



Coeur d'Alene Tribe GIS Unmanned Aerial System (UAS) Program

JAMES TWOTEETH | BERNE JACKSON | GIOVAN ALCALA | SABINE KRIER

What is an Unmanned Aerial System (UAS)?

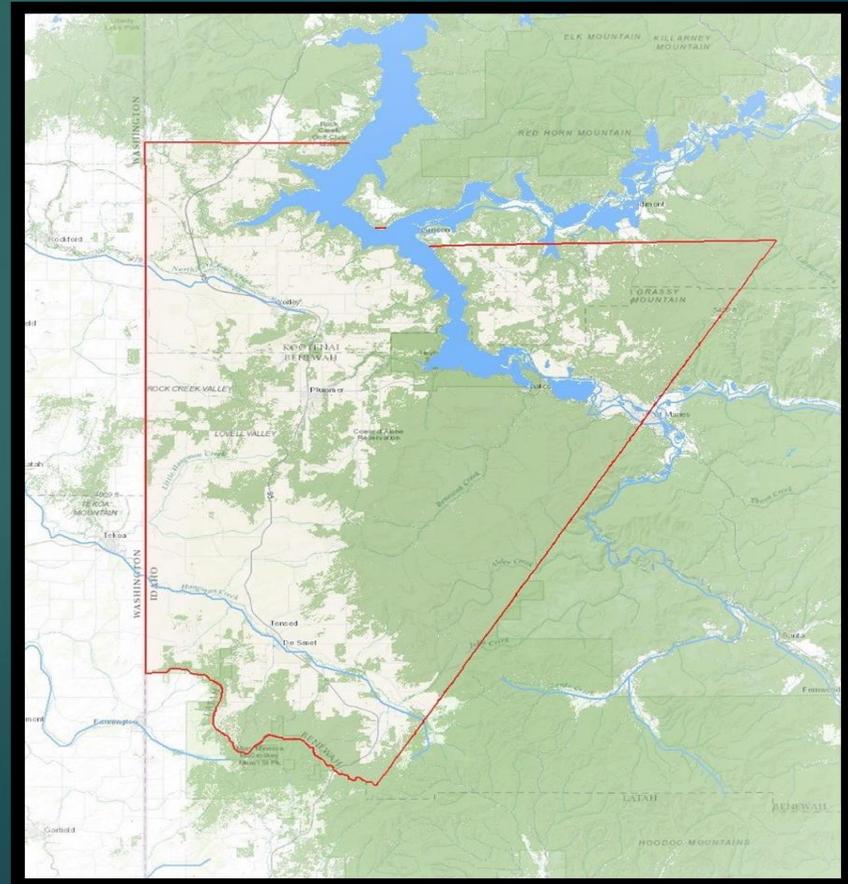
- ▶ Small, unmanned aircraft under 50 lbs. remotely piloted/programmed from ground control stations (computers)
- ▶ Rotary flight system with 3 or more propellers flown like a helicopter in hover mode
 - ▶ “quad-copter,” “hexa-copter,” “octa-copter”
 - ▶ Manufacturers: DJI, GoPro, Hubsan, Intel, YUNEEC, FREEFLY, Parrot, many others
- ▶ Fixed-wing, hand or catapult launched, typically with a single propeller flown like an airplane, but may have multiple motors and propellers with VTOL (Vertical Take Off and Landing) capabilities
 - ▶ Manufacturers: Trimble, Honeycomb, UASUSA, Parrot, Birdseyeview Aerobotics, Altavian, QuestUAV, PrecisionHawk, QuantumSystems, DroneAmerica many others
- ▶ aka, Unmanned Aerial Vehicles (UAV), “Drones”

About our Land

The 350,000-acre Coeur d'Alene Reservation is located in Northern Idaho. It includes the southern portion of Lake Coeur d'Alene, the lower end of the St. Joe River and many other creeks and wetlands. The eastern side of the reservation is mostly conifer covered mountains maintained by an active timber industry. The western part includes four small towns, but is otherwise mainly dry-land agricultural.

The Tribe manages a large portion of this land through their Natural Resources, Lake Management, Land Services and Public Works Departments. These departments were excited about the new possibilities opening up with a UAS program.

Lake Coeur d'Alene and Coeur d'Alene and St. Joe rivers are the heart of the Coeur d'Alene Tribe. It is where Tribal members go for ceremony, food, transportation and recreation. The Lake and its surrounding waters have always held great spiritual significance for Tribal members. The tragic effects of over a century of North Idaho Silver Valley mining are still having effects on the entire Coeur d'Alene Basin ecosystem. Mining sites' toxic by products run into the streams, rivers, and wetlands, and ultimately into the Lake itself.



