



Renewable Energy Program

North Dakota Industrial Commission

Application

Project Title: Onsite Installation of Secure, Remote, Autonomous, Multi-Drone Operations within the North Dakota Renewable Energy Sector

Applicant: Evolve Analytics, LLC

Principal Investigator: Dr. Joshua M. Riedy

Date of Application: 04/15/19

Amount of Request: \$500,000

Total Amount of Proposed Project: \$1,403,373

Duration of Project: 18 Months

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Attachment B – Certificate of Good Standing

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- **Xcel Energy**
- **Microsoft**
- **UND-RIAS**
- **Northern Plains UAS Test Site**

Attachment E – “Nest” Conceptual Design (CONFIDENTIAL)

Attachment F – Xcel Energy Wildlife Mortality Proposal (CONFIDENTIAL)

Attachment G – Expert Development Estimate (CONFIDENTIAL)

Attachment H – Microsoft TechSpark Award (CONFIDENTIAL)

Attachment I – Detailed Budget

***Attachments B, D-H are provided in separate documents.**

Participants - Evolve Analytics (EA), a North Dakota limited liability corporation located in Grand Forks, and supported by the UND Aerospace Foundation, Microsoft TechSpark, the Grand Forks Region EDC, and the City of Grand Forks; has partnered with the University of North Dakota, specifically the Research Institute for Autonomous Systems (RIAS), the Northern Plains UAS Test Site, and corporate partners Xcel Energy and Microsoft.

PROJECT DESCRIPTION

Objective - This proposal seeks product development funding to build Airtonomy, a first of its kind, readily available (365 day x 24 hours) commercial deployment of a secure, remote, autonomous, multi-drone, operations solution, that offers significant time, convenience, scalability and accuracy advantages over existing processes within the Renewable Energy Sector. Installed on site, powered by solar energy, and operated remotely; such a system will revolutionize efficiency of asset inspection and maintenance within the Renewable Energy Sector, using drones to enhance critical operational aspects such as:

- Wildlife Mortality Monitoring and Mitigation
 - Monitoring
 - Improving safety by reducing the required walking distance of a biologist in potentially hazardous areas.
 - Obtaining more accurate results by allowing the drone to fly in the areas that may be temporarily inaccessible.
 - Lowering costs by reducing the man-hours necessary for these programs.
 - Mitigation
 - Application of AI to active video monitoring of bird traffic through wind sites can identify intervention opportunities facilitated by onsite drones.
 - The outcome will be significantly reduced mortality, especially for protected bird species.
- Inspection and Maintenance
 - Visual inspections can automatically be triggered by events (storm, lightning strike), equipment control systems (gearbox friction, power cell degradation, reduced power curve), technicians, or command centers.
 - Artificial Intelligence/Machine Learning (AI/ML) based inspections are highly repeatable and highly accurate offering an unparalleled basis for time-based change detection.
 - Readily obtaining timely, high-quality imagery and video as needed.
 - Drone hardware resilience coupled with ready availability is a staff force multiplier.
 - Regular visual inspections combined with data collected from equipment control systems will provide an unparalleled foundation for predictive maintenance.
 - Predictive maintenance modeling should inform repair and replacement decisions.
 - Expediting insurance claims and work orders with access to historical inspection information and timely visual information.
 - The overall intended outcome is to lower repair costs, while simultaneously increasing power output.
- Safety and Security

- Current manual practices, such as climbing or rappelling, can be supplanted.
- Enhanced timeliness of reconnaissance positively impacts the outcome, especially when automatically triggered by equipment control systems or following a natural disaster,
- In the unfortunate event of an accident, drone-based surveillance can aid emergency response.
- Using vigilant site monitoring to mitigate unsafe trespassing.
- Rigorous testing of safety-oriented processes and safeguards will ensure safe system operations. Humans, including onsite staff and manual aviation, unconditionally receive “right of way” priority.
- Routine site surveillance can be conducted remotely and be event driven.
- Improving emergency response efforts via additional situational awareness.

Methodology - Proposed SRA-MDO product development will be completed within 18 months of project initiation and will coincide with a separately funded Research North Dakota project working with the Federal Aviation Administration. The milestones for this project, which are aligned with its tasks, are:

- Selection of site/domain (April 2019)
- Safety case justification functional elements document (June 2019)
- Microsoft AirSim simulation framework for the site/domain (November 2019)
- Safety case and CONOPS (April 2020)
- Completed set of simulations of chosen scenarios (April 2020)
- **Buildout of corresponding hardware/software solution (July 2019 to April 2020)**
- Integration of Evolve Analytics solution with Xcel Energy enterprise resource planning and control systems (April 2020)
- Safety case submission (May 2020)
- Flight tests and report (August 2020)

Hardware Solution

The following table illustrates tasks and timeline to build 6 prototype custom drone housing units including: solar charging unit, uninterruptible power source (UPS), microcomputer, inductive charging system, ceramic heater, locking mechanism, and Microsoft Farm Beats kit (wind, light, ambient temperature, humidity, and precipitation sensors) as part of the SRA-MDO solution.

	Month 1				Month 2				Month 3				Month 4				Month 5				Month 6			
	W-1	W-2	W-3	W-4	W-1	W-2	W-3	W-4	W-1	W-2	W-3	W-4	W-1	W-2	W-3	W-4	W-1	W-2	W-3	W-4	W-1	W-2	W-3	W-4
3D design	█				█																			
Vacuumed formed pattern build for shells					█				█															
Sourcing, final chosen supplier alignment, metal and plastic					█				█															
Cover prototype (qty 1)					█				█															
Metal prototype (qty 1)					█				█															
Prototype assembly (qty 1)					█				█															
Prototype controls engineering build (qty 1)					█				█															
Review					█				█															
Engineering changes					█				█															
Controls changes					█				█															
Production vacuumed form tool build, (water-cooled alum tool)					█				█				█				█							
Pilot run vacuum form (qty 5)					█				█				█				█							
Pilot build metal components (qty 5)					█				█				█				█							
Pilot build controls (qty 5)					█				█				█				█							
Pilot build assembly (qty 5)					█				█				█				█							
Minimum time required for task	█																							
Maximum range required for task	█																							

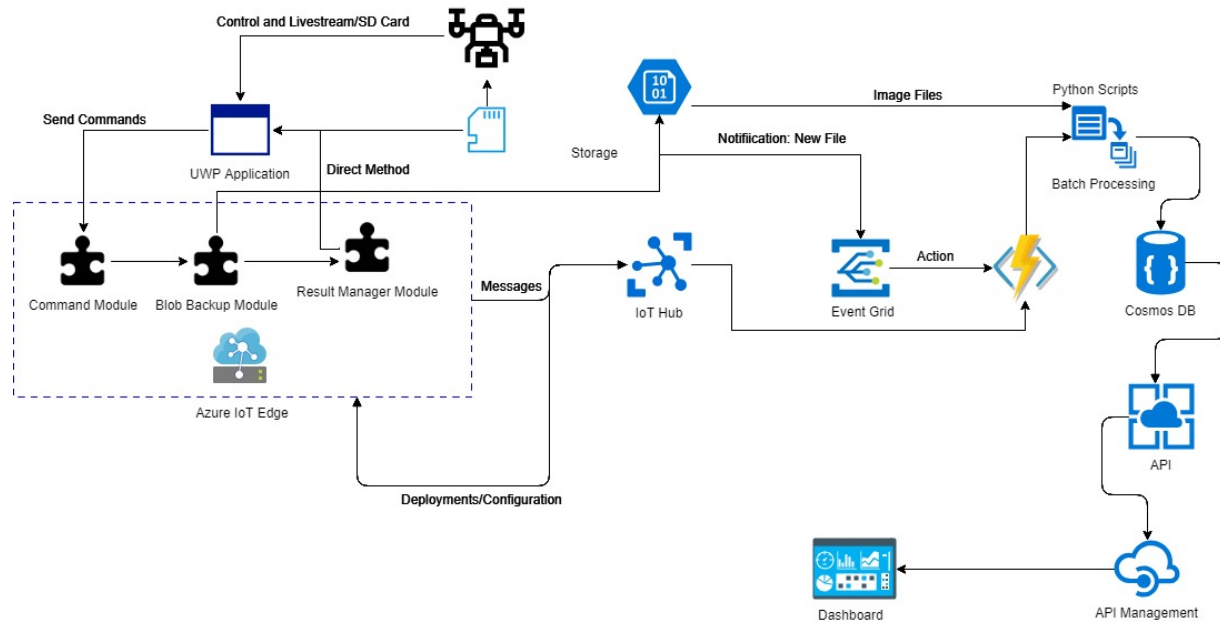
Software Solution

The following table illustrates timeline to build 3 high level software components including: **technician field application improvements** (authentication, API enhancements, inspection type, “Nest” hardware integration, error handling/messaging, UI updates, live video streaming), **command center portal** (leverage existing UWP app functionality for replication, launch pre-requisite assessment, set thresholds for pre-requisites, choose inspection types and assets, scheduling function, real-time drone tracking, SCADA integration, IoT Hub interface with engineering portal, ability to launch multiple drones, with multiple missions, to multiple assets, drone status, service logs), and **on-drone modules** (wireless image transfer from SD card, IoT Edge setup script/documentation, data push from repository instead of config file, check conditions, confirm data transmission, service management & logging).

