IMSO
INTERNATIONAL MOBILE SATELLITE ORGANIZATION

Operational impact of maximum LRIT periodic information exchange under the coastal state entitlement

STATISTICAL BASIS FOR THE GENERALISATION OF LRIT SAMPLE TRAFFIC DATA TO ANNUAL ESTIMATES

Contents

List of Acronyms

CI	Confidence Interval
CV	Coefficient of Variation
DC	LRIT Data Centre
EU	European Union
HHI	Herfindahl-Hirschman Index
IDE	International Data Exchange
LRIT	Long-Range Identification and Tracking
NCP	Non-Centrality Parameter
NS	Not Statistically significant (at $\alpha = 0.05$)
R^2	Coefficient of Determination
SE	Standard Error
SOLAS	International Convention for the Safety of Life at Sea

1 Executive Summary

1.1 This annex documents the statistical validity of the one-month-per-DC sample used to extrapolate LRIT message traffic to annual estimates, and to assess IDE capacity requirements under full coastal State monitoring conditions. The scope of the analysis is limited to ships transmitting LRIT information to a registered Data Centre; no external fleet reference is used.

2 Description of the Sample

2.1 The dataset used in this experiment comprises LRIT traffic data drawn from 71 Data Centres (DCs) registered in the LRIT system, collectively representing 135 flag States. Each DC contributed one calendar month of operational LRIT traffic data, with the 71 DCs distributed across all 12 calendar months of the year, spanning the period July 2024 to July 2025.

2.2 Of the 71 DCs, 65 recorded at least one transmitting ship during their respective sample periods, accounting for a total of 39,517 SOLAS-compliant ships. The remaining 6 DCs recorded zero transmitting ships during their sample month. This outcome is operationally valid and consistent with historical LRIT data from previous years: it reflects periods during which no ships registered under those flag States transmitted LRIT information to the respective DC, rather than any deficiency in the sample design. These six DCs are therefore retained as valid observations in all statistical analyses, with a ship count of zero. The distribution of the sample data across the DCs is presented in table 1 of appendix 2.

2.3 The distribution of fleet size across DCs is highly heterogeneous, reflecting that some DCs have associated CGs with which Administrations have a large number of ships registered; in contrast, there are DCs receiving information from a limited number or no ship at all. The ten largest DCs account for approximately 81% of all ships in the dataset. The Herfindahl-Hirschman Index (HHI) was computed on the fleet-share distribution across all 71 DCs. The outcome was 0.0992, indicating a non-concentrated distribution of ships across DCs.

Table 1 - Distribution of Data Centres and Ships by Sample Month

Calendar Month	DCs Sampled	Ships Represented	Flag States
January	9	6,210	23
February	6	5,987	8
March	6	471	6
April	4	7,816	4
May	7	615	7
June	6	1,170	9
July	5	5,463	5
August	5	1,549	7
September	7	1,019	7
October	7	7,791	43
November	3	181	6
December	6	1,245	10
Total	71	39,517	135

2.4 All 12 calendar months are represented in the sample (Table 1), ensuring temporal completeness across the full annual cycle. The variability in ship counts across months reflects the unequal distribution of fleet sizes among the DCs assigned to each month, rather than any systematic seasonal pattern in vessel activity (a distinction that is confirmed statistically in Section 3).

3 Statistical Assessment of Sample Quality

3.1 Nature of the Dataset

3.1.1 The 71 DCs in this dataset constitute the entire population of LRIT Data Centres registered in the system; it is a complete census, not a random sample. The aggregated ship count of 39,517 is the directly observed total for the full DC population.

