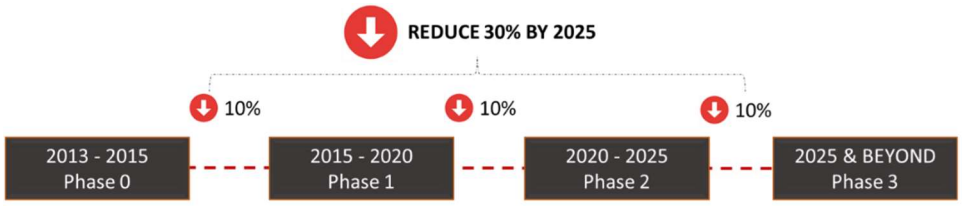
Maritime Energy Efficiency

AUTHORS:

Widya Salim (A0231857Y)
Rachel Sng Wei Lin (A0231921N)
Susan Koruthu (A0231905L)
Gino Martelli Tiu (A0231956Y)

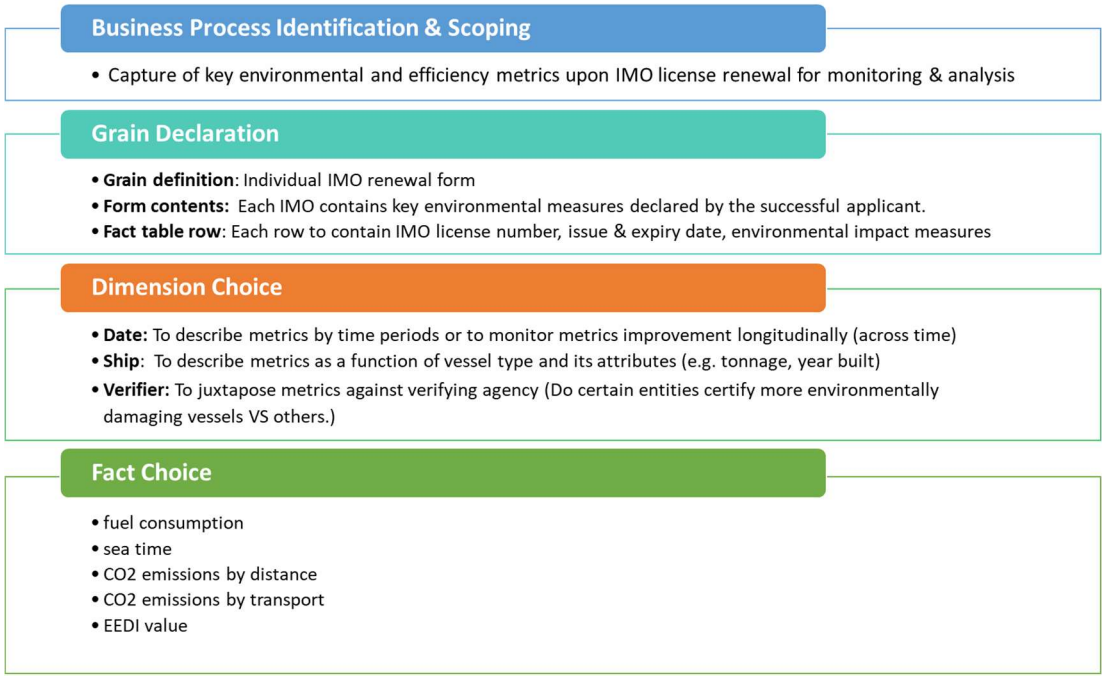
Section 1: Four-Step Dimensional Design

Owing to climate change impacts in recent years, there has been increased international focus on our effect on the environment. The shipping industry takes this into account when reviewing ship licenses for renewal. Verifiers are mandated to check various environmental impact metrics submitted by applicants, along with benchmarking a vessel's EEDI value against milestone reduction targets.



