



Marine Management Organisation

Mapping UK shipping density and routes technical annex

June 2014



Mapping UK Shipping Density and Routes technical annex

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List of Abbreviations

ABPmer	ABP Marine Environmental Research Ltd
AIS	Automatic Identification System
AIS-A	Shipborne mobile equipment intended for vessels meeting the requirements of IMO AIS carriage requirement.
AIS-B	Shipborne mobile equipment intended for non-IMO AIS vessels (for example, small commercial vessels below 300 GT, fishing vessels, recreational vessels)
ASCII	American Standard Code
COG	Course over the Ground
DECC	Department for Climate and Energy Change
DG	Dangerous Goods
DfT	Department for Transport
DGNSS	Differential Global Navigation Satellite System
DTE	Data Terminal Equipment
EIA	Environmental Impact Assessment
EPFS	Electronic Position Fixing System
ESRI	Environmental Research Systems Institute
ETA	Expected Time of Arrival
FTE	Full Time Equivalent
GDP	Gross Domestic Product
GIS	Geographic Information System
GLONASS	Globalnaya Navigatsionnaya Sputnikovaya Sistema
GPS	Global Positioning System
GT	Gross Tonnage
HS	Harmful Substances
HSC	High Speed Craft
ICO	Information Commissioners Office
ID	Identification
IPR	Intellectual Property Rights
ITU	International Telecommunication Union
IMO	International Maritime Organization
MCA	Maritime and Coastguard Agency
MEDIN	Marine Environmental Data and Information Network
MP	Marine Pollutants
MPA	Marine Planning Area
MMO	Marine Management Organisation
MMSI	Maritime Mobile Service Identity
MS	Microsoft
NM	Nautical Miles
PA	Position Accuracy
Reefer	Refrigerated vessel
RoRo	Roll-on, Roll-off vessel
TI	Turn Indicator
QA	Quality Assurance
RNLI	Royal National Lifeboat Institution
ROT	Rate of Turn
SAR	Search and Rescue
SART	Search and Rescue Transponder

SEP	Strategic Evidence Plan
SIC	Subject Indicator Code
SOG	Speed over the Ground
SOLAS	Safety of Life at Sea
SQLite	Structured Query Language 'Lite' database
UK	United Kingdom
UKCS	United Kingdom Continental Shelf Boundary Area
UN/LOCODE	United Nations Code for Trade and Transport Locations
UTC	Universal Time Coordinated
UTM	Universal Transverse Mercator
VHF	Very High Frequency
VTC	Vessel Transit Class
VMS	Vessel Monitoring System
WIG	Wing-In-Ground

SI units are used unless otherwise stated.

Executive Summary

This technical report has been written to present the methodology developed in the MMO project number 1066, entitled 'Mapping UK Shipping Density and Routes from AIS – Open Source Data and Methods'. This report is targeted at the technical specialist and refers where relevant to additional documentation produced during the development of the project. To guide the development of the project, a Steering Group was convened with an oversight of the project's development and outputs; this group was comprised of the MMO, Marine Scotland, the Department of the Environment Northern Ireland, the Welsh Government and The Crown Estate.

The report explains how the raw AIS data from the MCA is processed to provide outputs that can be mapped. From the mapped vessel information, routing patterns can be observed and national shipping statistics created. The report's technical description outlines how the processing stages are achieved. The first part of the process is undertaken by two complementary pieces of software; the Stage 1 and Stage 2 MMO AIS processors.

The Stage 1 and Stage 2 MMO AIS processors are provided as "Click Once" applications, where the application is downloaded to an application 'cache' on the local computer and does not require the software to be installed. Stage 1 and 2 processes both require the use of a database to hold the AIS decoded information, this project uses a SQLite database for storing and processing AIS data where required.

Stage 3 provides steps for creating transit lines which can be viewed geographically, followed by steps to clean up transit lines to improve the quality of the dataset. Further processing stages provide a method to validate transit line information against a comparison database, followed by assigning vessel transit classification and draught classifications.

Stage 4 provides instructions for identifying final vessel transit classification, density grid creation, calculate temporal differences and provides summary statistics. The report concludes with a list of potential future developments for enhancing the use of AIS data for marine planning, including combining information with Satellite data, expanding the sampling duration for input data and outputting information to compliment other UK port and shipping datasets from Government.

1. Introduction

The Marine Management Organisation (MMO) has commissioned ABP Marine Environmental Research Ltd (ABPmer) to develop open source data and methods for the mapping of Automatic Identification System (AIS) data supplied by the Maritime and Coastguard Agency (MCA).

The MMO project 1066¹ is part of the MMO's requirement to generate a robust evidence base to contribute to the Strategic Evidence Plan (SEP) which has eight priority areas of research including a Socio-economic Evidence Programme. The SEP research programme aims to improve MMO understanding and management of marine socio-economic activities (including shipping) and inform decision making to contribute to sustainable development in the marine environment. In order to fully consider shipping as an activity in co-location/co-existence studies, the MMO needed a source of data which can be manipulated to address bespoke questions, in particular, relating to displacement as a result of plan policies.

This technical report has been written to present the methodology developed in the project. The project builds upon the previous technical work completed in the MMO project 1042, in which an AIS processing methodology and display standard for the output of AIS derived information was developed.

This report is targeted at the technical specialist and refers to associated documentation produced during the development of the project, for example, MMO data processing logs and MMO confidence assessments. This document updates the methodology presented in MMO project 1042 report entitled 'AIS Data Standards Report' (MMO, 2013a)

1.1 Project remit

This project provided flexible data processing tools and associated database solutions to decode and display AIS data. Through the use of common routines and methodology, future AIS processing and analysis can be conducted by devolved administrations to a consistent and commonly agreed approach. A consistent approach across the UK is important given the cross-border nature of the shipping industry. To guide the development of the project, a Steering Group was convened with an oversight of the project's development and outputs; this group comprised:

- The MMO
- Marine Scotland
- Department of the Environment Northern Ireland
- Welsh Government
- The Crown Estate.

¹ http://www.marinemanagement.org.uk/evidence/documents/1066_Shipping_Tools_Report.pdf
http://www.marinemanagement.org.uk/evidence/documents/1066_AIS_Software_Tools.zip

In addition to the creation of tools and routines for AIS data processing, the project also created a National AIS dataset for 2011 and 2012 comprised MCA AIS data records collected by the network of UK receiving stations. The project scope required that data analysis extended as far as credible information was recorded, which in some instances exceeds national boundaries. The national AIS dataset was delivered as a geodatabase of vessel transit lines and associated density grids and is described within the associated MMO report 'Mapping UK Shipping Density and Routes from AIS' (MMO, 2014a).

The scope of the commission identified four clear objectives that provided the remit for the study, these are namely:

- Objective 1: Building upon MMO project 1042, the study team was required to further develop the methodology including the development of a custom AIS pre-processing approach. This approach extracts, transforms and bulk-loads MCA AIS data records from raw form into an open source database for subsequent post-processing in GIS. These pre-processing tools, and the spatial database products, have been made available as open source software (IPR free). The tools have been developed to extract all AIS data messages, include AIS-A and AIS-B.
- Objective 2: Building upon MMO project 1042, the methodological approach has been updated using guidance and information from the Steering and Stakeholder Group. This includes replacement of the previously used Microsoft (MS) SQL-Server approach with a SQLite² method. The methodology has also been updated to include temporal outputs and the generation of National statistics.
- Objective 3: Building upon MMO project 1042, the study team has produced UK data products for vessel (shipping) density and routing, broadly in-line with the data specification developed in the previous project, with the addition of temporal variation. The study team has engaged with the project Steering Group to agree modifications to the outputs/methodology to include National trans-boundary data requirements. The methodology has been recorded, logged and reported on.
- Objective 4: The study team has undertaken Stakeholder consultation with key government delivery partners, industry bodies and Non-Governmental Organisations (NGOs). Comments and amendments from Stakeholders, in agreement with the Steering Group, have been considered and addressed in the methodological update.

1.2 Project outputs

The MMO project 1066 produced a number of outputs including:

- Open source (IPR free) software for the decoding and thinning of AIS data
- SQLite database template and schema
- ArcGIS transit line and density grid methodology (provided as four MMO Data Processing templates)

² SQLite is an embedded SQL database engine requiring no client installation and is freely available in the public domain.

- A Microsoft (MS) Excel template used as part of the data processing and validation methodology
- National geographic masks (provided as ArcGIS Shapefiles)
- Geodatabase with 2011 and 2012 national AIS datasets containing transit lines, density grids and temporal (difference) grids. The geodatabase also contains metadata records, to MEDIN standard
- An MMO report 'Mapping UK Shipping Density and Routes from AIS'
- An MMO report 'Mapping UK Shipping Density and Routes technical annex' (this document).

The outputs from this project built upon the technical work completed in the MMO project 1042 (MMO, 2013a). The scope of the project required further development of the previous methodology including consideration of temporal differences.

1.3 Report sections

This report provides the technical reader with an understanding of the processing tools developed during the project, plus the validation and confidence processes applied to the project outputs.

The report is structured into the following sections:

- **Raw data** detailing the collection network, AIS message types and input format
- **Data processing overview** providing a summary of the processing stages
- **Stage 1 data processing** identifying how raw data is validated, the creation of the SQLite database, vessel data decoding and database population
- **Stage 2 data processing** which details AIS decoding, transit identification and thinning
- **Stage 3 data processing** explaining the creation of transit lines, cleaning transit lines and initial vessel transit classification
- **Stage 4 data processing** describing final vessel transit classification, the vessel validation process, calculating draught classifications, creating density grids and calculating temporal differences
- **Confidence** section describes the confidence assessment on the project outputs and
- **Recommended developments** suggesting options for further research and development to enhance the approach and use of AIS data for marine planning.

2. Collection and Provision of Raw Data

AIS data provides a source of information which can be used to spatially represent vessel movements within receiving range of the transmission. The technology works with transponders which automatically broadcast information at regular intervals via a Very High Frequency (VHF) transmitter.

There are 27 different types of AIS signal (see Section 2.2) the signals used to prepare the outputs from this project can be broadly classified as 'Class A' and 'Class B'. AIS-A is carried by international voyaging ships with gross tonnage (GT) of 300 or more tonnes, and all passenger ships regardless of size. AIS-B is carried by smaller vessels and is aimed at the leisure and fishing sector. The scope of this project required the development of tools and routines for the decoding and display of MCA supplied AIS data, as MCA data is the primary source of information to UK Government administrations.

The MCA provided twelve, seven-day periods of AIS-A and AIS-B data from 2011 and 2012. The data sets were sampled from the first seven days of each month, commencing with January, at two-monthly intervals. The even spread of data from selected weeks and months over the two-year period reduced any seasonality effects for combined (annualised) datasets. This approach is consistent with previous AIS projects, for example, the MMO project 1042 and data contained within the Maritime Data website (Maritime Data Website, 2014) created for the Department of Energy and Climate Change (DECC).

MCA data was provided for the following periods:

- January 1st to 7th, 2011
- March 1st to 7th, 2011
- May 1st to 7th, 2011
- July 1st to 7th, 2011
- September 1st to 7th, 2011
- November 1st to 7th, 2011
- January 3rd to 9th, 2012*
- March 1st to 7th, 2012
- May 1st to 7th, 2012
- July 1st to 7th, 2012
- September 1st to 7th, 2012
- November 1st to 7th, 2012.

* Note: Data validation checks identified that data from 1st to 2nd January 2012 was incomplete; therefore the date range was amended to the next nearest date range with consistent records.

2.1 Collection network

The MCA has a wide ranging UK shore based reception and monitoring network. Their network of reception stations is shown in Figure 1 together with an indicative

reception radius of 40 nautical miles. The range of reception can be variable and is dependent on factors including signal propagation conditions, sea state, the height of the transmitting and receiving antenna and the strength of the vessel transmitter. Poor reception could be as little as 20 nautical miles, or as much as 350 nautical miles for powerful transmissions during appropriate atmospheric conditions. It is considered likely that a 40 nautical miles reception radius will be achieved by the MCA AIS network subject to the factors previously mentioned.

2.2 Message types

The MCA provided AIS-A and AIS-B data constituting the following message types:

- Message Type 1, 2 and 3 'Positional Report' (AIS-A)
- Message Type 5 'Voyage Message' (AIS-A)
- Message Type 18 and 19 'Positional Report' (AIS-B) and
- Message Type 24 'Static Data Report' (AIS-B).

In each case the data is provided in the format:

- Time and date of message reception
- Maritime Mobile Service Identity (MMSI) vessel identification number
- Message type and
- AIS message string.

Processing tip: Annex A provides the exact database extraction script used by the MCA to provide the raw data used in this project. In subsequent data requests, this script should be specified to ensure the supplied data is compatible with the tools developed to process the data.

This project used only seven of the available 27 different message types, Table 1 presents a list of all available AIS messages. The provided UK national AIS dataset 'AIS-A and AIS-B' for 2011 and 2012 as used within the project includes over 320 million AIS messages representing nearly 16.6 million nautical miles of vessel transits.

