Infrastructure Health Monitoring and Management Using Unmanned Aircraft Systems

Presented by
Halil Ceylan, Ph.D., Director, PROSPER
ISU Site Director for PEGASAS

Dept. of Civil, Construction and Environmental Engineering (CCEE)
Program for Sustainable Pavement Engineering and Research (PROSPER)
Institute for Transportation (InTrans)
Iowa State University (ISU)

August 17, 2017
• ISU Graduate/Undergraduate Students/InfraDrone Members:
  – Robert Philpott III
  – Akash Vidyadharan
  – And many others

• ISU Faculty:
  – Dr. Halil Ceylan (ISU CCEE, InTrans, PROSPER)
  – Dr. Christina Bloebaum (ISU AeroE)
  – Dr. Sunghwan Kim (InTrans, PROSPER)
Program Objectives:
• Advance research, development and implementation of next-generation sustainable roadway systems.
• Integrate cutting-edge technologies from various disciplines to tackle real-world highway and airport pavement infrastructure problems.
• Investigate sustainable paving materials and construction technologies, pavement non-destructive testing and evaluation, performance monitoring, maintenance, repair and rehabilitation.

The overall goal of the Program for Sustainable Pavement Engineering & Research (PROSPER) is to advance research, education and technology transfer in the area of sustainable highway and airport pavement infrastructure systems.
Program for Sustainable Pavement Engineering & Research (PROSPER)
**Roadway Infrastructure Assessment and Modeling**
- Rapidly and reliably evaluate the existing condition of infrastructure systems using non-destructive technologies augmented by numerical simulations and artificial intelligence.
- Wireless Radio Frequency Identification (RFID) tags in highway and airport construction projects for temperature monitoring and concrete strength estimation using PCC maturity concept.

**Mechanistic and Performance Based Pavement Analysis, Design and Construction Technology**
- Improving the pavement performance prediction accuracy of Mechanistic-Empirical Pavement Design Guide (MEPDG)/AASHTOWare Pavement ME through local calibration.
- Use of RFID/MEMS based real-time field data for mechanistic calibration of pavement performance models.
- Development of simplified flexible and rigid pavement design models.
- Improved pavement forecasting models for repaired/rehabilitated pavement sections in Iowa.

**Sustainable Infrastructure/Engineering Materials**
- Development of electrically conductive concrete (ECC) with nano-structured superhydrophobic surfaces to achieve ice- and snow-free pavement surfaces.
- Economic and energy viability of heated airport pavement systems.
- Integrating Alternative/Recycled Materials into PCC Mix Design System.
- Use of biomass derived lignin in roadway geo-materials stabilization and unpaved road dust mitigation.
Halil Ceylan, Ph.D., Director, PROSPER

- **93 research projects**, serving as PI or Co-PI
  - Over $13.5 million of cumulative research funds (over $16.1 million project funds including matching funds)
  - Sponsored by the FHWA, the FAA, NSF, NCHRP, SHRP 2, IA DOT, IHRB, MN DOT, MN LRRB, PCA, GIVF, and other funding agencies

- Over **230 technical publications** authored

- Over **230 invited presentations and technical lectures** with several keynote lectures

- More than **20 national and international technical committees and organizations**
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and over 25 Ph.D. and M.S. students
• Iowa startup pioneered by ISU students
• Introduction

• Summary of Previous Studies

• Vision and Approaches

• Proof of Concept

• Applications

• Summary
Welcome to the World of UAVs/UASs!

• An Unmanned Aircraft System (UAS) is a system:
  – Unmanned Aircraft
  – Ground Control Station
  – Command & Control Link(s)

• Also known as:
  – Unmanned Aerial Vehicle (UAV)
  – Remotely Piloted Aircraft System (RPAS)
  – RC Model Aircraft
  – Drone
Welcome to the World of UAVs/UASs!
(Cont’d)

IN THE U.S., DRONES ARE HELPING TO:

- Fight wildfires
- Speed and assist emergency response and search and rescue operations
- Monitor and fix critical infrastructure
- Protect endangered species and sensitive ecosystems
- Transport medical supplies to remote locations and underserved communities

#Drones  go.wh.gov/drones
Welcome to the World of UAVs/UASs!

