

## Final Report Summaries as of February 2014 - #10 Projects

### **#10-04 Absolute Calibration of a CW-FM LADAR Length Metrology System**

**Zeb Barber – Montana State University - Bozeman**

**\$138,000**

*Final report approved: November 2010*

#### **Summary**

The broad goal of this project was to improve the FMCW ladar system jointly developed and patented by MSU-Spectrum Lab and Bridger Photonics by ensuring that the system could be accurately calibrated. The project was designed to proceed along two tracks: (1) To investigate and develop methods to measure the chirp rate of the laser using molecular absorptions in gases; (2) To transport the chirped laser system to the National Institute of Standards and Technology (NIST) in Boulder, Colorado, to compare the chirp laser against an optical frequency comb provided by Dr. Nate Newbury of the Optoelectronics Division. For the measurements at NIST, a major design and packaging effort of the chirp laser system was performed through a subcontract to Bridger Photonics. The final system transported to NIST was a rack-mountable package and took less than two hours to set up and get running. The comparisons with the optical frequency comb were very successful and the results of these comparisons are being prepared for publication in a scientific journal.

Overall, the objectives were achieved. A simple method to calibrate with a relatively inexpensive molecular reference gas cell was developed. Bridger Photonics was able to refine its laser system packaging, which brings it closer to a full commercial product. The improvements are being implemented into the ladar systems developed by Bridger Photonics for government contracts and commercial applications.

#### **Commercialization**

Bridger Photonics' SLM Series Precision Distance Measurement System provides world-best precision measurements of absolute distances and thicknesses over very small and very large measurement ranges. This system will enable BP to perform additions and customizations to fit OEM metrology instrument needs ranging from spatial scanning to multiplexed measurement probes to long-range transceivers and high-power amplifiers. The SLM-Series can also be purchased as a stand-alone unit.

#### **Target market including size**

The broad target market is metrology (measurement), particularly the nano sector, which covers accuracies and repeatabilities below 1 micron. The sector includes global manufacturers of precision components for the optics and engineering industries. The micro and nano sectors are secondary metrology sectors for BP's technology.

Total size of the metrology market was estimated to be more than \$7.7 billion in 2005 with the nano sector comprising around \$1.2 billion. Five producers of optical metrology instruments could yield an estimated \$5 to \$15 million/year in annual revenues to BP. Since these companies represent less than 10% of the number of established companies,

further projected yield to BP could be \$50 to \$150 million per year in the US market. The international OEM market could roughly double the US market size.

In addition to the five potential OEM customers, identification of seven direct sales customers represents potential annual revenues up to \$2.4 million per year. Assuming this pool represents 5% of the total available customers, BP estimates the direct sales market size to be \$40 to \$48 million per year.

### **Production or manufacturing plan**

BP will follow an OEM manufacturing and supply business model that incorporates strategic partnerships with larger, established, and reputable precision metrology companies for integration, marketing, and distribution. BP's marketing research suggests an emphasis on strategic partnerships with larger companies as opposed to direct sales is a preferable commercialization strategy.

### **Business risk assessment**

The primary business risk factors are technology evolutions and competition. Success depends on the ability to establish a competitive position with respect to many factors, including knowledge of new technologies, the ability to introduce new products with enhanced functionality, and the completeness of the product offering reputation, geographic presence, and pricing.

### **Economic Impacts**

#### **New businesses created or expanded**

By improving and testing the high resolution lidar technology developed, this project has contributed to the growth of Bridger Photonics, Inc. (BP) business in this area. It has helped BP acquire further funds from NSF as well as enabled partnerships with national and international partners. The project has also led to a partnership with WaveSource, Inc., a Montana company developing custom optical solutions for the consumer vision market. Part of this partnership involves a subcontract to MSU-Spectrum Lab on a WaveSource project funded by MBRCT.

#### **Increase in employment levels**

During the term of this project, BP has grown from 7 to 13 employees.

#### **Patents applied for or granted**

Bridger and MSU have filed an international patent covering the innovation. BP has licensed MSU's share of the patent so it has exclusivity. The IP is felt to be critical to success.

### **#10-11 Development of a Commercial Production System for Protein Cage**

#### **Nanoparticles (PCNs) for Immunotherapeutic Applications**

**Mark Young – Montana State University - Bozeman**

**\$160,000**

*Final report approved: January 2012*

## **Summary**

The goal of the project was to develop commercially relevant production systems for protein cage nano particles (PCNs) that have shown to provide highly effective protection against lung pathogens including flu (influenza), RSV and SARS. This is the first step in a long term goal of building a Montana-based biotech company based on PCN technology.

The following types of research were performed:

- Research to develop PCN production system using the baculovirus-based insect cell culture system
- Research towards development of industry acceptable protocols of production (GLP towards GMP)
- Research to advance towards the production of PCNs for the next generation of efficacy and safety studies

Research results include:

- Development of baculovirus-based insect cell culture systems for the expression of the CCMV and sHSP PCNs
- Development of GLP-like protocols for the production of the CCMV and sHSP PCNs
- Animal testing of safety and efficacy of CCMV and sHSP PCNs produced utilizing baculovirus-based insect cell culture expression system

The major goal of the project to develop a baculovirus-based insect cell culture expression system for the target PCNs was achieved. The disappointing result of the baculovirus-based insect cell culture expression system for expression of the CCMV and sHSP PCNs was that the overall production yields were low for both PCNs.

## **Commercialization:**

Commercial potential has *diminished* since the start of the project due to two major factors:

- Competing technologies that achieve similar levels of protection against respiratory viruses without using a biological material such as PCNs have been developed.
- The achieved production levels using the baculovirus-based insect cell culture expression system for expression of the CCMV and sHSP PCNs are still too low for commercial production.

## **Economic Impacts:**

No major direct economic impacts have resulted from this project. The PCN technology continues to be a promising technology that is being pursued for eventual commercial purposes. The objective is to engineer PCNs functions with such clear medical applications that will attract investments to overcome the difficulties encountered in the production systems. The long-range goal is still to create a Montana based company based on the PCN technology. There is still considerable basic research to be done and that is continuing at the labs at MSU.

**#10-16 Development of New Antibacterial Dendrimers**  
**Mary Cloninger – Montana State University - Bozeman**  
**\$64,200**  
***Final report approved: March 2012***

**Summary**

The purpose of the project was to perform a large scale synthesis of the antibacterial dendrimer and to perform toxicity evaluations on a series of bacteria, on eukaryotic cells, and on biofilm. The objectives were all achieved. The project successfully synthesized enough antimicrobial dendrimers to perform studies on *E. coli*, *P. aeruginosa*, *S. oralis*, *S. aureus*, and *B. cereus*. Minimum inhibitory concentrations were comparable to, or lower than, those for monomeric control compounds. Evaluation of toxicity of the compounds cells found the antimicrobials had comparable toxicity to eukaryotic and bacterial cells.

During the second year, resistance assays were performed using *E. coli* and *B. cereus*. For the most part, these studies showed that the bacteria are unable to develop resistance to the new antibacterial compounds.

Although the objectives of the proposal were achieved, duplicate toxicity studies are currently underway with *P. aeruginosa*, *S. oralis*, and *S. aureus* to ensure publication quality. Upon completion of the duplicate toxicity assays, the findings will be published.

The new antibacterial compounds show promise for applications including cleaning of medical equipment. Upon completion of the duplicate toxicity studies, the MSU Technology Transfer will be enlisted to develop a commercialization plan.

**Commercialization**

The commercialization path for the new antimicrobial is to out-license the technology through the Montana State University Technology Transfer Office. MSU has strong ties to the antimicrobial industry through the Center for Biofilm Engineering and has a history of developing antimicrobials. MSU is also well positioned to work with industry to conduct collaborative sponsored research and conduct further testing.

**Product description**

The product is a new antimicrobial platform that is based on synthesizing highly cationic quaternary ammonium units that have a long alkyl chain.

**Target market including size**

The MSU Center for Biofilm Engineering has over 30 member companies with interest in antimicrobials in general and not limited to biofilm applications. The CBE provides an opportunity for direct contact with the industrial R&D community that could benefit from the proposed new antimicrobials.

**Path to Commercialization**

The commercialization path for the new antimicrobial is to out-license the technology through the Montana State University Technology Transfer Office, which manages MSU technologies from intellectual property protection to out-licensing. The TTO is currently prosecuting a patent for the new quaternary ammonium antimicrobial. A solicitation for licensing interest was released in 2008. This effort includes sending technology descriptions to target companies, a press release and posting on the MSU TTO web site.

### **Economic Impacts**

#### **Increase in employment levels**

This grant has allowed for employment for a M.S. level research technician and a graduate student.

#### **Patents applied for or granted**

The MSU Technology Transfer Office is currently prosecuting a patent for the new quaternary ammonium antimicrobial.

### **#10-23 Enhancement of Applied/Translational Research in Biomedicine**

**Richard J. Bridges – University of Montana - Missoula**

**\$197,066**

*Final report approved: November 2011*

### **Summary**

The overall goal of this award was to establish *CSFN* for the purposes of increasing critical mass of researchers and providing the needed infrastructure to increase the competitiveness of biomedical research efforts in Montana. As part of this multi-year effort, the overall goal of this sixth MBRCT COBRE award was to supplement this effort in a manner that would positively impact economic development in Montana within the area of applied biomedical research. Collaborators included departments within the University of Montana, St. Patrick Hospital and Health Sciences Center, the Montana Neuroscience Institute in Missoula, and emerging biotech companies in Montana.

