A data analytics, decision support and circular economy – based multi-layer optimization platform towards a holistic energy efficiency, fuel consumption and emissions management of vessels

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Org: ITML

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Big Data Analytics

Big Data analytics tools make it possible to analyze a large quantity of data to gain insight that supports decision-making.

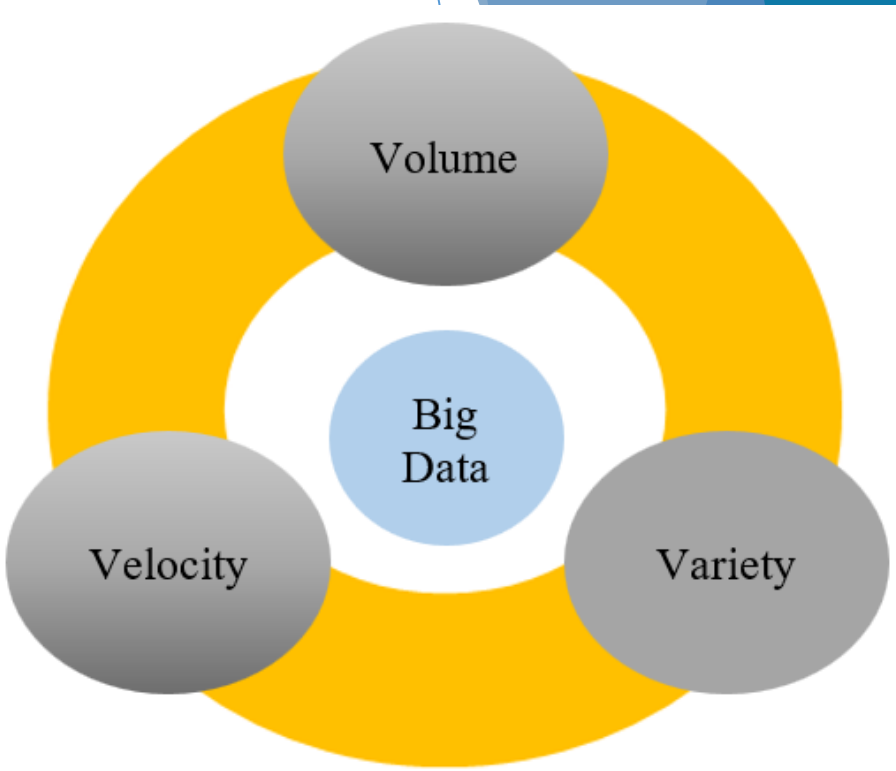
SmartShip is targeted to foster knowledge exchange between experts of complementary technology fields (***IoT***, ***Data Analytics***, ***Visualization Tools***, ***Optimization Algorithms***) applied in the frameworks of Energy Efficiency & Emissions management, towards a holistic framework for energy efficiency and emissions control, thus **materializing the next-generation paradigm for the maritime industry.**

Big Data Analytics

According to the definition of big data , **it is the name given to the large volume of structured and unstructured data produced in our personal and professional lives.**

It **can be defined by its variety, velocity, and volume with which it is generated.** Big data analysis is exceptionally advantageous since it allows businesses to expose hidden patterns, unknown correlations, uncertainties, market trends, and other meaningful information.

- ✓ Big data offers great capabilities to optimize operations to chime with ship calls, renew port assets, and ensure optimum cyber-security.
- ✓ Big data has the possibility to transform the Maritime Industry.



Application areas for Big Data in the Maritime industry

ROLE	FUNCTION	EXAMPLE OF BIG DATA APPLICATION
Ship Operator	Operator	• Energy saving operation • Safe operation • Schedule management
	Fleet planning	• Fleet allocation • Service planning • Chartering
Ship Owner	Technical Management	• Safe operation • Condition monitoring & maintenance • Environmental regulation compliance • Hull and propeller cleaning • Retrofit and modification
	New building	• Design optimization

Key trends in the use of Big Data in Maritime industry

TREND	DESCRIPTION
Technology capabilities are developed through Partnerships	Big data analytics are implemented through collaboration between shipping companies, technology suppliers, institutions, and universities. Collaboration can unlock synergies to generate direct value for customers/end users creating a unique ecosystem.
Through big data could be achieved the bunker cost reduction	One of the most crucial matters in the Maritime industry is fuel consumption/prices. Ship Owners and Operators are trying to eliminate their bunker costs. The use of big data through maritime software, there will be performance monitoring and optimization solution for fuel energy reasons.
Maritime companies are willing to set up internal infrastructure for big data execution	Maritime companies are developing internal platforms and entities to ensure efficiency, forecasting, and data security.
Big data entry in shipping is supported by funding	There are many types of funding (i.e., EU H2020 Calls, tenders, EMFF programs) in order to boost the use of big data in different applications of shipping.

Big Data Analytics & SmartShip

- SmartShip takes advantage of existing hardware and software to present a total framework for energy efficiency management. Within this framework SmartShip combines Data Analytics and IoT tools.