		Two Week Sprints											
		1	2	3	4	5	6	7	8	9	10	11	12
High Level Components	Technician Field Application Improvements												
	Command Center Portal												
	On-Drone Modules												

Airtonomy Solution - The Airtonomy solution, consists of the following components: custom drone housing unit “Nest” and associated hardware (installed onsite), Robot Operating System application, Universal Windows Protocol application, Azure Internet of Things Framework, Azure, Artificial Intelligence/Machine Learning/Computer Vision, optimization algorithms, and an integrated backend control system intended to facilitate remote drone operation. Together they form an end-to-end autonomous operations solution that will be integrated with Xcel Energy Enterprise Resource Planning and control systems.

Expansion of the Evolve Analytics’ Airtonomy solution to include rules based & safety-oriented processes, and safeguards that will ensure safe remote system operations. Development will take place to coincide with design and manufacturing of a prototype custom drone housing unit as well as route optimization work conducted by Evolve Analytics’ computer scientists. Testing will occur on three staffing levels using advanced simulation (Microsoft AirSim) followed by field tests to ensure rigor: 1) Development (Blue Metal/Level 12); 2) Evolve Analytics; 3) UND-RIAS/Northern Plains UAS Test Site. All development activities will be coordinated through the Research North Dakota grant in order to ultimately obtain Federal Aviation Administration approval in the form of a permanent waiver. (The preliminary Concept Design is contained in Attachment E.)



It is expected that Xcel Energy will establish initial capability to deploy SRA-MDOs within an incident response framework and as an internal business asset. By working with government counterparts, it is expected that Xcel Energy will lead the industry in establishing SRA-MDOs as a viable commercial tool used within the Renewable Energy Sector, and EA, Xcel Energy, Microsoft, UND-RIAS, and NPUASTS will have built a pathway for continued growth of SRA-MDOs and related technologies to support the Renewable Energy industry through the expansion of technology and regulatory options.

Anticipated Results - Anticipated Results are as follows:

- **Develop, deploy, and test two primary components that combined will ensure safe remote system operations: 1) a custom drone housing unit or “Nest”; 2) control software that includes rules based & safety-oriented processes, and safeguards.**
- Validate the Federal Aviation Administration safety case and associated simulation through physical testing at the selected Renewable Energy site.
- Successfully demonstrate to the Federal Aviation Administration, safe deployment of SRA-MDO capabilities to enhance Wildlife Mortality Monitoring and Mitigation, Inspection, Maintenance, Safety, and Security aspects of Renewable Energy sites.
- Obtain a permanent Federal Aviation Administration waiver for SRA-MDO installation within a given Renewable Energy domain.
- **Seize a first of its kind opportunity by commercializing the SRA-MDO solution, installed on renewable energy sites (via a permanent FAA operational waiver), with the intention to grow market share within the Renewable Energy and Utility Sector in real-time as the Federal Aviation Administration (FAA) loosens regulations such as Beyond Visual Line of Sight (BVLOS), thereby allowing drones to operate in civilian airspace.**

Facilities - This project will be hosted at a North Dakota Renewable Energy site owned and operated by Xcel Energy. The site selection process is as follows:

- Federal Aviation Administration (FAA) input is crucial. Criteria will be predicated on factors including 1) domain appropriateness, especially as it relates to controlled airspace, remoteness, and autonomous deployment suitability; 2) site availability and convenience; 3) site simulation feasibility; 4) safety factor analysis.
- Ideal circumstances consisting of domain (hydroelectric, solar, wind) and site (geographic) are vital for the enablement of an SRA-MDO solution within the Renewable Energy Sector. Therefore, the first task is the establishment of criteria for domain and site selection.
- Once criteria are established, representatives from UND, NPUASTS, EA, Xcel Energy, and Microsoft will jointly select the appropriate domain and site.

Resources - As observed above, there will be three types of resources in this project:

- Hardware
- Software
- Human

Hardware includes:

1. Custom drone housing units (The preliminary Concept Design is contained in Attachment E.)
2. Components related to the custom drone housing units, including: solar charging unit, uninterruptible power source (UPS), microcomputer, inductive charging system, ceramic heater, locking mechanism, and Microsoft Farm Beats kit (wind, light, ambient temperature, humidity, and precipitation sensors)
3. Commercially available drones and accessories

Software includes:

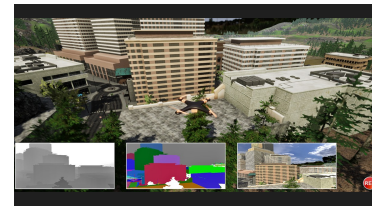
1. Airtonomy solution with control software that includes rules based & safety-oriented processes, and safeguards
2. Microsoft Azure, including Azure IoT (Internet of Things), serves as the data storage, processing, visualization, and transportation platform
3. Microsoft AirSim (Aerial Informatics and Robotics Simulation), an open-source robotics simulation platform

Significant Human Resources will be provided by the participants and subcontractors to accomplish the tasks identified above.

The Project Team has substantial experience in performing and managing all these areas.

Techniques to Be Used, Their Availability and Capability - The combined, proven expertise of EA, UND-RIAS, the Northern Plains UAS Test Site, Xcel Energy, and Microsoft Aerial Informatics and Robotics, is necessary to the creation of a highly sophisticated, first of its kind, SRA-MDO solution. The main techniques applied are as follows:

- **Hardware Design:** 6 custom drone housing units including: solar charging unit, uninterruptible power source (UPS), microcomputer, inductive charging system, ceramic heater, locking mechanism, and Microsoft Farm Beats kit (wind, light, ambient temperature, humidity, and precipitation sensors) will be built as part of the SRA-MDO solution.
- **Software Design:** Expansion of the Evolve Analytics' Airtonomy solution to include rules based & safety-oriented processes, and safeguards that will ensure safe remote system operations. Development will take place to coincide with design and manufacturing of a prototype custom drone housing unit as well as route optimization work conducted by Evolve Analytics' computer scientists. Testing will occur on three staffing levels using advanced simulation (Microsoft AirSim) followed by field tests to ensure rigor: 1) Development (Blue Metal/Level 12); 2) Evolve Analytics; 3) UND-RIAS/Northern Plains UAS Test Site. All development activities will be coordinated through the Research North Dakota grant in order to ultimately obtain Federal Aviation Administration approval in the form of a permanent waiver.
- **Artificial Intelligence (AI), Computer Vision (CV), Machine Learning (ML), and Robotics (RO):** Significant use of AI, CV, ML, and RO are essential to the enablement of an SRA-MDO solution. Extensive algorithmic logic is necessary to facilitate the logic that removes human factors, thereby affording remote operation on Renewable Energy sites.
- **Complex Simulation:** The Microsoft AirSim platform solves these two problems: the need for large data sets for training and the ability to debug in a simulator. It provides a realistic simulation tool for designers and developers for seamless generation of the amount of training data they require. Also, AirSim leverages current game engine rendering, physics, and perception computation to create accurate, real-world simulations. Together, this realism, based on efficiently generated ground-truth data, enables the study and execution of complex missions that are time-consuming or risky in the real world. For example, collisions in a simulator cost virtually nothing, yet provide actionable information for improving the design of the system.



MICROSOFT AIRSIM

Environmental and Economic Impacts while Project is Underway - There are no adverse environmental and economic impacts of this project. The project should achieve the Ultimate Technological and Economic Impacts described below.

Ultimate Technological and Economic Impacts - Onsite installation of SRA-MDOs creates an entirely new dynamic within the Renewable Energy Sector. Significant increases to operational efficiencies will be profound, as SRA-MDO provides an immediate, safe, and cost-effective first-response layer that is autonomous, prompted by control systems as well as the emergency response center, and integrated directly with the enterprise resource management system. This capability delivers unparalleled situational awareness, enabling entities like Xcel Energy to benefit from actionable intelligence in the form of timely decisions, reduced outages, and most importantly significantly enhance safety.

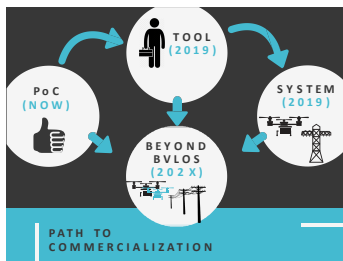
Anticipated economic impact of having a readily available (365 day x 24 hours) commercial deployment of a secure, remote, autonomous, multi-drone, operations solution installed on site and powered by

solar energy is multi-faceted. Considering multiple drones can continually conduct operations at any given time the need for onsite staff is significantly lessened, if not eliminated. This can provide instant operational efficiencies measured in hundreds of thousands of dollars. Staff can now focus on “hands on” tasks related to maintenance. Using a conservative wind energy scenario, at a price of \$23/MWH, assuming a monthly daytime output of \$12,000/turbine, an 3% increase in output by virtue of enhanced blade maintenance equates to roughly \$360 per turbine per month. At a 100-turbine wind site, this equates to roughly \$432,000 in increased revenue generation.