(Cont’d)

The White House Office of Science and Technology Policy (OSTP)

The First-Ever OSTP Workshop on Drones and the Future of Aviation

Harnessing the Potential of Unmanned Aircraft Systems Technology

AUGUST 2, 2016

SUMMARY: With today’s workshop, OSTP is announcing new public and private efforts to support the safe integration and innovative adoption of unmanned aircraft systems.

Today, the White House Office of Science and Technology Policy (OSTP) is hosting a workshop on Drones and the Future of Aviation—the first-ever event of its kind at the White House—to advance and celebrate the potential of unmanned aircraft systems (UAS), or drones. The event will gather experts from government, industry and the academic research community in order to accelerate opportunities and address challenges posed by this emerging technology.

Watch Live: The White House OSTP Workshop on Drones and the Future of Aviation
Welcome to the World of UAVs/UAS!
(Cont’d)

• The White House OSTP announced a series of actions to promote the innovative adoption of UAS across the US:

  - $35 million in research funding by the National Science Foundation (NSF) over the next five years to accelerate the understanding of how to intelligently and effectively design, control, and apply UAS to beneficial applications. This will include areas such as monitoring and inspection of physical infrastructure, smart disaster response, agricultural monitoring, the study of severe storms, and more;
  - A broad range of actions by the U.S. Department of the Interior (DOI) to use UAS to support search and rescue operations, to augment manned aircraft operations, and improve government processes around technological adoption;
  - A $5 million down-payment by the state of New York to support the growth of the emerging unmanned aircraft systems industry across New York; and
  - A collective commitment made by UAS industry associations to implement a broad educational effort around privacy best practices for users of UAS technology, among other private-sector commitments to support UAS technologies.
Why Use a UAS?

• UAS operations are particularly effective for missions that are dangerous or dull
  – Humans are not put at risk
  – Continuous operations are possible

• Operations with UAS often cost less than using manned aircraft
Predicted Value of UAS by Industry

- Infrastructure: $45.2 billion
- Agriculture: $32.4 billion
- Transport: $13 billion
- Security: $10 billion
- Media & Entertainment: $8.8 billion
- Insurance: $6.8 billion
- Telecommunication: $6.3 billion
- Mining: $4.4 billion

Value of business services and labor in billions

Source: PwC
UAS and Infrastructure Inspection/Monitoring

• Perform civil/transportation structural & functional health monitoring (S/FHM)
• Use a network of Unmanned Aircraft Systems (UAS)
• Equipped with visual and non-destructive evaluation (NDE) capabilities
• Increased accuracy of UAS
• Significantly reduce infrastructure monitoring costs
• Testing can occur more frequently
• Removes need to hinder regular operations during testing
• Ease of accessibility and navigation through complex structures
• Introduction

• Summary of Previous Studies

• Vision and Approaches

• Proof of Concept

• Applications

• Summary
Summary of Previous DOT Studies

- **Washington (2008)**
  - Weather data
  - Seismic data
  - Traffic surveillance
  - Border security
  - Avalanche control

- **Utah DOT (2012)**
  - Construction monitoring
  - Wetland plant species classification
  - Georeferencing
  - NIR and RGB

- **Georgia DOT (2013)**
  - Real time digital photo and video of traffic scenes
  - Aerial data in GDOT drawing software programs
  - Operations with limited or restricted personnel access

- **Michigan DOT (2014)**
  - Bridge condition assessment
  - LiDAR
  - Pump station inspection
  - Live traffic monitoring
  - Roadway asset detection

- **Ohio DOT (2015)**
  - Dam inspection
  - Crash investigation
  - Forensic mapping

- **Minnesota DOT (2015)**
  - LiDAR roadway data
  - Bridge inspection
  - NIR imaging
  - Created employee UAS policy

And many universities (Michigan Tech, South Dakota State University, etc.)
Illinois Department of Transportation (IDOT)

Drones to Offer New View on Transportation

SPRINGFIELD - The Illinois Department of Transportation (IDOT) has begun testing drone technology to potentially help improve the safety of workers and the public, reduce costs and introduce new strategies on everything from bridge inspections to determining the appropriate responses to emergency incidents.

