

Autonomous Ship : Current and Future Issues

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- 2. Analysis of Current Issues**
- 3. Future Issues and Technology Assessment**

1. Key Trends

1. Key Trends (Project)

◆ Rolls-Royce



◆ MUNIN (Maritime Unmanned Navigation through Intelligence in Networks)

- EUR 3.8 M (total) / EUR 2.9 M (EU)
- Dry bulk carrier + deep-sea voyage
- USD 7 M (present value / over 25-year period)

Base Scenario

Scenario description:

Fuel price: med.

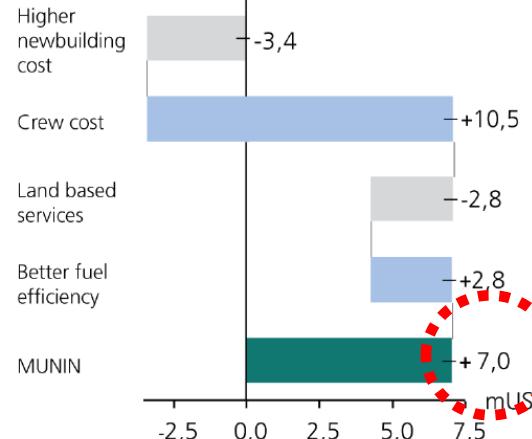
New building: 110%

Main fuel type: HFO

Considers effects of

- Reduced crew
- Improved ship efficiency

MUNIN compared to a conventional bulker Expected present value over lifetime



Scenario Reduced Crew Only

Scenario description:

Fuel price: med.

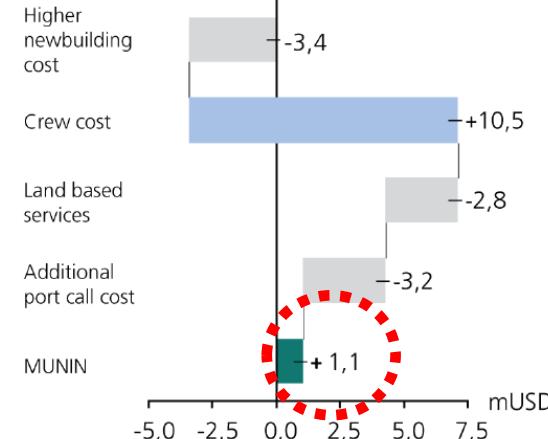
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Main fuel type: HFO

Considers effects of

- Reduced crew
- Improved ship efficiency

MUNIN vs conventional bulker Expected present value of savings over lifetime

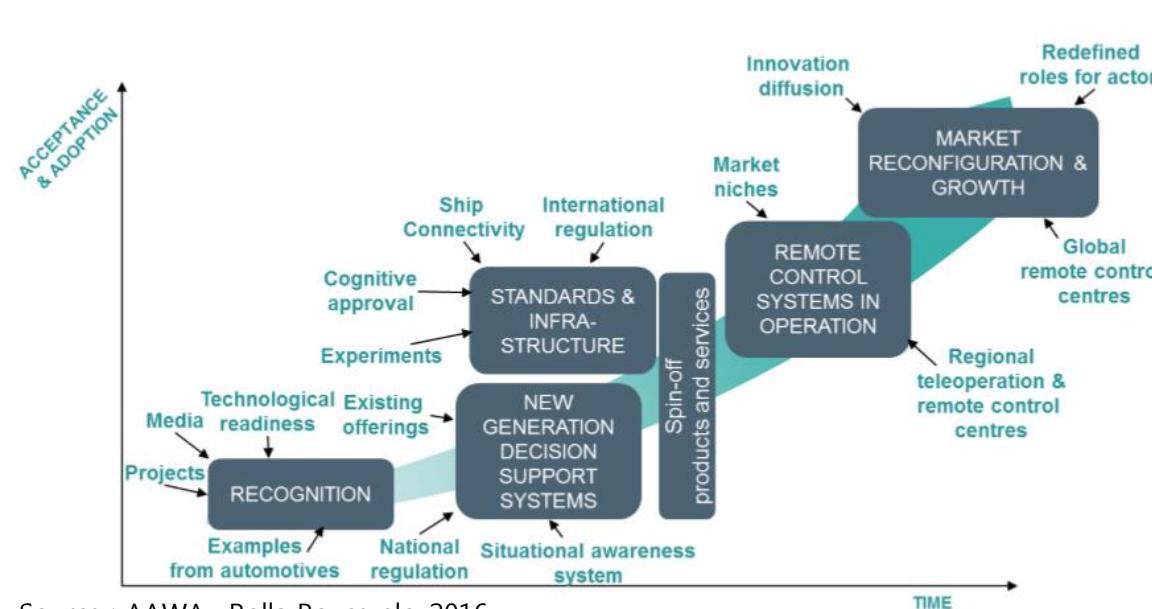


Source : MUNIN (final brochure)

1. Key Trends (Project)

◆ AAWA (Advanced Autonomous Waterborne Applications)

- Finland (Tekes : EUR 6.6 M)
- Rolls-Royce, Inmarsat, DNVGL, VTT, Tampere Univ., etc.
- Produce the specification and preliminary designs
- Technology + Market + Law + Safety



Source : AAWA , Rolls-Royce plc, 2016

◆ One Sea

- Finland (Baltic Sea)
- Rolls-Royce, ABB, ERICSSON, Wartsila, etc.
- Ecosystem (for commercialization) by 2025

DIMECC One Sea Timeline for autonomous ships

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2017	2020	2023	2025
Remote monitoring	Fully remote controlled vessel (manned) – unmanned with special approval	Gradual increase of autonomous control	Autonomous ship traffic commercial
Test areas	National pilots	Several pilots globally	Full scale testing / validation
		Domestic authority approval / certificate	Class/IMO reg. in place
International collaboration	Design requirements for autonomous power and propulsion systems	Satellite becomes cheaper	Strongly decreased data communication
	Autonomous automobile commercial	Developed data transfer tech eg. 5G (limited to ferries/ports)	"Industry standards in place"
Ethical issues		Mobility as a service	Infrastructure
Development of cyber security			
Projects, IPR, competences, education			
National, IMO and global legislation development			

Source : DIMECC/One Sea

1. Key Trends (Project)

◆ Yara Birkeland

- Kongsberg + Yara
- Autonomous + Battery Operation
- 120 TEU (scale up : 10,000 TEU level)
- Remote control(2019) → Autonomous(2020)



Source : Kongsberg/Yara

◆ ReVolt

- DNVGL + NTNU
- Autonomous + Battery Operation
- 100 TEU (short maritime transport)
- Operation cost : USD 34 M (over 30 year period)



Source : DNV GL

1. Key Trends (Project)

◆ Roboat

- MIT + AMS (Amsterdam Institute for Advanced Metropolitan Solutions)
- To solve complex urban problems
- Improve urban waterways
- 5-years project (from 2016)



◆ Hrönn

- Kongsberg + Automated Ship Ltd
- 2017 (contract) → 2020 (operation)
- Test bed (Trondheimsfjord)
- Utility ship (offshore energy, scientific, fish-farming, etc.)



