**USDA Project Narrative**

**(I) Responsiveness to USDA NIFA SBIR Program Priorities**

The AgShift Hydra solution directly addresses USDA Research Priority #2 as described in the USDA Topic of Interest document, “Food Quality--Engineering”, in that it contributes to a reduction in post-harvest losses maintains safety and quality of agricultural produce, while its growing database as an IoT technology will contribute to reduction of post-harvest losses in general as growers and processors learn from the data. This application is designed specifically to address agricultural concerns by introducing a better, more objective way to approach quality management and safety inspection.

This application is for an agriculturally-related efficiency technology, the AgShift Hydra food quality assessment system, to be installed at the locations of two partners in a Phase I trial in order to gather data and determine feasibility preparatory to a Phase II trial, with the intent of leading eventually to full commercialization of the Hydra technology.

AgShift has developed “Hydra”, a patented IoT device (WO2019/177663 A1, “IoT BASED APPARATUS FOR ASSESSING QUALITY OF FOOD PRODUCE”) that automates quality assessment of agricultural produce. This novel “QMS-in-a-box” solution features AI and computer vision algorithms to automate food quality assessment, enabling better, faster and completely objective inspections throughout the food supply chain. The Hydra hardware communicates with integrated SaaS data collection to create a digitalized audit trail to reduce recalls and food waste.

Hydra is the world’s first food quality analyzer to automate quality assessment for batch inspections. The patented turn-key analyzer enables operators to complete quality assessment of inspection samples in less than half the time of manual inspections, providing sensitivity and accuracy levels on par with the best quality inspector benchmarks.

AgShift is the leading AI automation platform for food quality assessment, enabling better, faster, completely objective quality assessment at scale. Compared to current manual processes, our solution improves the operational efficiencies of the food supply chain, creating an audit trail and growing cloud-based data set, and significantly reducing food waste.

**(II) Problem or Opportunity**

The problem addressed by this application is the slow, subjective, error-prone and non-data-driven inspection of agricultural produce in the post-harvest phase, by packers, shippers, processors and other post-harvest intermediaries. To ensure safety and quality, required inspections are carried out by human workers, who inspect the required sample sizes and must do so subjectively, with human hands and eyes. In this process, errors may be made, the sample size is limited, and no data are retained from the process. The opportunity exists for our application to revolutionize the post-harvest inspection of agricultural produce by applying computer vision and AI/machine learning in a process that will enable the objective inspection of produce for quality issues, while at the same time building a database of quality information that will grow with time and lead to an overall reduction of food waste at the post-harvest stage. Our technology-driven answer to this billions-of-dollars-per-year problem has the potential for highly successful commercialization as well.

With successful trials that lead to commercialization and wide industry adoption of the Hydra technology, the problem of slower and limited inspections at different stages of the food supply chain can be greatly ameliorated, leading to a number of significant benefits for the agriculture industry, the consumer public, and the Nation.

**Key Benefits of the AgShift Hydra solution include:**

Reduction of food waste across the supply chain: Annually, in North America, 58 million tons, or 33% of total food waste, occurs across the supply chain in the post-harvest, processing and distribution phases. AgShift improves the quality assessment of food with objective, accurate and pre-emptive quality assessment, resulting in significant reduction in food waste across the supply chain. In the U.S. alone, inconsistent food quality assessment costs $15.6 billion in lost sales for food growers, packers, shippers, distributors and retailers, who are already dealing with low margins. The AgShift solution can significantly reduce recalls and food waste due to inconsistent quality assessment. The development of data sets for measuring the shelf-life of perishables also will result in the reduction of food waste. The AgShift solution can accurately do shelf-life analysis of perishables such as fresh berries, baby carrots and other commodities. The AgShift solution can measure advanced attributes such as extent of dehydration in baby carrots and other commodities, with the goal of repurposing compromised but edible food. For example, we have hypothesized that baby carrots and broccoli stalks that currently are thrown away could be dehydrated to preserve nutritional content and reduce waste.

Reduction in greenhouse gas emissions (GHG):Food waste represents 4.4 billion tons of annual greenhouse gas emissions. Food supply chains account for 18% of those emissions. The estimated annual impact of the AgShift solution is 58 million tons, a ~2% reduction in GHG caused by inefficiencies in the food supply chain.