Environmental survey costs are significant. Typical post-construction mortality monitoring for birds and bats in general is about \$100,000 per year at wind sites. Similar mortality monitoring for eagles (large birds) is about \$150,000 per year at wind sites. The cost to do a raptor nest survey is about \$75,000 per year at wind sites. The cost to do the special habitat surveys (native prairie surveys) is about \$25,000 per wind site and only one is done prior to construction. Wetland Surveys are completed pre-construction and vary widely depending on how many wetlands are in the area. \$50,000 is a rough for one-time wetland surveys. The opportunity to significantly reduce, if not eliminate such costs using the installed Airtonomy SRA-MDO solution, is tangible.

The proposed solution also generates new in-state manufacturing and assembly opportunities in addition to new employment opportunities in fast-growing and highly desirable careers such as data science and UAS in North Dakota, helping the region to retain and attract top talent professionals in competitive areas. As a first mover in the space, by virtue of a permanent FAA operational waiver, the market for custom drone housing units “Nests” could explode. For each sale, services such as simulation and route optimization are necessary. So too is the Airtonomy software solution. Collectively the economic impact of this project is profound considering the fast-growing Renewable Energy Sector. Expansion within the energy industry to areas such as power distribution/transmission and pipeline inspection are targeted areas of growth as most are located in remote areas not unlike renewable energy.

Why the Project is Needed - The Renewable Energy Sector is ripe with opportunity for operational efficiencies. The heavy reliance of costly manpower and outdated tools is a drawback. Airtonomy’s SRA-



MDO solution will transform Renewable Energy Sector operations by introducing a modern, readily available, cost-effective tool installed onsite. Such a tool has nearly endless uses such as Wildlife Mortality Monitoring & Mitigation, Inspection & Maintenance, and Safety & Security. Each of the following aspects, as well as others, will see significant cost reductions using the SRA-MDO solution.

The following is an Xcel Energy excerpt from a recent submission to the Edison Electrical Institute (EEI):

“In partnership with Evolve Analytics, Xcel Energy is testing using drone technology to estimate the mortality of birds and bats within wind farms. Xcel Energy reports wind turbine-related deaths of birds and bats to the U.S. Fish and Wildlife Service. The current method of discovering the deceased birds and bats is labor intensive. A bird or bat carcass is found by visual inspection of the ground around the wind

turbine. A biologist must walk in a grid pattern on the pad to look for carcasses. The distance walked can reach two miles for one wind turbine because of the followed grid pattern.

In collaboration with Xcel Energy's field detection surveys, we would use drones instead of ground crews to conduct bird mortality assessments. Our initial testing would involve multiple surveys at different altitudes once a month throughout the April-November monitoring season to account for vegetation and species diversity changes. In the case of Xcel Energy's Courtenay wind farm, 100 turbines must be examined monthly, resulting in close to 200 miles of walking. Currently, the number of man-hours spent walking the fields is costly. The cost of the program at one wind farm can exceed \$300 thousand annually.

Introducing drones into the wildlife mortality monitoring programs at Xcel Energy wind farms will improve safety, produce more accurate results and reduce cost. It will improve safety by reducing the required walking distance of a biologist in potentially hazardous areas. More accurate results will be obtained by nature of the potential for drones to fly in the areas that may be temporarily human-inaccessible. Costs will be reduced by reducing the man-hours necessary for these programs. Through this method, the time previously spent by the biologist walking through a field can now be used elsewhere. Also, less staff will be required.

Xcel Energy is also working to develop an automated approach to prevent eagle collisions with wind turbines. In this instance, we would install camera stations on the periphery of the turbines and using a variety of probability models we would decide whether or not a turbine or section of turbines should be shut down to avoid eagle collisions. This system of operations would remove or reduce the need for biologists to sit and observe eagle activity at the site to determine if turbines should be shut down to reduce collisions. Cameras will leverage infrastructure and power resources from equipment already on site for blade inspections.

In the near future, Xcel Energy sees drones becoming commonplace among the tools we use to deliver energy reliably and cost-effectively to our customers. Drones may not only be used for inspection but may eventually be able to assist in repairs to our power lines as the technology evolves. The data collected from the work we are doing will be shared with utilities to help improve operations industry-wide."

The systems and networks that comprise our society's and economy's infrastructure, such as energy, transportation, emergency and health/safety services, finance, and communications are critical to life as we know it. Natural disasters or deliberate acts of destruction, while relatively rare, can have devastating consequences for life and limb, property, business operations, the economy, and national security. The ability to provide a safe, timely, reliable and efficient response to such disasters is critical to maintaining public confidence and to the nation's safety, public health, and prosperity. Utilization of unmanned aircraft systems (UAS) to improve the restoration of compromised infrastructure after a natural disaster is consistent with the U.S. Department of Homeland Security's goals of increasing the security and resilience of America's critical infrastructure including energy, transportation,

communications, and water systems as well as emergency services (including the highest priority lifeline infrastructure).

The proposed project advances the capabilities of Xcel Energy and the Renewable Energy industry as a whole by allowing a timely, efficient, and cost-effective response to natural disasters which will, in turn, provide many significant safety and economic benefits to affected populations. Public and employee safety is a core value at Xcel Energy and a primary concern during emergency response situations. The benefits of preventing any injury or saving a life by being able to respond faster and more effectively to a natural disaster are immeasurable. Considering the high costs of rebuilding power generation and distribution systems and restoring service to their customers typically incurred by electric utilities in the aftermath of large-scale natural disasters, even small gains in the ability to respond has the potential to translate into tens of millions of dollars in savings per large-scale event. There are also intangible benefits; specifically, the ability to safely and efficiently gather the needed quality and quantity of information quickly without risking the safety of workers represents a substantial technological breakthrough.

Additional benefits of the project for the North Dakota Renewable Energy Sector include:

- Developing capabilities that can be easily leveraged for other infrastructure and disaster response agencies.
- Increasing the viability of UAS application for electric utilities by developing technology (e.g., simplified control systems) needed to reduce the personnel required to deploy and utilize UAS for a variety of utility-related tasks.
- Establishing an initial capability to deploy UAS within a disaster response framework.
- By working collaboratively with government counterparts, cementing North Dakota Renewable Energy's role as an industry leader in implementing UAS as a commercial tool.
- Building a pathway for the continued growth of UAS support to the Renewable Energy industry through technology and regulatory expansion of UAS operations and its related technologies.

STANDARDS OF SUCCESS

Simply put, the standard of success is creation of a product, with hardware and software components, that combined constitute a first of its kind, readily available (365 day x 24 hours) commercial deployment of a secure, remote, autonomous, multi-drone, operations solution. Installed on site, powered by solar energy, and operated remotely; such a system will revolutionize efficiency of asset inspection and maintenance within the Renewable Energy Sector.

In relationship to the proposal, creation of a viable FAA safety case seeking operation on a single site within a chosen domain is a crucial step toward the ultimate objective of deployment across the spectrum of critical assets including: distribution/transmission, hydroelectric, solar, wind, and substations. Seeking unprecedented approval from the FAA will require a first of its kind approach to demonstration of the corresponding safety case. This is enabled by a full-scale simulation including operational, technical, and environmental elements utilizing Microsoft AirSim; an open-sourced, high-fidelity system for testing the safety of artificial intelligence systems.

The project will address the following elements of SRA-MDOs, which can be considered deliverables:

- **Develop, deploy, and test two primary components that combined will ensure safe remote system operations: 1) a custom drone housing unit or “Nest”; 2) control software that includes rules based & safety-oriented processes, and safeguards.**
- Validate the Federal Aviation Administration safety case and associated simulation through physical testing at the selected Renewable Energy site.
- Successfully demonstrate to the Federal Aviation Administration, safe deployment of SRA-MDO capabilities to enhance Wildlife Mortality Monitoring and Mitigation, Inspection, Maintenance, Safety, and Security aspects of Renewable Energy sites.
- Obtain a permanent Federal Aviation Administration waiver for SRA-MDO installation within a given Renewable Energy domain.
- **Seize a first of its kind opportunity by commercializing the SRA-MDO solution, installed on renewable energy sites (via a permanent FAA operational waiver), with the intention to grow market share within the Renewable Energy and Utility Sector in real-time as the Federal Aviation Administration (FAA) loosens regulations such as Beyond Visual Line of Sight (BVLOS), thereby allowing drones to operate in civilian airspace.**

BACKGROUND/QUALIFICATIONS

Below the relevant experience of the key participants is summarized. More detailed information on these key people is provided in Attachment E.

UND Research Institute for Autonomous Systems (RIAS) - A global leader in unmanned and autonomous systems research, application and policy development, we provide solutions to present and future challenges. The UND Research Institute for Autonomous Systems (RIAS) is built upon the core University of North Dakota values of community, lifelong learning and discovery. With a well-articulated plan, expertise across a broad set of disciplines, and an organized, committed team, we continue to **RIAS** to the challenge of providing autonomous technologies and policies that serve society.

