce.com/~/media/Files/R/Rolls-Royce/documents/customers/marine/tug-brochure-2017.pdf

Assumption for Economical Evaluation

(1) Equipment (CAPEX and OPEX)

- The onboard equipment and the onshore facility cost, which are required additionally to the autonomous ship are estimated.
- The reliability and redundancy of the system are taken into account.
- Assumed life of equipment as 10 years

Type	Additional On-board Equipment	Additional On-shore Equipment
1.Current	-	-
2.Manned Autonomous	Action Planning System 1 $300,000	-
3.Remote	Action Planning System 2 $500,000	Remote Control Center $500,000
4.Unmanned Autonomous	Action Planning System 3 $700,000	Remote Monitor $50,000

* The annual maintenance cost of additional equipment is estimated as five percent of the equipment cost.

Assumption for Economical Evaluation

(2) Personnel Expenses(OPEX)

- The manning of bridge team and additional costs are estimated as below.
- For the remote navigation, five remote operators are set to comply with the ILO regulations.
- The Master and other crew members involved in other operations are excluded from this consideration, assumed being onboard as they are.

Type	Officer $5,000/month	Rating $2,000/month	Remote Operator $5,000/month	Additional Cost
1.Current	3	3	0	—
2.Manned Autonomous	3	2	0	—
3.Remote	0	0	5	Mooring & Cargo Operation $1,000 per operation per person
4.Unmanned Autonomous	0	0	0	

Assumption for Economical Evaluation

(3) OPEX (communication and cyber security)

- In case of remote navigation, high speed satellite communication to transmit visual images from the ship to shore is assumed.
- As for unmanned autonomous navigation, the communication cost for monitoring from shore is assumed.
- In addition, countermeasure cost for cyber security is assumed.

Type	Additional Communication Cost	Cyber Security Cost
1.Current	None	$1,000/month
2.Manned Autonomous	None	$2,000/month
3.Remote	$40,000/month	$10,000/month
4.Unmanned Autonomous	$10,000/month	$10,000/month

Assumption for Economical Evaluation

(4) Accident Loss

- Assumptions are based on the P&I and H&M insurance payments
- Occurrence frequency and average loss amount of navigational accidents, as 0.02 times per year per vessel, and $300K per case.
- 90 percent of the losses can be reduced by manned autonomous and remote navigation, and 95 percent of the losses can be reduced by unmanned autonomous navigation

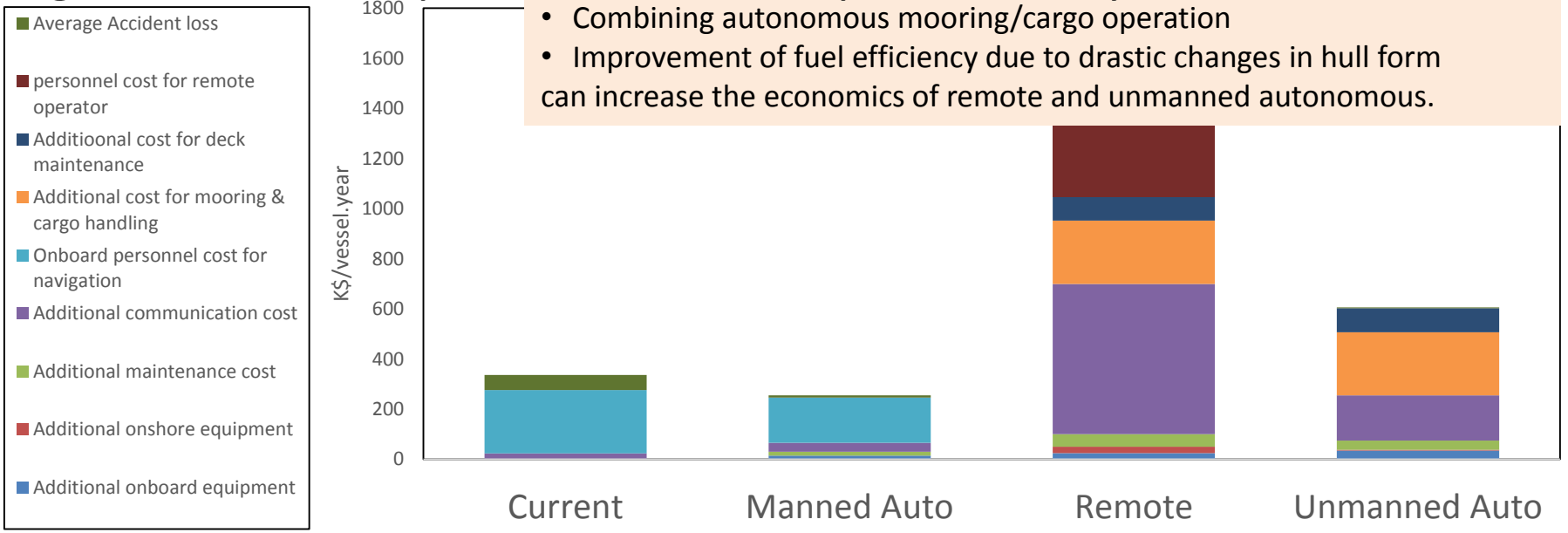
Type	Occurrence Frequency	Average Loss Amount per year
1.Current	0.02 times/year・vessel	$60,000
2.Manned Autonomous	0.002 times/year・vessel	$8,700
3.Remote	0.002 times/year・vessel	$8,700
4.Unmanned Autonomous	0.001 times/year・vessel	$3,000