Reduction of hunger: Preventing food waste, importantly, can contribute to eliminating hunger as food is distributed more efficiently. An examination of the contextualization of food waste reduction initiatives (Atkins, 2018) noted the need for sustainable scenarios for food waste reduction, especially in developing countries. According to the EPA hierarchy, the place to start is at production. The insights a grower/producer will gain from the use of an IoT-enabled hardware/software system for QM may contribute to better decisions about planting/harvesting schedules. Researchers on sustainable supply chain management have found that the higher up the supply chain waste is eliminated, the less costly it is overall (Ocicka & Razniewsk, 2018).

*Sources:*

[www.ourworldindata.org](http://www.ourworldindata.org)

Atkins, R. (2018). Supply chain food waste reduction and the triple bottom line. *Social Business. 8*(2), 121-144.

Ocicka, B. & Razniewsk, M. (2018). Food waste reduction as a challenge in supply chains management. *LogForum, 14*(4), 549-561.

**(III) Background and Rationale**

AgShift is a Silicon Valley-based AI startup with existing strategic partnerships with three major agriculture firms in the U.S. We also have research and testing operations in India, Singapore and Nepal. AgShift’s core team of seasoned entrepreneurs, deep learning data scientists, research scientists and advisors from the food and agriculture ecosystems together will build an innovative AI-driven technology to reduce post-harvest food waste across the supply chain. All our team members have substantial entrepreneurial or scholarly track records, often both.

AgShift was founded with a vision to bring technical and operational efficiencies to the food supply chain and to reduce food waste. AgShift’s journey began with reaching out to industry leaders in the food industry such as Driscoll’s, Olam Group and others who are leaders and innovators in the food supply chain. By establishing early strategic partnerships with these organizations, we were able to distill the value proposition and work collaboratively to solve the food quality inspection problems faced by the industry.

AgShift’s technical approach to inspection, QA and QM issues across the food supply chain has a technical approach that combines computer vision with AI/machine learning to create an internet-of-things device that can objectively assess commodities while creating an auditable digitized data trail.

**Technical metrics**:

The highly scalable proprietary AI framework gathers data and supports rapid expansion to hundreds of commodities, while creating a unique food quality data repository that will transform the industry and lead to far less waste.

* + Extensible AI framework to rapidly support hundreds of commodities.
  + Support for any new commodity in 10-12 weeks’ timeframe.
  + Builds a unique food quality data repository for higher value services such as shelf life indicators, freshness detection patterns, dehydration detection, etc.

**Data collection:**

Our patented analyzer, the Hydra, is used to collect images of all defects for a given commodity, such as berries, nuts or baby carrots. The Hydra has an integral sophisticated imaging system with power machine vision cameras that take multiple images of a pre-defined defect class. A data training set of up to 1,000 images per defect is in place. Computer vision algorithms are applied to clean up the images in a post-processing step so the data can be consumed and integrated by our AI model.

**AI training:**

Once the training data set is complete it goes into the AI model for training. The first step in training is object detection, i.e. identifying every object in a given image. For object detection we use Mask-RCNN, which has given us 98% accuracy and is superior to other approaches we have tried. When the object detection is established then the AI model is trained for defect detection. The AI framework we use is Tensorflow with Keras. This is one of the most extensible AI frameworks with rich built-in libraries, which helps with our requirements. We are using Inception as our AI model. (The choice of model depends on the commodity.) We build a framework in which we can try various available AI models and assess the one that would work best for the given commodity.

# **AgShift’s Technology Stack:**

Model architectures used for the Hydra solution include Inception V3, Resnet 50, VGG 16 and MaskRCNN. Our deep learning framework is built upon the Keras neural network library and the TensorFlow open source deep learning library (used with Keras Tuner). We also use PyTorch, the open source machine learning library based on the Torch library, for computer vision. All of these are publicly available.

**Company/Team (Commercial)**

Miku Jha, Founder and CEO of AgShift, is a serial entrepreneur in the technology space and has taken technologies to market that required a similar degree of research and pilot and commercial readiness testing to the Hydra.

Nickle Sitoula, Director of Customer Success, is founder of Zyoba Labs and co-founder and CEO of Transmete Network Solutions.

Naveen Tiwary, Director of Business Development, has served in an executive capacity at ICICI and Prudential Insurance.

Scott Diament, Director of Sales, was division manager at Heartland Payment Systems and Hibu.

