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Introduction to Automated Identification System (AIS)

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Overview of Talk

- Overview/History of AIS
- Terrestrial AIS vs. Satellite AIS
- Sources of AIS, How to View/Record AIS
- AIS message specifications and decoding AIS messages
- Example – Reading AIS log file, decoding messages, and writing vessel tracks to file

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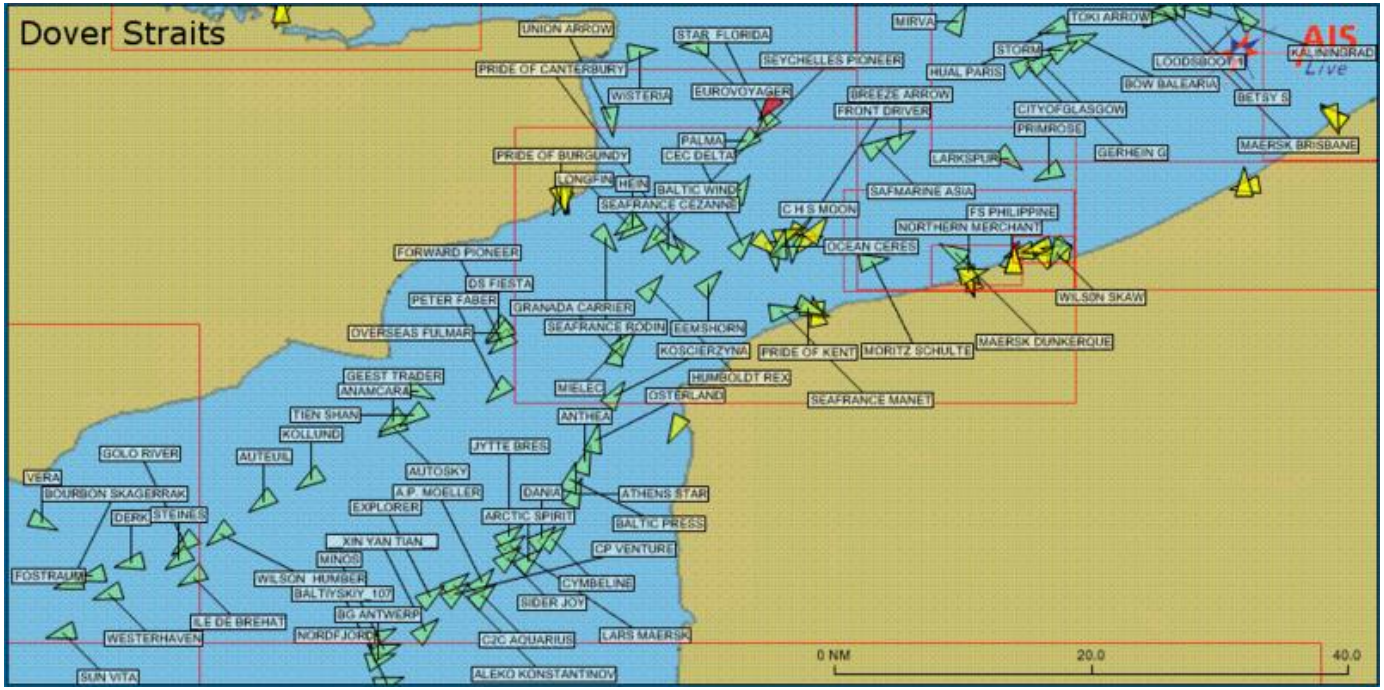
What is Automated Identification System?

- System allowing vessels to automatically report their position and navigational information to all recievers within range, and simultaneously to receive other vessels positions.
- Consists of transceiver, VHF antenna, and GPS antenna
- Operates at VHF maritime channels
  - 87B (161.975 MHz)
  - 88B (162.025MHz)
- Primary Uses-
  - Search and Rescue
  - Collision Avoidance
  - Accident investigation

What is Automated Identification System?

- Typical range of AIS signal is 30 nm in horizontal
  - In vertical, range is much higher…can be received by satellites
- Two main classes of AIS for vessels
  - Class A and Class B



History of AIS

- 1998 - International Maritime Organization's (IMO)International Convention passes Safety of Life at Sea (SOLAS)
  - Requires AIS be fitted aboard international voyaging ships with gross tonnage (GT) of 300 or more tons, and all passenger ships regardless of size NLT 31 December, 2004
  - Estimated 40,000 ships currently carry class A AIS equipment.
- 2007- Class B AIS standard introduced which enabled a new generation of low cost AIS transceivers.
  - Class B equipment now required in many nations (Singapore, China, Turkey and North America) → 100,000 vessels

4 Types of AIS Systems

Class A
Integrated display showing other AIS transmissions
12W transmitting power
Interface to ship navigation systems (GNSS, gyrocompass)
Transmission rate every 3-5 seconds

Class B
2W transmission power
Transmission rate every 30 seconds
Requires at least GPS and VHF antenna

Base Stations
Shore-based AIS transceivers able to control/interrogate individual transponders within range

Aids to Navigation (AtoN)
Shore or buoy based transceiver designed to collect and transmit sea and weather condition messages

Class A AIS Transciever Details

- A vessel Class A AIS systems consist of 3 main components;
  - AIS Transciever – transmits binary formated messages at regular intervals.
  - VHF antenna – recieves and transmits AIS messages to be decoded by the AIS transciever
  - GPS antenna – used to provided GPS position of vessel in AIS messages
  - In addition, the AIS transciever will often be hooked into ship-board gyro

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Class A AIS Transponder Details

- The vessel's Maritime Mobile Service Identity (MMSI) – a unique nine digit identification number.
- Navigation status – "at anchor", "under way using engine(s)", "not under command", etc.
- Rate of turn – right or left, from 0 to 720 degrees per minute
- Speed over ground – 0.1-knot (0.19 km/h) resolution from 0 to 102 knots (189 km/h)
- Positional accuracy:
- Longitude – to 0.0001 minutes
- Latitude – to 0.0001 minutes
- Course over ground – relative to true north to 0.1°
- True heading – 0 to 359 degrees (for example from a gyro compass)
- Time stamp – UTC time accurate to the nearest second when these data were generated

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Class A AIS Transponder Details

- In addition, the following data are broadcast every 6 minutes:
- IMO ship identification number – a seven digit number that remains unchanged upon transfer of the ship's registration to another country
- Radio call sign – international radio call sign, up to seven characters, assigned to the vessel by its country of registry
- Name – 20 characters to represent the name of the vessel
- Type of ship/cargo
- Dimensions of ship – to nearest meter
- Location of positioning system's (e.g., GPS) antenna on board the vessel - in meters aft of bow and meters port of starboard
- Type of positioning system – such as GPS, DGPS or LORAN-C.
- Draught of ship – 0.1 meter to 25.5 meters
- Destination – max. 20 characters
- ETA (estimated time of arrival) at destination – UTC month/date hour:minute

Class B AIS Transponder Details

- Transmits at lower 2.5W
  - Range is consequently lower than for class A AIS.

- Transmits with lower frequency (30seconds – 5 minutes)
- Does not require integrated display (may act only as transponder)
- Much cheaper, easier to mount/install, good solution for smaller vessels.
- Receives both class A and class B AIS messages (aware of surrounding ship traffic)

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Web-based Sources for AIS

http://www.shippingexplorer.net/ - Live Vessel Tracking

http://www.marinetraffic.com/ais/default.aspx?language=_EN – Marine Traffic

http://www.digital-seas.com/ - Worldwide real time vessel tracking

http://Vesseltracker.com - Worldwide AIS tracking Website

http://www.vtexplorer.com/ - AIS vessel tracking based on standalone VT Explorer application

http://www.ios-hellas.gr/ais - Vessels from around the world update every sec!!

http://www.mariweb.gr/ecs - On-Line tracking of vessels from around the world, weather reports and live cameras!

http://www.shipspotting.com/modules/myalbum/ais.php - Shipspotting.com - Vessels in Northern Europe

http://www.vesseltrax.com/ - Vessels in the Gulf of Mexico and Texas Ports

http://www.shipais.com/ - Vessels in the Irish Sea, around Great Britain, United Kingdom, and Ireland

http://www.lrfairplay.com/ - Loyds register of ship information

http://www.atlanticsource.es/sat/ - Vessels around the world

http://www.shipplotter.dk/dk-kort.html - Vessels around Denmark

http://www.northernbaltic.se/ais/ - Live AIS @ Landsort Vessels in Northern Baltic Sea around Landsort!