Our mission is simple, create new autonomous systems through multidisciplinary research and lead development of world-changing autonomous policies, with the goal of driving a vibrant, diverse and sustainable economy consistent with ethical and legal standards.

Xcel Energy - Xcel Energy is the largest investor-owned utility in North Dakota. It serves approximately 114,000 customers in the state and maintains 257 circuit miles of electric power lines within North Dakota as well as renewable energy generation sites. Power generation and distribution components may need repair after a major storm, onsite incident, or other natural disaster, resulting in power outages for some of its customers. Restoration in North Dakota can be particularly challenging because the affected infrastructure may be in remote areas that are not readily accessible. Xcel Energy’s community, customers, and shareholders will benefit greatly if the company’s distribution operations have access to fast, accurate and reliable asset inspections made possible with SRA-MDO capabilities

during escalated operations as well as for routine operations when major storms or emergencies happen in any part of the North Dakota service territory.

One of the greatest challenges during escalated operations is the up-front damage assessment requiring “boots on the ground” (i.e., foot patrols) in areas of destruction to evaluate damage to the area and equipment and to determine the right materials, equipment, and personnel needed to quickly and safely restore power or functionality. Foot patrols are time-consuming and, depending on the domain and site, can be dangerous.

The length of time required to restore power or functionality during escalated operations is directly a function of the extent and time spent on the damage assessment. The use of SRA-MDOs will help Xcel Energy significantly speed up this important damage assessment process by providing important information in a quicker and safer manner, thus improving restoration times and reliability for customers. Following Hurricane Sandy, expectations within the industry, by customers and by stakeholders is that power restoration will be better, faster, and safer in the future. This outcome of this project will help Xcel Energy meet these expectations in North Dakota.

Microsoft Aerial Informatics and Robotics Group - The Aerial Informatics and Robotics (AIR) group builds intelligent and autonomous flying agents that are safe and enable applications that can positively influence our society. The core technology builds upon cutting-edge research in machine intelligence, robotics, and human-centered computation in order to enable an entire fleet of flying agents ranging from micro-UAVs to commercial jetliners.

AIR research approach brings together ideas from machine learning and perception and enables Decision making under Uncertainty for various challenges that arise in AI platforms. The synthesis of algorithms and systems enables aerial vehicles such as quadrotors, soaring gliders, small aircraft, and commercial airliners. Applications scenarios include monitoring for precision agriculture, pathogen surveillance, weather sensing, enabling digital connectivity, etc.

Northern Plains UAS Test Site - North Dakota's Northern Plains UAS Test Site is one of seven FAA-approved UAS test sites. The test sites conduct crucial research to determine how to integrate UAS safely into the national airspace. The Northern Plains UAS Test Site was the first FAA test site to conduct flights, launching its first research flight in early May 2014. The Northern Plains UAS Test Site is headquartered in Grand Forks, ND.

The Northern Plains UAS Test Site will provide support for FAA waiver submission and operations to test concepts and technologies under the proper FAA approval to test this concept of operations. Part 107 does not currently allow for 1-to-many control. This will likely need to be enabled via the Part 107 waiver process. The Northern Plains UAS Test Site has a close working relationship with the FAA and will lead the effort to obtain approval to execute these flights. This likely will require an information exchange between the research team, OEMs, and technology developers with the FAA. The Northern Plains UAS Test Site will organize the information packet and waiver application to submit to the FAA, which will include a safety risk analysis, initial flight location, and Concept of Operations. As the project

and systems mature, the areas of operations may be expandable to other similar locations. This will need to be coordinated with the FAA.

Evolve Analytics - Evolve Analytics (EA), a North Dakota limited liability corporation located in Grand Forks, and supported by the UND Aerospace Foundation, Microsoft TechSpark, the Grand Forks Region EDC, and the City of Grand Forks, was founded in 2018. EA founders have unique experience in unmanned aerial systems, artificial intelligence, and underlying technical framework, specifically in the energy asset inspection industry. Our team comes with deep regional connections, renewable energy expertise, airspace integration, strategic relationships with major technology providers, principals who have successfully launched businesses in similar spaces, and thorough knowledge of the renewable energy industry including key relationships. After a competitive process, Evolve Analytics recently received an inaugural Microsoft TechSpark grant award intended for work with aerial imagery (See Attachment I).

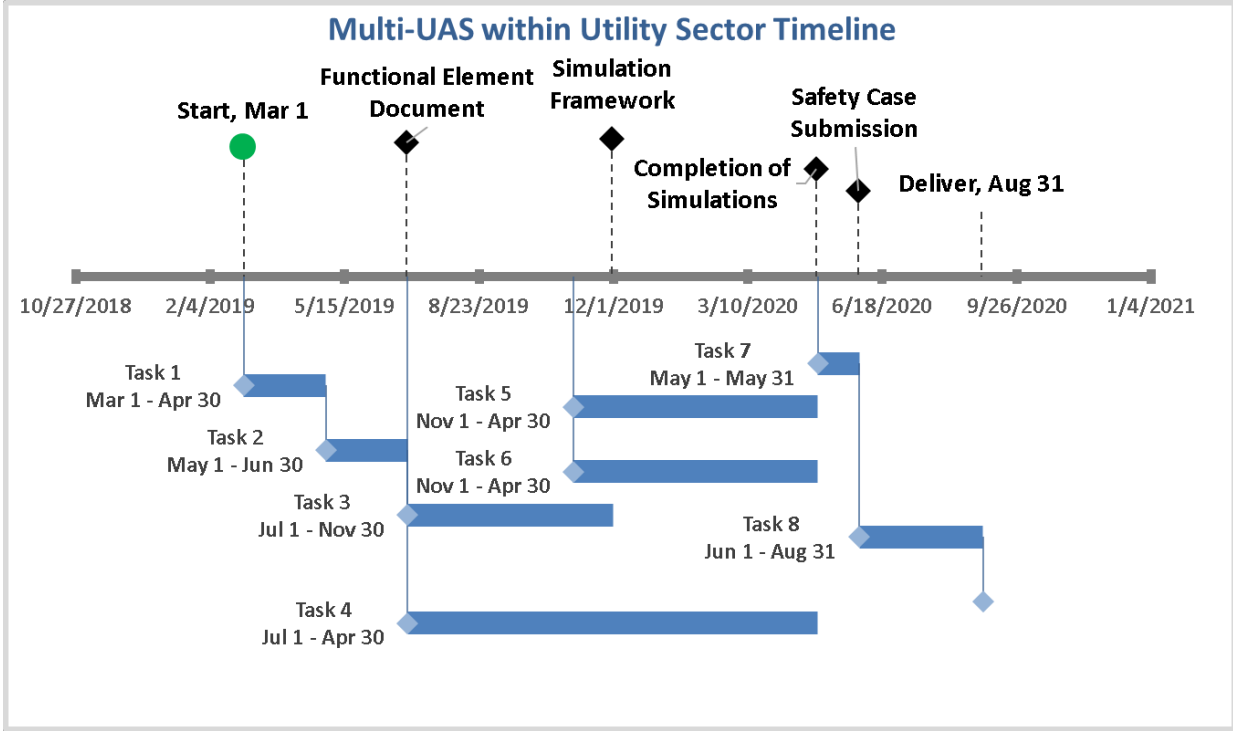
MANAGEMENT

Evolve Analytics will provide the overall project leadership drawing upon the strengths of each participant and subcontractors. The lead person for each is identified in the Background/Qualifications section. Key milestones throughout the project, as shown on the timeline below, will occur as each task is completed and also in a quarterly progress report to the North Dakota Renewable Energy Council.

The UND project manager will be responsible for management of project activities and effective communication between EA, Xcel Energy, Microsoft, UND-RIAS, and NPUTS. The communication plan will include periodic meetings and/or conference calls with team members to allow for the exchange of information and input on planned activities, ensure that the project is progressing according to schedule, and ensure that project goals are being met. Project Team meetings will be held monthly and shall include the personnel from the EA, Xcel Energy, Microsoft, UND-RIAS, and NPUASTS that support the project deliverables. Personnel who are unauthorized foreign nationals shall be excluded from all or portions of the project in accordance with United States law regarding access by foreign nationals to equipment covered under the International Traffic In Arms Regulations (ITAR) and Export Administration Regulations (EAR).

TIMETABLE

The tasks and milestones are illustrated in the following figure. To reduce clutter, not all milestones are highlighted.



BUDGET

Evolve Analytics is making a significant investment in this project, including resources raised outside of the scope. A \$1,403,373 budget is proposed, of which approximately 1/3 of the funding is sought from the North Dakota Renewable Energy Program. The vast majority of funding is cash dedicated to software development, engineering, and hardware creation. Attachment G is a software development estimate provided by a Microsoft Gold Partner and a nationally recognized expert in Microsoft Azure IoT.

Additionally, it is important to note that: 1) Above and beyond this proposal, Xcel Energy and Microsoft pledge to contribute Private Sector (Cash Reserved) resources as well that with Evolve Analytics will substantially exceed the required match; 2) The estimated project cost **DOES NOT** include recent funding in the amount of \$267,974 from the Research North Dakota program, that is related but **WILL NOT** fund any budget items below; 3) Evolve Analytics, **WILL NOT** duplicate matching contributions from the aforementioned Research North Dakota project.

