**California Institute of Drone Engineering Research (CIDER)**

**(May 2, 2014)**

1. **Executive Summary**

90 percent of potential markets for UAVs (unmanned aerial vehicles, or commonly known as drones) will be accounted for by public safety and precision agriculture including agriculture and environmental engineering. UAVs will inject $82 billion in economic activity and generate up to 100,000 new jobs between 2015 and 2025. (<http://www.auvsi.org/econreport>)

UC Merced is uniquely geographically located to establish CIDER (California Institute of Drone Engineering Research) with significant national and international prominence and local and regional economic impacts. Our ultimate vision is to build “Data Drone Valley” between Silicon Valley and Yosemite National Park through this unique intellectual and engineering platform – CIDER. UC Merced already has a significant preparation for this “Data Drone Valley” vision to become true. It could also be expected to symbolize “data drones” as one of the distinguishing aspects of UC Merced from other UC campuses.

1. **Succinct definition of Thematic area**
	1. **Does it fit in one of the nine (9) defined Themes?**
		1. **Is this a more sharply defined theme *within* one of the nine Themes?**

CIDER is inherently multidisciplinary. It best fits a Theme not on the list that we would name it as “Unmanned Systems and Engineering.” A more sharply defined Theme would be “Information, Computational, and Data Sciences, and Engineering”.

* + 1. **Is this an area of research and scholarship that cuts across more than one Theme?**

CIDER cuts across the following Theme areas

* Human Health (PM mapping, air quality mapping, Valley Fever study, water quality, food safety etc.)
* Innovation and Entrepreneurship (Startups, intellectual property development, student I&E training, e.g., SoE’s Innovation to Grow program)
* Environmental Sustainability (Data drones as essential tools)
* Energy and Energy Systems (Health check for solar farms, wind farms, algal lagoon, and, pipeline and power line inspection etc.)
* Information, Computational, and Data Sciences, and Engineering (core)
* Matter Science and Engineering: from theory to application (Composites, nanomaterial based sensors, additive manufacturing, mechatronics, design for manufacturing etc.)
	1. **Is it part of a different Theme?**

Maybe. We would like to name it “Unmanned Systems and Engineering.” Given the pervasive use of automated farming machines, given the new Google driverless car test lab as well as the Loon project test lab[[1]](#footnote-1) both settled in Castle Airport, given strong faculty in EECS/ME/MSE, we believe UC Merced could have a thrust Theme area in “Unmanned Systems and Engineering” which could be nicely named as UCMUSE (UC Merced Unmanned Systems and Engineering) but this could have a system wide significance, so UCMUSE could be (UC Multidisciplinary Unmanned Systems and Engineering).

* 1. **Are there other SAF Initiatives that, in your opinion, might contribute to this Theme?**

Yes, they are alphabetically:

* Applied Mathematics
* CHASE
* Chemistry & Chemical Biology
* Cognitive Science
* Electrical Engineering & Computer Science
* Environmental Sustainability
* Hard Rock Institute
* Materials Science & Engineering
* Mechanical Engineering
* Management of Innovation, Sustainability, and Technology (MIST)
* Next Generation Materials
* Center for Statistical and Quantitative Research
* School of Management & Economics
* SpARC
* UC Merced Center for Theory & Computation
* UC Merced’s Library
1. **Intellectual components of the strategic initiative**
	1. **Why is this area(s) important?**

Over the past five or so years, small UAVs (unmanned aerial vehicles) have shown much promise in their future role as a primary tool to collect critical information for decision making. Whether used as a smart farmer’s companion or a co-ecologist, personal remote sensing via “data drones” with associated system applications is rapidly increasing in number and sophistication. We are limited only by our imagination for potential future applications, much like the dawn of personal computing.

