ASTD Data

The Cooperative Agreement among the Arctic States Regarding Arctic Ship Traffic Data Sharing outlines access to the Arctic Ship Traffic Data (ASTD) System and the use of ASTD data.

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ASTD Data Document Version History

1.1: Prepared in January 2019.
1.2: Updated in April 2020.
1.3: Updated in January 2021.
1.4: Updated in March 2021.

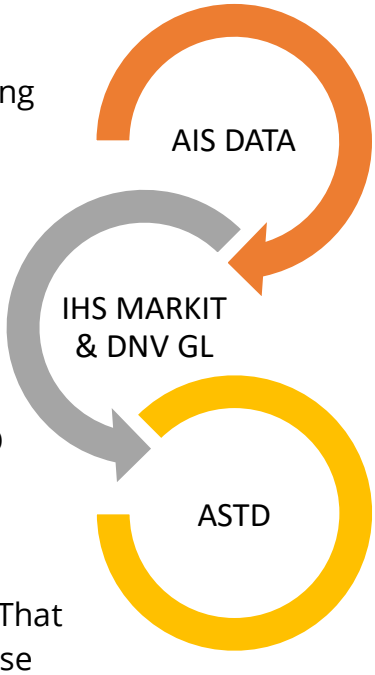
PAME
Protection of the Arctic Marine Environment

Data Defic Alert:

Please note that all 2020 ASTD information on fuel and emissions is potentially incorrect. Please contact the PAME Secretariat for more information (pame@pame.is)

ASTD Data

The ASTD Database contains four types of information. These are:



1. Automatic Identification System (AIS data) from ships operating in the Arctic.
2. Ship characteristic information (e.g., type, size, flag, gross tonnage, ownership, construction date) from IHS Markit. Since 1760 Lloyds Register collected information on ships and maintained a collective ship registry. In 2009 IHS acquired Lloyds Register. IHS Fairplay is a company servicing the IMO for a database of ships, and is the sole issuer of IMO numbers, contained in AIS information. An IMO number is a unique number to each ship. The IMO ship identification number scheme was introduced in 1987 as a measure to enhance ship safety and security. It assigned a permanent number to each ship for identification purposes. That number would remain unchanged through the ships life. These numbers appear on Port State Control required ships documentation such as the CSR – Continuous Synopsis Record, ISM and ISPS certificates.[1] From this, information in the table below is generated.
3. Information on the types of fuel ships are burning and calculated air emissions from such combustion, obtained from DNV. DNV is the world's largest classification society and a recognized advisor for the maritime industry.
4. Sea ice data from the National Snow and Ice Data Center (NSIDC). ASTD contains monthly sea ice extent information obtained from the NSIDC Sea Ice Index.

[1] Information on the IMO identification number scheme

ASTD Data Access Levels

Access to ASTD data may be granted to eligible applicants at one of three access levels: Level I, Level II and Level III

ASTD DATA ACCESS LEVEL COMPARISON

	Level 1	Level 2	Level 3	*Explanation*
mmsi	YES	NO	NO	*MMSI Number*
imonumber	YES	NO	NO	*IMO Number*
shipid	NO	YES	YES	*Ship number in the file downloaded.*
date_time_utc	YES	YES	YES	*Date of signal*
vesselname	YES	NO	NO	*Name of ship*
flagname	YES	YES	YES	*Flag of the ship or ship registry*
iceclass	YES	YES	YES	*Ice class (PC polar ice classes)*
astd_cat	YES	YES	YES	*Ship type according to the ASTD Category where over 200 ship types are aggregated to 13 ship types. Click this link to read more.*
lloyds3_cat	YES	YES	NO	*Ship types according to Lloyds/IHS Category 3 where over 200 ship types are aggregated to around 50 ship types. Click this link to read more.*
lloyds5_cat	YES	NO	NO	*Ship types according to Lloyds/IHS Category 5 - A detailed list of over 200 ship types where each ship is identified. Click this link to read more.*
sizegroup_gt	YES	YES	YES	*Ship Size (in gross tons) (7 groups)*
The 7 ship size groups are: ***1:*** *<1000 GT* ***2:*** *1000-4999 GT* ***3:*** *5000-9999 GT* ***4:*** *10000-24999 GT* ***5:*** *25000-49999 GT* ***6:*** *50000-99999 GT* ***7:*** *>= 100000 GT*				
fuelquality	YES	YES	YES	*Type of fuel used (6 categories)*

The 6 fuel types are:

Note: Fuel data after 1 Jan 2020 are not 100% accurate due to new fuel definitions.