“One of our main priorities has been to encourage staff to find opportunities to innovate and seek out new ways to use the latest technology that supports the important work we do," said Illinois Transportation Secretary Randy Blankenhorn. "While we are still in the experimental stage, we know that drones can gather valuable data to support a wide variety of applications. We are excited to launch this initiative that puts us on the path to becoming the most innovative department of transportation in the country."

Recently, IDOT purchased two drones to explore ways to enhance mapping practices and regular inspections of bridges, as well as documenting progress in work zones. The drones are expected to play an important role in increasing efficiency and improving employee safety by reducing the need to have workers in the field in high-risk situations.

Testing of live-streaming video also is underway on how to manage and respond to disasters or emergency situations by providing real-time footage to key decision-makers on the ground.

The department envisions the new technology to eventually assist in 3-D design on projects, geological studies and technical exhibits. The drones also will be looked at as a resource to prepare materials that educate and inform the public about impacts of construction and future projects.

Use of the drones will follow strict adherence of Federal Aviation Administration guidelines and be overseen and deployed by experienced personnel in IDOT’s Division of Aeronautics.

Visit IDOT’s YouTube channel to watch drone footage of recently completed highway projects in Illinois.
Previous Case Study: UAV for Unpaved Road Assessment

• Funded by USDOT Commercial Remote Sensing and Spatial Information Program through Office of the Assistant Secretary for Research and Technology (USDOT/OST-R)

• Executed by Michigan Tech University (PI: Colin N. Brooks)

• Phase I and Phase II were scoped, funded and completed by November 3th, 2016
  – Phase I: enhance and develop an unpaved road assessment system
  – Phase II: a commercially-available, implemented system available to transportation agencies
Previous Case Study: UAV for Unpaved Road Assessment (Cont’d)

• Bergen Hexacopter
  – Total flight time: up to 30 minutes with small payloads
  – Weight: 4kg unloaded
  – Maximum payload: 5kg
  – Easier to fly, less cost than single-rotor
Previous Case Study: UAV for Unpaved Road Assessment (Cont’d)

• Field tests on Welch road, Michigan

Potholes, washboarding (corrugation) and float aggregate on test section

Aerial view of the test section

3-D point cloud generated by the remote sensing processing system

3-D height map showing pothole distresses
• UAV, high-resolution camera, and good-quality lens
  – Cost per mile rated $30,590/yr/1575 mile/yr = $19.42/mile rated
  – HOWEVER...two 100-foot measured segments represent one mile of road, so 5,280 ft/200ft is 26.4
  – Therefore each mile of measured road represents a road network 26 times larger
  – Therefore cost is **$0.74 per mile** (= $19.42/mile dived by 26)
Previous Case Study: UAV for Bridge Inspections

• Phase I project was scoped, funded and completed by June 30th, 2015
• Phases II and III are underway
• Evaluate UAV’s safety and effectiveness for bridge inspection
• Capabilities and effectiveness in improving inspections and reducing inspection costs
• Fly without GPS, under bridge decks
• Photo, Video and Thermal Imaging
Previous Case Study: UAV for Bridge Inspections (Cont’d)

• Bridge 13509 – Chisago County
  – Small Local Bridge
  – Prestressed Concrete Beam Bridge
  – Unable to fly under bridge
  – Infrared images
  – Orthographic Mapping