3.1.2 The purpose of the statistical assessment of the data sample is to verify that the one-month-per-DC audit sample for the 2025 audit schedule is suitable for extrapolating LRIT message traffic to annual estimates and for assessing IDE capacity under full coastal State monitoring conditions. Specifically, the sample assessment addresses two conditions that must hold for the extrapolation to be valid:

(a) the single month assigned to each DC must not be systematically biased: that is, months with disproportionately large or small fleets must not cluster together in ways that would skew the annual projection; and

(b) fleet composition must be sufficiently stable across the year that the observed ship counts can be treated as representative of the full 12-month period.

3.1.3 The tests that follow serve as diagnostic checks against these two conditions, and their results are interpreted in terms of whether any bias of practical significance, i.e. large enough to materially affect the annual message load estimate or the IDE capacity assessment, is present in the data.

3.2 Scope of the Dataset

3.2.1 The scope of this experiment is explicitly defined as all ships transmitting LRIT information to a registered DC in the 2025 audit schedule. A ship falls within scope if and only if it meets this criterion during the sample period; ships outside this definition are excluded by design. The fleet total of 39,517 ships, therefore, constitutes a complete count rather than an estimate drawn from a wider population, and no coverage ratio against an external reference is applicable or required.

3.3 Distribution of Fleet Size Across Data Centre

3.3.1 The fleet size distribution across the 71 DCs is strongly right-skewed (skewness = 3.456; excess kurtosis = 11.435), reflecting the concentration of ships registered under a small number of Administrations. A Shapiro-Wilk normality test confirms a significant departure from normality ($W = 0.4414$, $p < 0.001$). Applying a log(1+x) transformation, which accommodates the six DCs with zero-ship, produces a near-normal distribution ($W = 0.9744$, $p = 0.1557$; skewness = 0.003; excess kurtosis = -0.733). The log(1+x)-transformed fleet sizes are consistent with normality; accordingly, the original scale is highly skewed and non-parametric methods were used. The distributional statistics of fleet size across DC are summarised in Table 2.

Table 2 - Distributional Statistics for DC Fleet Sizes (n = 71)

Mean fleet size per DC	556.6 ships
Geometric mean	60.6 ships
Standard deviation	1,378.2 ships
Coefficient of variation	247.6%
Skewness (raw)	3.456
Excess kurtosis (raw)	11.435
Shapiro-Wilk W (raw)	0.4414 $p < 0.001$
Shapiro-Wilk W (log(1+x))	0.9744 $p = 0.1557$

3.4 Check for Seasonal Assignment Bias: Kruskal-Wallis Test

3.4.1 For the monthly-to-annual extrapolation to be valid, the fleet sizes of DCs must not vary systematically across the calendar months to which they were assigned. If, for example, months sampled early in the year consistently contained DCs with larger fleets than months sampled later, the resulting annual projection would be distorted. A Kruskal-Wallis test was applied as a diagnostic check to verify that no such grouping effect is present in the data.

3.4.2 The test yields $H = 9.6456$ (degrees of freedom = 11), $p = 0.5625$. The observed statistic is only 0.4902 of the critical value $\chi^2(11, \alpha = 0.05) = 19.6751$, well below the threshold at which a grouping effect would be considered detectable. The epsilon-squared effect size is $\varepsilon^2 \approx 0$, indicating that calendar month assignment accounts for essentially none of the variance in DC fleet sizes. The minimum effect size that would be detectable at 80% sensitivity is $\varepsilon^2 = 0.241$, but no effect approaching this magnitude was found. No statistically detectable month-group effect on fleet size was observed. The summary of the outcomes of the Kruskal-Wallis test is presented in Table 3**.**

Table 3 - Kruskal-Wallis Test Results

Test statistic H	9.6456
Degrees of freedom	11
Critical value $\chi^2(11, \alpha = 0.05)$	19.6751
H / χ^2_crit ratio	0.4902
p-value	0.5625
Effect size ε^2	≈ 0
Significance level α (Type I error)	0.05
Power $(1-\beta)$ at observed effect	0.05 (= α, as $\varepsilon^2 \approx 0$)
Sensitivity $(1-\beta)$ at observed effect	0.05 (effect ≈ 0; see note)
Minimum detectable bias (ε^2) at 80% sensitivity	0.241

3.4.3 The sensitivity figure $(1-\beta = 0.05)$ is a mathematical consequence of the negligible observed effect size: when the true effect is absent, no test can have power to detect it. The H statistic at less than half the critical value is a strong indication that no assignment bias of practical relevance to the annual extrapolation exists in this dataset.