These “personal data drones” often weigh less than 55 pounds, but have the ability to capture remarkably high resolution thermal, near infrared (NIR), and red-green-blue (RGB) standard video and imagery and LIDAR for 3D mapping. These data can then be used for a variety of timely decisions, such as determining not only the species of plants, but also their water and nutrient stress status. This type of applications is only the beginning, as we believe there are many more untapped agriculture and environmental research abilities, such as to take air samples, track plumes of gases, monitor water, health-check for forests, pest management and much more.

Data drones are in effect an Unmanned Aircraft System (UAS), which is an autonomous aircraft, capable of not only flying without a human pilot onboard, but can also include advanced intelligence to conduct search, tracking and rescue mission without the need for human control. Industry experts predict a significant surge in UAS deployment, especially within the agricultural industry (AUVSI Economic Report, 2013). This exponential increase is expected from two major developments: the increase in availability of advanced sensor technology and the pending implementation of U.S. Federal Regulations allowing commercial use of UASs. As the use of UAS in the National Airspace (NAS) increases, the need to develop meaningful scientific and environmental research sUAS also increases. To improve the Central Valley’s economy and environmental sustainability, a leading effort through CIDER must be established.

The California Institute of Drone Engineering Research will prove to be beneficial not only for the University of California, Merced, but for the Great Valley and beyond. We propose that UAVs can be utilized in an effort to tackle difficult agricultural and environmental monitoring and actuation problems (such as cropdusting drones, invasive weed management, stochastic bird chasing etc.) that are currently boundaries in the field of Environmental Science and in high demand.

* 1. **What are the current key areas/achievements in this field, and those going forward?**

Intellectual drivers for CIDER are 1) local, regional and global demand for more real-time and finer spatial resolution remote sensing products, 2) technological progress in navigation and control performance and cost reduction, 3) FAA (Federal Aviation Agency) rule making allowing for integration of UAS (unmanned aerial systems) into NAS (National Air Space).

We plan to focus on various drone engineering research questions driven by regional demands, mainly for agriculture and environmental sectors, but will also include urban applications, such as natural hazard mitigation and real-time emergency response. Compelling scenarios where original research questions can be asked and answered when UAS drones are routinely deployed include, but are not limited to, the following topics (which are presently being asked of UCM faculty):

* + Early detection of crop stresses due to drought, nutrient, heat/frost, salinity, pests, heavy metal etc.
	+ Search and rescue, aftermath assessment of major disasters such as earthquakes
	+ Human dimensions in drone engineering i.e. drone control and human compatibility, human-robot teams, etc.
	+ Forest health monitoring using airborne LIDAR
	+ Migratory Bird Monitoring; Ground Squirrel Tracking and Monitoring
	+ Gas Leak Detecting
		- UC Merced in Conjunction with MESA Lab and PG&E have begun these efforts in Spring of 2013. In that scenario, leaks from pipelines were the source of natural gas. In the Central Valley, there has been efforts to increase oil shale fracking, which has many unknown environmental impacts. In an effort to monitor fracking sites and the surrounding areas, UAVs can be deployed in search of potential leaks and ground compromises.
	+ Factory Emissions and Fugitive Emission Detection and Monitoring
	+ Water Discharge and Pollution Monitoring
	+ Data Capture (aka “Flying Data Mules”) for Weather Stations or Environment Stations
		- Current methods for weather station and environmental field station data collection is through either satellite and cell reception transmission, or by hiking-in to the station and extracting data manually. A UAV is able to fly to the station, circle above head while downloading data, and finally fly home with the data.
	+ Multi-UAV Crop-dusting Network
		- In an effort to minimize harmful fertilizers and insecticides/pesticides into the environment, a multi-UAV crop-dusting network can be developed.
	+ Vernal Pool Mapping and Water Sampling to understand the pool dynamics and its coupling to the nearby ecosystems.
	+ Sierra Nevada Wildfire Monitoring and Mitigation
	+ Air Quality Monitoring and Aerial Microbial Sampling
		- Valley Fever
1. **UCM’s role in this Theme**
	1. **The UCM Campus’ unique position in this particular field**
		1. **Current strengths on campus in this area**
* Faculty expertises around CIDER complement each other very well;
* Cross-disciplinary joint research initiatives and proposal efforts;
* Leading position in unmanned aerial systems research, education and development communnity;
* Experience in FAA regulation compliance (FAA Certificate of Authorization)
* Good connections to aerospace industry, growers, farmers, UC extensions, environmental nonprofit organizations
* Outreach, service learning and undergraduate research experience
	+ 1. **Potential research areas of expansion**