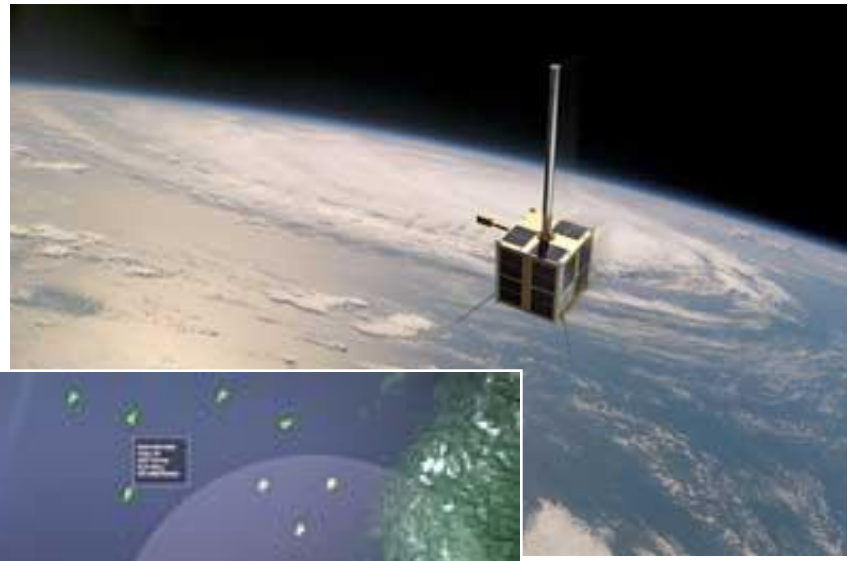
http://www.trackaship.com - Ship and vessel tracking world wide. Includes maps optimized for mobile devices. Free iPhone App for live tracking.

Web-based Sources for AIS

- The U.S. Department of Transportation's VOLPE Center takes AIS feeds from around the world and pushes them onto the MSSIS network.
- AIS on this network is viewable using several web tools (VRMTC-A and the Non-Classified Enclave (NCE)). Data can also be viewed/logged using the TV-32 application.

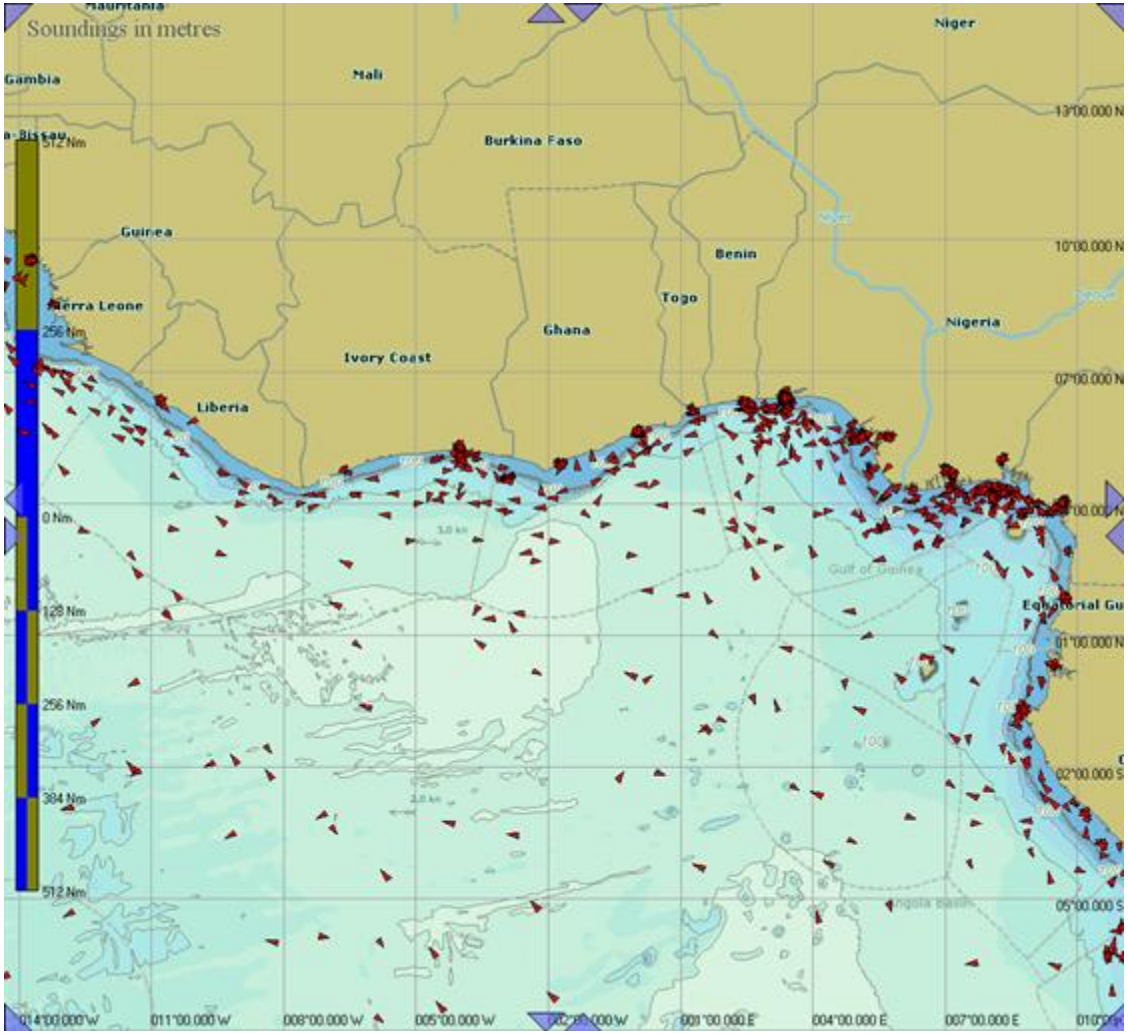
Satellite AIS

- Vertical range of VHF transmission is much greater than horizontal range
  - ~74km horizontal vs. ~400km vertical
- Collected by LEO, Polar orbiting satellites
- First satellites launched in June 2008
- Two main data providers
  - ORBCOMM
  - exactEarth



Satellite AIS

- Example of SatAIS over the Gulf of Guinea
- Shows Contacts
- Shows ship tracks
- Combination



AIS Binary Message Formats

- AIS is decoded as binary message in format called NMEA 0183
- Several standards exists (NMEA 3.0 and NMEA 4.0)

- Two main types of AIS messages
  1) Dynamic messages (types 1, 2, and 3 for class A, types 18 and 19 for class B).
  2) Static messages (type 5 for class A, types 18,19, 24 for class B)
  3) Message types 1,3, 5, 18, & 24 are the most common

- 26 total possible messages

- ***Details of AIS messages (AIVDO and AIVDM messages) found at*** http://gpsd.berlios.de/AIVDM.html