Success has been achieved in relationship in the areas of: (Aim I) increasing research-related funding and jobs, (Aim II) supporting shared instrumentation, (Aim III) training students, (Aim IV) increasing opportunities for private sector collaboration; and, (Aim V) IP commercialization (e.g., SBIR awards, university-private sector collaborations). This grant award period overlaps with #11-22, and shares some of the same benchmarks and accomplishments.

Significant accomplishments during the award period are:

- Almost **\$12,000,000** in total new funding (excluding MBRCT funding) was awarded to CSFN investigators. Also more than **\$53,900,000** in grants was submitted by CSFN researchers.
- Federal research contract dollars contribute to the salaries of more than 70 employees, including 30 students. Significantly, these dollars are from federal

- research contracts represent new dollars coming into Montana and are estimated to have a “Business Activity Multiplier” of almost 2-fold.
- Clinical research trials at the Montana Neuroscience Institute (MNI) have reached a total of about 30 projects and mark significant increase of the access of Montana patients to new therapeutic strategies.
  - CSFN investigators continue to increase the number of ongoing collaborative ties established with emerging Biotech companies in Montana, especially with companies in the immediate vicinity of UM and MSU. These companies include four new “spin-off” companies directly started using CSFN-related IP: TranSynaptic, ATERIS, GT Pharma/Rio Pharmaceuticals, and Sinapsis Pharm.
  - Provisional or follow-up patent applications began for six new pieces of intellectual property.
  - Eleven students participated in the Summer Undergraduate Research Fellowship program, receiving hands-on experience in biomedical and translational research.

Collectively, this project is intended to have a long-term positive impact on Montana’s economy by increasing jobs through the acquisition of federal research grants and contracts, by enhancing collaborations with private sector companies, and by developing (and protecting) intellectual property that can be commercialized through existing or new companies. This last mechanism presents the greatest potential for the direct commercialization of technology.

### **Commercialization:**

Because of the nature of this effort, the project is focused on enhancing discovery, capturing it as intellectual property, and transferring it to the private sector rather than on commercialization of a particular technology or product. In other words, the most successful projects resulting from this effort have relied on the academic environment of the CSFN to help develop the product/technology and on the collaborating private sector company to commercialize it. Therefore, the development of a commercialization plan occurs after collaboration has been initiated and is developed by the corporate side of that collaboration. This strategy is exemplified by the fact that a number of recent seed projects have developed to the point where they have spun off new companies or partnered with existing ones to apply for SBIR and MBRCT support.

### **Economic Impacts:**

The economic impact is long-term and focused on capturing IP developed by CSFH investigators, then transferred to the private sector via collaboration and tech transfer. Each Specific Aim does, however, have an impact:

- (1) Aim I – The \$12 million in extramural grants has had a significant impact on Montana’s economy. In addition, the Business Activity Multiplier for NIH awards, determined between 1.9 and 3, translates into a minimal total impact of \$23 million. Since about 60% of grant funding is estimated to go to salaries for staff, students and faculty, this funding has helped create and/or maintain many

- jobs – an important consequence of research funding in the current state of the economy!
- (2) Aim II – Access to equipment in the instrumentation cores has saved emerging Montana companies the cost of acquiring such instrumentation, which would often be unobtainable. It is also an important factor in determining the competitiveness of grants submitted by CSFN investigators.
  - (3) Aim III – Although a long-term impact, the student training opportunities contribute to developing a stronger bio-tech work force. In addition, collaborations with private sector companies have added to new job creation for students involved in the projects.
  - (4) & (5) Aims IV and V – The two most important outcomes of this project have been marked increase in the generation of intellectual property and creation and/or continued collaboration with new Montana-based biotech companies. These efforts represent a critical step in the development of the bio-tech sector in Montana. The hire of Dr. Fanguy attests to the significance of these accomplishments. Design and implementation of this project represents one of the best ways in which university-based research can be leveraged and directed toward economic development in Montana!

### **#10-26 Novel Controlled Release Fertilizer Materials Derived from Renewable and Environmentally Degradable Polymers**

**Don Kiely – Rivertop Renewables - Missoula**

**\$150,125**

***Final report approved: April 2011***

#### **Summary**

The purpose of the project was to carry out applied research directed toward the commercial development of novel controlled release fertilizers (CRF) capable of delivering nutrients to plants in a controlled manner. The goal of the project was to develop CRF systems that overcome the deficiencies of both common commercial fertilizers and current commercial CRF systems in both cost and performance.

It is expected that commercial development of low-cost, efficient controlled release fertilizer systems will have a significant positive environmental and economic impact around the world, including addressing serious water quality problems. Two companies in the fertilizer business have expressed interest in the products. The company has received a \$1.75 million infrastructure grant award from the U.S. Economic Development Administration that is matched by a \$1.75 million award from the University of Montana to continue its research.

#### **Commercialization:**

The report states that “the commercial development of low cost and efficient controlled release fertilizer systems will have a huge positive environmental and economic impact across the entire globe. Decrease in the amount of fertilizer run-off and the associated waterway contamination can result in vastly improved water quality around the world

along with associated economic gains. Combining a renewable based CRF system with a lower cost product with good performance is of considerable commercial interest to companies in the fertilizer business, two of which have recently expressed interest in our products”.

### **Product description**

Controlled release fertilizers that require less fertilizer to achieve the same yield, are delivered at the appropriate times making them more effective, and result in less run-off. This last advantage addresses recent state and federal regulations to protect water systems.

### **Target market including size**

Feasibility of multiple product lines will allow for targeting of particular products to specific market needs and a highly segmented pricing strategy for individual products.

### **Marketing strategy**

The company will likely select a single partner to broadly distribute the technology and polymers and provide related services to fertilizer companies.

### **Production or manufacturing plan**

Rivertop Renewables intends to build a plant in Montana to manufacture the polymers. Economics work well for distribution of the polymers to a wide variety of locations by Montana’s efficient rail system. The existence of excellent manufacturing sites and work force also makes Montana a good place for Rivertop to manufacture its products.

### **Economic Impacts:**

Future favorable economic impact will be achieved from a \$1.75 million infrastructure grant from the U.S. Department of Commerce’s Economic Development Administration and matched with a \$1.75 million grant from the University of Montana.

## **#10-27 Hyperspectral Sensor for Large-Area Monitoring of Carbon Dioxide Reservoirs and Pipelines**

**Rand Swanson – Resonon - Bozeman**

**\$149,985**

*Final report approved: October 2011*

### **Summary**

The purpose of this project was to develop a sensor for monitoring leakage from carbon dioxide sequestration sites and pipelines. This project was performed in parallel with a DoE STTR Phase II sensor to advance Resonon’s airborne hyperspectral imaging system from a system suitable for proof-of-concept measurements to a system ready for real-world, large-scale use. In addition to carbon-dioxide leakage monitoring, this would expand the system for use in other remote sensing applications.

The project has resulted in development and integration of a down-welling sensor, improvements in the flight computer, and easier to use and more reliable software. Related results from the parallel DoE STTR Phase II include improved understanding of the effects of

carbon-dioxide leaks on vegetation and knowledge of procedures for deploying the hyperspectral imaging system on UAVs. In addition, the project has resulted in publications, conference proceedings, promotional materials, contributions, two Master's theses, and ongoing R&D projects involving MSU, INL, and Idaho State University.

This project was quite successful in reaching its primary objective, which was to make the system usable for real-world applications. A down-welling sensor was developed and integrated. This sensor simplifies removal of the effects of illumination variations.

Improvements were made in the flight computer, including better temperature control, improved break-out of connectors, and improved system monitoring. Software troubleshooting and improvements included fixing errors in the atmospheric corrections code, implementing self-checking code to decrease user-error, and making speed improvements to accommodate the large volumes of data.

Commercial prospects for the carbon-dioxide sensor system are mixed. Operationally, the system is much improved evidenced by a Resonon airborne system that is being used on a near daily basis. From a marketing perspective, however, there are many obstacles, i.e. whether there is a need for large-scale carbon-dioxide monitoring now or ever. For other applications, there are numerous other obstacles. In spite of this, Resonon receives numerous inquiries for airborne hyperspectral imaging systems and is scheduled to deliver two systems to new customers.

### **Commercialization**

Resonon's airborne hyperspectral imaging system is being commercialized although the market for the technology is challenging.

### **Product description**

The product is an airborne hyperspectral imaging system that can be deployed on either manned or unmanned aircraft and that have a wide range of applications, such as carbon dioxide leaks, pipeline monitoring, prospecting, etc.

### **Target market including size**

The specific target market is monitoring for underground carbon dioxide leaks from pipelines and sequestration sites. The system is primarily targeted for relative low-cost airborne platforms. Applications for the technology are emerging and most sales are for R&D. Because it is an emergent market, there exists considerable uncertainty both in its size and on what timeline it will develop.

### **Marketing strategy**

Resonon's marketing strategy includes a dedicated webpage (<http://www.resonon.com/airborne.html>), articles in trade magazines, displays at trade shows, working with existing customers, offering the system via distributors, and working with strategic partners.

### **Production or manufacturing plan**

Demand for the system is likely to remain low for the next few years. At low levels, it is possible to maintain in-house production due to Resonon's efforts to increase its production capabilities and hiring a production engineer.

