SW Functional Safety for Autonomous Ships

:Where is it going now?

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Marine casualty

- An event or sequence of events that occurred directly in connection with the operation of a ship
  - The death of or serious injury to a person
  - The loss of a person, a ship, materials
  - The ship not to proceed or to require flag state approval or a condition of class before it may proceed
  - A breakdown of the ship at sea requiring towage
  - Pollution caused by ship or ship's damage
  - Material damage to marine infrastructure

(Source: A day in life of a container ship in middle of the ocean, Youtube)

European Maritime Safety Agency (EMSA) *Overview of Marine Casualties* (2011-2018)
23,073 casualties and incidents, 7,694 persons injured, 696 fatalities, 230 ships lost

International regulations

- United Nations Convention for the Law of the Sea (UNCLOS)
- International Maritime Organization (IMO, 국제해사기구) Conventions

The IMO is responsible for update the conventions as well as developing new ones as the needs arise.

- *International Convention for the Safety of Life at Sea (SOLAS), 1974*
- *International Convention for the Prevention of Pollution from Ships (MARPOL), 1997*
- *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 2010*
- *Convention on the International Regulations for Preventing Collisions at Sea (COLREG), 1972*

Impacts of automation regarding safety : Survey on autonomous shipping by Nautilus Federation

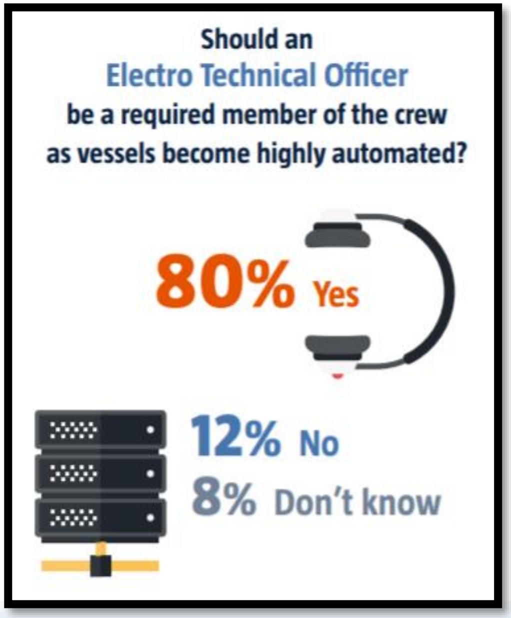
- 60% from 900 professionals thinks that technology could improve safety and automation offers the potential to deliver improved operational performance.
- Concerns

		scale 1-10
1	**Cyber Security**	8.16
2	**Reliability of communications and the data exchange link**	7.96
3	Legal and liability issues	7.81
4	**Quality of software**	7.62
5	Risk assessment and public acceptance	7.5
6	Opposition from seafarers and their unions	7.43
7	Regulatory issues	7.09
8	**Technical feasibility**	6.52
9	Training and reskilling	5.77
10	Economic feasibility	5.65

