S-AIS Performance Analysis

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Outline

- Integration of S-AIS with SAR for ship detection and iceberg discrimination
- AIS dynamic and static reports
- Performance measures
  - Probability of detecting a single AIS position report
  - Probability of an (important) bit error

SAR Detections

- SAR provides accurate position reports
  - Requires correction due to Doppler shift
- AIS is *self-reporting* and may provide accurate position, speed, course, rate of turn, heading and MMSI
- Integration permits cross-validation of ship data and discrimination

AIS Reports

■ Dynamic messages (position reports)
- Message ID (Type): 1, 2 and 3 (Class A)
- Message ID (Type): 18, 19 (Class B)
- MMSI, position, etc.

■ Static messages
- Message ID: 5 (Class A), 24 (Class B)
- MMSI, IMO number, etc.

Performance Measures

- Probability of detecting a ship transmission
  - Signals from different SOTDMA cells interfere
  - Type 1 messages occupy 1 time slot
  - Type 5 messages occupy 2 consecutive slots
- Types 1 and 5 are affected differently by signal collisions
- Compare ratio of observed number of Type 1 to Type 5 to expected ratio
- In practice this needs the average time interval between transmissions

AIS Data Characteristics

- Reporting interval varies with ship speed, rate of turn, etc.
- Less than 100 Type 5 messages per day
  - Analyze several days for statistical stability
- Mainly Class A messages received: Very few Class B messages
  - No Type 19 observed

Typical Data

#	Message Description	N1	N2	N3
1	Position report (Scheduled)	22358	31351	31575
2	Position report (Assigned)	1	2	0
3	Position report (When interrogated)	1998	2608	2302
5	Static voyage and related data	76	102	106
18	Standard class B equipment position report	39	38	60
19	Extended class B equipment position report	0	0	0

Methodology

- Take the mean of the position reporting rates (Type 1) taking into account speed and rate of turn (course change)
  - Find average reporting rate and interval
- Type 5 reporting interval is 360 sec
- Calculate ratio of rates as if all AIS signals received
- Calculate observed ratio of rates
- Compare

Transmission Detection

Mean rate of reporting for type 1 (s^{-1})	0.123
Mean reporting interval for type 1 (s)	8.15
Mean reporting interval for type 5 (s)	360
Ratio of type 1 to type 5 reporting rates	44.17
Observed ratio of type 1 to type 5 messages	>121

Simplified Model

- Poisson signal collision statistics
- Assumes collisions occur at random
- Probability of receiving a one-slot message is p
- Probability of receiving a two-slot message is p^2
- Ratio of expected to observed ratios gives p

Frequency of Messages (29 files or days)
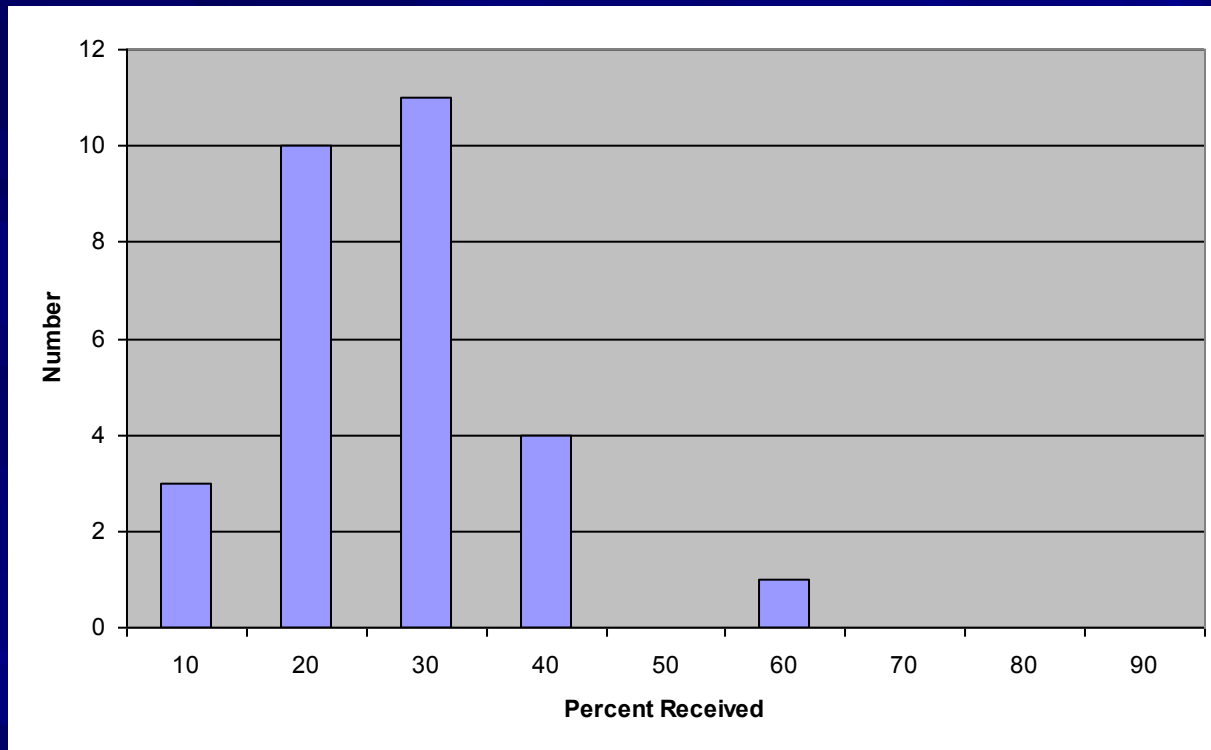
Probability is proportional to frequency

Bit Errors

- Terrestrial AIS uses Cyclic Redundancy Check to remove messages with errors
- Multiple bit errors may occur during S-AIS processing
- Check received positions (latitude and longitude) for large obvious errors
- Gives estimate of significant bit error rate
- Check against less significant bit errors

Typical Error Rates

File	N1	N2	N3
Number Type 1 Reports	22207	31141	31400
Number of Lat/Long Errors	8	4	5

Average Significant Error Rate: 0.014%

Bit Error Interpretation

- Error rate reflects errors in most significant digits of latitude, longitude or both
- If acceptable error bounds are reduced, error rate increases by factor of 5 or more
- Single slot contains 256 bits: Type 1 message length is 168 bits
- MMSI numbers could be incorrect

Error Sensitivity (Type 1)

- MMSI   30 bits
- Rate of Turn   8 bits
- Speed over Ground   10 bits
- Lat/Long   28 bits
- Course over Ground   12 bits

Conclusions

- Only Class A AIS reports are important

- Mainly Type 1 and Type 5 reports are useful

- According to simplified model, about 75% of messages are lost

- At least 2 ship reports are required for reliable AIS ship location

- Statistical model needs validation/improvement

- A full statistical analysis is needed to establish proper performance measures and bounds

END