D1.1 Concept of Recommended Routing Corridors

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1 Introduction

The main aim of this document is to define the concept of "Recommended Corridors". The principle is to use a large volume of tracking and position data from Satellite AIS, Terrestrial AIS and AIS from onboard vessels as well as weather data, to do big data analysis and provide recommended corridors for marine traffic based on the information about vessels which have sailed those navigable waters in the past. In this way HANSA may help to "streamline" traffic along the complete route, berth to berth, and create "virtual TSS"; the "virtual TSS" will in this case correspond to the way vessels actually travel. If all or most vessels follow the recommended corridors, this may lead to a reduced risk of hazards to navigation. It may not only decrease the number of potentially dangerous situations to marine traffic such as crossing or oncoming traffic, but it will also enhance the safety by allowing the mariner to better predict the movement of other vessels in his surrounding area.

Furthermore, intrusions of vessels into MPA (Marine Protected Areas), which are mostly caused by the mariner's negligence in route planning, can be mitigated as well.

2 Concept of Recommended Corridors

2.1 Definition

A recommended corridor should guarantee a vessel a specific safe route from a starting point to a destination. More specifically, it depends on a vessel's dimensions, type and current destination. The prevailing weather conditions are also taken into account. Information about a typical vessels' movement pattern, depending on the attributes mentioned in Section 2.2, is obtained by analysing historic vessel movement data in form of AIS messages.

Since recommended corridors are, by their very definition, safer waterways, vessels, whose routes lie in these corridors, are also much less prone to encounter shallow or unsafe waters. Recommended corridors will lead to an increased safety of navigation. By using HANSA principles, two of the most severe threats to life at sea and the marine environment – collisions and groundings - can be mitigated.

Furthermore, intrusions of vessels into MPA (Marine Protected Areas), which are mostly caused by the mariner's negligence in route planning, can be mitigated as well.

2.2 Relevant attributes to be considered

2.2.1 Attributes available in AIS messages

The first group of attributes that might be considered in generation of recommended corridors are parameters available in AIS messages.
For the classification of ships AIS Message Type 5 is most relevant. Apart from administrational fields, the parameters in these messages are:

- User ID (MMSI number)
- IMO number
- Call sign
- Name
- Type of ship and cargo type
- Overall dimension / reference for position
- Type of electronic position fixing device
- ETA
- Maximum present static draught
- Destination

After consulting with maritime experts from Innovative Navigation and nautical officers, the following parameters from AIS have been selected as potentially the most important when it comes to distinguishing routing corridors and sailing behavior: draught, overall dimension, type and destination.

Draught

This parameter says how deep in the water a vessel lies. This parameter is not always reliable as it is updated manually by an officer of the vessel. However, when it is provided it might be a good indicator. Sensible thresholds (to determine whether it is reliable or not) should be drawn from the analysis of AIS data and through statistical correlation.

Overall Dimension

The overall dimension is a static parameter and therefore more reliable than the draught. It indirectly provides the width and length of the vessel. The bigger/longer the vessel, the distances travelled within one route are usually further. Smaller vessels tend to hop from one port to another along the coast.
Sensible thresholds for further grouping of vessels according to their dimensions should be drawn from the analysis of AIS data and through statistical correlation.

Type

The type may be correlated with the size of a vessel. For some types we may not find enough data to find a specific pattern.
The main types are:

- WIG (Wing in Ground Craft)
- Vessel (engaged in activities, e.g. fishing, towing, dredging, diving, military, sailing, pleasure craft)
- High Speed Craft
- Special Craft (pilot, search and rescue, tug, port tender, anti-pollution, law enforcement, medical, or state not party to an armed conflict)
- Passenger Ship
- Cargo Ship (with hazardous liquid materials classification)
- Tanker (with hazardous liquid materials classification)
- Other ship

This parameter can be used to detect whether there is any correlation between vessel type and route taken. After internal discussion it was decided that there are four types of vessels which are particularly interesting when it comes to generation of recommended corridors. These types are: cargo ships, tankers, passenger ships and (optionally) High Speed Craft.

Destination

This parameter is provided manually by a captain and should be updated regularly dependently on the actual vessel's route. It may give a rough indication for the direction of travel – especially in open sea.

2.2.2 Preliminary Analysis of AIS Data: Type, Draught, Dimensions, and Destination

Having identified the possible AIS parameters, an initial statistical analysis of AIS data has been conducted to assess the quality of these parameters and to see whether they are reliable enough to be used in the generation of recommended corridors.