### **Business risk assessment**

The primary risks are: (1) Failure for a market segment to develop; (2) Poor acceptance of the technology; and (3) Regulatory risk. Also, are the risks of competition and technical barriers.

### **Economic Impacts**

Positive business developments have occurred that have benefitted from this effort:

- System sale and ongoing relationship to a large agriculture company, although NDA restricts details. Sales could be as large as 60 just for the research sector of the company, and potentially many more for production and services.
- System sale to a researcher in China, first sale to China, to be delivered in October, 2011.
- System sale to the USDA, to be delivered in late 2011.
- A University R&D project to integrate an imaging spectrometer into an Insitu UAV, a large UAV company.
- A NASA sponsored demonstration deployment was conducted in Costa Rica, with results presented to 19 agencies and organizations.
- Resonon is a subcontractor for an advanced airborne hyperspectral imaging system for the Navy and one for NASA.
- Work carried out by the Jet Propulsion Laboratory in cooperation with NOAA acquired data from a helicopter platform over the ice fields of Greenland.

### **#10-28 Clinical Trials of a Lypolytic Compound**

**Jeff Golini – All American Pharmaceutical Inc. – Billings**

**\$10,000**

*Final report approved: July 2010*

### **Summary**

The goals of the project were to: (1) Determine the antilipidemic mechanism of Lipo-Effect of a newly developed, over-the-counter dietary supplement designed to lower blood lipid levels, by using human cell cultures; (2) Test and confirm the efficacy of Lipo-Effect to lower blood lipid levels in man by performing a clinical trial; (3) Design the most “consumer friendly” delivery method for the new lypolytic compound. The project originally sought to identify the biochemical functionality of this new lypolytic compound, its effective dose in a group of volunteers participating in a clinical study, and the acceptance of the compound by its test users. Since the MBRCT award was substantially less than the request, the project was reduced to performance of only one additional toxicity study. The study was positive and proved that Lipo-Effect was completely safe and ready to be tested on humans. Success of the first studies in mice could predicate success in humans, which could lead to a product with considerable potential for All American Pharmaceutical and for Montana.

### **Commercialization**

Since the funding award was substantially reduced from the requested amount, the project was limited in its ability to achieve the original objectives. Therefore, commercialization has not taken place, but may in the next year as money allows.

### **Economic Impact**

The project is expected to impact the economy in the future. The project resulted in a positive pre-clinical study and is ready to move to Phases II and III involving human studies.

### **#10-30 Structured Nanophase Catalysts**

**Yuval C. Avniel – EIP International - Missoula**

**\$110,930**

*Final report approved: November 2010*

### **Summary**

The technology developed in this project enables the production of materials engineered on the nanoscale using commonly available vapor deposition equipment. The thin films produced are characterized as being anisotropic, referring to a material being structured in all three dimensions. This is distinctive because present technology is capable of controlling in at most two dimensions. The technique is analogous to building with LEGOs®, except this effort uses molecular clusters organized by vapor deposition.

A second goal of the project was to prove that these types of nano-dimensionally controlled systems offer performance advantages. EIP initially is pursuing novel catalytic systems for use in emerging energy and hydrogen industries. Investigation of the hydrogen producing water-gas-shift reaction demonstrated that the anisotropic metal films exhibited lower reaction initiation temperatures, higher surface areas and increased activity compared to standard catalytic films.

The project achieved all of its technical milestones and is moving forward to the next stages of technology development.

### **Commercialization**

#### **Product description**

Technology for use of nanostructured materials in microchannel reactors, which will leverage the increase in catalytic activity and the ability to coat existing microchannel patterns with a structured catalyst.

#### **Target market including size**

In 2003 products utilizing nanomaterials accounted for \$26.5 billion of revenue. It is estimated that nanostructured materials and processes will have a market value of over \$340 billion within seven years, and demand will rise 21% annually through 2013.

Catalyst manufacturing is a \$10 billion market with four major vertical market segments: refining, polymerization, chemicals, and environmental.

## **Marketing strategy**

### Potential customers:

IP licensing: Initial efforts will focus on closing a deal with Applied Materials, controller of approximately 64% of the market, and Novellus, controller of approximately 22% of the market. In addition, key domestic players for wear-resistant electrical contacts, such as Amphenol Aerospace, Intermark and Boeing will be pursued.

Catalytic systems: Over 100 firms currently compete in the manufacture of industrial catalysts worldwide. Key targets in the US will be pursued. They are Bayer Material Science, Dyneon, 3M, Evonik, Degussa, Herson Manufacturing and DoD.

### Other potential customers targeted for contact within the next six months are:

3M, IBC Coating Technologies, Vergason Technology, Angstrom Sciences, Innovative Systems Engineering, Sandia National Laboratory, and the Navy's weapons research facility NSWC. These relationships will be pursued in the form of product development partnerships, likely with a revenue mix of IP licensing and materials sales.

## **Business risk assessment**

Competition in the advanced materials industry from nanomaterial producers, thin film manufacturers, start-up/academia, and academia is seen as both an opportunity and a threat. The threat stems from competing for positioning in the same marketplace. The opportunity is in the form of potentially working together to meet common goals or developing licensing opportunities.

Barriers to entry EIP must overcome include: timing, funding, infrastructure, quality control, and novelty. The barriers will be addressed by engaging customers early in the development process, educating them about the technology and managing their expectations and timetables.

## **Estimate of sales revenues for five-year period into the future**

Revenue history in 2009 included \$100,000 MBRCT funds and \$60,000 private investment. EIP has secured the patent rights and funded project development while MSU commissioned equipment and trained personnel specifically for the technology development. An additional \$20,000 of private investment has been recently received for participation in industry conferences and production of marketing materials. EIP will pursue Phase I SBIR/STTR/BAA funding in 2010 and 2011 to further develop the technology and production of microchannel reactors. If successful in Phase I, EIP will pursue Phase II funding. If unsuccessful, EIP will approach Angel investors for seed financing (\$240,000) to produce demonstration samples, capital investment, customer development and team expansion. EIP will continue to pursue relationships with customers in 2010 and 2011, and is making presentations to Angel investors in November and December 2010. An initial meeting was held with the GETI Group in August where the technology was well received and resulted in subsequent discussions focused on further developing the anisotropic deposition technology for catalytic systems.

## **Economic Impacts**

The project produced many tangible and intangible economic benefits, the momentum continues to increase, and future positive economic impacts are expected. Some of those economic benefits are:

- EIP's investors committed an additional \$20,000 beyond the \$65,670 matching funds, for conference attendances, marketing material and business development. The results of this work will be presented at three conferences, the first in December 2010.
- Local Montana companies, i.e. Lockwood Graphic Design and Rockthree Interactive in Missoula, were used for producing marketing materials and website development.
- The equipment commissioned for the project will remain at the MSU laboratories. The equipment provides an on-going economic impact in that EIP and other organizations can access catalysis characterization with minimal expenditure of time and money. The equipment also offers MSU students hands-on experience in catalysis characterization.
- Funding from other sources was leveraged to perform some of the laboratory work for the program, i.e. Mexico-UNAM, the Kazakhstani Government, USP and MSU external contracts.
- Dissemination of program results has resulted in interest from academic, corporate, institutional and investor communities (see page 28 for a listing).
- The GETI Group, a Utah venture-funding firm, has taken an interest in the program and hosted Dr. Avniel for discussions concerning the potential of the technology particularly as far as advances in catalysis. The GETI Group is considering partnering with EIP in a joint development effort.
- The program utilized equipment that had sat idle at MSU, thus re-leveraging prior purchases by other programs.
- The possibility of bringing in a Masters or Ph.D. student to study and develop the technology at MSU is being discussed. This would further the technology development, provide tuition and living expenses to Montana, and potentially prepare future employees versed in the technology.
- Conversations with interested parties have increased exposure of other opportunities in Montana including other potential technology programs, Montana real estate and in-state recreational opportunities.
- Discussions with parties interested in EIP's deposition technology and catalytic systems have evolved into the potential for other technical projects to bring revenues into the state.

**A project to be closely watched, as the next steps are taken toward further development and commercialization of the technology.**

## **#10-35 Fluorescent Reports for Cre Recombinase: New Tools for Manipulating Animal Genomes to Study the Genetic Factors of Disease**

**Anne Marie Quinn – Montana Molecular - Bozeman**

**\$99,805**

***Final report approved: February 2011***

### **Summary**

The objective of this project was to create new fluorescent molecules that would enable scientists to track Cre recombinase in living cells. The objectives were successfully completed and the project has resulted in two new fluorescent report products. Cre Stoplight is a synthetic gene that indicates the Cre activity in living cells by switching fluorescence from green to red. Cre Shine is a synthetic gene that produces two different proteins in balanced proportion: the Cre enzyme and a fluorescent protein targeted to the cell's surface. The commercial potential of these tools will be handled through out-licensing in a sales and distribution partnership, including up-front license revenue and royalties from sales. Successful commercialization of fluorescent detection technologies will enhance MM's ability to attract additional investment through private and SBIR Phase 2 funding. Also, Cre Shine and Cre Stoplight are fundamental tools with the potential to lead to new understanding of the genetics of disease and will play a role in the development of preclinical drug testing.

