

# Modeling and Simulation Framework for Airborne Camera Systems

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WAAMI 2020



# Overview

## Introduction

- Who we are?
- Motivation

## Simulator Capabilities Overview

## Camera Geometry and Sensor Platform

## Experimental Result

- Structure from motion using FMV
- Generation of a simulated WAMI dataset for vehicle detection

## Conclusion

# NRC and DRDC

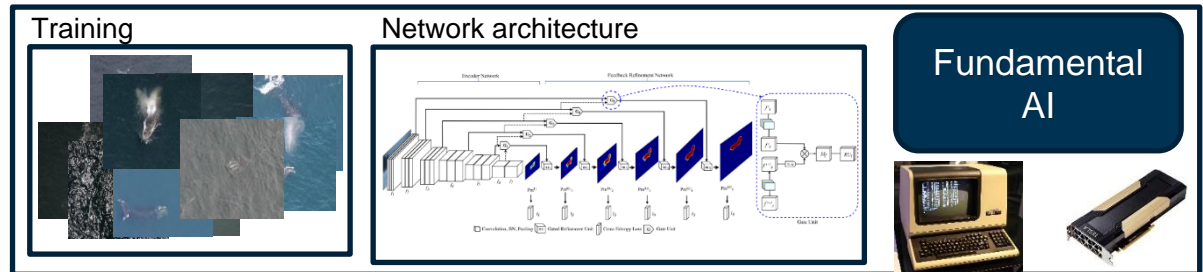
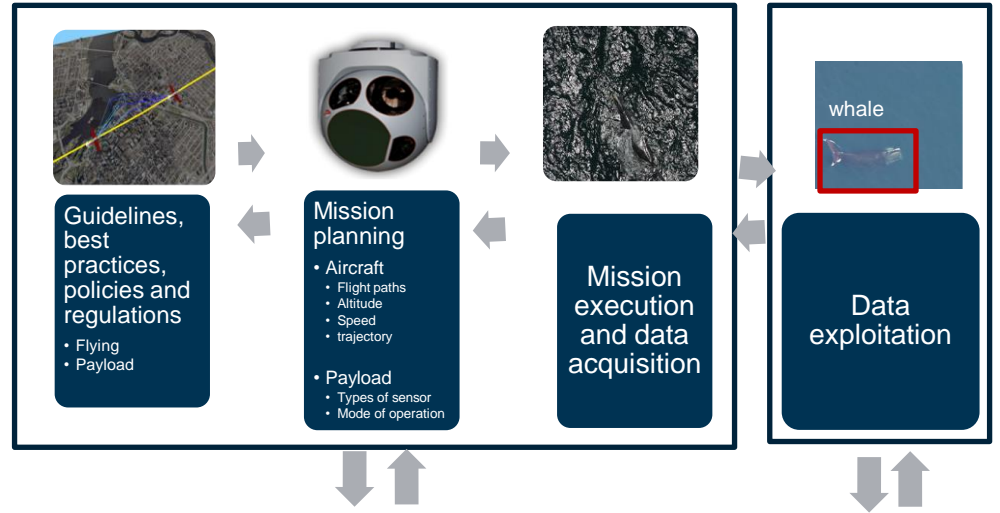
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# Modeling and Simulation Framework for ACS

## Motivation

- M&S is a powerful and low-cost solution to characterize and optimize the performance of ACS for specific applications.



# Simulator Capabilities Overview

| Simulated entities                   |
|--------------------------------------|
| - Vehicles, drones (3D models)       |
| - Trajectory (SUMO, generation tool) |
| - Terrain (DEM, 3D models)           |