1. Key Trends (Project)

◆ Mayflower (autonomous + renewables)



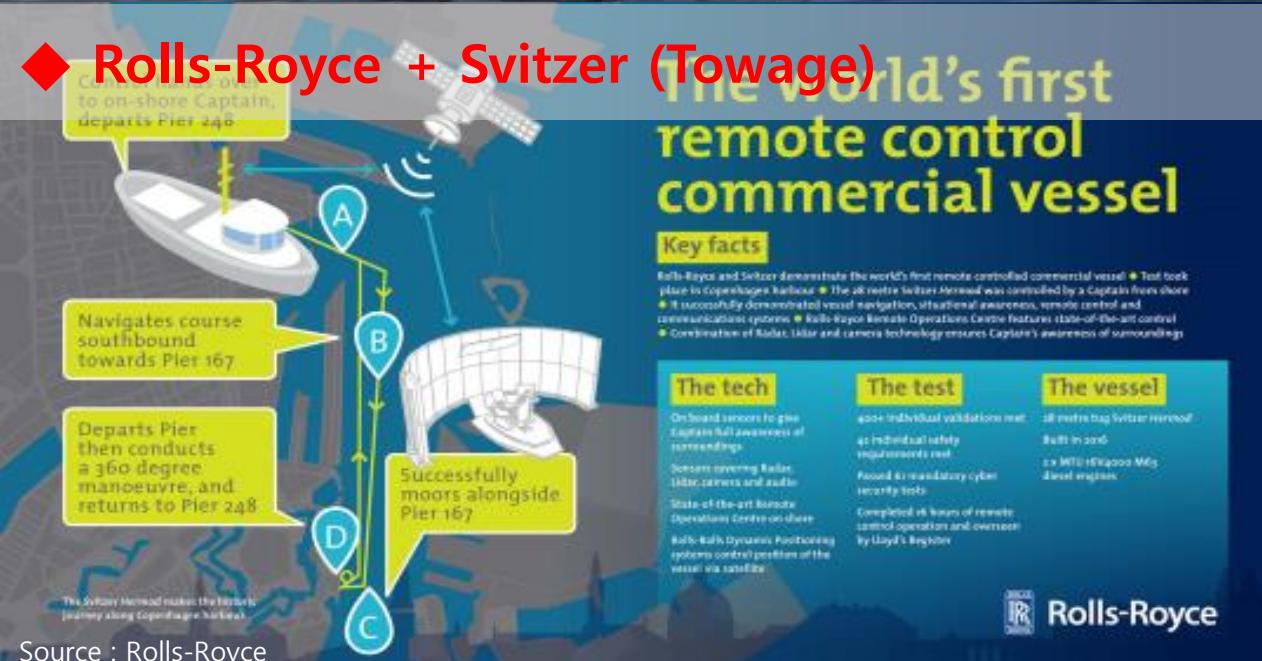
Source : mayflower autonomous ship

◆ SpaceX



Source : SpaceX

◆ Rolls-Royce + Svitzer (Towage)



Source : Rolls-Royce

◆ SEAture



Source : Maritime Executive (2017, MarEx)

1. Key Trends (Test bed)

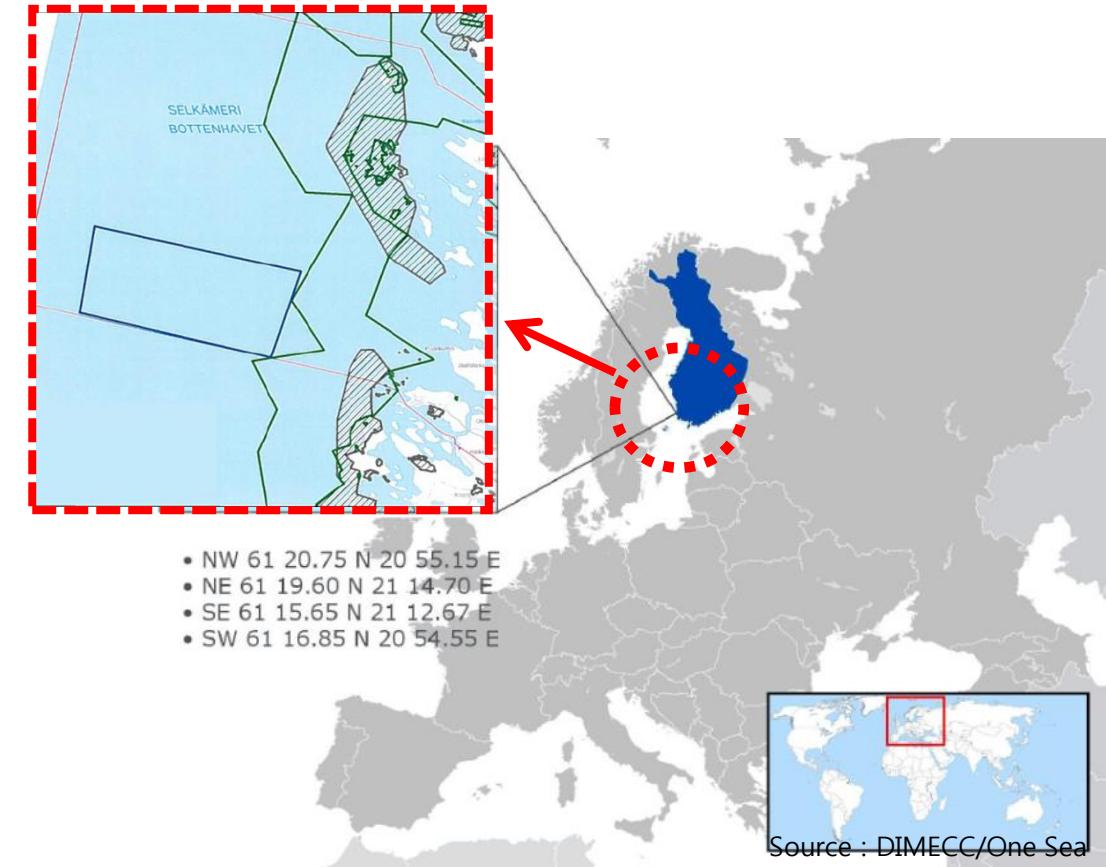
◆ TRONDHEIMSFJORD (Norway)

- World's first official test bed for autonomous ships
- 2016.9 (presented)
- ReVolt(DNVGL) / Hrönn(Kongsberg) / etc.



◆ Jaakonmeri Test Area (Finland)

- by One Sea Project (Finland/DIMECC)
- Open to all companies, research institutes, etc.
- Ice conditions during winter



1. Key Trends

◆ Lloyd's Register

- Autonomy Level (AL 0 – AL 6) (2016.7)
- New code to certify unmanned vessels (2017.6)

Description	Operator role
AL 0: Manual steering. Steering controls or set points for course, etc. are operated manually.	The operator is on board or performs remote control.
AL 1: Decision-support on board. Automatic steering of course and speed in accordance with the references and route plan given. The course and speed are measured by sensors on board.	The operator monitors the route in the form of "waypoints" and desired speed. The operator monitors and changes the speed, if necessary.
AL 2: On-board or shore-based decision support. Steering of route through a sequence of desired positions. The route is calculated so as to observe a wanted plan. An external system is capable of uploading a new route plan.	Monitoring operation and surroundings and speed if a situation necessitates the proposal for internal algorithms.
AL 3: Execution with human being who monitors and approves. Navigation decisions are proposed by the system based on sensor information from the vessel and its surroundings.	Monitoring the system's function and approving actions before they are carried out.
AL 4: Execution with human being who monitors and can intervene. Decisions on navigation and operational actions are calculated by the system which executes what has been calculated according to the operator's approval.	An operator monitors and intervenes if necessary. Monitoring can be shore-based.
AL 5: Monitored autonomy. Overall decisions on navigation and operation are calculated by the system. The consequences and risks are countered insofar as possible. Sensors detect relevant elements in the surroundings and the system interprets the situation. The system calculates its own actions and performs these. The operator is contacted in case of uncertainty about the interpretation of the situation.	The system executes itself. The operator is contacted in case of its interpretation of the surrounding environment of its own accord. With current and expected developments in autonomous and remote systems LR envisages that, within the near future, UMS will enter into widespread use through many sectors of the maritime industry. LR has been active in understanding how it can support the industry to demonstrate safe design and quality manufacture of critical aspects for unmanned systems.
AL 6: Full autonomy. Overall decisions on navigation and operation are calculated by the system. Consequences and risks are calculated. The system acts based on its analyses and calculations of its own capability and the surroundings' reaction. Knowledge about the surroundings and previous and typical events are included at a "machine intelligent" level.	The LR Unmanned Marine Systems Code provides an assurance process in order to certify the safe design, build and maintenance of UMS against an established framework that minimises the effort required by an owner or operator to achieve certification and which is acceptable to Flag States, local regulators and other parties. Whilst initially targeted at small non-convention sized UMS, including naval systems, it is scalable and is capable of application to larger, more complex vessels as technology and regulation develops.