Coeur d'Alene Tribe GIS Staff:



	IN	OUT	RETURNING										
			8	9	10	11	12	1	2	3	4		
GIS													
JAMES TWOTEETH	●												
BERNE JACKSON		●											
Giovan A		●											
SABINE K		●											
I.T.													
ANDY S		●											

Flying!

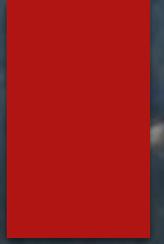


▶ Top: James Twoteeth, Berne Jackson
Bottom: Sabine Krier, Giovan Alcala

Career Day at the local High School

What launched our interest in acquiring a UAS?

- ▶ Need for higher resolution imagery; custom flown imagery is very expensive to fly
- ▶ Maturation of the UAS industry with models capable of long flights with heavier payloads
- ▶ The capability of flying areas multiple times of the year
- ▶ The ability to easily change imagers depending on the imagery requirements
- ▶ Grant monies becoming available



Selection criteria considered

- ▶ It was impossible to find a small UAS capable of imaging the amount of acreage we need to fly. We wanted the ability to fly as many acres as possible and still stay within the FAA line-of-sight contact rule. Rotary-style (“quad-copter”) UAS’s had very limited flight times (around 15 minutes).
- ▶ Fixed-wing UAS’s only had a single motor and often had large wing-spans making them very energy efficient in the air. These types of UAS’s could remain aloft for up to 90 minutes increasing their acreage coverage dramatically. The larger of these could also carry more payload increasing the versatility of the aircraft. The UASUSA Tempest was the finalist in the Tribe’s selection process. It had a wingspan of 9 feet and could carry about 7 pounds for well over an hour on a single battery. This gave the capability of acquiring imagery on close to 600 acres per flight gathering both RGB and near-infrared imagery simultaneously.



Acquisition of the Aero Systems West X8

- ▶ During Coeur d'Alene Tribe GIS's flight training with their Tempest conducted by Aero Systems West (ASW) in Morgan Hill, California, they realized that using the Tempest for training was not the best use of its time. ASW offered to sell one of its relatively inexpensive used foam UAS's, the X8, to the Tribe to use as a trainer. It uses the same autopilot and flight software as the Tempest. So operationally, it is very similar to the Tempest. In the event of a "hard landing," its foam airframe is relatively inexpensive to replace (available at Walmart!) and by swapping the internal components, it can quickly be back in service.
- ▶ We use it for improving our fly-by-wire skills, in particular our landing approaches, a vital maneuver in some emergencies.



Legal Preparations

- ▶ We knew we had to comply with the FAA regulations. For commercial UAV use, we would have to apply for a Section 333 exempt form to fly our UAS on the Reservation, but during the filling process, we found out that the FAA Part 107 UAS rules had just been released eliminating the need for the 333 exemption. North Idaho College in Coeur d'Alene offered approved in-classroom training for the FAA test. We signed up, took the course and passed our FAA exams, and are now licensed small UAS remote pilots. On the FAA UAS website, we could quickly register our new UAS and then proudly place the serial number on it. The last step was insure the UAS and all sensors with an insurance company specializing in UAS's.



Training and planning a Mission

So what all does it take to get flying and to capture the data we are looking for?

We did not have a background in Remote Control (RC) aircraft flying, thus, we had to have training in using the Mission Planner software that is used by the autopilot. This tells the autopilot how the UAS will take off, land and grid collection areas. We had to learn how to conduct maintenance on the UAS and all related equipment.

We needed a way to process the UAS's images. We knew about Pix4D, but, we already have the suite of ESRI products. Knowing that ESRI's Drone2Map uses the Pix4D engine under the hood, we were confident this software would be adequate for our processing needs. ESRI support has helped us along the way and we have been able to generate high quality and understandable data that we can now share on our Portal for ArcGIS in a web application.