### **Commercialization**

#### Partnership:

The original proposal indicated that Montana Molecular would partnership with Invitrogen Corporation to commercialize the Cre products. This arrangement did not materialize because of a corporate reorganization within Invitrogen. Montana Molecular began working with Clontech, which offers a better market for Cre products because their focus is the genetic engineering market. With net sales of over \$16 million in genetic engineering reagents, Clontech's partnership improves the commercialization potential of MM's products. The marketing plan with Clontech will include articles in *Clontechniques*, a widely distributed publication that highlights genetic research. Discussions with Clontech have focused on terms such as upfront payment and royalty revenue based on net sales.

#### Exhibits:

Montana Molecular and Fluorescence Innovations will co-exhibit at two Society for Lab Automation and Screening (SLAS) events early in 2011. SLAS is an international organization of more than 10,000 scientists, engineers, and researchers from academic, government and commercial laboratories. These events provide a forum to advance technology for drug discovery in agrochemical, biotech and related industries, to increase awareness of this technology in these markets, to establish new partnerships and to prospect for new customers.

#### Featured Article:

The products being co-developed by Montana Molecular and Fluorescent Innovations were featured in a *Drug Discovery World* article, a high-profile, international trade

publication with an estimated readership of 40,000 in the target market of pharmaceutical and biotech industries and academic and government research organizations.

### **Economic Impacts**

This project provided funds to hire a Montana native with a recent degree in Cell Biology and Neuroscience from MSU to play a key role in MM's R&D efforts.

This project provided a bridge between NIH STTR funding that ended in August 2010, and the next round of NIH funding. The bridge enabled MM to maintain its strategic alliance and shared laboratory space with Fluorescence Innovations with whom MM submitted three NIH grants since partnering with FI a year ago.

The expansion of commercial partnerships establishes a distinguishing advantage in MM's competition for Phase 2 SBIR funding.

### **Unique features/success stories/news clippings, brochures/other information**

An article in *Drug Discovery World* (pages 78 – 79) reports on the collaboration between Montana Molecular and Fluorescence Innovations to develop new live cell assays for FI2's fluorescence lifetime microplate reader.

### **#10-38 Study of How Morphology and Physiology of Native Wildflower Seed Affects its Harvestability in Particular by the Arbuckle Native Seedster**

**Lee Arbuckle – Native Seedsters - Billings**

**\$87,722**

***Final report approved: June 2012***

### **Summary**

The objective of this project was to analyze the effect of botanical characteristics on the seed harvestability of commercially significant native wildflower perennials of the continental U.S. The NSI objective was to identify species for Seedster harvest technology and develop a Wildflower Seedster. 384 species were identified and 13 characteristics for each were described. Conclusions from field validation trials are:

- The descriptions of characteristics and harvestability are very useful.
- Field trials will lead to some score adjustments.
- Another seed dislodgement mechanism would have a new index.
- NSI should assess seed dislodgement mechanisms for seed crop recovered, impurities collected and damage to perennial plants.

These study conclusions were presented at two major forums, one in 2010 and one in 2011.

### **Technology**

This MBRCT project meshed with a NSI Phase I USDA/SBIR machinery project for carrot and yarrow seed harvest and positions NSSI well for a Phase II USDA/SBIR for development of a Wildflower Seedster.

## **Market**

Growing demand and limited seed supply lead to prices over \$100 per ounce for some hand harvest species and represents opportunity for a Wildflower Seedster. NSI has sold 13 native grass seed Seedsters to commercial seed producers and research centers. The wildflower seed industry is similar to the native grass seed industry as far as producers, processing and customers. Annual sales of wildflower Seedsters are projected at 8 to 10 units annually. The NSI target markets are research centers, specialized native wildflower seed producers and others that produce seed. NSI strategy is to leverage first mover advantage to become the dominant mechanical wildflower seed harvester complementing grass seed Seedsters.

## **Impact**

NSI has successfully presented 3 Phase II USDA/SBIR proposals. It utilizes lean practices for design, manufacturing and marketing.

## **Commercialization**

### **Product description**

Seedster used for both native and wildflower seed harvest. Harvestability Indexes available to producers to guide selection of harvest technology.

### **Target market including size**

NSI has identified two potential market segments: producers and research centers.

### **Marketing strategy**

A fully developed wildflower Seedster will be launched using web marketing strategies as seen on [www.nativeseedsters.com](http://www.nativeseedsters.com) relating to three models currently in the product line. It is anticipated there will be a wildflower version of each of these models. Further marketing strategies, include a web-leveraged direct business-to-business sales strategy would be employed using Salesforce.com, a cloud computing sales management tool to log data on contacts with potential customers and track follow-up actions.

### **Production or manufacturing plan**

The wildflower Seedsters would be contract manufactured by Midwest Welding and Manufacturing, Bozeman.

## **Economic Impacts**

### **Patents applied for or granted**

Arbuckle Ranch, Inc. and NSI have established patent protection, and market position for the cooperating brush and comb seed dislodgement mechanism.

### **Development of intellectual property**

Licensing opportunities include:

- In-house design, contract manufacture, and web-based marketing of the Wildflower Seedster

- Licensing to firms that manufacture main line harvesting equipment and that have an international presence.
- Field of Use licenses to major manufacturers of harvesting equipment for specialty crops.

### **Other**

As a result of this project and a successful USDA/SBIR Phase I project, NSI is well positioned to submit a Phase II USDA/SBIR proposal in February 2013. A successful outcome of this proposal would result in an award of approximately \$400,000 to Montana.

**#10-40 Nutrient Management for the Optimization of Biofuels Production in a Proprietary CTW Energy Algal Photobioreactor**  
**Joseph Menicucci – CTW Energy - Bozeman**  
**\$241,398**

*Final report approved: January 2012*

### **Summary**

The primary objective of this project was to optimize lipid production for conversion to biodiesel in a prototype of the proprietary CTW Energy Algal Photobioreactor (P-CAP) system. Research conducted at MSU suggests that the nitrogen source, pH and CO<sub>2</sub> concentration may have a significant impact on algal growth rate and lipid production.

During the project, changing market conditions caused re-design of the P-CAP to better demonstrate MSU's findings regarding the nutrient management plan. The plan has afforded CTW Energy the opportunity to bring to market a technology that has potential to significantly optimize algal biofuels yields. This is exciting because the technology stands to be developed possibly before the first algal biofuels are produced commercially, giving CTW Energy the option of either licensing the process or coupling it with an operation and maintenance contract.

CTW will pursue additional funding but recognizes MBRCT funding as fundamentally important in developing the nutrient management plan and helping facilitate a relationship between CTW Energy and MSU that is vitally important to the future success of the company.

The landscape of algal biofuels production has changed since the inception of this project. Stabilization of the cost of diesel has prevented diesel produced from algal sources from competing in the open market and a major state-of-the-art algal biofuels production has transitioned toward growth using wastewater as a substrate for growth. CTW Energy has adapted to the changing market and appears to be in a prime position to become a leader in process optimization related to algal biofuels development. In order to do so, the company must act on the knowledge learned from this project. Economic value of the project lies in finding an appropriate outlet for the demonstration of the nutrient management plan.

### **Commercialization**

The product is a nutrient management plan that can be either further developed and sold to already established algae biofuels companies or (more likely) offered as part of a design/build/operate/maintain process optimization to the same biofuels companies. The best case scenario is that the process development will be funded by a federal agency interested in developing a pilot scale M-CAPs facility. Whichever is the case, CTW Energy will need private investment or smaller grants to bridge the financial gap from building the P-CAP to funding the M-CAPs. Significant additional data must be produced in order to obtain federal funding on a pilot scale and CTW will need to target SBIR Phase I and II grants to continue toward commercialization of the nutrient management plan. Because the current value of biodiesel is not as high as it was at the beginning of the project, further development is considered very high risk. Upon demonstration of the nutrient management plan process on a pilot scale, marketing the process could be undertaken, most likely by presenting the results at international biofuels conferences.

### **Economic Impacts**

The project partially supported two MSU faculty members, two MSU graduate students, and at least seven MSU undergraduate or post-undergraduate students. A thesis was supported by this funding and findings will soon be submitted to a professional journal for publication. Future work at CTW Energy would allow for the application of a process patent if pilot scale results support those found during the project. A complete analysis of economic impacts is pending a decision whether to pursue further funding for development of the process on a pilot scale.

### **#10-51 A New Cost-Effective, Non-Invasive, Geophysical Methodology for Exploration and Development of Geothermal Resources in Montana**

**Leif Cox – Montana Tech - Butte**

**\$93,130**

*Final report approved: May 2011*

### **Summary**

The goal of the project was to develop a new methodology to explore for geothermal resources using near-surface and non-invasive geophysical techniques. This project was a collaborative effort between Montana Tech and Gradient Geophysics, Inc., Missoula. Fairmont Hot Springs was selected as the site for the research. Two spectral induced polarization (SIP) surveys were performed at Fairmont; however SIP data could not be collected because the site proved to be highly electrically conductive. A new thermal surveying method using temperature measurements at 1m and 2m depth was successfully developed. Also, an algorithm which transforms the measurements to geothermal heat flux was successfully developed. This algorithm is the best near-surface thermal property with which to map geothermal anomalies at depth. This new method is fast, inexpensive, non-invasive, and has the potential to identify geothermal resources. Gradient Geophysics has begun to commercialize this method, sees potential to greatly expand the business, and is planning to hire new employees to begin data collection this summer.