AL 0

AL 6

◆ IMO

- Regulatory scoping exercise
- MSC 98/20/2 (2017.6)

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IMO INTERNATIONAL MARITIME ORGANIZATION

MARITIME SAFETY COMMITTEE
98th session
Agenda item 22

MSC 98/INF.13
4 April 2017
ENGLISH ONLY

ANY OTHER BUSINESS

A pre-analysis on autonomous ships
Submitted by Denmark

SUMMARY

Executive summary: This document contains a pre-investigational report on autonomous ships – Maritime Autonomous Surface Ships (MASS). The purpose of the report is to describe the potentials of autonomous ships, on the basis of international activities of direct relevance to the investigation. The report briefly summarizes how to define various levels of autonomy

Strategic direction: 5.2 and 5.4

High-level action: 5.2.1, 5.2.2, 5.2.4 and 5.4.1

Output: No related provisions

Action to be taken: Paragraph 7

Related documents: MSC 98/20/2 and MSC 98/22/7

Introduction

1 One of the IMO's objectives according to the strategic plan is to "provide an effective and efficient response to shipping trends, developments and incidents and, in so doing, stave off regional or unilateral tendencies that conflict with the Organization's regulatory framework". To achieve this, the IMO will need to proactively identify, analyze and address emerging issues, thus maintaining its role as the global regulator of international shipping.

2 In order to support the Committee in this task, Denmark hereby provides a report on the issue for the perusal of the members of the Committee.

3 The Danish Maritime Authority has requested the assistance of the Technical University of Denmark (DTU) for connecting and planning a number of tasks to be included in coming efforts to shed light on the importance of unmanned ships. The Danish Maritime Authority considers technological developments to be at the core of these projects and has

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IMO INTERNATIONAL MARITIME ORGANIZATION

MARITIME SAFETY COMMITTEE
98th session
Agenda item 20

MSC 98/INF.13
27 February 2017
Original: ENGLISH

WORK PROGRAMME

Maritime Autonomous Surface Ships
Proposal for a regulatory scoping exercise

Submitted by Denmark, Estonia, Finland, Japan, the Netherlands, Norway, the Republic of Korea, the United Kingdom and the United States

SUMMARY

Executive summary: The use of Maritime Autonomous Surface Ships (MASS) creates the need for a regulatory framework for such ships and their interaction and co-existence with manned ships. This document invites the Committee to undertake a regulatory scoping exercise to establish the extent of the need to amend the regulatory framework to enable the safe, secure and environmental operation of MASS within the existing IMO instruments.

Strategic direction: 5.2 and 5.4

High-level action: 5.2.1, 5.2.2, 5.2.4 and 5.4.1

Output: No related provisions

Action to be taken: Paragraph 25

Related document: MSC 95/INF.20

1 This document is submitted in accordance with paragraphs 4.8 and 6.12.6 of MSC-MEPC.1/Circ.5 on Organization and method of work of the Maritime Safety Committee and the Marine Environment Protection Committee and their subsidiary bodies, taking into account resolution A.109(29) on Application of the Strategic Plan and High-level Action Plan to the Organization, and proposes a new output to undertake a regulatory scoping exercise to establish the extent of the need to amend the regulatory framework to enable the safe, secure and environmental operation of entirely or partly unmanned Maritime Autonomous Surface Ships (MASS) within the existing IMO instruments.

H:\\MSC\\98\\MSC 98-13.docx

I:\\MSC\\98\\MSC 98-20.docx

IMO CONNECTING SHIPS, PORTS AND PEOPLE

1. Key Trends

◆ Customers (BHP Billiton)

- World's largest mining company (250 M tons per year)
- In 10 years (already works with driverless trucks an AUS)

BHP seeks partners for autonomous shipping

Thu 08 Jun 2017 by Martyn Wingrove

 Print story  Email us



BHP exports dry bulk from Port Headland, Australia

Mining conglomerate BHP Billiton is considering the use of autonomous ships for its huge dry bulk transportation requirements. It has outlined plans to manage or charter unmanned ships for freighting its iron ore, coal and copper around the world's oceans within a decade.

The group said its vision of the future of dry bulk shipping would include "safe and efficient autonomous vessels carrying BHP cargo and powered by BHP gas". Its bold vision brings significant power to the visionaries developing technology for more autonomous vessel operations.

BHP's vice president for freight Rashpal Bhatti said "autonomous vessels offer significant opportunities to improve safety". This would be achieved by removing people from dangerous tasks and generating more data-driven decision-making. Mr Bhatti also said autonomous ships would provide better efficiency outcomes for the

Source : Marine Electronics and Communications(2017, Martyn Wingrove)



Recent whitepapers

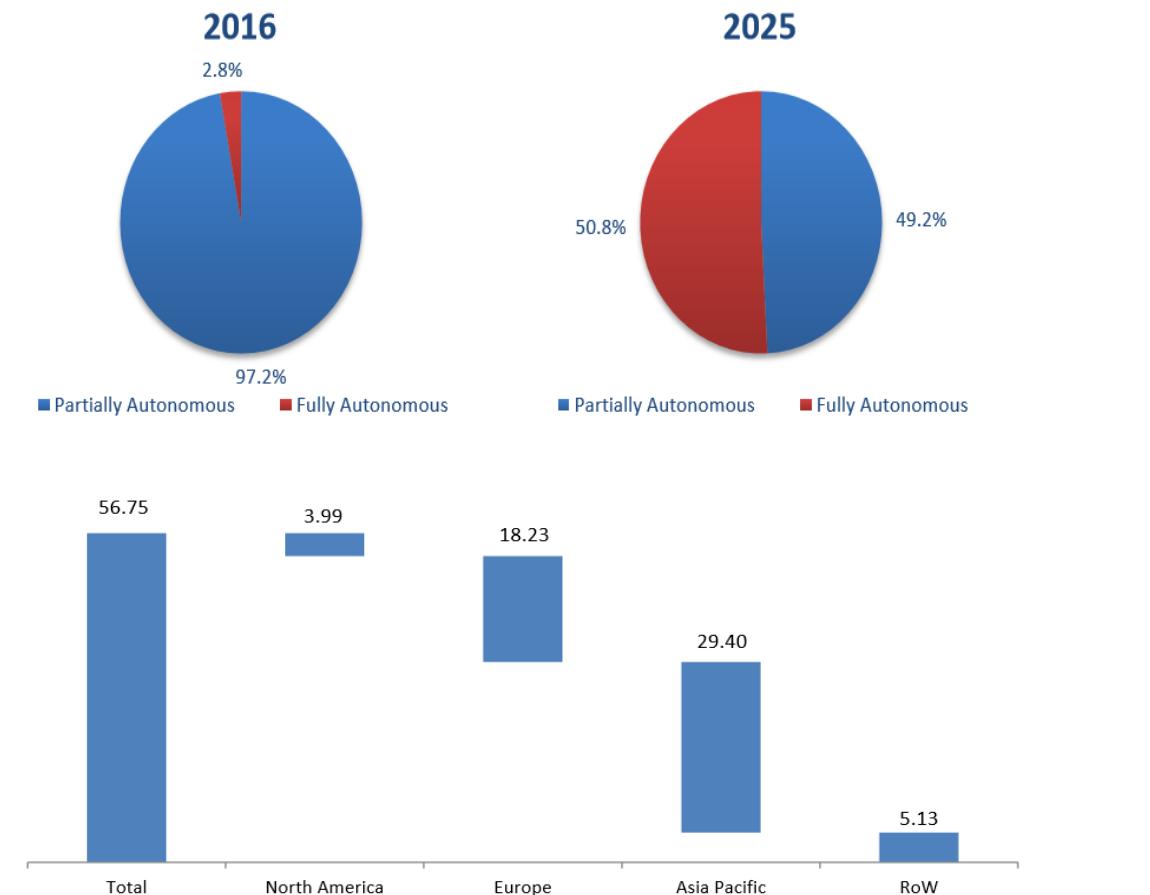
Extending Your Systems to the Very Edge of Your Operation
By SRO Technologies

An Investigation into Connectivity at Sea
By Nautilus International

Maritime Cyber Security: From the Margins to the Mainstream
By Singtel

◆ Market Growth

- Global market : USD 56.75 B(2016) → USD 155.05 B(2025)
- Overall CAGR : 12.8 % (the largest market : AP)



Source : Acute Market Report(2017)