0 = Distillate marine fuel (MGO/MDO)
1= Residual marine fuel and heavy distillate (ISO-F-10 - 80)
2= Residual marine fuel (IFO-F-80 - 180) heavy fuel oil
3= Residual marine fuel (IFO-F-180 - 380 or above) heavy fuel oil
4= Liquid natural gas (LNG)
5=Battery power

fuelcons	YES	YES	YES	*Fuel Consumption*
co	YES	YES	YES	*Carbon monoxide*
co2	YES	YES	YES	*Carbon dioxide*

so2	YES	YES	YES	*Sulfur dioxide*
pm	YES	YES	YES	*Particulate matter*
nox	YES	YES	YES	*Nitric oxide*
n2o	YES	YES	YES	*Nitrous oxide*
nmvoc	YES	YES	YES	*Non-methane volatile organic compounds emission*
ch4	YES	YES	YES	*Methane*
blackcarbon	YES	YES	YES	*Black carbon*
organiccarbon	YES	YES	YES	*Organic carbon*
oilbilgewater	YES	YES	YES	*Oily bilge water*
blackwater	YES	YES	YES	*Blackwater*
greywater	YES	YES	YES	*Greywater*
garbage	YES	YES	YES	*Garbage*
dist_nextpoint	YES	YES	YES	*Distance to next point*
sec_nextpoint	YES	YES	YES	*Seconds to next point*
longitude	YES	YES	YES	*Longtitude*
latitude	YES	YES	YES	*Latitude*
Example: December 2013 Download:				
File format	ZIP	CSV	CSV	*Format downloaded from ASTD*
File size	258 mg (1,97 gb)	1,69 gb	1,58 gb	Size of file downloaded

What is AIS?

AIS is a maritime navigation safety communications system standardized by the International Telecommunication Union (ITU) and adopted by the International Maritime Organization (IMO) to provide information about ship type, position (recorded every 6 minutes in ASTD), course, speed, navigational status, and other safety-related information. The information is transmitted automatically and is received by appropriately equipped shore stations, other ships, and satellites.

SOLAS regulation 19 requires AIS to be fitted aboard all ships of 300 or more gross tonnage engaged on international voyages; cargo ships of 500 or more gross tonnage not engaged on international voyages; and all passenger ships irrespective of size. SOLAS regulation 19 became effective 31 December 2004.[2]

AIS Class A and B

Automatic identification systems (AIS) transponders are designed to be capable of providing position, identification and other information about the ship to

[2] https://www.imo.org/en/OurWork/Safety/Pages/AIS.aspx

other ships and to coastal authorities automatically. There are two types of AIS transponders: Class A and Class B. Class A transponders:

- Class A transponders send a stronger signal than Class B transponders. Class A transponder signals may travel further and be received by a greater number of land-based stations and by satellites.
- Class B transponders provide the safety and navigation benefits of Class A transponders to smaller vessels with lower cost and simpler installation. Class B transponders send fewer messages than Class A transponders.

The frequency of AIS signals from Class A depends on the ships position and speed. For example, a Class A transponder on a ship traveling at a speed of 23 knots transmits an AIS signal every two seconds, while a Class A transponder on a ship traveling at a speed between 0-14 knots transmits an AIs signal every 10 seconds.[3]

Only AIS signals from ships carrying AIS Class A transponders is included in ASTD. Many ships not required to carry AIS still opt to use it, and are therefore included (this includes smaller fishing vessels, and pleasure crafts, for example).