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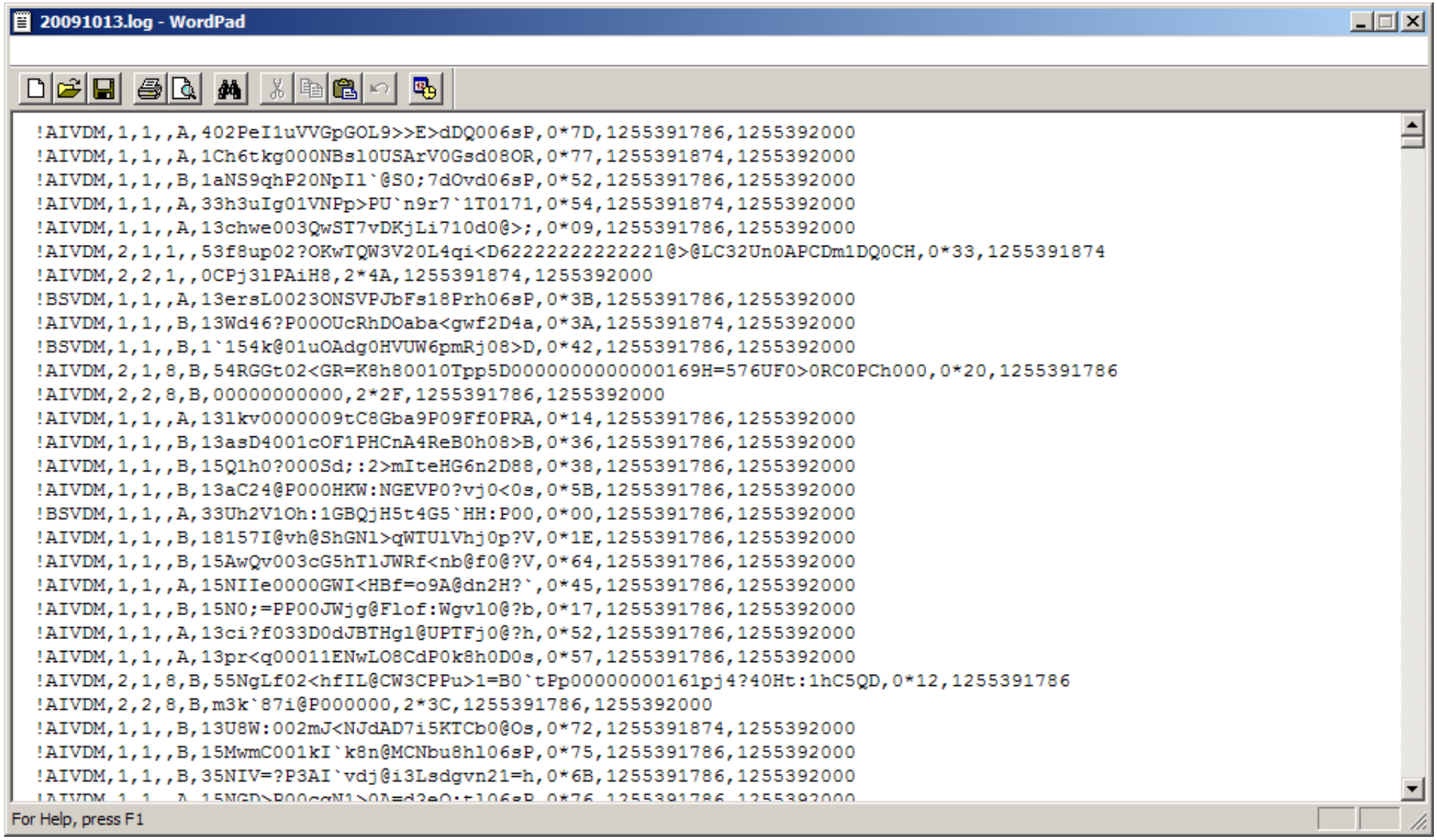
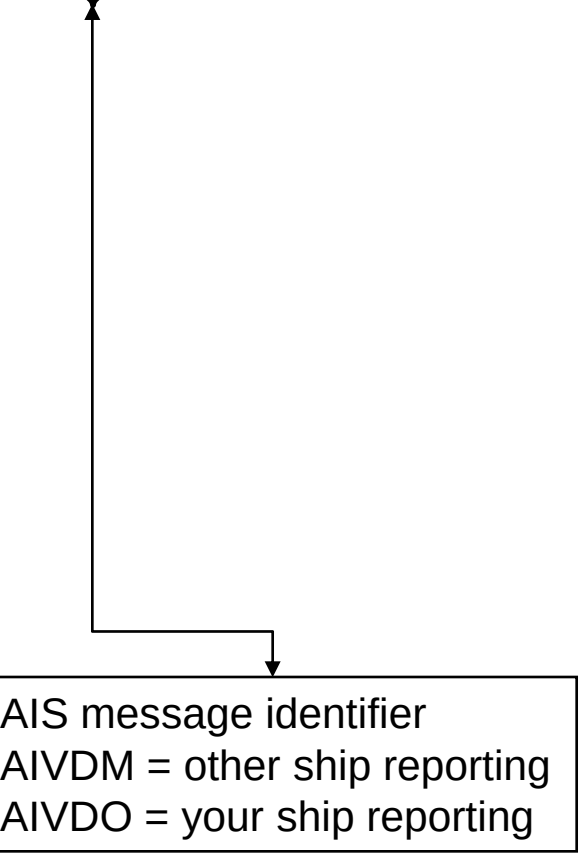
AIS Message Formats



AIS Message Formats

```
!AIVDM,1,1,,A,1Ch6tkg000NBs10USArVOGsd08oR,0*77,1255391874,1255392000
```



