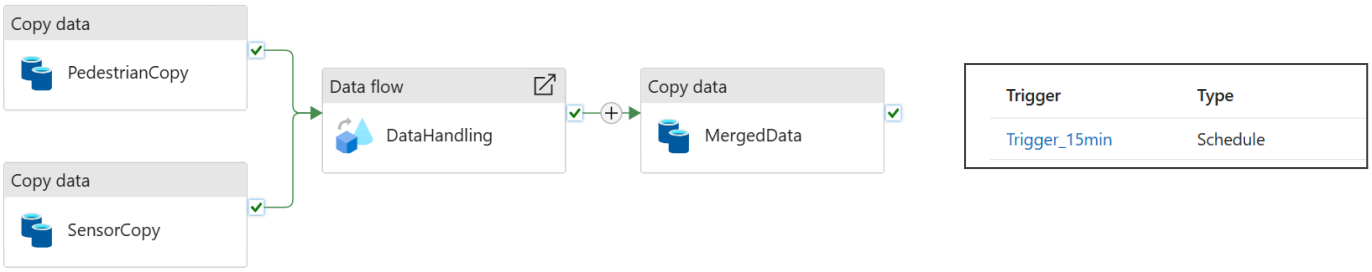
THE CITY OF MELBOURNE'S URBAN MOBILITY STRATEGY AND PEDESTRIAN MOVEMENT

Azure Data Factory pipeline



The Azure Data Factory pipeline is designed to simulate real-time data ingestion and processing for Melbourne's pedestrian monitoring system. It begins with two Copy Data activities that extract data directly from the official open data CSV endpoints. The PedestrianCopy activity retrieves minute-level pedestrian counts from the *Past Hour Counts per Minute* dataset, while the SensorCopy activity gathers sensor metadata from the *Sensor Locations* dataset. Both datasets are ingested and stored in Azure Blob Storage as raw input files for further processing. Following ingestion, the datasets are passed into a dedicated Data Flow activity where data transformation takes place.

To replicate a streaming-like data pipeline, the entire process is orchestrated using a schedule trigger named Trigger_15min, which executes the pipeline every 15 minutes. This recurring execution enables timely updates to downstream analytics and dashboards, allowing for near real-time visibility into pedestrian activity across Melbourne.

Azure Data Factory's Mapping Data Flows

This Azure Data Factory Mapping Data Flow transforms raw pedestrian and sensor data into an analysis-ready format for storage in an Azure SQL Database. It begins with JoinData, where pedestrian counts are merged with sensor metadata using location_id as the key. The SelectRelevantFields step filters out unnecessary columns to streamline processing and remove redundancy.

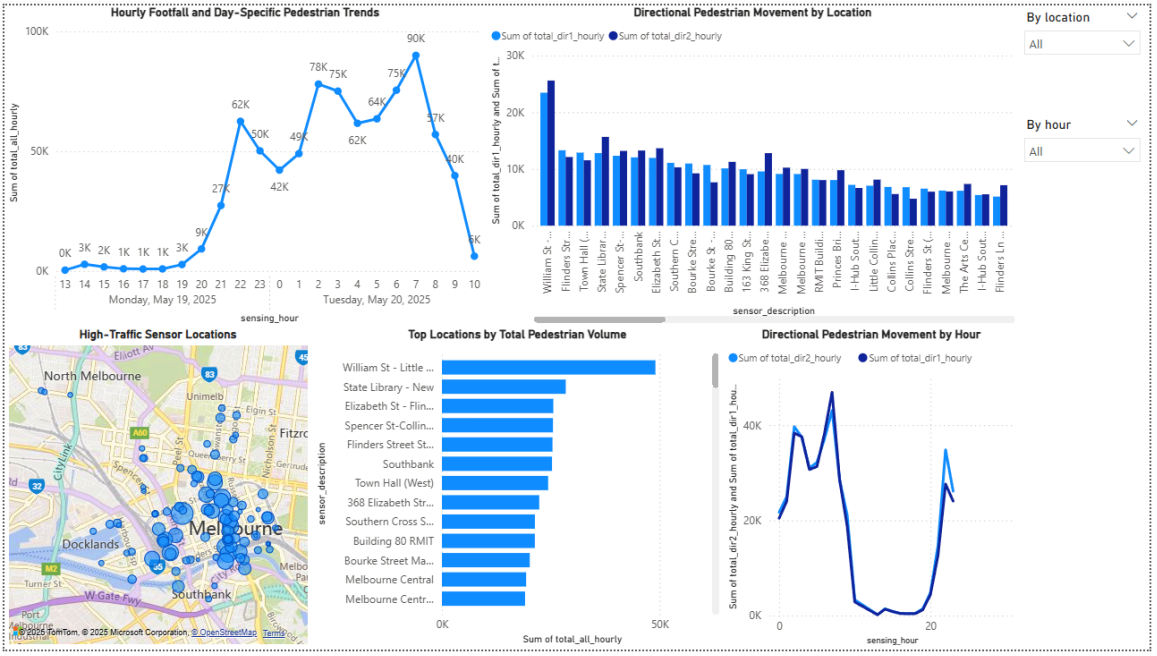
Next, CleanseData ensures data quality by removing rows with null timestamps, missing sensor IDs, or negative pedestrian counts. The AddDerivedColumns step extracts new attributes such as sensing_hour from timestamp fields to support time-based aggregation.