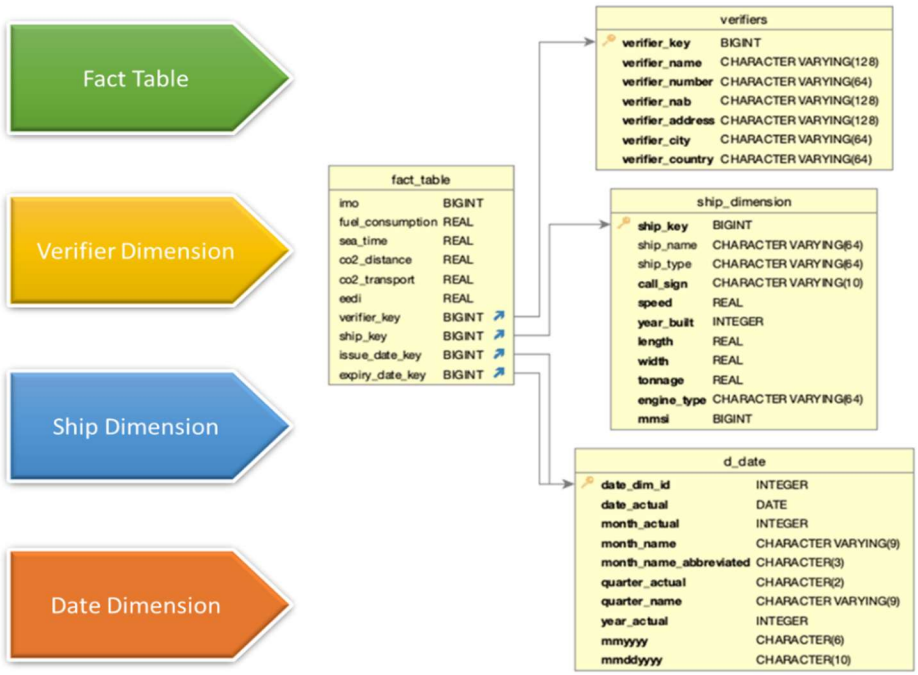
To assess the effectiveness of this process, the team designed 3 core visualizations aimed at assisting verifiers and various governance bodies to see the environmental footprint of these approved ships through different data slices post renewal.

With this in mind, we go through the below four-step dimensional design to come up with our design schema.



Section 2: Star Schema and Dimension Tables

Aligned with Kimball's recommendation of a star join schema, this design ensures ease of slicing data for analytical purposes as well as scalability in updating tables in case new measures or dimension attributes are needed in the future. We examine each of the individual components more closely in the following subsections.



2.1 Fact Table (FT)

The fact table consists solely of the business process measures we want to evaluate together with foreign keys connecting it to each dimension table.

Some important notes:

- All measures save for sea time and fuel consumption are non-additive and must be averaged.
- There also are two date columns (issue & expiry). Analysis will primarily be carried out based on issue date as we would like to measure changes in environmental measures with each successive month of license issuance.

2.2 Ship Dimension Table (SD)

Linked to the fact table via ship key, the ship dimension contains defining characteristics of vessels up for renewal. These include physical measurements of the ship, year built, engine type as well as various identifiers such as call sign and MMSI. Attributes such as year the ship is built and engine type will later factor in the analysis of EEDI compliance.

2.3 Verifier Dimension Table (VD)

The verifier dimension contains particulars of agencies tasked with vetting monitoring plans, emissions reports and the subsequent issuance or renewal of licenses. Details such as name and number are captured together with location particulars such as address rolling up to city and country level. Linked to the fact table by a static verifier ID, intent is to analyze the effectiveness of verifiers based on the performance of ships they license.

2.4 Date Dimension Table (DD)

The date dimension has been structured at a monthly level, rolling up to quarterly and yearly. Daily data, while captured in the IMO form, is not needed for this business process as it is overly granular.

2.5 On the Nature of Keys

All primary keys in the dimension tables (and by extension, the foreign keys in the fact table) are represented by sequential integer surrogate keys. This is to ensure that overall the linkages are robust to change and avoid embedding non-static intelligence in the keys.

For example, the initial operational key to *verifier* would have been the verifier name, but this is open to change (even if rare). The only exception is the date dimension key which remains an integer consisting of the year, month and day as this is not likely to change.