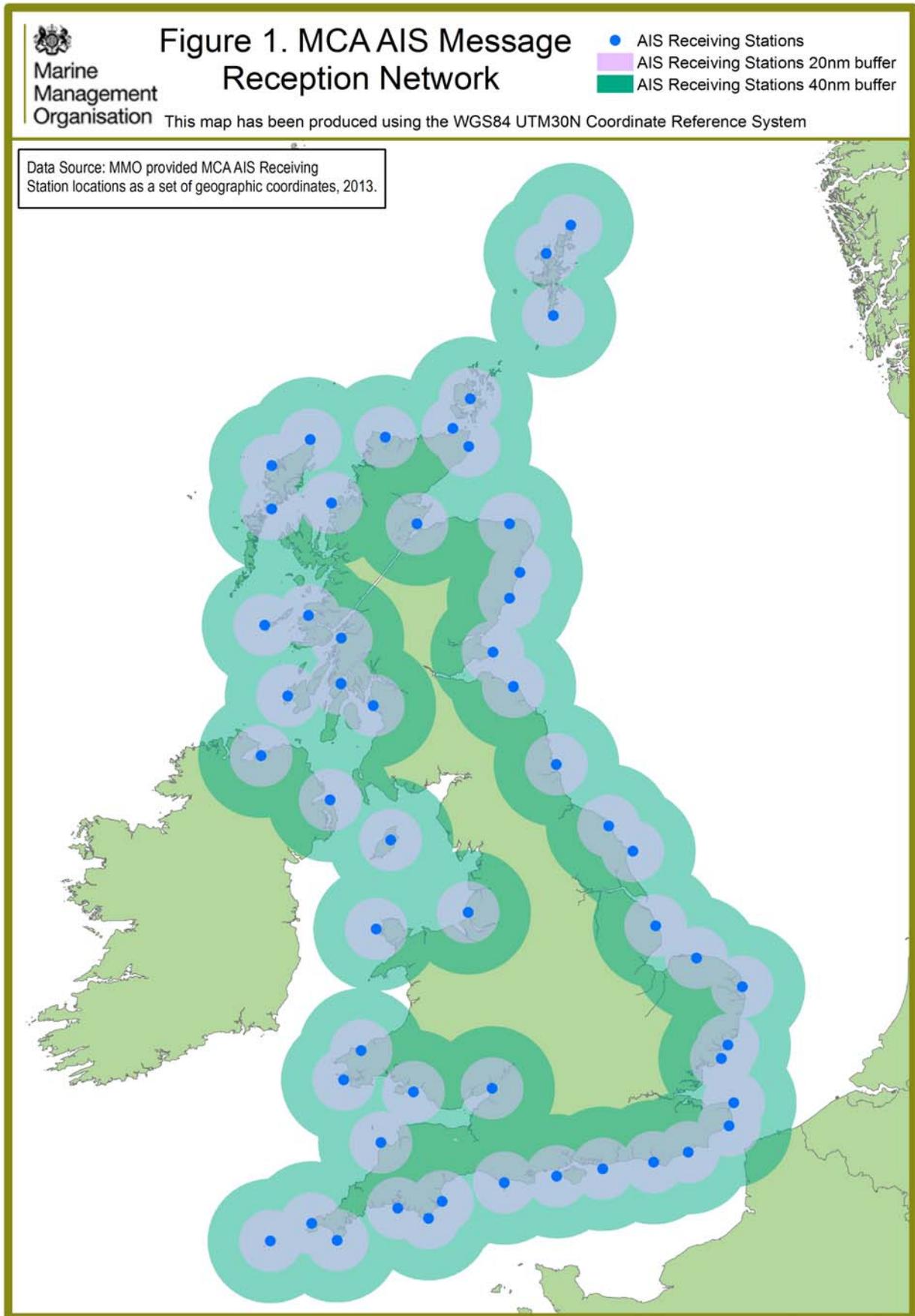


Table 1: AIS message types.

Message ID	Name	Description
1	Position report	Scheduled position report (Class A shipborne mobile equipment)
2	Position report	Assigned scheduled position report; (Class A shipborne mobile equipment)
3	Position report	Special position report, response to interrogation (Class A shipborne mobile equipment)
4	Base station report	Position, UTC, date and current slot number of base station
5	Static and voyage related data	Scheduled static and voyage related vessel data report (Class A shipborne mobile equipment)
6	Binary addressed message	Binary data for addressed communication
7	Binary acknowledgement	Acknowledgement of received addressed binary data
8	Binary broadcast message	Binary data for broadcast communication
9	Standard SAR aircraft position report	Position report for airborne stations involved in SAR operations, only
10	UTC/date inquiry	Request UTC and date
11	UTC/date response	Current UTC and date if available
12	Addressed safety related message	Safety related data for addressed communication
13	Safety related acknowledgement	Acknowledgement of received addressed safety related message
14	Safety related broadcast message	Safety related data for broadcast communication
15	Interrogation	Request for a specific message type (can result in multiple responses from one or several stations)
16	Assignment mode command	Assignment of a specific report behaviour by competent authority using a Base station
17	DGNSS broadcast binary message	DGNSS corrections provided by a base station
18	Standard Class B equipment position report	Standard position report for Class B shipborne mobile equipment to be used instead of Messages 1, 2, 3 (8)
19	Extended Class B equipment position report	Extended position report for class B shipborne mobile equipment; contains additional static information
20	Data link management message	Reserve slots for Base station(s)
21	Aids-to-navigation report	Position and status report for aids-to-navigation

Message ID	Name	Description
22	Channel management(6)	Management of channels and transceiver modes by a Base station
23	Group assignment command	Assignment of a specific report behaviour by competent authority using a Base station to a specific group of mobiles
24	Static data report	Additional data assigned to an MMSI. Part A: Name. Part B: Static Data
25	Single slot binary message	Short unscheduled binary data transmission (Broadcast or addressed)
26	Multiple slot binary message with Communications State	Scheduled binary data transmission (Broadcast or addressed)
27	Position report for long range applications	Scheduled position report (Class A shipborne mobile equipment outside base station coverage)
28-63	Undefined; Reserved for future use	N/A
Source: United States Coastguard, 2014		

Annex B contains Table B1 to B5 which describe the field contents of AIS message types constituting AIS-A and AIS-B:

- AIS-B: Table B1 details the components of the positional report. The vessel location is identified from the positional data report and can be presented as spatial 'point' data. Through a combination of the MMSI number and reception time, individual vessel locations can be identified. Table B2 provides the components of the Voyage message. It is this message that defines the ship type, which is matched against the MMSI number and reception time.
- AIS-B: Table B3 provides the positional information for AIS-B transmissions. Message 18 is sent every 3 minutes where the vessel speed over ground (SOG) is less than two knots, or every 30 seconds for greater speeds. Table B4 details the fields from Message 19. This message is too long to be transmitted automatically; however a coast station can poll the transponder for this message to be sent. Base stations have the ability to interrogate individual transponders for message 19 status reports. Table B5 provides the static voyage information for AIS-B transmissions; this message is sent every six minutes, the same time interval as an AIS-A transmission. However, due to its length, this message is divided into two parts, the second part of which is sent within one minute of the first.

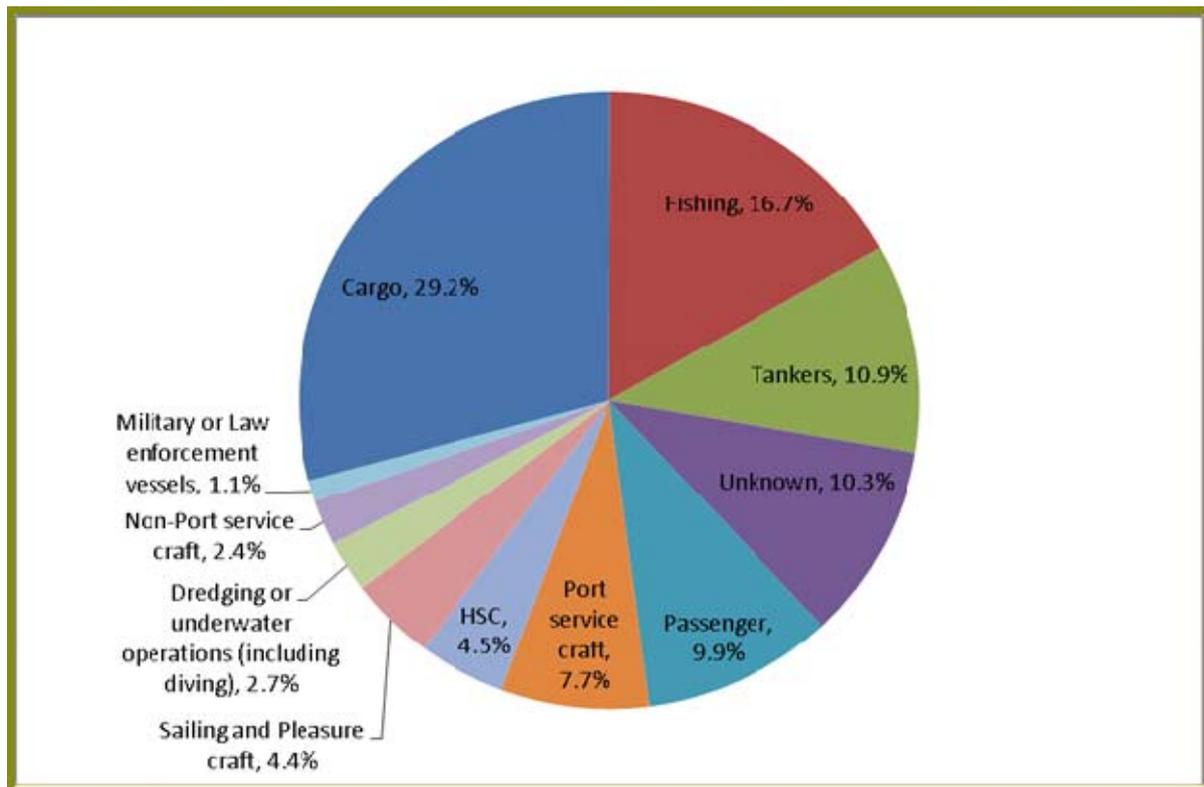
The AIS message information includes vessel type, which has been summarised in into the following groups shown in Table 2.

Table 2: Vessel grouping.

Group	Type	Description
0	Unknown	
1	Non-Port service craft	Search and rescue vessels Towing & Towing where length of the tow exceeds 200m or breadth exceeds 25m Medical transports (as defined in the 1949 Geneva Conventions and Additional Protocols) Ships according to Resolution No. 18 (Mob-83) Other special craft (56 & 57 reserved for local use)
2	Port service craft	Pilot vessels Tugs Port tenders and vessels with anti-pollution facilities or equipment
3	Vessels engaged in dredging or underwater operations	Vessels engaged in dredging or underwater operations Vessels engaged in diving operations (see note)
4	High Speed Craft	-
5	Military or law enforcement vessels	-
6	Passenger vessels	-
7	Cargo vessels	-
8	Tankers	-
9	Fishing	Fishing vessels
10	Sailing and Pleasure craft	Pleasure craft Sailing vessels
Note: 'Vessels engaged in diving operations' are predominantly commercial diving operations, for example, related to underwater maintenance.		

From the MCA provided AIS-A and AIS-B data for 2012, Figure 2 presents a percentage of the different vessel type split. Cargo vessel present the largest proportion with 29%, Fishing vessels provide the next largest percentage with 17%. This can be contrasted with the MMO project 1042, in which 48% of 2010's data was made up of Cargo vessels. This shift can be accounted for with by the inclusion of AIS-B data.

Figure 2: Vessel type within 2012 AIS data.



2.3 Input format

The raw AIS-A and B input data from the MCA was provided as single week (seven-day) text files with the following naming conventions:

- 0000-2359 01 to 07 MMM YYYY
- 0000-2359 01 to 07 MMM YYYY B.

The format of the individual messages was provided in the following format:

- YYYY-MM-DD HH:MM:SS,MMSI,MessageType,AIS_MessageString.

For example:

- 2011-01-01 00:00:00,247002000,2,23cSkT1v@:06R7hMK7I9<mv00<1H.

Each week of raw AIS data for the UK in the above format was *circa* 3 GB in size.

