Leveraging UAS and GIS to Optimize Open Channel Condition Assessment for the Tulsa CMS Program

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2016 EPA REGION 6 STORMWATER CONFERENCE

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PROJECT BACKGROUND

Channel Management System (CMS) for City of Tulsa

- Developed by Swift Water Resources Engineering ~2006
- Provides standardized methodology for inventorying the elements that make up a natural or improved open stream channels.
 - Condition assessment based on field inspection
 - Designed to prioritize open storm channel maintenance and capital improvement projects.
 - To be updated every 10 years
- Streams divided by basin into Flood Management Areas (FMAs) and then further subdivided into homogenous channel segments.
 - Segments field inspected and corresponding form(s) completed.
- CMS Inspection Manual
 - 20 pages of forms and instructions

FRED CREEK FLOOD MANAGEMENT AREAS



FRED CREEK FMA SUB-REACHES



CONDITION INVENTORY FORM

ATT THE REAL PROPERTY OF THE R	Number of Infrastructure Items Affected by Channel Condition
CHANNEL MANAGEMENT SYSTEM	Not Slightly Moderately Highly
PROPERTIES BY CHANNEL REACH	Affected Affected Affected Affected
	Side Headwall/Outfall
70Lex 05**	Weir/Blocks/Drop
Creek Council District City of Tulsa, Oklahoma FMA Atlas Sheet Public Works Department	Roadway (LF)
Reach ID	Bridge Pier
Description Inspection Date	Culvert Wingwall
Insp. By	Culvert Apron/End
	Low Water Crossing
Does the City Perform Maintenance	Other Structure
On this Channel Reach? Access	Public Utilities Private Utilities
Y/N	
	Sanitary Sewer Line Exposed (LF) # of Gas Line Exposures
Reach Description	# of San. Sewer Manholes Exposed # of Electric Line Exposures Water Line Exposed (LF) # of Other Util Exposures
Reach Description	
D/S Sec #	Channel Conveyance Condition
Descr. Descr.	# of Trees with Europed Roots
	# of Trees in Immediate Danger of Falling
Computed Channel Length	# of Trees Down in Channel
Adjacent I and Use for this Reach by Percent	
Commercial Open / No	Trees/Brush/Undergrowth Impeding Flow (LF)
Single Family Multi Family Industrial Structures	Drift Accumulation Impeding Flow (LF)
%%%	Bank Erosion/Scour (LF)
Number of Adjacent Structures in Floodplain	Sediment Deposition (LF)
Single Family	Improved Channel Condition (LF)
Multi Family	Good Slight Moderate Severe
Commercial/Industrial	Condition Defects Defects Defects
Public Buildings	Concrete Side Slopes
Number of Adjacent Overbank Properties Affected by Channel Condition	End of Concrete Channel
	Trickle Channel
Sightly Moderately Highly Affected Affected Affected	Rip Rap
Houses	Gabion
Apartment/Condo Buildings	Interlocking Blocks
Detached Garages/Out Buildings	Fabric Formed Concrete
Fences	Retain Wall, Masonry
Other Appurtenances	Retain Wall, Timber
Commercial/Industrial Buildings	Other
Public Buildings	Comments
Parking Lots	

CURRENT PROJECT OBJECTIVE

2016 CMS Update

- Streamline CMS Database Interface
 - Provide a Web Based Interface for data entry and retrieval
 - Mobile access essential



CMS DATABASE INTERFACE



CONDITION ENTRY

Stream Images





Channel Conveyance Condition

of Trees with Exposed Roots # of Trees in Immediate Danger of Falling # of Trees Down in Channel

0	=
1	
0	=)

-

-

+

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Moderate

0

0

0

0

0

-

-

÷

-

+

Severe

0

0

0

0

0

-

+

+

=

÷

Slight

20

30

0

0

310

Bank Erosion/Scour (LF)	
Bottom Scour (LF)	
Sediment Deposition (LF)	
Trees/Brush/Undergrowth Impeding Flow (LF	=)
Drift Accumulation Impeding Flow (LF)	

Improved Channel Condition (LF)

