

## **Applications of UAV Systems for Post-Disaster Damage Assessment of Transportation Infrastructure**

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**ASPRS/CaGIS 2013 Fall Conference  
San Antonio, TX**

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2. Michigan Technological University (MTU)
3. USDOT Research and Innovative Technology Administration

# Abstract

- Advances in UAS airframes, control system technology and image processing make small unmanned systems practical and cost effective for more frequent flights
- Multiple platforms have recently become practical for remote damage assessment
  - Large to small, fixed wing, rotary wing, multi-rotor



# Overview

- Damage assessment important element in recovery process post-event
- Condition of transportation infrastructure important to response and recovery process
- High resolution (6''-1' per pixel) aerial imagery often captured after major events but not necessarily after smaller regional/local events
- Weather may limit aerial imagery collects for several days post event
- Cost may limit number of flights during recovery phase (if any after initial flights)

# Rotary wing/multi rotor



Mikrokopter Octokopter



# Small Fixed wing



Trimble UX5



IntelliTech Microsystems Vector P

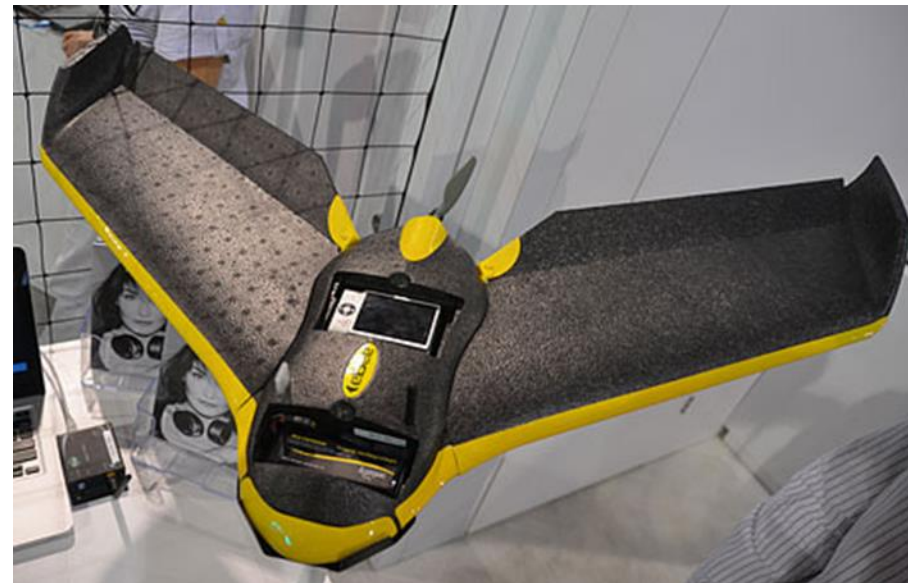


senseFly Swinglet

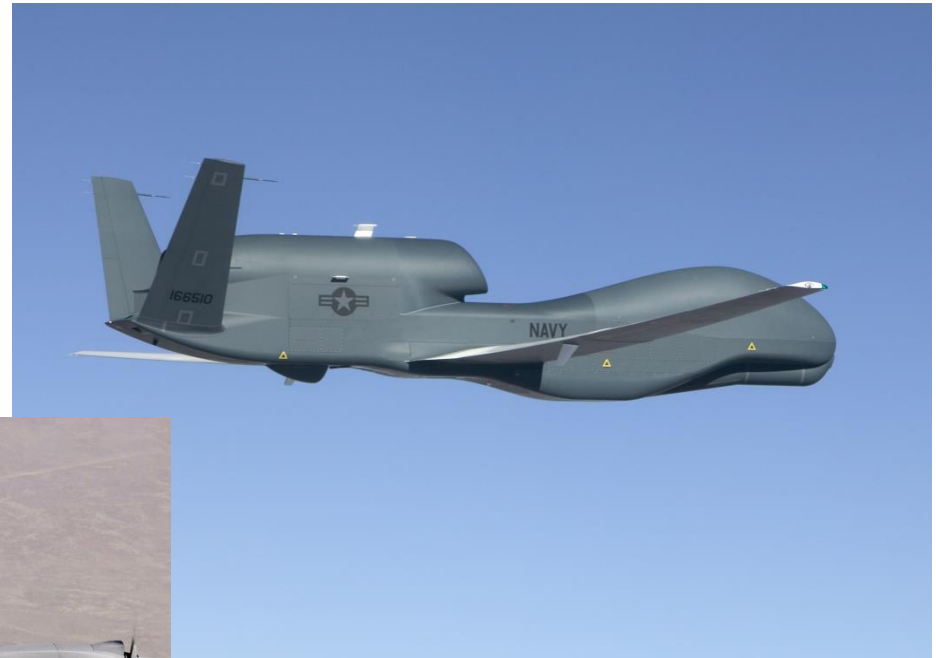


Trimble Gatewing X100

# Small Fixed Wing



# Large Fixed wing



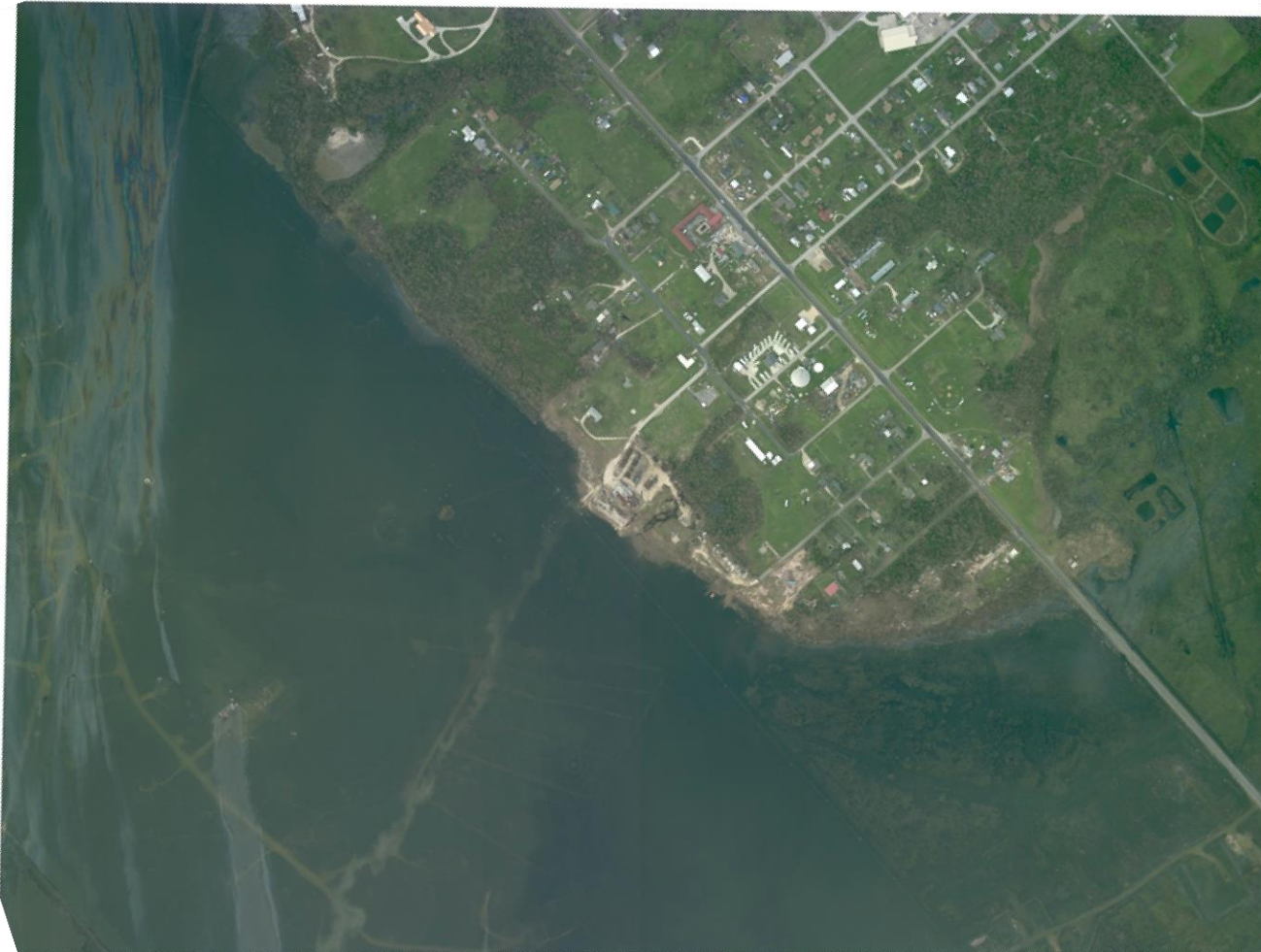


# The right system for the job

- Continuum from small fixed wing/multirotor UAVs with point and shoot cameras collecting imagery from low altitude over a small area to the manned, rotary or fixed wing aircraft and metric aerial photography cameras capturing imagery from high altitude over a large area
- Select the right sensor and airframe for the event
  - Small airframes and sensors for limited areas (inspecting transportation infrastructure – bridges)
  - Larger airframes for synoptic imagery of larger events (hurricanes, flooding, volcanic events)



