Unmanned Aircraft System Traffic Management (UTM)
TCL 4

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Technical Capability Level (TCL) 4 Overview

- Testing was conducted in two cities to demonstrate UTM capabilities in urban environments
  - Reno, NV June 17-28, 2019
  - Corpus Christi, TX August 12-23, 2019
- Nevada Institute of Autonomous Systems (NIAS) and the Lone Star UAS Center of Excellence (LSUASC) contracted to coordinate the tests for NASA
- Each test site formed industry-academia teams to provide equipment and services for the tests. Totals:
  - 7 UAS Service Supplier companies
  - 10 different UAS platforms
  - 35 participating organizations
- Test Scenarios put UTM through the paces:
  - Multiple UAS flying around and landing on buildings
  - Degraded communication and GPS signal environment
  - Normal and high priority first responder operations

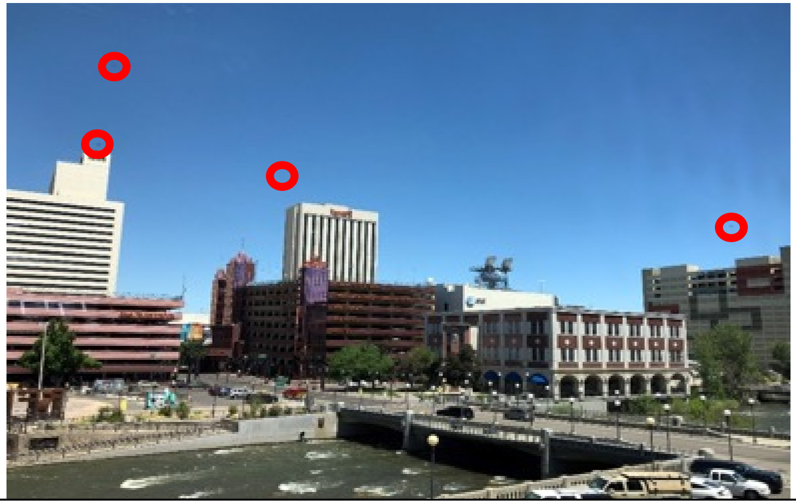
Reno test range

Corpus Christi test range

Technical Capability Level (TCL) 4 Outcomes

- TCL 4 is a demonstration of how UTM can manage high density, Unmanned Aircraft System (UAS) air traffic in urban areas
- TCL 4 testing demonstrated:
  - Complex multi-aircraft operations over buildings and near densely populated areas
  - A network of traffic management services provided by industry successfully coordinating and separating UAS
  - UTM safely managed large numbers of UAS in crowded air space
  - Cloud-based UTM provided a secure and efficient platform for all users
  - Network-based remote identification using UTM
  - Effective coordination with local municipalities to conduct trials in urban environments
  - The integration of multiple onboard technologies to address hazards of dense urban operations