<table>
<thead>
<tr>
<th>Table 5.1 Bridge 13509 Inspection Element Table</th>
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<tbody>
<tr>
<td>Bridge Element</td>
</tr>
<tr>
<td>012 Top of Concrete Deck</td>
</tr>
<tr>
<td>109 Prestressed Concrete Girder or Beam</td>
</tr>
<tr>
<td>215 Reinforced Concrete Abutment</td>
</tr>
<tr>
<td>311 Expansion Bearing</td>
</tr>
<tr>
<td>313 Fixed Bearing</td>
</tr>
<tr>
<td>331 Reinforced Concrete Bridge Railing</td>
</tr>
<tr>
<td>361 Scour Smart Flag</td>
</tr>
<tr>
<td>380 Secondary Structural Elements</td>
</tr>
<tr>
<td>387 Reinforced Concrete Wingswall</td>
</tr>
</tbody>
</table>
• Bridge 448 – Oronoco Bridge
  – Historical Concrete Arch Bridge
  – Prestressed Concrete Beam Approaches
  – Unable to fly under bridge
  – Able to fly in rain
• Bridge 49553 – Morrison County Pedestrian Bridge
  – Large Steel Truss
  – Great detail in images
  – Pack rust visible
  – Concrete deterioration visible
Previous Case Study: UAV for Bridge Inspections (Cont’d)

• Arcola Railroad Bridge
  – Large Complex Bridge
  – Normally inspected using rope access
  – National Park Service Permission
  – Difficult to access
Previous Case Study: UAV for Bridge Inspections (Cont’d)

• Nielsville Bridge 5767
  – Infrared Imaging
  – Thermal Camera results were similar to high end Flircameras
  – Drone has the ability to map chain drag markings for quantities in CAD
• UAVs can be used in the field during bridge inspections safely.
• Image quality allows for the identification of defects
• Tactile functions cannot be replicated using UAVs
• UAVs can be cost effective
• UAVs can provide a very efficient way to collect infrared images
• Safety risks could be minimized with the use of UAVs
• UAVs can be utilized to determine channel conditions
• UAVs can provide important pre-inspection information
• “Off the shelf” UAV’s have limited inspection capability
• Phases II and III are underway
• UAS must be within line of sight
• Daylight and twilight flights allowed
• Max height < 400 feet above structure
• Max speed < 100 mph
• UAV weight < 55 lbs
• Cannot fly directly over airports
• Remote pilot airman certificate to fly
• UAS must be registered with FAA
• Introduction

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• Proof of Concept

• Applications

• Summary
• Monitor multiple structures with UAS: Pilot studies
  – Road infrastructure (pavements and gravel roads)
  – Bridges
  – Energy infrastructure
  – Hazardous locations
• Design UAS with multipurpose & modular design
• Validate precision control and navigation of UAV
• Incorporate NDT and visual monitoring equipment into UAV
• Infrastructure HM&M using developed UAS
Approaches

• Different UAS for different purpose:
  – Fixed Wing
  – Light Quadcopter
  – Heavy-lift Hexacopter

• Retrofit sensors on UAS based on task:
  – 3D rendering & virtual reconstruction
  – HD visual inspection
  – Mobile LiDAR
  – Infrared thermal camera
  – NDE probes
• Proposed systems architecture
Capabilities: Fixed Wing UAV Design - Phantom FPV Flying Wing EPO Airplane

- Wingspan: 1,550 mm
- Motor: 900 kv brushless
- Endurance: 45 min
- Cruise speed: 40 mph
- FPV camera attachable
- Hero5 GoPro equipped
Capabilities: Hexacopter UAV Design - Advantages

• Larger speed and more power than quadcopter
• Higher altitudes than quadcopter
• More robust & safer than a quadcopter
  – Allows failure of up to 2 motors (Tested)
• Higher payload capability
  – Platform for mounting equipment
  – Highly customizable
• Greater precise stability and control
• Bottom 2 axis rotatable gimbal
Capabilities: Hexacopter UAV Design - Specifications