A **detailed budget** is provided as Attachment I.

Project Associated Expense	NDIC's Share	Applicant's Share (Cash)	Applicant's Share (In-Kind)
Personnel			\$125,100
Field Equipment		\$37,000	
Travel		\$18,000	
Software Development	\$349,828	\$605,828	
Other Direct Costs			\$117,500

Custom Drone Housing Unit Prototype Engineering	\$80,212		
Custom Drone Housing Unit Equipment	\$69,960		
Total:	\$500,000	\$660,828	\$242,600
	\$500,000	\$903,428	

Please use the space below to justify project associated expenses, and discuss if less funding is available than that requested, whether the project's objectives will be unattainable or delayed.

Given the significance to primary North Dakota industries (Renewable Energy and Unmanned Aircraft Systems), coupled with the substantial cost assumed by Evolve Analytics, we believe funding of the proposal is value added. However, if grant funding must be reduced, it will increase external funding necessary for the project, thereby potentially limiting scope and/or extending duration. In this event, Evolve Analytics is willing to entertain a lessened target funding number and correspondingly determine the impact.

CONFIDENTIAL INFORMATION

Hardware, software, and AI/ML/CV, including designs and source code that comprise the Evolve Analytics solution and all associated outcomes including data, will be considered confidential information that needs protection under North Dakota Century Code 54-17.6.

Upon project completion, when the resulting solution goes to market, **ALL** confidential information will be included in the final project summary and can therefore be released to the public.

1. A general description of the nature of the information sought to be protected, **The Evolve Analytics' Enterprise Autonomy architecture including hardware (Attachment E) and software components (Attachment G).**
2. An explanation of why the information derives independent economic value, actual or potential, from not being generally known to other persons, **The Evolve Analytics' Enterprise Autonomy solution for SRA-MDO consists of hardware and software components considered intellectual property.**
3. An explanation of why the information is not readily ascertainable by proper means by other persons, **The Evolve Analytics' SRA-MDO solution is currently in the planning phase and will be developed for testing, including FAA waiver consideration, in Spring 2020. The final product is intended to be released for sale in Q4 of 2020 or Q1 of 2021.**
4. A general description of any person or entity that may obtain economic value from disclosure or use of the information, and how the person or entity may obtain this value, **Inspection companies, especially those in the drone-based utility inspection sector, would gain a competitive advantage by having access to intellectual property owned by Evolve Analytics.**
5. A description of the efforts used to maintain the secrecy of the information. **To date, Evolve Analytics has exercised discretion by selectively engaging development partners, employing**

non-disclosure agreements, and not sharing its intellectual property, which it intends to patent.

Corresponding appendices (attachments) are clearly labeled confidential.

PATENTS/RIGHTS TO TECHNICAL DATA

Since this project builds upon existing tools of Evolve Analytics and Microsoft, both reserve the Intellectual Property Rights (IPR) to any tools and results of such tools developed in this project. Furthermore, they reserve the right to use any data from this project for commercial purposes.

Attachment A – Project Fit with ND REC Goals

Project Fit with Goals, Purposes, and Priorities of the North Dakota Renewable Energy Council.

This project is consistent with several goals and purposes including:

- *Promote efficient, economic, and environmentally sound development and use of North Dakota's vast renewable energy resources, particularly in the areas of wind energy, biofuels (ethanol & biodiesel), and biomass.*
 - Onsite installation of SRA-MDOs creates an entirely new dynamic within the Renewable Energy Sector. Significant increases to operational efficiencies will be profound, as SRA-MDO provides an immediate, safe, and cost-effective first-response layer that is autonomous, prompted by control systems as well as the emergency response center, and integrated directly with the enterprise resource management system.
 - The SRA-MDO solution also generates new in-state manufacturing and assembly opportunities in addition to new employment opportunities in fast-growing and highly desirable fields such as data science and UAS in North Dakota, helping the region to retain and attract top talent professionals in competitive areas.
 - This project promotes efficient, economic, and environmentally development and use of North Dakota renewable energy resources by using SRA-MDO capabilities to enhance Wildlife Mortality Monitoring and Mitigation, Inspection, Maintenance, Safety, and Security aspects of Renewable Energy sites.
- *Encourage and promote the use of new technologies and ideas that will have a positive economic and environmental impact on renewable energy development and production in North Dakota.*
 - Significant use of sophisticated technologies such as Artificial Intelligence, Computer Vision, Machine Learning, Robotics, and Complex Simulation is essential to the enablement of a SRA-MDO solution installed on Renewable Energy sites.
 - Realization of project objectives will further enhance vital North Dakota Renewable Energy and Unmanned Aircraft Systems industries.
- *Create jobs related to the production and utilization of North Dakota's renewable energy resources.*
 - Success will directly translate to job creation in the Renewable Energy Sector in the areas of manufacturing, construction, training, service, computer science, data science, software development, UAS, engineering, sales, marketing, and management.
- *Ensure economic stability, growth and opportunity in the renewable energy industry.*
 - The Renewable Energy Sector is ripe with opportunity for operational efficiencies. The heavy reliance of costly manpower and outdated tools is a drawback. Airtonomy's SRA-MDO solution will transform Renewable Energy Sector operations by introducing a modern, readily available, cost-effective tool installed onsite.

This project is also consistent with the ND REC priorities such as:

- *Identify and develop renewable energy technologies presently not used in North Dakota.*
 - Technologies developed by this proposal will be first to market within the Renewable Energy Sector.
- *Generate information and knowledge that will have the highest probability of bringing new renewable energy companies and industry investment to North Dakota.*
 - The benefits of realizing this project are profound. Not only will a successful outcome complement current companies within the Renewable Energy Sector, but it also has the potential to generate an entire subset of complementary new ventures including instate manufacturing; and technology, engineering, & computer science careers.
- *Maximize the market potential for renewable energy resources and the associated byproducts produced therewith.*
 - Same answer as above.
- *Have the highest potential for creating new renewable energy jobs, wealth, and tax revenues for North Dakota.*
 - As noted above, innovative application of technologies such as Artificial Intelligence, Computer Vision, Machine Learning, Robotics, and Complex Simulation will transform the Renewable Energy Sector with North Dakota at the epicenter.
- *A higher priority will be given to those applications having private industry investment equal to at least 50% or more of total cost.*
 - Evolve Analytics, with private sector partners Microsoft and Xcel Energy, substantially exceed the 50% investment match.

Attachment B – Certificate of Good Standing

State of North Dakota

SECRETARY OF STATE



Certificate of Good Standing of EVOLVE ANALYTICS, LLC

SOS Control ID#: 0000172458

Certificate #: 015915119

The undersigned, as Secretary of State of the state of North Dakota, hereby certifies that, according to the records of this office,

EVOLVE ANALYTICS, LLC

a Limited Liability Company - Business - Domestic was formed under the laws of NORTH DAKOTA and filed with this office effective October 5, 2018. This entity has, as of the date set forth below, complied with all applicable North Dakota laws.

ACCORDINGLY, the undersigned, as such Secretary of State, and by virtue of the authority vested in him by law, hereby issues this Certificate of Good Standing.

DATE: February 1, 2019

A handwritten signature in cursive script, reading "Alvin A. Jaeger".

Alvin A. Jaeger
Secretary of State

Attachment C – Bios of Key People

UND – RIAS

Dr. Mark Askelson is a Professor of Atmospheric Sciences at the University of North Dakota. He has over 20 years of research and applications experience with weather radar, including advanced applications involving radar polarimetry and phased array technologies. His areas of expertise include radar meteorology, numerical weather prediction, data assimilation, and unmanned aircraft systems (UASs). His current foci include the use of phased array radars in aircraft deconfliction systems for UASs and the use of cooperative information to enable deconfliction of unmanned aircraft with other aircraft. Dr. Askelson has led multiple UAS research efforts, including multimillion-dollar research efforts, focused on integration of UAS into the National Airspace System using both ground-based phased-array radars (development of the Ganged Phased Array Radar-Risk Mitigation System; GPAR-RMS) and cooperative data (the Limited Deployment-Cooperative Airspace Project; LD-CAP). He is currently a lead in the ASSURE "Small UAS Detect and Avoid Requirements Necessary for Limited Beyond Visual Line of Sight (BVLOS) Operations" effort.

Northern Plains UAS Test Site

Chris Theisen graduated from the University of North Dakota (UND) with a B.S. (May 2003) and M.S. (May 2006) in Atmospheric Sciences. During his M.S. studies, he specialized in polarimetric radar meteorology with an emphasis on cloud microphysics while also working as a weather forecaster for Meridian Environmental Technology, Inc. He then joined the faculty of the Atmospheric Science Department at UND (August 2006) as a temporary instructor of radar meteorology. In June of 2007, Mr. Theisen became a full-time staff member of the Regional Weather Information Center at UND. As of January 2014, he assumed duties and responsibilities of the Director of Research and Development for the Northern Plains Unmanned Aircraft Systems Test Site (NPUASTS) and joined full time with the NPUASTS in December 2018. He plays an active role in planning and overseeing research performed at the NP UAS TS. He works closely with NPUASTS research partners (UND & NDSU) as well as with industry to perform research to integrate UAS safely into the NAS. Mr. Theisen has a solid knowledge base on UAS technologies, regulations, applications, and capabilities. He also has a strong background in radar meteorology including Doppler, polarimetric and phased array radar applications. His other areas of interest include radar weather applications, autonomous vehicle applications and technologies, airspace visualization systems, and sensor data fusion applications.