3.5 Check for Monotonic Seasonal Trend: Spearman Rank Correlation

3.5.1 A complementary diagnostic check was applied to detect any monotonic trend across the calendar year; specifically, whether DC fleet sizes increase or decrease progressively from January to December. Such a trend, if present, would mean that the annual extrapolation is anchored to a systematically high or low portion of the year, introducing a directional bias in the estimated message load.

3.5.2 A Spearman rank correlation between the assigned calendar month number (1–12) and DC fleet size yields $r_s = -0.2039$, $p = 0.0881$ ($n = 71$). The observed correlation accounts for only $R^2 = 4.2\%$ of the variance in fleet sizes across DCs: a negligible proportion with no practical bearing on the annual estimate. The test has sufficient sensitivity to detect a medium-strength trend ($|r_s| = 0.327$, $R^2 = 10.7\%$) with 80% probability; no trend of this magnitude was found. Table 4 presents the Spearman Rank Correlation test results.

3.5.3 The p-value of 0.0881 is noted transparently. It falls short of the conventional 0.05 significance threshold and reflects a weak, practically insignificant negative tendency in the data. The Spearman test found only a weak, non-significant negative trend, with no practical effect on the annual estimate. Taken together, the Kruskal-Wallis and Spearman diagnostic checks provide convergent evidence that the monthly assignment of DCs introduces no seasonal distortion into the annual extrapolation.

Table 4 - Spearman Rank Correlation Test Results

Spearman r_s	-0.2039
p-value (two-tailed)	0.0881
R^2 (variance explained by month)	4.2%
Significance threshold α	0.05
Sensitivity ($1-\beta$) at observed r_s	40.0%
Practical significance threshold $|r_s|$ at 80% sensitivity	0.327
Min. detectable $|r_s|$ at 90% sensitivity	0.374
Min. detectable $|r_s|$ at 95% sensitivity	0.411

3.6 Temporal Representativeness: Jackknife Estimate

3.6.1 A jackknife resampling procedure was applied to the 12 monthly ship totals. In each of the 12 iterations, one month was omitted, and the mean monthly total was recomputed from the remaining 11 observations. The jackknife standard error is 883 ships, yielding a 95% confidence interval for the mean monthly total of [1,350 – 5,236 ships], with an observed mean of 3,293 ships. The width of this interval reflects the substantial variation in fleet sizes across months, driven by the unequal distribution of ships among Data Centres assigned to each month, rather than any instability in the underlying census total of 39,517 ships.

3.7 Annual Position Transmissions, Transmission Completeness & Confidence Interval

3.7.1 This section quantifies the total number of LRIT position transmissions generated annually by the ships in scope. These transmissions are the input to the main experiment: for each position received, the experiment determines which coastal States have that position within their 1,000 nautical mile monitoring polygon and records each such occurrence as a potential message to be exchanged between the flag State Data Centre and the relevant coastal State Data Centre via the IDE. The results are stored in a dedicated database for subsequent calculation of average IDE message load and peak traffic in messages per second. The annual transmission count, therefore, represents the volume of position events entering the experiment, not the IDE message load itself, which is determined downstream by the coastal State polygon analysis.

3.7.2 Under SOLAS Regulation V/19-1, each ship transmits LRIT information at a default interval of six hours, equivalent to four transmissions per day. Given that the 39,517 ships in the dataset constitute the complete in-scope population, the calculated total number for annual transmissions entering the experiment is:

$$39{,}517 \text{ ships} \times 4 \text{ transmissions/day} \times 365 \text{ days} = 57{,}694{,}820 \text{ transmissions/year}$$

3.7.3 This figure represents the upper bound for capacity planning purposes, assuming full and continuous transmission by all ships throughout the year. It is used for IDE infrastructure dimensioning in Annex 2.

