I-FAST Application

1. Briefly describe the I-Corps team

Our I-Corps team will bring to market two software packages that allow crop advisors to work with farmers to run on-farm, whole-field agronomic trials, and use the data to recommend to farmers profitable nitrogen fertilizer (and other input) management strategies. Each member of our I-Corps team brings skills, expertise, and personal qualities necessary to turn the underlying conceptual bases of the NIFA-funded project into viable market-ready products and services. Together they bring broad intellectual expertise and practical experience in research, entrepreneurship, and commercial leadership.

Entrepreneurial Lead ***Laila Puntel*** will first provide technical and scientific expertise in our interviews with agribusinesses and farmers, and later in the running of the commercial enterprise. Puntel is currently finishing her PhD in the Department of Agronomy at Iowa State University (ISU). She is also co-founder of Clarion in Argentina (www.precisionclarion.com), an enterprise that since 2012 has been offering an integrated approach based on data-intensive methods to provide site-specific management advice to farmers. Puntel has experience in crop production and advising, and technical expertise in field research and crop systems modeling.

Entrepreneurial Lead ***Krystal Montesdeoca*** will lead our market research and take chief responsibility for project and start-up organization and communication. Montesdeoca graduated with her M.S. from the University of Illinois (U of I) Dept. of Agricultural and Consumer Economics, where her thesis examined maize and soybean production management in Brazil. She has been closely working with Bullock as the Project Coordinator for the NIFA-funded Data-Intensive Fertilizer Management ("DIFM") project.

Principal Investigator ***David Bullock*** will be in charge of the project's economic and data analysis. Bullock is a Professor in the U of I Dept. of Agricultural and Consumer Economics. He has been conducting research on the economics of fertilization and precision agriculture for over twenty years, and has published results in flagship agronomic and agricultural economics journals. He is also the PI of the 4-year, $4 million NIFA grant that motivates this proposal. Bullock and Puntel recently travelled together to South America to begin negotiations with several agribusinesses about running field trials. Bullock, Puntel, and Montesdeoca recently travelled to St. Louis to hold discussions with Monsanto subsidiary Climate Corporation about mutual business and research interests.

Mentor ***Kristine Johansen*** will guide the project in the practical legal and technical steps of starting up an enterprise. Johansen is a PhD-microbiologist and MBA with hands-on experience moving research results into the commercial marketplace with two start-up biotech companies, Xtrana and Invenux. She also brings extensive expertise in the federal SBIR and STTR programs. Johansen works in ISU's Office of Economic Development and Industry Relations Startup Factory program, connecting external partners, stakeholders, and ISU personnel, to help move ISU research into the marketplace

Mentor ***Daniel Schreiber*** will advise the project on the technical details of software development, licensing and distribution, and in business negotiations with companies wishing to use the software for commercial purposes. In 1997, Schreiber co-founded SourceGear, Inc., a software development company that sold its Teamprise division to Microsoft and was named one of Inc Magazine's 500 Fastest Growing Companies. One of three partners, he was involved in all aspects of product and company decision-making, until he sold his shares of the firm in 2007. In the mid-1990s he worked as project manager for Spyglass, Inc, which enhanced and distributed Mosaic, the first mass-market browser (originally developed and licensed from the University of Illinois), and subsequently licensed to Microsoft to become Internet Explorer.

2. Lineage of the Proposed Innovation (one page limit)

a. Provide a table of previous awards with managing program officer (if applicable) identified.

Award Title	Funding Agency and Program	Time Span	Funds	Principal Investigator	Managing Program Officer
"Using Precision Technology in On-farm Field Trials to Enable Data-Intensive Fertilizer Management."	NIFA-AFRI Food Security Grant	Jan 1, 2016 – Dec 31, 2019	$4,000,000	David Bullock	Mathieu Ngouajio

b. Briefly describe how this research has led the Team to believe that a commercial opportunity exists for the effort moving forward.

