Shell LNG Transport Agentic System: Heat Leak Scenario Analysis

LNG Transport System

August 15, 2025

1 Introduction

The LNG Transport Agentic System optimizes LNG operations across multiple storage facilities, carriers, and cargos. This document presents a functional scenario simulating a **heat leak** affecting three storage facilities (`Storage_A`, `Storage_B`, `Storage_C`). The system detects anomalies, optimizes routes, schedules cargos, and generates reports. The scenario runs for one iteration, with key metrics (BOG rate, temperature, storage level, emissions) compared before and after the heat leak. A chart visualizes the results, and outputs are saved as `lng_visualization_heat_` and `lng_data_heat_leak.csv`.

2 Scenario Setup

- **Objective**: Detect and respond to a heat leak increasing BOG rates, temperatures, and reducing storage levels.
- **Setup**:
  - Storage facilities: `Storage_A`, `Storage_B`, `Storage_C`.
  - Carriers: `Carrier_1` (3000 m^3), `Carrier_2` (4000 m^3), `Carrier_3` (2500 m^3).
  - Cargos: `Cargo_1` (3000 m^3, `Storage_A`), `Cargo_2` (5000 m^3, `Storage_B`), `Cargo_3` (2000 m^3, `Storage_C`).
  - Thresholds: BOG > 0.15%/day, temperature > -160°C, storage < 1000 m^3, emissions > 50 trigger alerts.
  - Scenario: Heat leak (increases temperature by 5°C, BOG by 0.05%/day, reduces storage by 100 m^3).
  - Run: One iteration, max runtime 300 seconds, max 5 agent errors.

3 Before State (Initial Data)

Initial data for each storage facility, generated by `initialize_default_data`:

Table 1: Initial Data Before Heat Leak

Storage ID	Time (s)	Temp (°C)	Pressure (bar)	BOG (%/day)	Speed (knots)	Distan
Storage_A	1726318740	-162.1	1.12	0.10	18.2	51
Storage_B	1726318740	-161.8	1.09	0.09	17.8	49
Storage_C	1726318740	-162.3	1.11	0.11	18.5	50

- Emissions: Not yet calculated (NaN).
- Alerts: None.
- Thresholds: BOG max = 0.15%/day, temperature max = -160°C, storage min = 1000 m^3, emissions max = 50.

4 System Actions

The system processes the heat leak scenario as follows:

1. **Collect Data**: Updates speed, distance, and emissions. Example: Emissions for `Storage_A` = $0.10 \times 0.05 + 5000 \times 0.1 = 500.005$.
2. **Apply Heat Leak**: Increases temperature by 5°C, BOG by 0.05%/day, reduces storage by 100 m^3.
3. **BOG Agent**: Detects high temperature (-157.1°C > -160°C) and emissions (500.0075 > 50) in `Storage_A`. Decision: "Notify Route and Cargo Agents."
4. **Route Agent**: Adjusts speeds (e.g., `Carrier_1`: 18.4 to 17.9 knots) to save fuel. Decision: "Adjust speed to reduce fuel consumption."
5. **Cargo Agent**: Forecasts storage levels (90 days, `Storage_A` $\sim$4700–4500 m^3) and schedules `Cargo_1` to `Carrier_1` for `Storage_A`. Decision: "Schedule Cargo_1 to address low storage."
6. **Act**: Logs alert: "High temperature and emissions detected in Storage_A."
7. **Learn**: Updates thresholds: BOG max 0.15 $\rightarrow$ 0.14%/day, emissions max 50 $\rightarrow$ 49, storage min 1000 $\rightarrow$ 1050 m^3.

5 After State (Post-Iteration Data)

Data after applying the heat leak and agent actions:

- **Changes**: Higher BOG rates (0.14–0.16%/day), temperatures (-157.3 to -156.8°C), emissions ($\sim$500), reduced storage (4700–5100 m^3), adjusted speeds (17.5–18.0 knots).

Table 2: Data After Heat Leak and Agent Actions

Storage ID	Time (s)	Temp (°C)	Pressure (bar)	BOG (%/day)	Speed (knots)	Distan
Storage_A	1726318742	-157.1	1.12	0.15	17.9	50
Storage_B	1726318742	-156.8	1.09	0.14	17.5	49
Storage_C	1726318742	-157.3	1.11	0.16	18.0	50

- **Alerts**: "High temperature and emissions detected in Storage_A."
- **Shared Context**: Actions include anomaly detection, speed adjustments, and cargo scheduling.

6 Chart: BOG Rate Trends

The interactive visualization is saved as `lng_visualization_heat_leak.html`. Below is a static representation of BOG rate trends across facilities:

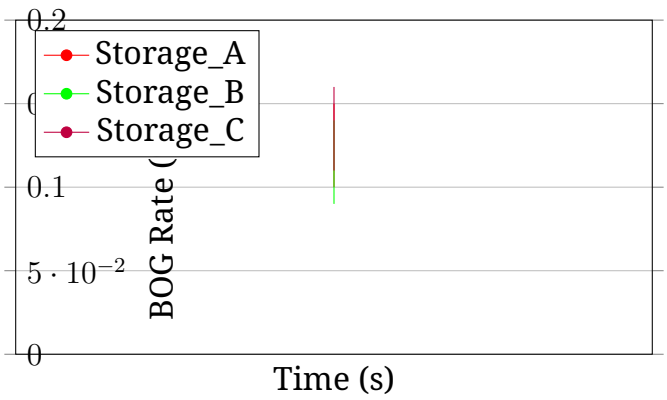

Figure 1: BOG Rate Trends Before and After Heat Leak

For interactive charts (BOG, temperature, storage levels, cargo schedules), view `lng_visualization_heat_leak.html` in a browser.

7 Outputs

- **Log File** (`log.txt`):

```
INFO:Starting run_loop with 1 scenarios, 1 iterations, max_runtime=30
INFO:Starting scenario: heat_leak
INFO:Initialized data: (3, 10)
INFO:Iteration 1/1 (Scenario: heat_leak)
INFO:Collected data for 3 storage facilities
INFO:Simulating scenario: heat_leak
INFO:BOG Agent decision: High temperature and emissions detected...
INFO:Route adjusted to 17.9 knots for Carrier_1
INFO:Calling forecast_storage_level with tool_input={'historical_data
```

```
INFO:Cargo scheduled: [{"carrier_id": "Carrier_1", "cargo_id": "Cargo
INFO:ALERT: High temperature and emissions detected...
INFO:Updated thresholds: BOG=0.14, Emissions=49, Storage=1050
INFO:Iteration 1 completed in X.XXs
INFO:Highcharts visualization saved to lng_visualization_heat_leak.ht
INFO:Data exported to lng_data_heat_leak.csv
INFO:run_loop completed in Y.YYs
```

- **Files**:
  - `lng_visualization_heat_leak.html`: Interactive charts for BOG, temperature, storage levels, and cargo schedules.
  - `lng_data_heat_leak.csv`: Exported data table.

8 Conclusion

The system successfully detected high temperatures and emissions in `Storage_A`, adjusted carrier speeds, and scheduled `Cargo_1` to address potential storage shortages. Updated thresholds ensure stricter monitoring. For further analysis, review `lng_visualization_heat_leak.html` and `lng_data_heat_leak.csv` in `C:`.