- Technologies that have already started to be used in the maritime sector. IoT technologies are essential: Connected Sensors and unified platforms are designed to provide increased visibility for crews and the marine management.

- IoT Sensors and technologies are appli
management parameters:

✓ Transforming Maritime navigation/ Route optimization (
softwa
✓ Asset/Cargo Tracking (status and te
✓ Equipment monitoring- Ensuring critical c

IoT use in Maritime aims at the prevention of unpredicted downtime, energy efficiency monitoring and achievement in operations and reduction in maintenance costs, and the specific technologies that usually materialize this scope include a variety of monitoring/sensing and actuating equipment such as RFID readers, sensors, actuators, cameras, and GPS.

Big Data Analytics and IoT

The volume and variety of data continue to increase day by day due to the application of sensor technology in the industry. Big data analytics are new to the maritime industry and address many issues, such as adaptability and integration.

It is expected that such a combined framework of Big Data Analytics and IoT can help obtaining:

- real-time analytics results to support vessel operations;
- analytics results to support diagnosis of vessels,
- prediction for maintenance needs
- analytics results on operation challenges in different waters and weather situations so as to facilitate and prioritize new components and designs.

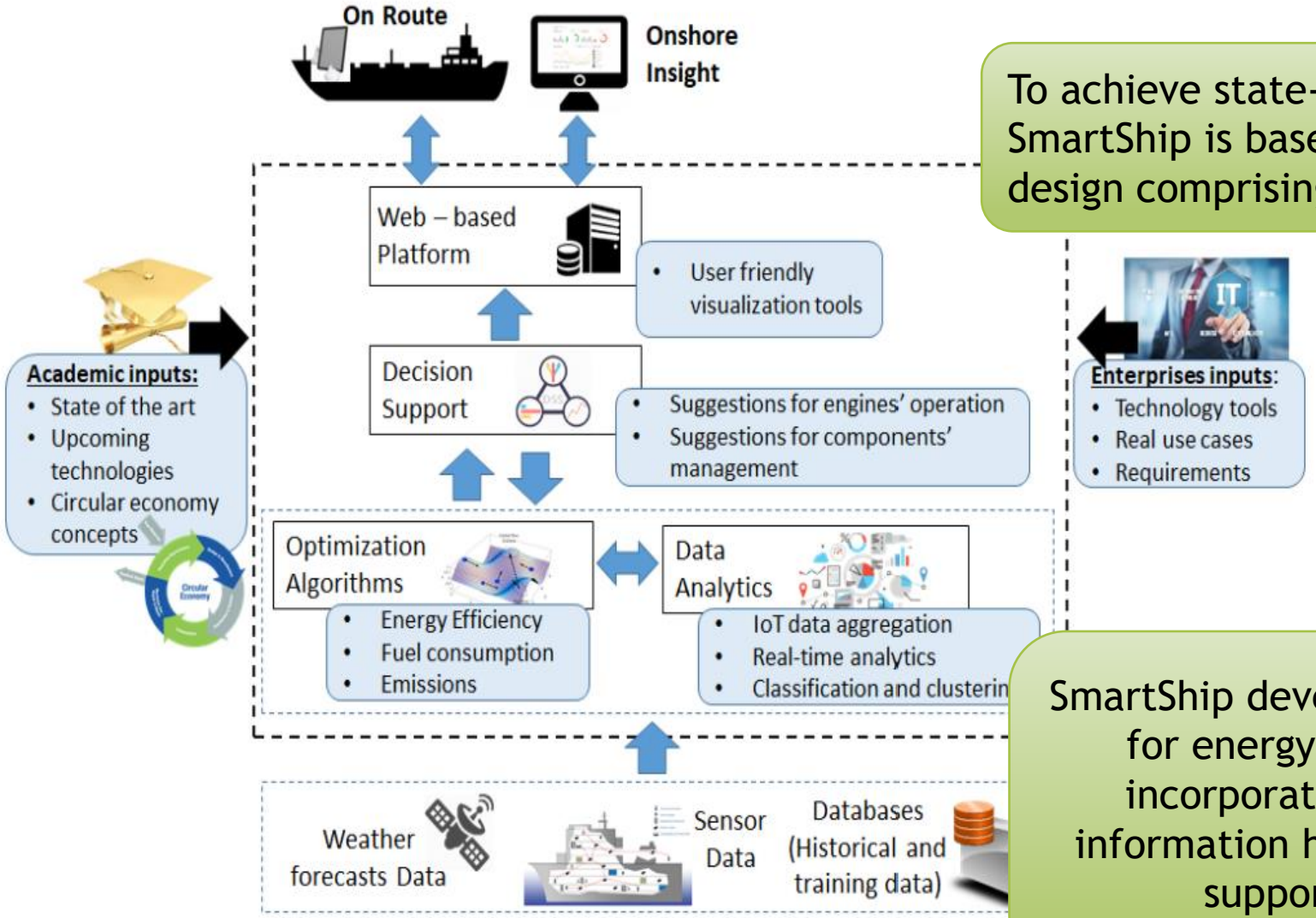
Challenges for Maritime Industry of Big Data Analytics

Data Transfer: Ships typically have **a very** large number of sensors onboard. A major cause of uncertainty comes from data transfer from those sensors. Every sensor requires a specific communication bandwidth, so it is important to have appropriate data communication for the individual sensor to transmit the information to the database. The data transfer speed may be accelerated with the help of high-tech communication systems.