This project has produced a unique methodology for geothermal exploration. The new product is the intellectual property potential, of which the key product is the workflow to interpret the field data resulting in a robust, rapid, state-of-the-art interpretation to delineate geothermal resources. Gradient Geophysics is currently the only US company with the capability of making near surface measurements of the geothermal heat flow which can be used to pinpoint drill targets for geothermal.

### **Commercialization:**

#### **Target market including size**

- a) The market has expanded for big companies looking for large geothermal resources in the Great Basin of the western United States from the Nevada-California region to Idaho, Oregon, Utah and Montana.
- b) Heat pumps represent a large potential market. Such organizations as the Geothermal Energy Association are just starting to incorporate and organize efforts of heat pump exploration technology.

#### **Marketing strategy**

- a) The marketing strategy for large geothermal resources will be through attending conferences, reaching out to companies in the area, and continuing to give talks and presentations at meetings. Gradient Geophysics will expand the company by setting up offices in Mexico and Canada.
- b) The marketing strategy for the heat pump technology will involve exploration of marketing the methodology through the International Ground Source Heat Pump Association <http://www.igshpa.okstate.edu>.

#### **Production or manufacturing plan**

- a) Source-to-Machine, in Winnemucca, Nevada, will continue to build and advance the field probes. This company is ideally located for projects in Nevada, California and Idaho and has expertise in drilling techniques for exploration in the United States.
- b) Gradient Geophysics has computer and programming capabilities with the exception of a MATLAB software program. It is in negotiations with MATLAB to utilize the program under a Developers License.

#### **Business risk assessment**

Competition from similar products and from other products is being addressed by Gradient.

#### **Estimate of sales revenues for five-year period into the future**

Rapid expansion in the industry over the last four years indicates an increase in exploration in a somewhat predictable upward trend over the next decade. Gradient expects to see revenues of greater than \$2 million per year as it expands worldwide by 2015.

#### **Economic Impacts:**

##### **New businesses created or expanded**

- a) *Expansion in new US business opportunities.* As a result of this project, it appears the new method is well suited to investigate the best locations for heat pumps. Gradient Geophysics is investigating the best ways to exploit the heat pump market and this will create an entirely new business opportunity as a result of this project effort.
- b) *Expansion in worldwide business model.*
- Gradient Geophysics has developed a relationship with the Icelandic geothermal community particularly in regard to joining up with Icelandic companies to expand globally.
  - In an effort to link its overall global competitiveness to the use of geothermal and to leverage its long history of working in Mexico, Gradient Geophysics will begin marketing out of an Hermosillo, Mexico, office for projects in Mexico this spring.
- c) *Expansion in Montana.* Gradient Geophysics is using the technology to continue geothermal exploration in the Deer Lodge Valley, an upside potential which could be enormous for Montana due to the possibility of a geothermal resource with power plant potential. Other areas in Montana will be investigated to develop resources in Montana and promote the technology to the state.

### **Increase in employment levels**

Gradient Geophysics will hire 10-15 new employees to begin collecting and interpreting data this summer. The company anticipates to at least tripling that in the next three years! These will be highly-technically trained, well-paid personnel. In addition Gradient plans to hire 20-30 field employees to support the data acquisition when the company expands worldwide.

### **Acquisition of investment capital**

Gradient does not need to seek outside funding at this time as it has the capability of funding, and marketing, the technology as a result of years of working in the industry. However, Garry Carlson maintains contacts with the persons in charge of funding for energy projects at Microsoft and Google and will use those contacts if necessary in the future.

### **#10-54 High Efficiency Hybrid Solar Power System – Producing Electricity and Hot Water Simultaneously**

**Michael Utter – Rural Community Innovations - Bozeman**

**\$150,000**

*Final report approved: April 2012*

### **Summary**

The objective of this project was to develop hybrid solar power system prototypes that simultaneously produce electricity and hot water. This was a collaborative project between Rural Community Innovations (RCI) and Montana State University (MSU) to devise a high-efficiency combined solar photovoltaic and solar thermal energy capture system for commercial

application in rural settings or other areas where alternative power generation is desirable.

RCI purchased high-efficiency triple-junction solar cells and designed an apparatus to convert concentrated sunlight to electricity and capture excess heat not used by the solar cells in a fluid medium for heat transfer to a water storage device. A series of experiments were designed by which known amounts of sunlight could be used to generate both electricity and heat through and around the solar cells. The experiments proved to be more difficult than originally expected. Thermal performance was less than projected and the system proved to be more costly than existing commercial systems using other technologies. After multiple attempts to redesign the cost factors, the system was deemed infeasible on a commercial scale.

The costs and complexity of designing and machining alternate heat sink types rendered iterations of the heat sink and thermal adhesives non-competitive in the marketplace. An alternative concept using a light funnel also proved infeasible.

In summary, the RCI concept failed to prove it could compete in the solar/thermal industry on a cost per kWh basis with existing technologies. In terms of overall energy efficiency, the system achieved less than half of the original desired efficiency. The effort to further modify the technology alternative was abandoned.

### **Commercialization:**

After much research and reiterations of the design concepts, the concept is not sufficiently competitive with the cost of generation of power from other sources, including other solar photovoltaic (PV) sources, to warrant commercialization.

Some of the issues involve:

- The cost of solar panels currently on the market, both well understood and robust, is far less per kilowatt generated than that of this concept.
- The actual cost of silicon solar cells has fallen approximately 200 percent due to manufacturing competition from the Chinese since beginning of this project.
- The ever-shrinking costs of pure solar PV being achieved by massive manufacturing scale, inexpensive labor and technology innovation will cause the gap to continue to widen. National governments, including the United States, are investing billions of dollars in technology innovation and manufacturing scale.
- Due to the nature of triple-junction solar cells absorbing much of the infra-red (heat) spectrum of solar radiation, it appears there is insufficient efficiency to recommend this alternative over traditional solar PV.

### **Economic Impacts**

This concept initially anticipated the potential for numerous manufacturing and assembly jobs in Montana, but has proven to lack financial feasibility to achieve a competitive

position in the marketplace. Therefore, the positive, measurable long-term economic impacts resulting from this research are limited. There may be technology breakthroughs which, in the future, might provide viability to the idea of combined electrical generation and water heating in a unified format. However, existing technologies capture solar energy for much less per kilowatt-hour, making it inappropriate to continue the research at this time.

#### **Unique features/success stories/news clippings, brochures/other information**

Under separate email, the PI provided two articles concerning the current fate of the solar industry in Germany. A *Wall Street Journal* article, updated 4/4/12, discusses several solar companies, headquartered in Germany, that have recently filed for bankruptcy for issues including those identified above. One particular issue is that “green manufacturing” has proven vulnerable to low-cost competition from countries such as China. The other article, dated 4/03/12, from [www.spiegel.de.html](http://www.spiegel.de.html), titled “Bankruptcies Have German Solar on the Ropes”, discusses the negative effect of German government subsidies on the German solar industry. The article states that the “Germans solar industry is at a turning point. The bankruptcy of the German company, Q-Cells, this week shows that the days of German solar cell production are numbered. Asian competitors took the lead years ago, and German government subsidies were part of the problem”. The industry appears to be changing due to this fierce competition with Asian companies and could likely impact the United States as well as Germany and other European countries.

#### **#10-63 Metallic Nano Particle Filter to Remove Mercury from Coal Fired Power Plant Flue Gas**

**Kumar Ganesan – Montana Tech - Butte**

**\$90,499**

*Final report approved: October 2011*

#### **Summary**

The goal of this research was to fabricate a marketable and cost effective device to remove mercury from flue gas, including the flue gas emitted from coal fired power plants. The main objective was to develop a metallic nanoparticle (MNP) filter based on ceramic substrates. Through a US DOE/CAST program in 2008, the PI was previously successful in developing a new filter based on metallic nanoparticles (MNP) and completed initial testing use one type of commercially available ceramic substrate material. During this project, the PI developed a new generation of filters that are as effective as the previous ones, but at a much lower cost. A combination of metallic nano particles and ceramics enabled reduction in the overall cost of the mercury removal system.

The objectives set forth in the proposal were accomplished. They are:

- (1) Six different new generation filters were prepared depositing metallic nanoparticles on commercially available ceramic substrates.

- (2) Mercury removal efficiency tests were conducted to identify filters that achieve mercury removal efficiencies above 90%.
- (3) Thermal desorption temperature was optimized for effective regeneration of the filters.
- (4) Evaluated performance of the MNP filters based on the mercury removal efficiency.
- (5) Evaluated length of time necessary for mercury saturation and potential for thermal desorption.
- (6) Established different mercury concentration levels to evaluate the filters.

Preliminary laboratory results indicate that the MNP filter removes elemental mercury from contaminated air with greater than 90% efficiency, and that the captured mercury can be released from the MNP filter through a simple thermal de-sorption process, after which the filter can be reused.

### **Conclusion (as taken directly from the Final Report)**

The main objective was to develop a nano metallic filter that will have the potential for commercialization. Several nano metallic filters with ceramic substrate were developed and tested for their efficiency to select the best performing filter. The best performing filters were then subjected to desorption process to evaluate its ability to readily release the captured mercury and to identify the optimum temperature and time required for the desorption process. The desorbed filters were then tested for its ability to capture mercury again. The best filters showed over 27 hours of 90% mercury removal efficiency at a flow rate of 2.5 liter per minute at an average mercury concentration of 38ug/m<sup>3</sup>. The chemical process used for this filter was replicated in making the filters that were tested for its desorption capabilities. The de-sorption tests were performed at five different temperatures at an increment of 50 degrees starting at 300 degrees, to identify the optimum temperature for desorption. The test results indicated that the 450 degree test showed the most effective thermal desorption which released the captured mercury in less than 60 minutes. However, this can be accomplished even at a lower temperature like 350 F, except, it takes longer (90 minutes) to completely release the captured mercury. Therefore, these tests provided very valuable information to make this filtering system closure to commercialization. However, further field tests are needed to confirm the laboratory test results and that will add another layer of required information necessary for commercialization.