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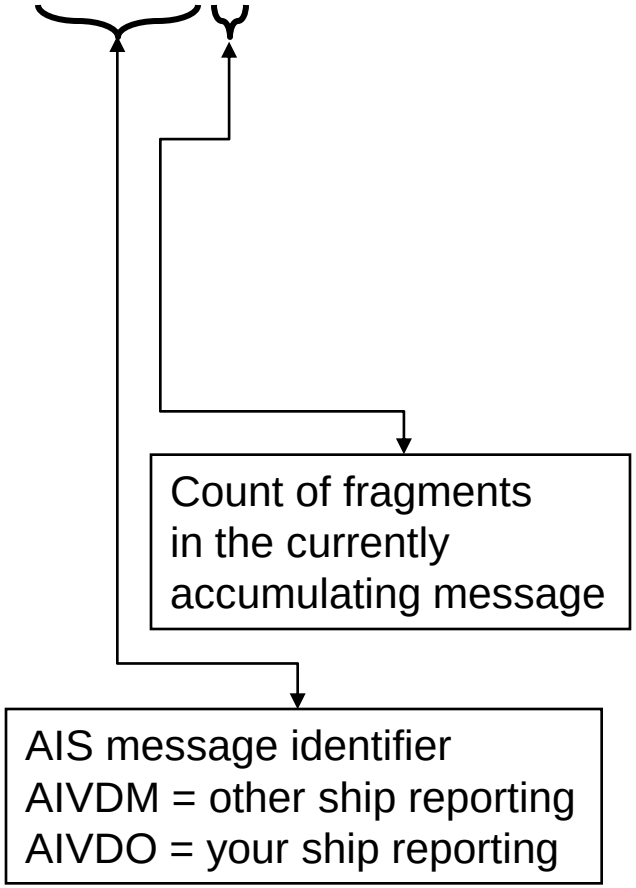
```



AIS Message Formats

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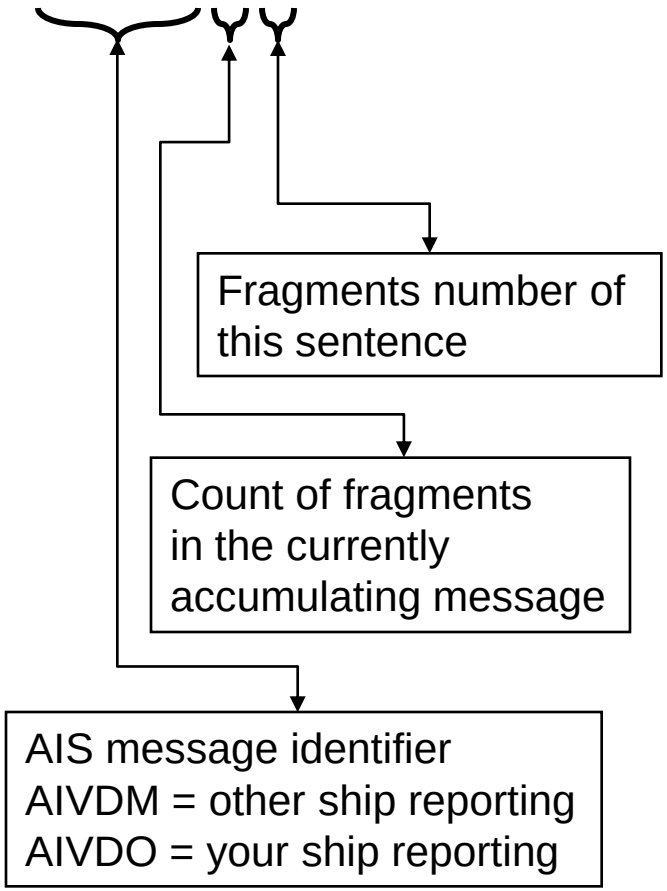
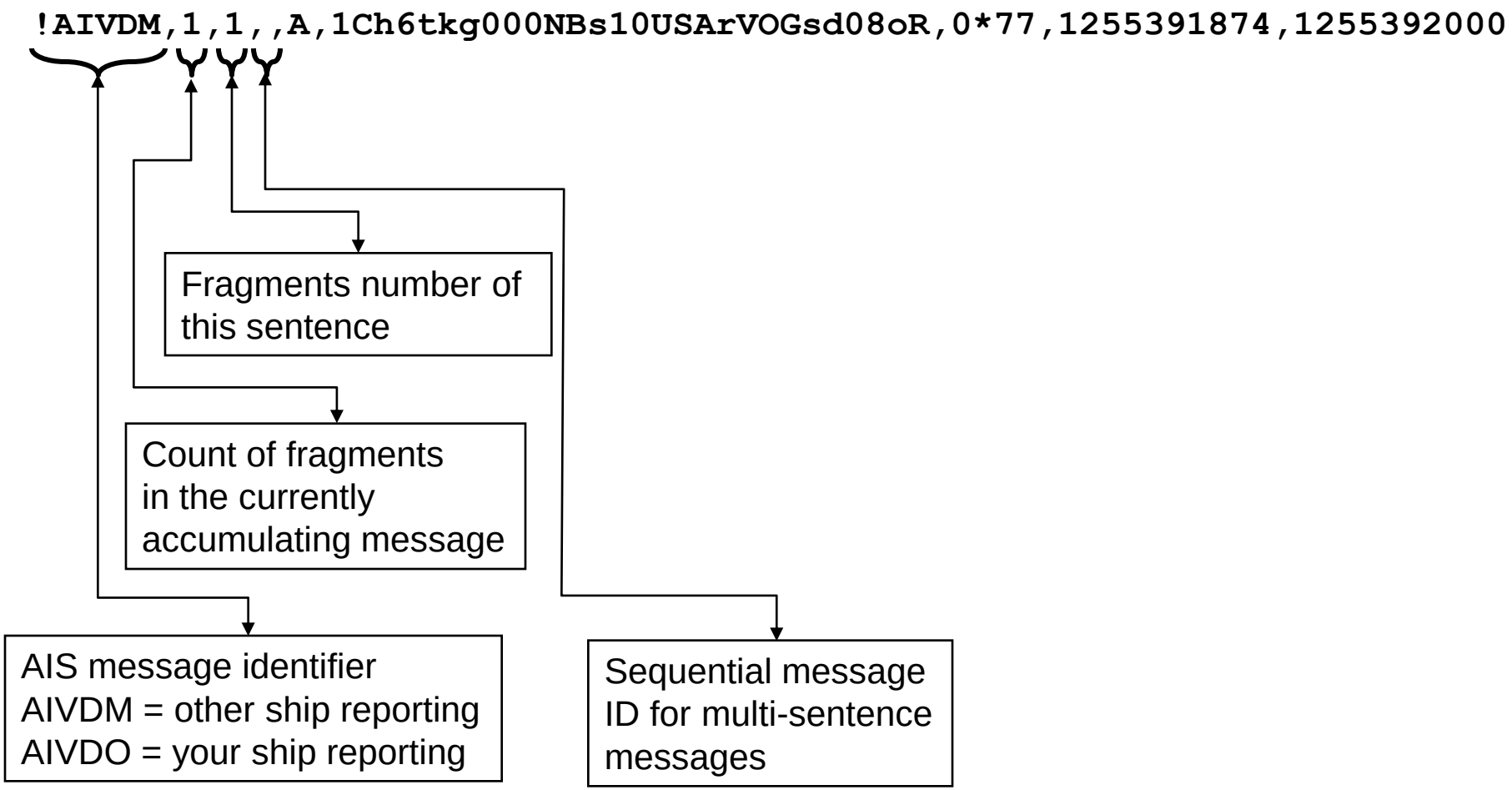
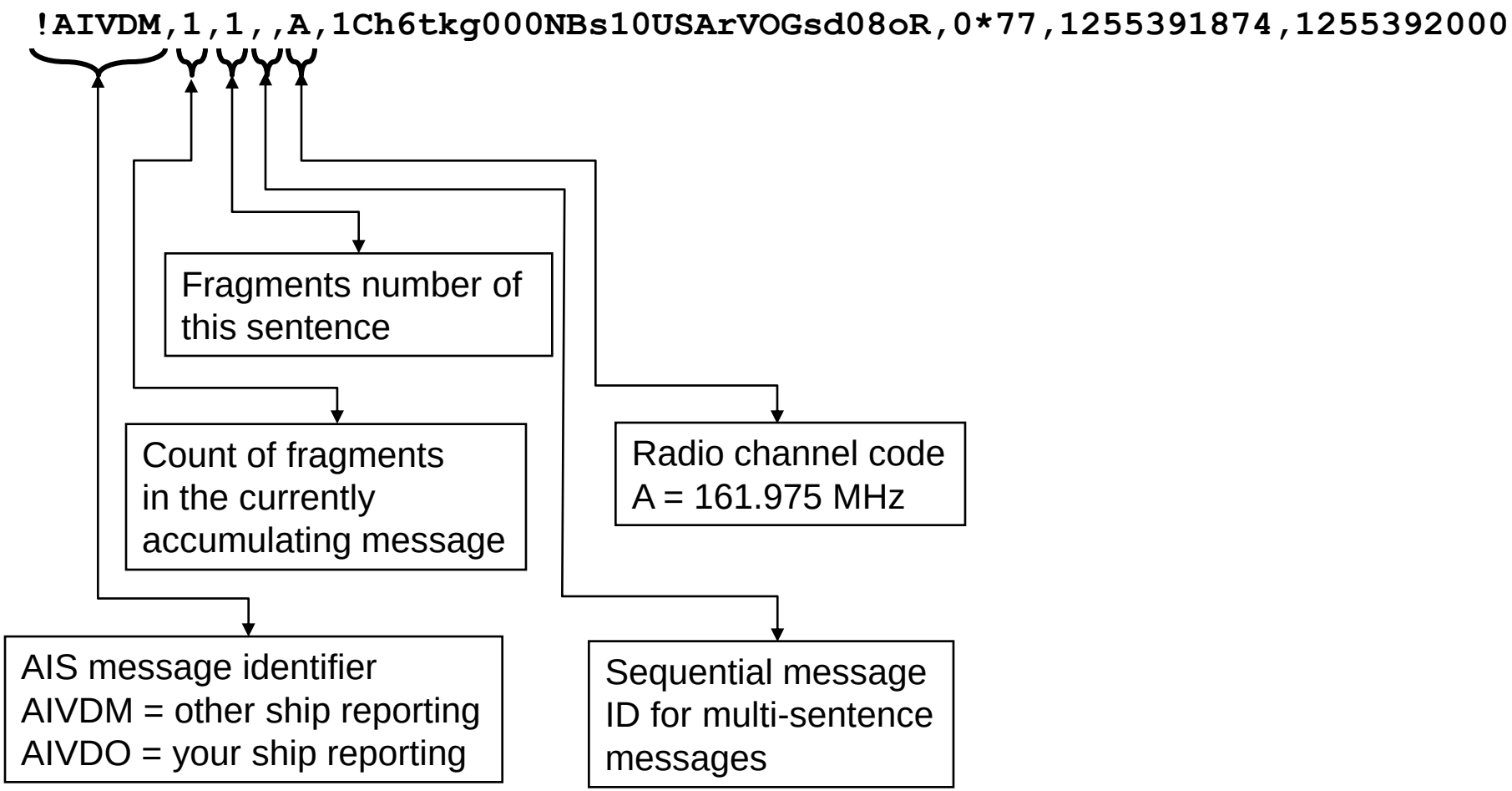