Xcel Energy

Eileen Lockhart leads Xcel Energy's Unmanned Aircraft System (UAS) program. She has been involved with the UAS program since its inception and has served as the program manager for the last two years. Xcel Energy was the fourth utility to obtain FAA approval for UAS missions. Eileen leads Xcel Energy's multidisciplinary UAS team and business focused UAS operations. The UAS team has successfully executed several proof of concept missions spanning Xcel Energy's electric transmission & distribution, high pressure gas transmission & distribution, and generation operations to demonstrate that the technology can successfully improve safety and productivity across a number of businesses. Under

Eileen's leadership, the UAS team developed a governance framework, ensuring Xcel Energy is compliant with all federal and local regulations, and recently completed the first beyond-line-of-site mission in the history of the U.S. electric utility industry. Eileen joined Xcel Energy in 2011. She represents Xcel Energy on the EEI Unmanned Aircraft Systems team, IEEE UAS team, NYSERCH UAS team and is involved in EPRI's UAS tailored collaboration project. When she is not developing UAS missions and governance, Eileen enjoys spending time outdoors and with her family.

Mark Nisbet is the North Dakota Principal Manager for Xcel Energy, the fourth- largest combination natural gas and electricity company in the nation; serving 3.3 million electricity customers and 1.8 million natural gas customers in eight Western and Midwestern states. In 2018, Xcel Energy is breaking ground on the Foxtail Wind Farm in Dickey County which will bring Xcel Energy to 500 MW of owned wind plus 112 MW of purchased wind power in North Dakota. Mark has shown a personal commitment to renewable energy by installing 40 KW of solar panels on his farm and purchasing the all-electric Chevy Bolt. Mark serves on the board for the North Dakota EmPower Commission, North Dakota Renewable Energy Council, the West Fargo Economic Development Authority and incoming Chair for the Fargo Moorhead Chamber of Commerce. He also has served as chairman of the governor's Centers of Excellence Commission, and was the 2016 United Way of Cass Clay Campaign and United Way Board member. Mark received a bachelor's degree in business administration from Minnesota State University, Moorhead. He is a graduate of the Minnesota Management Institute at the Carlson School of Business, University of Minnesota. Mark lives in Fargo with his wife, Sandy and they have three sons.

Microsoft

Ashish Kapoor, Principal Researcher & Research Manager – I am a Principal researcher with the Adaptive Systems and Interaction Group at Microsoft Research, Redmond. My research focuses on Machine Learning, Computer Vision, Robotics and Quantum Computation. My recent work has focused on the use of near-realistic simulation to build ML/AI systems.

Jim Piavis, Principal Program Manager – R&D-focused professional leading various operational and development projects including , simulations and synthetics, Geographical Information Systems, Unmanned Autonomous Systems, logistics, and customer facing digital products.

Evolve Analytics

The Evolve Analytics team is comprised of a wide array of seasoned and talented individuals, including substantial experience with large technology companies including Adobe, Microsoft, and Spotify. Collectively, Evolve Analytics is well positioned to achieve grant objectives with demonstrated capability to deliver results with complex product development and commercialization. The UND Aerospace Foundation, the nation's leading provider of flight training services, is Evolve Analytics' partner and provides unparalleled access to resources including staff and equipment. Contributing organizations include award winning development teams from Insight (Blue Metal), Flytbase, the Center for Advanced Design, and Level 12, as well as corporate resources from Xcel Energy and Microsoft. Evolve Analytics is also in the process of expanding its team with an emphasis on software engineering and data science.

(CEO) **Dr. Joshua M. Riedy** – Josh has expertise as a Chief Operating Officer in the renewable energy inspection sector and more than 15 years of expertise managing complex, multi-party technology projects, coordinating government agencies, higher education systems and private parties. As a former CIO and with a software development background, Josh is proficient in the areas of research computing, IT architecture, and development. He also has substantial drone knowledge having received grant funding from notable organizations including the North Dakota Department of Commerce, Bill & Melinda Gates Foundation, and National Science Foundation.

(COO/CMO) **Beth Davis** – Having served as a Senior Vice President at Adobe, Beth has experience conceiving, launching and exiting multi-million dollar technology products and businesses. She was the founder of a predictive analytics business and has overseen the development, management and commercialization of large, national datasets. Beth demonstrated expertise in launching new products into emerging market segments, exemplified in her increasing responsibilities for product development at Macromedia that contributed to Macromedia's ultimate acquisition by Adobe for \$3.4B.

(Vice President of Flight Operations) **Dr. Jim Higgins** – Jim is an aviation industry expert, with more than 15 years direct experience as a pilot, instructor, and professor with project and research expertise in air traffic safety and Unmanned Aircraft Systems, including drones use in power industry inspections. In his role, Jim will be our conduit with standards organizations, monitor and respond to federal and local policy, and set approach to flight given current and evolving regulatory conditions.

(Chief Computer Science Officer) **Dr. Travis Desell** – Travis has overseen and managed large, big data and predictive analytics projects, including a mission critical system for FedEx, similar in nature to Airtonomy. He is a prior awardee and technology specialist on NSF grants and is a recognized expert in programming, Java and C++. Travis has been a professor of Computer Science at UND and Rochester Institute of Technology. In his role as Lead Developer, Travis will be responsible for integrating the systems developed by 3rd party partners and our CCS and delivering the user experience layer as well as the underlying models and applications for measuring, storing, analyzing and reporting on the data generated during inspections.

(Director of Computer Science) – **Ahmed El-Siad** – Ahmed is a PhD Computer Science candidate and Aerospace Engineer. He is also a patent-holding expert in computer science, predictive modeling, location-based services and aerospace engineering. Ahmed is responsible for developing all data capture models and development aspects associated with analyzing data and developing predictions for primary and secondary customers.

(Mentor) **David Kaefer** – David is a technology industry veteran and licensing and partnership expert. Currently Vice President of Licensing for Spotify, David has a 19 year tenure at Microsoft, culminating with his role as General Manager - Windows Store, VR and Quantum Platforms. David brings his expertise to forging viable partnerships, devising and managing first of their kind licensing relationships, and complex multi-billion dollar multi-party agreements.

Attachment D – Letters/Statements of Support



Dr. Ashish Kapoor, PhD.
Research Manager, Microsoft Biz AI
Microsoft
One Microsoft Way
Redmond WA 98052

31 Jan 2019

RE: Demonstration of a Framework for Secure, Remote, Autonomous, Multi-Drone Operations within the Utility Sector

Microsoft is pleased to partner with Xcel Energy and support entering into cooperative research with the University of North Dakota, specifically the Research Institute for Autonomous Systems (RIAS), and private sector partner Evolve Analytics.

In addition, Microsoft looks forward to the collaboration by engaging in research via company personnel and technical skills to see the project through, specifically with regards to technical expertise supporting AirSim functionality and feature capability. Upon successful completion of this project, Microsoft will explore licensing opportunities with project team members as well as outside entities.

We look forward to working with UND, Evolve Analytics and Xcel Energy and we strongly feel that the research generated will benefit the growth of our business, the community, increase our knowledge base, and help commercialize and scale the use of unmanned aircraft systems across the industry.

Sincerely,

A handwritten signature in black ink that reads "Ashish Kapoor". The signature is stylized and includes a large flourish at the end.

Ashish Kapoor



Karlene Fine, Executive Director
North Dakota Industrial Commission
State Capitol – 14th Floor
600 East Boulevard Ave Dept 405
Bismarck, ND 58505-0840
kfine@nd.gov

RE: Enterprise Autonomy – Secure, Remote, Autonomous, Multi-Drone Operations within the Renewable Energy Sector

Xcel Energy is excited to partner with Microsoft, the University of North Dakota, specifically the Research Institute for Autonomous Systems (RIAS), and private sector partner Evolve Analytics. Mark Nisbet and Eileen Lockhart are supportive of this innovative project and look forward to the prospects it will have for the State of North Dakota as well as within the industry.

Xcel Energy acknowledges its responsibility toward supplying company personal and expertise to see the endeavor through as well as access to select company sites and integration with various control systems. Upon realization of this project, Xcel Energy intends to utilize the developed solution package that enables federally approved commercial use of autonomous multiple unmanned aircraft vehicles and related systems to support safe data collection of our company property and assets. Added benefits such as technician safety, site security, and wildlife impact mitigation are vital as well.

We look forward to working with Evolve Analytics and their industrial application of drone technologies within the Renewable Energy sector. Specifically, the outcome will help us improve productivity and reliability of our system which will in turn benefit our customers by continuing to keep energy costs low.