The analysis has been conducted using Type 5 AIS messages only, received in January-December 2015 from Orbcomm satellites (globally). The analysed dataset contained 1,390,219,742 messages from 425,166 unique MMSI numbers.

Below we present the main conclusions derived from this analysis. The detailed results have been presented in a separate report.

The analysis shows that there are four potential vessels' attributes that might be used for generation and differentiation of recommended corridors.

The first attribute is the vessel type declared in AIS. Based on the conducted analysis and consultations with maritime experts, it may be concluded that there are four vessel types for which recommended corridors should be calculated: cargo vessels, tankers, passenger vessels (excluding ferries) and (optionally) High Speed Craft (HSC). Selection of these types results from the fact that they constitute the majority of ships equipped with AIS (almost 60%), travel mainly on longer routes (outside port or coastline) and provide transport services for a fee.

The second attribute is a vessel's draught. This attribute is provided in Type 5 messages and is entered manually by a captain - thus it might not be updated regularly. From the conducted analysis it might be concluded that this attribute, in fact, for some vessel types is not updated at all and the vast majority of vessels don't change draught information in AIS. In case of the four selected types, the draught value is updated regularly in case of tankers and cargo vessels (once in 13-14 days). In case of passenger vessels and HSC this value is more stable (rarer changes), which might result from the specifics of these types of vessels.

Moreover for these four vessel types, the mean values of draught also seem reliable and might be used for determinations of recommended corridors.

Finally, analyses of distribution of draught values for the four vessel types give some first indication how this information might be used to further categorize vessels among a given type into sub-groups as well as how to define a minimum value of draught that a ship should declare in AIS to consider it as a reliable information. The threshold might then be used to filter out vessels that should not be taken into account while generating the recommended corridors.

The third potential attribute that has been analysed is vessel's dimensions declared in AIS. The results in this case show that for the four selected types the provided dimensions seem to be reliable and might be used for generating recommended corridors. However, some further comparison with other data sources

might be necessary to check whether the values provided in AIS correspond to the actual (real) size of the ship.

Moreover, the declared dimensions might also be used to define different sub-categories of a ship based on its dimensions (e.g. small, medium, large) for each vessel type separately and then to assign a given vessel to one of a defined sub-group. Based on the conducted analysis, we received some indication how many sub-groups for a given vessel type can be defined. For example, in case of tankers even 5 or 6 sub-groups (with different intervals) can be distinguished, while for cargo vessels 2-3 sub-groups and for passenger ships and HSC 2 subgroups.

The last AIS attribute that might be used in some cases of generating recommended corridors is the destination. The conducted analysis of destinations declared in AIS show that in case of popular vessel types such as cargo ships or tankers, these vessels travel on average to a relatively small number of unique ports (between 3 and 4), but among them there are also vessels that visit a much higher number of ports (relatively high standard deviation). In case of passenger vessels and HSC these values are slightly higher – they travel to a higher number of unique ports. Moreover, the destination is updated relatively often in AIS (several times a day).

However, few issues should be kept in mind while using the destination attribute. Firstly, this value is provided manually by a captain and should be regularly updated. The conducted analysis of AIS revealed that almost one in five vessels does not provide this information at all. Secondly, the quality of this value is often unprecise. Therefore, it is necessary to apply some dedicated methods and rules for disambiguation of destinations/ports names in order to use this attribute in further analysis, also in the generation of recommended corridors. Finally, the received statistics on how often different types of vessels update information about their destination should be analysed by some domain experts to assess whether the received mean values seem reliable (i.e. if they may correspond to actual/real changes).

2.2.3 Weather data

Another group of attributes that might be considered in the generation of recommended corridors is weather data. The main idea is that a recommended corridor is defined for specific weather conditions.

In general a lot of different weather parameters are available. However, with respect to the goals of the HANSA project, considering all available weather information is too complex. Therefore, only such parameters have been selected that may have the biggest impact on manoeuvring a vessel and thus the selection of a sailing corridor. These parameters are: wind (speed & direction), wave height, current and ice cover.

The above parameters might be used to define different weather categories in which vessels are sailing and then classify vessels routes according to these categories. For example, for wind speed possible categories might be defined according to the Beaufort scale, i.e.:

- Cat 1: 0 – 3 Bft

- Cat 2: 4 – 7 Bft
- Cat 3: 8 – 12 Bft

Such categories might be further refined according to a wind direction (each category may contain wind intervals) and a wave height (since wave height correlates with wind speed).