# 50cm (16") per pixel orthophoto



High Island TX after Hurricane Ike, Sept 2008

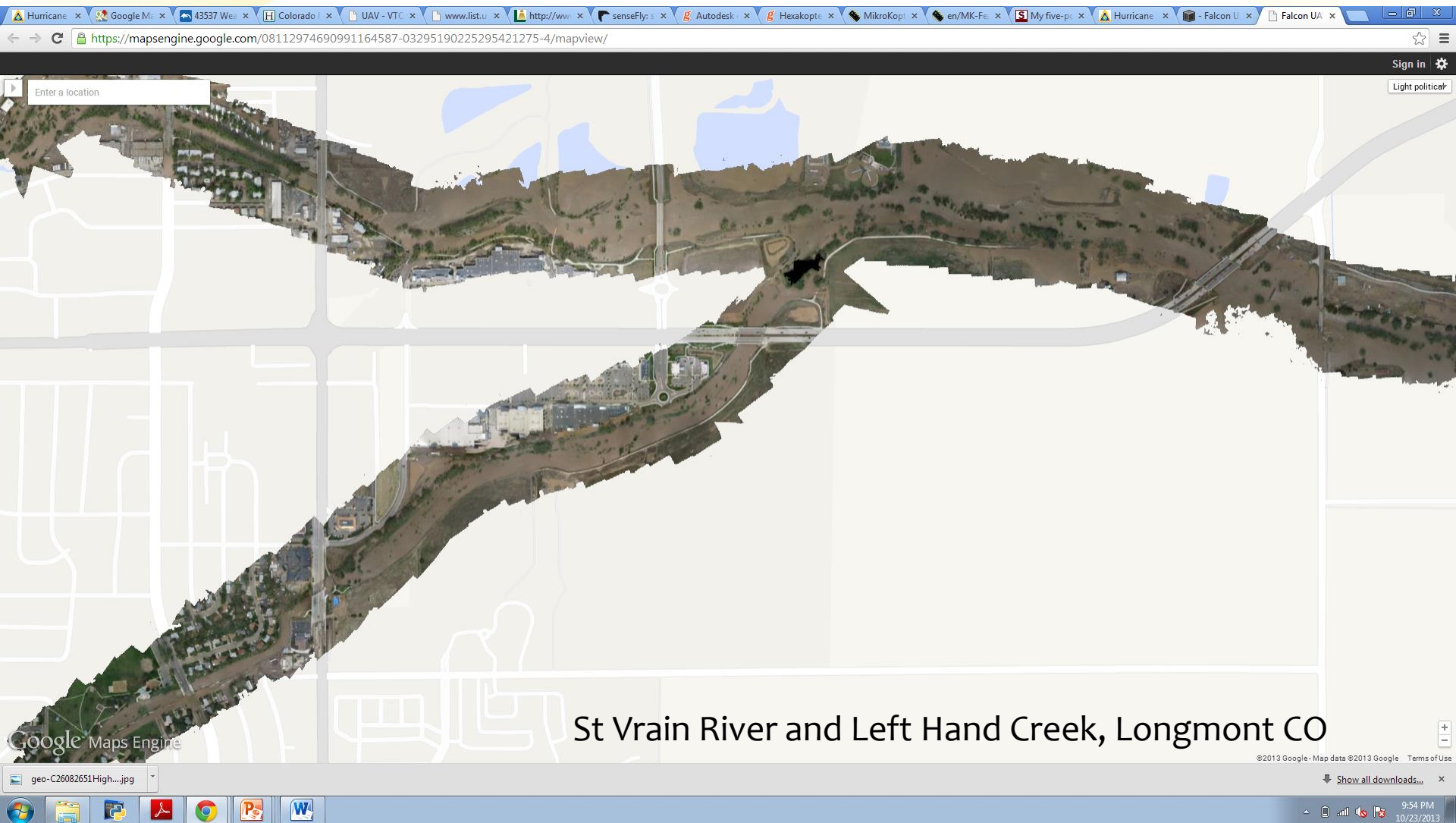


# Small UAVs for Response and Recovery

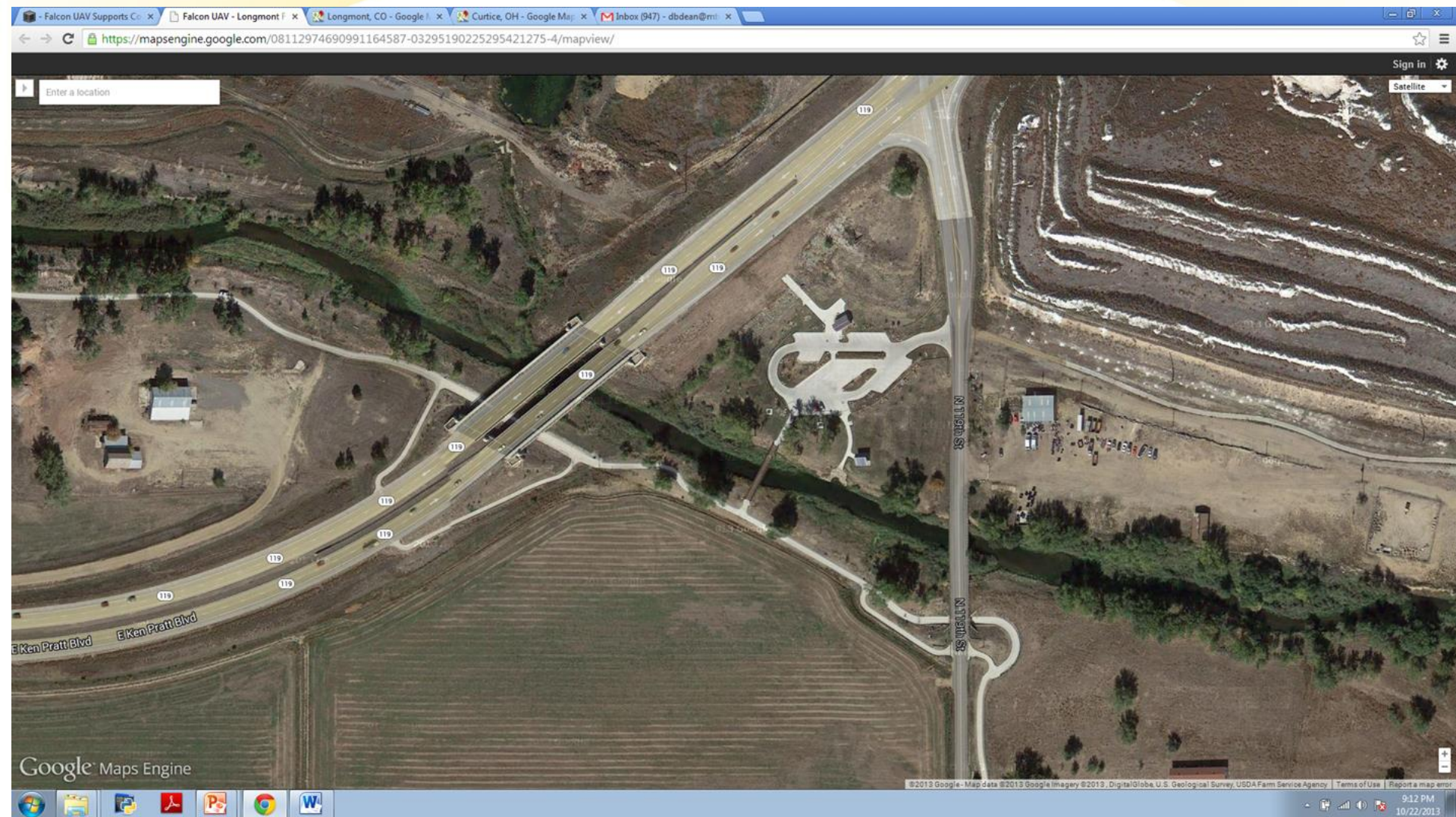
- Larger manned/unmanned aircraft fly at high altitudes, collect imagery at ~ 1 foot per pixel over large areas
- Smaller unmanned aircraft fixed wing or multicopter (hexacopter/octocopters) fly lower (100-400 feet) collect imagery at higher GSD (1 inch) over smaller areas
- Provide high resolution imagery, relatively inexpensive to operate, can revisit sites to document recovery progress
- May be able to collect imagery in weather where larger aircraft cannot (ceiling)