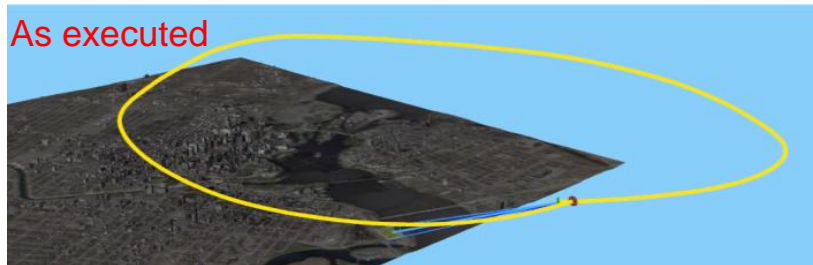
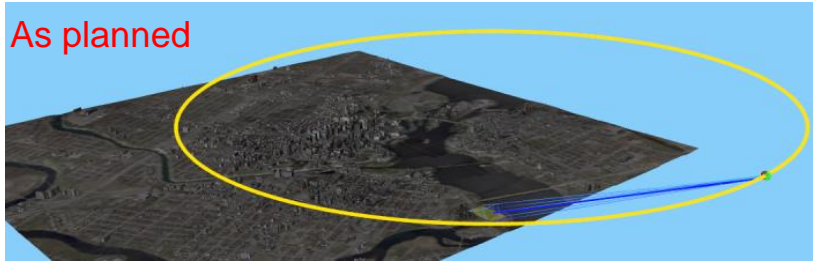
| Image processing                     |
|--------------------------------------|
| - Style transfer (real to synthetic) |
| - Range image generation             |
| - Feature matching                   |

| Imaging Sensors                   |
|-----------------------------------|
| - Configurable optics             |
| - Configurable camera pose        |
| - Variable zoom and focal lengths |

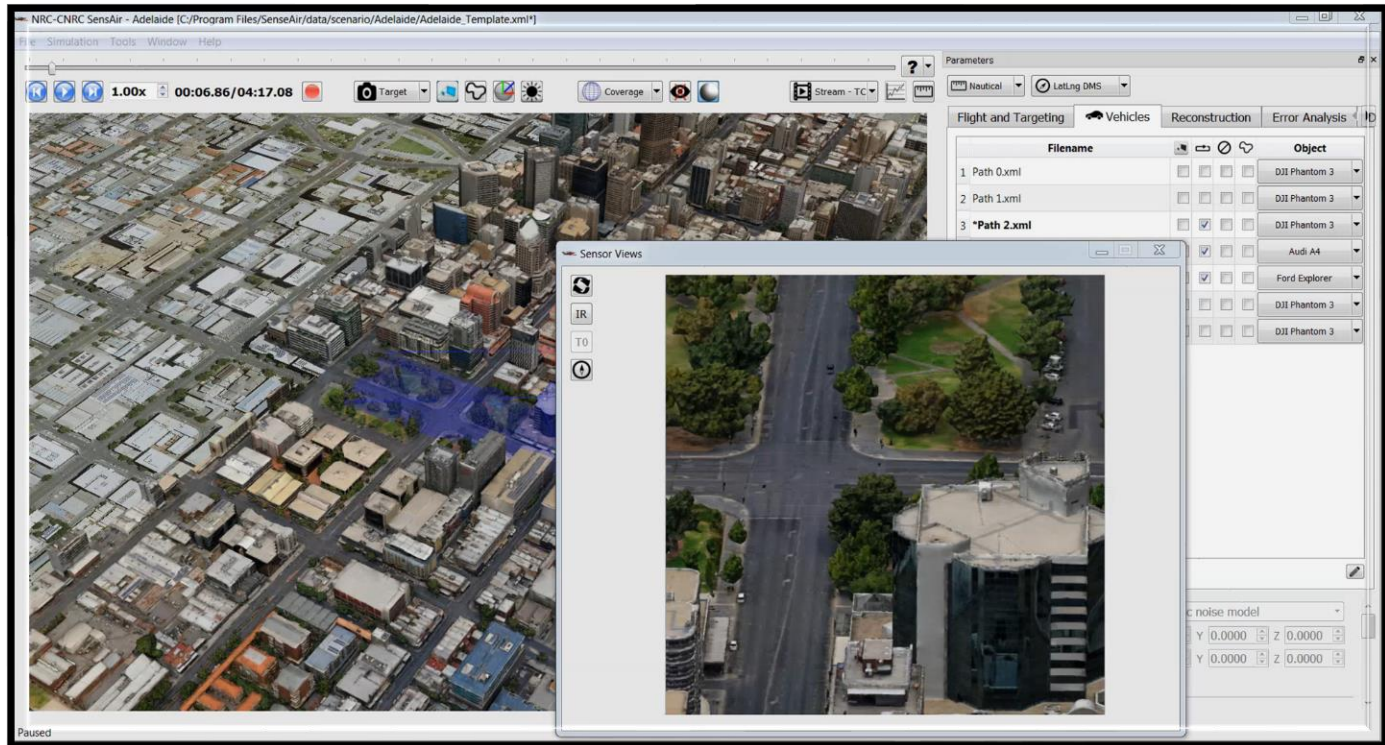
| Interfaces                         |
|------------------------------------|
| - Video streaming                  |
| - Images and trajectory recording  |
| - Remote control interface and API |

| Camera geometry                |
|--------------------------------|
| - Epipolar geometry assessment |
| - Homography assessment        |
| - Monte Carlo simulation       |

| Sensor platform               |
|-------------------------------|
| - Land and airborne platforms |
| - Configurable trajectory     |
| - Simulated GPS and IMU       |