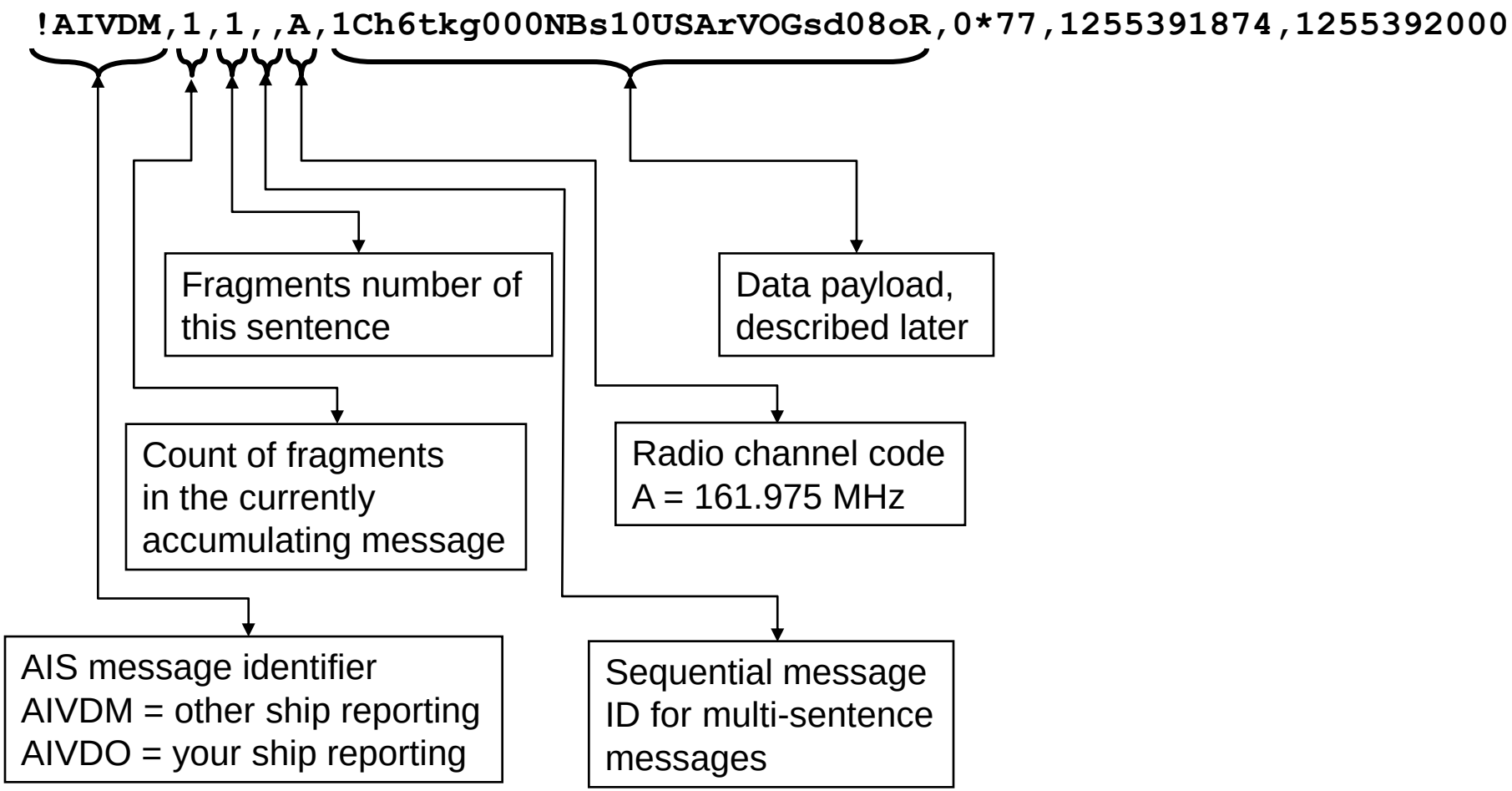
AIS Message Formats



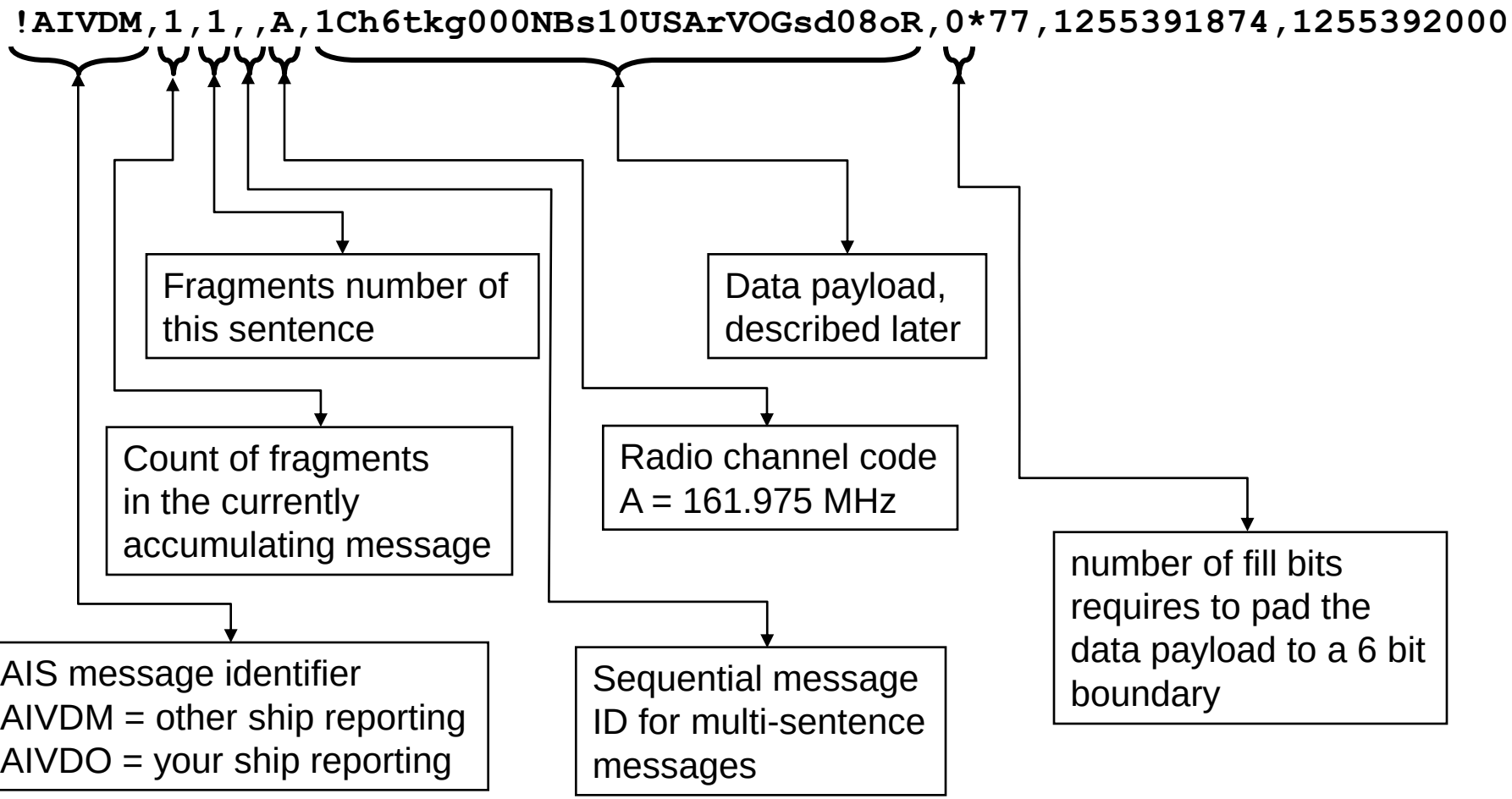
AIS Message Formats



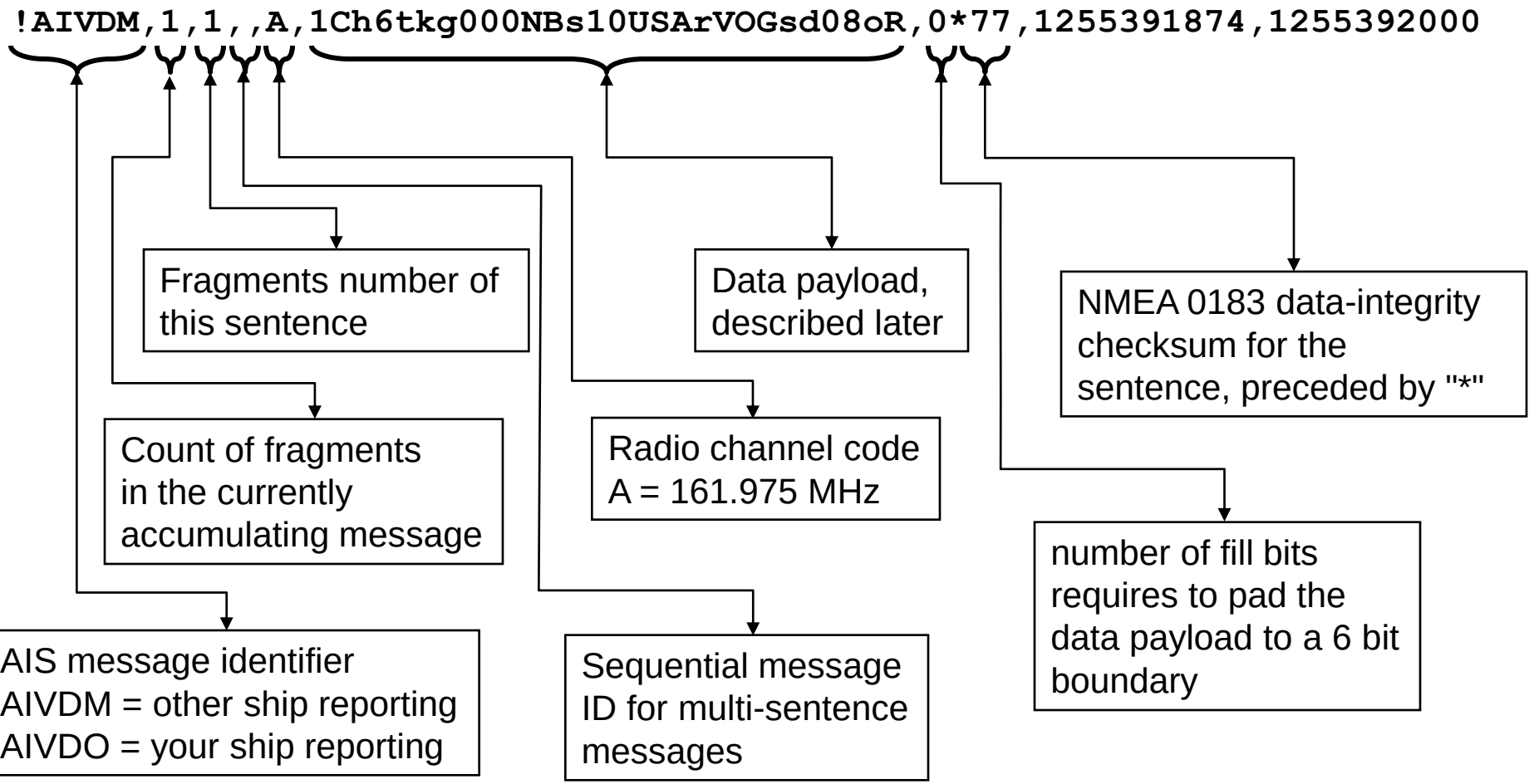
AIS Message Formats



AIS Message Formats



AIS Message Formats



AIS Message Formats – Data Payload