UTM generated flight volumes for each UAS

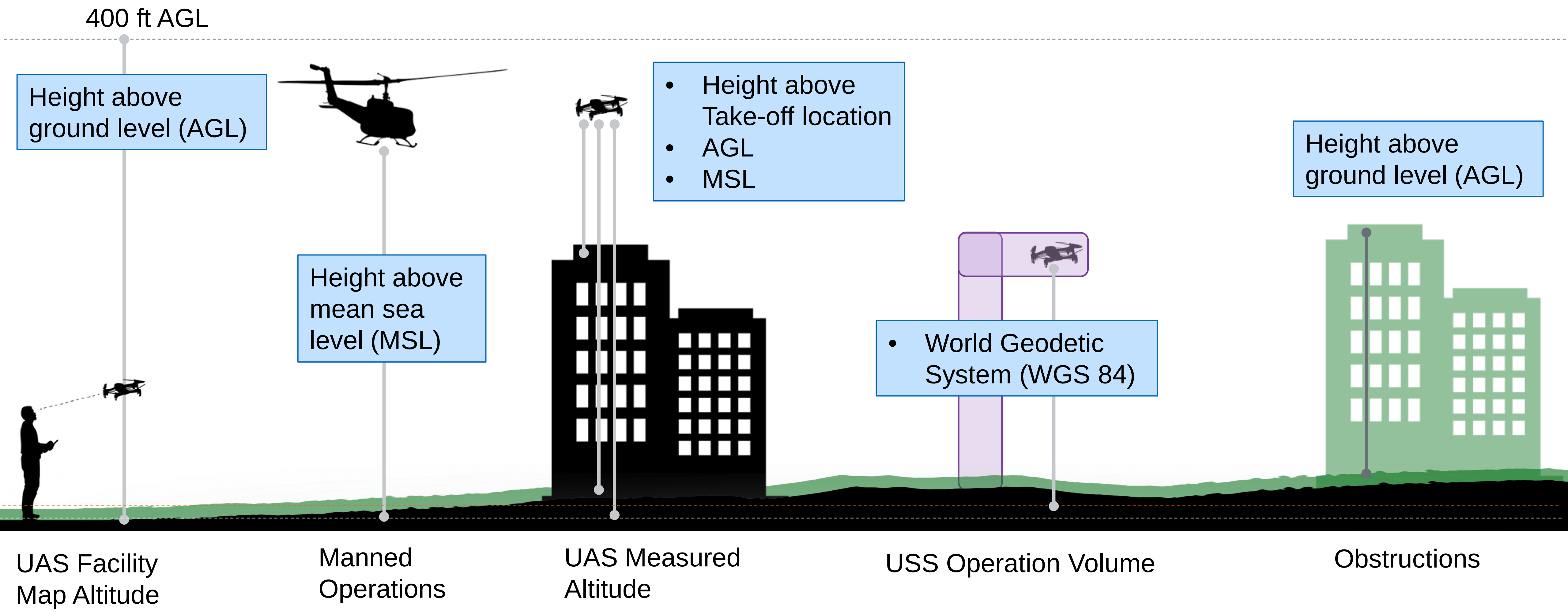


Four UAS autonomously flying over Reno managed by UTM

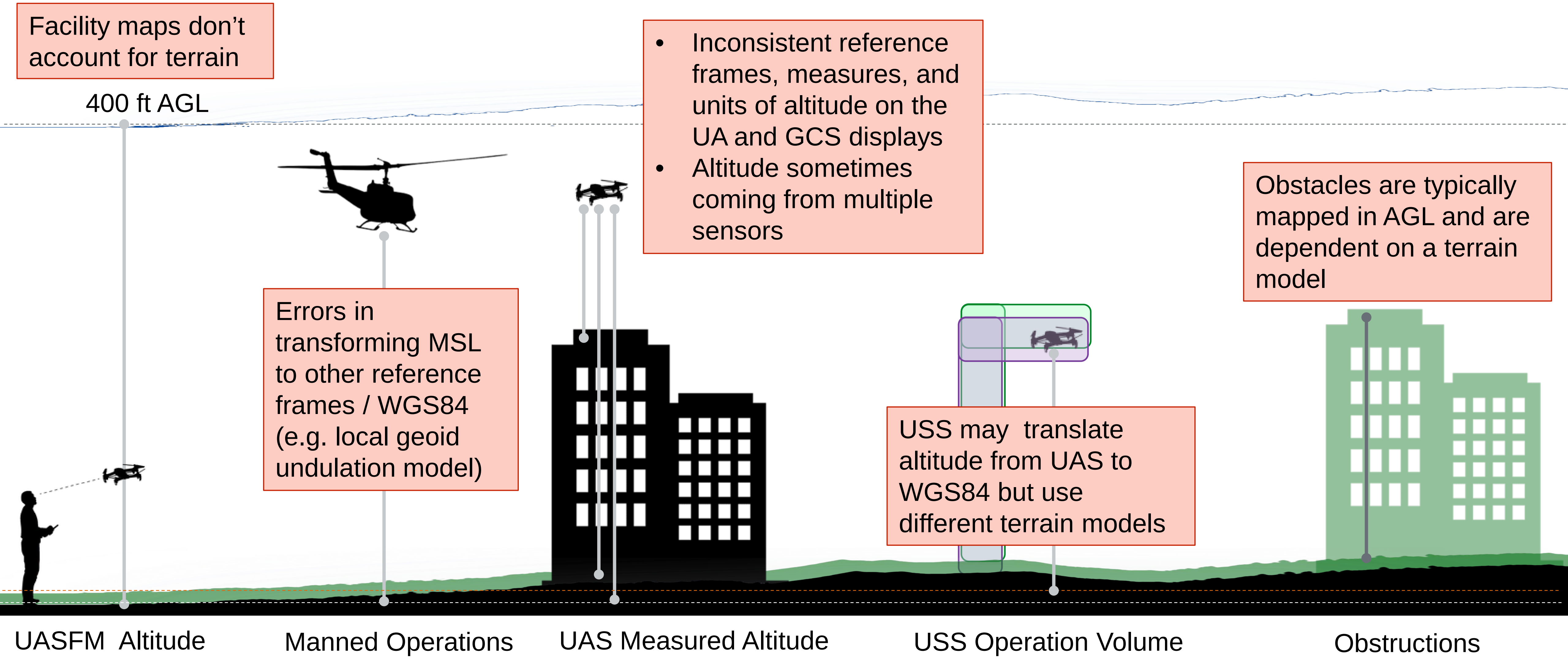
Overview

- Technical:
  - Urban environments highlighted increased hazards due to UAS industry employing non-standardized altitude reference systems
  - Urban environments contained diverse micro-climates and the lack of precision in existing weather measurement and forecasting poses a significant hazard for urban operations
  - Office buildings contained a high concentration of Wifi routers and of RF equipment which interfered with UAS that utilized unlicensed bands (e.g. creating unexpected loss link conditions near buildings)
  - UAS experienced multi-pathing and GPS degradation due to loss of radio line of sight from being near tall buildings
  - UAS and onboard mitigations lacked appropriate reliability. Single point failures of nominal systems (e.g. motors) or safety mitigation systems (e.g. parachute) created hazardous conditions for people on the ground
- Non-Technical:
  - Significant community and local government involvement is critical to successful testing and adoption of future commercial UAS operations in populated areas
  - Testing highlighted that local municipalities need to consider the balance between supporting safety and enabling commerce.