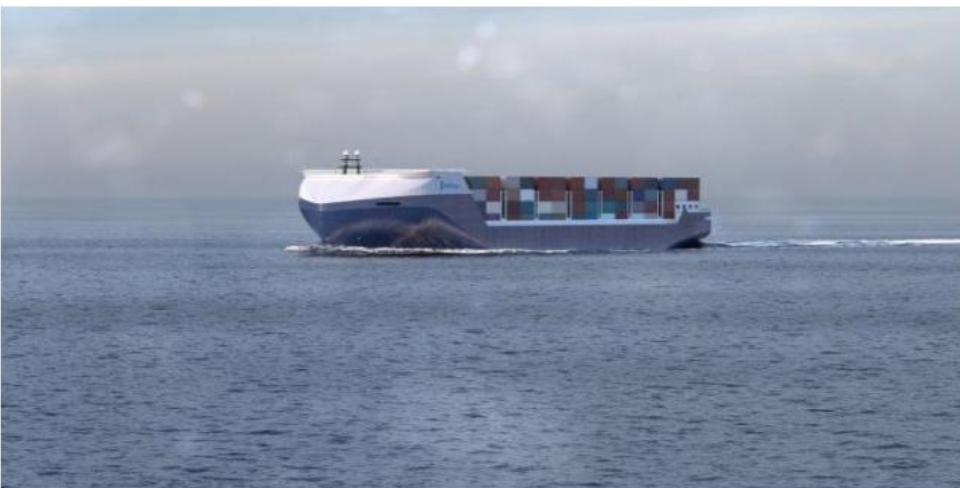
1. Key Trends

◆ Other Asia Countries

·China : Unmanned Cargo Ship Development Alliance(2017)

·HNA Group + ABS + Rolls-Royce + Wartsila + etc.

HNA Group Forms Chinese
Alliance for Autonomous Ships



File image courtesy Rolls-Royce

By MarEx 2017-07-28 17:31:23

Class society ABS has joined the Unmanned Cargo Ship Development Alliance, a group of class organizations, shipyards, equipment manufacturers and designers that seeks to advance autonomous shipping. The alliance intends to deliver a working autonomous cargo ship by October 2021, with a design that integrates independent decision-making, autonomous navigation, environmental perception and remote control.

Source : Marine Executive (2017, MarEx)

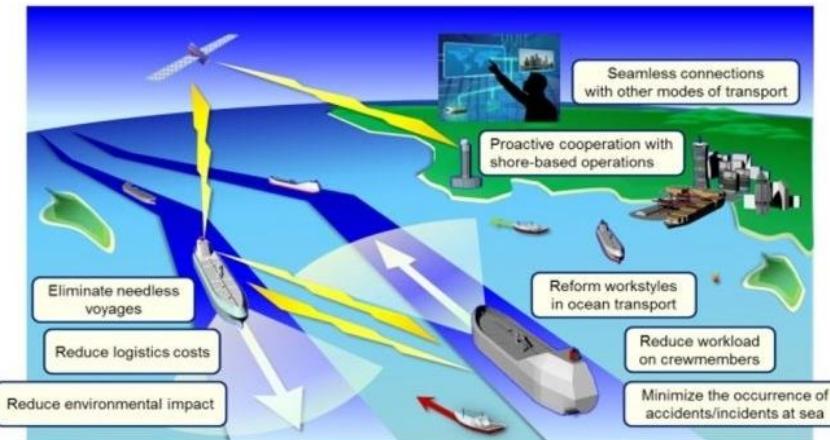
·Japan : 250 ships by 2025

·Mitsui OSK Lines + Mitsui Engineering&Shipbuilding + etc.

Japan turns to autonomous shipping

Fri 26 May 2017 by Martyn Wingrove

Print story Email us



Japan expects the development of autonomous vessels will have multiple benefits to shipping and the environment

Japan is moving ahead with research into autonomous ocean transport by selecting Mitsui OSK Lines (MOL) and Mitsui Engineering & Shipbuilding for development work.

The research contract was delivered by Japan's Ministry of Land, Infrastructure, Transportation and Tourism for its transportation research and technology promotion programme.

Source : Marine Electronics and Communications(2017, Martyn Wingrove)

2. Analysis of Current Issues

2-1. Analysis of Current Issues : 2-track methodology

**International and Domestic
News Analysis
(recent 3-years)**



**Experts Group
(16 experts)**

2-2. Analysis of Issues : News Analysis

News DB

- Naver News (domestic)
- Google News (international)

Data Range

· Recent 3-years (2014.8 ~ 2017.7)

Total 295 articles

- 112 articles (domestic)
- 183 articles (international)

Google search results for "autonomous ship" on the News tab.

Search term: autonomous ship

Results: About 92,600 results (0.43 seconds)

Filter: News

Recent news snippets:

- Rolls-Royce has plans for an **autonomous naval ship**
The Verge - Sep 13, 2017
Rolls-Royce has become the latest company to enter the autonomous shipping arena, revealing plans for a 197-foot-long (60m) autonomous ...
- Rolls-Royce planning **autonomous naval ship** for patrol, surveillance ...
TechCrunch - Sep 12, 2017
- Rolls-Royce unveils plans for an **autonomous patrol ship**
Engadget - Sep 12, 2017
- Rolls-Royce reveals self-piloted navy **ship** powered by artificial ...
USA TODAY - Sep 12, 2017
- Rolls-Royce Might Build the World's First Autonomous Naval Vessel
Futurism - Sep 13, 2017

Image thumbnails from various sources:

- TechCrunch
- Engadget
- USA TODAY
- Futurism
- Mashable

More results:

- Final Design Of **Autonomous**, All-Electric Container Vessel — Yara ...
CleanTechnica - Sep 30, 2017
The final design of the all-electric, autonomous container ship known as the Yara Birkeland has now been completed, and testing has ...
- VIDEO: Design of zero-emission **autonomous** box ship revealed
Marine Log - Sep 29, 2017
The zero-emission ship will initially operate as a manned vessel, moving to remote operation in 2019 and to fully **autonomous** operations from ...
Norway's Enova Pledges Over \$16 Million in Support of Electric ...
Ship & Bunker - Sep 29, 2017

2-2. Analysis of Issues : News Analysis



< International >

< Domestic >

Crew(9th), People(34th) VS. 인력(61위), 선원(106위)

Safety(11th) VS. 안전(29위)

Shipping(18th) VS. 조선(9위), 해운(95위)

Reality(14th), Risk(45th) VS. ??



No.	Word	The number of exposure
2	Autonomous ship	238
3	Technology	142
5	Future	123
9	Crew	90
11	Safety	80
14	Reality	63
18	Shipping	52
34	People	41
38	Maritime industry	38
순위	단어	노출 빈도
2	개발	423
3	기술	339
7	사업	294
9	조선	273
10	산업	262
25	시장	97
27	투자	88
29	안전	85
61	인력	47

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Thumbnail images from various sources:

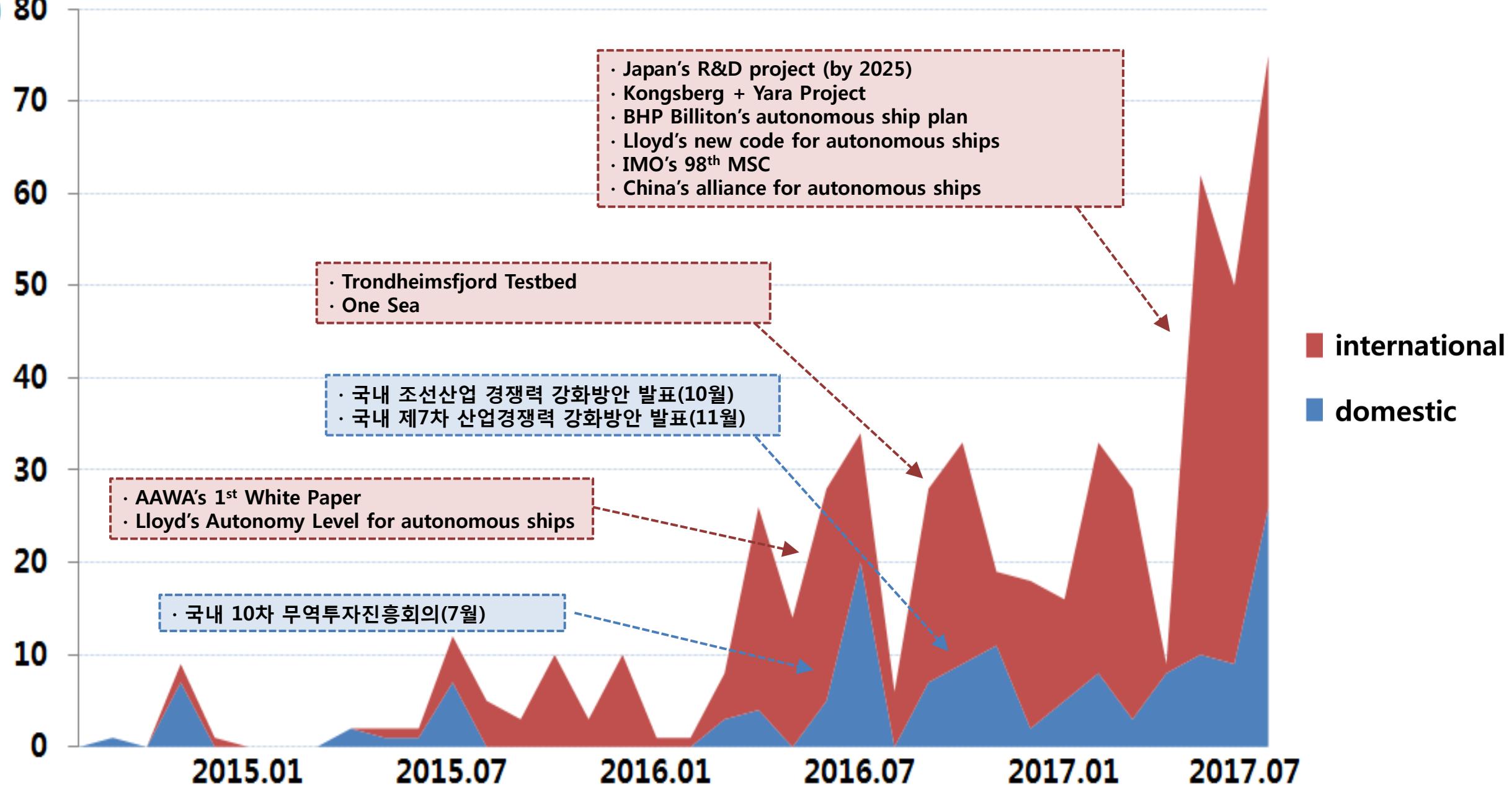
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Ship & Bunker - Sep 29, 2017

2-2. Analysis of Issues : News Analysis

(건) 80



2-2. Analysis of Issues : News Analysis

Total 549 issues

Information
(Technology, R&D, etc.)

Economic Issues

Social Issues

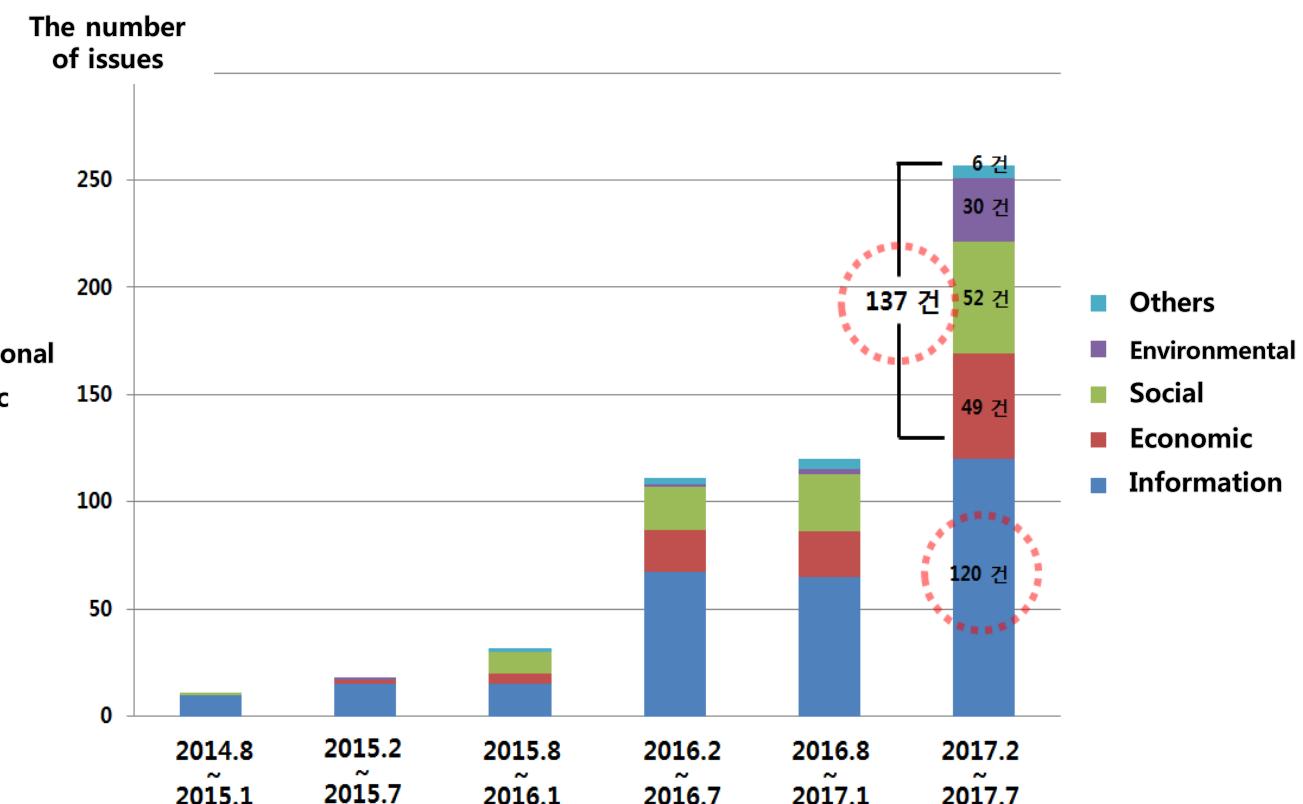
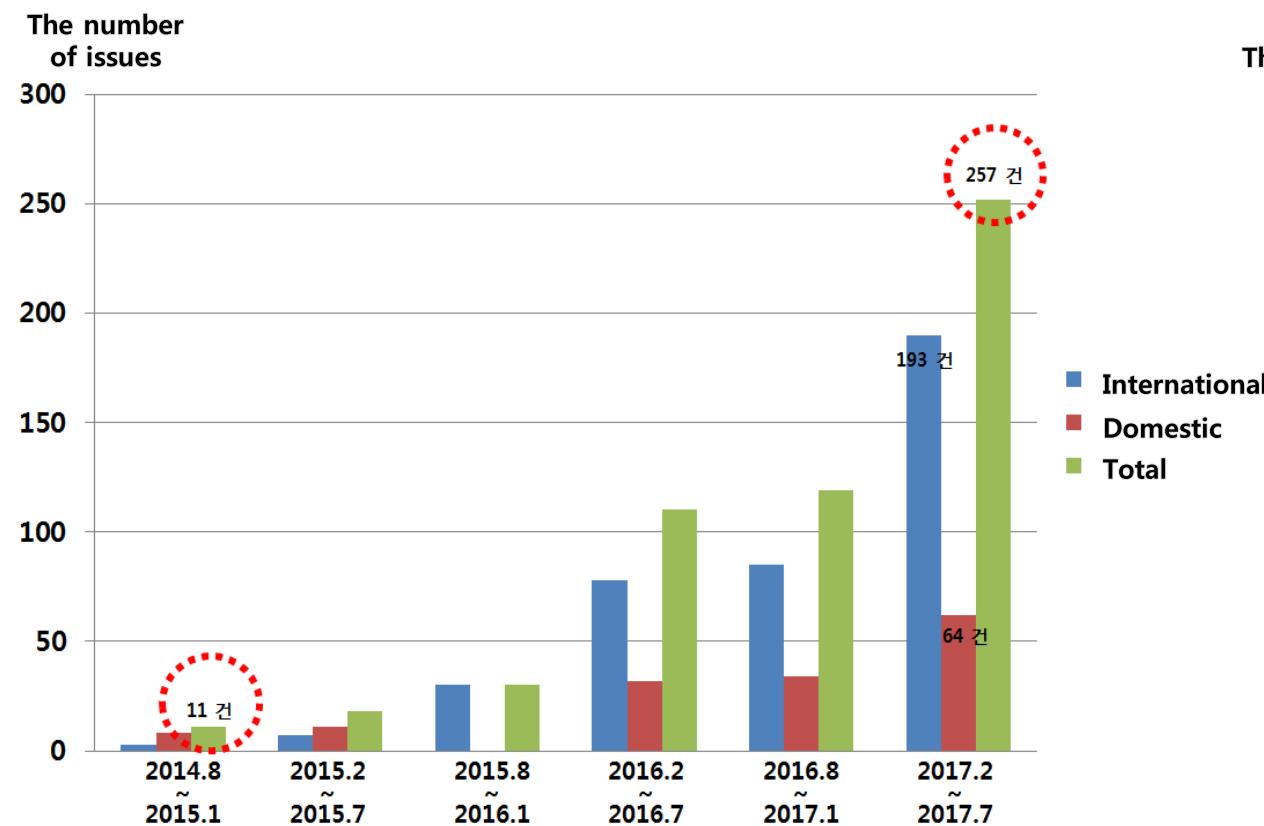
Environmental Issues