	Good Condit	ion	Slight Defects		Moder Defect	Moderate Defects		Severe Defects	
Concrete Side Steps	0	÷	0	3	0	=	0	3	
Concrete Bottom	0	=	0	=	0	=	0	=	
End of Concrete Channel	0	÷	0	=	0	=	0	3	
Trickle Channel	0	3	0	3	0		0	3	
Rip Rap	0	3	0	=	0	=	0		
Rip Rap, Grouted	300	÷	0	÷	0	3	0	=	
Gabion	0	÷	0	±)	0	=	0	=	
Interlocking Blocks	0	÷)	0		0	=	0		
Fabric Formed, Concrete	0	÷	0	±)	0	3	0	=	
Retain Wall, Concrete	0	-	0	=	0	=	0	=	
Retain Wall, Masonry	0	÷	0	÷	0	=	0	=	
Retain Wall, Timber	0	÷	0	3	0	=	0	=	
Other	0	3	0	3	0	=	0		

CURRENT PROJECT OBJECTIVE

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- Streamline CMS Database Interface
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- Field Inventory / Condition Assessment
 - ~285 Miles of open channel
 - 2006 Field Inventory
 - 2 person crew
 - 9 months field time
 - Thousands of paper forms
 - ~\$90,000



CITY OF TULSA OPEN STREAM CHANNELS



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 - ~285 Miles of open channel
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 - Thousands of paper forms
 - ~\$90,000
 - Can we use UAS to reduce field time and save \$\$??



WHY USE UAS FOR DATA COLLECTION

Ease of access to site

- Rugged terrain
- Thick vegetation
- Towers/tanks/rooftop inspection
- Photographic record of condition
 - Change over time
 - Archive/Records
- Faster
 - Reduce field time
 - Reduce cost
 - They're Really Cool!!

UAS PROJECT CONSIDERATIONS

Operate it yourself?

- Commercial use
 - If you charge for the data or derived data
 - Potential \$10,000 fine for violations
- Equipment
 - Multi Rotor
 - Most Common & Flexible
 - Shorter Flight Times/Smaller Areas
 - \$5000 and up
 - Fixed Wing
 - Need large takeoff/landing areas
 - Longer Flight times/Larger Areas
 - \$25,000 and up
- Training
 - WWW.FAA.GOV/UAS

LATEST UAS FAA REGULATIONS

\Box Training & Regulations \rightarrow www.faa.gov/uas

- New Small UAS Rule (Part 107) Effective August 29, 2016
- Pilot Requirements
 - Must be at least 16 years old
 - Must be vetted by the Transportation Safety Administration
 - Must pass an initial aeronautical knowledge test at an FAAapproved knowledge testing center
 - Remote Pilot Certification
 - www.faa.gov/uas/getting_started/fly_for_work_business/becoming_a_pilot
- Aircraft Requirements:
 - Weigh less than 55 lbs
 - Registered at www.registermyuas.faa.gov
 - Any UAS that weighs 8oz or greater (commercial or hobby)

LATEST UAS FAA REGULATIONS

- Basic Operating Rules (ALL of these are subject to waiver)
 - Class G airspace
 - All airspace below 14,500 feet not otherwise classified as controlled.
 - » Completely uncontrolled
 - Must keep the aircraft in sight (visual line-of-sight)
 - Even when the controller range is 2 miles!
 - Must fly under 400 feet AGL
 - When inspecting tall object, object itself is considered ground level
 - » Tower, rooftops, etc.
 - Must fly during the day
 - Must fly at or below 100 mph
 - Must yield right of way to manned aircraft
 - Must NOT fly over people
 - Must NOT fly from a moving vehicle

UAS CONTRACTOR - HOVER VISIONS

We decided to use a licensed UAS contractor

- Hover Visions
 - Dale Parrish Owner/Operator
 - Pilot since 1978 with over 400 hours flight time.
 - FAA 333 Exemption #16632
 - FAA Docket #FAA-2015-4751
 - http://hovervisions.com/
- UAS --DJI Inspire
 - 25 minute flight time
 - GPS & Glonass
 - 12 MP camera
 - 5cm(2in) pixels

PROJECT DESIGN & WORKFLOW

Collect aerial photos of all open channels in CMS project

- Tree lined Channels ~ 145 miles
 - Collect "Leaf-off" Late November to early March *no snow
- Open Channels ~ 138 Miles
 - Collect anytime it's not windy or raining
- Process Raw Images into Georeferenced Mosaics
 - Pix4D
 - Mobile flight planning
 - Desktop image processing
 - DroneDeploy
 - Subscription based Flight planning & processing service
 - Drone2Map for ArcGIS
 - Desktop image processing