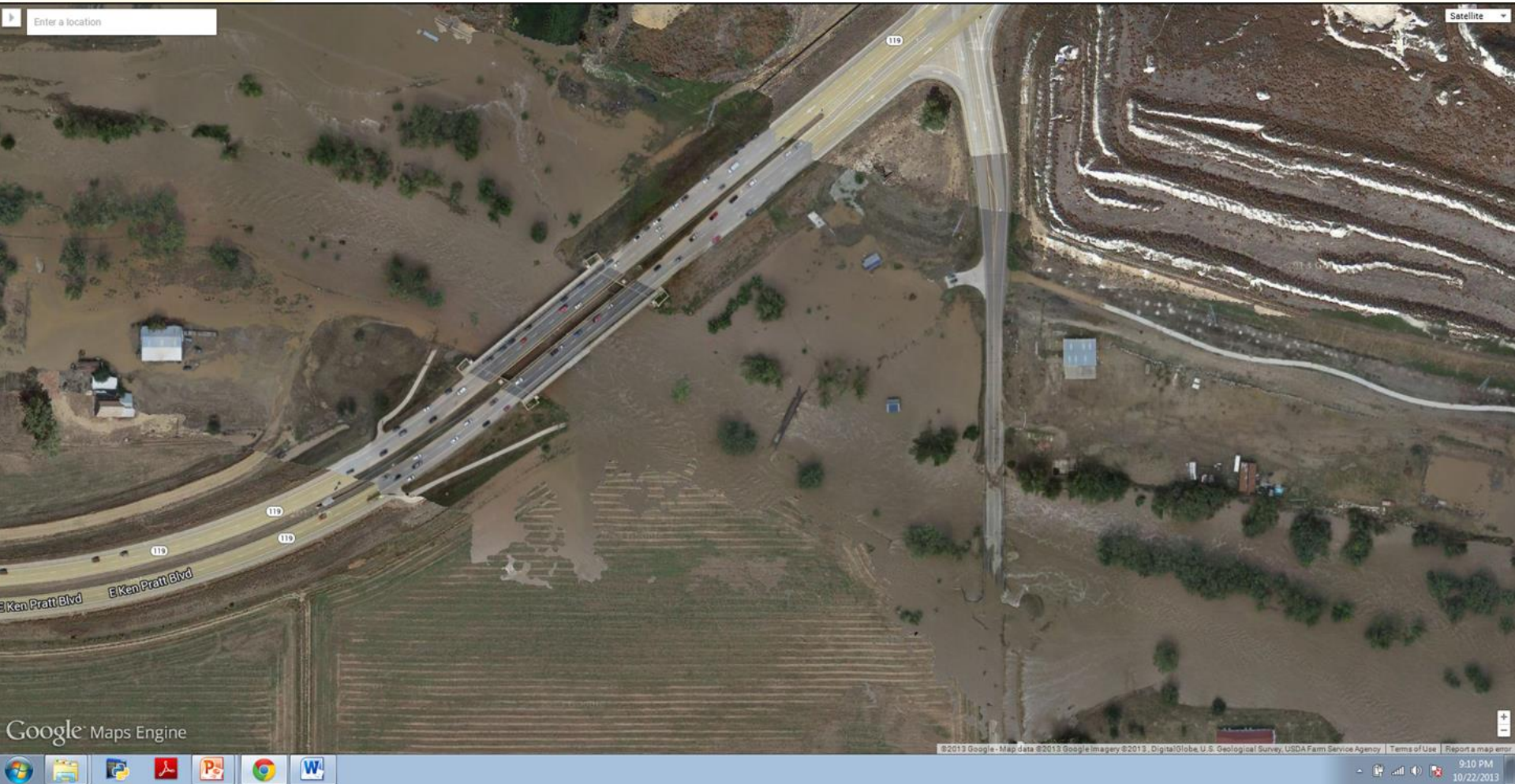
# Falcon UAV Orthomosaic



# St Vrain River before flood



# St Vrain River during flood



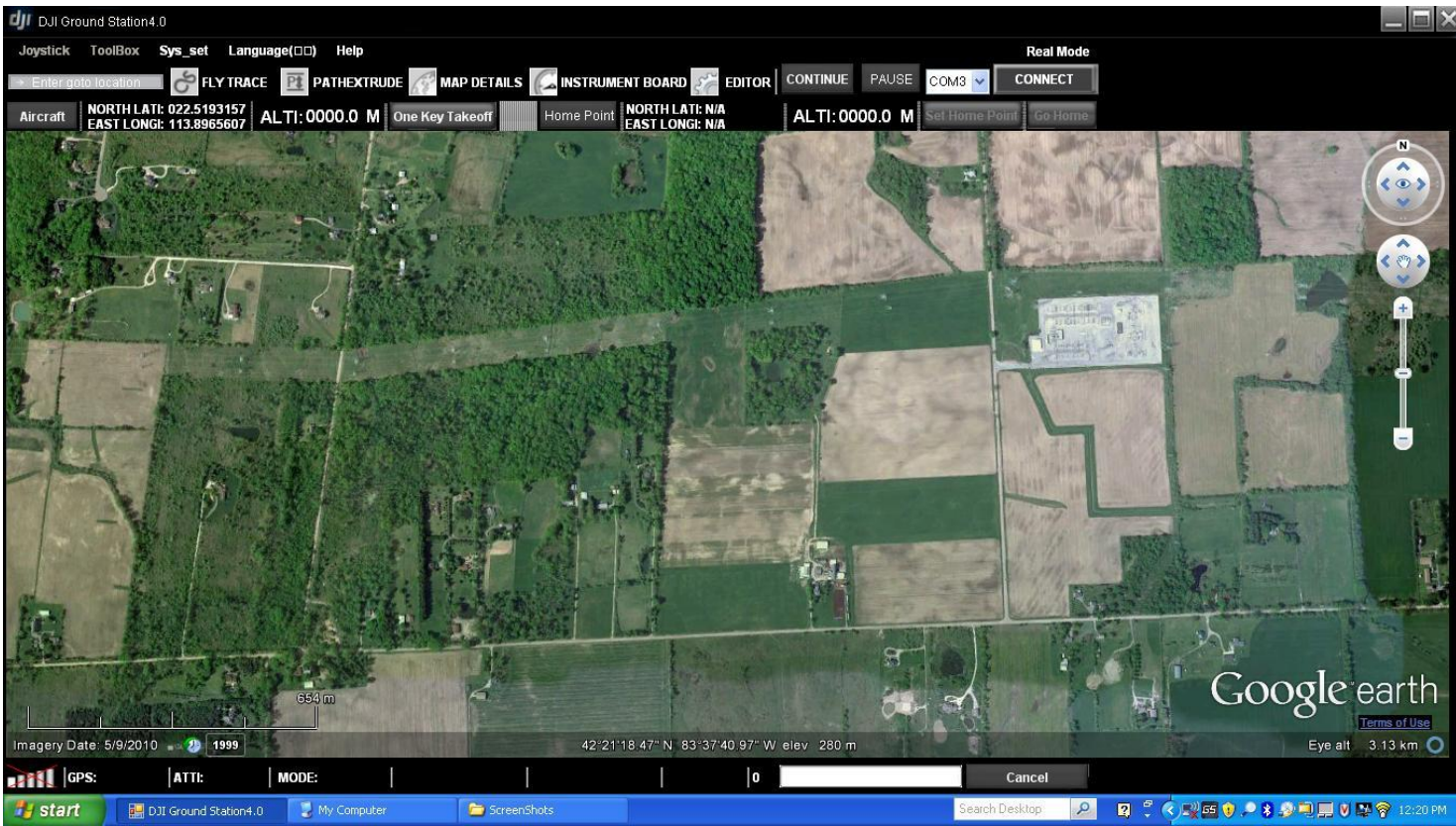


# Mission planning

- Allows planning flight trajectory using known GPS locations or map interface
  - Recognizable landmarks, signs, bridges, buildings may be missing or damaged
  - Multiple locations can be inventoried on a single flight