Ⅰ. Safety in maritime sector

Impacts of automation regarding safety : STCW survey

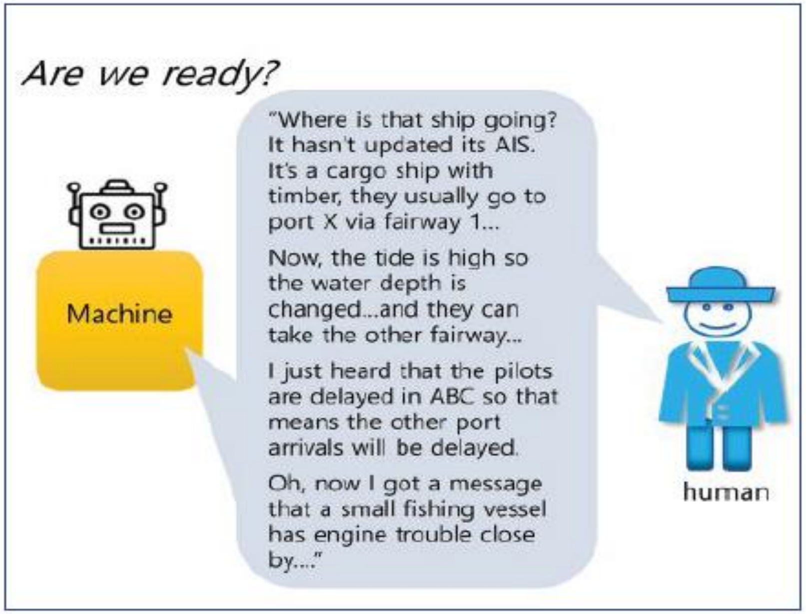
- The Nautilus Federation surveyed almost 1,000 maritime professionals from more than 18 different countries to give a voice to the maritime education side.
- The participants are representing captains/masters with 27%, deck officers with 22%, chief engineers with 21% and engineering officers with 12% and few of university lecturer and legal professionals.
- The training gaps in STCW identified by respondents:
  - computing/IT skills
  - people skills (social, communication etc)
  - basic practical skills
  - modern machinery
  - new propulsion systems/fuels
  - Ballasting
  - business skills



Ⅰ. Safety in maritime sector

Impacts of automation regarding safety : Considerations on hand-over between human and machine

- If the machines onboard can function as an adaptive team player, they will communicate and have joint awareness with humans of context and goals as the way human does.
- To complete the watch change between human and machine, the current handover related guidelines and checklists are needed to change to be applicable for human-machine hand-over.



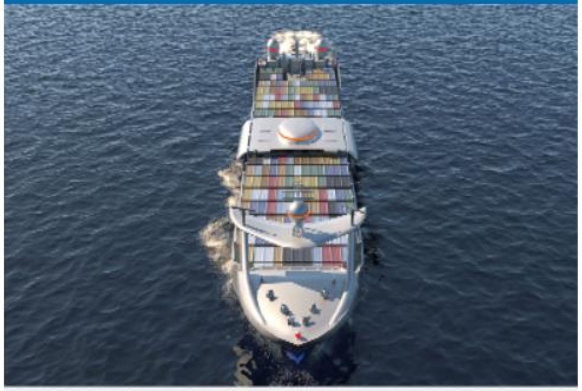
(Source: *"Human-Machine Interaction" The Challenges of New Teamwork for Smart Ship Navigation* By Seojeong Lee and Margareta Lützhöft, Sea Technology, May, 2020)

Maritime Autonomous Surface Ships (MASS)

- The IMO, at its 103rd session in May 2021, has completed a regulatory scoping exercise to analyze relevant ship safety treaties, in order to assess how MASS could be regulated.
- Varying degrees of autonomy were considered
  - crewed ship with automated processes and decision support (Degree One);
  - remotely controlled ship with seafarers on board (Degree Two);
  - remotely controlled ship without seafarers on board (Degree Three); and
  - fully autonomous ship (Degree Four).

Ⅱ. Autonomous Ships

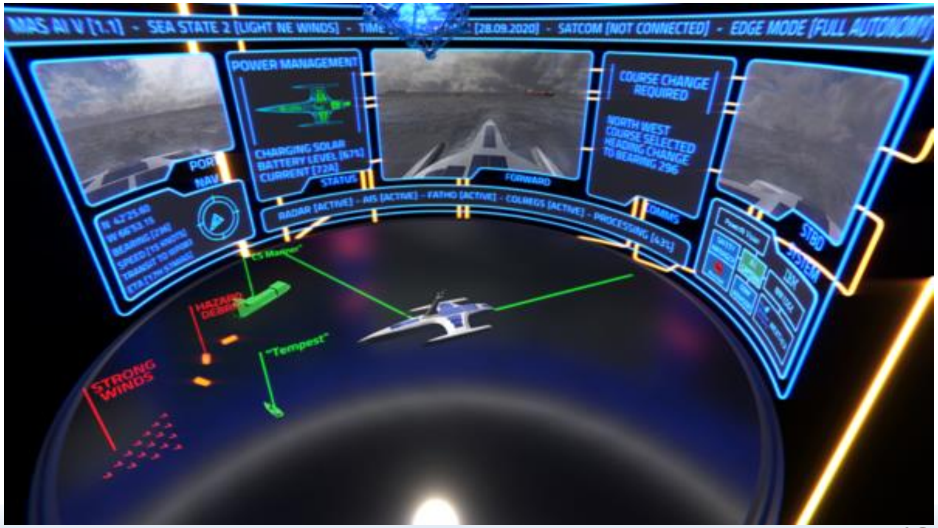
Maritime Autonomous Surface Ships (MASS) project in Korea - KASS