Other Issues

2-2. Analysis of Issues : News Analysis

◆ Total Issues

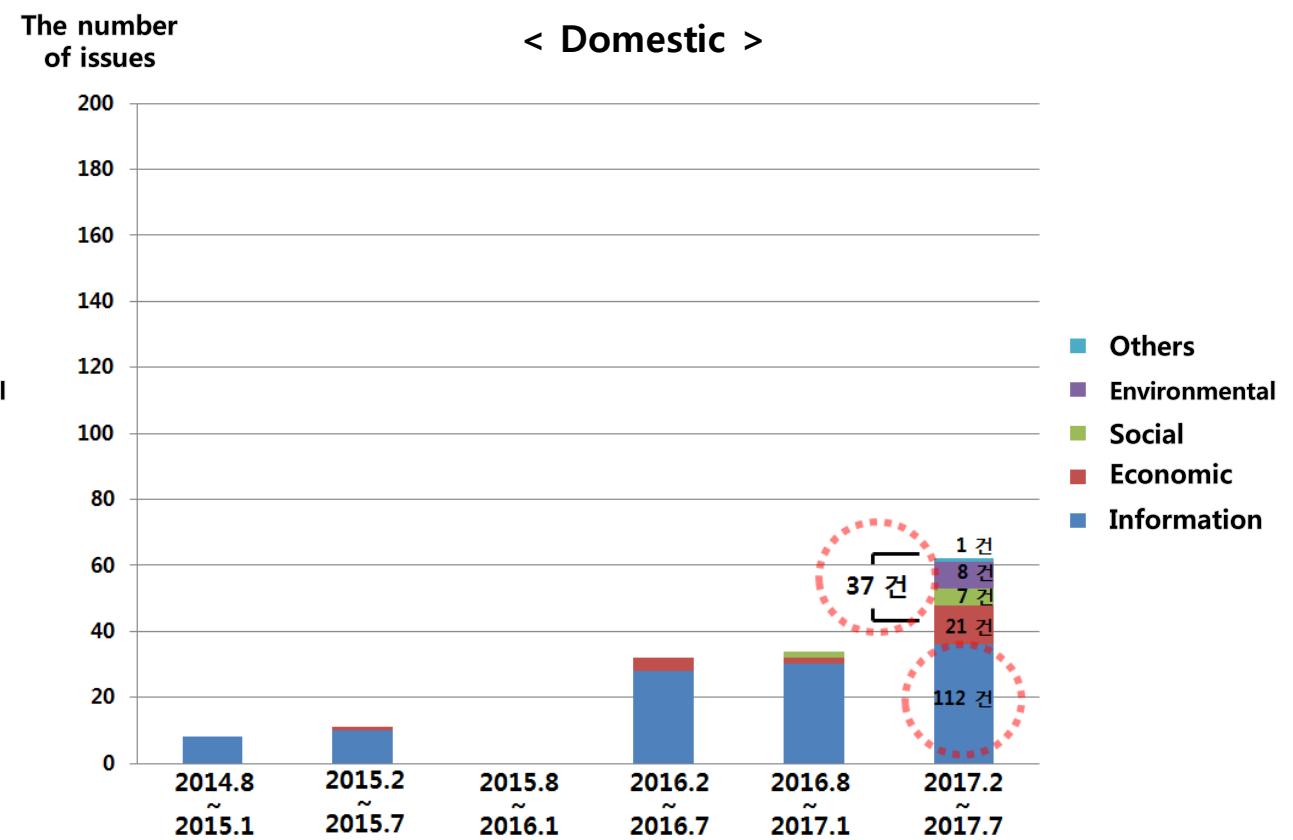
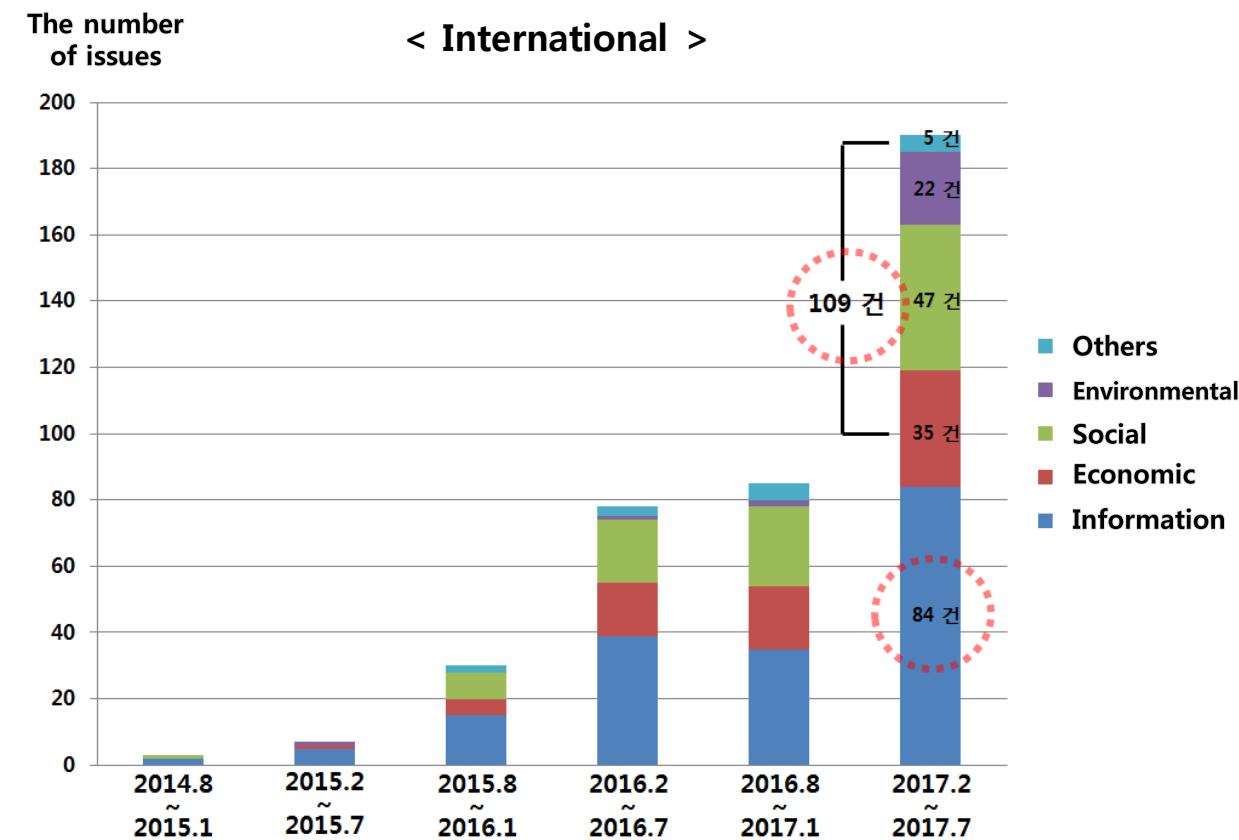
- only 11 issues → 257 issues (international + domestic / recent 6 months)
- International : 193 issues (domestic : 64)
- Rapid Growth of Economic + Social + Environmental Issues : 137 issues (compare to 120 information)