```
!AIVDM,1,1,,A,1Ch6tkg000NBs10USArVOGsd08oR,0*77,1255391874,1255392000
```

Data payload, described later

- Data payload uses 6-bit ASCII
- After recovering each 6-bit sequence they are combined together to provide the full binary of the data payload
- Each binary sequence then corresponds to information about the track
- Details of AIS messages (AIVDO and AIVDM messages) found at http://gpsd.berlios.de/AIVDM.html

Table 2. Sixbit ASCII

000000	0	"@"	010000	16	"P"	100000	32	" "	110000	48	"0"
000001	1	"A"	010001	17	"Q"	100001	33	"!"	110001	49	"1"
000010	2	"B"	010010	18	"R"	100010	34	"""	110010	50	"2"
000011	3	"C"	010011	19	"S"	100011	35	"\#"	110011	51	"3"
000100	4	"D"	010100	20	"T"	100100	36	"$"	110100	52	"4"
000101	5	"E"	010101	21	"U"	100101	37	"%"	110101	53	"5"
000110	6	"F"	010110	22	"V"	100110	38	"&"	110110	54	"6"
000111	7	"G"	010111	23	"W"	100111	39	"\'"	110111	55	"7"
001000	8	"H"	011000	24	"X"	101000	40	"("	111000	56	"8"
001001	9	"I"	011001	25	"Y"	101001	41	")"	111001	56	"9"
001010	10	"J"	011010	26	"Z"	101010	42	"*"	111010	58	":"
001011	11	"K"	011011	27	"["	101011	43	"\+"	111011	59	";"
001100	12	"L"	011100	28	"\"	101100	44	","	111100	60	"<"
001101	13	"M"	011101	29	"]"	101101	45	"-"	111101	61	"="
001110	14	"N"	011110	30	"\^"	101110	46	"."	111110	62	">"
001111	15	"O"	011111	31	"_"	101111	47	"/"	111111	63	"?"

AIS Message Formats – Data Payload

- This is the field that includes all of the data that typically is desired to be parsed out
  - Latitude and Longitude
  - Time stamp
  - Ship Name
  - Ship dimensions
  - MMSI – Mobile Marine Service Identifier
  - IMO ship identification number
  - Departure and Arrival ports
  - ETA
  - Can include shipping manifests

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NMEA 3.0 AIS Parser and KML File Writer