General AIS Limitations

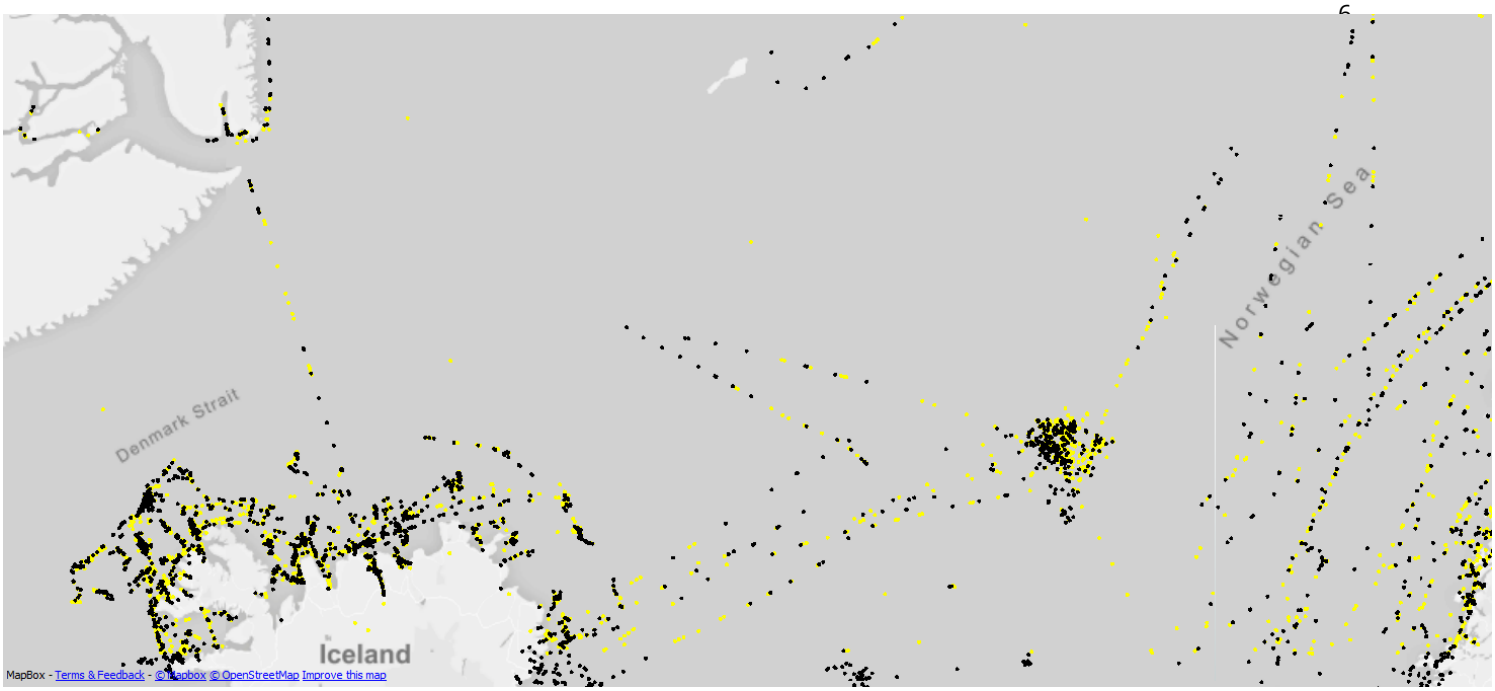
AIS data in the ASTD system does not cover 100% of all ship traffic, but data quality is very high. This has been confirmed by comparing data from other sources, including national collected information. Identifying smaller pleasure craft and fishing vessels can be challenging because of limitation in registries and AIS information.

Numerous factors can affect the transmission and/or receipt of AIS signals, including:

- Technical failure due to faulty infrastructure (vessel and data flow).
- Erroneous onboard installation (vessel infrastructure)
- Problems with data links/networks
- AIS signals being manipulated
- Data noise
- Challenges regarding satellite coverage

The image below shows how AIS Class A transponder data from the USA (yellow dots) supplements AIS Class A transponder data from Norway (black dots) to give ASTD a provide more detailed and more accurate coverage of ship traffic information.

[3] https://www.oceantimemarine.com/class-a-and-class-b-automatic-identification-system-ais/



ASTD Data Quality/Accuracy

The data in ASTD is very accurate. The data collected is vast, hundreds of gigabytes every year. Approximately 4 million records are added to the database every 24 hours. As outlined above, AIS signals are not 100% accurate, there are many variables which effect databases like ASTD. There are many other data sources like ASTD, and when comparing data between them, the information might not be 100% aligned. This could for example be differences in satellites who collect AIS signals. However, data quality in ASTD is *very high*.

Data Calculations

Certain data in ASTD is based on calculations using algorithms included in the database. These algorithms were prepared in a very comprehensive work by Norway, including NCA and DNV, when information from thousands of ships operating in the Arctic was collected. This includes all the information in the *Statistics* section in *Arctic area traffic in ASTD*.

$$E_{i,j} = \sum_{t=0}^{t=n} ((P_{ME_i} * \left(\frac{SOG_{i,t}}{V_{max_i}}\right)^3 * EF_{ME_{j,k,l,m}} + D_{AE_{p,i}} * EF_{AE_{j,k,l,m}} + D_{BO_{p,i}} * EF_{BO_{j,m}}) * 1\,\text{hour})$$

Where:

- i = ship
- j = pollutant
- t = time (operating hour, h)
- k = engine type
- l = engine tier
- m = fuel type
- p = phase
- $E_{i,j}$ = emissions (g) for ship i and pollutant j
- P_{ME_i} = main engine power (kW) for ship i
- $SOG_{i,t}$ = speed over ground (knots) for ship i at time t
- V_{MAX_i} = maximum speed (knots) for ship i
- $EF_{ME_{j,k,l,m}}$ = main engine emission facor (g/kWh) for pollutant j, engine type k, engine tier l, and fuel type m
- $D_{AE_{p,t}}$ = auxiliary engine power demand (kW) in phase p for ship i
- $EF_{AE_{j,k,l,m}}$ = auxiliary engine emission factor (g/kWh) for pollutant j, engine type k, engine tier l, and fuel type m
- $D_{BO_{p,i}}$ = boiler power demand (kW) in phase p for ship i
- $EF_{BO_{j,m}}$ = boiler emission factor (g/kWh) for pollutant j and fuel type m

One example of these data calculations is statistics on fuel consumption. The calculation is prepared for each ship. The algorithm utilizes the information from AIS to determine the engine the ship uses, find its KW numbers, adds the speed the

vessels travels and calculates the fuel consumption. Where the fuel type is unknown, it is filled in by looking at a “sister ship” or similar ships (RPM engine).