What We Can Do Currently/Long Term

- ▶ Fly as often as needed
- ▶ Determine study areas
- ▶ Forestry or crop monitoring multiple times of the year
- ▶ Archaeology
- ▶ Stream/River bank
 - ▶ Restoration (Hangman Creek)
 - ▶ Erosion over time (St. Joe River)
- ▶ Timber sale
 - ▶ Health (Beetle or other tree disease)
 - ▶ Stand examine (sample plots)
 - ▶ Tree counts / Fire safety (brush)
 - ▶ Fly on cloudy day = better analysis of species
- ▶ Agriculture
 - ▶ Crop health (disease)
 - ▶ Harvest yield prediction vs. what makes it to the elevators (compare)
 - ▶ Pest control
 - ▶ Fertilizer optimization
 - ▶ Improve efficiency to farm marginal areas
- ▶ Animal tracking (thermal)
- ▶ Lake monitoring temperature (thermal)

Processing the Data

- ▶ We would love to just go out and fly every day – weather permitting – and obtain imagery. Nevertheless, we need to be able to process all that imagery and have a usable end product.
- ▶ We did research and discussed the different available image processing software packages with others who had experience. Using a free trial version of **Pix4D** seemed showed us a very capable software option, but seemed overly difficult to learn, so we decided on **Drone2Map**, an **ESRI** software available to us and more easy to learn and use. It seemed natural since we already use many other **ESRI** products like **ArcGIS Desktop**, **Server**, **Portal** and several field apps. Processing with **Drone2Map** is quite easy once you have flight logs to assign coordinates to the images.
- ▶ We learned that you need a very powerful computer to process the many images from a flight. It takes time; 580 acres of RGB imagery took the most capable workstation we had over 24 hours. The program may have difficulty with some flights' imagery, but **ESRI** support can walk you through those issues. **Drone2Map** will show 2D and 3D views of the finished data, and end products such as mosaicked ortho-imagery, NDVI, Digital Surface Models (DSM) and Digital Elevation Models (DEM). The final full **Drone2Map** report shows everything about the data and how to perfect our data collection procedures.



EPA Grant and Acquisition of Hyperspectral Sensor

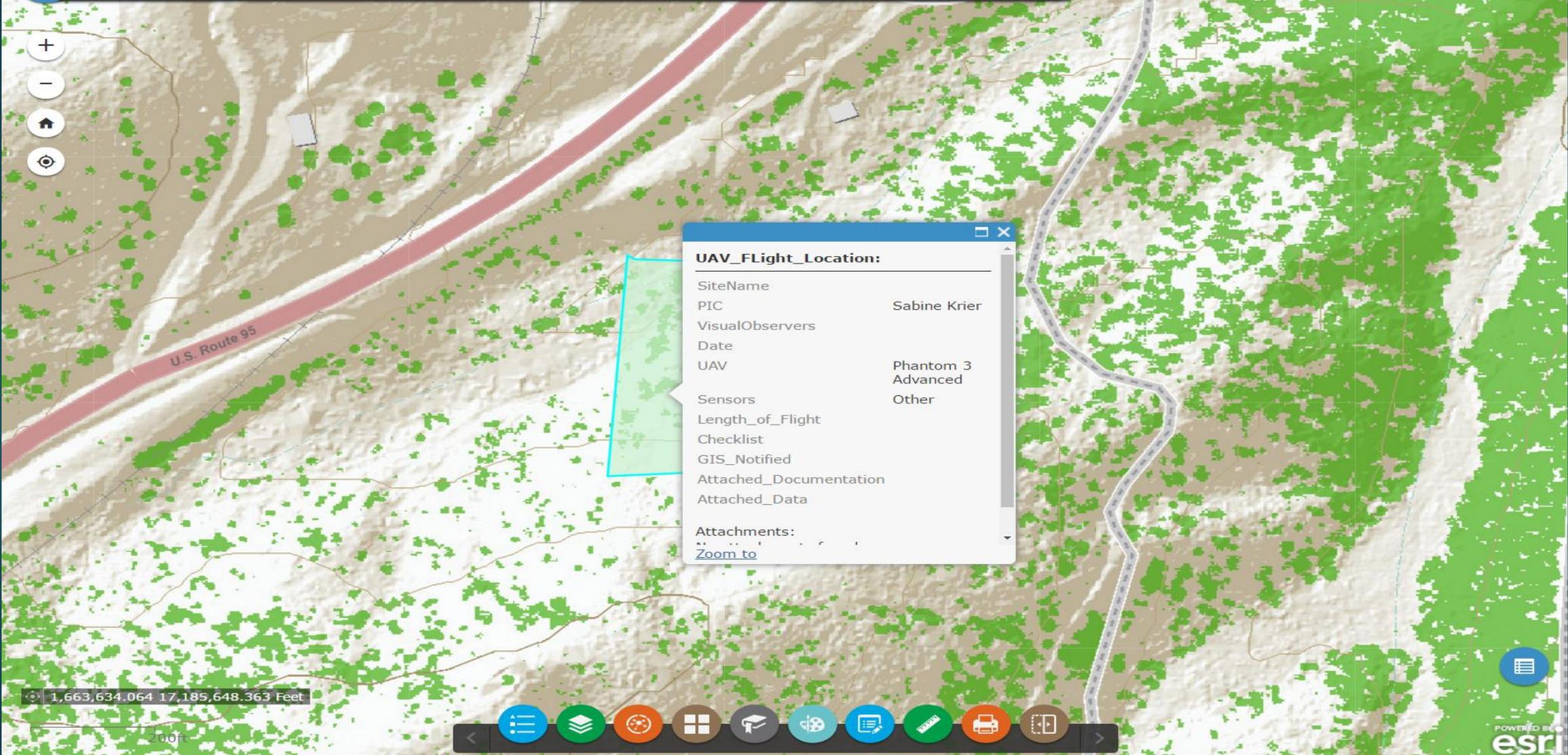
- ▶ Recently we were awarded an EPA Environmental Network Exchange grant. Our goal is to research, evaluate and map our many wetlands, streams and lakes and the impact of heavy metals, a by-product of the mining industries in the Silver Valley. With the help of this grant we are able to purchase our third UAS, a **DJI M600**. It is a rotary-style model with which we will be able to fly in tighter spaces like forest stands and over water. It will be equipped with a **Headwall Nano Hyperspec** hyperspectral sensor.