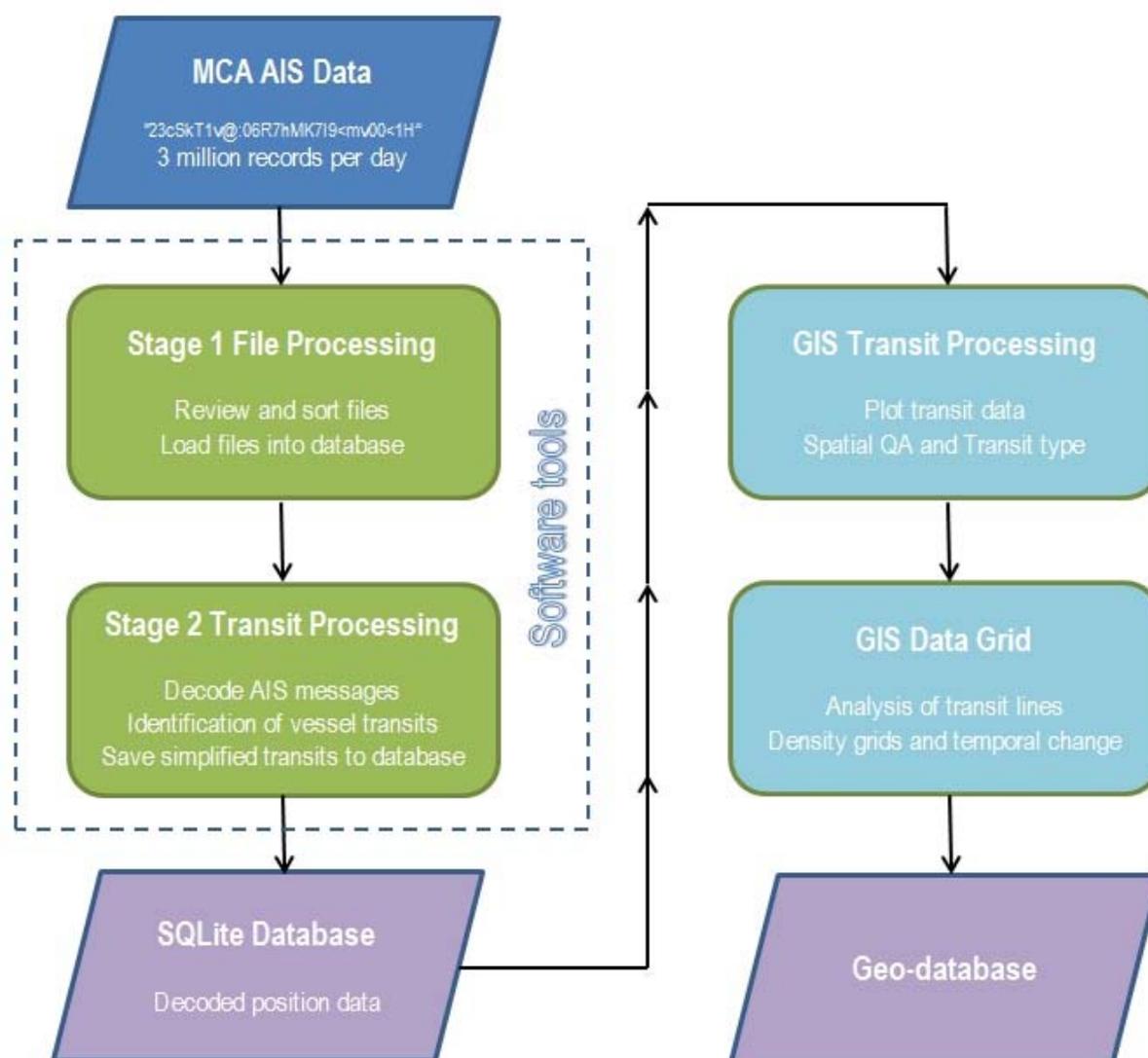
3. Data Processing Overview

The AIS data processing is largely based on the previous MMO project 1042. The changes introduced in this project (as compared to the methodology from MMO project 1042) are:

- The use of SQLite as the processing database
- Inclusion of Fishing and Pleasure vessels as different vessel types
- Inclusion of AIS-B messages
- Validation and correction process using metadata from an external database
- Creation of national buffers and sea area to create national statistics
- Temporal density grid comparisons.

In summary, Figure 3 provides a process flow diagram of the steps involved.

Figure 3: AIS data processing stages.



AIS data, once decoded and processed can provide vessel (static or voyage) details and positional history. Vessel positions are further processed to provide vessel transit tracks.

The following provides a summary of the AIS decoding and processing steps prior to presenting the derived AIS data and the software tools provided to facilitate this task.

Stage 1 data processing includes the following:

- Decoding and sorting of AIS signal (positional reports and voyage information)
- Associating ship static and voyage information with positional reports for each vessel.

Stage 2 data processing includes the following:

- Identification of vessel transits
- Quality assurance of vessel transit lines
- Transit simplification
- Identification and reporting of vessel AIS processing statistics.

Stage 3 data processing includes the following:

- Plotting of vessel transits in GIS
- Spatial QA of transit lines to remove overland transit segments
- Identification of vessel transit start/finish points within regional zones
- Validation and correction of vessel information against a third party vessel statistics database.

Stage 4 data processing includes the following:

- Calculation of Vessel Transit Classification (VTC)
- Creating density grids
- Calculating temporal differences
- Calculation of regional shipping statistics.

For the majority of these processing stages each week of AIS data is processed separately with the information subsequently stored in a SQLite database or a GIS Geodatabase.

The first two steps are undertaken by two complementary pieces of software; the Stage 1 and Stage 2 MMO AIS processors. Stage 1 and 2 require use of a SQLite database, and a database browser. A number of open-source SQLite browsers are available to enable the user to create, edit and inspect database schemes and information stored in the SQLite database. Details of two such SQLite browsers are:

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- SQLite Database Browser 2.0 b1 (<http://sqlitebrowser.sourceforge.net/>)*
- Sqlitestudio-2.1.5. (<http://www.softpedia.com/>)*

* It should be noted that third-party software identified above should not be considered as a recommendation, endorsement or warranty of these software packages. Use of the referenced websites for download is at the risk of the user.

The Stage 1 and Stage 2 MMO AIS processors are provided as “Click Once” applications, where the application is downloaded and installed to an application cache on the local computer and does not require the software to be installed or any associated registry entries made.

The following application files are required to run the software:

- NET Framework 4 (Not included)
- MMO_AIS_Processor_Stage01.application
- \Application Files
 - MMO_AIS_Processor_Stage01.application
 - MMO_AIS_Processor_Stage01.exe.config.deploy
 - MMO_AIS_Processor_Stage01.exe.deploy
 - MMO_AIS_Processor_Stage01.exe.manifest
 - System.Data.SQLite.dll.deploy
- MMO_AIS_Processor_Stage02.application
- \Application Files
 - MMO_AIS_Processor_Stage02.application
 - MMO_AIS_Processor_Stage02.exe.config.deploy
 - MMO_AIS_Processor_Stage02.exe.deploy
 - MMO_AIS_Processor_Stage02.exe.manifest
 - System.Data.SQLite.dll.deploy

The application file and the associated application files folder must be kept together but the input data and processed database files do not need to be located in the same folder as the application. The appropriate SQLite Binary assemblies are included in the application files folder. The software also requires the .NET4 Framework (<http://www.microsoft.com/>) to be pre-installed and this is not included in the application folder.

Stage 3 provides steps for creating transit lines which can be viewed geographically, followed by cleaning of transit lines that run over land. Further processing stages provide a method to validate transit line information against a comparison database, followed by assigning vessel transit classification and draught classifications. Stage 4 provides final vessel transit classification, density grid creation, calculate temporal differences and provides summary statistics.

Stage 3 and 4 require the following software to complete the processing steps:

- For importing SQLite database tables into ArcGIS, ESRI ArcGIS 9.3.1 with the Data Interoperability extension (or ESRI ArcGIS 10.2.1 Basic) is required

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- For processing transit line data in ArcGIS, GIS extensions are required (included in Advanced/ArcInfo versions) or alternatively a suitable third-party software, for example ET GeoWizards
- For data processing steps in MS Excel, the latest version of Excel (2010) may be required if large datasets are being processed (i.e. more than 60,000 records, up to a maximum of 1 million records).

4. Stage 1 Data Processing

The Stage 1 software deals with the initial processing and sorting of the input files. These stage 1 files are then loaded into a pre-prepared SQLite database.

4.1 Raw data validation

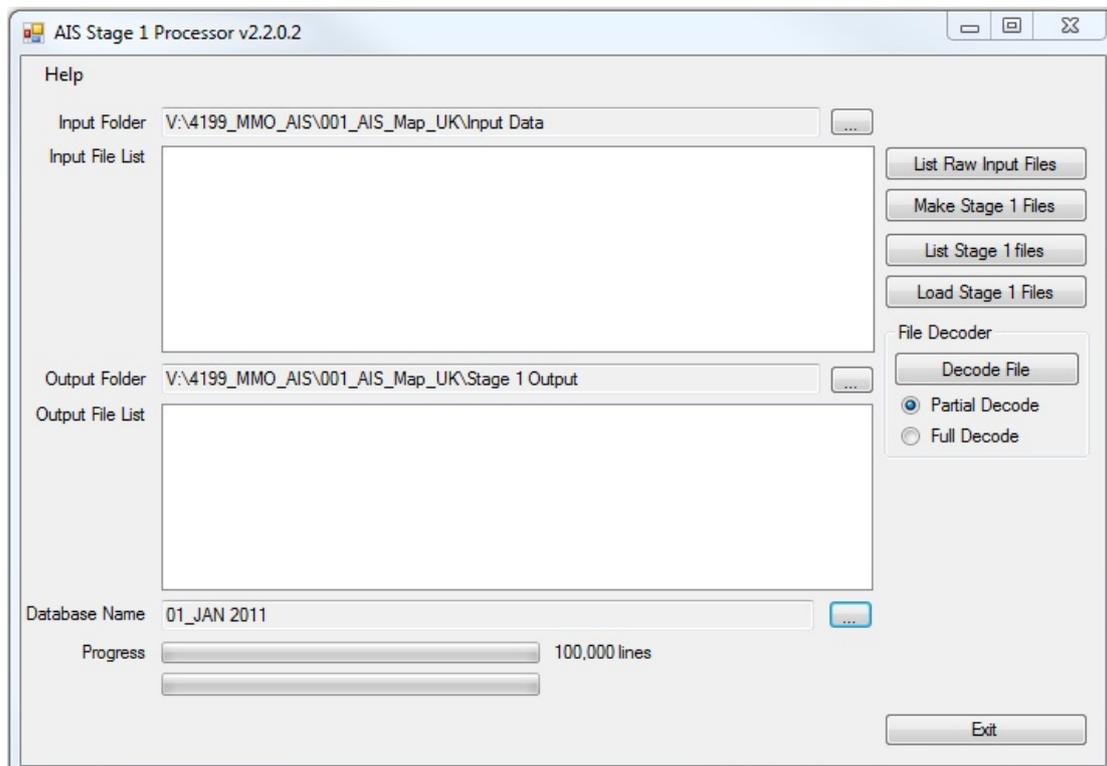
The raw AIS data is provided in a series of text files including both AIS-A and AIS-B message types. Using the Stage 1 AIS processor, the input files are checked to ensure valid AIS message data packages and then sorted into separate files for each of the following message types, which will be required for subsequent processing:

- 1,2,3 AIS-A Position reports
- 5 AIS-A Static or Voyage reports
- 18 AIS-B Position report
- 19 AIS-B Extended position report
- 24 (A+B) AIS-B Static or Voyage reports and
- 27 Long range reports.

Other message types, which are not required for processing, or where the AIS message fails to decode, are excluded.

To run the Stage 1 software simply open/run the MMO_AIS_Processor_Stage01. application. The application interface is shown in Figure 4.

Figure 4: Stage 1 processor interface.



To use the Stage 1 software:

- Select the parent directory folder of the input data files and the use “List Raw Input Files” function, to identify and then select the required input files for processing.
- Select the directory to be used to store the processed “Stage 1” files.
- Select the Make Stage 1 Files function to read the input files and generate the “Stage 1” output files (typically, 30 minutes processing per week of data). The output files are stored in a separate folder, automatically generated for each input file. The output directory also includes a statistics report (FileStats.txt) for each input file processed.

The Stage 1 file statistics reports (FileStats.txt) can be inspected at this stage to ensure the input data is as expected. If the input data includes unwanted AIS messages or messages failing to successfully decode these are reported as Bad Data Reports in the file statistics. Since the input data has already been pre-processed and sorted by the data supplier, corrupted or unwanted AIS reports are not expected and therefore reported problems are normally indicative of incorrect input data formatting.

The statistics report also includes line count statements for each date of the input file. Assuming the raw data file has been provided in chronological order, these statements can be used to ensure a plausible temporal data distribution has been included in the raw input data file.

4.2 SQLite database creation

The project requirement was to use the open source database SQLite. A suitable database schema was developed to meet the processing requirements and is detailed in Annex C.

An empty database template (AIS_MMO_Blank.sqlite) is provided in the templates folder which accompanies the software, which includes the necessary tables for the data processing stages 1, 2 and 4. This blank database should be copied and suitably renamed prior to loading the raw data. The database can be located on a shared network drive or stored locally. However the processing efficiency will be affected by the capabilities of the host computer system and the speed of network connectivity.

Each database should nominally hold a week (7-day period) of AIS data, however the software process will theoretically operate for any period of information, assuming sufficient computer resources and disk storage space is available. Larger databases are likely to require disproportionately more processing time. Typically, each weekly database will require 3 GB of disk storage.

4.3 Database population

After completing these initial stages, the resulting Stage 1 files are loaded into the pre-prepared SQLite database:

- Change the input parent directory folder to match the location of the stage 1 files, previously defined, and select the “List Stage 1 Files” function, to identify and then select the required stage 1 files for processing.
- Select the database into which the AIS data is to be loaded and test the database connection.
- The “Load Stage 1 Files” function should then be used to load the raw data Stage 1 files into the database.

Each AIS message type is stored in an appropriate raw database table, with any unwanted or invalid messages recorded in the tblRawBad database table. Typically, depending on PC specifications and hardware, this process will take approximately three hours per week of data.

At this stage the raw “coded” AIS information has been loaded into the database and is ready for Stage 2 processing.

4.4 Vessel data decoding

As part of the “Load Stage 1 Files” function, the Static or Voyage related information is also decoded. This information is then used to generate the Ship Name and Vessel Dimensions summary tables. A list of the vessels for which position information has been identified (tblMmsiList) is also generated at this stage.

4.5 File AIS decoder

An additional file processing function, a file-to-file decoder, has also been included in the Stage 1 application. This function provides a simple duplication and decode function of any raw input data file. The output file can be fully or partially decoded. A fully decoded file includes text labels, units and other coded text answers (for example ship type code descriptions). The partially decoded file provides a more simple output where the message parameters are correctly ordered but not labelled.