Result of Economic/Practicability Evaluation

At the current stage, manned autonomous navigation has the highest economic performance with practicability.

- Combining autonomous mooring/cargo operation
- Improvement of fuel efficiency due to drastic changes in hull form

can increase the economics of remote and unmanned autonomous.

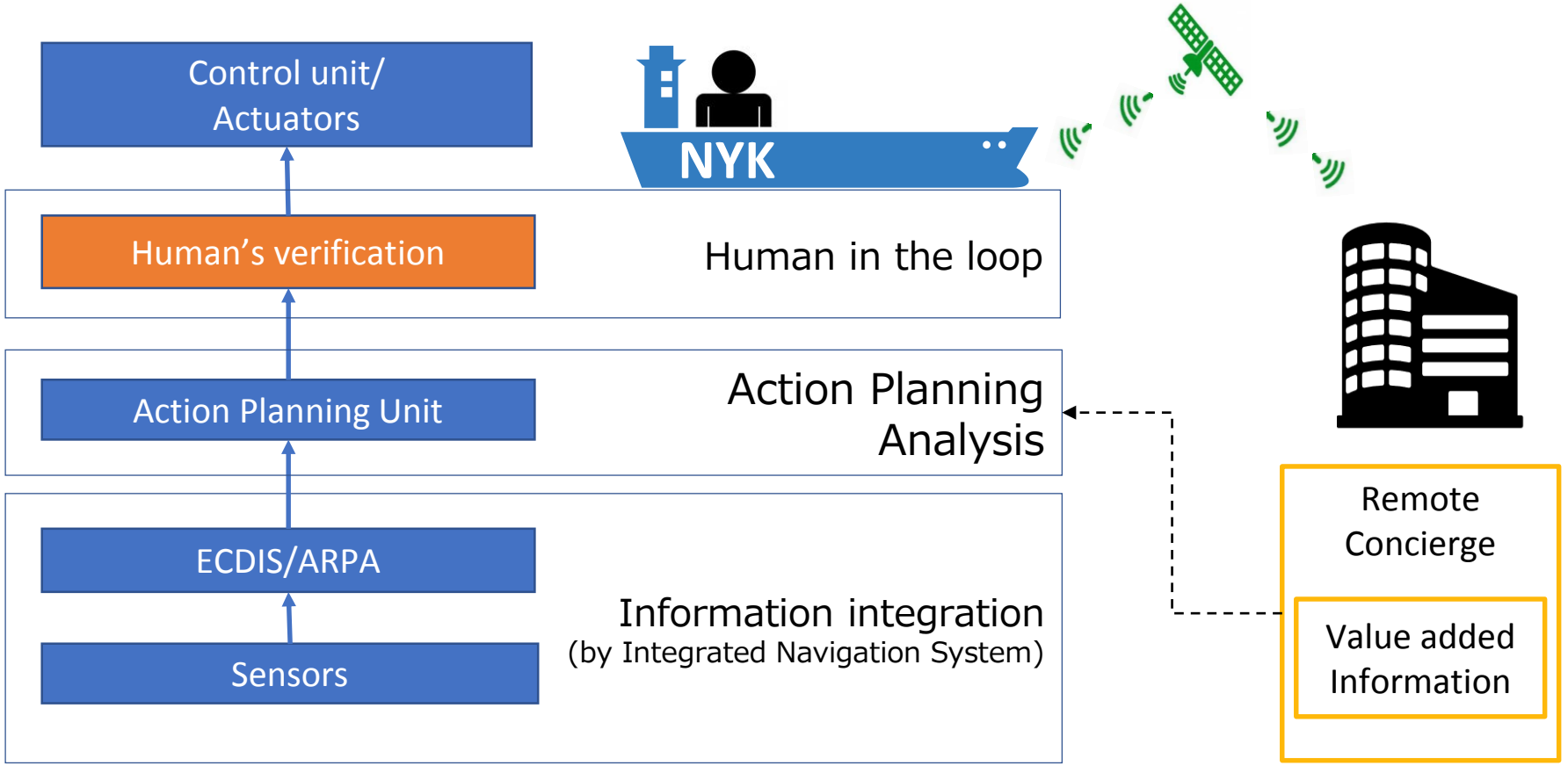