Cybersecurity: This is a burning issue for any IT system. The data network's safety, security, and management will become vital for future shipping. This will need to be protected from external interventions such as piracy, viruses, or terrorist attacks. Cyber security will be the key issue for any naval system to prevent corruption in maritime security. A cyber-attack on the sensor network would interrupt the overall system and could be responsible for significant losses in the business.

Data Quality: Low-quality data would potentially lead to errors in interpretation. The database will not be able to keep track of all new entries. Therefore, ideally, the data should be error free. Data quality will be a big concern for the industry.

SmartShip Architecture



To achieve state-of-the-art deployment, SmartShip is based upon an architectural design comprising concrete components.

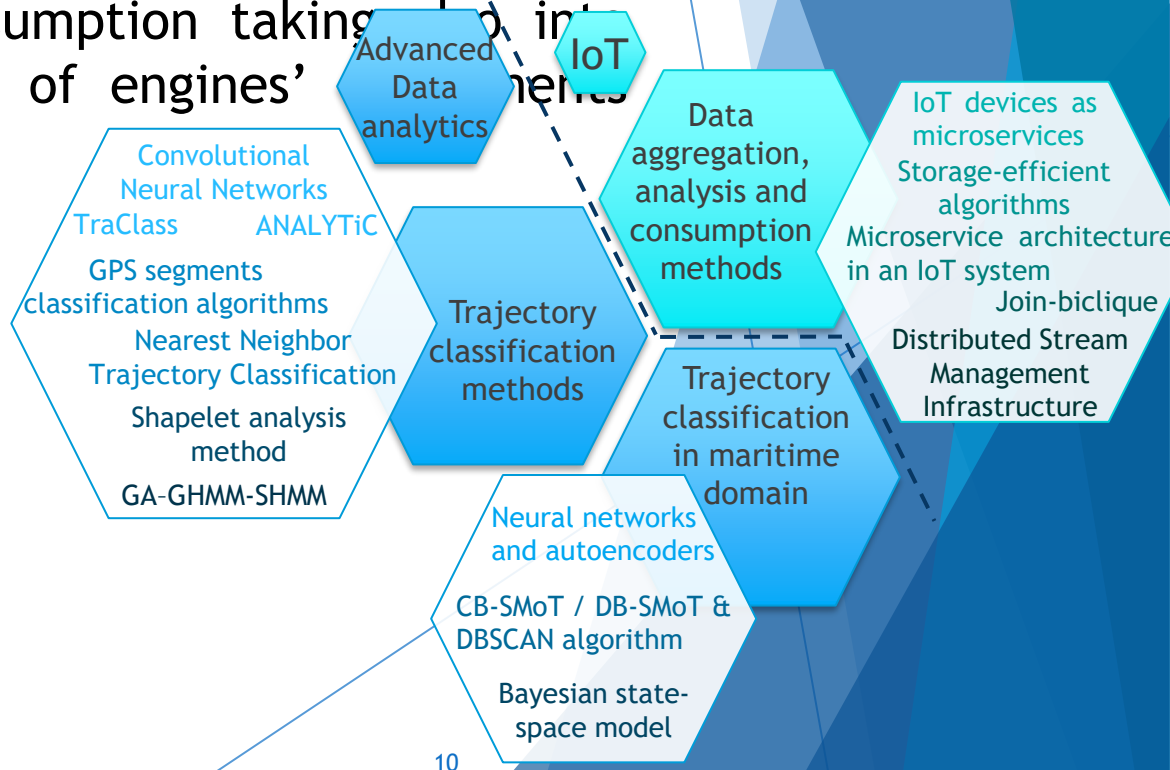
SmartShip develops & delivers a holistic framework for energy efficiency and emissions control incorporating technological advancements, information harvesting, short/mid-term decision support tools and human intellect!

SmartShip Data Analytics Module

The overall framework comprises the IoT backbone based on existing sensing devices applied in several parts within a vessel, focusing on engines' operation.

The data analytics module aggregates all this data and analyzes them in real-time and is coordinated by a set of optimization algorithms that focus on energy efficiency, emissions control and fuel consumption taking [illegible] into consideration circular economy concepts in terms of engines' [illegible] utilization.

- **Progress:**
  - The advanced methods and technologies used for data aggregation, analysis, consumption and classification in the fields of IoT & Advanced Data analytics have been defined within the first year of the SMARTSHIP project.