PROJECT SCOPE



IMAGE PROCESSING

Drone Deploy

- Used by Hover Visions
- Subscription service
- Fully automates flight planning & camera through tablet application
- Upload raw photos to website and they email you the georeferenced mosaic.
- \$500/month unlimited processing
- Drone2Map for ArcGIS
 - Just for processing collected images
 - Uses Pix4D processing engine
 - Stand alone app from ESRI
 - Just out of Beta testing

UAS PROJECT MANAGEMENT

- Drone Deploy automates individual flights but how do I keep track of what has been completed?
 - ArcGIS Web Mapping Application
 - Web maps built and deployed in house
 - ArcGIS Server
 - Web Mapping Application built in ArcGIS Online
 - Web Application Builder
 - » Consumes web maps from in house server
 - » Compatible with Android/Apple devices
 - Available to Project Managers and UAS Contractor
 - Password Protected
 - QA/QC



WEB MAPPING APPLICATION



- □ The new FAA rules are opening the door for UAS applications and uses to increase dramatically.
- Software is making it easier than ever to collect professional quality images
- Weather can really slow down your project
- Be prepared for extremely large file sizes
 - #1 Issue with this project is Data Storage & Management.
 - A 5cm resolution image is roughly 36x as large as 1 foot resolution image covering the same area.
 - Thirty six 5cm pixels will fit in a single 1 foot pixel
 - The images are amazing when compared to existing sources

IMAGE COMPARISON-ESRI WORLD IMAGERY



IMAGE COMPARISON-GOOGLE HD (ARC2EARTH)



IMAGE COMPARISON-2015 CITY OF TULSA 1FT



IMAGE COMPARISON-UAS & DRONE DEPLOY



ADDITIONAL COMMENTARY

Progress in 5 months

- Open Channel 70% Completed
- Closed Channel 40% Completed
- Projected 70-80% reduction in field time...
 - Most "Open Channels" can be assessed from images alone.
 - Need to assess some "Tree Lined" channels in the field.
- Cost ~\$50/ stream mile
 - Assessment still needs to be completed for each segment.
 - Can be done from the comfort of your office
 - Photographic record of condition an important benefit.



STORMWATER QUALITY APPLICATIONS

- Potential Stormwater Quality Applications
 - Identify potential violations
 - Industrial runoff
 - Algae Blooms
 - Identify Erosion and Sedimentation issues
 - Stream turbidity
 - Others?



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MonJul04131626_DD_3B_SPN.tif

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QUESTIONS?

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DRONE2MAP FOR ARCGIS

Drone2Map for ArcGIS

- Requires ArcGIS Online account
- Takes raw photos with GPS coordinates and automatically determines orientation and overlap and combines them into a seamless mosaic.
- Benefits
 - Detailed control over the image priority and processing techniques
 - Work completed in house
- Drawbacks
 - Learning curve
 - Many large files, long processing times.



DRONE2MAP PROJECT TYPE

Exit

Create New Project

Select Project Template	
Rapid	
Mapping	
Inspection	

Create

Mapping

Create high resolution orthomosaics, multispectral indices, digital surface models, 3D colorized point clouds, and 3D textured meshes.



Aerial images with a high amount of overlap including oblique images.





Drone2Map





NDVI



Orthomosaic





3D Textured Mesh

3D PDF

Example Usage

- · Create 2D and 3D products ready for use in ArcGIS
- · Create multispectral products ready for analysis
- · Share Imagery as fast performing tiled caches

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PROJECT NAME & WORKSPACES

E	test1 - Drone2Map	_
New	Create New Project	
Open		
Help	A Drone2Map project is created on your local file system and stores your project settings, processing outputs, and other information about your project.	
About		
Exit	Give Your Project A Name 0 Detected Images	
EXIL	Select Where To Store Your Project A new project folder will be created Browse Source Imagery Select a folder with imagery to be processed Browse Optional Select the GPS file and the data format Latitude - * OK Cancel	

FLIGHT AND PHOTO INFORMATION



COMPLETED PROJECT

