

북극항로 운항 선박의 항해안전지원시스템(KARS) 개발 개요

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요 약 : 지구 온난화로 인해 여름철 북극해의 해빙이 점차 감소함에 따라서 북극항로를 이용한 선박의 화물운송이 점차 증가하고 있다. IMO에서는 극지해역운항선박의 안전성과 해양오염방지를 위하여 2014년에 Polar Code를 개정하였으며, 2017년 1월부터 SOLAS협약과 MARPOL73/78협약에 추가되어 시행되고 있다. 본 연구는 해양수산부 해양안전 및 해양교통시설기술개발 사업으로 1) Polar Code 강제화에 따라 '극지해역 운항선박용 항해안전지원시스템의 개발'의 필요성과 2) 북극항로에 대한 국제선의 안전 운항 확보를 위한 '북극권 국가와의 국제협력 및 공조체계 구축'과 '극지 구난, 구조 및 환경보호 관련 국내법 및 규정 제정'을 위한 기반 연구의 필요성에 의거하여 2014년 11월 10일에 시작되었으며 2018년 12월 31일에 종료될 예정이다. 연구내용은 1) 고정밀도 북극항로 기상정보 수치예측 시스템 개발, 2) 북극항로 안전속도 예측, 평가, DB구축 및 항행 모델 개발, 3) 북극항로 안전운항을 위한 항해계획 기술 개발, 4) 북극항로 운항선박 건조 및 안전항해 가이드라인 개발이다. 본 논문에서는 개발 중인 KRISO Arctic safe Routing System (KARS)에 대한 소개와 활용 결과 및 향후 계획에 대해서 설명하고자 한다. 본 KARS는 향후 지속적인 수정보완 작업을 통해서 완성도를 높여갈 예정이며, 검증단계를 거쳐서 최적하고 안전한 항로와 운항 관련 정보를 선사와 해기사에게 제공함으로써 북극항로 중·단기 운항계획 수립과 안전 운항을 지원할 수 있을 것으로 기대된다.

핵심용어 : 북극항로 안전운항 지원시스템, KARS, 북극 해양정보, 북극항로 안전속도, 북극 최적항로, 북극항로 항해계획

Main Objective

- KARS is designed to assist captains and vessel crews in the voyage planning process. The safe voyage planning process can be fully supported by the KARS

- Benefits

- Voyage Plan for NSR Administration
- Pre-calculation of Ship Performance in Ice
- Integrated Optimization Tool (Optimal Route, Safe Speed)
- Minimize the Risk, Time, and Fuel Consumption
- User-friendly Software Tool

System Concept

- KARS includes the prediction of ice, weather and sea conditions, and ship performances derived from the ship transit model based on model tests and numerical simulations.

*Operational assessment method of Polar Code: Polar Operational Limit Assessment Risk Indexing System

Main Specifications

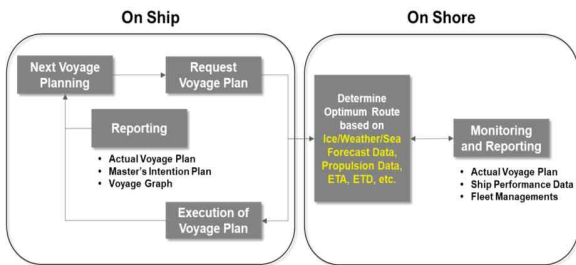
- General specification of software
 - Window 8, Microsoft .NET Framework 4.5
 - Bathymetry Data (IBCAO ver. 1.0, 2.5km resolution)
 - Standard Map (OpenStreetMap only visualization's purpose)
 - Ice Prediction (Ice thick.: TOPAZ-4, Ice conc.: AMSR2, MODIS, 24hrs)
 - Weather Prediction (Wind, Wave, Swell height/period/direction: NCEP Wave Watch 3, 6hrs)
 - Sea Environmental Prediction (Sea level pressure, Atmosphere temperature, Eastward wind velocity, Northward wind velocity: Global Forecasting System, 6hrs)
 - Route Optimization Method (with A* and Genetic algorithms)
 - Ship Transit Model (Ship resistance, V-DHP curve, H-V curve)
 - Target Area (Default: NSR, NWP-Option)
 - Virtual Reality Visualization (Option)

General Layout of System

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Systematic Diagram of Voyage Planning

- Voyage planning process

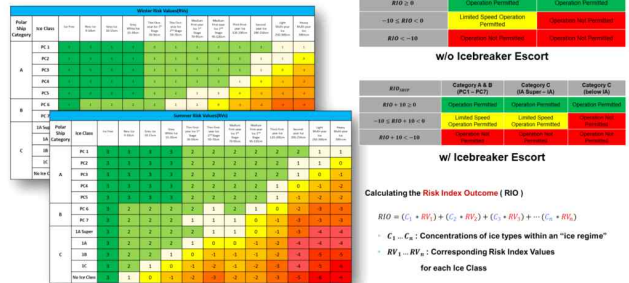


- Provide the safe speed and optimal route based on the ice, weather and sea forecast data

