UAV Applications in Road Safety Engineering

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Outline

Objective: To provide a compressed overview of considerations for unmanned aerial vehicle (UAV) use in transportation engineering, with specific applications in road safety engineering

Topics of Discussion:

- Regulatory environment
- Technology options
- Applications
- Applying for your first Special Flight Operator's Certificate (SFOC)

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Definition

Unmanned Aerial Vehicle:

a power-driven aircraft, other than a model aircraft, that is designed to fly without a human operator on board

Examples:

- Quadcopters / quad-rotors
- Hexacopters / hex-rotors
- Helicopters
- Fixed-wing aircraft

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Regulatory Environment

Transport Canada regulates recreational and non-recreational UAV use (602.41).

The Canadian Aviation Regulations (CARs) require unmanned air vehicle (UAV) operators to apply for Special Flight Operator's Certificates (SFOCs) so Transport Canada can ensure operators use their UAV reliably and safely. Each SFOC contains conditions for where and how to fly, such as:

- maximum altitudes
- minimum distances from people and property
- coordination requirements with air traffic services

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Important Regulatory Considerations

- The SFOC application process ensures flight operations do not place members of the public or property at risk
- Most applicants first apply for a series of project-specific SFOCs prior to applying for a blanket SFOC
- Transport Canada provides recommendations on training for flight operators with *Knowledge Requirements for Pilots of UAV Systems (TP 15263E)*

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Upcoming Regulatory Considerations

- Further clarification and structure is expected for the minimum requirements for UAV operators (including training and testing) in the coming year(s)

- Transport Canada is also considering additional requirements for UAV systems, specifically the possibility of restricting commercial UAV use to a list of Transport Canada-compliant systems (also potential aircraft marking and registration requirements)

- Refinements to the Canadian Aviation Regulations are inevitable; organizations should stay informed of upcoming changes and requirements

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UAV Data Collection

Advantages:
- Relative ease of use
- Positioning / repositioning
- Vantage

Disadvantages:
- Stability (e.g. during high winds)
- Short battery life

Image source: DJI

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Technology Options

Image source: BrainFarm

Key components to discuss:

- Control station
- Unmanned aerial vehicle (UAV)
- Payloads (e.g. sensors)
- Tethers
- Software (e.g. software that enables semi-autonomous behaviour or other automated flight operations: return to home, sense and avoid, and more complex functions)

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Image source: Hoverfly

Overcoming UAV constraints

Stability issues:	Improved GPS/GLONASS positioning
	Video stabilization techniques and algorithms
Short battery life:	Tethers provide constant power source
	No fly-away risk
	Data up/down
	Data encryption

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Applications

Application: Work Zone Safety

Image source: FNI

Considerations:

Ease of repositioning allows a team to time capture dynamic nature of work zones compared to pole-mounted cameras

Blanket SFOC requirement allows greater flexibility

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Application: Video-Based Conflict Analysis

Use of computer vision and machine learning to automatically extract safety indicators and safety data from video

Considerations:

- Vantage point improves feature tracking and object grouping
- Vantage point prevents occlusion of objects, however shadows need to be addressed
- Tethers may be required for sufficient length of video collection

Five Steps of Video-Based Conflict Analysis:

- Homography and masking
- Feature tracking
- Object grouping
- Develop classified trajectory database
- Analyze database for near-miss indicators