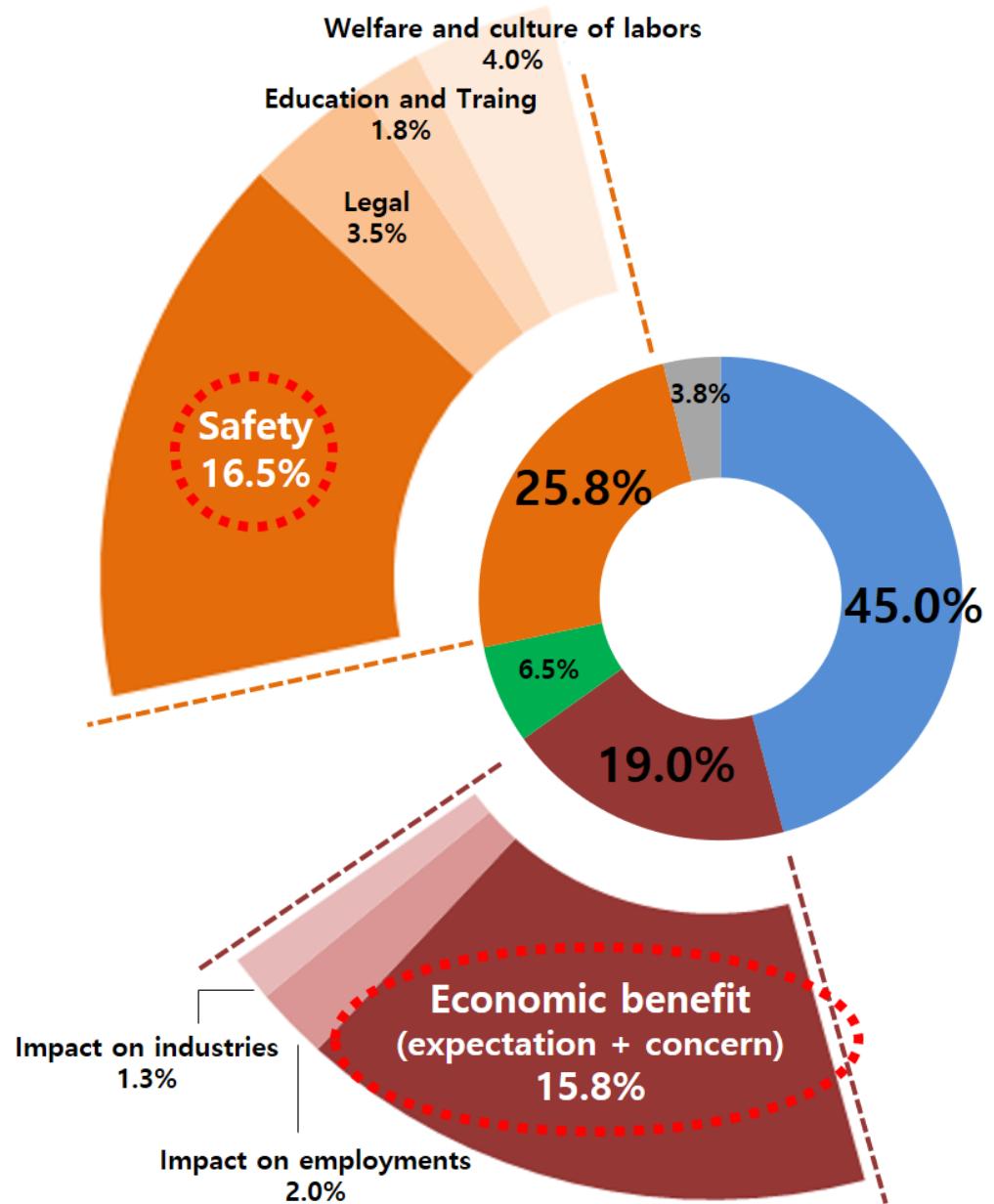
2-2. Analysis of Issues : News Analysis

◆ Recent 6 months

- International : 109 Economic + Social + Environmental Issues (information : 84)
- Domestic : only 37 issues (information : 112)
- Social (international) vs. Economic (domestic)