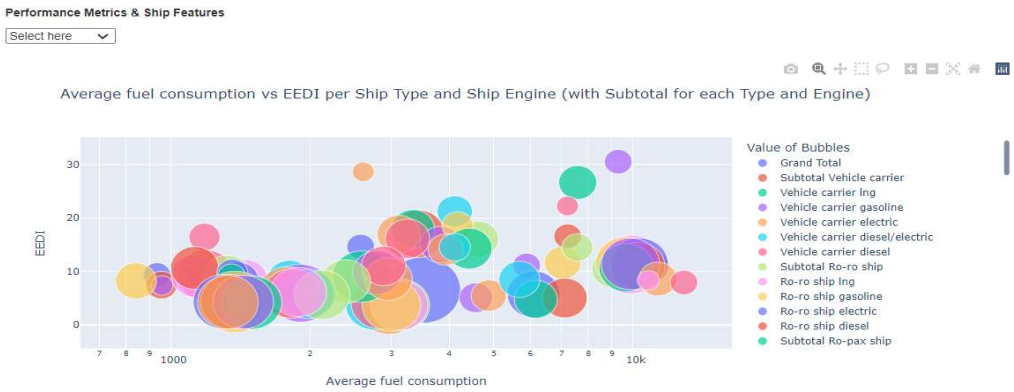
In this star schema structure, IMO number is now a degenerate dimension that does not link to any specific dimension table but remains as simply an operational transaction number. As IMO number may be reassigned in subsequent years, it cannot serve as a primary key of the fact table on its own and should be combined with the foreign keys to identify a unique transaction.

Section 3: Key Queries & Visualization

To allow users a better platform for analysis, we designed interactive dashboards together with supporting SQL queries to answer the below questions:

- How does the efficiency metric or ship dimension of each type- engine pair correlate VS fuel consumption?
- Which verifiers are prone to certifying or re-certifying non-efficient/ more damaging ships?
- What is the reported efficiency variance of ships (in percentile) based on year built?

3.1 Ship Performance (FT)/ Ship Dimension (SD) VS. Fuel Consumption



Rationale:

- Different performance metrics and ship dimension for each vessel type and engine pair are plotted against fuel consumption

- Intent is to determine if there is correlation between different performance metrics or ship dimensions with fuel consumption.

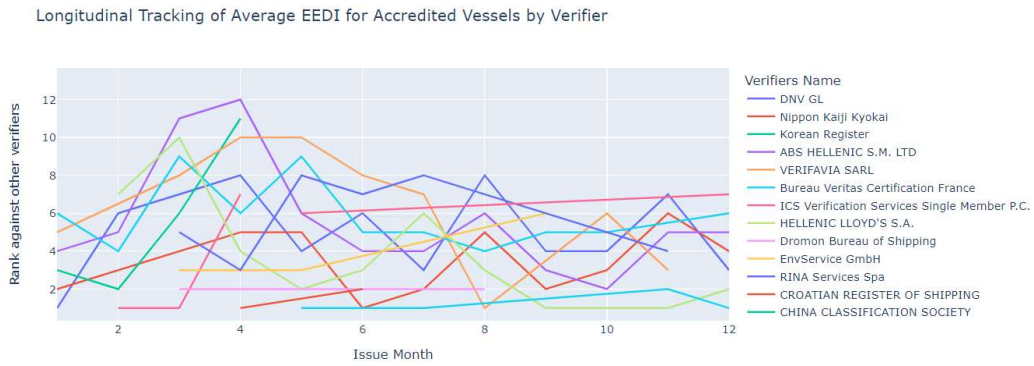
Visualization Notes:

- Variable to correlate VS fuel consumption can be selected from dropdown.
- Legend housing vessel type – engine pairs can be selected and deselected by user to include or exclude from visual.
- Size of bubble is the ln count of ships under each vessel type – engine pair.