The fuel consumption is also used to calculate information about air emissions from ships. The box to the right shows how emissions are calculated. ASTD contains many types of ship air emissions and is capable of showing these emissions in a certain time and for certain areas.

Ship Types Aggregation

Asa a main rule, ships need to be registered to be eligible to navigate. Each ship is designated a ship type. ASTD utilizes the IHS Markit StatCode 5 Shiptype Coding System to categorize ship types. IHS has 5 category levels which are then aggregated from around 230 ship types to 15.

For example, level 5 of the IHS Fairplay information has over 10 different types of chemical tankers, including Vegetable Oil tanker and Wine tanker. This information is aggregated to Chemical tankers in the ASTD ship types.

However, when downloading data, users with Level I access may obtain the information in Ship Type Level 5, and therefore analyze more specific ship types.

A document showing how the ASTD System aggregates ship types
is available to download here.

Working with Data

If data is downloaded - ASTD requires GIS analysis experts to work with data from the system.

Those who have access to ASTD can download data for analysis. The data can be downloaded in different formats, but .CSV is the most common format. CSV stands for comma-separated values and is a delimited text file that uses a comma to separate values. A CSV file stores tabular data in plain text. Each line of the file is a data record. Each record consists of one or more fields, separated by commas. Each .csv file can contain millions of rows and can be very large, up to many gigabytes in size. Smaller .csv files can be opened with Microsoft Excel, but others require specialized programs to work with, like CSV Explore, Python or SQL databases like MySQL and PostgreSQL. This work requires not only a data expert, but a powerful computer as well.

Keep this in mind when downloading large amounts of data.

However, smaller data samples can be downloaded by regular users, not specific GIS experts, and analyzed Excel. One has to download data and convert from CSV but from there analysis can be performed.

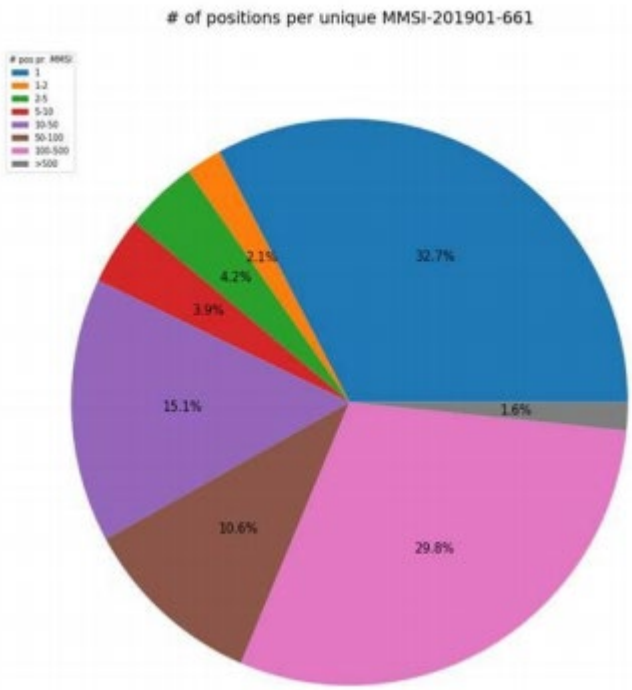
Cleaning up Data

Please note that specific corrections are needed after downloading data to have as correct data as possible.

Satellites in orbit randomly pick up signals from far away, outside the Arctic area, under certain atmospheric conditions. In the prefixed reports made directly from the System, we have filtered out all AIS Class A transponder signals from ships with less than 10 positions in one month. This means that ships with sailing time less than one hour in a whole month are filtered out and therefore not included in the report. This has very limited effects for the reports as most of the signals are from ships outside the Arctic area covered by the ASTD System that satellites pick.

Please be aware that when downloading data, you need to do this cleanup yourself as you are downloading raw data. We recommend cleaning up positions of less than 10 positions each month.

This pie chart is an example of data from a data expert who worked with the data. It shows that 42.9% of the data is from ships with less than 10 positions in one month. A large majority of these positions are signals picked up by error. Hence, filtering (clean-up) is needed before using the data for analysis.



Citations

When using data from the ASTD System, use the following citation:
PAME - Arctic Ship Traffic Data. (insert date when data is collected). Retrieved from ASTD.is.