Sincerely,

A handwritten signature in black ink that reads 'Mark Nisbet'. The signature is written in a cursive, flowing style.

Mark Nisbet
North Dakota Principal Manager
2302 Great Northern Drive, Fargo, ND 58102
P: 701.241.8607
E: mark.nisbet@xcelenergy.com

Karlene Fine, Executive Director
North Dakota Industrial Commission
State Capitol – 14th Floor
600 East Boulevard Ave Dept 405
Bismarck, ND 58505-0840
kfine@nd.gov

RE: Enterprise Autonomy – Secure, Remote, Autonomous, Multi-Drone Operations within the Renewable Energy Sector

The University of North Dakota (UND) Research Institute for Autonomous Systems (RIAS) is excited to partner with Evolve Analytics, Xcel Energy, and Microsoft to support development of transformative technologies involving drone operations (multi-drone operations, increased autonomy, etc.) within the energy sector. UND RIAS acknowledges its responsibility for supplying expertise to enable this endeavor.

We look forward to working with Evolve Analytics, Xcel Energy, and Microsoft to develop this application of drone technologies within the Renewable Energy sector. The outcome will help improve productivity and reliability of power generation and distribution systems, which will provide significant benefit to energy customers.

Sincerely,



Mark Askelson
RIAS Executive Director



NORTHERN PLAINS UNMANNED AIRCRAFT SYSTEMS TEST SITE

4149 University Ave
Grand Forks, ND 58202



February 1, 2019

Karlene Fine, Executive Director
North Dakota Industrial Commission
State Capitol – 14th Floor
600 East Boulevard Ave Dept 405
Bismarck, ND 58505-0840
kfine@nd.gov

RE: LETTER OF SUPPORT, IN RESPONSE TO THE PROPOSAL BEING SUBMITTED BY EVOLVE ANALYTIC FOR A RENEWABLE ENERGY GRANT THROUGH THE NORTH DATKOTA INDUSTRIAL COMMISSION

Dear Ms. Fine:

The Northern Plains Unmanned Aircraft Systems Test Site (NP UAS TS) is excited to partner with Microsoft, Xcel Energy, the University of North Dakota, specifically the Research Institute for Autonomous Systems (RIAS), and private sector partner Evolve Analytics to expand on research in areas directly affecting the use of UAS in the energy sector. The NP UAS TS is dedicated to support UAS initiatives within the state of North Dakota and nationwide.

This project will certainly spur continued growth in the energy sector on a regional and national level, so the NP UAS TS looks forward to collaborating with the team under this research effort. We can provide the research team support for National Airspace System access through a Part 107 waiver approval from the FAA. Our relationship with the FAA puts us in a great position to achieve approval for these complex operations expected as part of this proposal. We feel that supporting this project is would help push the industry forward to support these types of operations.

We look forward to working with Evolve Analytics and their industrial application of drone technologies within the Renewable Energy sector. Specifically, the outcome will help us work with the FAA to further define how approvals would work for highly automatic UAS in defined energy sector environments.

Sincerely,

Nicholas Flom, Executive Director
Northern Plains UAS Test

NPUASTS.com

North Dakota

Attachment F – Xcel Energy Wildlife Mortality Proposal (CONFIDENTIAL)



Overview

This document describes a new use case for Unmanned Aircraft Systems (UAS) (drones) at Xcel Energy. It explores the idea of introducing drones into the wildlife mortality monitoring programs at Xcel Energy's windfarms. The document provides a background of the programs, describes the current process of locating bird and bat carcasses, and identifies safety concerns and other challenges. Finally, the document describes how these challenges can be met with the assistance of a drone.

Background

Contractual obligations, combined with federal regulations, require Xcel Energy to implement processes that report wind turbine related deaths of birds and bats to the U.S. Fish and Wildlife Service. Reported data includes the species of bat/bird, location of carcass, sex, discovery date, and more. Xcel Energy typically uses with a third party vendor, such as Tetra Tech, Inc., to assist with the implementation. These vendors bring expertise, have a history of accuracy, and specialize in implementing wildlife mortality programs such as the **Post Construction Mortality Monitoring and Eagle Conservation Plan**.

Current Conditions

The current method of discovering the deceased birds and bats is labor intensive. A bird and/or bat carcass is found by visual inspection of the ground on the wind turbine "pad". (The "pad" is the land immediately surrounding the wind turbine.) A qualified individual (often a biologist) must walk in a grid pattern on the pad to look for carcasses. The distance walked can reach 2 miles for one wind turbine because of the followed grid pattern.

The number of turbine inspections can vary, depending on the program scope at each individual windfarm. Some windfarms require 10% of the turbine pads to be monitored on a monthly basis. Some windfarms require all of the turbine pads to be examined. In the case of Courtenay Wind Farm, 100 turbines must be examined monthly, resulting in close to 200 miles of walking.

Challenges of Locating Carcasses:

- **Safety** - Walking long distances on uneven terrain exposes individuals to hazards such as: animal/insect bites, sunburn/frostbite, potential for injuries resulting from falls, and more.
- **Staffing** - Individuals hired for these programs are required to have a college degree in a biology related field. Finding enough qualified individuals (biologists), that are willing to walk long distances can prove challenging.
- **Time / Money** - The amount of man hours spent walking in fields is costly. The cost of the program at one windfarm can exceed \$300k annually.
- **Inaccessible Areas** - Environmental factors, such as large amounts of snow or standing water, may prohibit a person from being able to walk the required grid pattern on the pad.
- **Winter Season** - In the winter months, very few carcasses are found in the northern states because most birds migrate south. Even with a low probability of locating a carcass, the biologist is still required to walk in a grid pattern on the wind turbine pad.

Proposal

Implement the use of drones to assist in visually locating the bird and bat carcasses. Helping the Tetra Tech biologist partner with the capabilities available in a drone will improve safety, increase accuracy of results, and reduce costs.

Future Conditions

Allow a drone to be piloted in the same grid pattern that was formerly walked by the biologist. When a bird or bat carcass is identified through the camera, the location can be given to the biologist. The biologist can then directly walk to the location of the carcasses to perform the necessary work of saving and documenting the specimen. The drone will fly low to the ground, and won't interfere with wind turbines or other types of aircraft.

Benefits to Locating Carcasses

- **Improved Safety** - The distance walked by the biologist on uneven terrain is greatly decreased. This reduces exposure to risk of injuries, animal/insect bites, and other environmental hazards.
- **Improved Staffing** - Attracting qualified personal will be easier as the job will be more desirable by eliminating the requirement for excessive walking.
- **Time / Money** - Time originally spent by the biologist walking through a field can now be used elsewhere. Also, less staff will be required.
- **Improved Accessibility** - A hard-to-reach area, such as a snow covered area, can be easily accessed by a drone. Using a drone in these instances will produce more accurate results.
- **Reduced Winter Exposure** - The biologist won't unnecessarily be exposed to the extreme cold at the time when few carcasses exist.

Summary

This document has shown that introducing drones into the wildlife mortality monitoring programs at Xcel Energy windfarms will improve safety, produce more accurate results, and reduce cost. Safety will be improved by reducing the required walking distance of a biologist in potentially hazardous areas. More accurate results will be obtained by allowing the drone to fly in the areas that may be temporarily inaccessible. Cost will be reduced by reducing the man hours necessary for these programs.

Contacts

Author: Kristin Ottem - Cyber Security Engineer
E: Kristin.L.Ottem@xcelenergy.com

SME: Jayme Orrock: Operations Manager - Borders & Courtenay Wind Farms
E:jayme.m.orrock@xcelenergy.com



Attachment H – Microsoft TechSpark Award (CONFIDENTIAL)



Regional Grant Competition-Aerial Data Imagery Research

The **Research Mission** is to prove the economic viability for and facilitate commercial technology transfer of aerial imaging solutions that leverage AI/ML to advance the transformation of agriculture, renewal energy, public utilities and/or public safety in the Red River Valley. A successful applicant will submit a proposal to complete 2-3 aerial imaging related AI/ML proof of concept field tests that can be conducted in 2019 and 2020. Each field test will specify a "problem to solve" for the related field in the region and have a clear plan to complete an at-scale proof of concept of a technologically sound and economically feasible path to solve the problem.

Grant Recipient Criteria: A successful applicant must be a Red River Valley-based University or Non-Profit capable of advancing the Research Mission. The applicant must include as a part of its grant team a new or existing company headquartered in the Red River Valley who will be significantly involved in the development of the proof of concepts. Additional criteria:

- Grant recipient must commit a team with suitable expertise in aerial image collection, processing, and AI/ML-based analysis.
- Grant recipient must agree to work directly with a local company who is committed to commercializing the IP created as a result of the research.
- Grant recipient shall enter a suitable technology transfer agreement with its commercial partner that allows that commercial partner to make, use and sell products and services derived from the grant-funded intellectual property.
- Grant recipient must show the ability to operate an owned or leased fleet of small-engine aircraft, including arrangements for required pilots.
- Grant recipient will agree to build its technology solution using Microsoft Azure and Azure AI/ML/IOT solution stacks.