Smart Ship	Partial Autonomous Ship	Fully Autonomous Ship
		
Comprehensive technology that applies advanced equipment and ICT to ships of meaning	Integrating IOT, platform, and control technology into existing ships The system replaces the role the crew was playing Vessels that can be operated with only minimum crew	Fully autonomous operation that can be operated without human intervention Ship

(Source: https://kassproject.org/en/info/info.php)

해양수산부와 산업통상자원부에서 약 1,600억 원 지원, 2020부터 2025년까지 6년

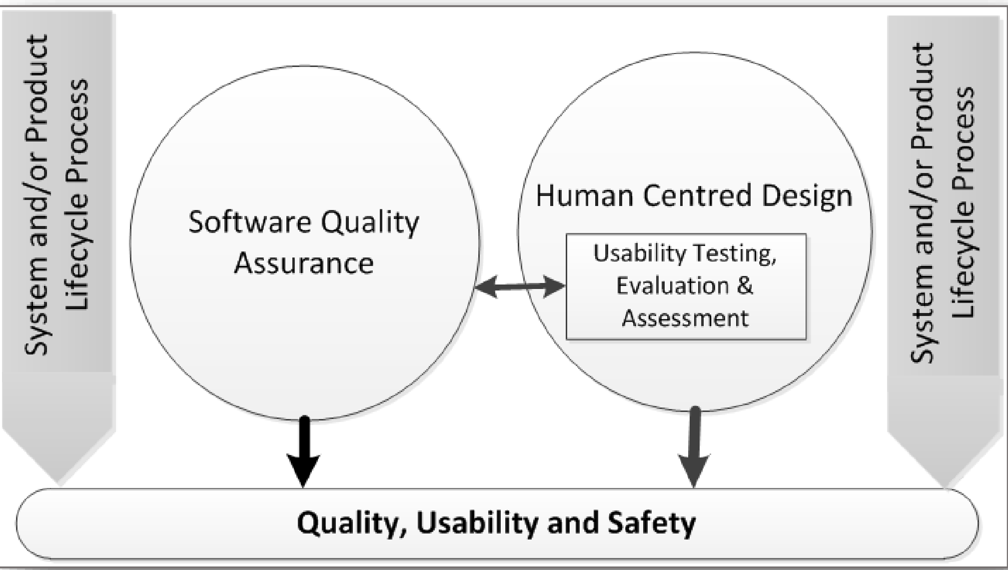
The Autonomous Mayflower



(Source: 연합뉴스, IBM)

Science projects:	Marine mammals, micro plastics, sea level height &wave patterns, oceanographic and environmental data collection
Length:	15M
Width:	6.2M
Max speed:	10 knots
Weight:	5 tons/4535KG
Equipment capacity:	0.7 tons/700KG
Hull design:	Trimaran (central hull with two outrigger wings)
Power:	Solar-driven hybrid electric motor
Software:	IBM Visual Insights computer vision technology, IBM edge systems, IBM Operational Decision Manager automation software, IBM Maximo asset management software, data from The Weather Company
Hardware:	IBM Power Systems AC922, 6 Jetson AGX Xavier, 2 Jetson Xavier NX, 4+ Intel-based computers, 4+ custom microprocessor systems
Navigation equipment:	Precision GNSS (Global Navigation Satellite System), IMU (Inertial Measurement Units), radar, weather station, SATCOM, AIS

Guideline on SQA and HCD for e-navigation (IMO MSC Circ.1512)



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MSC.1/Circ.1512
13 July 2015

GUIDELINE ON SOFTWARE QUALITY ASSURANCE AND HUMAN-CENTRED DESIGN FOR E-NAVIGATION

1 The Sub-Committee on Navigation, Communications and Search and Rescue (NCSR), at its second session (9 to 13 March 2015), agreed on the *Guideline on Software Quality Assurance and Human-Centred Design for e-navigation*.