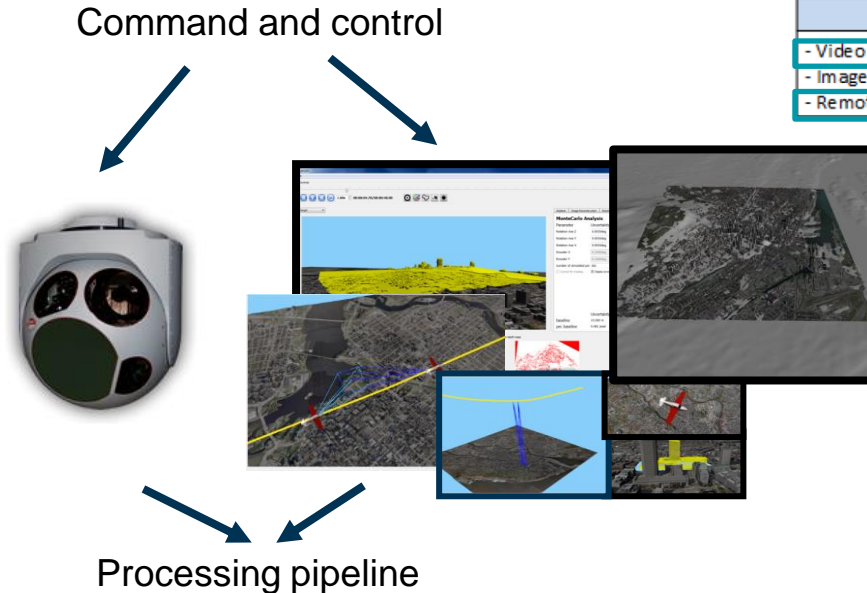
# Simulator Capabilities: Simulated Entities



multi-resolution rendering techniques [Borgeat et al. 2005]

# Simulator Capabilities: Interfaces

## Digital Twinning Application



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## Video Streaming:

- STANAG 4609 H.264
- HD-SDI
- Proprietary binary format

## Remote control interfaces:

- web-based
- TCP/IP

# Simulator Capabilities: Image Processing

## Realistic Imagery



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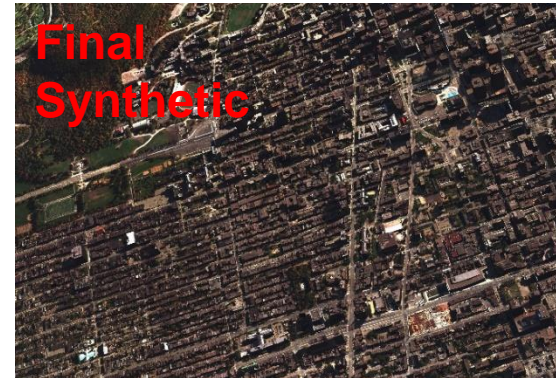
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# Camera Geometry and Sensor Platform

## Simulated entities

- Vehicles, drones (3D models)
- Trajectory (SUMO, generation tool)
- Terrain (DEM, 3D models)

## Image processing

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- Feature matching

## Imaging Sensors

- Configurable optics
- Configurable camera pose
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## Camera geometry

- Epipolar geometry assessment
- Homography assessment
- Monte Carlo simulation

## Sensor platform

- Land and airborne platforms
- Configurable trajectory
- Simulated GPS and IMU

The screenshot displays the NRC-CNRC SensAir simulation environment. The main 3D view shows a city model with a camera trajectory overlaid. A 'Data Plot' window is open, showing an 'Error Analysis' graph. The graph plots Position (m) on the y-axis (0 to 0.3) against Orientation (deg) on the x-axis (0 to 0.015). Three regions are shown: 'poor (error > 0.50 pixels)' in red, 'fair (error > 0.25 pixels)' in yellow, and 'good (error < 0.25 pixels)' in green. A blue line represents the Monte Carlo simulation path. A 'Create a new trajectory' dialog is also visible, showing parameters for a circular orbit.