# Mission Planning

- Ground Station software
  - Set waypoints for helicopter collect
  - Google Earth interface
  - Ability to set the altitude and speed



# Mission planning

dji DJI Ground Station4.0

Joystick ToolBox Sys\_set Language(□□) Help

Enter goto location FLY TRACE PATH EXTRUDE MAP DETAILS INSTRUMENT BOARD EDITOR CONTINUE PAUSE COM3 CONNECT

Aircraft NORTH LATI: 022.5193157 ALTI: 0000.0 M One Key Takeoff Home Point NORTH LATI: N/A EAST LONGI: N/A ALTI: 0000.0 M Set Home Point Go Home

**dji**

Current point flight time: 00:00:00  
Total flight time: 00:00:00  
Total estimated time of one way: 00:05:58  
Total distance of one way: 1.032km

0(30m) 1(30m) 2(30m) 3(30m)

108.08m 107.44m 235.00m

184m

Imagery Date: 5/9/2010 1999

42°20'56.96" N 83°37'47.91" W elev 272 m

GPS: ATTI: MODE: 0

**dji EDITOR**

0 1 2 3 4 5

☐ 1.Way point properties

Latitude	42.347023010253906
Longitude	-83.63104248046875
Altitude	30
TurnMode	StopAndTurn
Forward_Flight_Speed	4
HeadingDegree	360
HoldTime	3

Altitude  
Altitude of the selected way point.

+ - CLEAR SAVE OPEN

+1 +10 -1 -10

CANCEL UPLOAD GO

start DJI Ground Station4.0 My Computer Screenshots untitled - Paint Search Desktop 1:13 PM

# Mission planning

dji DJI Ground Station4.0

Joystick ToolBox Sys\_set Language(□□) Help

Enter gate location FLY TRACE PATHEXTRUDE MAP DETAILS INSTRUMENT BOARD EDITOR CONTINUE PAUSE COM3 CONNECT

Aircraft NORTH LATI: 022.5193157 ALTI: 0000.0 M One Key Takeoff Home Point NORTH LATI: N/A ALTI: 0000.0 M Set Home Point Go Home

Current point flight time: 00:00:00  
Total flight time: 00:00:00  
Total estimated time of one way: 00:10:40  
Total distance of one way: 1.891km

Google earth

Imagery Date: 5/9/2010 1999 42°20'17.44"N 83°37'14.97"W elev 261 m Eye alt 538 m

GPS: ATTI: MODE: 0 Cancel

start DJI Ground Station4.0 My Computer ScreenShots Search Desktop 1:20 PM

# Mission Planning





# Infrastructure inspection

- Use of smaller UAVs for local infrastructure inspection
  - Road usable?
  - Bridge/culvert unusable, damaged but usable, undamaged?
  - UAV able to reach infrastructure beyond obstacles, faster inventory, documentation for recovery phase

# Other useful data

- High resolution ( $<1\text{cm/px}$ ) imagery can be used for evaluation of area around structure
- Structure from motion algorithms can derive point cloud to create high resolution DEM



# Photogrammetric point cloud



Photogrammetrically derived point cloud of the Muscatatuck IN Urban Training Complex  
Image courtesy Ohio DOT

# High Resolution Orthomosaic



Orthomosaic courtesy Ohio DOT

# Infrastructure evaluation



# Infrastructure evaluation



# Infrastructure evaluation



# Incident management



Muscatatuck Urban Training Center, Indiana  
Orthomosaic courtesy Ohio DOT

# Incident management



Muscatatuck Urban Training Center, Indiana  
Orthomosaic courtesy Ohio DOT

# Incident management



Muscatatuck Urban Training Center, Indiana  
Orthomosaic courtesy Ohio DOT



# Summary

- Many proposed systems, varying sizes and capabilities
- Potential to provide useful information for response and recovery operations
- Difficult to get COA approved to fly
- Many proposed systems, little actual experience
- September 2015 FAA UAS in the NAS