### **Commercialization**

A cost-effective metallic mercury filter capable of removing mercury from flue gas, including the flue gas emitted from coal fired power plants.

### **Target market including size**

Under the Clear Skies Initiatives two-phase reduction plan, 45% reduction in mercury emissions beginning in 2010 and another 70% beginning in 2018, equates to a market of 123,360 pounds of mercury reduction, or an estimated \$3.08 billion worth of market in the United States alone. This does not include the new plants projected to be constructed to meet the U.S. demand for electricity.

The potential for this technology exported to other countries, such as China and India, is very high as well.

#### **#10-67 Development of a Field-Portable Biodetector**

**Timothy Troutman/Harold Howe**

**\$379,532**

*Final report approved: February 2014*

#### **Summary**

The purpose of the project was to develop a field portable biodetector for detecting a broad

range of analytes, such as chemical compounds, biomolecules and pathogens. The proposed objectives were:

- 1) Construct a biodetector.
- 2) Develop chemistries to enable the measurement of three chemicals or biologics.
- 3) Test the biodetector prototype extensively to verify proper function, configuration, chemistry, component design and integration.
- 4) Design, construct and test a field portable biodetector to a beta level (pre-production) based on surface plasmon resonance (SPR) immune-biosensor technology.

The strategy began by developing several single channel biodetector prototypes based on an off-the-shelf SPR component termed SPREETA™. The SPREETA™ approach provided a basic understanding of how to modify and implement SPR technology into a hand held portable device. However, as the sensor market evaluation was evolving, it became apparent that there would be limited commercial prospects for a single channel detector. Therefore, the strategy evolved into developing a multichannel SPR technology, which there is a strong market for and there were no competitors in this market space for SPR. The multichannel approach required developing completely custom designed and built SPR hardware. The multichannel detector was developed to a bench top prototype level. Test results of this system demonstrated the ability to sense six channels of SPR response. Other successful outcomes for the remainder of the multi analytes biodetector system were the development of custom disposable fluidics cards, custom molded optical gold plated prism sensor chips, a custom electronic control circuit, embedded firmware that resides on the circuit, and software for interpreting SPREETA™ SPR responses to correlate with analyte detections. The last two no cost project extensions were used to complete and refine the hardware to where it is able to sense SPR responses on multiple channels to buffer solutions.

Bio detections using the detection chemistries, discussed next, were not demonstrated as the resources were consumed to make the hardware and software operational.

Reportable outcome for the objective of developing chemistries to enable measuring three chemical or biologic analytes was accomplished as follows. A bacteria chemistry was developed to sense E-coli. A virus chemistry was developed to sense M13 bacteriophage. A protein chemistry was developed to sense Ricin A. To this end, three

chemistries were successfully developed that can detect a variety of harmful analytes. Additional chemistries that were explored but not successful were Ricin B and Protein S1009A.

Chemical detections were not actively pursued; the project focus stayed on bio detection because there are a number of commercial chemical detectors already on the market based on mass spectrometry. The Department of Defense solicitations, by far, seek bio detector devices, not chemical detectors. It was felt that future funding would most likely come from bio detection needs.

The report extends thanks to The Montana Board of Research and Commercialization Technology (MBRCT) for enabling the development of a technology platform for field portable biodetection based on SPR. The platform will be used to solicit new funding sources from U.S. government and commercial entities. A Phase I award for \$150,000, from the Defense Health Program, topic number 13-005, titled, "Rapid ID of Microbial Pathogens from Food, Water and Environmental Samples, has already been granted, and project work on it will begin shortly. The proposed work will make use of the multi analyte hardware system developed with MBRCT funds and extend the development of new chemistries for additional analyte detections. The next goal is to demonstrate the viability of a two year Phase II funded project that will be used to iterate the bench top prototype into a field portable alpha prototype, and then to next refine the alpha prototype into a commercial beta level prototype.

### **Commercialization Plan**

- **Product description**

Resodyn portable biodetector analyzer

- **Target market including size**

Market opportunity is for the detection of harmful chemicals and biological agents that can cause death, illness, or disease and that are a threat to humans, animals and plants in a non-laboratory setting with a device that can be operated in a non-laboratory setting and can be easily used by relatively unskilled technicians in the field.

Applications are broad and include: Military, Industrial, Food monitoring, medical, groundwater and toxic waste, contraband detection, and substance-abuse.

- **Marketing strategy**

Two application segments, military users and industrial users, require substantially different marketing strategies to maximize the commercial opportunities they each offer. The report describes in detail the multi-year, multiproduct strategies applicable to both segments. [Please see pages 26 – 29]

- **Manufacturing and Production Plan**

The Resodyn Biodetector Analyzer hardware will be designed, manufactured and assembled by Resodyn Corporation in Butte with some of the specialty components being contracted to other manufacturing facilities. This will require highly skilled and trained tradesmen and it is estimated that the project will result in the addition of 24 man-years of manufacturing labor over 5-year project projections. Resodyn has the necessary fabrication capabilities.

○ **Business Risk Assessment**

The most significant business risk is the need for local authorities to be able to satisfy their obligations to the FDA in responding to outbreaks, and the need of commercial suppliers to demonstrate their diligence in preventing such outbreaks. The business model is contingent on the product and biosensing technology receiving approval from the FDA as an accepted means of contaminant detection. The second business risk comes from potential new entrants into the market.

○ **Market Acceptance**

Resodyn Biodetector Analyzer will enter the market with several advantages:

- 1) It is handheld and can be easily taken to sites.
- 2) Results are obtained in minutes, compared to over a day by traditional means.
- 3) It can be operated by untrained personnel.
- 4) It costs less than 25% of traditional testing solutions.

□ **Extended Economic Impact Opportunity**

The technology offers a solution to the FDA's dilemma of how to protect the public against repeated fatal outbreaks of salmonella, and pages 32 – 33 discuss the significant potential of this extended market opportunity, including the generation of around 100 full time positions.

**#10-71 SFRJ (Solid Fuel Ramjets) Technology Development and Testing**

**David Micheletti**

**\$106,000**

*Final report approved: August 2011*

**Summary**

Under this project, the Montana Aerospace Development Association (MADA) and Space Propulsion Group, Inc. (SPG) developed a new and unique test fixture for testing Solid Fuel RamJet (SFRJ) propulsion and other advanced air-breathing propulsion technologies. The new test fixture was developed at the MADA Butte AeroTec Facility utilizing hardware previously developed for a Defense Advanced Research Projects Agency (DARPA) Small Business Innovative Research (SBIR) program. This test fixture provides a unique, low-cost alternative to the aerospace propulsion community for testing and evaluating the feasibility of medium to high dynamic pressure air-breathing technologies and systems. The MADA/SPG team designed,

fabricated, and installed a test fixture that uses a turbojet engine to supply high pressure, non-vitiated flow to a SFRJ engine/combustor. Preliminary small-scale testing of an SFRJ combustor was also conducted utilizing SPG's paraffin-based SFRJ combustor in order to begin the compilation of design methodologies and performance estimation for real-world SFRJ systems. The successful completion of this project provides MADA/SPG and the State of Montana with an innovative quick turn-around system for testing the feasibility of missile-scale mid to high dynamic pressure air-breathing propulsion technologies and systems.

High speed air-breathing propulsion in the form of Liquid Fuel RamJet (LFRJ) systems or SFRJs is a highly competitive solution to certain high performance tactical applications. While significant development has occurred and several operational systems have been developed using traditional liquid ramjet technology and solid-fuel ram-rocket systems, little resources have been devoted to SFRJ's despite the significant demonstrated potential. During this project the team developed a new ground test capability for SFRJ technologies that will enable an improvement in mission performance at lower development and recurring cost than those of liquid rocket (LFRJ) systems. The project included design and optimization studies for a generic high performance ground test system capable of meeting the demanding mission requirement of these advanced propulsion systems.

Compared to the high-dollar investment of typical electric driven turbo-compressor-based facilities capable of producing the pressures and flow rates required for this testing, the ground test technology developed during this project uses a low capital cost approach to provide high volume, high pressure and temperature air to SFRJs, as well as other air-breathing propulsion systems.

### **Commercialization**

The successful development of this new ground test capability at the Butte AeroTec Facility represents a unique, low-cost option for the aerospace propulsion community for testing and evaluating SFRJ and other advanced air-breathing propulsion technologies and systems. The project has developed a ground test capability that can be offered to the high speed flight industry for economically developing a new generation of flight vehicles utilizing air-breathing propulsion technology. MADA/SPG can assist these organizations with the development of propulsion systems that have the potential to lead to a new generation of space launch systems, missiles, unmanned aerial vehicles, and global-reach aircraft. This development has positioned MADA/SPG and Montana at the forefront of the next revolutionary advancement of high-speed aerospace technologies and systems of interest to DOD, NASA, FAA, and the private sector for a long time. The unique ground test facility has extended national capability to test advanced aerospace propulsion technologies for both supersonic and hypersonic flight, a predicted multi-hundred million dollar industry within the next 30-50 years. History suggests that communities that possess key assets for developing and testing these technologies will play a leading role, and become primary economic beneficiaries, of these revolutions.