Hyperspectral Data Collection

- ▶ Remote sensing techniques have the ability to identify soil properties for both environmental and agricultural purposes. Hyperspectral sensor data has been used for over a decade to help researchers detect chemicals and heavy metals. For future decision-making, targeted cleanup and on-going maintenance and rehabilitation efforts in our wetland areas, the hyperspectral sensor attached to the **DJI M600** UAS can scan large sections to determine where runoff starts and where contaminated areas are located.
- ▶ The hyperspectral sensor collect vast amounts of images per flight. This would quickly fill the Tribe's current storage capabilities. To meet the demand of the incoming sensor data we had to acquire a higher storage capacity server and tape libraries.

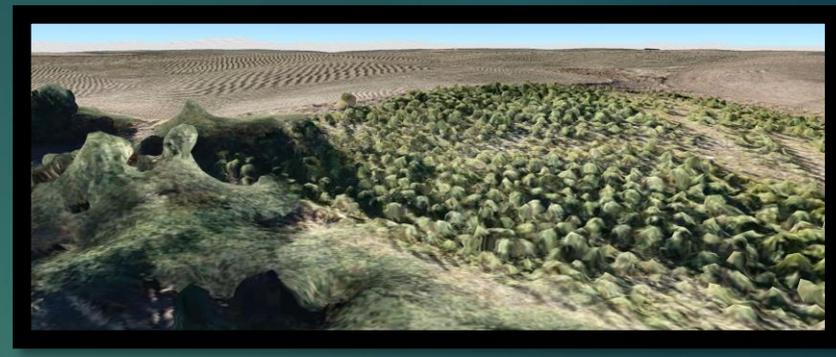




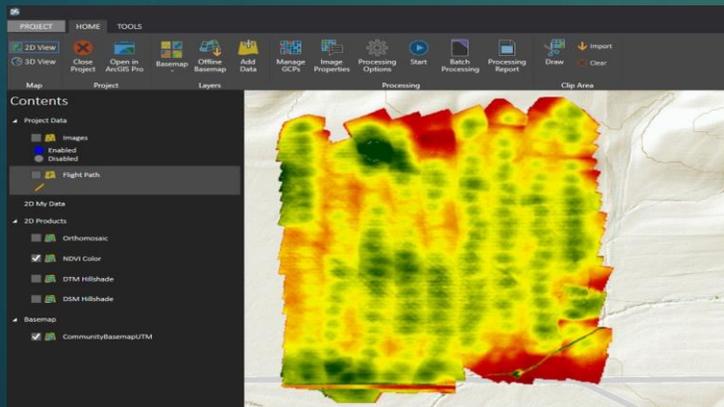
Launching!