2-2. Analysis of Issues : News Analysis



- Others
- Environmental
- Social
- Economic
- Information

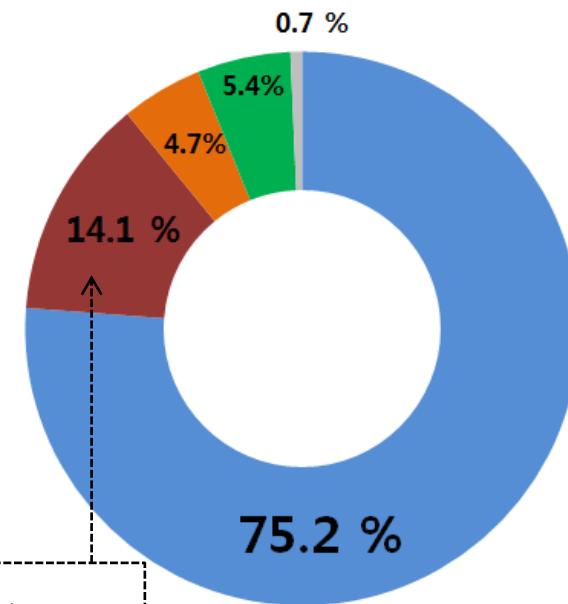
< Social Issues >

Safety : 1.3 %

Legal : 2.0 %

Education and traing : 0.7 %

Welfare and culture of labors : 0.7 %



< Economic Issues >

Economic benefits, e.g. cost reduction : 13.4 %

Impacts on industries : 0.7 %

< Information >

Domestic policy or some events : 38.9 %

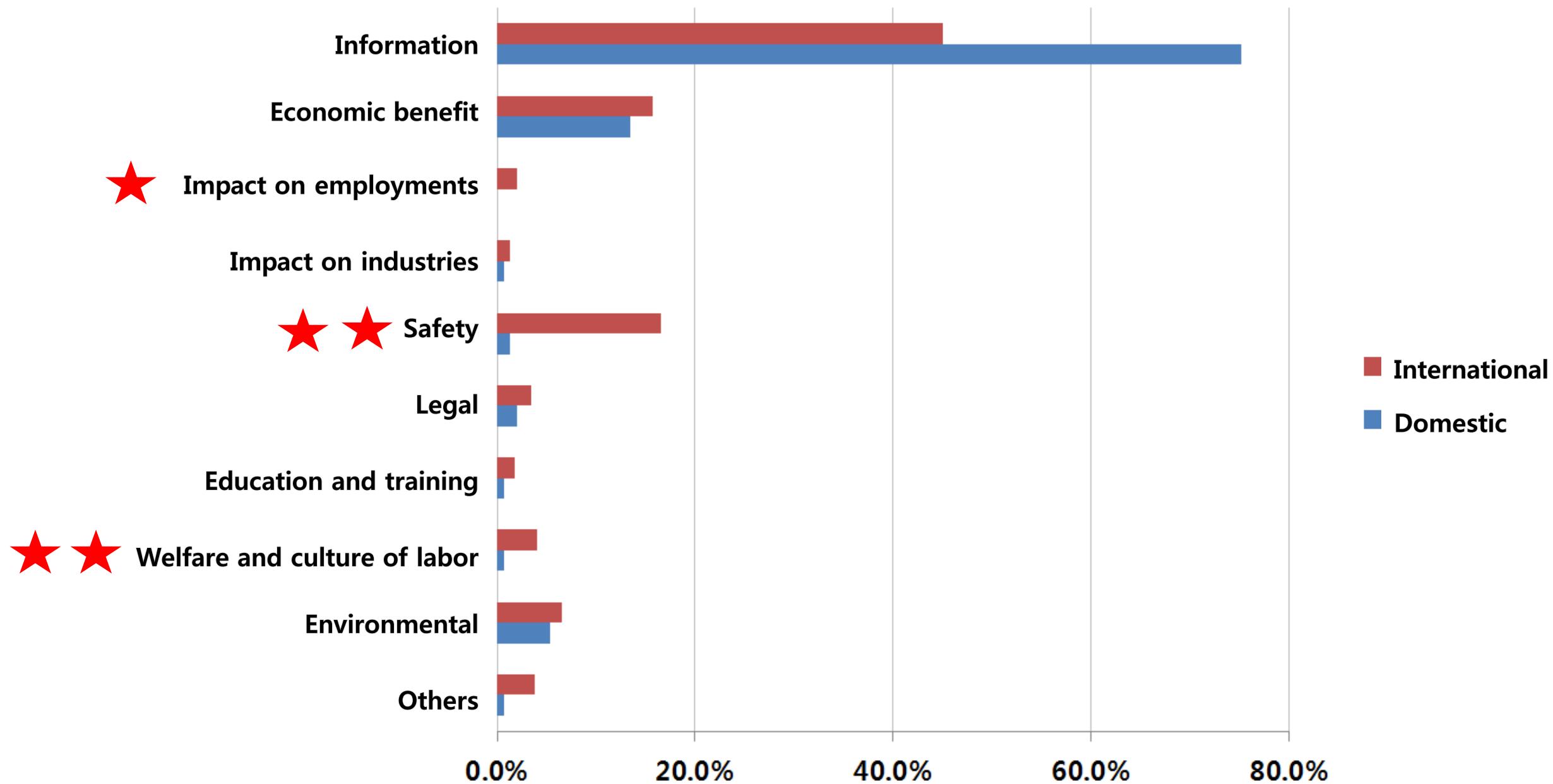
International News : 17.4 %

Domestic technologies : 13.4 %

Others : 3.4 %

Domestic market trends : 2.0 %

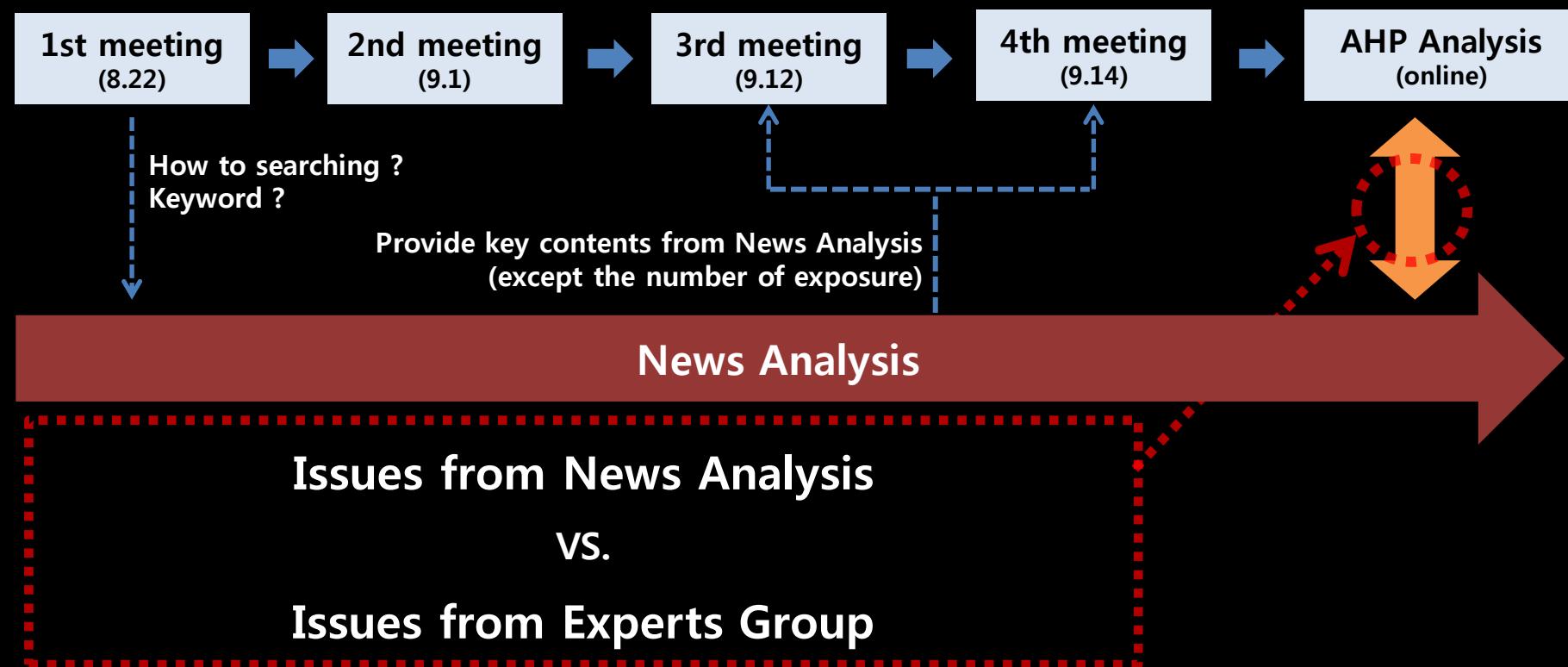
2-2. Analysis of Issues : News Analysis



2-3. Analysis of Issues : Experts Group

◆ Experts

- Industries + Universities + Research Institutions + Media + etc.
- Technology + Economics + Policy + Social + Law + Media + Future Study + etc.
- Total 16 experts



2-3. Analysis of Issues : Experts Group

◆ Relative Importance

- For Korean Society
- AHP Analysis / CI ~ 0.00X (excellent)

◆ Economic Issues

- 1. Impact on the ecosystem/value-chain of Korean industries
- 2. Economic impact on Shipping/Shipbuilding industries (+related services)
- 3. Impact on the regional economies
- 4. Impact on the foreign trade

2-3. Analysis of Issues : Experts Group

◆ Social Issues

- 1. Impact on the maritime safety**
- 2. Impact on the welfare and culture of labors**
- 3. Impact on the education and training**
- 4. Impact on the legal issues**
- 5. Impact on the national security**

◆ Cultural / Ethical / Environmental Issues

- 1. Impact on the ethics and responsibility**
- 2. Impact on the CO2 reduction**
- 3. Impact on the marine debris / discharge of hazardous substances**
- 4. Environmental impact caused by change of ship's lifecycle**
- 5. Changes in people's perceptions on maritime**

3. Future Issues and Technology Assessment

3-1. Future Issues : ecosystem

Opportunity

ICT & Security

Region with
Autonomous Ship Infrastructure

Threat

Conventional Equipment for Human
(e.g. Cabin)

Region without
Autonomous Ship Infrastructure

Protective Trade

3-2. Future Issues : economic benefits

about **30% ~ 40%**
(manning)

about **10%**
(contribution of Logistics in the GDP)

about **42%**
(Capital cost / manning : only 6 %)

2nd
weakest in the OECD

(redistributive impact of tax and transfer system)

8th
highest in the OECD
(relative poverty rate)

3-3. Future Issues : employment

Positive

Only about 30 Crews

Will not lose jobs

(shortage of approximately 150,000 officers by 2025)

New Attractive Jobs

Negative

Large-Scale Unemployment

Positive

"We're not, and shouldn't be thought of as Luddites, Seafarers have always been very good at adapting to technological change"

- Andrew Linington -

(director of campaigns and communications for Nautilus International / 22,000 maritime professionals in Europe)

Negative

"It cannot and will never replace the eyes, ears, and thought processes of professional seafarers,"

- Dave Heindel -

(600,000 member International Transport Workers' Federation)

3-5. Future Issues : Safety

Positive

Reduce Human Errors (75~96%)

Piracy ? No Crew !

Navigational Accidents ↓

(e.g. collision, grounding)

Negative

No Human for Emergency Action

Piracy ? Still Attractive !

(Freight)

Cyber Attack

Non-Navigational Accidents ↑ ?!?!?

(e.g. fire, ship loss due to structural failure)

3-6. Future Issues : Education + Training

"many seafarers are concerned about what autonomous technology will mean for their jobs, and are worried that they won't receive adequate training to adapt to it"

1st
in OECD

(Gap between young adults and older person in terms of tertiary graduation rates and skill level)

Only **21 %**

(55-64 age group participated in formal or non-formal education or training related to their job)

Under OECD Average

(Proportion of adults with weak skills who participate in adult education)

Positive

Reduce CO2 Emission
(Battery operation + economic sailing)

Negative

Pollutant / Hazardous Substances
(accident situation)

No Pollutant by Human

3-8. Technology Assessment on Autonomous Ship

Environmental

Social

Technology Assessment
(by KIMST)

Economic

Cultural

Ethical

For Better World

Thank You

iryoon@kimst.re.kr