### **Marketing strategy**

Utilizing their respective extensive networks, MADA/SPG have initiated a marketing campaign to inform the aerospace propulsion community of the new Butte AeroTec Facility capability. MADA is pursuing a Grant from the Big Sky Trust Fund to create a business plan for the commercialization efforts. The Butte AeroTec Facility is already becoming widely recognized for its rocket testing activities. Many organizations

involved in rocket development and testing are also involved in development and testing of air-breathing propulsion technologies. MADA/SPG is currently pursuing several new air-breathing propulsion development and test programs with DOD, NASA, and private-sector organizations to utilize the newly developed SFRJ Test Fixture.

MADA/SPG recently started testing a flight-weight version of the SPG hybrid rocket motor at the Butte AeroTec Facility that will soon be commercially available to the aerospace industry. Testing of this rocket motor technology was initiated at the Butte AeroTec in March 2009. SBG has incorporated a new subsidiary company in Montana and opened a new office in Butte. As its test activities continue to grow, the company plans to expand its business activities in the Butte area and to include manufacturing operations. Much of the infrastructure and hardware being utilized to support the hybrid rocket motor test program was made available by this grant, other Montana programs, the City of Butte, and Rhodia Corporation. It is anticipated, and planned, that the new SFRJ Test Fixture will lead to similar expansion of SPG's business activities in the Butte area.

### **Conclusions and Recommendations for Future Testing**

Construction of the SFRJ air-breathing test cell at the MADA Butte AeroTec Facility was successfully completed. A compressible flow model for the facility was developed that accurately calculates the air flow capability based on system parameters.

Though ignition of paraffin-based fuels was not achieved, it has been determined that regression rate of the paraffin-based fuels in the un-reacting modes is several times larger than the regression rate of the polymeric fuels. A modified ignition system was constructed in the SFRJ air-breathing test facility. Test 15 utilized a new high-speed DAQ system for acquiring test data.

### **#10-72 Bio-Agtive™ Emission Technology: Turning Fuels into Fertilizer**

**Jessica Windy Boy**

**\$19,080**

*Final report approved: July 2012*

### **Summary**

Bio-Agtive™ Emissions Technology is a patented method for introducing cooled exhaust from diesel engines into air tanks and seed drills and eventually into the soil during the direct seeding of agricultural crops and/or tillage of ground. It has been suggested that the reason this technology works is that it primes the soil microbiology. The primary objective of this project was to use the engine science and fuel chemistry capabilities of the MSU-Northern laboratory to examine the possibility that different fuels can be blended with diesel fuel as additives to add key fertilized ingredients and micronutrients to the soil from tractor exhaust emissions using the Bio-Agtive™ Emission Technology. Further objectives of the project were:

- (1) To examine the possibility that different fuels can be used to add key fertilizer ingredients and micronutrients to the oil from tractor exhaust emissions using the Bio-Agtive™ Emission Technology

- (2) To use understanding of the chemical composition of the emissions using farm scale equipment to test the ability of the exhaust emissions to augment or replace fertilizer applications to the fields
- (3) To determine which bio-derived and petrol-diesel fuels work best for stimulating microbiological activity in the soil, and thereby maximizing the availability of essential crop nutrients.

Emission results showed:

- (1) Carbon dioxide emission increases as the engine load increases while carbon monoxide and oxides of nitrogen decrease as the load increases.
- (2) Biofuels, including biodiesel and straight vegetable oil, do not always produce more nitrogen emissions than petro-diesel.
- (3) Other factors, particularly engine load, can increase or decrease the formation of nitrogen; for instance, biodiesel produces more nitrogen emission than petro-diesel at low engine loads, but at high engine loads has lower nitrogen emissions than petrol-diesel.

The state-of-the-art facility at MSU Northern was used to simulate field loads, engine timing, and heat generated and analysis was conducted. Field tests and analysis of the Bio-Agtive™ Emission Technology from two different fields were also conducted. Tests were conducted and analyzed by MSU-Northern Bio-Energy Center and included microbial biomass and activity, nutrient and chemical content analysis of the soil, protein content and actual crop yields. Because the center has no expertise on soil and plant tissue research, the interpretation of field results is based only on numerical values of the results from different laboratories and test instruments. Field tests showed conclusive trends in the chemical and microbial content of soils and plant tissue analysis, grain quality, yield and protein amount different fuel treatments tested in the project. A comprehensive examination of the field results from a soil scientist is recommended to provide a better interpretation of the data. A study conducted by an independent third party is attached to this Final Report.

### **Commercialization**

The Bio-Agtive™ Emissions Technology was developed by Gary Lewis, owner of N/C Quest Inc. Both the method and system technology are patented nationally and internationally. The method is the theory and practice of injecting exhaust emissions into the soil. The Bio-Agtive™ condenser system is mounted between the tractor and the seed cart fan to cool, condense and manage the exhaust. In 2008 there were more than 156 licensed users of the technology in North America. There are currently 26 licensed users in Montana and four in states outside of Montana. There are also licensed users in Australia, UK, Europe, Eastern Europe, Japan and Africa. The N/C Quest Technology also has numerous patents pending and international patents.

### **Target market**

- Growers who use seeding equipment
- Irrigation farmers
- Small land owners

- Golf courses
- Anyone who pumps water with diesel pumps for watering
- Reclamation contractors
- Gardeners
- Riding lawnmower owners

### **Marketing strategy**

The marketing strategy is straight forward and traditional: via word of mouth from farm to farm, neighbor to neighbor by demonstrating the effective use and beneficial outcomes to plant growth yield and quality of the technology. The technology is demonstrated at the Montana Grain Growers Annual meeting.

- Montana State University – Northern received EDA funding to help support local companies that are commercializing renewable technologies. Montana Bio-Agitive™ Montana LLC has been selected to receive technical assistance in developing business services, including a marketing plan and analysis.
- N/C Quest Inc. encourages Licensed Users to become Licensed Distributors, introduce their neighbors to the technology and mentor them in its use. Licensed Distributors have the opportunity to become Master Distributors. Distributors are required to fill their inventory and order kits from N/C Quest Inc. Reselling of the kits, installation and support are the responsibility of the distributor. All kits are custom made for the tractor and seeding system setup being installed.
- N/C Quest Inc. has a policy of pricing the technology within the reach of the average farmer in whatever country he/she may live. The technology is not sold through large multinational agriculture retailers. The turn key cost of the average system is \$45,000, which is much less than the average farmer spends annually on commercial fertilizer. The Annual Renewal Fee allows continued use of the technology as well as a software activation key for their computerized console.

### **Production or manufacturing plan**

A new manufacturing facility bought in April 2009 is capable of manufacturing 20-25 units annually. There are currently two employees and the need for 2-5 more employees is anticipated over the next 3-5 years.

### **Business risk assessment**

The risk to the licensee is not unreasonable, less than the risk presented by weather or other unknowns. The licensee receives a price support for each unit constructed and sold. Continued sales will rely heavily on the results of the preliminary field trials in the Chester area. A limiting factor is to find and train qualified personnel to manufacture and install the sold units. Also, delays with the aluminum pipes, which are custom manufactured by the aluminum supplier, have been experienced.

### **Present commercial status of the technology**

The technology is currently Patent Pending around the world and actively for sale in several countries including the United States.

### **Intellectual property issues**

The fuel recipes are considered proprietary information by Bio-Agtive™ pending non-disclosure agreements between Montana State University – Northern and Bio-Agtive™. New recipes for fuel mixtures and fuel additives resulting from collaborations between Montana State University-Northern and Bio-Agtive™ could be jointly patented.

### **Independent Studies**

Two independent studies are appended to the Final Report.

- (1) Experiments and Results performed by Earthspirit Consulting – M. Jill Clapperton, PhD, Principal Research Scientist/Owner – Submitted January 30, 2012 - This is an eight-page report detailing a field experiment conducted on hard white spring wheat at Fossen's Farm, Inverness, Montana. The report concludes that putting exhaust emissions onto the seed and into the soil does affect the soil microbiology. Whether these affects are significant enough to effect changes in soil chemistry or mineralization is not evident. Further investigation is needed, but Dr. Clapperton's opinion is that this should not limit the technology from moving forward. She also indicates that use of exhaust emissions as a seed treatment against seed-borne fungi should be explored and would extend the use of the Bio-Agtive™ technology.
- (2) Bio-Agtive™ Seed Sensing Emissions Escaping Detector - This is a six-page report describing results of testing the Bio-Agtive™ SEED at Bio-Agtive™ Montana LLC in collaboration with Montana State University-Northern Bio-Energy Center. This is a wireless monitor that has been developed by N/C Quest Inc. Canada to assist the operator of the Bio-Agtive™ system during seeding. The Bio-Agtive™ SEED monitors four wideband oxygen sensors at four different locations:
  - Engine's Turbo
  - After the Bio-Agtive™ System, Injection Fan
  - In the Seed Furrow
  - After Packer Wheel

The experiments were set up to data log and verify that the exhaust is staying in the soil and not escaping during spring seeding. The report concludes that the Bio-Agtive™ SEED has been successful at measuring, monitoring and verifying that the tractor emissions can be 100% sequestered into the soil during spring seeding. This study has successfully met the objectives by answering previously unknown questions.