3.7.4 The aggregated 30-day sample across all 71 DCs contains 3,042,131 standard six-hourly position reports. The theoretical expectation for the same period is:

39,517 ships × 4 transmissions/day × 30 days = 4,742,040 transmissions/month

3.7.5 The observed count is therefore 35.8% below the theoretical maximum. This shortfall is not a deficiency of the sample design, the sample contains all and only the 6/6 periodic messages actually transmitted during the respective sample periods, with no filtering or omission. The gap reflects real-world LRIT transmission behaviour: ships undergoing repairs, modifications or conversions in port or dry dock may reduce their transmission frequency to one per 24 hours or suspend transmission entirely in accordance with paragraph 4.4.1 of resolution MSC.263(84)/Rev.1; equipment failures and connectivity interruptions account for a further portion; and a fraction represents non-compliant gaps. This interpretation is consistent with the finding reported in document NCSR 12/INF.3, paragraph 29, that approximately 36% of ships across all DCs and participating flags experienced at least one reporting gap of 24 hours or more within a 30-day period, a figure that is broadly consistent with the 35.8% shortfall observed here and provides independent corroboration that the sample is capturing the operational state of the system accurately.

3.7.6 The 35.8% shortfall does not affect the validity of the annualized estimates for the following reasons. First, the theoretical maximum is retained as the basis for IDE capacity planning in Annex 2: dimensioning infrastructure against the upper bound is the conservative and appropriate approach. Second, the actual transmission rate observed in the sample is itself a stable empirical characteristic of the fleet that, provided it is not distributed unevenly across the calendar year, is equally valid as a basis for annualization of the observed traffic.

3.7.7 The only remaining source of temporal uncertainty in applying this figure to a full calendar year is fleet volatility: i.e. ships being added to or removed from the LRIT system by Administrations during the year. The uncertainty is quantified empirically from the LRIT system's own historical annual fleet counts, as shown in Table 5, requiring no external reference. Since the experiment processes each position transmission individually and stores results in a segregated database, any change in fleet composition during the year is naturally captured in the position records as it occurs. The confidence interval below therefore characterises the uncertainty in the annual transmission count used for capacity planning purposes.

Table 5 - Historical LRIT Fleet Size (Ships Transmitting to the System)

Year	Ships Transmitting	Annual Change	% Change
2018	35,589	—	—
2019	36,243	+654	1.84%
2020	36,364	+121	0.33%
2021	36,444	+80	0.22%
2022	36,882	+438	1.20%
2023	38,860	+1,978	5.36%
2024	38,767	-93	-0.24%
2025	39,517	+750	1.93%

3.7.8 Over the 2018–2025 period, the mean absolute annual change is 588 ships, with a standard deviation of 671.61 ships. The fleet shows a statistically significant upward trend (slope = +571.9 ships/year, $R^2 = 0.8967$, $p = 0.0004$), confirming that the 2025 figure of 39,517 ships highest recorded count and is appropriate as the basis for capacity planning. Applying the empirical standard deviation as the uncertainty measure and a 95% confidence interval ($z = 1.96$):

σ = 671.61 ships (calculated as the sample standard deviation of the absolute annual changes in LRIT transmitting fleet size over 2018–2025)

95% CI: [55,772,935 – 59,616,705] transmissions/year (±3.3%)

3.7.9 The corresponding 95% confidence interval for the empirical annual transmission estimate is:

95% CI: [35,779,000 – 38,308,000] transmissions/year (±3.3%)

3.7.10 Both intervals are grounded entirely in observed LRIT system data. The theoretical upper bound interval is used for infrastructure dimensioning; the empirical interval characterises the expected operational range.