To use the File Decoder:

- Select the parent directory folder of the input data files and the use “List Raw Input Files” function, to identify and then select a single input file for processing.
- Select the directory to be used to store the decode file.
- Select “Partial Decode” or “Full Decode” as required.
- The “Decode File” function then decodes the raw input data file, line by line, writing a new file with the _Decoded file label added to the file name.

Each line of the output file includes the input data and the decoded result. Please note, that because the output is an unsorted csv file and can contain many different message types (1 to 27), it does not include column header information.

5. Stage 2 Data Processing

The identification and subsequent simplification of vessel transits is undertaken by the Stage 2 processing software with both the input data and results stored in each “weekly” SQLite database. This stage of the processing decodes the sequence of position reports for each vessel, identifies vessel transits, undertakes various quality checks on these vessel transits and then saves the minimum number of these position reports required to adequately describe the vessels transit.

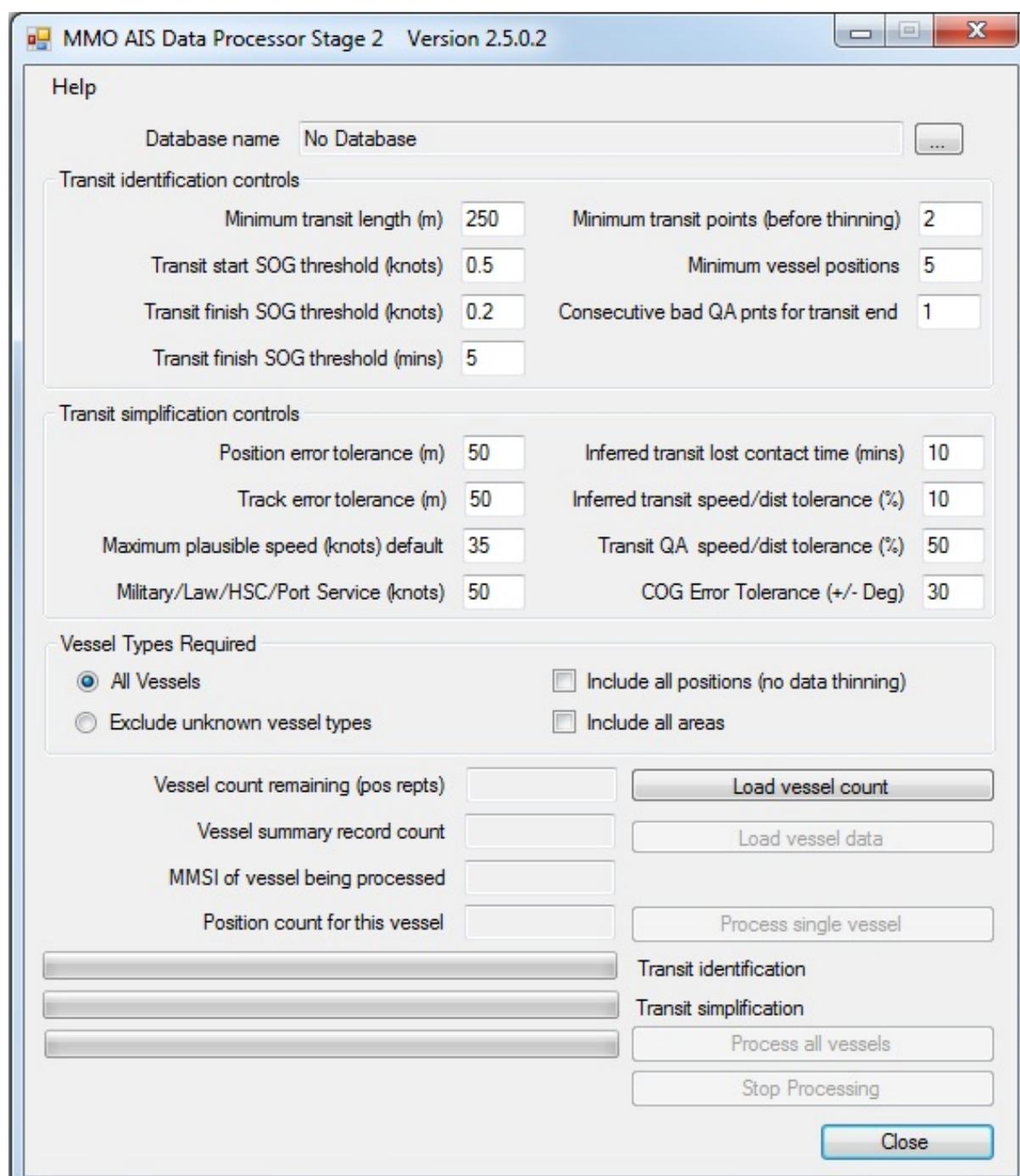
The beginning of each vessel transit is identified when the reported SOG exceeds 0.5 knots (or other specified threshold). The transit normally continues until the reported SOG falls below 0.2 knots for more than 5 minutes (or other specified threshold values). The transit can also be terminated for a number of other reasons. The full list of termination reasons is shown below in Table 3 together with the corresponding code used within the transit record.

Table 3: Transit termination codes.

Code	Transit termination reason
0	End of the period of the input dataset
1	Position outside the national area of interest
2	Contact lost
3	Intermittent contact (position reports greater than 10 minutes apart, start of an inferred transit)
4	Intermittent contact finished, normal contact restored (End of an inferred transit)
5	Normal transit termination, which includes SOG falls below 0.2 knots for more than 5 minutes
6	Quality Assurance (QA) checks on consecutive positions result in repeated invalid points and therefore a termination of the transit line.

To run the Stage 2 software simply open/run the MMO_AIS_Processor_Stage02 application. The application interface is shown in Figure 5.

Figure 5: Stage 2 processor interface.



5.1 Decoding, transit identification and thinning

The software is used, by first selecting the required SQLite AIS database. The user then sets:

- The required transit identification settings
- The required transit simplification settings
- Considers setting options to exclude unknown vessel types; include all areas; and include all transit positions.

The default settings shown in Figure 5 are those defined in the MMO project 1042 data standards report. (<http://www.marinemanagement.org.uk/evidence/1042.htm>)

The user should then select the function “Load vessel count” and then “Load vessel data” to load the MMSI list and vessel dimension summary data. This initial stage will take a few minutes to complete. The user can then initiate processing for a single vessel or all vessels in the database.

Typically, and again depending on PC specifications and hardware, this process will take between 30 and 100 hours per week of data to complete.

Progress is indicated on the three progress bars for transit identification, transit simplification and overall progress. A function is also provided to stop the programme after processing of the current vessel is complete.

The results of this processing, stored in the SQLite database, are the transit details (tblTransit), transit positions (tblPositions) and vessel processing statistics (tblVesselProcessStats). Whilst all vessel position reports are decoded as part of this processing stage, only those vessel positions that are identified as part of a vessel transit are stored in their decoded form. For this reason stationary vessel positions are not stored in their decoded form.

The effect of transit thinning is shown in Figure 6. The example shows a vessel swinging at anchor, before departing initially towards the East, and then turning to the South West. For reference and scale, the approximate diameter of the circle described by the vessel swinging at anchor, is 400 meters. The image on the left shows the vessel transit without thinning; the one on the right shows the effect of transit thinning using the default values for position and track error tolerance of 50 meters.

The reception of positional data can be affected by a number of factors, for example; increasing range to the reception station or data bandwidth congestion. As the reliability of reception decreases, the period between position reports can become longer. To cover these periods of missing signal reception (nominally where the period between position reports is greater than 10 minutes) the vessel transit can be extended or continued until the next position report location where it is feasible that a continuous track was followed by the vessel. These less certain transits are described as inferred transits.

Figure 6: Transit thinning example.



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These ‘inferred’ transits have a more stringent quality assurance check applied for this period of lost reception whereby two values are compared; these are the vessel’s reported speed (average for this transit segment) and calculated speed and distance between consecutive points. If the difference between these two values exceeds 10% (the specified tolerance) then the position report is discarded, if the values are within this set tolerance, then the transit is inferred. Inferred transits are identified in the tblTransit table as having a position density of zero. Normal transits have position density values (position reports per km) greater than zero.

Once a normal or an inferred transit has been identified, a further series of checks are applied and if necessary the transit is discarded. These checks are designed to simplify and tidy the dataset to remove short transits (vessels moving berths, ranging, etc.) or transit fragments.

The vessel processing statistics provided are detailed in the database schema description, examples include the number of positions identified for each vessel and the number of positions subsequently stored in the database. It should be noted that the total number of points identified (AllPointTotal) can be less than the original number of data records due to duplicate AIS messages or messages whose position lies outside of the area of interest (including those messages reported as -181 degrees Longitude / “Position Unavailable”).

The area of interest is defined as between latitudes 47 and 65 and between longitudes -10 and 10.

6. Stage 3 Data Processing - GIS Data Management Steps

The Stage 3 data processing deals with the spatial analysis and processing tasks required to create the transit lines from the AIS Position and Transit table data output from Stage 2. The Stage 3 GIS data processing was carried out using ArcGIS and ET GeoWizards tool for ArcGIS software.

6.1 Creating the transit lines

The transit lines were created by plotting each AIS vessel position contained in the AIS Position table and then converting the points to polylines using the “Points to Lines” tool in ArcGIS and specifying common attribute and sequential fields. The common attribute, Transit ID, determined which points were grouped together to form a line, while the sequence field, DateTime, determined the order in which the points were connected.

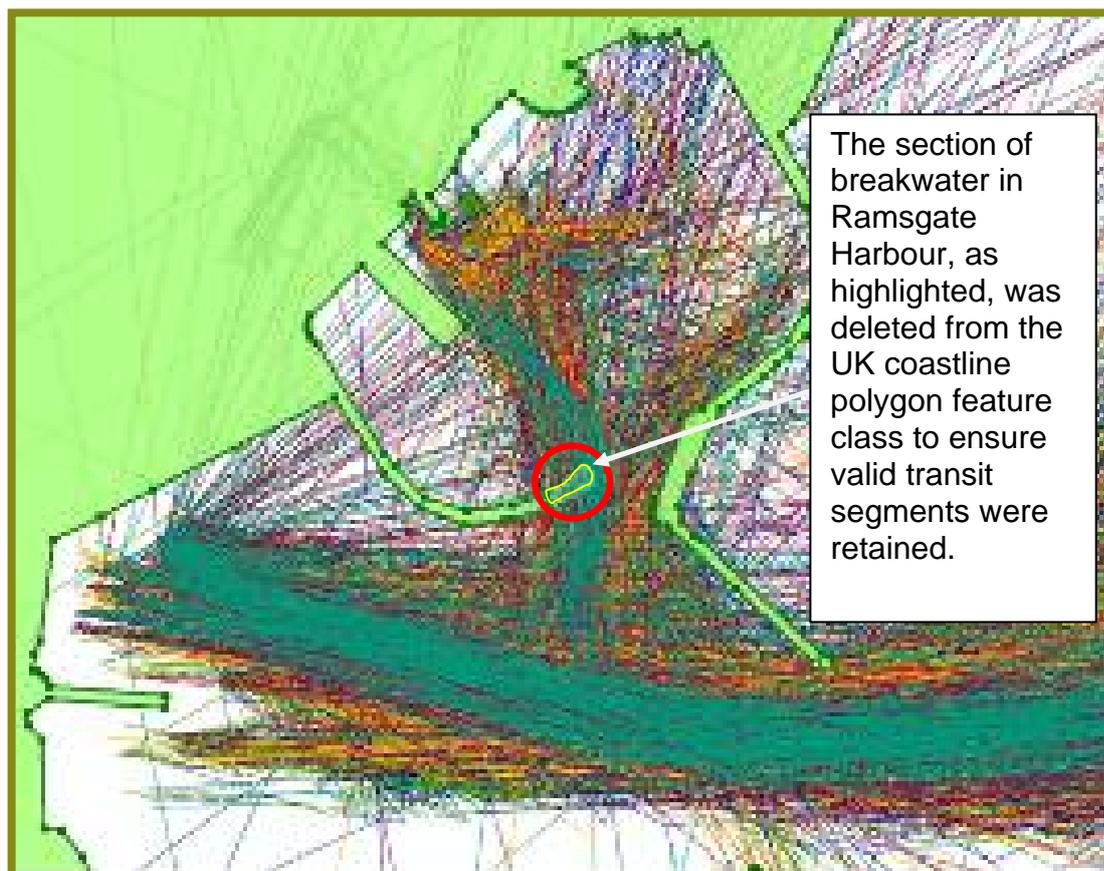
The following procedure is described in more detail in the Data Processing Log, ‘Transit Line Creation - Steps 1 to 9’ (MMO 2014b). The AIS vessel positions were plotted using latitude and longitude values, provided as geographic coordinates in decimal degrees, using the World Geodetic System 1984 (WGS84). As in the previous study, MMO project 1042 (MMO, 2013a), it was decided that all further data would be processed using the WGS84 Universal Transverse Mercator 30N (UTM30N) projected coordinate reference system. The projected UTM coordinate reference system has accurate distance and measuring capabilities and is particularly well suited for creating and presenting precise and accurate density grids. UTM30N is a popular choice when coverage pertains to that of mainland UK

6.2 Cleaning the transit lines

The steps involved in the cleaning of transit lines is described in more detail in the ‘Data Processing Log, ‘Transit Line Creation - Steps 10 to 19’ (MMO 2014b). When converting AIS point data into transit lines, segments of the transit lines may overlap with land areas. This may be due to incorrect vessel position data, or more commonly, missing or poorly sequenced data. The derived transit line will then deviate from the actual path taken by the vessel. These erroneous transit segments need to be removed from the dataset, a process which is described in more detail in Section 6.1.2 of the MMO Data Standards report (MMO, 2013a). After removal of all erroneous transit segments, the transit line segments were dissolved back into a single transit polyline feature.