- Max takeoff weight: 2,800 grams
- Empty weight: 1,800 grams
- Endurance: 20 min
- Auto stabilization in winds up to 30 mph
- E310 propulsion system
  - Max thrust: 800 g/axis $\times 6$
- NAZA M V2 flight control system
- Battery: 5,200mAh 4s 20C LiPo $\times 2$
- Modular attachments
  - HD Camera
  - LiDAR
Capabilities: Hexacopter UAV Design - Systems Integration

Step 1: Install bottom board
- Install screws by appropriate force to prevent breaking threads.
- Use adequate screw glue for installing screws.

Step 2: Install autopilot system
- Please wire neatly. Make sure wires will not be cut by frame boards and propellers.
- Smooth out the boards edge if necessary.

Step 3: Install motors, ESCs

Step 4: Install top board
- Please install propellers after autopilot system configuration procedure.
- Make sure the rotation direction of propellers are the same as the figure shows.

Step 5: Install propellers
Capabilities: Hexacopter UAV Design - Systems Integration (Cont’d)
Outline

• Introduction
• Summary of Previous Studies
• Vision and Approaches
• Proof of Concept
• Applications
• Summary
Proof of Concept: Overview

3D Rendering & Virtual Reconstruction

High Definition Visual Inspection

Infrared Thermography

LiDAR
3D Rendering & Virtual Reconstruction

- Fixed Wing / Quadcopter UAS
- Multiple images 360 degrees
- 3D image reconstruction
- 85% geometric accuracy
- Texture 3D model for color
- Visual SFM or Pix4D used
• ISU Town Engineering Building

Image Collection
Approx 60 pics

Dense Point Cloud

Solid Mesh

Final Texture Render

3D Printing
• Iowa DOT complex (August 8, 2016)
• Iowa DOT complex (August 8, 2016)
3D Rendering & Virtual Reconstruction (Cont’d)

• Iowa DOT complex (August 8, 2016)
• Iowa DOT complex: final render
• 3D rendering potential applications
High Definition Visual Inspection

• HD camera payload
• Live transmission
• Close up images
• Pre-plan flight
• Image processing:
  – BHT
  – HSV
  – P-Color threshold
High Definition Visual Inspection - Pavements
High Definition Visual Inspection – Bridge
High Definition Visual Inspection – Bridge
(Cont’d)
High Definition Visual Inspection – Bridge (Cont’d)
High Definition Visual Inspection – Unpaved Roads
High Definition Visual Inspection – Unpaved Roads (Cont’d)
High Definition Visual Inspection – Unpaved Roads (Cont’d)
High Definition Visual Inspection – Power Lines
Infrared Thermography

• Power engineering
  – Overheating & hot spots

• Roofing specialists
  – Shows insulation dips due to moisture

• Defect inspection
  – Cracks
  – Holes
  – Leaks

• Ecology & agriculture
  – Irrigation Inspection
  – Plant Yield Estimation

• Disaster response management
  – Search and rescue
Light Detection and Ranging (LiDAR)

- Surface condition survey
- Crack detection
- 3D pothole geometry
- Grade model
- Rut model
- Digital Elevation Model (DEM)
- Building elevation model
LiDAR - Example Scan Results

- Forestry
- Power Lines Inspection (Top & Bottom)
- Mining Survey
Other: Robotic Arm Extender

- Payload for Hexacopter-II UAV
- Holds ultrasound equipment
- Arm end holds transducer
- Easy to maneuver around
- 360 degree 3 axis movement
- Extendable reach on walls
- Allows safe distance b/w wall & UAV
- Controlled manually by ground station
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Application: Transportation Infrastructure Inspection

- Crack detection and inspection
- Crack depth analysis
- Rut and pothole detection
- Delamination detection
- Sight distance, slope, grade, and contour models
- Pipeline inspection associated with roadways
- 3D photogrammetric, LiDAR model and thermal image model
Application: Building Inspection

