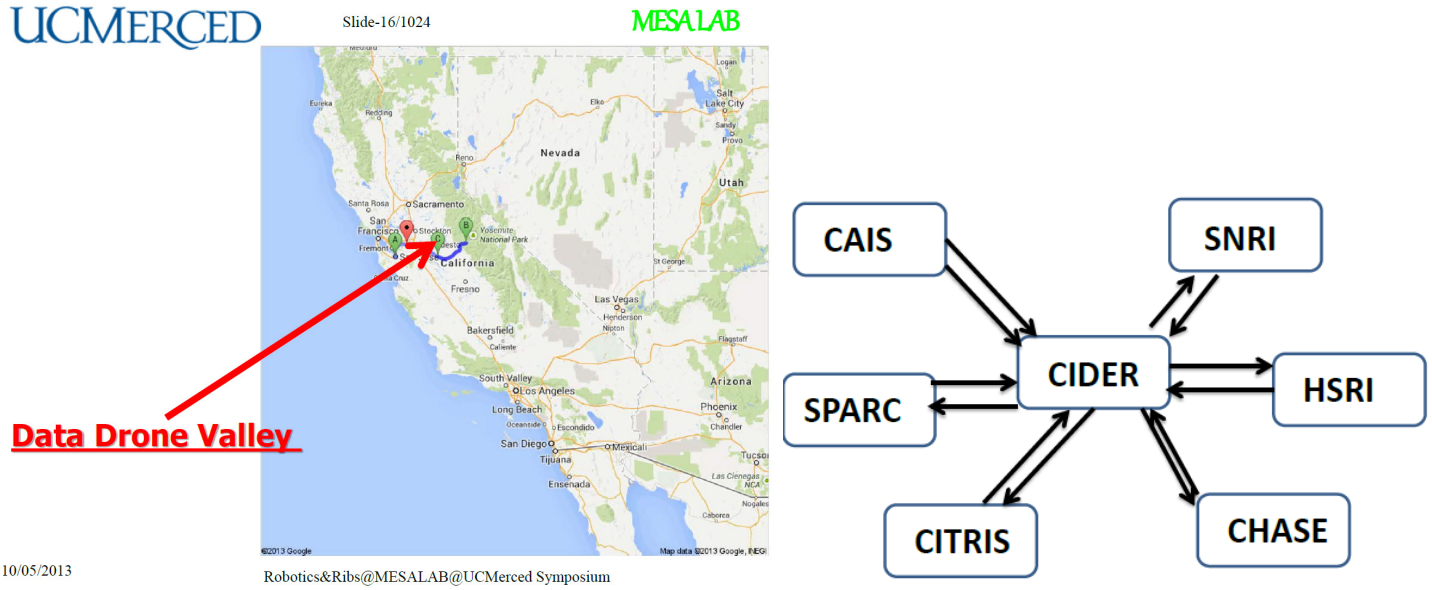
## Strategic Academic Focusing Initiative @ UC MERCED (2020)

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

**Planning Team:**
Stefano Carpin (EECS/ME), YangQuan Chen (ME/EECS/SNRI/CHASE), Qinghua Guo (ES/SNRI/SPARC), Chris Kello (CIS/CHASE), Joshua Viers (ES/CITRIS/SNRI)

**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 campuses.




| | |
|---|---|
| **CIDER:** | **California Institute of Drone Engineering Research** |
| **CAIS:** | **Center for Autonomous and Interactive Systems** |
| **SNRI:** | **Serra Nevada Research Institute** |
| **HSRI:** | **Health Systems Research Institute** |
| **CHASE:** | **Center for Human Adaptive Systems and Environment** |
| **CITRIS:** | **Center for Info Tech Research in the Interest of Society** |
| **SPARC:** | **Spatial Analysis and Research Center** |

**Description of the Initiative:**

1. **Background**

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.

Photo taken in July 2012 in Christchurch, New Zealand under NSF RAPID grant support. Run-way independent take-off and landing; airline luggage transportability.

Photo taken in July 2013 in MESA LAB @ UC MERCED's Castle Research Facility. UAV Water Sampler or "*Drone Co-ecologist*". Single person portable and operable.

## 2. Intellectual Drivers and Research Questions:

Intellectual drivers 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

**3. Campus Initiative Metrics**

- **Graduate Education and Research**

Drone-based remote sensing and remote application (or spraying, actuation) are becoming an enabler of new multidisciplinary research opportunities. Graduates from multiple graduate programs such as EECS, ME, CIS, ES, CSE, BIOE, BEST etc. will benefit from CIDER's broad research programs.

- **Undergraduate Education**

Currently, MESA Lab hosts over thirty undergraduate students in an effort to educate and spur meaningful involvement at the undergraduate level. We expect CIDER will attract even more undergraduate researchers for their capstone projects, independent research credits, and pure research experiences etc. CIDER will excite our student body and serve an active role for student recruitment and retention, in addition to enriching existent curriculum education.

**Investment needed**

Given the promising future of data drones, it is very reasonable to expect that CIDER will be soon in a self-sustaining mode of growth in both research and development. Timing is also perfect as FAA will be opening NAS in Fall 2015. We will be having full momentum if at the beginning, we have the following:

**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 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.

## Concluding Remarks:

Using an *analogy* to the "**personal computer**" of the 1970s, we are now at the entrance of the era of "**personal remote sensing.**" Timing is very good for UC Merced to invest and foster the next generation "Bill Gates" and "Steve Jobs" here in Central Valley, not far from Silicon Valley.