**Create a new trajectory**

Orbit:  Enable main view interactions

Center Position: Lat 45° 30.493' Lng -73° 33.860' Alt 3826.39 ft

Number of loops:

Radius:

Loop duration:

Speed:

**Details**

Duration: 4m 17s

Length: 7.7346 NM

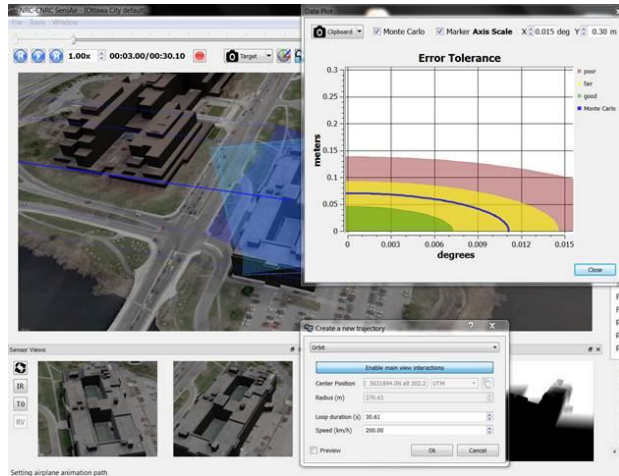
Preview

OK Cancel

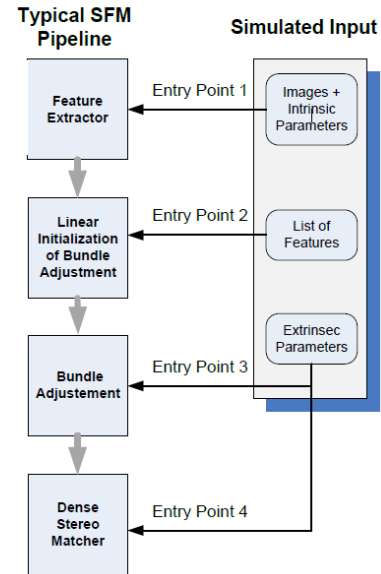
# Structure from motion using FMV

## 4-step optimization of the SfM pipeline from