4 Summary of Statistical Quality Metrics

4.1 The statistical analysis set out in this annex confirms that the one-month-per-DC sample is fit for the purpose of extrapolating LRIT message traffic to annual estimates and for assessing IDE and DC capacity requirements under full coastal State monitoring conditions.

4.2 The dataset constitutes a complete census of all 71 LRIT Data Centres registered in the system, covering 135 flag States and 39,517 SOLAS-compliant ships, representing the entirety of the in-scope transmitting population. All 12 calendar months of the year are represented. The distributional analysis confirms that DC fleet sizes follow a log-normal distribution, consistent with the known concentration of vessel registration, and that non-parametric diagnostic methods are appropriate throughout.

4.3 The Kruskal-Wallis test on fleet size ($H = 9.6456$, $p = 0.5625$; $\varepsilon^2 \approx 0$) confirms the absence of any seasonal assignment bias of practical significance in DC fleet composition. The Spearman rank correlation ($r_s = -0.2039$, $p = 0.0881$; $R^2 = 4.2\%$) detects no monotonic seasonal trend in fleet size capable of introducing a directional distortion into the annual extrapolation. The jackknife resampling procedure confirms the stability of the monthly mean across all 12 calendar months.

4.4 The aggregated 30-day sample contains 3,042,131 standard six-hourly position reports against a theoretical maximum of 4,742,040, yielding a fleet-wide Transmission Completeness Rate (TCR) of 0.642. This 35.8% shortfall reflects the known operational state of the LRIT system, including authorised transmission reductions, equipment and connectivity gaps, and non-compliant interruptions. This interpretations is corroborated by the findings in document NCSR 12/INF.3 that approximately 36% of ships experienced at least one reporting gap of 24 hours or more within a 30-day period.

4.5 Two annualized transmission estimates are therefore established. The theoretical upper bound (57,694,820 transmissions/year; 95% CI: 55,772,935 – 59,616,705; ±3.3%) assumes full and continuous transmission by all ships and is used as the basis for IDE infrastructure dimensioning in Annex 2, providing the conservative maximum load against which capacity must be assessed. The empirical estimate (37,043,672 transmissions/year; 95% CI: approximately 35,779,000 – 38,308,000; ±3.3%) reflects observed fleet-wide transmission behaviour and represents the expected operational load under realistic conditions. Both intervals are grounded entirely in observed LRIT system data and require no external reference.

4.6 Taken together, these results confirm that the sample design meets the requirements for statistical validity. The theoretical upper bound provides a reliable and demonstrably conservative basis for infrastructure planning; the empirical estimate characterizes the realistic operational range. The use of the upper bound for capacity dimensioning in Annex 2 ensures that the conclusions of this study do not underestimate the load that the LRIT system would need to sustain.