Cost efficiency	Base	+	−−	−
Incident risk	Base	+	+	++
Workload	Base	+	++	++
Cyber risk	Base	Base	−−	−
Total reliability	Base	+	−	−

3. A Framework of Action Planning System (APS)

Concept and Functions of APS

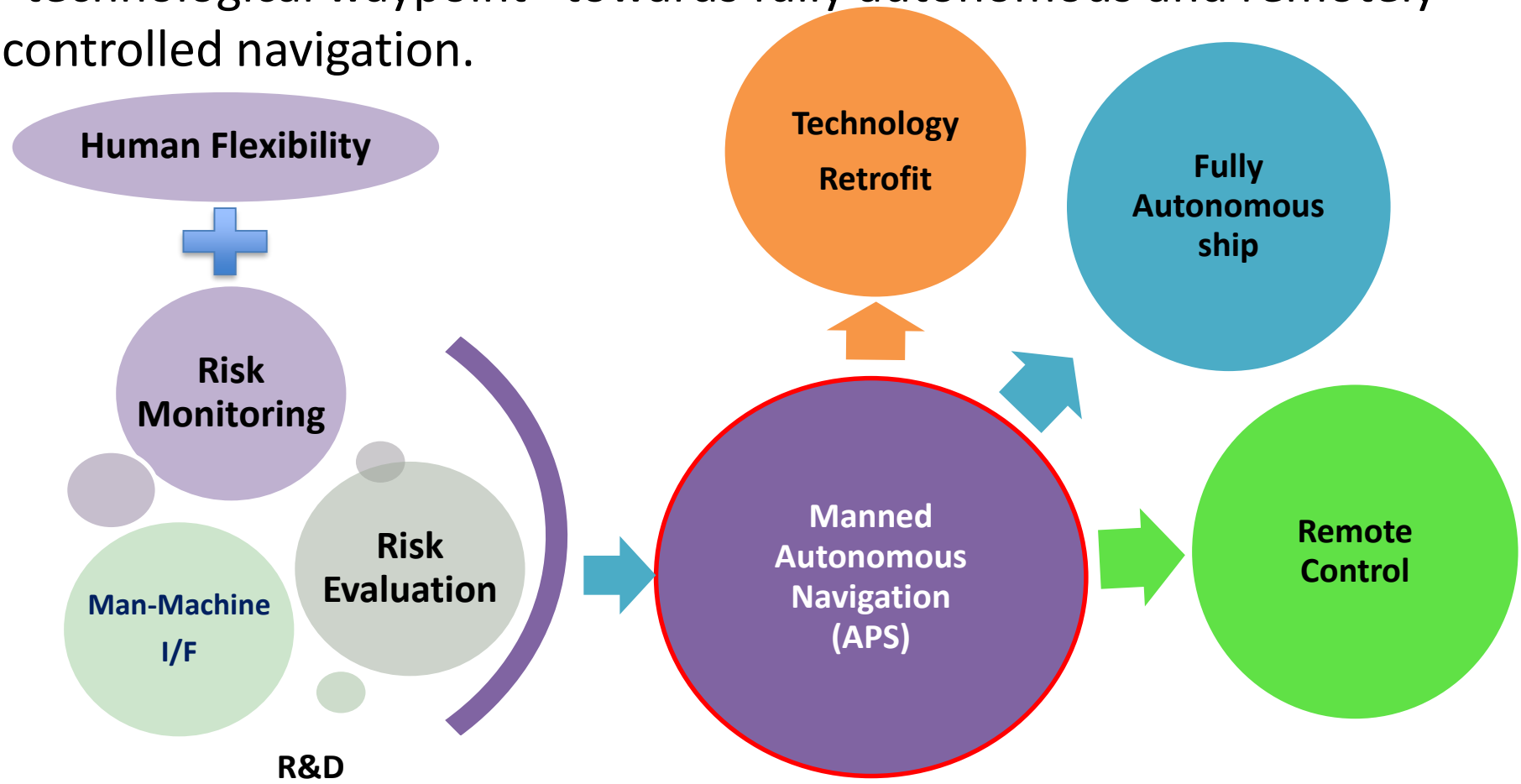
- NYK group currently aims to conceptualize Action Planning System as the first stage of autonomous navigation in 2019.