aerial imagery

### Step 1



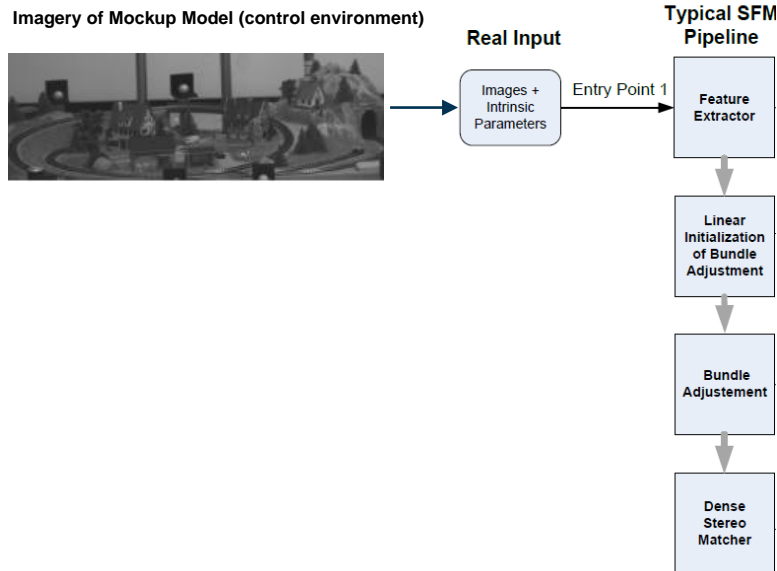
### Step 2



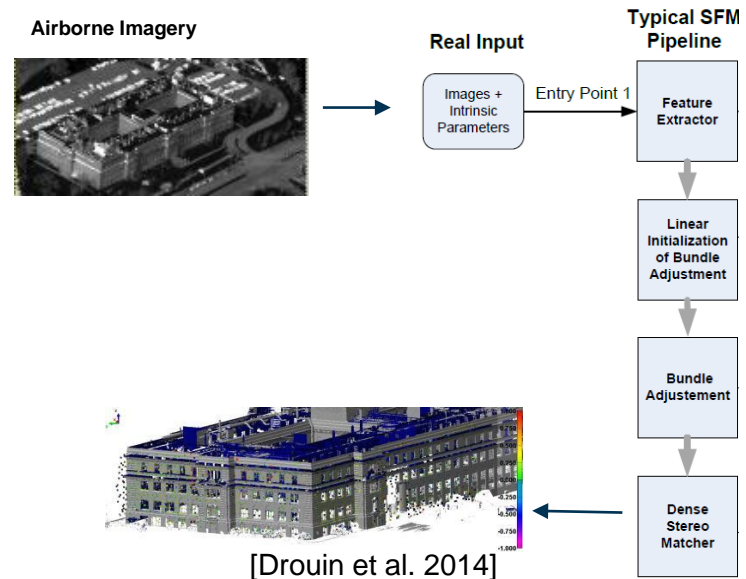
# Structure from motion using FMV

## 4-step optimization of the SfM pipeline from aerial imagery

### Step 3

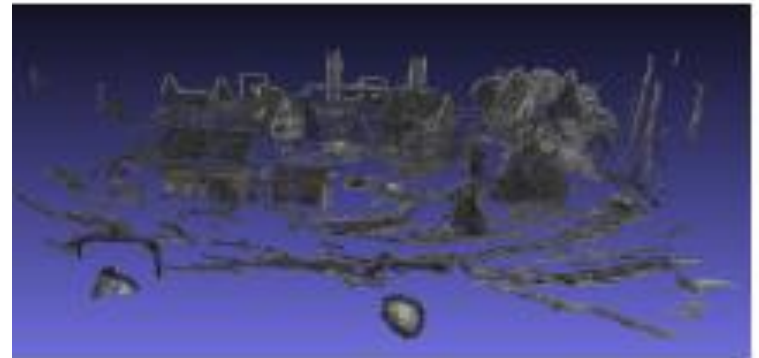
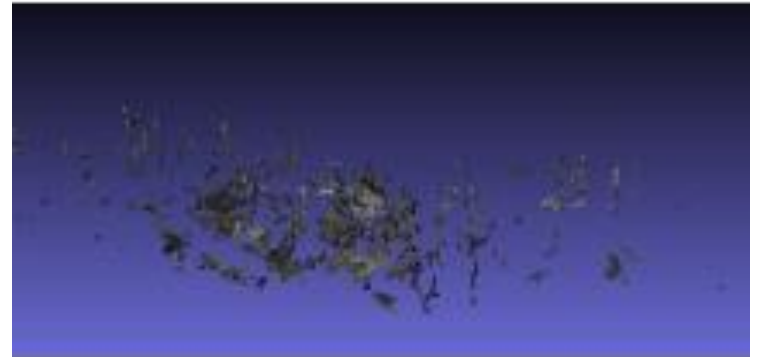


### Step 4

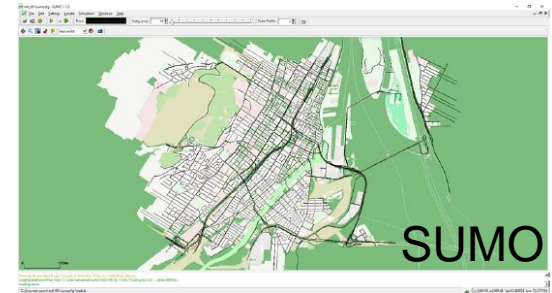
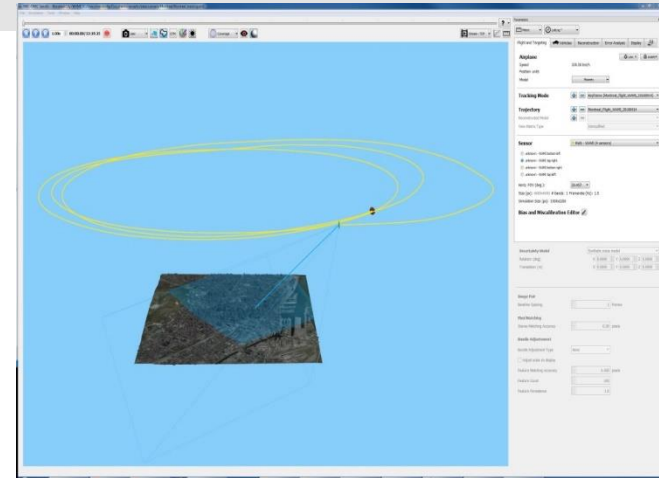