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AIS Parser and KML Output Writer

- C++ code to parse NMEA 3.0 AIS messages, form vessel tracks, and write to KML output files
- Support for all 26 messages types
- Sorts all AIS messages by MMSI/IMO and then by time to create “tracks”
- Combines static and dynamic message information to create track data

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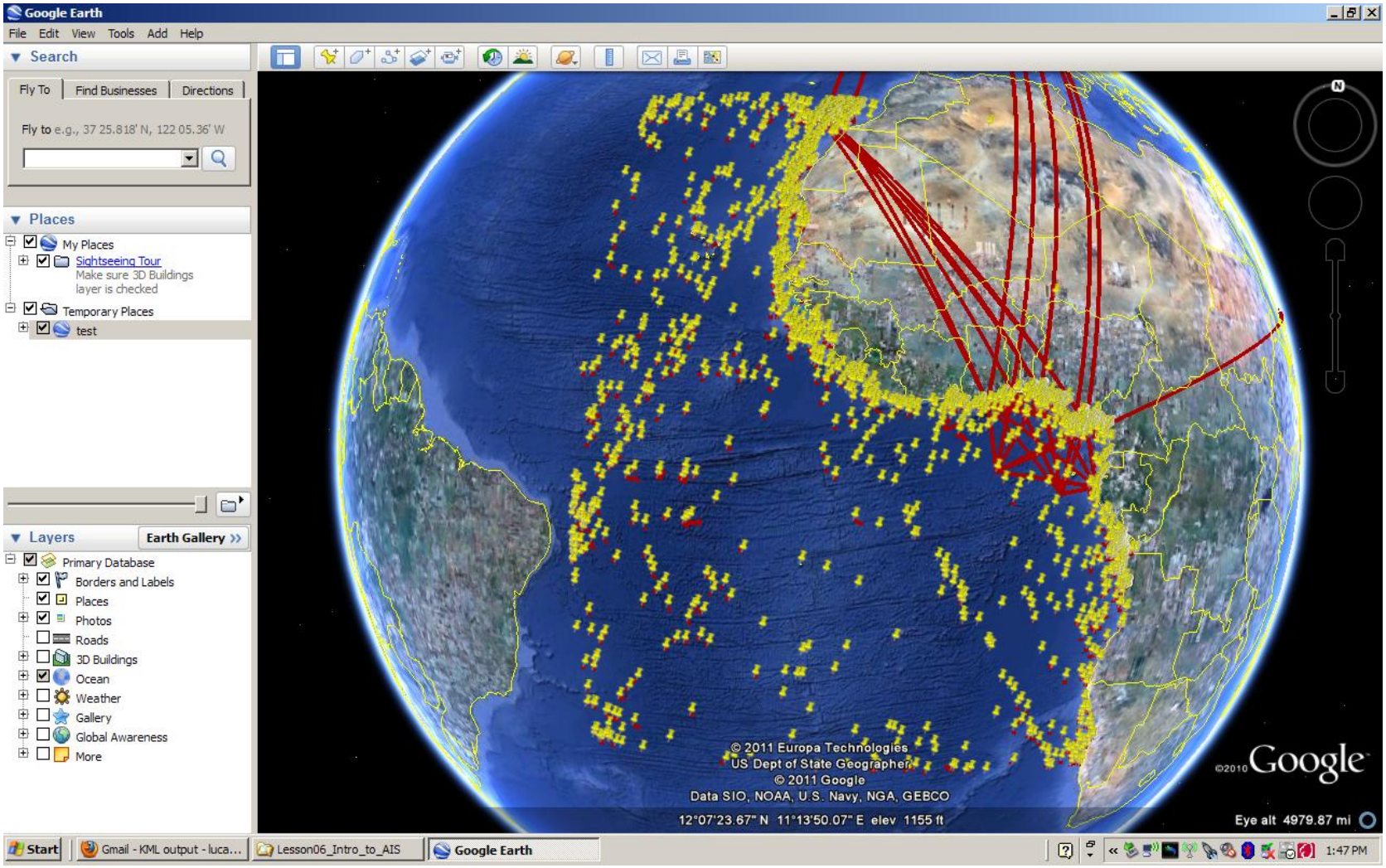
AIS Parser and KML Output Writer



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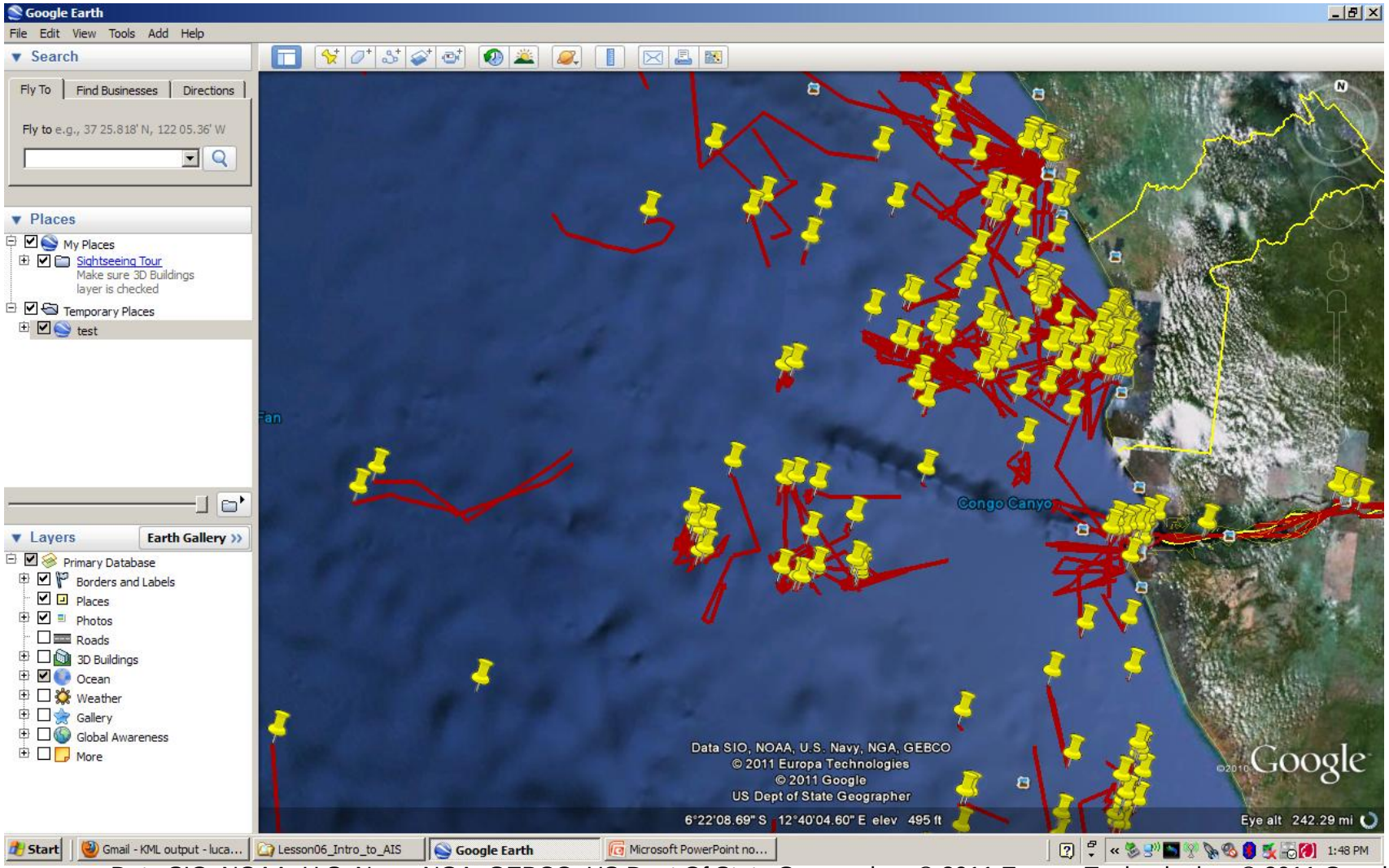
AIS Parser and KML Output Writer



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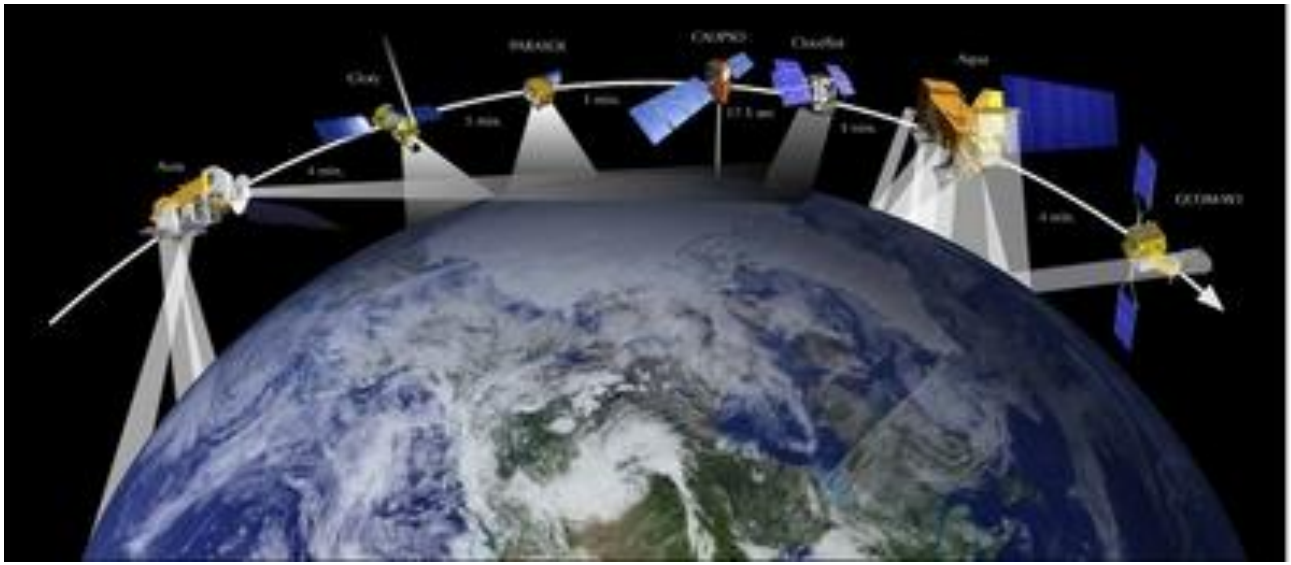
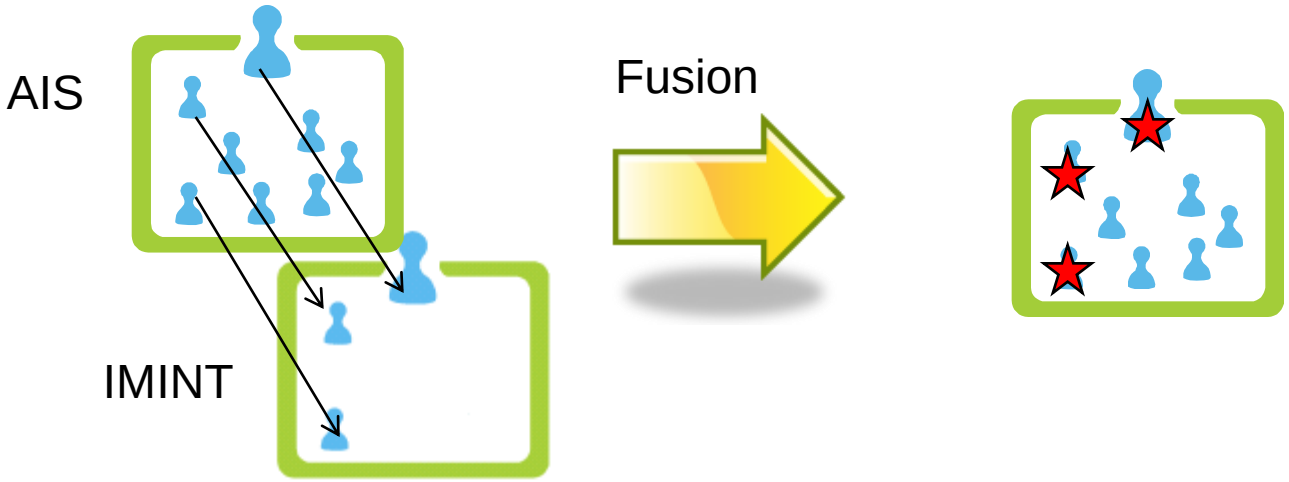
IMINT Overview

- IMINT – Imagery INTelligence
  - Intelligence gather via (satellites or aerial photography)
  - Possible to contain information such as geo-location, heading, size, etc…



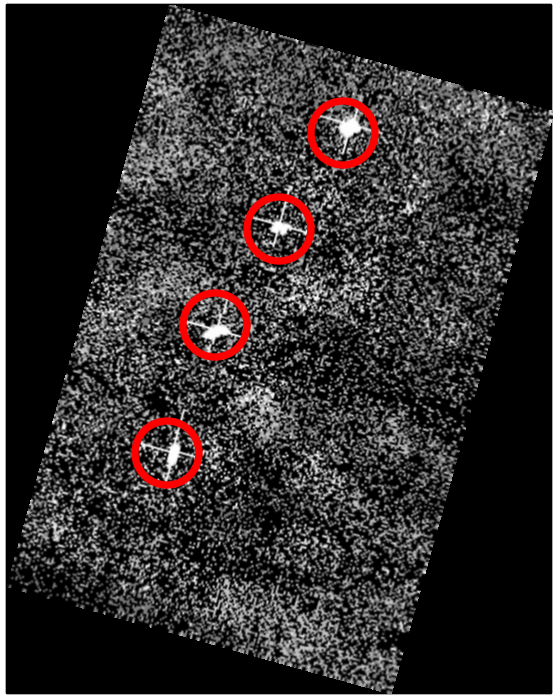
AIS / IMINT Fusion

- Fusion of two distinct intelligence sources to create a more complete picture of the environment
- Can be used to confirm IMINT detections of ships
- May find vessels which are large enough to have AIS, but do not have it enabled



AIS / IMINT Fusion

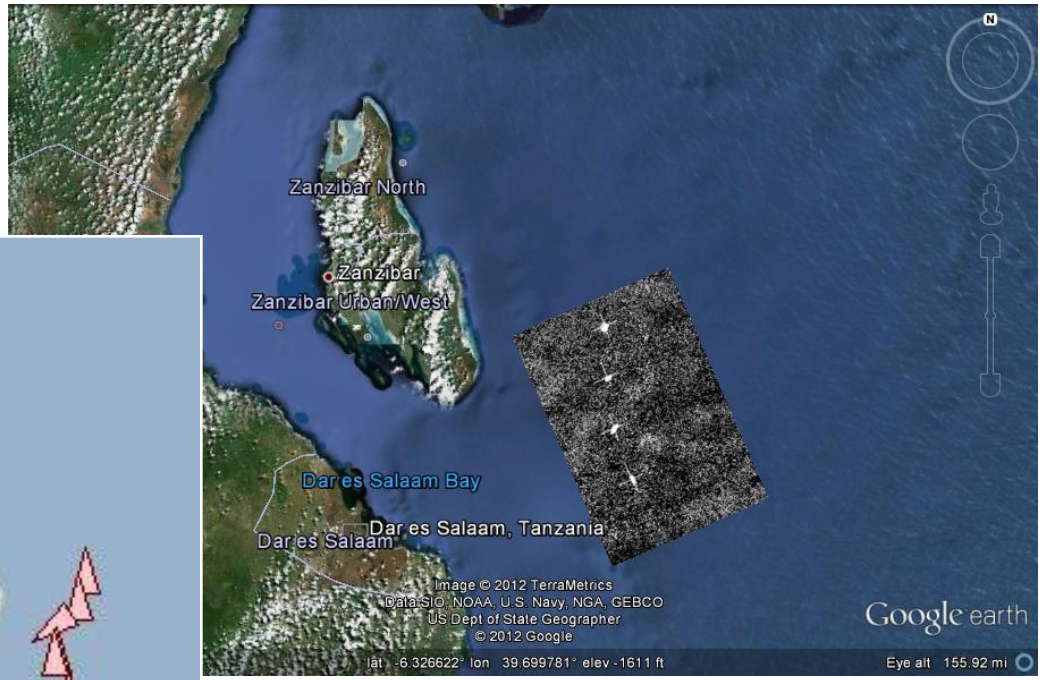
- Example of vessels detected via SAR imagery, not broadcasting AIS
- Series of “bright” objects on the ocean can be interpreted as ships
- Detection algorithm collects geolocation information for the contacts
- This information can be displayed in a wide variety of ways



Simulated SAR image

AIS / IMINT Fusion

- Example of vessels detected via SAR imagery, not broadcasting AIS
- Pink contacts are from SAR detection
- Green contacts are AIS