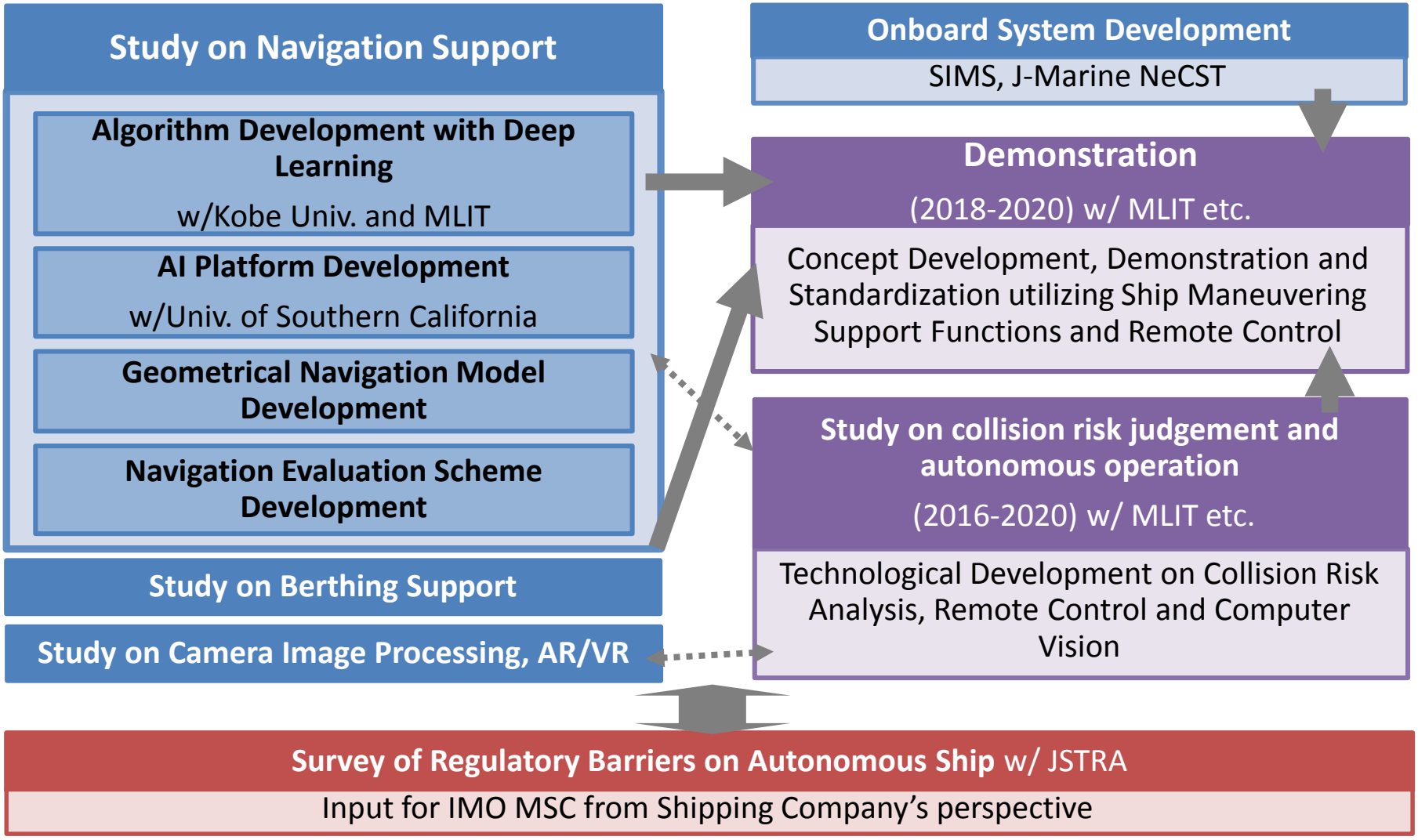
4. Summary

Manned Autonomous Navigation as a Waypoint

Manned autonomous navigation can be positioned as a “technological waypoint” towards fully autonomous and remotely controlled navigation.



NYK Group's R&D Projects around Autonomous Ship



Thank you very much for your attention