Processing tip: Ensure that the most detailed coastline available is used to clean the transit lines, including where required, shipping canals (such as the Caledonian and Manchester Ship Canals) and hovercraft landing stages. The ends of some breakwaters may need to be reduced in length in order to retain transits where vessels made a sharp turn into or out of the port/harbour. An example of these revisions made to the breakwater at Ramsgate is shown in Figure 7.

Figure 7: Example of coastline revisions.



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6.3 Initial vessel transit classifications (VTC)

The vessel transit classification (VTC) process is designed to identify vessels that are involved in UK trade and those that are only transiting through UK waters. The steps involved in the classification process are described in more detail in Section 6.1.3 of the MMO Data Standards report (MMO, 2013a).

In this project, the Steering Group requested modifications to the outputs and methodology to include national trans-boundary information as well as UK/non-UK information (see Section 1.1). Therefore, the 0.5 nautical mile buffer of the UK coastline included separate polygons for England, Scotland, Wales and Northern Ireland. This resulted in two new attributes per transit node, 'starting region' and 'ending region', as well as the 'starting zone' and 'ending zone' which were included in the original methodology (MMO, 2013a).

Processing tip: Ensure that the buffer zone used to determine the VTC includes all the known anchorage areas/point locations and any ship-to-ship transfer areas. If a national/regional breakdown is required, separate polygons for these should also be included in the buffer zone polygon feature (e.g. England, Scotland, Wales, NI).

The procedure for the initial classification of VTC per transit is described in more detail in the Data Processing Log, 'VTC Processing Steps - Steps 1 to 21' (MMO

2014b). The output from this stage of the data processing includes details of each separate transit line (several of which may form a complete vessel transit) along with corresponding vessel information, vessel type group, start and end positions of each transit line (i.e. UK/non-UK and individual nation information) and the VTC for each separate transit line.

7. Stage 4 Data Processing

Validation of vessel data may be required against a third party data source, i.e. Lloyds List. This validation is not critical to the process, but was required on this occasion.

In order to validate and revise, where applicable, vessel type groups and draughts with the Lloyds List data, and also to convert the VTC per transit line (referred to in Section 6.3) into VTC per vessel transit, the data output from Stage 3 needed to be exported from the GIS and joined with the Lloyds List data in SQLite.

After validation and final VTC classification, the data was exported into Excel and finally back into ArcGIS for calculation of the draught classifications (Section 7.3), creation of the density grids (Section 7.4) and creation of temporal comparison grids (Section 7.5) as well as the final report figures.

7.1 Validation process (Lloyds List)

The vessel type and draught, as reported in the AIS signal, was validated against data provided by Lloyds List. Data was requested for each weekly period for the vessels identified in the Ship Names table. Where this validation is required the data should also be loaded, using the SQLite browser “Import data to table” function, into the table tblLloydsList.

The Lloyds data did contain a very small number of duplicate entries for the requested vessel MMSI numbers. In these cases the first entry was used. A small proportion of the vessels identified in the AIS data were not recorded in the Lloyds data. These vessels relate to invalid MMSI identification or where the vessel is not listed, for example pleasure vessels whose registration with Lloyds is less common.

It is plausible that the AIS message may contain an incorrect MMSI identification and therefore to ensure a correct identification and match of the vessel in the Lloyds List a ‘Double Validation’ process was developed and used. This double validation makes a correction to the data only when the MMSI number and the vessel name or the MMSI number and the vessel call sign were identical. If there is a double validation match, Lloyds List data is used to compare with the AIS data. Double validation percentages for each week of process AIS data are presented in Table 4. The statistic is a measure of transit validation, which achieved an average of 70% transit match against Lloyds List data following the ‘double validation’ rule for the 12 weeks of AIS data. Transit line (vessel) records that did not pass the double validation used the information from the AIS signal. For all records with a double validation match, validation checks are carried out as described in the following sections.

The MMO Data Processing Log, ‘Final VTC & Draught Classification’ (MMO, 2014b) describes the steps in the validation process. The validation processing step also includes the ‘final’ VTC classification. The ‘initial’ VTC is provided as an output from Stage 3, in the form of a weekly results file, and this is read back into the tblTransit2

table of the database (Steps 1 to 6 of MMO Data Processing Log, 'Final VTC & Draught Classification' (MMO, 2014b)).

Processing tip: In order for the SQLite query to run successfully, ensure that the output from Stage 3 is re-structured with the specific number of columns in the correct order, as stipulated in Step 3 of the MMO Data Processing Log – Final VTC & Draught Classification (MMO, 2014b).

Once this data and the Lloyds data have been successfully loaded the database query qryTransit2_Join should then be used to combine the Stage 3 output data with the Lloyds data for each vessel transit. The resulting data is then exported as a CSV file, using the SQLite browser "Export table data" function (Steps 7 to 8 of MMO Data Processing Log, 'Final VTC & Draught Classification' (MMO, 2014b)).

Reading this CSV data into excel and then pasting into the excel data template XX_XXX_Transit2_JoinListing.xlsx provides the final transit data table which now includes the completed derivation of the VTC, validation of vessel type, correction for vessel draught where appropriate and regional statistical information on vessel transits. This file should then be renamed and saved for subsequent re-import to ArcGIS (Steps 9 to 10 of MMO Data Processing Log, 'Final VTC & Draught Classification' (MMO, 2014b)).

The steps in this process are described in more detail in the process log. Where a double validation of vessel identification was successful the following data corrections were made:

- Vessel type. This provides more consistency of vessel type identification.
- Where the indicated draught is greater than the recorded maximum draught then maximum draught value is used.
- Where no indicated draught is provided, the maximum draught value is used.

The percentages of vessel transits that have been corrected as part of this validation process are detailed in Table 4.

Table 4: Data validation against Lloyds List records.

Data period	Number of vessel transits	Lloyds double validation (%)	Corrected vessel type (%)	Corrected vessel draught (%)
January 01 to 07, 2011	81,002	81%	18%	15%
March 01 to 07, 2011	125,930	80%	20%	15%
May 01 to 07, 2011	158,988	80%	25%	16%
July 01 to 07, 2011	122,532	68%	17%	15%
September 01 to 07, 2011	85,959	71%	17%	16%
November 01 to 07, 2011	104,661	72%	13%	16%
January 03 to 09, 2012*	74,728	73%	13%	15%
March 01 to 07, 2012	86,818	73%	14%	15%
May 01 to 07, 2012	117,343	41%	12%	10%
July 01 to 07, 2012	96,402	62%	15%	15%
September 01 to 07, 2012	132,563	65%	14%	15%

Data period	Number of vessel transits	Lloyds double validation (%)	Corrected vessel type (%)	Corrected vessel draught (%)
November 01 to 07, 2012	113,485	73%	11%	15%
Summary	1,300,411	64%	69%	57%

7.2 Final vessel transit classifications (VTC)

The calculation of the final VTC for each vessel's transit is an automated process, which takes place alongside the validation of the vessel information described in the previous section and in the processing log. (MMO Data Processing Log 'Final VTC & Draught Classification' (MMO, 2014b))

The outputs from this step, which are required for the final stages of the GIS data processing, are the Transit ID, the Lloyds List vessel type description, the vessel type correction flag (which indicates whether or not the vessel type has been revised), the final vessel type, the vessel draught correction flag (which indicates whether or not the draught has been revised) and the final vessel draught (Steps 11 to 12 of MMO Data Processing Log 'Final VTC & Draught Classification' (MMO, 2014b)).

7.3 Calculate draught classifications

The vessel draught classification was calculated in ArcGIS after importing the output from the validation and calculation of the final VTC processing steps (Steps 13 to 16 of MMO Data Processing Log 'Final VTC & Draught Classification' (MMO, 2014b))

The vessel draught classification was not included in the automated procedure described in Sections 7.1 and 7.2 in order to allow the user the flexibility to determine the size ranges for the classification, depending on their own requirements and the range of vessels contained in the user's dataset.

The draught classification used in this project is shown in Table 5.

Table 5: Draught classification.

Vessel type	Large (m)	Medium (m)	Small (m)
Non-Port service craft	>7	2 - 7	<2
Port Service craft	>6	2 - 6	<2
Vessels engaged in dredging or underwater operation	>7	4 - 7	<4
High Speed Craft (HSC)	>4	2 - 4	<2
Military or Law enforcement vessels	>7	4 - 7	<4
Passenger vessels	>8	5 - 8	<5
Cargo vessels	>16	8 - 16	<8
Tankers	>16	8 - 16	<8
Fishing	>6	2 - 6	<2
Recreational	>6	2 - 6	<2

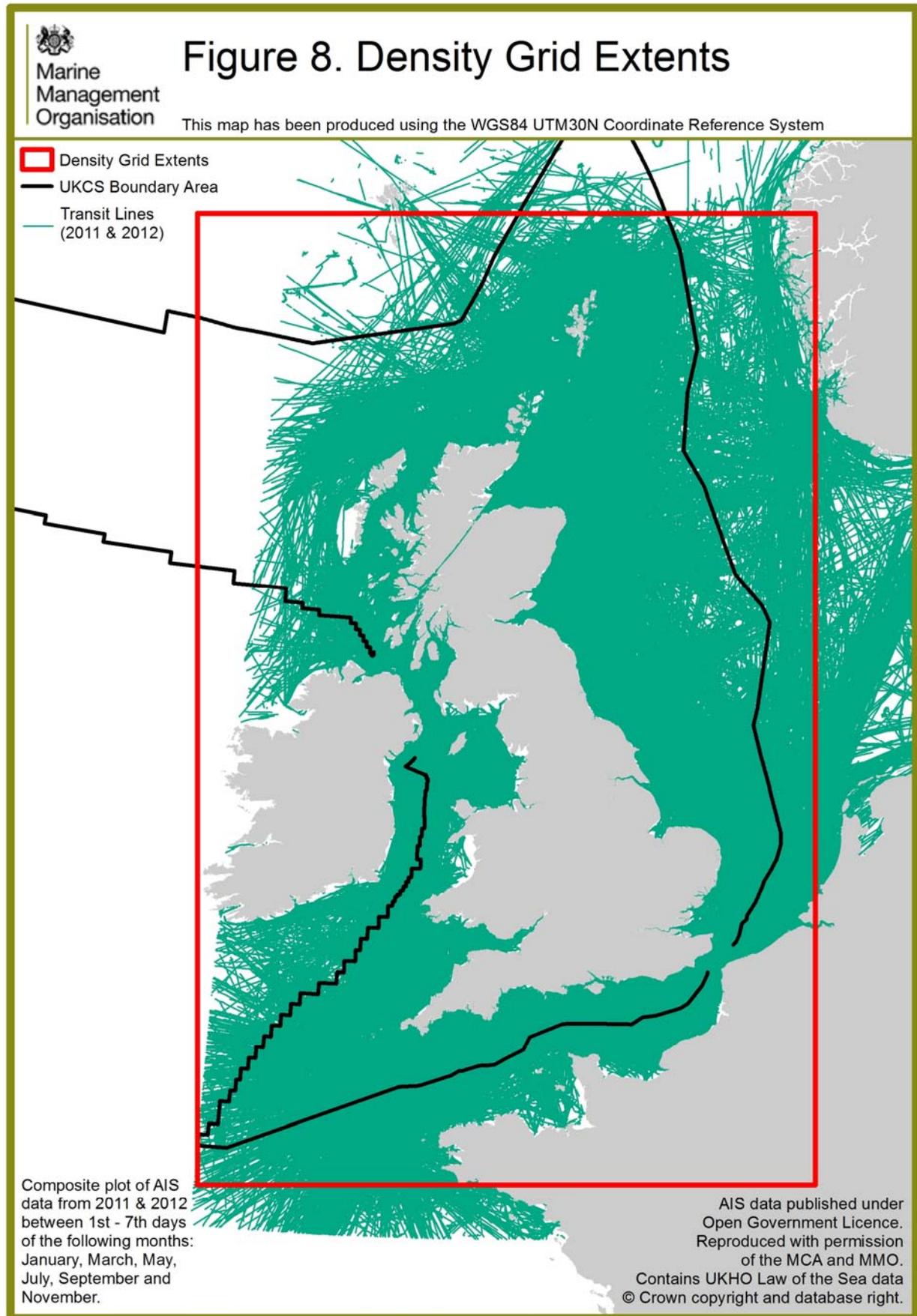
7.4 Density grids creation and population

The processing steps to complete a density grid are set out in Steps 1 to 14 of the MMO Data Processing Log 'Density Grid' (MMO, 2014b).

The extents and resolution of the density grid were determined based on the extents of the weekly AIS datasets, MMO's requirements and the limits of computer memory and speed. The extents and resolution (2km x 2km grid cells) were agreed with the project Steering Group prior to this stage of the work. The resultant grid contained 417,910 cells and the extents are shown in Figure 8.