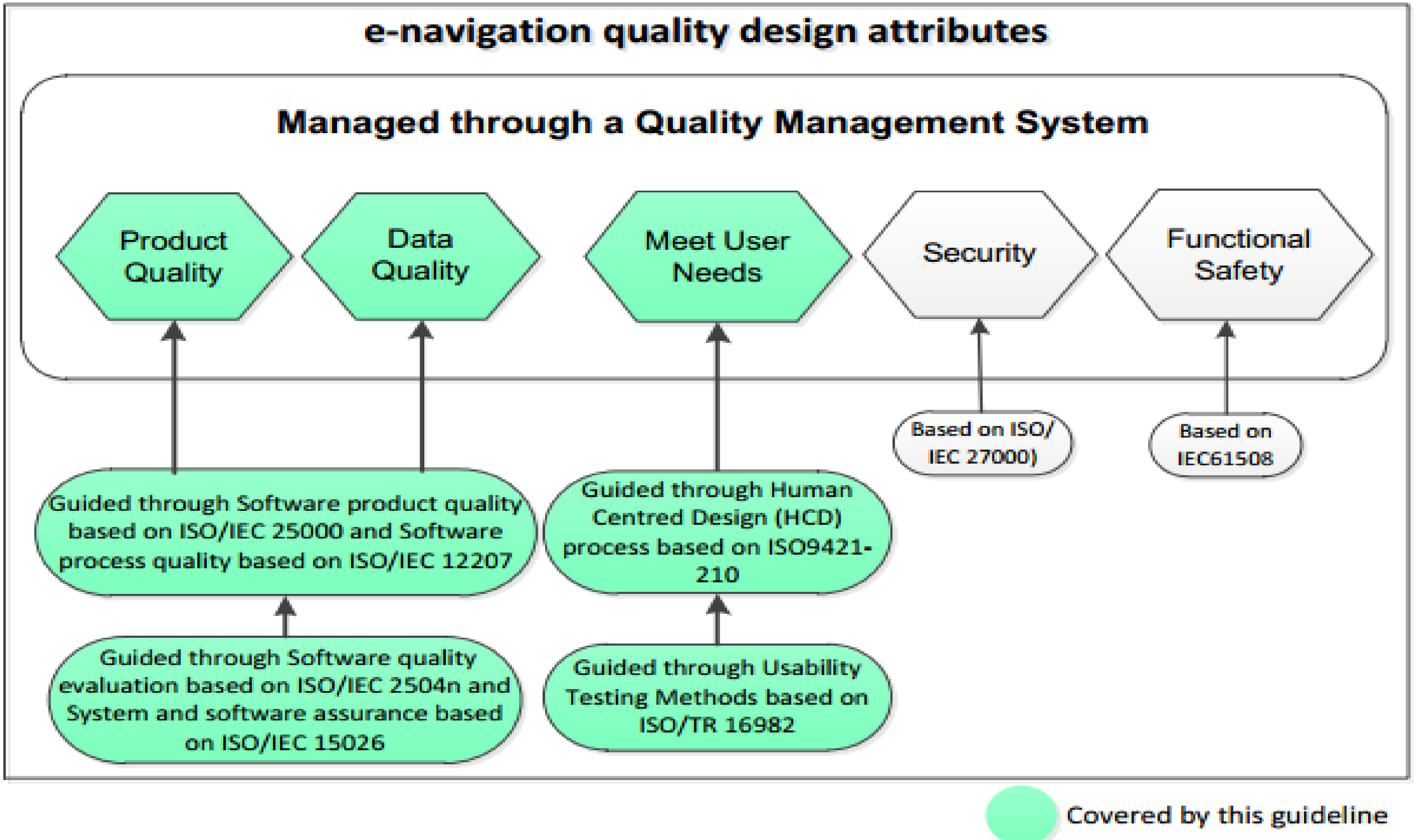
2 The Maritime Safety Committee, at its ninety-fifth session (3 to 12 June 2015), having considered the proposal by NCSR 2, approved the *Guideline on Software Quality Assurance and Human-Centred Design for e-navigation*, as set out in the annex.