### **#10-75 Continuation of Collaborative Research on Innovative Fluorescence Lifetime Spectrometers**

**Gregory Gillispie**

**\$200,000**

*Final report approved: June 2011*

### **Summary**

The goals of this project were to accelerate commercialization of novel fluorescence lifetime fluorescence spectrometers, expand the product line, and help advance research at MSU and the University of Montana. The intention was to conclusively establish the compelling advantages of the Fluorescence Innovations approach to fluorescence lifetime measurements in comparison to the conventional approach, time-correlated single photon counting (TCSPC). Significant accomplishments of the project included expanding the range of lasers (particularly in the blue region), improving the tunable UV laser, and successful evaluation of a digitizer that can handle MHz frequency pulsed lasers. An important finding was discovering that the difference in data quality between cuvette samples and microplate samples is very small. This was surprising even to the investigators who are the developers of the plate readers. The ability to use phrases such as, “Cuvette quality at microplate reading speed,” when backed by confirming data, affords a powerful marketing tool. Another positive impact of the acquired data was the University of Colorado’s interest in using intrinsic fluorescence, including fluorescence lifetime, for finding optimal conditions to stabilize proteins, specifically membrane proteins. **This led to a system order.** The commercialization section of the report supports commercialization potential for instruments based on this approach and forecasts \$50 to \$100 million in sales per year.

### **Commercialization**

Fluorescence Innovations has invented three completely independent instrumental approaches for recording full fluorescence spectra with unprecedentedly high speed. The technology may be a “game changer” across the entire application space, which represents annual instrument sales in excess of \$1 billion. Fluorescence Innovations is seeking a strategic partner to assist financially and technically in establishing proof-of-concept; and, who will then manufacture and distribute microplate readers, chromatography detectors, and research spectrometers incorporating the detection technology.

### **Target market including size**

The primary markets are microplate readers, research spectrometers and chromatography detectors. Based on technical superiority, versatility, and ease of use of the FI products, an obtainable goal appears to be at least 10% of the \$400-\$500 million accessible market by Year 5. In addition, emerging specialty product markets, secondary markets and tertiary markets present other opportunities.

### **Marketing strategy**

The technology will be introduced at three meetings during the next year: Colorado Protein Stability Conference in July 2011, 2012 SLAS meeting in San Diego in February 2012, and the 2012 Biophysical Society annual meeting in San Diego in February 2012.

An aggressive strategy will be undertaken to overcome the challenge of making people aware of the instrument. An applications laboratory will be established at the University of Minnesota, on-campus workshops and seminars will be held, regular attendance at conferences and exhibits, direct mailings, and short courses are all part of this awareness strategy.

### **Production or manufacturing plan**

- Establish a manufacturing facility in Bozeman; build sales and distribution force – contacts with local business development people have begun. These include Quantel USA, ILX Lightwave, FLIR and Quantum Composers. Contacts will also be made with TechLink, TechRanch, and Montana Department of Commerce. If this option is chosen, a general manager will be hired.
- Strategic agreement with Essen Bioscience, Ann Arbor, Michigan – partner with an existing company that is qualified to manufacture and distribute the instrument. Top candidate for this scenario is Essen Bioscience.
- Establish manufacturing facility and develop sales and distribution force in Minneapolis area – Gillispie has been approached to serve as the Executive Director of the newly created Center for Structural Genomics (CSG) at the University of Minnesota. The Biophysical Spectroscopy Facility (BSF) at the CSG could serve as an applications laboratory for FI equipment.
- License, technology sale, or strategic investment with Biotek – Located in Winooski, Vermont, Biotek ranks as the number four company in the world selling microplate readers and related equipment. With annual sales approaching \$100 million, they employ approximately 300 employees. This company is big enough to have resources, but not so big as to be calcified and too bureaucratic.
- Large company license or technology sale – Agilent is probably the most likely prospect in this scenario.

### **Economic Impacts**

FI is preparing a provisional patent disclosure that will cover all microplate reader assays based on spectral data. A belief in the value of IP will result in building a strong portfolio.

### **#10-76 Measurement of Optical Output of High-Power Laser Diodes**

**Larry Johnson – ILX Lightwave - Bozeman**

**\$107,885**

*Final report approved: October 2011*

### **Summary**

The purpose of the project was to research, develop and commercialize technology for high-accuracy optical output power measurement of high-power laser diodes.

The three objectives and resulting assessments are:

- (1) Development of integrating-sphere-based optical power measurement technology with <1msec response time, that is insensitive to ambient temperature fluctuations, and has a better than 0.2% measurement stability over a period of one year.

**Assessment:** The objective was technically achieved, but proved to be too expensive for the intended commercial application.

(2) Development of an optical calibration technology that will provide a total calibration uncertainty of better than 1%.

**Assessment:** The objective was achieved, but the technology could not be extended to work for pulsed measurement operation which, it was learned later, is required for the proposed commercial application.

(3) Develop and introduce a family of high-accuracy optical measurement heads to be released in 2010.

**Assessment:** The objective was not met as originally planned, but some of the technology developed has been successfully commercialized.

## **Commercialization**

### **Product description**

The developed technology can be used to enhance ILX's next generation fiber optic power meter, the FPM-8220, and associated FMH-87xx measurement heads. The detailed new product plan for these products is included in Appendix C of the Final Report. Full integration of the technology for the improved optical integrating sphere was completed June 3, 2011. Product testing was completed on August 3, 2011. Marketing plan implementation is ongoing and reviewed by management on a monthly basis. The sale and shipment of the first FMH-87xx Optical Measurement Head is scheduled for the week of October 3, 2011.

### **Economic Impacts**

Although the original objectives were not achieved, some of the technology developed has already been commercialized in alternative products. It is believed this technology will enhance ILX Lightwave's ability to penetrate the \$100 million market for optical power meters and increase the company's sales of these products from \$713,000 in 2011 to over \$1.4 million in 2013. This increase in revenue is expected to create approximate 5 new jobs during this time period.

## **#10-78 Commercial Introduction of Barley Protein Concentrate in Aquaculture Markets**

**Bob Kearns – Montana Microbial Products – Butte**

**\$118,900**

*Final report approved: July 2010*

### **Summary**

Montana Microbial Products developed a process to produce barley protein concentration (BPC) that can be used as a substitute for fish meal. The objective of this project was to expand MMP's pilot plant operation to provide BPC to commercial feed manufacturers for commercial testing. During the grant, MMP produced BPC for studies conducted by the USDA, Rangen Feeds, Clear Springs, Norwegian Aquaculture Protein Centre and others. Both Clear Springs and Rangen Feeds evaluated BPC in their own fish feeding studies and have provided purchase orders for BPC from a commercial plant. The

purchase orders are critical to demonstrating that a market exists and feed manufacturers are willing to purchase the material at prices equal to or above the numbers used in the business plan. The results of the project have enabled MMP to enter into detailed commercialization discussions with two corporations that are interested in forming joint ventures. These corporations are being presented as part of the Feasibility Study required for a USDA B&I Loan Guarantee.

### **Commercialization**

The Final Report includes a detailed Executive Summary from the company Business Plan, including revenue projections through 2017. The foremost task at this time is to build the first commercial production facility at a cost of \$12 million. This will require bank financing using a combination of \$ 3 million equity and USDA B&I Guarantees. The initial plant would directly employ 18 people, generate \$996,000 in wages and benefits, and purchase 800,000 bushels of barley. MMP is in negotiations with various companies concerning potential joint ventures and equity investments. Purchase orders obtained from this project are critical to the joint venture and equity discussions. In addition, the commercial trial results are an important part of completing a satisfactory Feasibility Study required for the USDA B&I Loan Program.

### **Product description**

Barley protein concentrate (BPC) is the first plant protein with nutritional quality, competitive cost, and potential volume to effectively replace fishmeal in the \$3 billion aquaculture protein market.

### **Target market including size**

\$3 billion aquaculture protein market

### **Marketing strategy**

MMP's marketing strategy has four elements:

- (1) Construct a first commercial facility which will supply the Idaho trout industry, a well defined and immediately accessible local market.
- (2) Market development by conducting feeding trials and testing programs with feed manufacturers in salmon and other species of farmed fish and shrimp. MMP currently has salmon trials in progress with USDA and Norwegian Aquaculture Protein Centre.
- (3) License BPC technology for international markets, the fees from which will provide revenue with minimal capital expense. MMP will execute the first licenses in 2012 with the first royalties expected in 2013.
- (4) Expand production in order to supply North American salmon markets.

### **Production or manufacturing plan**

The first plant will be a prototype commercial facility with a capacity of 5,300 tons BPC per year to supply trout markets in Idaho and will come on line in early 2011. An

expansion to take advantage of Montana's plentiful, low-cost barley will occur in 2012 and come on line in 2013.

**Economic Impacts**

**New businesses created or expanded**

This project has the potential to create a new industry in Montana, i.e. that of producing an alternative to traditional fish food.

**Increase in employment level**

The plant, when up and running will directly employ 18 individuals.

**Acquisition of investment capital**

Negotiations are underway for joint ventures, investment capital, bank financing, and technology licensing.

**Unique features/success stories/news clippings, brochures/other information**

Articles published in the May-June 2009 and February 2010 issues of *Agricultural Research* are included with the Final Report.