- Aerial construction monitoring & management
- Structural health monitoring
- 3D construction time lapse
- Structural warping recognition
- Crack detection and inspection
- Crack depth analysis
- 3D photogrammetric and LiDAR model
Application: Disaster Management

- Visual location of victims
- Aerial damage assessment
- UAV resource (food/water) delivery
- Medical first aid kit delivery
- LiDAR damage assessment
- 3D flood modelling using DEM
Application: Underwater Structural Inspections

• Underwater drones may be developed
• Dam & bridge scour inspections
• Underwater visual monitoring
• 2D & 3D image reconstruction
• Underwater acoustic images
• Underwater LiDAR & SONAR used
• Low risk & cost effective
Application: Construction Safety Assessment

• A tool to assist the field inspector

• Safety of traveling public
  – Temporary traffic control measures
  – Temporary markings (alignment/visibility)
  – Entrance and exit of work vehicles into traffic

• Safety of contractor
  – Potential OSHA violations
  – Improper construction practices

• Capture traffic movement during peak hours

• Capture traffic during temporary traffic control set up and removal

• Review all footage and images
Application: Accident Reconstruction

• Use a drone to capture data to reconstruct an accident scene

• Meet existing accuracy requirements

• Open roads to traffic quicker

• Minimize exposure of accident personnel to traffic
• Aggregate stockpile

• Assess loss and damage after fire, wind, water, and hail events

• Energy infrastructure inspection (electric powerlines, solar panels, oil pipelines, wind turbines, etc.)
• Introduction

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• Summary
• Positive impact will be massive on industry

• UAS can contribute to a new era of civil infrastructure health monitoring

• Helps inspectors become more efficient

• Applications span across multiple industries

• Lower cost, time and risks involved
• Use of UAVs in transportation engineering and asset management is revolutionary innovation and a paradigm shift in finding targeted solutions for Iowa's transportation future!
• The White House OSTP Workshop on Drones and the Future of Aviation
• FHWA Construction Webinar: Unmanned Aerial Systems (UAS)
• FAA Fact Sheet – Small Unmanned Aircraft Regulations (Part 107)
• Other related resources from web
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Thank You!

Questions & Comments?
• Extra slides

• Are you ready to ride on drones?
ISU PROSPER-Iowa DOT Unmanned Aerial Systems Research Partnership Meetings

• August 8 to 9, 2016, Iowa Department of Transportation Ames Complex, NW Wing, 2nd Floor Conference Room

• The purpose of the meetings was to inform Iowa DOT on the potential uses, capabilities and benefits of UAS or Drones for civil and transportation applications and the preliminary studies conducted by the ISU-PROSPER team so far in this regard

• An important outcome of both the meetings was the discussion among the attendees in identifying UAS applications and capabilities that are of interest and value to Iowa DOT
### Highlights of Discussions: Infrastructure Health Monitoring and Management - Bridges/Roadways/Unpaved Roads

- **Live loading assessment and monitoring**
- **In-service inspection**
- **Impact assessment of flooding/extreme events**
- **Safety of infrastructure during emergency/collisions**
- **Monitoring of threats/vandalism**
- **Inspection of concrete box culverts and large-size girders**

- **Unpaved road condition assessment**
- **Calibration of roadway geometry**
- **Drainage assessment**
- **Erosion and sediment control assessment**
- **Bridge/roadway design support**
- **Condition of drill shafts (bridges)**
Highlights of Discussions: Infrastructure Health Monitoring and Management - Bridges/Roadways/Unpaved Roads (Cont’d)