Pam Marrone, Ph.D., Advisor, is founder of Marrone BIO Innovations (Nasdaq: MBII) and has successfully commercialized solutions as founder of AgraQuest and Enotech.

**AgShift Deep Learning Research Team:**

AgShift has developed a strong strategic and long-term relationship with CONICET – one of the most renowned research universities in Argentina. The researchers from CONICET are at the cutting edge of deep learning research and are focused on applying these innovations to agriculture. This collaboration with AI researchers enables us to integrate their research and fine tune the AI solution to optimize it to meet the food industry needs.

Diego Milone, Ph.D. – Full Professor, Department of Informatics, FICH-UNL; Principal Researcher, CONICET; deep learning data scientist and AI researcher

Georgina Stegmayer, Ph.D. – Assistant Professor, Department of Informatics, FICH-UNL; Leader of the Bioinformatics Research Group; independent researcher, CONICET; AgShift Project Lead Scientist

Cristian Yones, Ph.D. – Machine learning engineer, AI researcher and AgShift Project Lead Scientist; Assistant Researcher, CONICET; Teaching Assistant, Department of Informatics, FICH-UNL

Pranav Mishra – Senior computer vision engineer, CEO, Yobi.ai

Vishal Kumar - Machine learning engineer, Co-founder, Yobi.ai

Leandro Bugnon – Assistant Researcher, CONICET; Teaching Assistant, Department of Informatics, FICH-UNL; deep learning data scientist

**Rationale for Project: Market for the Hydra Solution**

Target customers for the AgShift solution are food growers, packers, processors, shippers and retailers. Our target customer profile is every organization in the food supply chain, from post-harvest till the last-mile retail store.

Our current focus is on the following categories: Fresh produce and edible nuts.

* Fresh produce: fresh berries, other inspectable fruits and vegetables such as apples, oranges and peaches
* Edible nuts: almonds, pistachios, pecans, walnuts

The total volume of food across the above categories that requires inspection annually is in excess of 1.6 billion pounds.

Based on the above volume, AgShift’s addressable market opportunity is **US$1.7 billion.**

**End-user needs:** Food must be inspected for quality at every point in the supply chain. The Hydra food quality analyzer can meet the QA/QM needs of packers, shippers, processors and distributors who currently rely on subjective human quality analysis and necessarily limited sample sizes. In addition to the problem of food waste, fresh produce is a vector for food-borne illness (Tokar, 2015); all agriculture stakeholders, as well as the public have an interest in keeping produce safe for the consumer. Human error affects quality of agricultural products (Ngadiman et al., 2016). The verifiable quality of food can have an impact on prices within the supply chain (Yu, 2018). The Food Safety Modernization Act of 2011 regulates supplier verification and makes prevention of pathogenic foods reaching the consumer a prime concern.

*Our vision is that AgShift will be an essential requirement for the entire food industry.*

**(IV) Relationship with Research or Research and Development**

Phase I will establish the merit, feasibility and commercial potential of the Hydra solution as a problem solver for food waste. The Phase II continuation would enable AgShift to continue R&D efforts initiated in Phase I, providing a foundation for full commercial potential.

(a) Successful wide deployment of the Hydra solution will result in measurable economic benefits to individual privately-held growers, packers, shippers and entities at all points of the food supply chain, as well as the agriculture industry as a whole. The efficiency of the objective, machine-learning based QA/QM solution with its auditable data trail and ever-growing cloud-based IoT data repository will lead to better and safer produce across the food supply chain, which is a great benefit to the Nations’ economy and self-sufficiency and the potential dramatic reduction in food waste. Consumers will benefit from safer food that is assessed more frequently and at lower cost than was previously possible, when the solution is scaled. Researchers may also be able to gain valuable insight about crop cultivation, pests, diseases and agricultural best practices from the data repository created by the solution. The Federal government will also gain from a more robust and optimized agriculture industry that will require less Federal support, while the goal of reduction of food waste is achieved and maintained.

(b) The cost-to-benefit ratio of the AgShift application is highly satisfactory. For a total cost, in a typical scenario, the end-user with an investment of $60,000 (per Hydra unit) and a monthly data subscription of $21,600 will see a ROI of $300,000 savings in labor within the first two years, and an eventual reduction in product waste that can amount to $40,000-600,000 annually, depending on the produce item.