The primary purpose of the density grid is to map the density of vessel transits for a specific period of time represented within the data. The grid was created in ArcGIS using the "FishNet" tool. The transits were then incorporated into the grid by means of a spatial join, which counted the number of transits intersecting each individual grid cell and stored these values as an attribute by vessel type.

On completion of the join, each grid cell can be displayed as a different colour using the transit density attribute as the parameter. When viewed at its full spatial extent, the data can give a clear indication as to which areas experience the most or least amount of traffic. This method was validated in the previous study, MMO project 1042 (MMO, 2013a).



7.5 Creating temporal comparison grids

In order to compare density grids temporally, for example, to compare annual or seasonal variability of vessel traffic, the weekly density grids tables were joined together in ArcGIS and average density values for each vessel type grouping were calculated.

To create annual density grids for 2011 and 2012, the six weekly density grids for each year were joined in ArcGIS and averages for the year were calculated (Steps 15 to 17 of MMO Data Processing Log 'Density Grid' (MMO, 2014)).

To create the seasonal density grids, the weekly grids for January 2011 and January 2012 were joined and average values calculated to form a 'winter' density grid and the weekly grids for July 2011 and July 2012 were joined and average values calculated to form a 'summer' density grid (Steps 18 to 26 of MMO Data Processing Log 'Density Grid' (MMO, 2014b)).

Differences between years or seasons (or other temporal variations) can be analysed by joining the density grid tables and then subtracting the average density grid cell values from each other in ArcGIS. However, to avoid calculating differences which merely result from underlying differences in the spatial extents of the data, the density grids should be clipped to the same extent, based on the minimum coverage of the datasets to be joined. For this study, a buffer polygon of 40 nautical miles from the MCA AIS receiver stations was used to clip the data to the same extents, which ensured a reliable coverage for all months (see Section 2.1).

Figure 14 from the MMO Report 'Mapping UK Shipping Density and Routes from AIS' (MMO, 2014a) shows the difference in vessel densities between summer and winter using a 40 nautical mile buffer measured from the AIS stations.

7.6 Statistical summaries

Various statistical summaries may be run using the output datasets to obtain information on, for example, transit and vessel counts, by vessel type group, VTC or draught, at different spatial scales, such as national sea boundaries or the UKCS boundary or at different places.

In this project, as shown in the non-technical report (MMO, 2014) statistics were provided on:

- Number of transits, broken down by vessel type, crossing transect lines
- Number of vessels, broken down by vessel type, crossing transect lines
- Number of transits passing through national sea boundaries
- Number of transits stopping or starting within national buffers
- Number of vessels stopping or starting within national buffers
- Numbers of transits within each VTC grouping passing through national sea boundaries.

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To extract information on the numbers of transits and vessels crossing a transect line, firstly, the transect line was created as a feature class in ArcGIS and all the transits in 2012, which intersected the transect line, were selected using the 'Select by Location' tool in ArcGIS. The selected data was then exported into Excel and pivot tables were used to manipulate the data by vessel type to produce the output numbers and tables contained within MMO Report 'Mapping UK shipping density and routes from AIS' (MMO, 2014a).

To extract information on the numbers of transits and vessels passing through national sea areas and the UKCS sea boundary, firstly, a new feature class was digitised to represent the individual UK Sea Areas, then after selecting a sea area (i.e. England, Scotland, Wales, Northern Ireland) all the transits in 2012, which intersected with the sea area, were selected using the 'Select by Location' tool in ArcGIS. The number of selected transit lines was then noted.

To extract information on the numbers of transits and vessels stopping or starting within national boundaries, a definition query was then run on the selected transit lines from the above step to highlight only those transit lines where the SRegion or ERegion attribute was the same as the required sea area. The number of selected transit lines was then noted.

To extract information on the numbers of transits and vessels within each VTC category, all the transit lines for 2012 with the same VTC category (i.e. 1, 2 or 3) were exported as three new feature classes and the same 'Select by Location' process was carried out on these sub-datasets by individual sea area.

8. Confidence Assessment

The AIS system was developed primarily to aid safe navigation of vessels. Much of the information contained within the transmission provides quick and easy identification of the vessel, its navigational status and the relative risk posed by its cargo. Position reports are automatically generated from onboard vessel location equipment and transmitted at frequent (2-10 seconds) intervals, resulting in generally high quality information. Voyage data is largely user entered, and therefore has inherent limitations due to human data entering error or misrepresented information.

The confidence of the overall dataset has been assessed using the method and requirements of the MMO's confidence assessment methodology. The details of this assessment consider the following principles:

- Methodology confidence
- Timeliness confidence
- Spatial confidence
- Completeness confidence
- Confidence in quality standards.

The assessment concludes that there is a generally high level of confidence in the dataset. However it is important to understand the limitations of using specific details of any particular vessel or transit which will be reliant on the underlying information which can be broadly classified as follows:

- Best quality – automatically generated data (for example: position, COG)
- Variable quality – one time user entered data (for example: ship name, MMSI)
- Lower quality – frequently entered user data (for example: destination, draught).

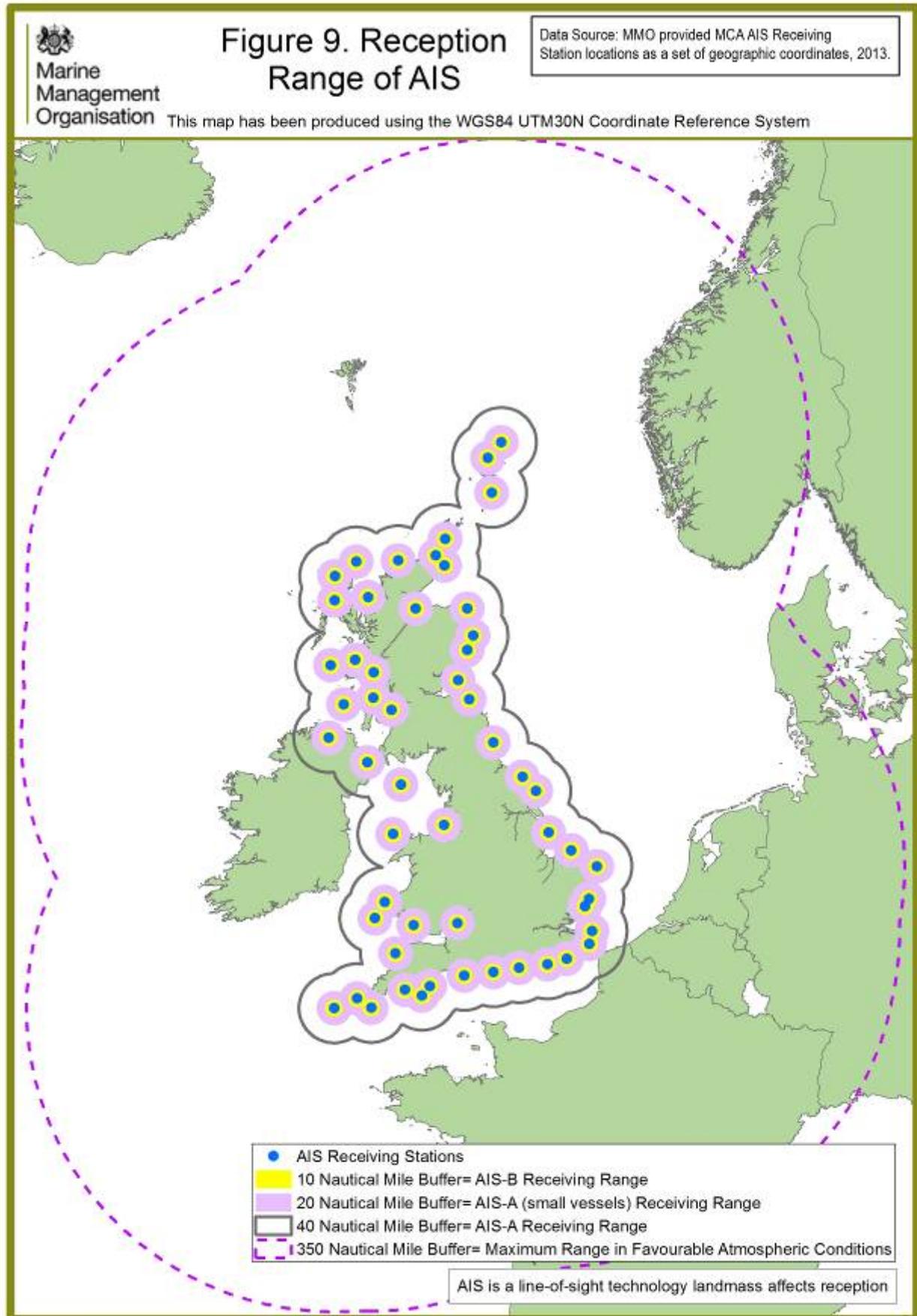
The validation of the vessel data against the Lloyds list information was undertaken (as described above) to improve the confidence of this lower quality data category.

A further measure of accuracy and therefore confidence is inherent within the processed data, where time separation of positional reports exceeds 10 minutes, the true path of the vessel can only be inferred. Inferred transits are identified in the dataset as having a position density of zero. Transits with a low or zero position density value (position reports per km) have a correspondingly lower confidence level.

It should be noted that not all vessels are required to carry or continuously operate AIS equipment. The previous MMO project 1042 (MMO 2013b) identified that a proportion (16%) of known vessel traffic had, for a range of reasons, failed to be included in the AIS data.

Another measure of confidence relates to the spatial coverage, which as previously discussed, is dependent on atmospheric conditions. It is considered that reception range of the MCA's network of receivers is reliable up to 40 nautical miles for AIS-A. It is considered likely that smaller vessel carrying AIS-A will be identified within a 20

nautical mile radius, which reflects the line-of-sight nature of the technology. AIS-B is used by small commercial craft, fishing vessels and recreational vessels. To prevent overloading of the available bandwidth, transmission power is restricted to 2Watts, giving a transmission range of up to 10 nautical miles. In favourable atmospheric conditions, reception up to 350 nautical miles is possible. At greater distances reception may be possible and shipping transits can be identified. However, at these greater reception distances, the absence of AIS signals cannot be a reliable indication of an absence of vessel traffic. Figure 9 provides a visual representation of the likely coverage based on the above factors



9. Future Developments

This project has provided flexible data processing tools and associated database solutions to decode and display AIS data. Further development of the methodology could provide different avenues for displaying and understanding vessel use of the sea and routing patterns. To enhance the use of AIS for marine planning, future development of the AIS processing and display methodology should seek to understand key vessel routes and how these change over time. Changing trade patterns have socio-economic effects that can be placed in context by understanding relative intensity of vessel patterns and dependency on particular routes. Examples of these patterns and dependencies include inter-island or continental ferry traffic, offshore construction, maintenance and support, cargo routes and fishing interests.

The following future developments could be explored further or expanded upon to investigate specific areas of interest:

- Temporal changes in vessel activity, which could be published on a quarterly or annual basis to complement existing forms of annualised port and shipping statistics.
- Continual assessment of a yearly AIS dataset representative of all vessels recorded across UK waters within the year. If this is not feasible, then extending the monthly sample period from one-week, to two-week would provide an improved VTC classification for vessels on short-sea shipping routes and improve temporal comparisons (summer to winter).
- Combination of terrestrial AIS with Satellite AIS to complete routing information in areas outside reliable receiver range.
- Quantification, through dedicated research and investigation, of the quantity of vessels not identified via AIS methods. A combination of a radar survey with a manned observation would provide the most robust outcome.
- Using AIS data, dwell time at berths or anchorages could be investigated; this would lead to a better understanding of the spatial and temporal distribution of vessels not engaged in transits.
- Identification of offshore installation traffic, with consideration to make this a specific AIS 'VTC' classification, this could include routing identification for:
 - Oil/Gas platform and support traffic
 - Wind farm traffic
 - Wet-renewable traffic.
- The combination of AIS data with tidal information at a regional scale to understand sea area use of different sizes of ship over different tidal periods.
- Traffic pattern differences based on changing sea conditions (i.e., match with historic weather / sea-state data).
- Use of AIS to identify and create data layers of Aids to Navigation.
- Use of AIS-B to help the understanding of recreational routing and sea area use, including temporal assessment of activity over shorter timescales (for example, weekly or summer months) and how these might compare with indicative routes identified by the Royal Yachting Association .
- Comparison of AIS-B data for fishing vessels With Vessel Monitoring system (VMS) data to test utility of AIS-B data for fisheries mapping;

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- Use of transit and density information to infer aspects of environmental risk, for example, pollution risk in relation to the proximity of sensitive marine environments, contribution to ambient underwater noise and the spatial distribution and intensity of ship emissions.

10. References

ICO (2012). Anonymisation: Managing data protection risk. Code of practice. Information Commissioner's Office, November 2012.