- Surface integrity of bridge elements
- Inspection of out-of-plane bending of plates (bridge)
- Snow removal management
- Sealing of minor cracks (using UAS robotic arm)
- QC/QA for pavement analysis
- UAV-borne Electromagnetic Induction (EMI) and Ground Penetrating Radar (GPR) geophysical surveys
- Inspect research gages
- Bridge scour inspections using SONAR (underwater UAS)
- Snow and ice removal crew tracking
- Monitor movement of rocks/sediments
- Monitor concrete pavement curling and warping
- Non-Destructive Evaluation (NDE) using UAS robotic arm
Highlights of Discussions: Infrastructure Health Monitoring and Management - Bridges/Roadways/Unpaved Roads (Cont’d)

- Bridge deck delamination (infrared)
- Spall detection
Highlights of Discussions: Planning and Construction

• Construction inspection

• Construction project documentation

• Construction/materials estimation on site/stockpiles

• Assessment of grading progress

• Monitor construction progress (4-D)

• Rebar inspection in congested areas

• Airport obstruction analysis

• Site evaluation/exploratory

• Confined space inspection
Highlights of Discussions: Surveying/Photogrammetry

• As-built surveying

• Deriving Digital Elevation Models (DEMs)

• Deriving Digital Terrain Models (DTMs)

• Estimation of amount and type of fill material required for repairs from digital surface models

• Project-specific small-scale Photogrammetry
Highlights of Discussions: Asset Management

- Inventory of bridges and related assets
- Inspection of roadway assets
- Inspections of pump stations
- Inspection of high mast lighting poles (HML)
- Roadside condition and inventory surveys
- Dam inspection
- Wetland survey/mitigation
- Pavement reflectivity
• Inspections of entrances to sewers and culverts
• Pavement condition surveys
• Surface type inventory

• Pavement marking retroreflectivity
• Tracking/monitoring traffic control devices
Highlights of Discussions: Traffic

• Live traffic monitoring and control
• Work zone management
• Traffic data collection
• Incident management

• Real-time traffic impact assessment
• Monitoring congestion of roadways
• Monitoring activities at traffic intersections
• Assessment of traffic patterns
Highlights of Discussions: Traffic (Cont’d)

- Crash investigation
- Forensic mapping
- Support Intelligent Transportation
- System (ITS) application of highway and transportation infrastructure monitoring
- Urban highway traffic monitoring
- Level of Service (LOS) determination
- Estimation of average annual daily travel
- Measuring origin-destination flows
- Traffic-related pollution monitoring
• Avalanche control on mountain slopes

• Mapping snow depths

• Landslide investigations/mapping

• Geomorphological mapping

• Disaster response

• Migration monitoring and stewardship

• Forest mapping

• Search and rescue operations

• Downscaling NASA satellite images

• Soil moisture (drought, fire)

• Identifying ecological impacts of climate or land-use change

• Modeling flood-beds (4-D dynamic modeling)
Highlights of Discussions: Other Topics (Cont’d)

• State and local emergency management
• Precision surveying and mapping
• Wetland plant species classification
• Risk management
• Classification of vegetation cover and type

• Inspection of quarries and pits
• Facilities management
• Rangeland health determinations
• Homeland security
• Law enforcement
• Monitoring plant phenology

• Identifying locations of potentially erosive soils

• Measuring gaps between vegetation patches

• Environmental impact assessment

• Decision support for transportation planning, operations, maintenance and program development
Highlights of Discussions: 2017 CERFG

• UAS related research topics selected from the 2017 County Engineers Research Focus Group Meeting (CERFG)
  – Three UAS related topics made the top 5 list based on the prioritization and votes cast by the Iowa County Engineers among some 30 potential proposed research topics
    • Use of Unmanned Aerial Vehicles in Surveying and Construction Works for Iowa Transportation Infrastructure System (No. 1, 16 votes)
    • Use of Unmanned Aerial Systems for Health Monitoring and Condition Assessment of Iowa Low Volume Road and Bridge Infrastructure Systems (No. 3, 13 votes)
    • Unmanned Aerial Vehicles based Traffic Sign Inventory and Condition Assessment (No. 4, 9 votes)