Simulated SAR image

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AIS / IMINT Fusion

- Example of vessels detected via SAR imagery and AIS – 12 hours apart

- Pink contacts are from SAR detection
- Green contacts are AIS
- Even 12 hours later you can still see some correlation!

AIS / IMINT Fusion

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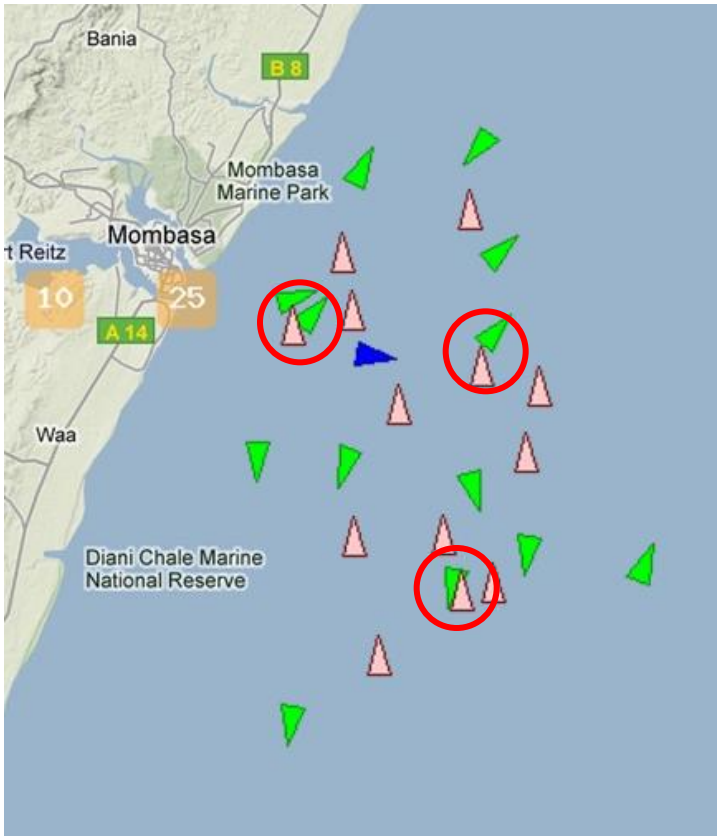

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OpenCV Matching

- OpenCV provides methods to find “keypoints” in an image
- Keypoints are interesting points in an image that are likely to be found in various lighting conditions and scales/rotations of the object
- We can compute “descriptor” vectors from those keypoints
- Descriptors are vectors that describe the keypoints mathematically (e.g. mean, standard deviation, etc of the surrounding keypoint)

OpenCV Matching

- Basic flow of matching
  - Find keypoints of image (using SIFT/SURF/HarrisCorners... etc)
  - Find descriptor vectors from those keypoints (sometimes based on local histograms)
  - Define a metric for distance between descriptors
  - Match descriptors from one set with descriptors from another set in a way that minimizes the distance

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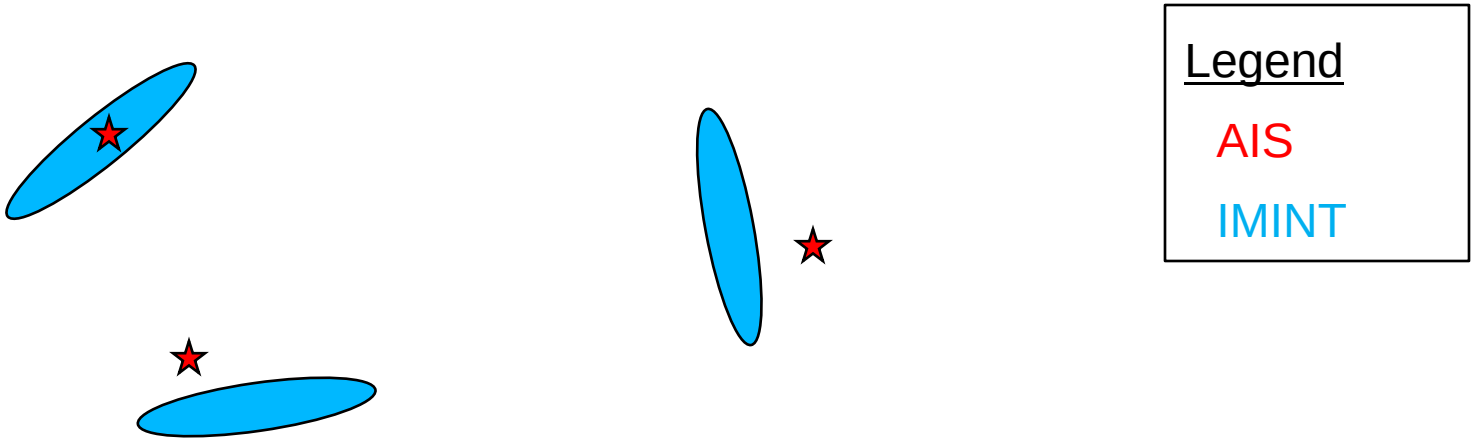
Code Example

- OpenCV has classes for matching descriptors
- We can use these classes to develop a simple AIS/IMINT correlator
- We used the BruteForceMatcher for this example. There are a few more with different functionality… check out the documentation for more information
- ..\Day5\codigo\AIS_IMINT_FUSION.zip

Code Example - Diagram



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Questions?

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