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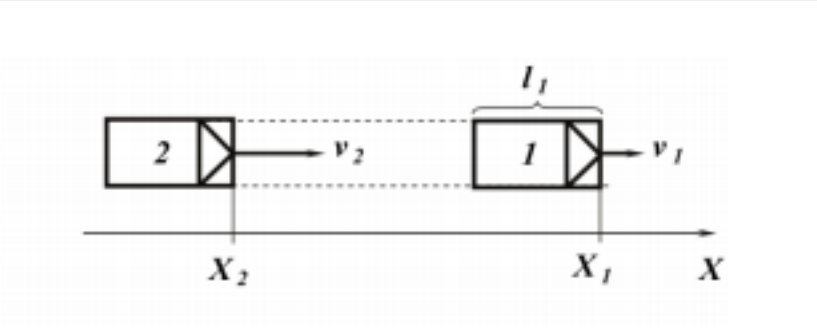
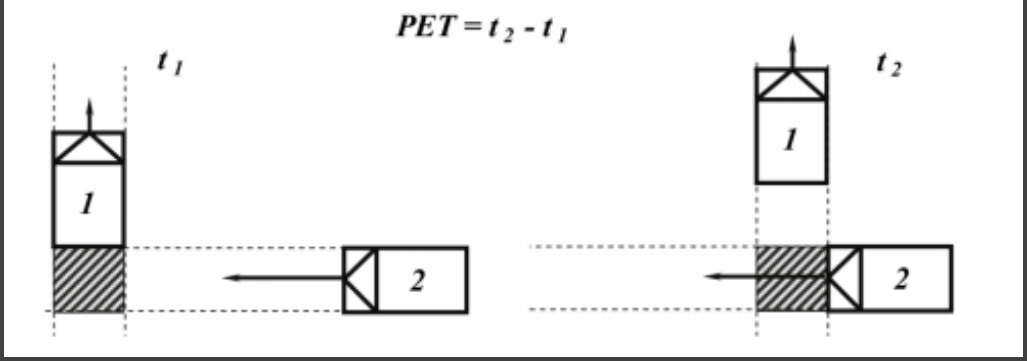
Application: Video-Based Conflict Analysis

Near-miss indicators:

Time-to-collision (TTC)



Post-encroachment time (PET)



Other safety indicators:

Speed differentials, deceleration rates, predicted collision energy transfer, Safe Systems-based indicators

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Application: Traffic Monitoring

Photo source: FNI

Benefits:

- Similarly uses computer vision and machine learning to identify all video objects (vehicles, cyclists, pedestrians, etc.)
- Ability to set up custom gates for monitoring (e.g. turning movements, lane keeping)