Challenges with Altitude



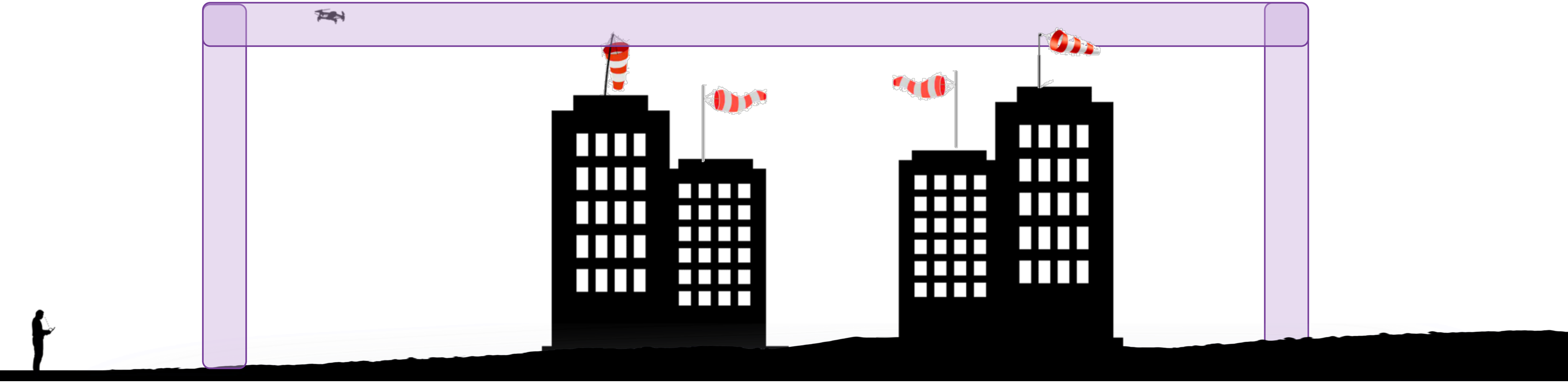
Challenges with Altitude



Standardization is needed for: (1) Reference Frame, (2) Measure, (3) Units, and (4) Translation Methods/Models used for each altitude measured, used, or communicated by/to a UAS and UAS Operator

Urban Micro-Climates

Significant variability in localized atmospheric conditions while operating in an urban environment: (1) Increased hazard due to unforeseen conditions and (2) loss of situation awareness due tolack of sufficient weather measurement/forecasting products



The lack of sufficient weather measurement and forecasting/prediction tools and products pose a significant gap in supporting safe BVLOS operations in urban environments

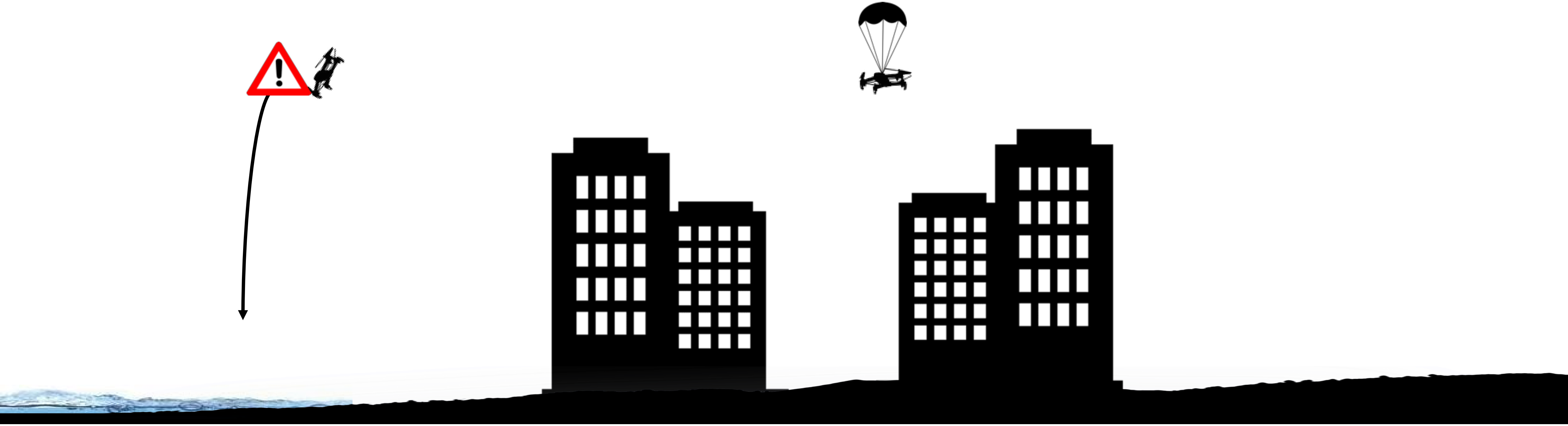
Electro-Magnetic Interference

Urban environments are ripe with electro-magnetic interference (e.g. Rebar in concrete / buildings, power wires) which can negatively impact the UA compass measurements prior to and during flight

UAS Operators should consider best practices of surveying any potential take-off/landing location to ensure area is free from magnetic interference