CIDER focuses on precision agriculture, natural resource management and environmental monitoring. The following integrative research areas have good potentials

* Cognitive science and human factors;
* Crew credentialing and drone operator certification;
* Big data management and groundtruthing;
* Computer vision and pattern recognition;
* Machine learning and artificial intelligence
* Biological, chemical, and optical sensing
* Search and rescue
	1. **How will investment in this area make our program distinctive/competitive when compared to programs within UC and other research universities?**

UC Merced’s multidisciplinary data drone research has good potential to become a signature area that distinguishes UC Merced from other UC campuses. To maintain our currently leading position, further investment is definitely needed in addition to MESA Lab’s startup fund. So far, no other UC campuses can compete with our data drone research. CIDER will further establish and maintain our leading position.

Comparing to other research universities, we are uniquely geographically located and we are not behind any one for now. However, with state support, institutional backing, other universities in other states may lead us if we do not have commensurate or stronger institutional and state support.

As said, CIDER could be symbolizing “data drones” as one of the distinguishing aspects of UC Merced from other campuses with national and international prominence.

1. **What bylaw units/grad groups might participate, and how would they participate?**

 The following units and graduate groups might participate in this research theme.

* Applied Mathematics (bylaw unit + graduate group)
* Chemistry & Chemical Biology (bylaw unit + graduate group)
* Cognitive and Information Sciences (bylaw unit + graduate group)
* Electrical Engineering & Computer Science
* Environmental Systems
* Materials Science & Engineering
* Mechanical Engineering
* Physics (bylaw unit + graduate group)
* Psychological Sciences

Three ways of CIDER participation:

* 1. Faculty and graduate student participation in research and development at CIDER in all above units/grad groups;
	2. Being an end user of data drones with specific innovative missions;
	3. Developing larger scale grant proposals for cross-disciplinary research on new missions, new sensor payloads; new data post-processing methods etc.
1. **General description of special programmatic needs (specialized space requirements, special library collections, etc.).**

**Space:**

* Castle would be a good place for a drone research and development center. CIDER could make shared use of UC MERCED’s Castle Research Facility with UC Solar. Future development will include showcase with CITRIS Hub, and use of workshop facilities for extension and STEM education events.
* A locked (renovated) barn/building at UC Merced’s Vernal Pool UC Reserve for flight tests on the Reserve.

**FTEs:** Full Time Equivalent 3

* + - * **Field Engineer**
				+ Responsible to lead a group of interested undergrad students for real missions and create revenue to CIDER.
			* **Research Engineer/Drone Scientist**
				+ Responsible for mission based systems integration, R&D, deploy data drones in shortest time, highest reliability, lowest cost.
			* **Data Engineer**
				+ Giving a mission with one data source is not enough, data fusion is necessary for truly “decision-quality” data. Generate decision quality data and decision quality information, for end user to make decisions easier and faster. Explore cloud computing, big data technology to make our CIDER data drones remote sensed data an integral part of big data that can create new type of services.

**CIDER’s Roadmap/Vision:**

* + CIDER as university CF (Core Facility) offering paid services
	+ CIDER as UC MRPI
	+ CIDER as FAA UAS COE (Center of Excellence)
	+ CIDER supports undergraduate minor and even major on MUSE (Multidisciplinary Unmanned Systems and Engineering).
1. * <http://www.mercedsunstar.com/2014/05/01/3628526/google-signs-second-lease-with.html>
	* <http://www.mercedsunstar.com/2014/01/24/3458766/google-set-to-lease-castle-site.html> [↑](#footnote-ref-1)