In AggregateHourlyCounts, the data is grouped by sensor and time dimensions (e.g., sensing_hour, date_only) and summarized into key metrics: total_dir1_hourly, total_dir2_hourly, and total_all_hourly. Sensor coordinates (latitude_1, longitude_1) are retained using the first recorded value to preserve location accuracy.

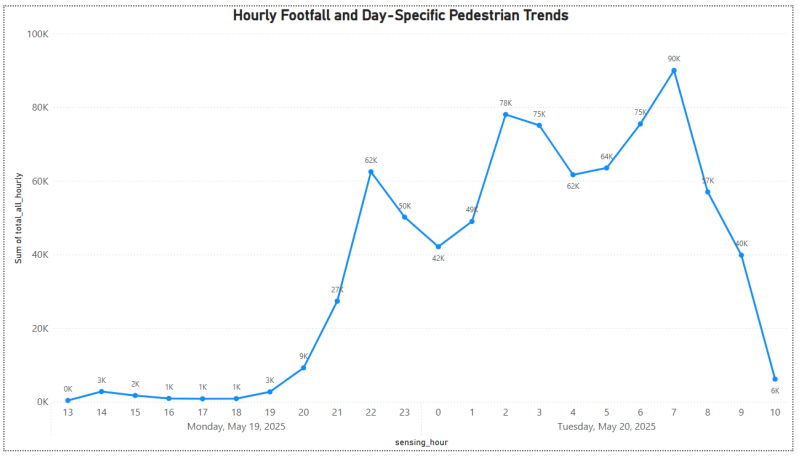
RankPeakHours identifies the busiest hours for each sensor by ranking hourly totals, enabling insights into peak pedestrian periods. Finally, the Sink step writes the fully transformed dataset to Azure SQL Database, ready for downstream visualization and reporting in Power BI.

Power BI dashboard

View the dashboard via this LINK



This dashboard presents a data-driven overview of pedestrian activity across Melbourne, capturing when, where, and how people move through the city. It integrates hourly trends, day-specific patterns, directional flows, and high-traffic sensor locations to highlight peak periods, spatial hotspots, and commuting dynamics.



Hourly Movement Patterns Across the Day

Pedestrian activity in Melbourne follows a distinct bimodal daily pattern, marked by two prominent peaks- one in the early morning and another in the late evening. From midnight to 2 AM, footfall steadily increases, reaching 78K at 2 AM, likely reflecting the city's vibrant nightlife, post-event commuting, and late-night transit usage. Although there is a dip between 2 AM and 4 AM, activity remains moderately high, suggesting that the city maintains a baseline of movement well into the early hours.

From 4 AM, foot traffic rises rapidly, culminating in the daily peak at 7 AM (90K), which aligns with the morning commute window as workers and students begin their day. Following this surge, activity falls sharply, dropping to just 1K by 1 PM, indicating a significant lull during the late morning and early afternoon. This quiet period continues through to 7 PM, with consistently low counts (0K-3K), making it an ideal window for maintenance, cleaning, or infrastructure upgrades with minimal disruption.

