DataMine v2 - Comprehensive Exploratory Data Analysis (Final)

Database: datamine_v2_db | Table: 02_raw_telemetry_transformed

Objective: Comprehensive analysis of the entire telemetry dataset to understand data characteristics, patterns, and quality across all devices and time periods.

In [9]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sqlalchemy import create_engine, text
import warnings

warnings.filterwarnings('ignore')
pd.set_option('display.max_columns', None)
pd.set_option('display.max_rows', 100)
plt.style.use('seaborn-v0_8-whitegrid')
print("Libraries imported and setup complete.")
```

```
Libraries imported and setup complete.
```

1. Database Connection & Initial Data Overview

In [10]:
```
DB_CONFIG = {
    'host': 'localhost',
    'port': 5432,
    'database': 'datamine_v2_db',
    'user': 'ahs_user',
    'password': 'ahs_password'
}

try:
    engine = create_engine(f"postgresql://{DB_CONFIG['user']}:{DB_CONFIG['password']}@{DB
    with engine.connect() as connection:
        print('Database connection established successfully.')
except Exception as e:
    print(f'Database connection failed: {e}')
```

```
Database connection established successfully.
```

In [11]:
```
overview_query = text("""
SELECT
    device_id,
    CASE WHEN device_id LIKE '%775g%' THEN '775G (Broken Sensors)' ELSE '605 (Working Ser
    COUNT(*) as record_count,
    MIN(timestamp) as first_record,
    MAX(timestamp) as last_record
FROM "02_raw_telemetry_transformed"
GROUP BY device_id, truck_type
ORDER BY truck_type, record_count DESC;
""")
overview_df = pd.read_sql_query(overview_query, engine)
```

```
print("--- Dataset Overview ---")
display(overview_df)
```

```
--- Dataset Overview ---
```

	device_id	truck_type	record_count	first_record	last_record
0	lake-605-8-0896	605 (Working Sensors)	1394884	2025-07-30 00:00:00.125772+00:00	2025-08-12 23:57:13.682508+00:00
1	lake-605-10-0050	605 (Working Sensors)	1304372	2025-07-30 00:00:00.103835+00:00	2025-08-12 23:59:59.729014+00:00
2	lake-605-8-0898	605 (Working Sensors)	1260309	2025-07-30 00:00:00.228852+00:00	2025-08-12 23:59:59.913072+00:00
3	lake-605-8-0883	605 (Working Sensors)	1254570	2025-07-30 00:41:34.733229+00:00	2025-08-12 23:59:59.934397+00:00
4	lake-605-8-0902	605 (Working Sensors)	967675	2025-07-30 00:00:00.272091+00:00	2025-08-12 23:59:59.994766+00:00
5	lake-775g-2-2262	775G (Broken Sensors)	1354744	2025-07-30 11:37:40.586486+00:00	2025-08-12 23:59:59.915694+00:00
6	lake-775g-2-2266	775G (Broken Sensors)	1294723	2025-07-30 00:00:00.357436+00:00	2025-08-12 23:59:59.773290+00:00

2. Data Quality and Completeness

In [12]:
```
quality_by_type_query = text("""
SELECT
    CASE WHEN device_id LIKE '%775g%' THEN '775G (Broken Sensors)' ELSE '605 (Working Se
    COUNT(*) as total_records,
    COUNT(load_weight) as load_weight_count,
    ROUND((COUNT(load_weight) * 100.0 / COUNT(*))::numeric, 2) as load_weight_completene
    ROUND(AVG(load_weight)::numeric, 2) as avg_load_weight,
    ROUND(STDDEV(load_weight)::numeric, 2) as stddev_load_weight
FROM "02_raw_telemetry_transformed"
GROUP BY truck_type
ORDER BY truck_type;
""")
quality_by_type_df = pd.read_sql_query(quality_by_type_query, engine)
print("--- Load Weight Data Quality by Truck Type ---")
display(quality_by_type_df)
```