Nevertheless, this is some initial indication for the weather classification and this problem will be further elaborated later in the project.

3 Requirements Identification

The requirements for the concept of recommended corridor were prioritized, using the MoSCoW technique[2]. To each requirement, one of four values was assigned:

- MUST – Describes a requirement that must be satisfied in the final solution for the solution to be considered a success.
- SHOULD – Represents a high-priority item that should be included in the solution if possible. This is a critical requirement but one which can be satisfied in other ways if strictly necessary.
- COULD – "nice to have", describes a requirement which is considered desirable but not necessary. This will be included if time and resources permit.
- WON'T – Represents a requirement that will not be implemented in a given release, but may be considered for the future (e.g. in the second phase of the project).

Req-Id	Requirements	Priority	Proposing partner	Responsible for realization
1	Recommended corridors are generated for a given vessel based on AIS dataset info, e.g. IMO, MMSI, Timestamp, Speed over Ground (SOG), and Destination (optional).	MUST	NVT	PUEB
2	Recommended corridors depend on vessels' types declared in AIS or defined by IMO (http://www.imo.org/en/OurWork/Safety/Regulations/Pages/Default.aspx); top level generic types are: tankers, passenger ships, Container ships (General Cargo).	MUST	NVT	PUEB
3	Recommended corridors depend on vessels' categories. Suggested categories for vessels are defined based on, e.g. Draft,	MUST	NVT, IN	PUEB

[2] https://www.agilebusiness.org/content/moscow-prioritisation

	Max Draft, Speed, Dimensions (width, length and size groups: small, medium, large), Rate of Turn.			
4	Recommended corridors depend on vessels' heading, navigational status.	MUST	IN	PUEB
5	Recommended routes, consisting of set of recommended corridors, depend on vessels' starting locations (e.g. port of departure) and destination points (e.g. port of destination).	SHOULD	NVT	PUEB
6	Recommended corridors are conforming to information in Official Nautical Charts (ENC's).	SHOULD	NVT	NVT
7	Recommended corridors depend on weather conditions / weather categories, such as wind (direction & speed), wave height and tide (current), ice conditions, etc.	MUST	IN, OFF	PUEB
8	Recommended corridors include determination of a port's border (when a vessel enters/departs a port).	MUST	PUEB	PUEB
9	Recommended corridors support the prediction of a course of an individual vessel based on its current position.	SHOULD	IN	IN
10	Recommended corridors support the prediction of a vessel's trajectory from its current position.	SHOULD	IN	IN
11	Recommended corridors are updated due to constant changes of sailing conditions or traffic patterns (e.g. change of a traffic separation scheme, change of a light house sector, etc.).	SHOULD	NVT	PUEB
12	Recommended corridors are updated in near real-time due to temporal changes of sailing conditions or traffic patterns (e.g. due to maritime accidents, weather changes) – detection of temporal 'NoGo' areas.	COULD	NVT	PUEB
13	A defined percentage of vessel traffic is within recommended corridors. The percentage has to be adjustable.	MUST	IN,NVT	PUEB
14	Recommended corridors are compared with (verified against) official "recommended" routes, e.g. from the Norwegian Coast Administration (NCA).	MUST	NVT	NVT
15	Patch updates of recommended corridors to on-board systems is possible.	MUST	NVT	NVT

16	A global mesh network of routes/legs from start port to destination port is generated. This can be sorted by vessel classes.	MUST	IN, NVT, SPRINT	PUEB, SPRINT
17	It is possible to display and analyse a recommended corridor within an Official Passage Plan.	SHOULD	SPRINT	SPRINT
18	It is possible to generate and display reports about most frequently selected corridor	COULD	SPRINT	SPRINT

4 Conclusion

The principle is to use large volumes of tracking and position data from Satellite AIS, Terrestrial AIS and AIS from on-board vessels, to conduct big data analyses and provide recommended corridors for marine traffic based on the information about vessels which have sailed navigable waters in the past. Based on partners' and users' requirements for the segmentation and break down of the total available information, the project intends to come up with a recommended corridor concept adapted to partner requirements for local, regional and (if possible) global navigation.

As shown above, a variety of vessel specific information can be obtained from AIS messages. The resulting complexity must be reduced for data analysis. For this purpose, classes for data, like ship length or weather information, can be created. In this context, the concept of recommended corridors will be further refined.