UA Safety and Reliability

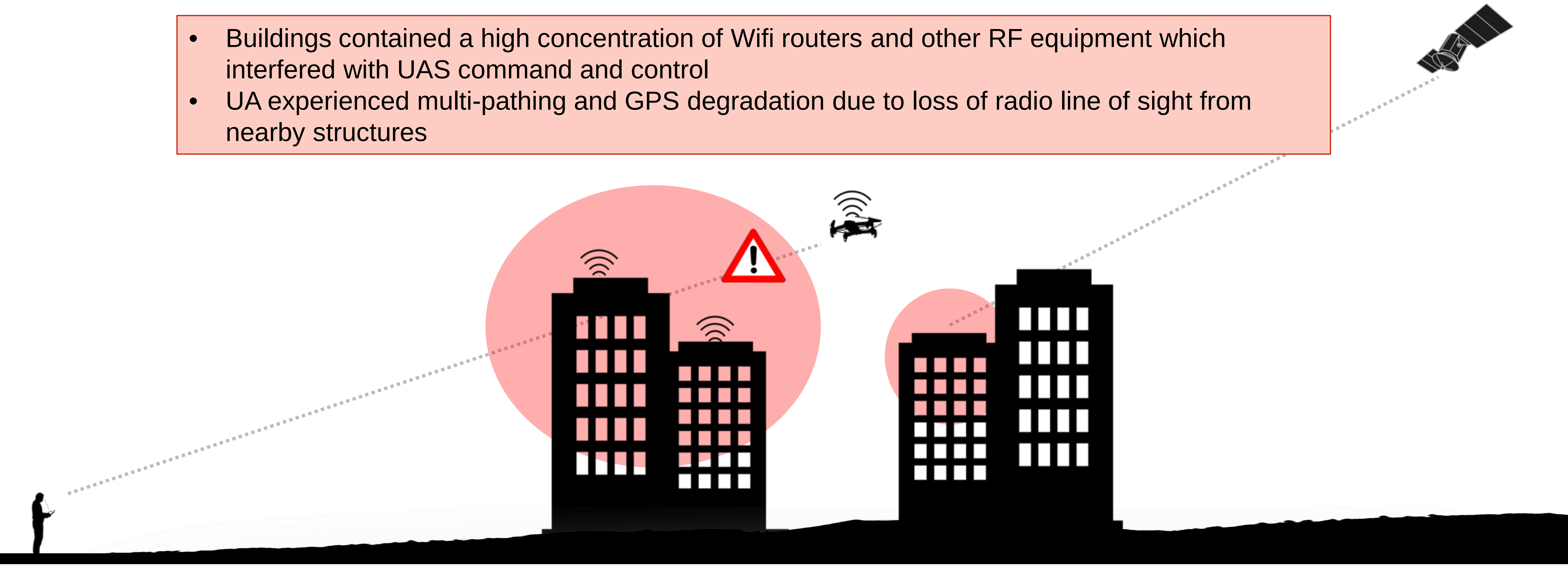
UAS and onboard mitigations lacked appropriate reliability. Single point failures of nominal systems (e.g. motors) or safety mitigation systems (e.g. parachute) created hazardous conditions for people on the ground



Improved and standardized system-level and component-level off-nominal testing should be considered as industry best practices to ensure that redundancy of safety mitigations does not mask unexpected hazards

Radio Frequency Interference

- Buildings contained a high concentration of Wifi routers and other RF equipment which interfered with UAS command and control
- UA experienced multi-pathing and GPS degradation due to loss of radio line of sight from nearby structures



Lack of sufficient situation awareness with respect to the spectral environment along and adjacent to flight path may pose hazardous conditions for UAS operations in urban environment. In the near term UAS Operators and local municipalities can survey RF environment for given areas of operations, future industry development may be necessary for spectrum monitoring and management as UAS density increases.

Commerce vs Safety

Significant community and local government involvement is critical to successful testing and adoption of future commercial UAS operations in populated areas

Testing highlighted that local municipalities need to consider the balance between supporting safety and enabling commerce and have some input into the UTM ecosystem. While enabling commerce in the air, UTM can simultaneously be impacting commerce from local business on the ground.