SmartShip Data Analytics Module

SmartShip ecosystem comprises three components. From a bottom-up perspective, these components are:

1. Data Sourcing (IoT)
2. SmartShip Core system
3. Users Applications

❑ Data Sourcing (IoT) definition

This component of the SmartShip system is considering tools, communication protocols and network topology for data retrieving, data pre-processing at the edge and finally transferring of information to SmartShip core for further processing and analysis.

SmartShip Data Analytics Module

- SmartShip Core system

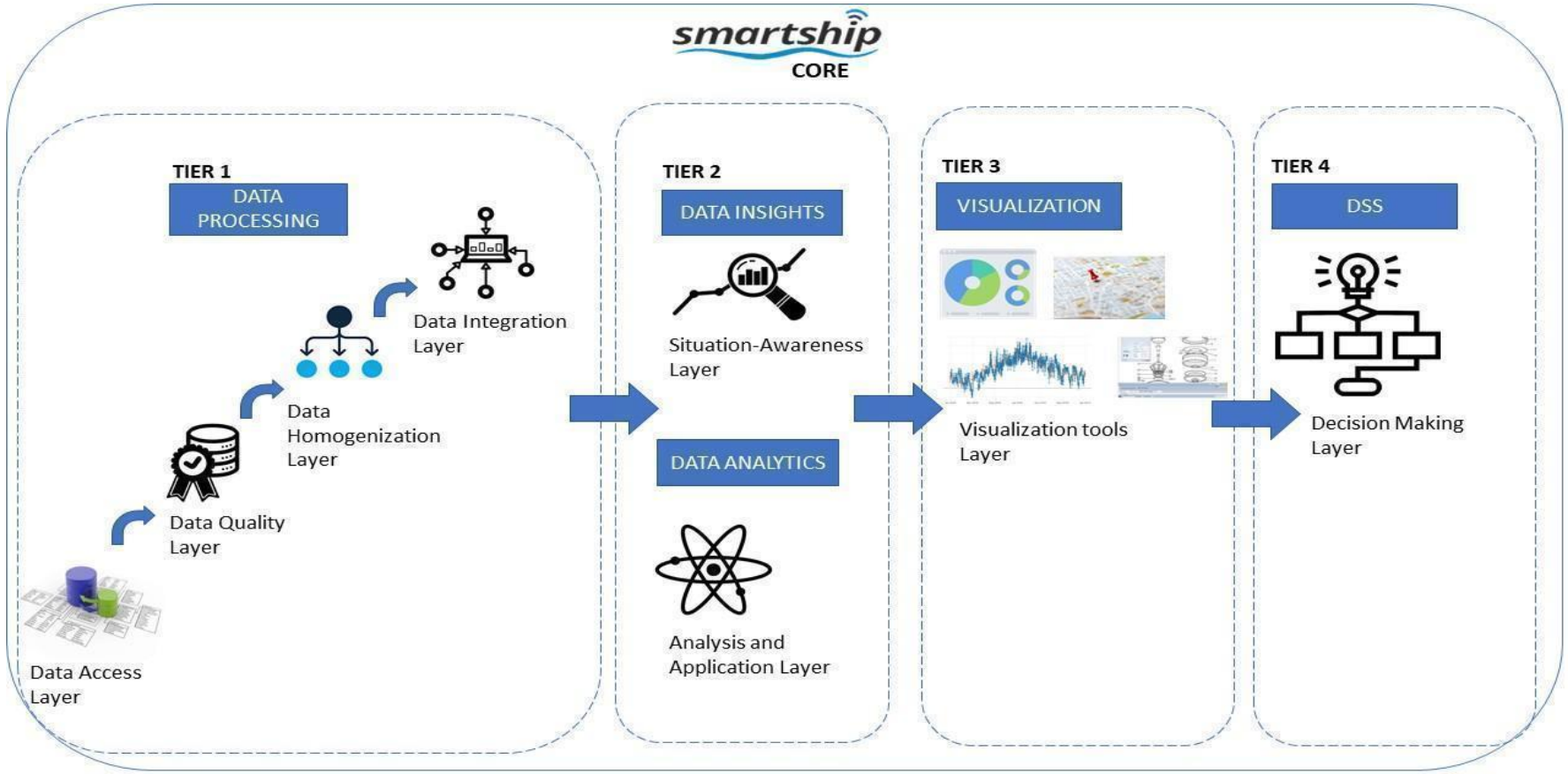
The SmartShip core is the heart of the whole ecosystem. Data is processed, analyzed, and visualized to support decision-making for critical maritime operational procedures defined in the project's Use cases.

- User Applications

This layer identifies how the meaningful information as product of data processing and analysis is consumed from users either ashore or on board.