3 The guideline is intended to ensure that software trustworthiness and user needs are met through the application of Software Quality Assurance (SQA) and Human-Centred Design (HCD) in the development of e-navigation systems.

4 The guideline is also intended to support the principles identified in SOLAS regulation V/15 (Principles relating to bridge design, design and arrangement of navigational systems and equipment, and bridge procedures).

5 Member Governments are invited to bring this Guideline to the attention of all parties concerned.

Guideline on SQA and HCD for e-navigation (IMO MSC Circ.1512)



Ⅲ. SW functional safety related works

Guidelines on maritime cyber risk management (MSC-FAL.1/Circ.3)

- Maritime cyber risk refers to a measure of the extent to which a technology asset could be threatened by a potential circumstance or event, which may result in shipping-related operational, safety or security failures as a consequence of information or systems being corrupted, lost or compromised.

Maritime cyber risk

Home ⟶ Our Work ⟶ Security ⟶ Maritime cyber risk

Maritime cyber risk refers to a measure of the extent to which a technology asset could be threatened by a potential circumstance or event, which may result in shipping-related operational, safety or security failures as a consequence of information or systems being corrupted, lost or compromised.

(Source: IMO website)

Ⅲ. SW functional safety related works

Classification rules

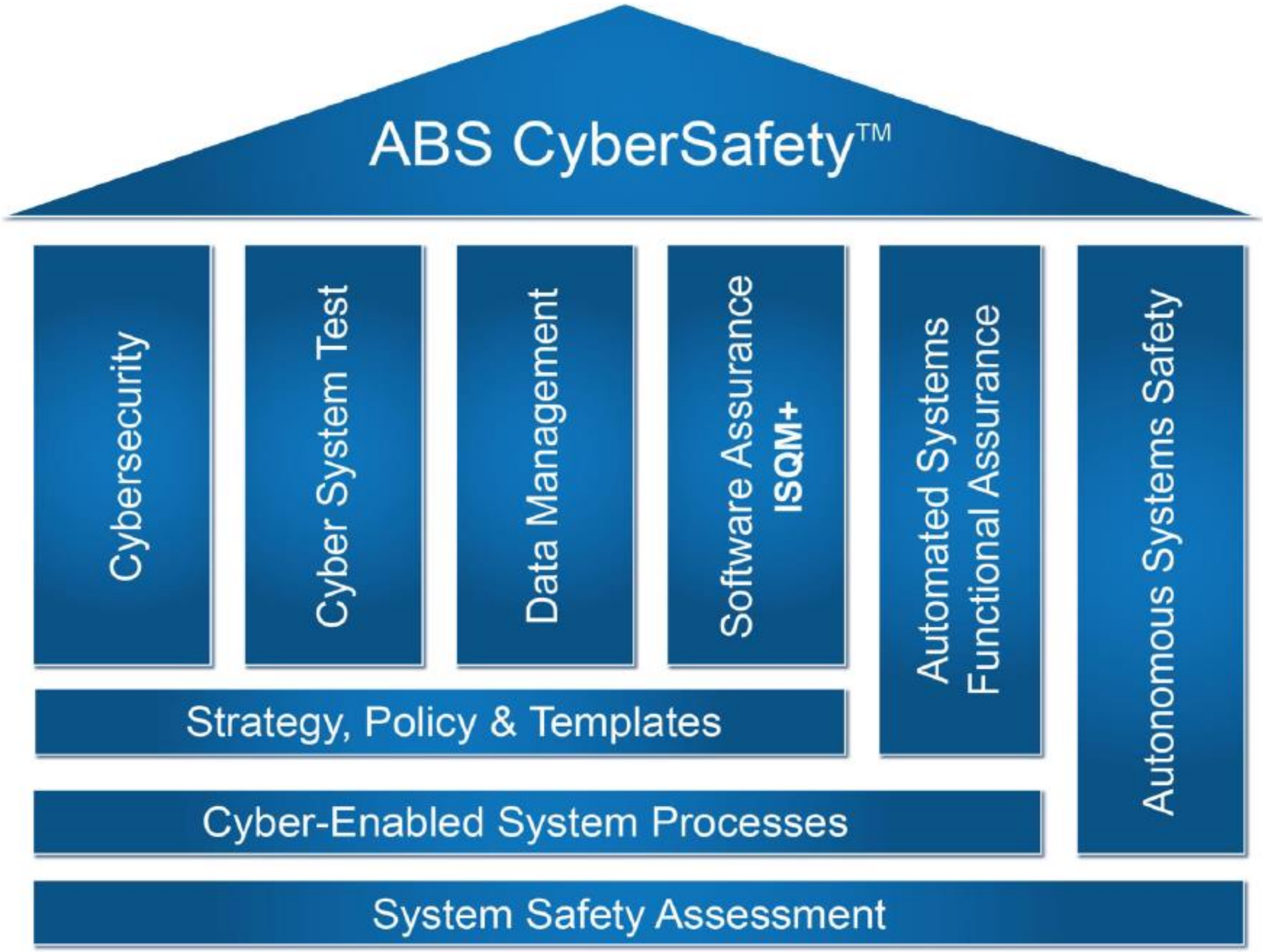
- KR(Korean Register of Shipping)'s guidelines for Type Approval of Maritime Cyber Security issued in Feb, 2020