A worldwide market (estimated to be worth $1.14 billion in 2016 by *Research and Markets*) for site-specific farm management advice has emerged. In preliminary market research, we have found over thirty firms worldwide that are claiming to be using "data-intensive" methods to offer farm input management advice, and many others that offer traditional, "rule-of-thumb" advice. These businesses range from very small firms to agribusiness giants like Monsanto, DuPont-Pioneer, and Syngenta. However, there are technology gaps and weaknesses in all of their methods of generating and analyzing data, and in how they communicate the technical management implications of the data to farmers. We believe that our research activities and results can be used to fill these gaps, and so offer farmers superior management advice. As part of our NIFA-sponsored research, we are working with developers at the National Center for Supercomputing Applications to create two software packages that will make it possible for crop advisors working with famers to inexpensively run large-scale, on-farm agronomic trials and generate vast amounts of valuable data on how crops respond to managed input strategies. The software will also feature data analysis algorithms to allow crop advisors to offer statistically-backed management advice based on that data and data generated in many other trials. The software will also allow advisors to present the analytical results to farmers in an intuitive, visual, user-friendly environment. In this first year of the project, we have begun to develop the software and its accompanying research infrastructure, and have succeeded in conducting several large-scale field trials. Farmers' willingness to participate in our research in 2016 has shown us that they are indeed interested in the kinds of information we can provide. We have already had many more U.S. farmers ask to participate in 2017 trials than we can currently fund. Moreover, we have had three well-established agribusinesses show serious interest in working with us. The DIFM project and the Argentinian agribusinesses ASP and YPF have agreed to cooperatively conduct large-scale maize trials during the 2016-17 growing seasons. ASP and YPF want to work with us because they realize the potential value of the kinds of data we will generate. Similarly, Monsanto's subsidiary Climate Corporation has approached us, asking us how they can help in our research. Recently, we met for dinner in St. Louis with around ten Climate Corp scientists and executives, followed the next morning by four more hours of detailed discussion. We have another meeting scheduled with them in mid-October. It seems clear to us that Monsanto/Climate Corp is talking with us because they believe that our methodologies may well be able to fill technology and service gaps in the current worldwide market for nitrogen fertilizer management advice.

3. Description of the Potential Commercial Impact (two page limit)

a. Provide a brief profile of a typical customer of the proposed innovation.

A typical customer will be a company that employs *certified crop advisors*. CCAs make their livings providing management advice to farmers. CCAs can be self-employed, but often work for firms that specialize in selling agricultural inputs and advice about how to manage those inputs (for example, Growmark FS dealerships). A CCA or his/her employer would license our software and take a training course with us on its use.

b. Describe the customer need that you believe will be met by the proposed innovation.

Crop advisors sell advice to farmers. Our innovations will allow CCAs and farmers to generate valuable data on their own farms, and derive data-driven, practical, profitable management implications in a user-friendly, visually powerful computational and presentation environment.

c. Describe how the customer currently meets those needs.

Currently, because insufficient data exist on how crop yields respond to nitrogen fertilizer and other managed inputs, our customers (CCAs) can only incompletely meet the needs of their customers (farmers). Past empirical studies generated only limited data because *field trials were labor-intensive and expensive.* Researchers marked plots, using measuring tapes and flags, applied inputs by hand or with specialized small equipment at varying rates on different plots, and harvested without large-scale farm machinery. It was financially feasible to run trials only on very small parcels of land, at few locations, usually only for a few years. Consequently, despite over one hundred years of agronomic experimentation, still little is known about optimal fertilizer management in practical settings. Industry fertilizer management recommendations have instead relied on "rules-of-thumb" (e.g., Hoeft and Peck 2007) based only loosely on data analysis and science (Rodriguez and Bullock 2015). An example is the small firm Cropsmith (www.cropsmith.com), based in Monticello, Illinois. Cropsmith provides several useful services to farmers, including soil sampling, soil analysis, and contract research. But in offering nitrogen fertilizer management recommendations, the company relies on yield-based algorithms that have been thoroughly discredited in recent agronomic research (Sawyer, 2006). Hundreds of such small U.S. firms use similar methodologies. Some very large agribusinesses are offering products that rely more on data than do these traditional approaches. For example, Monsanto subsidiary Climate Corporation offers FieldViewPro®, a suite of decision tool software products for farm management. One product in that suite is Climate Corp's Nitrogen Advisor (https://climate.com/fieldview-pro-for-your-farm/?&gclid=CNym7Sx2M4CFQIaaQodGKEOqQ). Climate Corp's business model is to run agronomic experiments at its research farms, to try to use the data to offer advice for other fields in distant locations, and to provide implicated management advice remotely, via the cloud. But the pertinence of one field's data to the management of a distant field can be questioned, and poses Climate Corp's key difficulty.