Function – Ship Propulsion Performance

- Ship transit model : safe speed

▪ Evaluation of safe speed in ice
> IMO Polar Code POLARIS



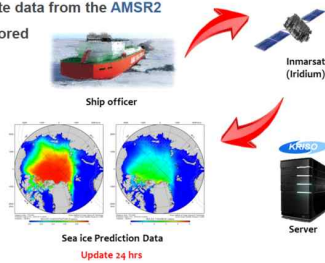
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Function – Ice/Weather/Sea Data Forecasting

- Ice information

▪ Ice information data are requested by the ship to the on-shore server system to determine the optimal route in the initial stage of voyage planning.

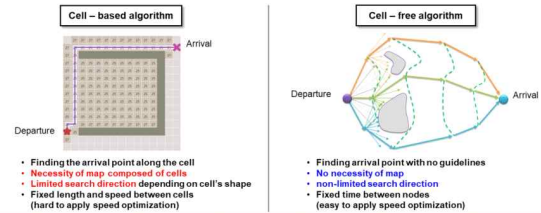
▪ The main data source is based on TOPAZ-4 model and satellite data from the AMSR2 and MODIS. These data are stored in the on-shore server.



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Function – Route Optimization

- Optimal route finding method : genetic algorithm



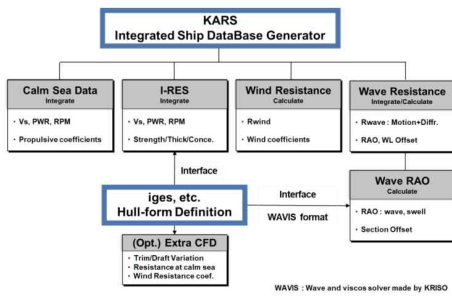
	Algorithm	Use of cells	Smoothing path	Speed optimization	Optimal solution	Computation time
Cell-based algorithm	Dijkstra's algorithm	○	X	X	Global optimum	normal
	A* algorithm	○	X	X	Local optimum	Short
Cell-free algorithm	3D Dynamic Programming	X	X	○	Global optimum	Long
	KARS	X	○	○	Global optimum	Long

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Function – Ship Propulsion Performance

- Ship transit model : open water condition

▪ Prediction of ship resistance characteristics



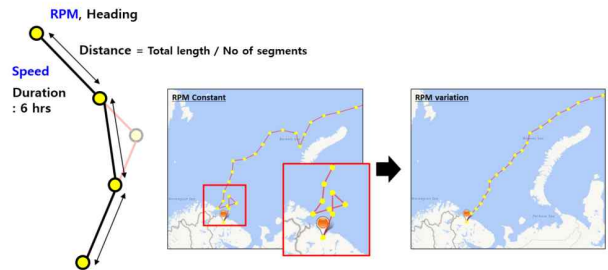
Based on ISO 15016:2002 - Sea trial analysis method

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Function – Route Optimization

- Optimal voyage route calculation process

▪ Water depth constraint (Default: two times the ship's draft, Changeable)
 ▪ Grid and pre-seed generations using A* algorithm
 ▪ Route generation (RPM variation) using Genetic algorithm



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Function – Target Area (Option)

- Voyage planning via. NSR or NWP

Busan → Murmansk vis NSR

Busan → Murmansk via NWP

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Function – Virtual Reality Visualization (Option)

- Education of vessel crews

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Validation

- Comparison of AIS data and calculated data (via. NSR)

[AIS data (2012)]

[Optimal route (2017.08)]

Source: <http://wwfarclicmaps.org/> - Ship traffic in 2012

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Validation

- Comparison of full scale ice trials data and calculated data

- Ice trials of IBRV "ARAON" around East Siberian Sea (5th to 26th Aug. 2018)

- Ice conditions (conc., thick., strength.), Voyage conditions (RPM, power, azimuth angle, trim, location, trajectory, etc.)

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Validation

- Comparison of AIS data and calculated data (via. NWP)

[AIS data (2012)]

[Optimal route (2017.08)]

Source: <http://wwfarclicmaps.org/> - Ship traffic in 2012

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Future Plan

- Application
 - Application of KARS on the vessels operating in NSR
 - Full scale data acquisition (real voyage data)
- Validation
 - Comparison between real voyage data and predicted data
- Improvement
 - Verification of accuracy for the ship transit model
 - Optimal voyage route finding method
 - On-shore system : monitoring and controlling registered ships
- International cooperation
 - Russia KSRC : ship transit model comparison test
 - Russia AARI : real voyage test and analysis for research icebreaker

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후 기

본 논문은 해양수산부의 국가연구개발사업인 “북극항로 운항선박용 항해안전지원시스템 개발(PMS3880)”에 의해 수행되었습니다.