Underlying SQL Query:

```
SELECT s.ship_type, s.engine_type,
        ROUND(AVG(f.{})::NUMERIC,2) as metric,
        ROUND(AVG(f.fuel_consumption)::NUMERIC,2) as fuelconsumption,
        LN(COUNT(*)) as scaled_count,
        (CASE WHEN s.ship_type ISNULL AND s.engine_type ISNULL THEN 'Grand Total'
                WHEN s.engine_type ISNULL THEN 'Subtotal'||' '||s.ship_type
                ELSE s.ship_type|| ' ' || s.engine_types
        END) as label
FROM fact_table f, ship_dimension s
WHERE f.ship_key = s.ship_key
GROUP BY ROLLUP(s.ship_type, s.engine_type)
ORDER BY s.ship_type DESC, s.engine_type DESC".format(y_axis)
```

3.2 Verifiers Ranking Board



Rationale:

- Average EEDI for all vessels accredited by verifier are plotted across months post issuance.
- Intent is to offer an oversight type of visual for verifiers to see if they are certifying more environmentally damaging ships relative to the rest of their peers.

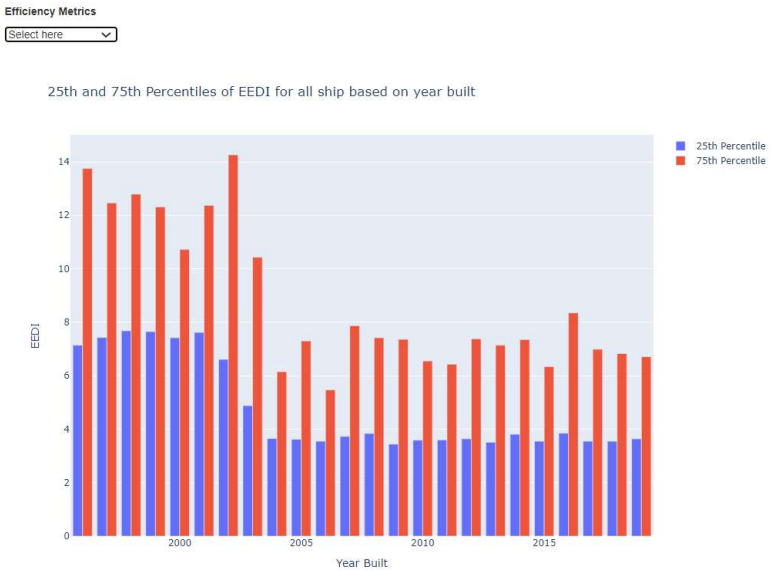
Visualization Notes:

- Y-axis shows the rank for each verifier.
- Legend housing the verifier name can be selected and deselected by user to include or exclude from visual.

Underlying SQL Query:

```
SELECT v.verifier_name, d.month_actual,
        ROUND(AVG(f.EEDI)::NUMERIC,2) as avg_eedi,
        RANK() OVER(PARTITION BY d.month_actual ORDER BY
        ROUND(AVG(f.EEDI)::NUMERIC,2) ASC) rank
FROM fact_table f, verifiers v, d_date d
WHERE f.issue_date_key = d.date_dim_id
        AND f.verifier_key = v.verifier_key
        AND f.verifier_key IN (SELECT DISTINCT verifier_key FROM verifiers)
GROUP BY v.verifier_name, d.month_actual
```

3.3 Efficiency of Ships (EEDI) Based on Year Build



Rationale:

- 25th and 75th percentile of various efficiency metrics are visualized for ships built from 1996 – 2019.
- Intent is to see if variance in efficiency metrics is contracting due to EEDI checks.

Visualization Notes:

- Efficiency metric to be visualized can be selected from dropdown.
- Percentile value can be selected and deselected by user to include or exclude from visual.

Underlying SQL Query:

```
SELECT s.year_built,
        ROUND(PERCENTILE_CONT(0.25) WITHIN GROUP (ORDER
        BY f.{} ASC)::NUMERIC,2) AS percentile_25,
        ROUND(PERCENTILE_CONT(0.75) WITHIN GROUP (ORDER
        BY f.{} ASC)::NUMERIC,2) AS percentile_75
FROM fact_table f, ship_dimension s
WHERE f.ship_key = s.ship_key
GROUP BY s.year_built'.format(y_axis, y_axis)
```