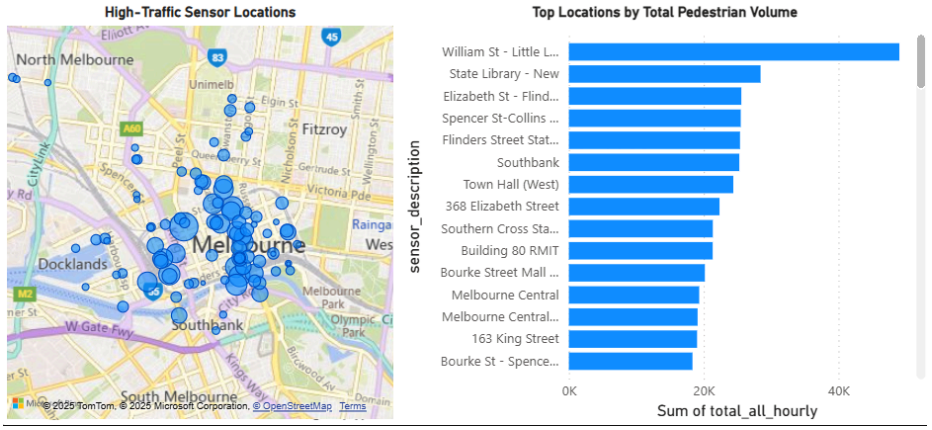
After 7 PM, movement picks up again, marking a second surge in activity that peaks at 10 PM with 62K pedestrians. This late evening wave likely corresponds to leisure activities, shopping, dining, and return commutes. Foot traffic then begins to taper off after 10 PM, completing the daily cycle of movement.

Variation in Patterns by Day (Monday vs. Tuesday)

When examining pedestrian activity by specific dates, clear day-of-week behavioral differences emerge. On Monday, May 19, the city exhibits a low mobility profile throughout the day. Pedestrian counts remain under

10K from early morning until early evening, with a noticeable surge only beginning at 7 PM. The day peaks at 9 PM with 62K, indicating that most movement is concentrated in the evening hours. This delay aligns with well-known urban behavioral trends-such as post-weekend recovery, hybrid work routines, and the tendency for businesses and events to operate with limited engagement on Mondays.

In contrast, Tuesday, May 20, reflects a more typical urban rhythm. High footfall levels are observed from midnight through early morning, followed by a sharp increase starting at 6 AM and peaking again at 7 AM with 90K pedestrians. Movement remains elevated through the morning, consistent with conventional weekday commuting patterns and workplace engagement.

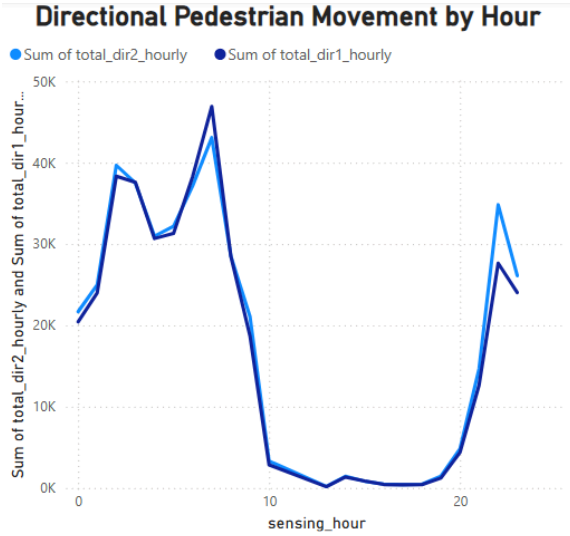


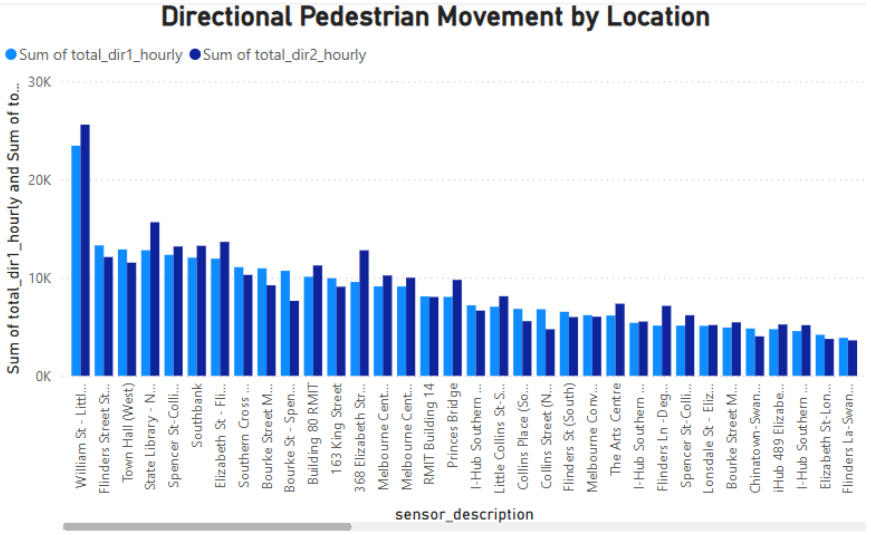
Melbourne's Busiest Pedestrian Zones

Melbourne's pedestrian activity reflects a clear spatial and functional structure shaped by two key urban dynamics. The highest foot traffic is concentrated along core CBD streets, especially those that intersect major public transit routes and retail corridors-serving as vital arteries for daily commuting, shopping, and business activity. Complementing this, special-purpose zones such as university campuses and entertainment precincts like Southbank and Docklands generate substantial off-peak movement, contributing to a more varied and temporally balanced pedestrian flow across the city.