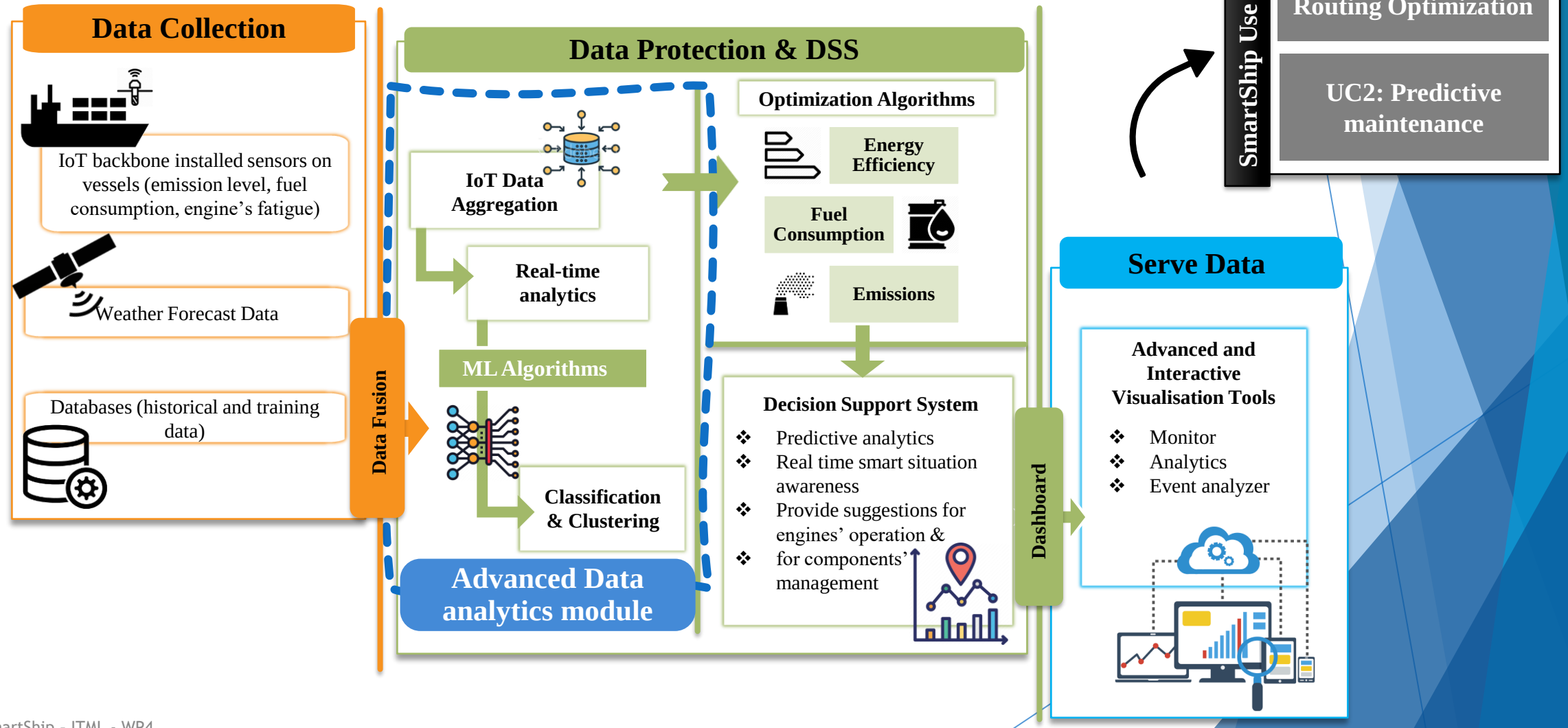
SmartShip Core system Description

SmartShip core system comprises four tiers. Data processed from the source and analyzed to be transformed into meaningful information for supporting users' decision making.



Design and Development of Advanced Data analytics module

Methodology



Smartship Data sourcing (IoT) and Advanced Data Analytics modules modelling, configuration and deployment.

- The development of the SMARTSHIP advanced data analysis module followed agile/adaptive methodology with an incremental release of two versions. The first iteration was completed in M36 with a first design/version of the module and the second iteration was concluded in M48.