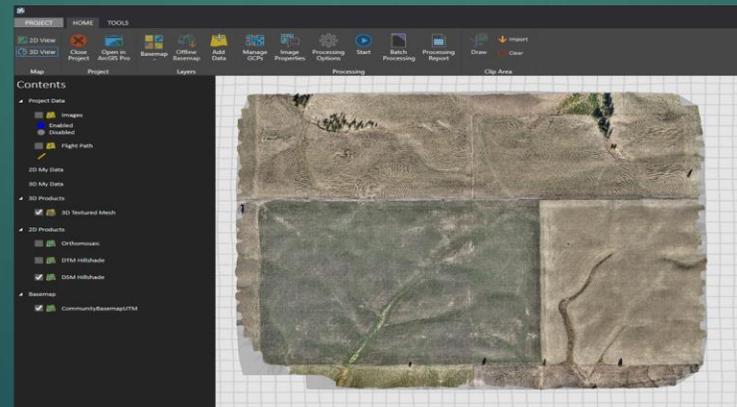
3D Imagery captured with the Tempest



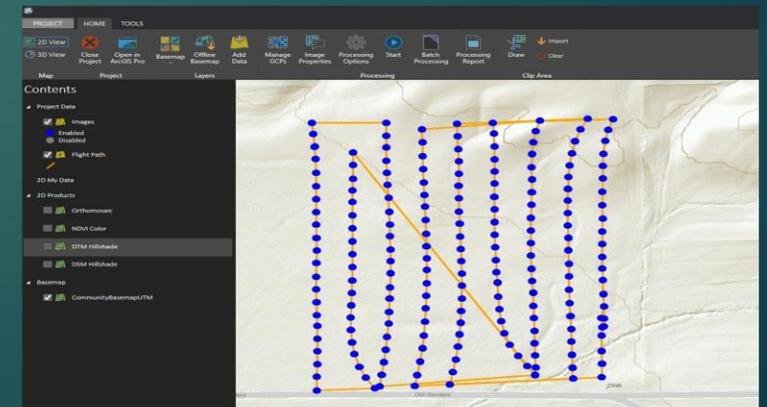
Hillshade produced from a DEM captured with the Tempest's Sony A6000 RGB sensor



NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI)



ORTHO IMAGERY @



Flight Path and Capture Points

Lessons Learned and Words of Advice

- You must be committed to creating a UAS program and have the need for the product it can produce. It's not about the "flying;" it's about data acquisition. Be patient. This will be a long and arduous process. And needless to say, it will be very expensive.
- Selection of a vendor is difficult. Many of these companies are young and going through growing pains of their own. Many companies out there selling UAS's can be gone next year or even next week. Vet them thoroughly. Choose carefully. An on-site visit can tell you a lot about a company. Ask for a list of other customers you can contact.
- If you are going to be flying different sensors, make sure they can easily be swapped in and out with minimal tools and rewiring. Some have a modular compartment where the different sensors just plug in and out.
- Flight times claimed by the vendors are highly inflated.
- Make sure you get actual flight training on your UAS, even if you have to pay for it outside the cost of the UAS. Everyone is unique and flight procedures can be very different. You may have to travel to their facility to do this training.
- Everything from take-off to landing is handled by the autopilot on a UAS used for image acquisition. However, it is a good idea to be able to fly them manually in the "stabilized" mode for emergency procedures and landings.
- Crashes are inevitable and UAS's break. Get over it. Don't forget to insure your bird for replacement value! Have a plan for recovering from a ground/obstacle "encounter," and get back flying!

Our Vision

- ▶ A year ago, all we had was a dream of a UAS Program. Now we have three UAS's, several sensors for various imagery bands, a dozen flights with data capture and image processing completed and a lot of flying stories! We are proud to have created a fully functioning UAS Program and look forward to many more possibilities and accomplishments.
- ▶ We would like to cover as much of the Coeur d'Alene Reservation as possible, assisting the other departments like Natural Resources, Planning, Lake and Land Managements with their research, analyses and management. In the future, our goal is to acquire thermal and LiDAR sensors, and an under-water unmanned vehicle for mapping our waters' subsurface.
- ▶ We want to assist in bringing greater insights into our environmental processes. We plan to share our knowledge and experience with other tribes, and hope to inspire our youth to choose a career in this important field.

<http://georunner28.maps.arcgis.com/apps/Cascade/index.html?appid=e8977298c03b4050b7e90bba6984a16f>

<https://youtu.be/mGSrmu75UME>



For the Road Ahead



- ▶ **THERMAL SENSOR**
- ▶ Evaluating environmental effects on lake, rivers and creeks

- ▶ **LIDAR SENSOR**
- ▶ Focused elevation calculations

- ▶ **UNDERWATER UAV**