# Structure from motion using FMV

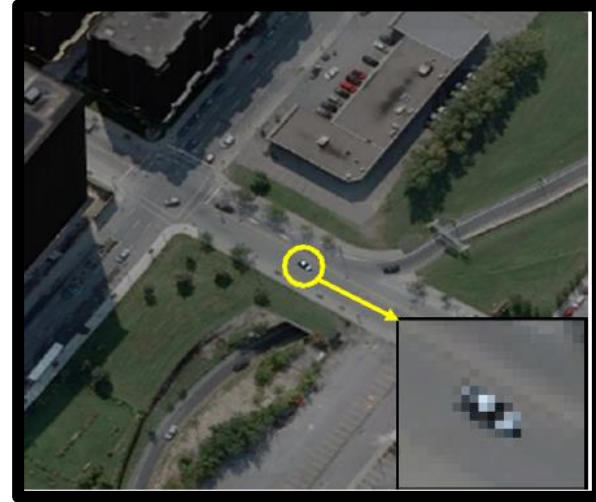
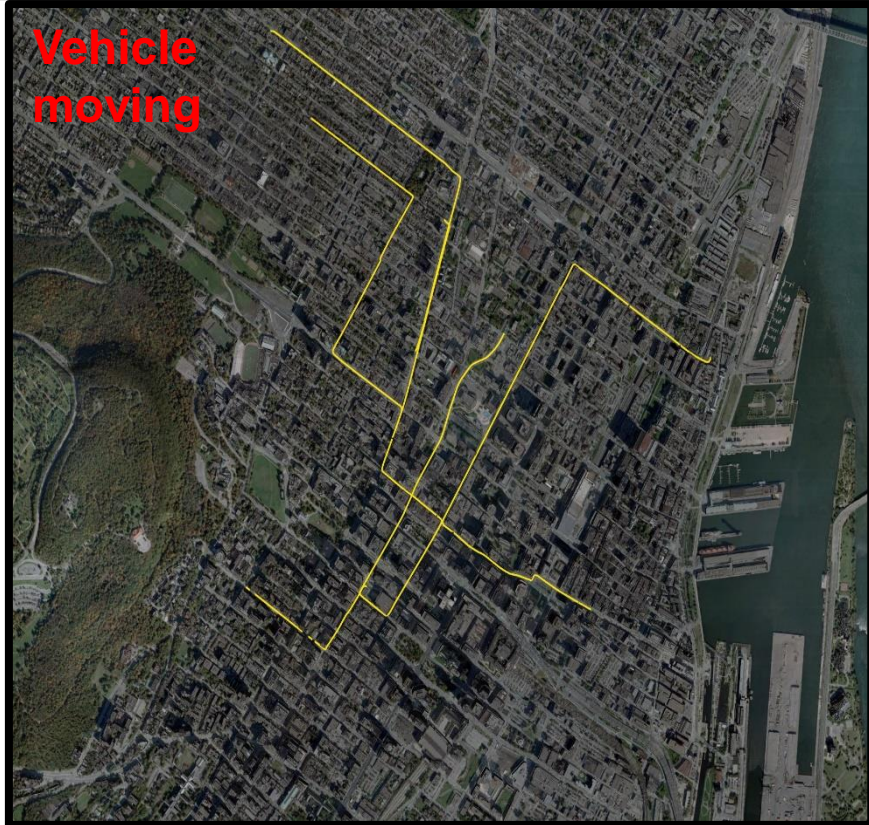
|                         | Scale Model (1:220) | Real size equivalent |
|-------------------------|---------------------|----------------------|
| Camera altitude         | 2.67 m              | 587 m                |
| Target ground distance  | 11.89 m             | 2615 m               |
| Target distance         | 12.12 m             | 2680 m               |
| Camera field of view    | 2.4 deg.            | 2.4 deg.             |
| Target area             | 0.45 m x 0.30 m     | 99 m x 66 m          |
| Target height variation | 0.12 m              | 26 m                 |



# Generation of a simulated WAMI dataset for vehicle detection



# Generation of a simulated WAMI dataset for vehicle detection



# Conclusion

The proposed M&S framework provides tools to study the factors impacting the processing of aerial images using computer vision approaches.

The analysis tools are especially useful:

- for examining scenarios where the camera geometries are close to degenerate configurations.
- for the simulation of airborne data collection in varied urban environments.



# THANKS

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