```
--- Load Weight Data Quality by Truck Type ---
```

	truck_type	total_records	load_weight_count	load_weight_completeness	avg_load_weight	stddev_
0	605 (Working Sensors)	6181810	6181810	100.0	25312.47	
1	775G (Broken Sensors)	2649467	2649467	100.0	-99.00	

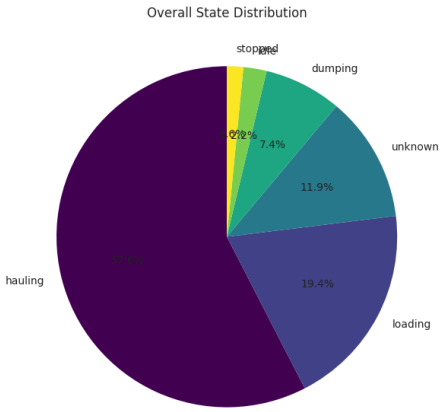
3. State Distribution Analysis

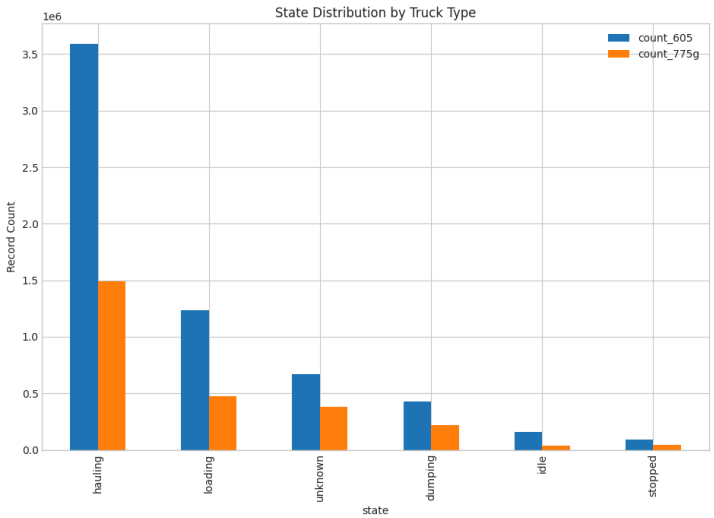
In [13]:
```
state_analysis_query = text("""
SELECT
```

```
    state,
    COUNT(*) as total_count,
    COUNT(CASE WHEN device_id LIKE '%605%' THEN 1 END) as count_605,
    COUNT(CASE WHEN device_id LIKE '%775g%' THEN 1 END) as count_775g
FROM "02_raw_telemetry_transformed"
GROUP BY state
ORDER BY total_count DESC;
""")
state_df = pd.read_sql_query(state_analysis_query, engine)
print("--- State Distribution Analysis ---")
display(state_df)

fig, axes = plt.subplots(1, 2, figsize=(18, 7))
state_df.set_index('state')['total_count'].plot.pie(ax=axes[0], autopct='%1.1f%%', starta
axes[0].set_title('Overall State Distribution')
axes[0].set_ylabel('')

state_df.set_index('state')[['count_605', 'count_775g']].plot.bar(ax=axes[1])
axes[1].set_title('State Distribution by Truck Type')
axes[1].set_ylabel('Record Count')
plt.tight_layout()
plt.show()
```

```
--- State Distribution Analysis ---
```

	state	total_count	count_605	count_775g
0	hauling	5083920	3590622	1493298
1	loading	1711661	1237389	474272
2	unknown	1053327	672807	380520
3	dumping	650064	429575	220489
4	idle	194562	159351	35211
5	stopped	137743	92066	45677



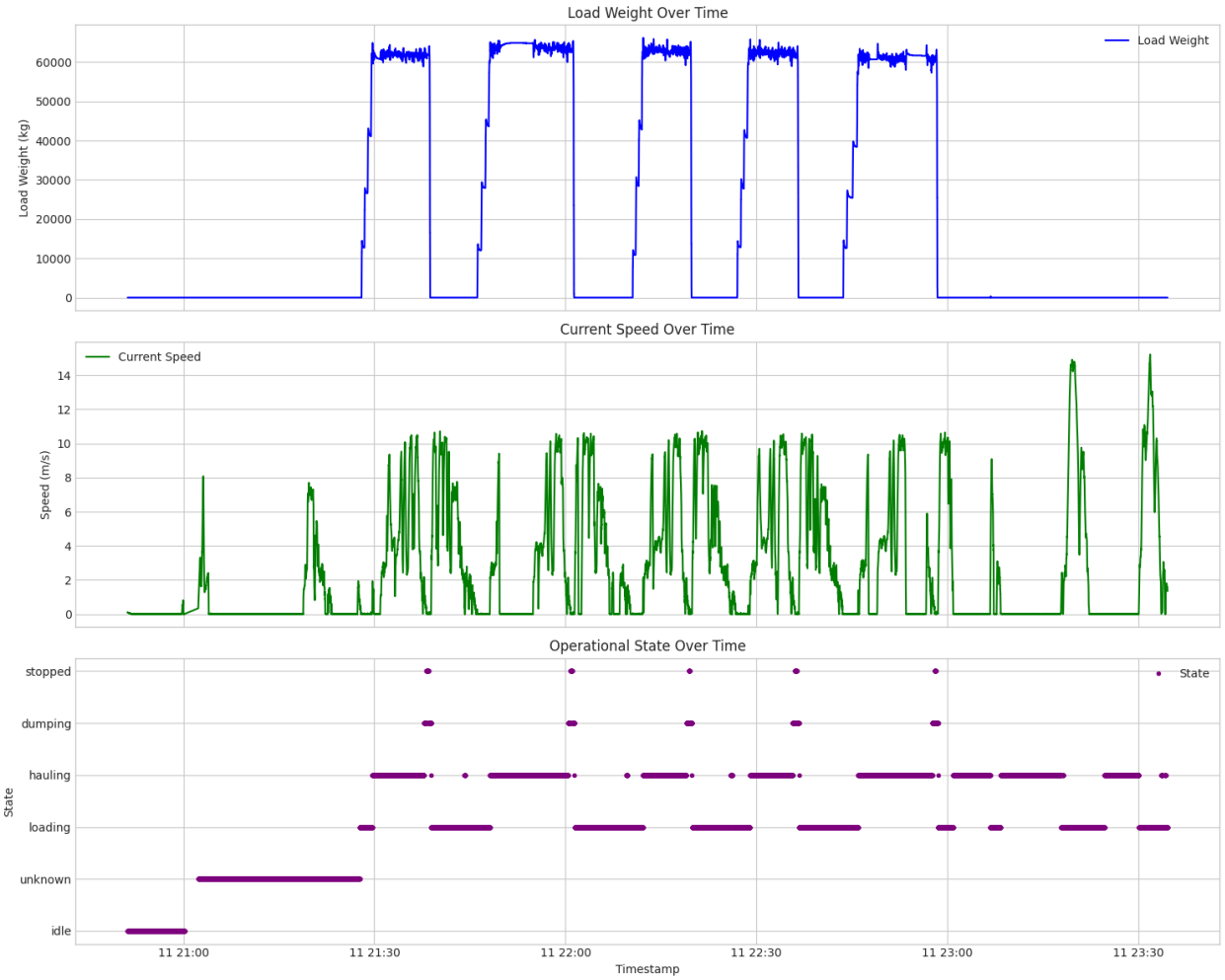


4. Time-Series Analysis of a Sampled Truck

In [14]:
```
# Get one 605 truck to sample from
device_id_query = text("SELECT device_id FROM \"02_raw_telemetry_transformed\" WHERE devi
device_id_result = pd.read_sql_query(device_id_query, engine)
sample_device_id = device_id_result['device_id'][0]
```