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Application: Speed Studies

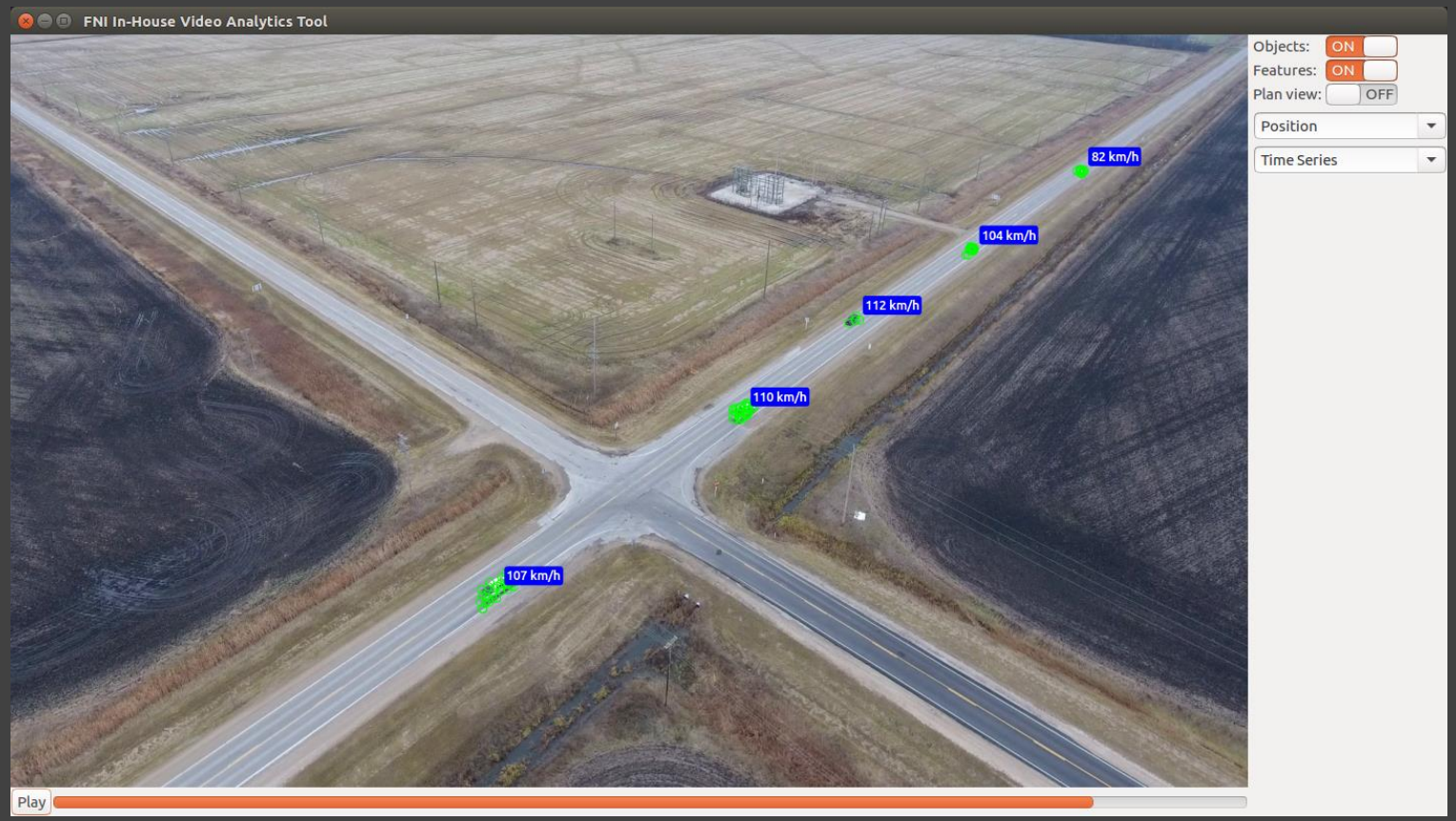

Photo source: FNI

Benefits:

- Ability to produce high-quality speed-based heat maps
- Similarly uses computer vision and machine learning to identify all video objects (vehicles, cyclists, pedestrians, etc.) and document their speed

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Application: Accident Reconstruction

Benefits:	Non-intrusive
	Rapid response time
Considerations:	Blanket SFOC required for fast deployment
	Site closure / policing
	Privacy / data

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Image source: Russell Aerial Photography

Application: Asset Management

- Pavement condition data collection
- Bridge asset inspection
- Thermal imaging
- LiDAR scanning
- Aerial mapping

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Other Applications

- Before-and-after studies
- Data collection for planning and design
- Emergency response
- Enforcement
- Event management
- Behaviour studies (e.g. driver behaviour, pedestrian behaviour)
- Micro-simulation research
- Traffic management

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Applying for your first SFOC

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Training

- Training of UAV flight operators may be achieved through UAV ground schools (both in-person and online) and other training facilities
- Previous experience is considered a major asset (e.g. commercial pilot license holders)
- Radio license requirement for operator

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Applying for your first SFOC

- Scoping the project and identification of risks is key
  - SFOC applications require detailed flight and contingency plans
  - Comprehensive scoping of flight operations reduces risks of returning to site
- An application must include information including the system specifications, the pilot and crew, the flight plan, and other safe operations information
- Scoping will also help inform liability insurance requirements

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Applying for your first SFOC

- Applications are submitted through one of the four regional Transport Canada offices
- Authorization times vary (e.g. 2 to 6 weeks)
- Blanket SFOCs may be considered upon first application if applicant team has significant past experience

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Safe Operations

Key considerations for road safety applications include:

- Perimeter / fencing
- Visual line of sight (VSOL)
- Property use / public notice
- Tethering

Image source: FNI

Potential challenges

- Underestimating the durability of UAV systems
- Underestimating the training and experience required of operators
- Underestimating the experience required to process and extract value from raw data
- Underestimating investment in maintaining a UAV program and complying with changing regulations

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Source: CCI, 2016

Privacy Considerations

- Data collection must adhere to privacy stipulations of the jurisdiction of the work
- Encryption of data may be a key factor in some cases; this may be addressed through selection of UAV system or through the use of a tether
- Data may have to be modified following collection (e.g. license plates / faces)

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Considerations when using a Third-Party Operator

- Technology / equipment
- Safety record (e.g. previous operations, SFOC history)
- Scope of previous work and relevant experience
- Cost, responsiveness

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Questions?

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