Marine Management Organisation, 2014a. 'Mapping UK Shipping Density and Routes from AIS', Project 1066.
http://www.marinemanagement.org.uk/evidence/documents/1066_Shipping_Tools_Report.pdf

Marine Management Organisation, 2014b. 'Data Processing Logs', Project 1066.
http://www.marinemanagement.org.uk/evidence/documents/1066_AIS_Software_Tools.zip

Marine Management Organisation (MMO) 2013a. 'Spatial Trends in Shipping Activity AIS derived shipping activity – data standards' November 2013.
<http://www.marinemanagement.org.uk/evidence/1042.htm>

Marine Management Organisation (MMO) 2013b. 'Spatial Trends in Shipping Activity', November 2013.
<http://www.marinemanagement.org.uk/evidence/1042.htm>

Marine Management Organisation (MMO) 2011. 'Confidence assessment method for marine geospatial data', 02 October 2011

Maritime Data Website, 2014. Department of Energy and Climate Change (DECC).
<http://www.maritimedata.co.uk/> Accessed 07 March 2014

United States Coastguard (2014). Website accessed 02 January 2014
<http://www.navcen.uscg.gov/?pageName=AISmain>

US Hydro (2009). Calder, B., Schwehr, K., Traffic Analysis for the Calibration of Risk Assessment Methods, US Hydro 2009, May 11-14, Norfolk, VA.

Annex A: MCA database extraction script

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Annex B: AIS message field tables

Table B1: Position report fields (message type 1, 2 and 3).

Parameter	Number of bits	Description
Message ID	6	Identifier for this message 1, 2 or 3
Repeat indicator	2	Used by the repeater to indicate how many times a message has been repeated
User Identification	30	MMSI number
Navigational status	4	0 = under way using engine, 1 = at anchor, 2 = not under command, 3 = restricted manoeuvrability, 4 = constrained by her draught, 5 = moored, 6 = aground, 7 = engaged in fishing, 8 = under way sailing, 9 = reserved for future amendment of navigational status for ships carrying dangerous goods (DG), harmful substances (HS), or marine pollutants (MP), or International Maritime Organization (IMO) hazard or pollutant Category C, high speed craft (HSC), 10 = reserved for future amendment of navigational status for ships carrying DG, HS or MP, or IMO hazard or pollutant category A, wing in grand (WIG); 11-13 = reserved for future use, 14 = AIS-SART (active), 15 = not defined = default (also used by AIS-SART under test)
Rate of turn (ROT)AIS	8	0 to +126 = turning right at up to 708 deg per min or higher 0 to -126 = turning left at up to 708 deg per min or higher Values between 0 and 708 deg per min coded by $ROT_{AIS} = 4.733 \text{ SQRT}(ROT_{\text{sensor}})$ degrees per min where ROT_{sensor} is the Rate of Turn as input by an external Rate of Turn Indicator (TI). ROT_{AIS} is rounded to the nearest integer value. +127 = turning right at more than 5 deg per 30s -127 = turning left at more than 5 deg per 30s -128 (80 hex) indicates no turn information available (default)
Speed over the Ground (SOG)	10	Speed over ground in 1/10 knot steps (0-102.2 knots) 1 023 = not available, 1 022 = 102.2 knots or higher
Position Accuracy	1	The position accuracy (PA) flag 1 = high (> 10 m) 0 = low (< 10 m) 0 = default
Longitude	28	Longitude in 1/10 000 min (+/-180°, East = positive, West = negative). 181 = not available = default
Latitude	27	Latitude in 1/10 000 min (+/-90°, North = positive, South = negative). 91° = not available = default
Course over the Ground (COG)	12	Course over ground in 1/10 = (0-3599). 3600 = not available = default. 3 601-4 095 should not be used
True heading	9	Degrees (0-359) (511 indicates not available = default)
Time stamp	6	UTC second when the report was generated by the electronic position system (EPFS) (0-59, or 60 if time stamp is not available, which should also be the default value, or 61 if positioning system is in manual input mode, or 62 if electronic position fixing system operates in estimated (dead reckoning) mode, or 63 if the positioning system is inoperative)
special manoeuvre indicator	2	0 = not available = default 1 = not engaged in special manoeuvre 2 = engaged in special manoeuvre
Spare	3	Not used. Should be set to zero. Reserved for future use
Note: An example of a typical MCA formatted position report is as follows: 2010-04-01 00:00:00, 304678000,1,14RT4L0026033jnLvUvQloMh08Rq		
Source: United States Coastguard, 2014		

Table B2: Ship static and voyage fields (message type 5).

Parameter	Number of Bits	Description
Message ID	6	Identifier for this Message 5; always 5
Repeat indicator	2	Used by the repeater to indicate how many times a message has been repeated.
User ID	30	MMSI number
AIS version indicator	2	0 = station compliant with Recommendation ITU-R M.1371-1 1 = station compliant with Recommendation ITU-R M.1371-3 2-3 = station compliant with future editions
IMO number	30	1-999999999; 0 = not available = default
Call sign	42	7 bit ASCII characters, @@@@ = not available = default
Name	120	Maximum 20 characters 6 bit ASCII
Type of ship and cargo type	8	0 = not available or no ship = default 1-99 = as defined in 'MEDIN definition list' 100-199 = reserved, for regional use 200-255 = reserved, for future use
Overall dimension	30	Reference point for reported position Also indicates the dimension of ship (m)
Type of electronic fixing device	4	0 = undefined (default) 1 = GPS 2 = GLONASS 3 = combined GPS/GLONASS 4 = Loran-C 5 = Chayka 6 = Integrated Navigation System 7 = Surveyed 8 = Galileo 9-15 = not used
Expected Time of Arrival (ETA)	20	Estimated time of arrival; MMDDHHMM UTC Bits 19-16: month; 1-12; 0 = not available = default Bits 15-11: day; 1-31; 0 = not available = default Bits 10-6: hour; 0-23; 24 = not available = default Bits 5-0: minute; 0-59; 60 = not available = default
Maximum present static draught	8	In 1/10 m, 255 = draught 25.5 m or greater, 0 = not available = default; in accordance with IMO Resolution A.851
Destination	120	Maximum 20 characters using 6-bit ASCII; @@@@@@@@@@@@@@@@ = not available
Data terminal equipment (DTE)	1	Data terminal equipment (DTE) ready (0 = available, 1 = not available = default)
Spare	1	Spare. Not used. Should be set to zero. Reserved for future use
<p>Note: an example of a typical MCA formatted voyage report is as follows: 2010-04-01 00:01:25, 538003268,5,58157A02?T19KM17J21<uE@Q0u9B22222222211JPV?M4p;NQS3miDm3iU8888888 88880</p>		
Source: United States Coastguard, 2014		

Table B3: Position report fields (message type 18).

Parameter	Number of Bits	Description
Message ID	6	Identifier for Message 18; always 18
Repeat indicator	2	Shall be 0 for "CS" transmissions
User Identification	30	MMSI number
Spare	8	Not used. Should be set to zero. Reserved for future use
Speed over the Ground (SOG)	10	Speed over ground in 1/10 knot steps (0-102.2 knots) 1 023 = not available, 1 022 = 102.2 knots or higher
Position Accuracy	1	The position accuracy (PA) flag 1 = high (> 10 m) 0 = low (< 10 m) 0 = default
Longitude	28	Longitude in 1/10 000 min (+/-180°, East = positive, West = negative). 181 = not available = default
Latitude	27	Latitude in 1/10 000 min (+/-90°, North = positive, South = negative). 91° = not available = default
Course over the Ground (COG)	12	Course over ground in 1/10 = (0-3599). 3600 = not available = default. 3 601-4 095 should not be used
True heading	9	Degrees (0-359) (511 indicates not available = default)
Time stamp	6	UTC second when the report was generated by the electronic position system (EPFS) (0-59, or 60 if time stamp is not available, which should also be the default value, or 61 if positioning system is in manual input mode, or 62 if electronic position fixing system operates in estimated (dead reckoning) mode, or 63 if the positioning system is inoperative)
Spare	2	Not used. Should be set to zero. Reserved for future use
Class B unit flag	1	0 = Class B SOTDMA unit 1 = Class B "CS" unit
Class B display flag	1	0 = No display available; not capable of displaying Message 12 and 14 1 = Equipped with integrated display displaying Message 12 and 14
Class B DSC flag	1	0 = Not equipped with DSC function 1 = Equipped with DSC function (dedicated or time-shared)
Class B band flag	1	0 = Capable of operating over the upper 525 kHz band of the marine band 1 = Capable of operating over the whole marine band (irrelevant if "Class B Message 22 flag" is 0)
Class B Message 22 flag	1	0 = No frequency management via Message 22, operating on AIS1, AIS2 only 1 = Frequency management via Message 22
Mode flag	1	0 = Station operating in autonomous and continuous mode = default 1 = Station operating in assigned mode
RAIM-flag	1	RAIM (Receiver autonomous integrity monitoring) flag of electronic position fixing device; 0 = RAIM not in use = default; 1 = RAIM in use
Communication state selector flag	1	0 = SOTDMA communication state follows 1 = ITDMA communication state follows
Communication state	19	SOTDMA communication state. Because Class B "CS" does not use any Communication State information, this field shall be filled with the following value: 1100000000000000110.
Number of bits	168	Occupies one slot
Note: An example of a typical MCA formatted position report is as follows: 2011-01-01 12:00:05,235006582,18,B3P7bMP0<owCPF8R@1Th;wS5oP06		
Source: United States Coastguard, 2014		

Table B4: Position report fields (message type 19).

Parameter	Number of Bits	Description
Message ID	6	Identifier for Message 19; always 19
Repeat indicator	2	Used by the repeater to indicate how many times a message has been repeated. See § 4.6.1, Annex 2; 0-3; 0 = default; 3 = do not repeat any more
User Identification	30	MMSI number
Spare	8	Not used. Should be set to zero. Reserved for future use
Speed over the Ground (SOG)	10	Speed over ground in 1/10 knot steps (0-102.2 knots) 1 023 = not available, 1 022 = 102.2 knots or higher
Position Accuracy	1	The position accuracy (PA) flag 1 = high (> 10 m) 0 = low (< 10 m) 0 = default
Longitude	28	Longitude in 1/10 000 min (+/-180°, East = positive, West = negative). 181 = not available = default
Latitude	27	Latitude in 1/10 000 min (+/-90°, North = positive, South = negative). 91° = not available = default
Course over the Ground (COG)	12	Course over ground in 1/10 = (0-3599). 3600 = not available = default. 3 601-4 095 should not be used
True heading	9	Degrees (0-359) (511 indicates not available = default)
Time stamp	6	UTC second when the report was generated by the electronic position system (EPFS) (0-59, or 60 if time stamp is not available, which should also be the default value, or 61 if positioning system is in manual input mode, or 62 if electronic position fixing system operates in estimated (dead reckoning) mode, or 63 if the positioning system is inoperative)
Spare	2	Not used. Should be set to zero. Reserved for future use
Name	120	Maximum 20 characters 6 bit ASCII
Type of ship and cargo type	8	0 = not available or no ship = default 1-99 = as defined in 'MEDIN definition list' 100-199 = reserved, for regional use 200-255 = reserved, for future use
Dimension of ship/reference for position	30	Dimensions of ship in metres and reference point for reported position
Type of electronic position fixing device	4	0 = undefined (default) 1 = GPS 2 = GLONASS 3 = combined GPS/GLONASS 4 = Loran-C 5 = Chayka 6 = Integrated Navigation System 7 = Surveyed 8 = Galileo 9-15 = not used
RAIM-flag	1	RAIM (Receiver autonomous integrity monitoring) flag of electronic position fixing device; 0 = RAIM not in use = default; 1 = RAIM in use
DTE	1	Data terminal ready (0 = available 1 = not available; = default)
Assigned mode flat	1	0 = Station operating in autonomous and continuous mode = default 1 = Station operating in assigned mode
Spare	4	Not used. Should be set to zero. Reserved for future use
Number of bits	312	Occupies one slot
Note: An example of a typical MCA formatted position report is as follows: 2011-01-01 12:01:19,232003891,19,C3M@I<h007vACe7oJO8Wf9aP@a04H28:00000000000J0t7TPR0		
Source: United States Coastguard, 2014		

Table B5: Ship static and voyage fields (message type 24).

Parameter	Number of Bits	Description
Part A		
Message ID	6	Identifier for Message 24; always 24
Repeat indicator	2	Used by the repeater to indicate how many times a message has been repeated. 0 = default; 3 = do not repeat any more
User ID	30	MMSI number
Part number	2	Identifier for the message part number; always 0 for Part A
Name	120	Name of the MMSI-registered vessel. Maximum 20 characters 6-bit ASCII, @@@@ = not available = default
Number of Bits	160	Occupies one-time period
Part B		
Message ID	6	Identifier for Message 24; always 24
Repeat indicator	2	Used by the repeater to indicate how many times a message has been repeated. 0 = default; 3 = do not repeat any more
User ID	30	MMSI number
Part number	2	Identifier for the message part number; always 1 for Part B
Type of ship and cargo type	8	0 = not available or no ship = default 1-99 = as defined in 'MEDIN definition list' 100-199 = reserved, for regional use 200-255 = reserved, for future use
Vendor ID	42	Unique identification of the Unit by a number as defined by the manufacturer (option; " @ @ @ @ @ @ " = not available = default)
Call sign	42	Call sign of the MMSI-registered vessel. 7 X 6 bit ASCII characters, " @ @ @ @ @ @ " = not available = default
Dimension of ship/reference for position. Or, for unregistered daughter vessels, use the MMSI of the mother ship.	30	Dimensions of ship in meters and reference point for reported position. Or, for an unregistered daughter vessel, use the MMSI of the associated mother ship in this data field
Spare	6	Spare. Not used.
Number of bits	168	Occupies one-time period
Note: An example of a typical MCA formatted voyage report is as follows: 2011-01-01 12:00:04,235076771,24,H3P;t ht<D4pT>1=@5800000000		
Source: United States Coastguard, 2014		

Annex C: SQLite AIS database schema

The following annex details the tables and queries provided in the AIS_MMO_Blank.sqlite database file. These database objects are required when processing AIS data using the software tools:

- MMO AIS Processor Stage 01
- MMO AIS Processor Stage 02.