4.7 The consolidated metrics supporting these conclusions are set out in Table 6 below.

Table 6 - Consolidated Statistical Quality Metrics

Metric	Value
Dataset Overview	
Total DCs in LRIT system	71
DCs with transmitting ships	65
DCs with zero ships (valid observations)	6
Total flag States represented	135
Total ships in scope (complete population)	39,517
Calendar months covered	12 / 12 (100%)
Fleet Size Distribution	
Distribution of DC fleet sizes	Log-normal (W = 0.9744, p = 0.1557)
Kruskal-Wallis H — fleet size (seasonal group test)	9.6456, $p = 0.5625$ (NS)
— Effect size ε^2	≈ 0
— Significance threshold α	0.05
— Sensitivity at observed effect ($\varepsilon^2 \approx 0$)	5% (= α; no detectable effect)
— Min. detectable bias ε^2 at 80% sensitivity	0.241
Spearman r_s — fleet size (monotonic trend test)	−0.2039, $p = 0.0881$ (NS)
— R^2 (variance explained by month)	4.2%
— Sensitivity ($1-\beta$) at observed r_s	40.0%
— Min. detectable $\|r_s\|$ at 80% sensitivity	0.327
Jackknife standard error of monthly total	883 ships
Jackknife 95% CI for monthly mean	[1,350 – 5,236 ships]
Transmission Completeness	
Standard position reports in sample (actual)	3,042,131
Theoretical maximum for sample period	4,742,040
Fleet-wide Transmission Completeness Rate (TCR)	0.642 (64.2%)
Cross-validation: NCSR 12/INF.3 gap finding	~36% of ships with ≥24 h gap (consistent with TCR)
Annual Transmission Estimates	
Theoretical Upper Bound (basis: full compliance assumed)	
Point estimate	57,694,820 transmissions/year
95% CI (empirical fleet variability)	[55,772,935 – 59,616,705]
Relative uncertainty	±3.3% ($\sigma = 671.61$ ships)
Purpose	Infrastructure dimensioning — conservative maximum
Empirical Estimate (basis: observed fleet-wide TCR = 0.642)	
Point estimate	37,043,672 transmissions/year
95% CI	[~35,779,000 – ~38,308,000]
Relative uncertainty	±3.3%

Metric	Value
Purpose	Expected operational load under realistic conditions
NS = not statistically significant at α = 0.05.	

Appendix 1 - Step-by-Step Statistical Calculations

1 Distributional Analysis

The following calculations characterise the distribution of ship counts across the 71 DCs.

$N = 71$ Data Centres
Sum of ships = 39,517
Mean (μ) = 39,517 / 71 = 556.6
Standard deviation (s) = 1378.2
$CV = s / \mu$ = 1378.2 / 556.6 = 247.6%
Skewness = 3.456 (strongly right-skewed; 0 = symmetric)
Excess kurtosis = 11.435 (heavy-tailed; 0 = normal)

Shapiro-Wilk test for normality (raw values):

$W = 0.4414$, $p < 0.001$ → Distribution is NOT normal

Log(1+x) transformation applied to accommodate zero values:

$\log(1 + x_i)$ applied to all 71 DC ship counts
Shapiro-Wilk on transformed values: $W = 0.9744$, $p = 0.1557$
Skewness (log) = 0.003 Kurtosis (log) = -0.733
Geometric mean = $\exp(\text{mean}(\log(1+x))) - 1$ = 60.6 ships

Conclusion: DC fleet sizes follow a log-normal distribution. Non-parametric tests are required for seasonal analysis.

2 Kruskal-Wallis Test Calculation

The Kruskal-Wallis H statistic checks whether DC fleet sizes differ systematically across the 12 calendar month groups, which would indicate a seasonal assignment bias that could distort the annual extrapolation.

$$H = [12 / (n(n+1))] \times \Sigma(R_j^2 / n_j) - 3(n+1)$$

where n = total observations, n_j = observations in group j, R_j = sum of ranks in group j.

$n = 71$ (total DCs across all months)
$k = 12$ (number of month groups)
$H = 9.6456$
Degrees of freedom = $k - 1 = 11$
Critical value: $\chi^2(df=11, \alpha=0.05) = 19.6751$
$H / \chi^2_{crit} = 9.6456 / 19.6751 = 0.4902$ (<< 1.0)
p-value = 0.5625 >> $\alpha = 0.05$ → No seasonal assignment bias detected

Effect size — epsilon-squared:

$\varepsilon^2 = \max(0, (H - k + 1) / (n - k))$
$\varepsilon^2 = \max(0, (9.6456 - 12 + 1) / (71 - 12))$
$\varepsilon^2 \approx 0$ → Month assignment explains ≈ 0% of variance in DC fleet sizes

Sensitivity analysis — minimum detectable bias at 80% sensitivity:

Using non-central chi-squared approximation: $H \sim \chi^2(k-1, NCP)$ where $NCP = \varepsilon^2 \times (n-1)$

$$\text{Solve: } 1 - F\_\chi^2(\chi^2\_crit;\ df=11,\ NCP=\varepsilon^2\times(n-1)) = 0.80$$
$\rightarrow$ Minimum detectable bias ε^2 at 80% sensitivity = 0.241

3 Spearman Rank Correlation Calculation

The Spearman rank correlation checks for a directional seasonal trend: whether DC fleet sizes increase or decrease monotonically across the calendar year in the order months were assigned. Such a trend would introduce a directional bias into the annual extrapolation.

$$r_s = 1 - [6 \times \Sigma d^2_i / (n(n^2-1))]$$

where d_i = difference in ranks between month number and ship count for DC i.

$n = 71$
$r_s = -0.2039$
$p = 0.0881$ (two-tailed) $> \alpha = 0.05 \rightarrow$ No directional seasonal trend detected
$R^2 = r_s^2 = (-0.2039)^2 = 0.0416$ (4.2% of variance explained)

Sensitivity analysis: minimum detectable trend at 80% sensitivity, using Fisher z-transformation (Cohen, 1988; Zar, 2010):

$z = \text{arctanh}(|r_s|) = \text{arctanh}(0.2039) = 0.2068$
$SE(z) = 1 / \sqrt{(n - 3)} = 1 / \sqrt{(71 - 3)} = 0.1213$
$NCP = z / SE(z) = 1.7053$
$z_{\alpha/2}$ (two-tailed, α=0.05) = 1.9600
Sensitivity $(1-\beta) = 1 - \Phi(z_{\alpha/2} - NCP) + \Phi(-z_{\alpha/2} - NCP) = 40.0\%$
β (missed-detection rate) = 1 − Sensitivity = 60.0%

Minimum detectable trend $|r_s|$ at 80% sensitivity:

z_β (80% power) = $\Phi^{-1}(0.80) = 0.8416$
$min\_z = (z_{\alpha/2} + z_\beta) \times SE(z) = (1.9600 + 0.8416) \times 0.1213 = 0.3397$
$\min |r_s| = \tanh(min\_z) = 0.327$ (R^2 = 10.7%)

4 Jackknife Resampling Calculation

The jackknife procedure assesses sensitivity of the mean monthly ship total to the omission of any single month. Table 1 presents the Jackknife mean calculated by excluding each month and the deviation from the grand mean.

Grand mean of monthly totals = 3293
Jackknife SE = $\sqrt{[(n-1)/n \times \Sigma(\hat{\theta}_i - \bar{\theta})^2]}$ = 883 ships
$t_{critical}$ (df=11, α=0.05) = 2.201
95% CI = [3293 ± 2.201 × 883]
= [1,350 – 5,236 ships]

Table 1 - Monthly Ship Totals and Jackknife Iterations

Month	Monthly Total (ships)	Jackknife Mean (−this month)	Deviation from Grand Mean
January	6,210	3028	-265
February	5,987	3048	-245
March	471	3550	+257
April	7,816	2882	-411
May	615	3537	+243
June	1,170	3486	+193
July	5,463	3096	-197
August	1,549	3452	+159
September	1,019	3500	+207
October	7,791	2884	-409
November	181	3576	+283
December	1,245	3479	+186

5 Annual Position Transmissions and Confidence Interval

Annual position transmissions from ships in scope: the input stream to the coastal State polygon analysis (deterministic calculation). IDE message load is derived downstream from the polygon matching results.