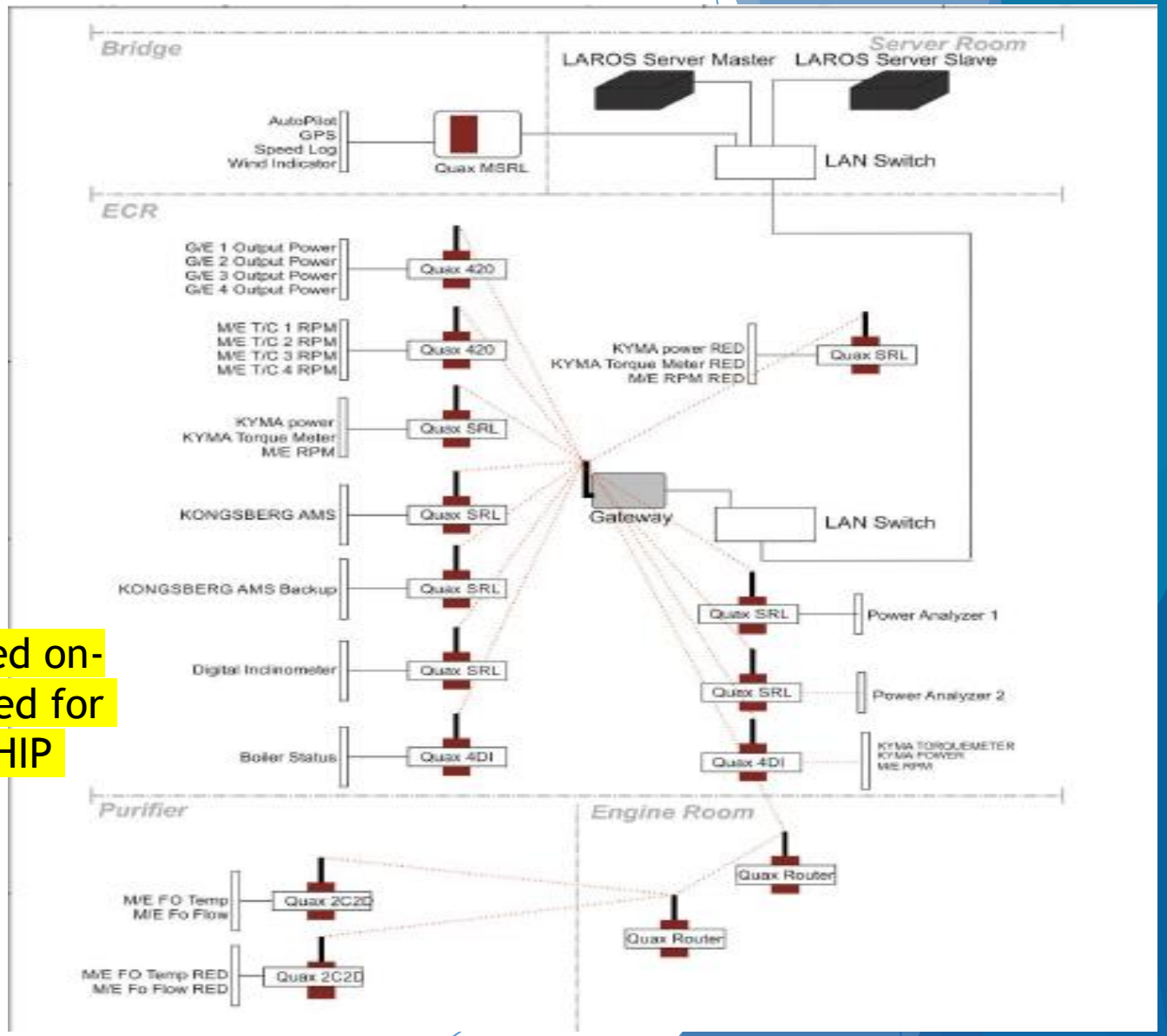
- The final release is capitalising on the existing DANAOS infrastructure for data sourcing and processing (DANAOS fleet performance system and DANAOS IoT network on-board) constituting a valuable increment to the system by advancing the functionalities and thus brining benefit to the existing design of vessel performance monitoring.

Smartship Data sourcing (IoT) and Advanced Data Analytics modules modelling, configuration and deployment.

The data sourcing is mainly referring to datasets streamed from vessel data points bundled together in an IoT network on-board.

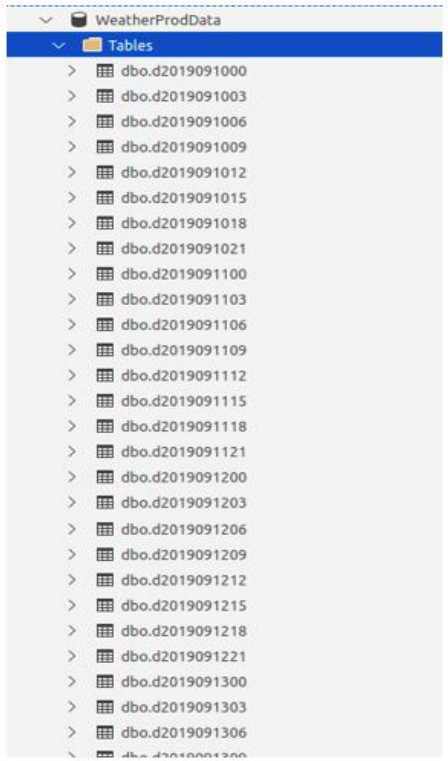
On-board IoT

A high-level depiction of the IoT network configured on-board the reference DANAOS vessel that was utilised for the training and the deployment of the SMARTSHIP advanced data analytics module.