## (c) Wasted food currently accounts for about a quarter of landfilled waste, contributing to methane emissions. Successful reduction in food waste across the agricultural supply chain will contribute positively and in alignment with USDA and EPA policy to address climate change, with the Federal goal of better nutrition in U.S. communities with safer and fresher produce, and in meeting the U.S. 2030 Food Loss and Waste Reduction Goal (2030 FLW reduction goal).

**(V) Technical Objectives**

The objectives of the research and development effort at present include:

* Successful implementation of the AgShift Hydra as a computer vision-driven, AI/ML-enabled, IoT-based device for objective and efficient food quality assessment in the post-harvest stage, for a variety of produce including nuts, berries and baby carrots.
* Development of the AI/machine learning algorithms such that objective assessment of produce will be more accurate, quicker, higher in volume and less expensive and error-prone than current methods.
* To gather sufficient clean, curated, labelled training data to train the AI for maximum effectiveness.

Technical feasibility questions for the solution include:

* Are the defects that determine the quality/grade of the commodity in the visual spectrum, i.e. accessible by computer vision technology?
* Are the defects prominent enough to be captured in images so that computer vision algorithms can be applied?
* Are the defects resolvable using Artificial Intelligence, i.e. is there enough training data to train the AI for maximum effectiveness?
* How much training data is needed to train the AI model for a selected commodity?
* Can the AI model be trained with a smaller data set to assess the efficacy of the solution?

**(VI) Work Plan**

The Work Plan for the USDA SBIR Phase I project includes the following tasks:

*Identify:* Identify viable partners in agriculture for Hydra installation and testing in order to begin data set for particular commodities; likely partners will process strawberries, nuts or baby carrots.

*Scale:* Install the Hydra analyzers at two customer facilities

*Facilities:* Install the Hydra food quality analyzer at selected customer facilities to do production trials and start the production testing

*Partners:* Driscoll’s, Grimmway, Olam or other shippers and customers in fresh produce and edible nuts are likely partners

*R&D:* Accelerate the AI R&D to build a base model for automation of inspection for strawberries, nuts and/or baby carrots.

*Commercialization:* Make the AI solution commercially ready with >80% defect detection accuracy on selected commodities.

*The Hydra unit prototype showing touch screen*

**AgShift USDA Phase I Work Plan**

*Goal Statement: To identify a Phase I partner food producer or processor to participate in Phase I R&D under the USDA SBIR program in order to establish merit, feasibility and commercial potential in preparation for Phase II R&D aimed at commercialization.*

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| --- | --- | --- | --- |
| **OBJECTIVE** | **TIMELINE** | **RESULTS** | **PERSONNEL** |
| 01 – Write Preliminary Report (DELIVERABLE) | Days 0-10 | An initial 14-slide report describing our research approach to the Phase I feasibility study. | Girinda Sharma (PI) |
| 02 – Partner Identification | Days 0-30 | We will begin by liaising with existing and potential Phase I partners already identified by our team. | Girinda Sharma |
| 03 – Problem Refinement | Days 30-45 | Site visits with the most promising Phase I partners discuss the Hydra solution | Miku Jha, Girinda Sharma |
| 04 – Technical Adaptation/Modification Study | Days 45-60 | Define appropriate Phase I milestones | Girinda Sharma, Pranav Mishra, Vishnal Kumar |
| 05 – Definition of Solution Trial with Phase I Partner | Days 60-90 | Install and adapt Hydra commercial solution to meet the needs of the pilot partner | Girinda Sharma |
| 06 – Hydra in Operation | Days 90-160 | Run Hydra solution and gather on-site data | Vishnal Kumar |
| 07 – Write Final Report (DELIVERABLE) | Days 160-180 | We will produce a written report incorporating all of the information derived from tasks 02-06 into our Phase II application. | Girinda Sharma |
|  |  |  |  |

**A picture containing indoor, food, open, sitting

Description automatically generated**

*The Hydra commodity tray is design to accommodate a variety of commodities—here, almonds are loaded for quality assessment.*

**A picture containing indoor, monitor, sitting, small

Description automatically generated**

*Almonds loaded for computer vision imaging*

**A screenshot of a cell phone

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*Key technology stack and related components*

*Projected Hydra project timeline for building the AI model*

**A screenshot of a cell phone

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*Proposed AI dataflow pipeline and framework for initial project*

**(VII) Related Research or Research and Development**

The AgShift solution, while it builds upon decades of research in produce assessment, brings a mix of technology never before combined for this result. Success with the project will lead to substantial improvement of post-harvest quality management across a wide variety of produce items, leading to enhanced food safety and a measurable reduction in food waste by individual processors.