Transmission rate = 1 per 6 hours = 4 per day (SOLAS V/19-1)
Transmissions/ship/year = 4 × 365 = 1460
Annual transmissions = 39,517 × 1460 = 57,694,820

Confidence interval based on empirical LRIT fleet variability (2018–2025):

σ = std(absolute annual ship count changes, 2018-2025, ddof=1) = 671.61 ships
95% CI lower = (39,517 - 1.96 × 671.61) × 1460 = 55,772,935
95% CI upper = (39,517 + 1.96 × 671.61) × 1460 = 59,616,705
95% CI = [55,772,935 - 59,616,705] transmissions/year (+-3.3%)

Appendix 2 - Sample dataset

Table 1 lists all 71 Data Centres included in the analysis, together with their LRIT ID, assigned sample month, number of flag States, and ship count. Data Centres with zero ships are retained as valid observations.

Table 1 - Complete DC Dataset (n = 71)

Data Centre	Sample Month	Flag States	Ships
LRIT DC 01	September 2024	1	6
LRIT DC 02	May 2025	1	30
LRIT DC 03	November 2024	1	12
LRIT DC 04	October 2024	6	546
LRIT DC 05	October 2024	1	117
LRIT DC 06	July 2025	1	1,168
LRIT DC 07	January 2025	4	234
LRIT DC 08	September 2024	1	60
LRIT DC 09	December 2024	1	313
LRIT DC 10	September 2024	1	0
LRIT DC 11	May 2025	1	17
LRIT DC 12	August 2025	1	64
LRIT DC 13	January 2025	2	65
LRIT DC 14	January 2025	3	2,570
LRIT DC 15	December 2024	1	2
LRIT DC 16	September 2024	1	78
LRIT DC 17	September 2024	1	0
LRIT DC 18	May 2025	1	5
LRIT DC 19	July 2024	1	34
LRIT DC 20	March 2025	1	80
LRIT DC 21	December 2024	1	6
LRIT DC 22	July 2025	1	23
LRIT DC 23	February 2025	3	426
LRIT DC 24	June 2025	1	232
LRIT DC 25	March 2025	1	87
LRIT DC 26	August 2024	1	2
LRIT DC 27	January 2025	1	10
LRIT DC 28	September 2024	1	407
LRIT DC 29	February 2025	1	14
LRIT DC 30	December 2024	1	0
LRIT DC 31	May 2025	1	11
LRIT DC 32	February 2025	1	5,257
LRIT DC 33	March 2025	1	244
LRIT DC 34	July 2025	1	4,221
LRIT DC 35	July 2024	1	17
LRIT DC 36	March 2025	1	17
LRIT DC 37	April 2025	1	10
LRIT DC 38	February 2025	1	1
LRIT DC 39	October 2024	1	34
LRIT DC 40	May 2025	1	6
LRIT DC 41	April 2025	1	6,441
LRIT DC 42	October 2024	1	0
LRIT DC 43	August 2024	1	130

Data Centre	Sample Month	Flag States	Ships
LRIT DC 44	May 2025	1	50
LRIT DC 45	September 2024	1	468
LRIT DC 46	April 2025	1	1,192
LRIT DC 47	January 2025	1	312
LRIT DC 48	June 2025	1	4
LRIT DC 49	April 2025	1	173
LRIT DC 50	February 2025	1	214
LRIT DC 51	January 2025	1	2,322
LRIT DC 52	January 2025	7	13
LRIT DC 53	June 2025	1	12
LRIT DC 54	August 2024	1	177
LRIT DC 55	June 2025	1	1
LRIT DC 56	January 2025	1	300
LRIT DC 57	November 2024	4	159
LRIT DC 58	November 2024	1	10
LRIT DC 59	June 2025	4	438
LRIT DC 60	October 2024	1	60
LRIT DC 61	June 2025	1	483
LRIT DC 62	February 2025	1	75
LRIT DC 63	March 2025	1	0
LRIT DC 64	May 2025	1	496
LRIT DC 65	December 2024	1	0
LRIT DC 66	March 2025	1	43
LRIT DC 67	October 2024	1	59
LRIT DC 68	December 2024	5	924
LRIT DC 69	October 2024	32	6,975
LRIT DC 70	January 2025	3	384
LRIT DC 71	August 2024	3	1,176

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