Weather API

- The weather service API constitutes an endpoint to retrieve the weather state and more specifically the sea state for a specific time and location.
- The weather is initially acquired from National Oceanic and Atmospheric Administration (NOOA), and after appropriately processing is stored in an SQL server in 3-hour intervals.
- The weather grid has a granularity of 0.5 degrees.




```
{
  "Timestamp": "2022-11-16 09:00:00",
  "combDirectionDegrees": 0.0,
  "combPeriod": 0.0,
  "combSWHMeters": 0.0,
  "currentsDirectionDegrees": 0.0,
  "currentsSpeedKnots": 0.0,
  "hum%": 34.7,
  "iceCover": 0.0,
  "lat": 10,
  "lon": 11.5,
  "mslhPa": 1010.81,
  "sea": false,
  "swellDirectionMeters": 0.0,
  "swellPeriod": 0.0,
  "swellSWHMeters": 0.0,
  "tempCelciousDegrees": 23.77,
  "visKm": 24.135,
  "wavesDirectionDegrees": 0.0,
  "wavesPeriod": 0.0,
  "wavesSWHMeters": 0.0,
  "windDirectionDegrees": 2.22,
  "windSpeedKnots": 4.393439999999999
}
```


Snapshot of the stored data as well as the acquired weather features, via the API, in json format is depicted

Weather Feature list

- The forecasting values for a particular time and location correspond to the closest point of the weather grid, as depicted below, as well as the closest time in the three-hour interval.

Model Integration/Deployment

The Knowledge Hub aims to largely simplify and standardise the way the various tools and services provided by the DT's ecosystem are operating and communicating with each other, following the standards of an ICT (Information Communication Technology) framework.

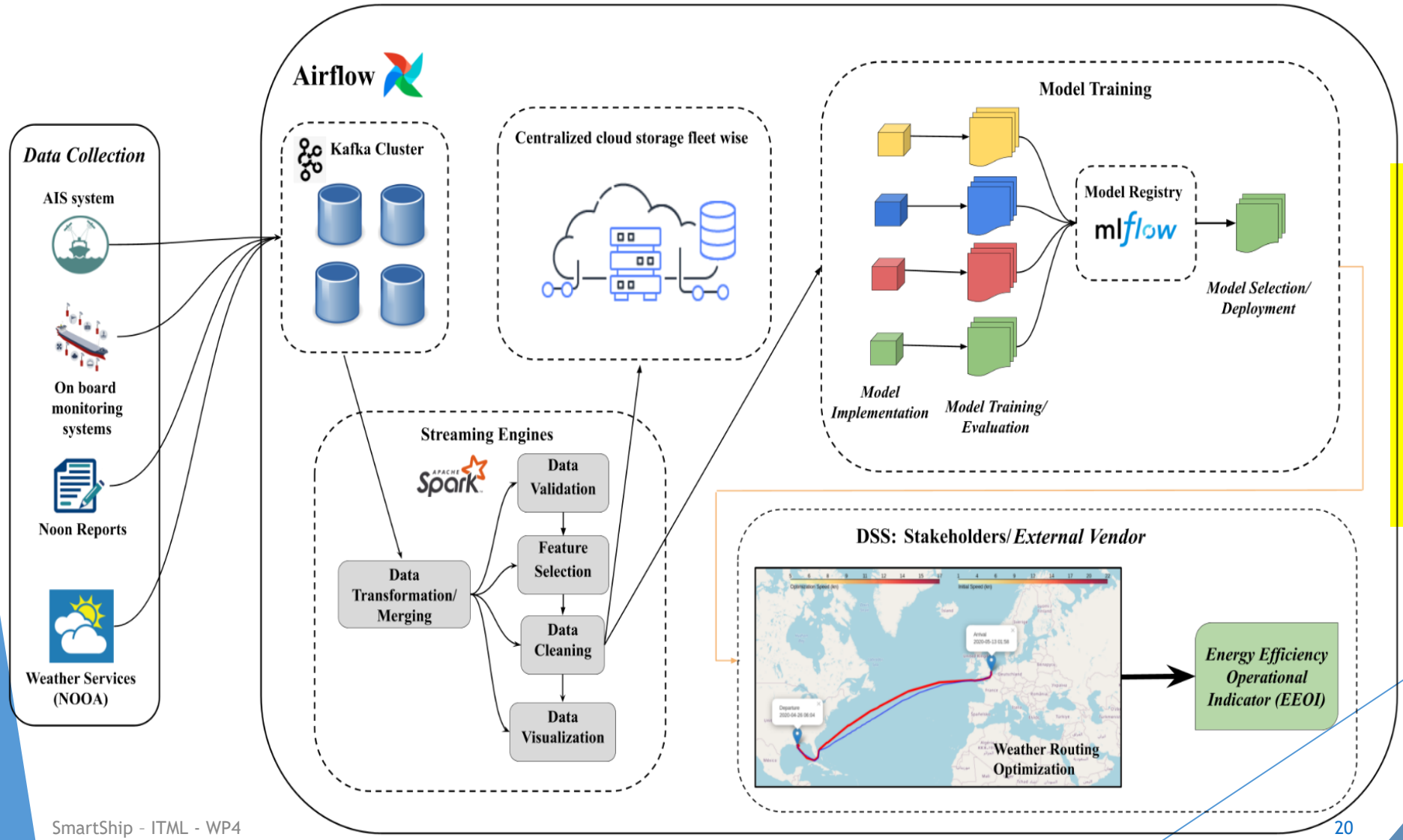
Data is continuously harvested from different sources (AIS, Sensors, Noon Reports, Weather Service API's) via a state-of-the-art scheduling framework *Apache Airflow*.