**Links to Hydra product videos**

* Almond inspection - <https://www.youtube.com/watch?v=2Ejg5lEuWoo>
* Strawberry inspection - <https://www.youtube.com/watch?v=smtMe28SLgU>
* AgShift company video - <https://www.youtube.com/watch?v=IMcGEIWcx9Q>
* Hydra product video - <https://www.youtube.com/watch?v=6kJSJ-5BIU0>
* Hydra in action (York) - <https://youtu.be/lOQivcCXmaM>

**(VIII) The Market Opportunity**

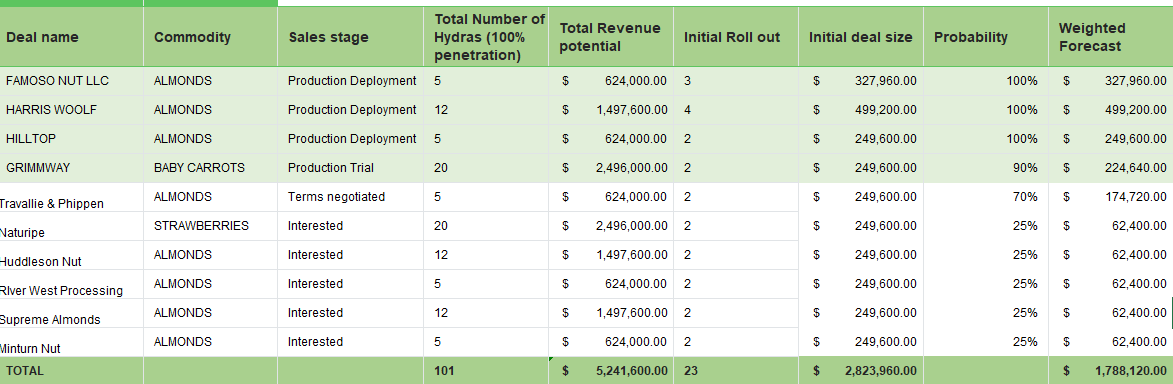
Our sales team and advisory board has researched the industry thoroughly, made well over 100 initial contacts and has conducted dozens of intensive customer visits, with the goal of forming strategic partnerships and conducting R&D trials. These have resulted in our existing strategic partnerships with Olam Group (almonds), Driscoll’s (berries) and Grimmway Farms (baby carrots).

The economics of agriculture/agribusiness are an arena of small margins and precariousness due to weather and other factors. Population growth or decline and also a rise or decline in consumer disposable income can have a profound effect on the market. Consumer demand for fresh produce continues to grow with an awareness of the health benefits that only fresh fruits and vegetables can offer (though fresh produce is too often an out-of-reach luxury for consumers experiencing food insecurity). While it is difficult to determine at this writing what the world economy will look like, the duration and severity of the COVID-19 pandemic, or even what the next Farm Bill will hold, it is certain that the agriculture industry and other entities in the food supply chain would benefit from less food waste and the ability to provide better, fresher, safer commodities to the consumer.

AgShift has validated its market opportunity with successful pilot programs in collaboration with Olam Foods (edible nuts), Driscoll’s (strawberries) and Grimmway Farms (baby carrots). At present, no other provider is offering a similar solution that introduces an objective quality assessment technology based on computer vision and artificial intelligence. When the product enters the market, copycat technology (which would be in clear violation of our patent) would be a danger, especially as a growing number of people are made aware of the device and its capabilities.

The project’s approach to commercialization combines an initial purchase of equipment with a monthly subscription model for software and data access. The economic benefits of an individual customer’s use of the Hydra unit include a reduction in labor costs and decrease in unusable/unsellable commodities. Widespread adoption of our product across the agricultural industry can have a profound beneficial impact on the economics of the industry.

The early revenue potential for full commercialization of the Hydra is between $1.2 and $1.8M in the first full quarter of operation. The underlying assumptions for these projections take into account the market research our team has completed, relationships already forged by our sales team, and market projections, always difficult but never more so than at present.



*AgShift sales pipeline for Q.4 2020 – Q.1 2021*