Grant Submission: Applicant shall provide a written proposal outlining the team, budget, timeline and proposed architecture for conducting 2-3 proof of concept tests between January 2019 and December 2020. The proposal shall include the key terms of the technology transfer agreement that will allow for commercialization of the offering. The proposal shall also include initial viability assessments for each of the 2-3 proof of concepts, summarizing current assumptions about the feasibility of each proof of concept as well as whether there is clear evidence of demand for the commercialization of the proof of concept by a target customer.

Grant Structure: Microsoft will make the following grant funding available to the successful applicant:

- \$100,000 in cash grants upon initial award of the grant to be used to test the initial viability for and plan for development of the proof of concepts.

Microsoft Corporation
One Microsoft Way
Redmond, WA 98052-6399

Tel 425 882 8080
Fax 425 936 7329
<http://www.microsoft.com/>



Please submit an application for review containing the above outline of criteria and proposal no later than November 2, 2018. Submit to techspark@microsoft.com.

Mike Egan's Consent:

This is to confirm Microsoft's awarding of the \$100,000.00 grant to UND Aerospace Foundation and their partnership with Evolve Analytics. Your team meets the criteria and was selected to prove out the below concepts and move forward on planning, execution, testing and development of proof of concepts. We are excited to partner and look forward to the progress and work ahead. Thanks!

X Mike Egan

Mike Egan

Sr. Director - TechSpark

Attachment I – Detailed Budget

EVOLVE ANALYTICS, LLC

PROJECTED DATES: 1 March 2019 – 31 August 2020

Personnel	NDIC's Share	Applicant Share (Cash)	Applicant Share (In-Kind)
Project Director (25%)			67,500
Operations (25%)			36,000
Graduate Intern (25%)			21,600
TOTAL PERSONNEL			125,100
FIELD EQUIPMENT		37,000	
Drones and Drone Accessories		34,000	
Microsoft Surface Devices		3,000	
TRAVEL		18,000	
Software Development	349,828	605,828	
Technician Field Application Improvements		226,844	
Command Center Portal	349,828	159,050	
On-Drone Modules		219,934	
OTHER DIRECT COSTS			117,500
Core EA Product			117,500
Prototype Engineering	80,212		
Custom Drone Housing Unit Equipment	69,960		
F & A Costs	-		
GRAND TOTAL	\$500,000	\$660,828	\$242,600

Evolve Analytics Funding Match Description

Personnel

An average weighted salary for various positions (management, field operations, computer science) was used for budgeting, and fringes of 20% have been added to that figure. A total of \$125,100 is allocated for private sector personnel.

Equipment

Essential equipment includes Microsoft Surface devices (2) as well as stereoscopic sensors and drone hardware (2), including onboard processors. A total of \$37,000 is allocated for private sector equipment.

Travel

Mileage and occasional overnight travel for partner meetings and to remote locations. Much of the EA team must travel from ND to Xcel Energy Offices (Minneapolis, MN or Denver, CO), Microsoft Corporate

Offices (Seattle, WA), as well as the selected test site. Private sector cash reserved for travel will total \$18,000.

Software Development

Expansion of the Evolve Analytics' Airtonomy solution to include rules based & safety-oriented processes, and safeguards that will ensure safe remote system operations. Development will take place to coincide with design and manufacturing of a prototype custom drone housing unit as well as route optimization work conducted by Evolve Analytics' computer scientists. Testing will occur on three staffing levels using advanced simulation (Microsoft AirSim) followed by field tests to ensure rigor: 1) Development (Blue Metal/Level 12); 2) Evolve Analytics; 3) UND-RIAS/Northern Plains UAS Test Site. All development activities will be coordinated through the Research North Dakota grant in order to ultimately obtain Federal Aviation Administration approval in the form of a permanent waiver.

Software development is divided into three categories:

- **Technician Field Application Improvements:** authentication, API enhancements, inspection type, "Nest" hardware integration, error handling/messaging, UI updates, live video streaming
 - Estimated Total Cost: \$226,844
- **Command Center Portal:** leverage existing UWP app functionality for replication, launch pre-requisite assessment, set thresholds for pre-requisites, choose inspection types and assets, scheduling function, real-time drone tracking, SCADA integration, IoT Hub interface with engineering portal, ability to launch multiple drones, with multiple missions, to multiple assets, drone status, service logs
 - Estimated Total Cost: \$508,878
- **On-Drone Modules:** wireless image transfer from SD card, IoT Edge setup script/documentation, data push from repository instead of config file, check conditions, confirm data transmission, service management & logging
 - Estimated Total Cost: \$219,934

Attachment G is a software development estimate provided by a Microsoft Gold Partner and a nationally recognized expert in Microsoft Azure IoT. A total of \$605,828 is allocated for private sector software development.

Other Direct Costs

Core EA product consisting of ROS application, UWP application, Azure IoT framework, Azure, AI/CV, and optimization algorithms. A total of \$117,500 is allocated for private sector systems.

Requested Renewable Energy Program Funding Description

Prototype Engineering

Engineering design and manufacturing of a prototype custom drone housing unit including climate monitoring and communication equipment. A total of \$80,212 is requested from the Renewable Energy Council for prototype engineering.

Breakdown - Estimated Development Cost:

- 3D Design: \$14,630 (105-140 hours @\$104.50 per hour)
- Vacuumed Formed Pattern: \$15,400
- Vacuumed Formed Tool: \$22,000
- Production Vacuumed Formed Parts: \$792 (\$66 per shell)
- Metal Components: \$13,200 (\$2,200 per set)
- Controls Engineering: \$8,910 (40-60 hours @\$148.50 per hour)
- Controls: \$5,280 (\$880 per set)

Total: \$80,212

Note: concrete pad and concrete anchors are not included.

Custom Drone Housing Unit Equipment (To Be Manufactured in North Dakota)

Equipment required to build 6 prototype custom drone housing units including: solar charging unit, uninterruptible power source (UPS), microcomputer, inductive charging system, ceramic heater, locking mechanism, and Microsoft Farm Beats kit (wind, light, ambient temperature, humidity, and precipitation sensors) as part of the SRA-MDO solution. A total of \$69,960 is requested from the Renewable Energy Council for custom drone house unit equipment.

Breakdown - Estimated Equipment Cost:

- Solar Charging Unit: \$4,620 (\$770 per unit)
- Uninterruptible Power Source (UPS): \$7,260 (\$1,210 per unit)
- Microcomputer: \$13,200 (\$2,200 per unit)
- Inductive Charging System: \$34,320 (\$5,720 per unit)
- Ceramic Heater: \$1,980 (\$330 per unit)
- Locking Mechanism: \$1,980 (\$330 per unit)
- Microsoft Farm Beats Kit: \$6,600 (\$550 per unit)

Total: \$69,960

Software Development

Expansion of the Evolve Analytics' Airtonomy solution to include rules based & safety-oriented processes, and safeguards that will ensure safe remote system operations. Development will take place to coincide with design and manufacturing of a prototype custom drone housing unit as well as route optimization work conducted by Evolve Analytics' computer scientists. Testing will occur on three staffing levels using advanced simulation (Microsoft AirSim) followed by field tests to ensure rigor: 1)

Development (Blue Metal/Level 12); 2) Evolve Analytics; 3) UND-RIAS/Northern Plains UAS Test Site. All development activities will be coordinated through the Research North Dakota grant in order to ultimately obtain Federal Aviation Administration approval in the form of a permanent waiver.

Software development is divided into three categories:

- **Technician Field Application Improvements:** authentication, API enhancements, inspection type, “Nest” hardware integration, error handling/messaging, UI updates, live video streaming
 - Estimated Total Cost: \$226,844
- **Command Center Portal:** leverage existing UWP app functionality for replication, launch pre-requisite assessment, set thresholds for pre-requisites, choose inspection types and assets, scheduling function, real-time drone tracking, SCADA integration, IoT Hub interface with engineering portal, ability to launch multiple drones, with multiple missions, to multiple assets, drone status, service logs
 - Estimated Total Cost: \$508,878
- **On-Drone Modules:** wireless image transfer from SD card, IoT Edge setup script/documentation, data push from repository instead of config file, check conditions, confirm data transmission, service management & logging
 - Estimated Total Cost: \$219,934

Attachment G is a software development estimate provided by a Microsoft Gold Partner and a nationally recognized expert in Microsoft Azure IoT. A total of \$349,828 is requested from the Renewable Energy Council for software development.

Notes:

1. Xcel Energy and Microsoft pledge to contribute Private Sector (Cash Reserved) resources as well that with Evolve Analytics will substantially exceed the required match.
2. The Evolve Analytics grant match **DOES NOT** include funds or in-kind resources used as match for the recently funded Research ND grant.
3. The estimated project cost **DOES NOT** include recent funding in the amount of \$267,974 from the Research North Dakota program, that is related but **WILL NOT** fund any budget items.
 - a. These funds will go directly to UND-RIAS and provide subcontractor funding to the Northern Plains UAS Test Site as well.
 - b. Intended to develop a CONcept of OPERations (CONOP) and safety case that will provide the feasibility and conceptual framework to enable the FAA to grant an operational waiver necessary to install and operate the system on Renewable Energy Sites.