Conclusively, the proposed framework consists of the following components:

- IoT backbone suite - Data acquisition layer
- Knowledge Hub - Processing - Orchestration - Computing - Deployment layer
- Main GUI - Visualization layer
- Edge Computing - Sensing & Control actuation layer - Requirements & Refinements elicitation

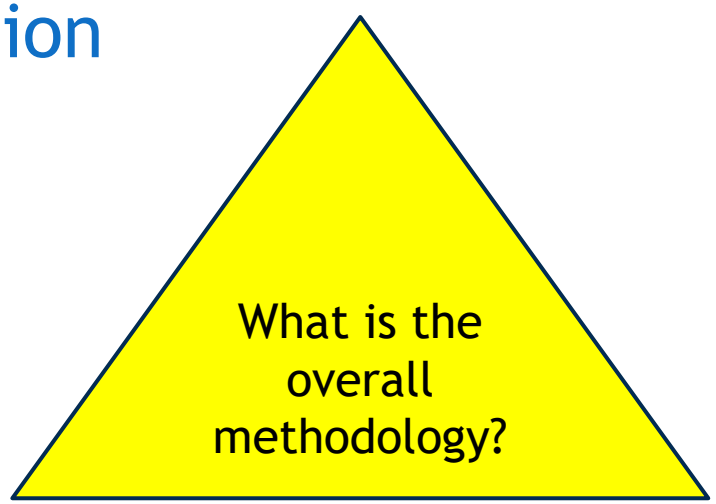
The streamlined procedure from data collection to model deployment.

A high-level visualisation of the streamlined procedure

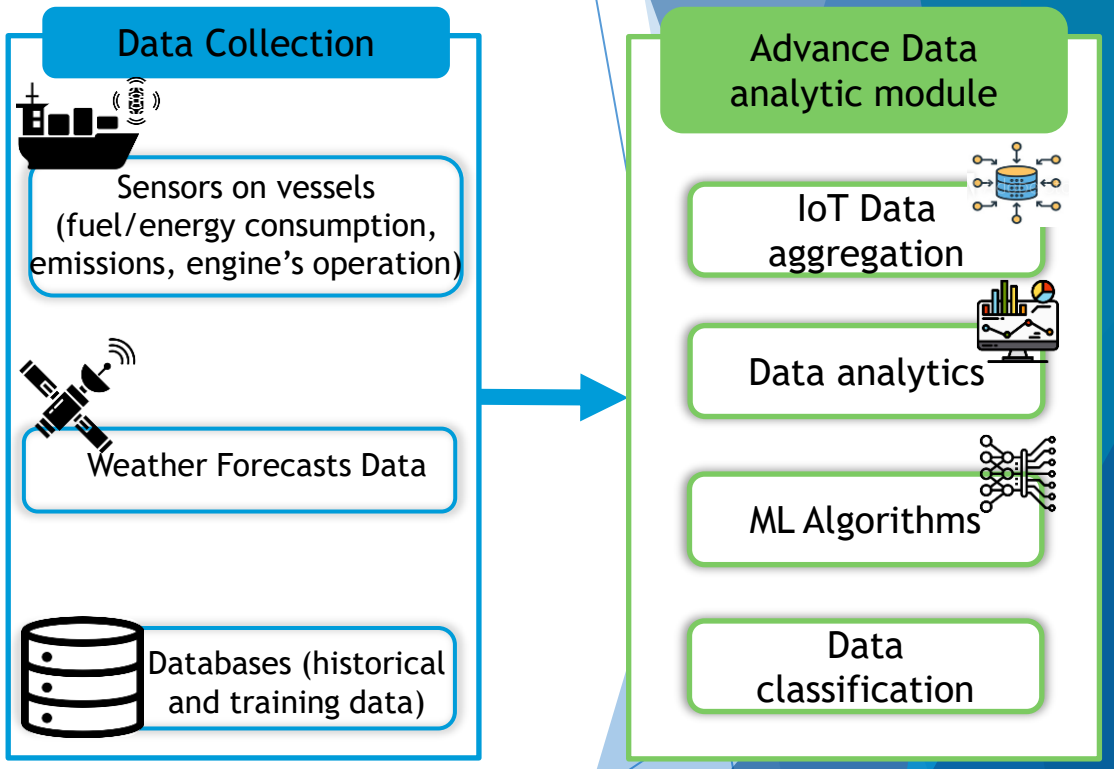


It comprises several steps from data collection and filtering to model building, evaluation, selection and deployment as well as the inter-linkage with a DSS described thoroughly in WP5.

Conclusion



- ✓ The methodology we followed was to collect data from the sensors on the vessels, weather data and historical data.
- ✓ Accordingly, the data analytic module will aggregate and analyze the data, while will also deploy ML algorithms and classification methods for the data collected. The output of this task will be used as base for the development of the decision support module.



Deliverables of the SmartShip tools and modules are accessible in our website.

Thank you!

https://www.smartship2020.eu/

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