At the forefront is William St - Little Lonsdale St (West), which records the highest overall footfall. Positioned near government buildings and major office towers, it serves as a central corridor for legal professionals, office workers, and weekday commuters. Close behind is the State Library precinct, one of Melbourne's busiest intersections, driven by its proximity to RMIT, University of Melbourne, and major tram lines-drawing steady traffic from students, public transport users, and city shoppers.

Other topperforming areas - Elizabeth St - Flinders St, Spencer St - Collins St, and the Flinders Street Station Underpass - illustrate the role of multifunctional urban zones. These locations combine transit accessibility with strong retail and cultural anchors, supporting steady movement throughout both peak and nonpeak hours. Meanwhile, Southbank and Docklands attract substantial foot traffic during evenings and weekends, driven by riverside dining, entertainment venues, and recreational pathways. Additionally, sites like Building 80 RMIT and Town Hall (West) generate consistent activity tied to education and civic services.





Directional Movement Patterns Across Time and Space

The analysis of directional pedestrian flows across Melbourne reveals a well-balanced, cyclical pattern that aligns closely with daily commuting and activity rhythms. During the early morning hours (midnight to 2 AM), foot traffic rises steadily in both directions, likely driven by late-night social activity and shift-based workers. From 2 AM to 7 AM, volumes escalate sharply, peaking around 7 AM-at which point movement in direction 1 slightly exceeds direction 2, suggesting a dominant inbound flow into the central city for work or education.

This trend reverses in the evening hours. After a pronounced midday lull (7 AM to 1 PM), pedestrian movement begins rising again from 7 PM onward. Notably, direction 2 overtakes direction 1 during this period, reflecting a clear outbound flow as people return home or disperse from evening engagements. These directional shifts confirm that Melbourne's pedestrian network supports a typical inbound-outbound commuting structure, with distinct morning and evening surges.

Spatially, directional loads vary by location, revealing how different parts of the city support unique movement patterns. High-traffic corridors such as William St – Little Lonsdale St (West) and the Flinders Street Station Underpass exhibit strong bi-directional flow, though with a slight dominance of direction 2, likely indicating concentrated outflows at peak times due to office and legal district functions. Other transit-oriented areas like State Library – New Footpath and Spencer St – Collins St maintain consistent two-way movement, reflecting their multi-purpose urban roles as both destinations and transit links.

Some areas exhibit directional imbalances, such as 368 Elizabeth Street and locations in Southbank, where foot traffic is skewed toward a single direction. These trends may be shaped by site-specific factors such as one-sided attractions, riverside pathways, or venues with unidirectional access. Such insights are crucial for optimizing pedestrian infrastructure-highlighting where asymmetrical designs or flow management measures may be necessary to accommodate directional surges.

Urban Planning Implications and Recommendations

Melbourne's pedestrian movement patterns reveal clear spatial and temporal dynamics that can inform more responsive and efficient urban planning.

1. **Time-Aware Infrastructure Planning**

- Prioritize wider footpaths, efficient crossings, and lighting during peak hours (7 AM, 10 PM).
- Allocate midday lull (1 PM – 7 PM) for street cleaning, minor works, or non-disruptive events.

2. **Directional Flow Management**

- Address morning inbound and evening outbound surges with dynamic signage and crowd-flow designs.
- Focus on directional imbalances in key corridors (e.g., William St, Southbank) for better pedestrian routing and safety.

3. **Location-Specific Strategies**

- Reinforce infrastructure at high-traffic CBD intersections (e.g., Flinders–Elizabeth).

- Enhance leisure zones (Docklands, Southbank) with flexible, high-capacity pedestrian pathways and event-ready designs.

4. **Support for Educational & Civic Nodes**
- Improve connectivity, seating, and shelter near universities and civic buildings to support non-commute-based movement.

5. **Crowd Safety & Emergency Readiness**
- Implement clear evacuation plans and surge management systems at high-density transit and entertainment zones.