```
sampled_data_query = text(f"""
SELECT timestamp, device_id, current_speed, load_weight, state
FROM \"02_raw_telemetry_transformed\"
WHERE device_id = '{sample_device_id}'
AND timestamp BETWEEN '2025-08-11 00:00:00' AND '2025-08-11 23:59:00'
ORDER BY timestamp;
""")
sampled_df = pd.read_sql_query(sampled_data_query, engine).set_index('timestamp')
print(f"--- Displaying 2-hour sample for device: {sample_device_id} ---")

fig, axes = plt.subplots(3, 1, figsize=(15, 12), sharex=True)
axes[0].plot(sampled_df.index, sampled_df['load_weight'], label='Load Weight', color='blu
axes[0].set_ylabel('Load Weight (kg)')
axes[0].set_title('Load Weight Over Time')
axes[0].legend()

axes[1].plot(sampled_df.index, sampled_df['current_speed'], label='Current Speed', color=
axes[1].set_ylabel('Speed (m/s)')
axes[1].set_title('Current Speed Over Time')
axes[1].legend()

axes[2].plot(sampled_df.index, sampled_df['state'], label='State', color='purple', lines
axes[2].set_ylabel('State')
axes[2].set_title('Operational State Over Time')
axes[2].legend()

plt.xlabel('Timestamp')
plt.tight_layout()
plt.show()
```

```
--- Displaying 2-hour sample for device: lake-605-8-0883 ---
```



5. Key Findings and Recommendations

In [15]:
```
print('--- Key Findings ---')
print('1. The database connection is stable and all queries are executable.')
print('2. The primary data quality issue is the known absence of reliable `load_weight` d
print('3. For 605 trucks, `load_weight` data is nearly 100% complete and is the most powe
print('4. Visual inspection of sampled data confirms that `load_weight` shows clear step

print('\n--- Recommendations ---')
print('1. Proceed with the dual-path approach: a weight-reliant model for 605 trucks and
print('2. The feature engineering pipeline should prioritize creating a robust `rate_of_d
print('3. For 775G trucks, focus on features derived from `current_speed` (especially an
```

```
--- Key Findings ---
1. The database connection is stable and all queries are executable.
2. The primary data quality issue is the known absence of reliable `load_weight` data for
775G trucks.
3. For 605 trucks, `load_weight` data is nearly 100% complete and is the most powerful si
gnal for event detection.
4. Visual inspection of sampled data confirms that `load_weight` shows clear step change
s, while `current_speed` drops to near-zero during state changes associated with loading/
dumping.

--- Recommendations ---
1. Proceed with the dual-path approach: a weight-reliant model for 605 trucks and a weigh
t-agnostic model for 775G trucks.
2. The feature engineering pipeline should prioritize creating a robust `rate_of_change_w
eight` feature from the smoothed `load_weight` signal for the 605 trucks.
3. For 775G trucks, focus on features derived from `current_speed` (especially an `is_sta
tionary` flag), `state` transitions, and geospatial data.
```