Classification Society	Class notation name
ABS (U.S.A)	CyberSafety
Bureau Veritas (France)	Cyber Managed and Cyber Secure
CCS (China)	Cyber Security (P,S)
ClassNK (Japan)	CybR-G, Digital Smartship
DNV (Norway)	Cyber Secure
Lloyd's Register (U.K)	ShipRight

선급 업무 : 선박의 최초 설계로부터 건조 완료 시까지 선체구조설비에 대한 도면승인과 건조의 모든 과정 중에 제조검사와 완성검사를 통하여 선박을 등록하고, 또한 운항중인 선박에 대한 정기적 검사로서 해상에서의 선박의 안전을 확보하는 제반 업무. 이를 위한 IMO 규정을 기반으로 자체 규칙 수립 및 적용. 증서발행

Ⅲ. SW functional safety related works

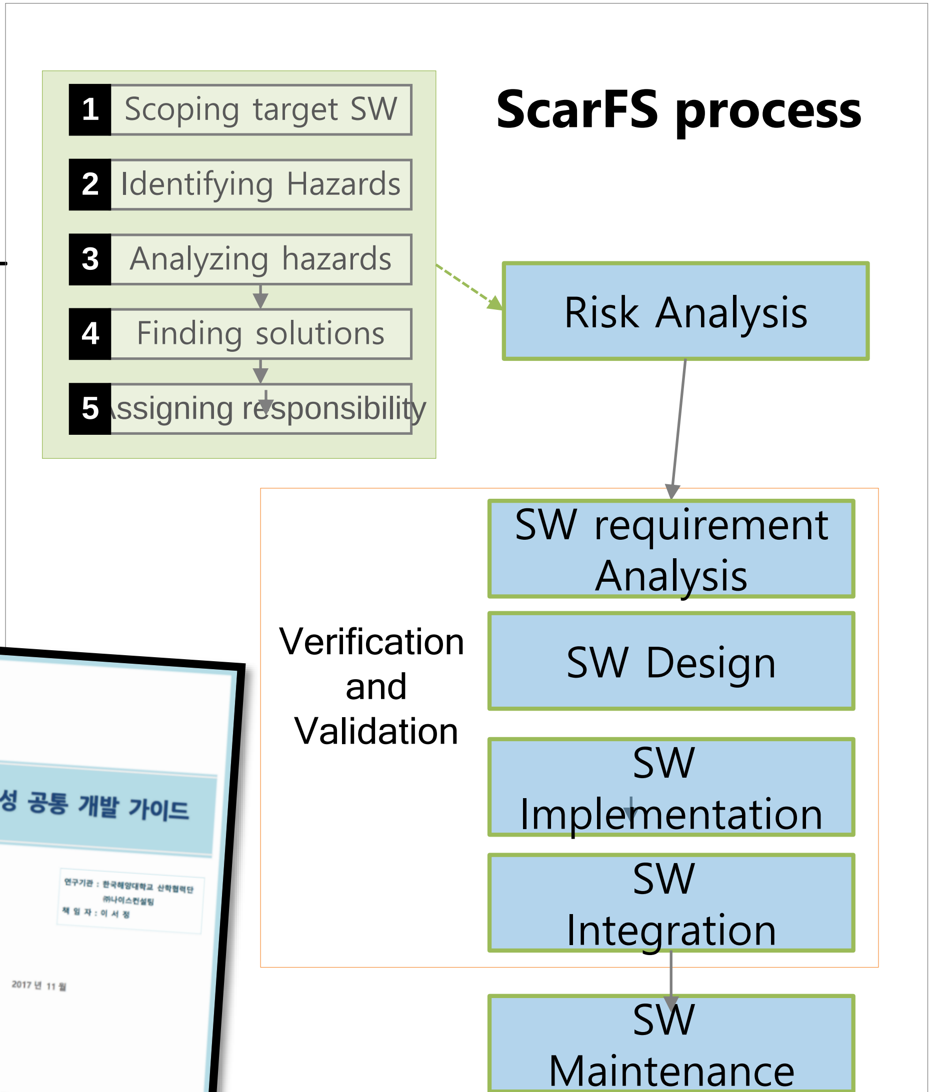
Cyber security, finctional safety and SQA in ABS CyberSafety

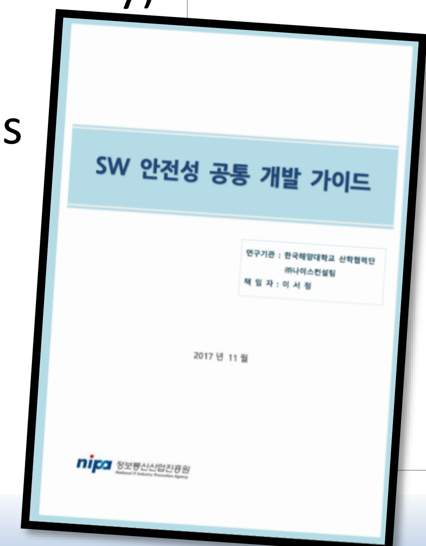


(Source: American Bureau of Shipping)

NIPA 소프트웨어 안전 가이드

- Supported by NIPA(National IT Industry Promotion Agency) in 2016-2017
- Helping SW companies in railway, medical and maritime sectors
- Introducing the ScarFS (Software to be Careful about Functional Safety) model
- Providing practical templates





IV. Expected efforts afterwards

Providing appropriate regulation, useful guidance and appropriate training

- Identifying existing regulations and guidance that already apply to lower levels of autonomy
- Ensuring the improvement of IMO developments for autonomy, leading and guiding
- Encouraging a positive environment and culture for growth of autonomous systems in maritime sector
- Encouraging classification societies, educational institutes and all related bodies to ensure growth of understanding

V. Conclusions

To make the society safer

- Revising the safety standards and regulations for safety critical AI-based systems, behavioral aspects of AI-human and AI-AI
- Considering road sector's effort to develop "Safety of the Intended Functionality" standards
- Changing culture to no blame to report incidents
- Investing more into the validation and verification of safety related/critical systems, training and education

감사합니다