Details of any primary keys and indexes have been omitted but can be inspected in the blank database.

Table C1: tblLloyds data.

Table Description		
Validation data provided by Lloyds. This data is used to validate vessel type and draught.		
Field Name	Type	Description
MMSI_ID	Integer	MMSI number.
Vessel_Name	Text	Vessel name.
Call_Sign	Text	Vessel Call Sign.
Vessel_Type	Text	Vessel type description.
Draught	Numeric	The maximum (summer) draught of vessel (m).
Breadth	Numeric	The maximum breadth of vessel (m).
Length	Numeric	Length of vessel (m).

Table C2: tblLloydsTypes.

Table Description		
Lloyds vessel type descriptions together with the equivalent AIS ship type group.		
Field Name	Type	Description
ID	Integer	Auto increment ID.
Vessel_Type	Text	Vessel type description.
Type_Group	Text	Lloyds vessel group description.
AIS_Group	Integer	AIS ship type group.

Table C3: tblRaw1_2_3.

Table Description		
Raw AIS type 1,2 and 3 messages (AIS A position reports)		
Field Name	Type	Description
ID	Integer	Auto increment ID.
DateTime	Real	Date Time (Excel) value for the position.
MMSI_ID	Integer	MMSI number.
MessageType	Integer	AIS message type.
AIS_MessageString	Text	AIS coded messaging string.

Table C4: tblRaw5.

Table Description		
Raw and partially decoded AIS type 5 messages (AIS A static data)		
Field Name	Type	Description
ID	Integer	Auto increment ID.
DateTime	Real	Date Time (Excel) value for the position.
MMSI_ID	Integer	MMSI number.
AIS_MessageString	Text	AIS coded messaging string.
ShipType	Text	AIS vessel type.
ShipGroup	Integer	AIS vessel type group.
ShipLength	Integer	Length of vessel (m).
ShipWidth	Integer	Breadth of the vessel (m).
ShipDraughtx10	Integer	Report current draught of vessel (m) x 10.

Table C5: tblRaw18.

Table Description		
Raw AIS type 18 messages (AIS B position report)		
Field Name	Type	Description
ID	Integer	Auto increment ID.
DateTime	Real	Date Time (Excel) value for the position.
MMSI_ID	Integer	MMSI number.
MessageType	Integer	AIS message type (18).
AIS_MessageString	Text	AIS coded messaging string.

Table C6: tblRaw19.

Table Description		
Raw and partially decoded AIS type 19 messages (AIS B extended position report)		
Field Name	Type	Description
ID	Integer	Auto increment ID.
DateTime	Real	Date Time (Excel) value for the position.
MMSI_ID	Integer	MMSI number.
MessageType	Integer	AIS message type (19).
AIS_MessageString	Text	AIS coded messaging string.
ShipType	Text	AIS vessel type.
ShipGroup	Integer	AIS vessel type group.
ShipLength	Integer	Length of vessel (m).
ShipWidth	Integer	Breadth of the vessel (m).
ShipDraughtx10	Integer	Report current draught of vessel (m) x 10.

Table C7: tblRaw24A.

Table Description		
Raw AIS type 24, part A, messages (AIS B vessel name)		
Field Name	Type	Description
ID	Integer	Auto increment ID.
DateTime	Real	Date Time (Excel) value for the position.
MMSI_ID	Integer	MMSI number.
MessageType	Integer	AIS message type (24).
AIS_MessageString	Text	AIS coded messaging string.

Table C8: tblRaw24B.

Table Description		
Raw and partially decoded AIS type 24, part B, messages (AIS B static data)		
Field Name	Type	Description
ID	Integer	Auto increment ID.
DateTime	Real	Date Time (Excel) value for the position.
MMSI_ID	Integer	MMSI number.
AIS_MessageString	Text	AIS coded messaging string.
ShipType	Text	AIS vessel type.
ShipGroup	Integer	AIS vessel type group.
ShipLength	Integer	Length of vessel (m).
ShipWidth	Integer	Breadth of the vessel (m).
ShipDraughtx10	Integer	Report current draught of vessel (m) x 10.

Table C9: tblRaw27.

Table Description		
Raw AIS type 27 messages (Long range reports)		
Field Name	Type	Description
ID	Integer	Auto increment ID.
DateTime	Real	Date Time (Excel) value for the position.
MMSI_ID	Integer	MMSI number.
MessageType	Integer	AIS message type (27)
AIS_MessageString	Text	AIS coded messaging string.

Table C10: tblRawBad.

Table Description		
Unwanted or unrecognised, raw AIS messages identified during data loading.		
Field Name	Type	Description
ID	Integer	Auto increment ID.
DateTime	Real	Date Time (Excel) value for the position.
MMSI_ID	Integer	MMSI number.
MessageType	Integer	Message type.
AIS_MessageString	Text	AIS coded messaging string.

Table C11: tblShipGroups.

Table Description		
Ship group look up table.		
Field Name	Type	Description
GroupID	Integer	AIS vessel type group.
GroupName	Text	Group name.

Table C12: tblShipNames.

Table Description		
Summary table of vessel names derived from the voyage (static) AIS messages.		
Field Name	Type	Description
MMSI_ID	Integer	MMSI number.
ShipName	Text	Vessel name.
AisType	Integer	Minimum of the AIS message types provided for this vessel.
Call_Sign	Text	Call Sign.

Table C13: tblMmsiList.

Table Description		
List of vessel MMSI numbers for which AIS position reports have been provided.		
Field Name	Type	Description
ID	Integer	Auto increment ID.
MMSI_ID	Integer	MMSI number.
Message Type	Integer	Minimum of the AIS message types provided for this vessel.

Table C14: tblPositions.

Table Description		
Transit position data resulting from the software decoding and transit processing		
Field Name	Type	Description
PositionID	Integer	Auto increment ID.
Transit_ID	Integer	ID Number of the associated transit.
DateTime	Real	Date Time (Excel) value for the position.
LatDeg	Numeric	Latitude (Decimal degrees).
LongDeg	Numeric	Longitude (Decimal degrees).

Table C15: tblTransit.

Table Description		
Transit static data resulting from the software decoding and transit processing.		
Field Name	Type	Description
Transit_ID	Integer	Auto increment ID.
DateTimeStart	Real	Start date time (Excel) value of the transit.
DateTimeFinish	Real	Finish date time (Excel) value of the transit.
MidTime	Real	Mid- date time (Excel) value of the transit.
MMSI_ID	Integer	MMSI number.
ShipTypeGroup	Integer	AIS vessel type group.
ShipLength	Integer	Length of vessel (m).
ShipWidth	Integer	Breadth of the vessel (m).
ShipDraughtx10	Integer	Report current draught of vessel (m) x 10.
VoyageDataSource	Integer	Indicates if the voyage information (particularly draught) was consistent for the duration of the vessel transit. 1 = consistent vessel draught. 2 = Minimum value of adjacent voyage draught values.
TransitLength	Integer	Length of the vessel transit prior to any transit thinning process (m).
PositionDensity	Integer	The number of vessel position reports per km that are represented by the transit. A value of zero indicates an inferred transit
TransitEndReason	Integer	This code indicates the reason the transit was terminated. 0. End of the period of the input dataset 1. Position outside the area of interest 2. Contact lost 3. Intermittent contact (position reports greater than ten minutes apart) 4. Intermittent contact finished, normal contact restored 5. Normal transit termination. SOG falls below 0.2 knots for more than 5mins 6. QA checks on consecutive positions result in repeated invalid points
AisType	Integer	Minimum of the AIS message types provided for this vessel.

Table C16: tblTransit2.

Table Description		
Transit static data resulting from the VTC and validation data, transit processing. The table is similar to the tblTransit table but normally has fewer data, some transits having been removed as part of the process to identify overland transit sections.		
Field Name	Type	Description
Transit_ID	Integer	Auto increment ID.
DateTimeStart	Real	Start date time (Excel) value of the transit.
DateTimeFinish	Real	Finish date time (Excel) value of the transit.
MidTime	Real	Mid- date time (Excel) value of the transit.
MMSI_ID	Integer	MMSI number.
ShipTypeGroup	Integer	AIS vessel type group.
ShipLength	Integer	Length of vessel (m).
ShipWidth	Integer	Breadth of the vessel (m).
ShipDraughtx10	Integer	Report current draught of vessel (m) x 10.
VoyageDataSource	Integer	Indicates if the voyage information (particularly draught) was consistent for the duration of the vessel transit. 1 = consistent vessel draught. 2 = Minimum value of adjacent voyage draught values.
TransitLength	Integer	Length of the vessel transit prior to any transit thinning process (m).
PositionDensity	Integer	The number of vessel position reports per km that are represented by the transit. A value of zero indicates an inferred transit.
TransitEndReason	Integer	This code indicates the reason the transit was terminated. 0. End of the period of the input dataset. 1. Position outside the area of interest. 2. Contact lost. 3. Intermittent contact (position reports greater than ten minutes apart). 4. Intermittent contact finished, normal contact restored. 5. Normal transit termination. SOG falls below 0.2 knots for more than 5mins. 6. QA checks on consecutive positions result in repeated invalid points.
AisType	Integer	Minimum of the AIS message types provided for this vessel.
SZone	Text	The UK zone in which the transit starts.
SRegion	Text	The region in which the transit starts.
EZone	Text	The UK zone in which the transit finishes.
ERegion	Text	The region in which the transit finishes.
VTC	Integer	Vessel Transit Classification (VTC). 1) Transits that originate and terminate at a UK port (UK 0.5 nautical miles buffer zone where this includes anchorage within UK waters). 2) Transits where the vessel has at least one transit within the data period that originated or terminated at a UK port (UK 0.5 nautical mile buffer zone where this includes anchorage within UK waters), but excludes Transits of VTC 1. 3) Transits where the vessel has not had any transits within the data period that originated or terminated at a UK port (UK 0.5 nautical mile buffer zone where this includes anchorage within UK waters).

Table C17: tblVesselDimsSummary.

Table Description		
Summary time series of vessel dimensional information.		
Field Name	Type	Description
ID	Integer	Auto increment ID.
MMSI_ID	Integer	MMSI number.
MinDateTime	Real	Minimum Start date and time (null)
MaxDateTime	Real,	Maximum Start date and time (null)
ShipType	Integer	AIS vessel type
ShipGroup	Integer	AIS vessel type group.
ShipLength	Integer	Length of vessel (m).
ShipWidth	Integer	Breadth of the vessel (m).
Draughtx10	Integer	Report current draught of vessel (m) x 10.
DataSourceFlag	Integer	Indicates if the vessel dimensional information is consistent between adjacent reports. 1 = consistent values. 2 = changing values.

Table C18: tblVesselProcessStats.

Table Description		
Summary table of transit processing results and error logging, with one data row for each vessel.		
Field Name	Type	Description
ID	Integer	Auto increment ID.
MMSI_ID	Integer	MMSI number.
AllPointTotal	Integer	The total number of position reports for this vessel, excluding duplicate points (identical AIS message strings).
ValidPointTotal	Integer	The total number of valid position reports.
InvalidQAPointTotal	Integer	The total number of invalid position reports after QA checks are complete, excluding points outside the national area of interest.
PointsSaved	Integer	The total number of positions saved, after transit thinning.
PointTrackTolerance	Integer	The number of positions deleted as part of the transit thinning process due to Track Tolerance.
PointPositionTolerance	Integer	The number of positions deleted as part of the transit thinning process due to Position Tolerance.
PointSogDistanceErrors	Integer	The number of positions rejected by the QA process due to speed over ground (SOG) / distance errors.
PointCogErrors	Integer	The number of positions rejected by the QA process due to course over ground (COG) errors.
PointOverSpeed	Integer	The number of positions rejected by the QA process due to vessel over speed
PointDuplicate	Integer	The number of positions rejected by the QA process due to duplicates (identical position report, with differing time stamp).
TransitTotal	Integer	Total number of transits.
TransitsTooShort	Integer	Total number of transits deleted because they were too short.
TransitsTooFewPoints	Integer	Total number of transits deleted because they contained too few points.

Table C19: View Summary.

Query Name	Description
qryVesselsWithNoPositions	List of vessels for which no positions were found for processing.
qryEndPointIDs	Intermediate query used to identify transit end points.
qryRawPositionDataTablesUnion	Raw position data listing.
qryRawVoyageDataTablesUnion	Raw voyage data listing.
qryShipGroupCount	Ship group statistics based on voyage data.
qryShipGroupCountDetail	Ship group statistics with ship group names.
qryShipGroupTransitSummary	Ship group statistics based on transit data.
qryTransit2_Join	Output query for stage 4 processing.
qryTransitEndPoints	Intermediate query used to identify transit end points.
qryTransitEndPointsUnion	Output query used for 3 processing.
qryTransitStartPoints	Intermediate query used to identify transit start points.
qryVTC_Summary	Intermediate query used to identify VTC values.
qryVessels_England	List of vessels having transits starting or finishing in England.
qryVessels_N_Ireland	List of vessels having transits starting or finishing in N. Ireland.
qryVessels_Scotland	List of vessels having transits starting or finishing in Scotland.
qryVessels_Wales	List of vessels having transits starting or finishing in Wales.