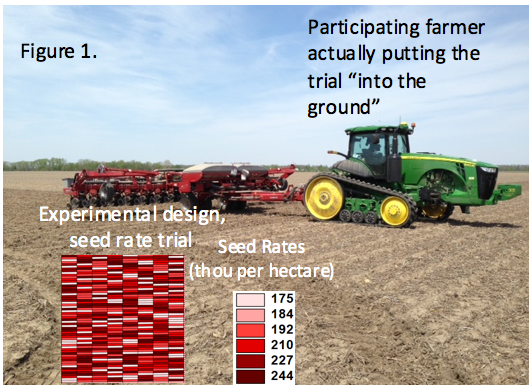

Figure 1.

d. Your approach—What is the proposed innovation? How does it relate to the fundamental research already conducted under previous award(s).

Our software will allow CCAs to work with farmers to implement, with very little work or bother to the farmer, large-scale "checkerboard" field trials right in their own fields. Figure 1

depicts one such trial, which we recently ran with a cooperating farmer in central Illinois. The figure also shows the farmer actually putting the trial "into the ground" by *simply driving his machinery through the field in the usual way*, while our GPS-linked software works with a computer on board the machinery and a variable rate planter to automatically vary seed rates in the (statistically superior) checkerboard pattern that we have used our software to dictate. Our methodology makes generating huge amounts of high-quality agronomic data simple and inexpensive, getting rid of small plots, flags and measuring tapes, and greatly expanding the frontiers of agronomic experimentation and data analysis.

Figure 2 depicts the flow of our proposed business and research model. The process begins when the crop advisor consults with the farmer, garnering basic information about field characteristics and management. Our OFRD software can then be used to easily design and implement checkerboard field trials by transmitting those designs to

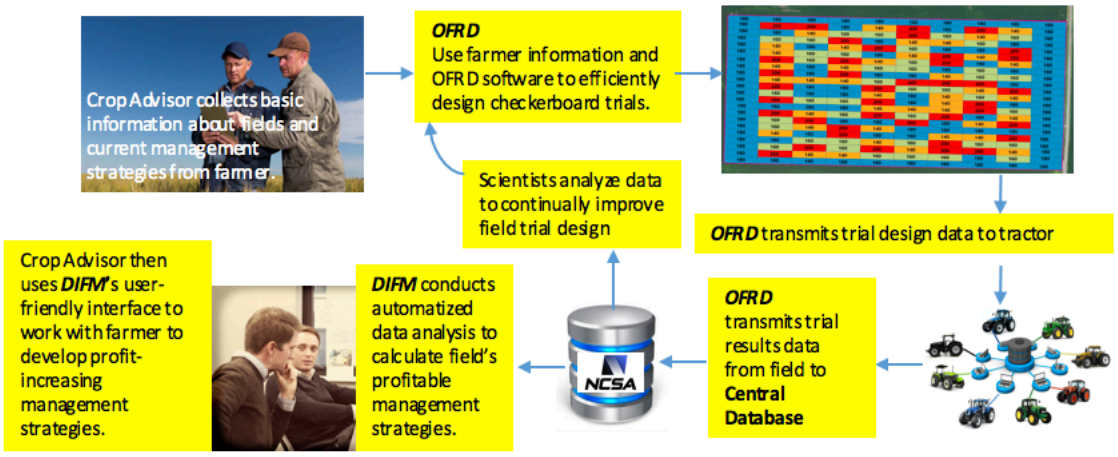

Figure 2.

tractors in fields. Accumulated data can be used to improve design of field trials and improve the automatic analysis algorithms in our DIFM software. A crop advisor then uses DIFM's user-friendly interface to work with the farmer to develop profit-increasing management strategies.

As is stated in our original NIFA proposal narrative, major objectives of our fundamental research are to develop exactly the kind of software that we are now well into the process of developing, to begin running large-scale, on-farm "checkerboard" field trials, and to develop a central databank system that stores and transmits the data from the farms to the researchers and then transmits the implications of the data analysis back again to the farmers. Indeed, in our NIFA-funded research, we have been conducting very large (80 acres and larger) field trials very inexpensively, and are beginning to generate vast amounts of data that can be used to learn how crops grow and to what they respond. As more data comes in, we will increasingly be able to give farmers profitable input management advice.

e. How much do you think a customer would pay for your solution?

Climate Corp charges $3/acre for annual access to its FieldViewPro® software with its *Nitrogen Advisor* component. Our product will be based on better data and better science, and thus will address the technology gaps described above. Midwest commercial grain and oilseed farms typically exceed 1500 acres, and in 2016 over 225 million U.S. acres were planted to major grains and oilseeds, and over 1.5 billion acres were planted in the world. With pricing similar to Climate Corp's, the total annual addressable market opportunity exceeds $5 billion.

4. Brief description of the project plan (one page limit)

a. Current Status - In what stage is the development: proof-of-principle, proof-of-concept, prototype (alpha, beta), etc...

The DIFM project currently is running several on-farm trials, from which we will obtain data in October after harvest. So, we have proved that we can run the experiments and generate data from them at very low cost.

The software package that we have been using so far to design and implement checkerboard trials has been useful. But because it was not specifically designed to run such trials, with it we can only design very simple experiments, and using it is far less efficient than we would like. Therefore, as part of our NIFA-sponsored DIFM project, we are designing along with our partners at the National Center for Supercomputing Applications (NCSA) the far more sophisticated On-farm Research Design (OFRD) software. We have recently finished a draft-prototype of the OFRD software, which we hope to use in September to design and implement field trials in South America. We still have a great deal to do to get all we want out of OFRD, and we are looking forward to continuing to improve it as we obtain more experience using it and understanding farmers' needs that can be satisfied with it. Also, with our NCSA software developers, we have entered early stages of the creation of the Data-Intensive Farm Management software. This is the software that crop advisors and their clients will use as a decision tool. Farmers will be able to access many kinds of information and data from the cloud, and they will be able to work with trained crop advisors, using DIFM to visualize the data and the analytical results of the on-farm experiments. We are very confident that we will have a beta version of DIFM up and running in early 2017. Finally, the OFRD and DIFM systems will be the endpoints for a data moving and storage system, which we are calling the Central Database. We are currently working with NCSA, employing their expertise in Big Data management, and are in the beginning stages of developing the Central Database.

b. Provide a brief description of the proof-of-concept or technology demonstration that will be provided at the end of the project.

At the end of training, we will use OFRD to design the complicated, statistically controlled field trial for one of the actual 2017 DIFM fields. Then we will use a crop growth simulation model to simulate the yield response on each of the field's sites, and take the harvest data, show how we can move it to the Central Database, and also how we can move it from the Central Database to a researcher, who can access the data on-line via the cloud. Then we will show how a crop advisor could use DIFM to work with a farmer to develop a profitable management plan.