

Agricultural Technology Research Program

2008 ANNUAL REPORT



Mission Statement

To promote the economic growth of Georgia agribusiness (especially the poultry industry) through:

- **Research focused on the development of new technologies that improve productivity and efficiency;**
- **Exposure of students to the challenges of developing and adapting these technologies;**
- **Technical assistance to Georgia-based industry members with special problems;**
- **Release of information on emerging technologies and improved operational management through newsletters, articles, seminars, and presentations to speed ultimate commercial use.**

The program is conducted in cooperation with the Georgia Poultry Federation with funding from the Georgia Legislature.

Cover photo: ATRP researchers are evaluating new methods to enhance the conversion of poultry processing waste materials (particularly fats, oils, and brown grease) into biodiesel. To learn more about ATRP's biofuels research, see page 10.

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The Year In Review

Fiscal Year 2008 proved a challenging year for both the industry and the economy as grain and oil prices skyrocketed and the dollar declined against foreign currencies. It was also a year in which yet another food safety breakdown (vegetable-based) proved both difficult to isolate and deadly. For the Agricultural Technology Research Program (ATRP), it was a year in which strong advances were made in research targeted at enhancing food safety, increasing efficiency, making the workplace safer, improving product quality, and improving the recovery of waste byproducts. It was also a year in which the program provided 46 technical assists, produced 45 articles and technical presentations, generated 3 records of invention, coordinated the 2008 National Safety Conference for the Poultry Industry, and hosted numerous demonstrations of ongoing research developments to an array of industry, government, and school groups.

With food safety high on everyone's mind, the program continued studies on a range of innovative technologies. Bench-scale testing began on a promising new chlorine sensor designed to help manage disinfection levels in poultry chillers. In addition, a new four-channel waveguide was designed for the system and modifications were made to its software to simplify setup and operation. A new cone-mounted imaging cell, also under development, underwent testing and refinements to enhance detection accuracy. This system is designed to detect missing bone elements on a deboned poultry cage. And pilot studies began on the program's advanced UV disinfection system, confirming preliminary bench-scale performance estimates and focusing on needed design refinements to increase volumetric throughputs. The unit holds promise for disinfecting water, juices, brines, and marinades without adding heat or chemicals.

With mounting pressure on industry to control production and labor costs, the program pursued research on new advances to further control quality and yield management while extending automation performance. Program engineers completed preliminary development and testing of a novel automatic shackle loading system designed to transfer birds from a chiller to a moving shackle line. Plans are underway to refine and ultimately field test the concept which promises to eliminate labor demand for this key transfer function. Researchers also finalized modeling and testing of new cutting control techniques designed to introduce



“intelligent” deboning processing concepts that will allow automated deboning systems to match if not exceed the yield and quality performance of the best manual deboning processes. Engineers also refined the singulating and grasping design of the program's intelligent live bird transfer system to improve its performance by incorporating several novel control concepts.

Because plant operations, no matter how automated, will continue to rely on line workers as part of processing operations, research continued on human factor tools to make the job easier on line workers. Program researchers completed modifications to the augmented reality laser projection system to enhance its brightness on the product and to prepare it for installation in a plant. In addition, a team of engineers and scientists completed the first set of in-plant tests using the new wireless Ergonomic Work Assessment System to measure worker motions and exertion while deboning product. Initial test results have observed a distinct motion difference between experienced and novice workers that diminishes as the more experienced worker fatigues.

With growing national interest in renewable energy, program researchers also made new inroads in converting low-quality waste oils (such as brown grease) into high-grade fuels. A promising advance has been in the extraction of free fatty acids from these streams for subsequent conversion into fuel. With water restrictions still in force in many regions of the state, researchers also continued studies directed at sharing best management practices related to water recycling and conservation across the industry. And on the technology transfer front, the program's *PoultryTech* newsletter earned its second APEX Award for Publication Excellence and a MarCom Gold Award.

On behalf of everyone on our research team, allow me to close by extending a special thanks to all of our sponsors and supporters who have and continue to make our efforts possible.

A handwritten signature in dark ink, reading "J. Craig Wyvill". The signature is fluid and cursive, with the first letters of the first and last names being capitalized and prominent.

J. Craig Wyvill, ATRP Director

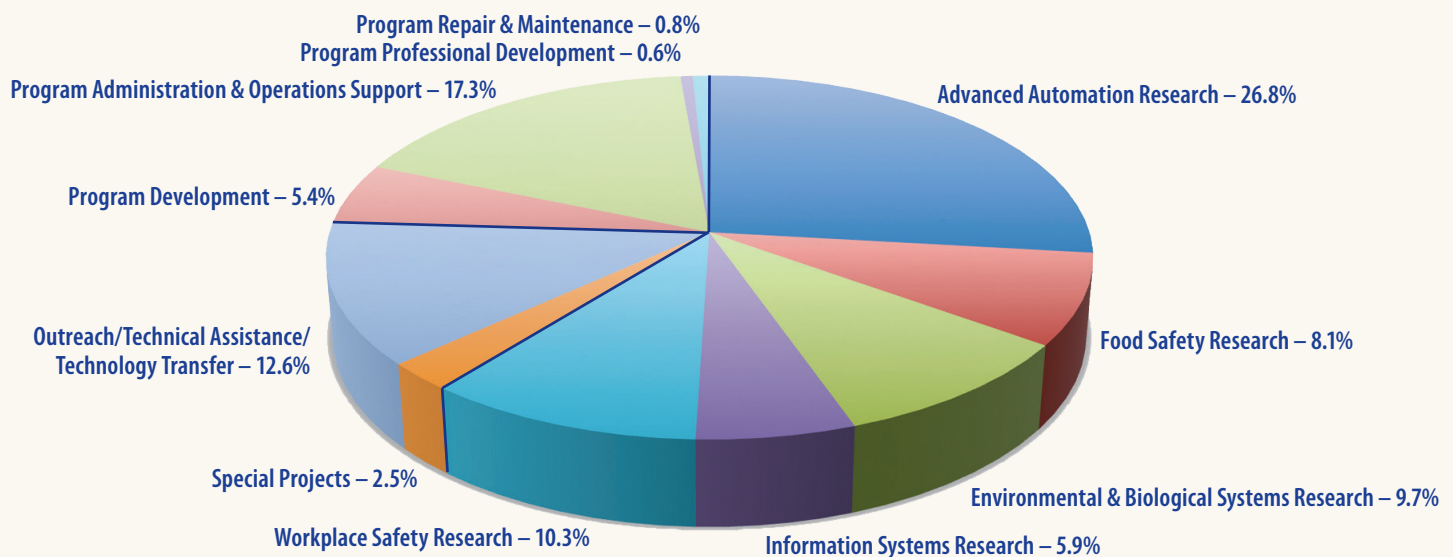
Financial Summary

Fiscal Year 2008 saw state funding support for the program grow for a third consecutive year.

In all, eight systems development efforts were undertaken in five research focus areas in FY 2008: advanced automation technologies, food safety technologies, environmental and biological systems, information systems technologies, and workplace safety. In addition, three special projects were undertaken, and the technical assistance element expanded to meet growing interest in in-depth energy audits due to mounting energy costs.

More than 63% of the FY 2008 program budget was directly invested in research and special projects. More than one-third of the remaining program budget was invested in program support functions and outreach/technical assistance/technology transfer.

FISCAL YEAR 2008 BUDGET \$1,879,807



Industrial Partnerships

INDUSTRIAL COLLABORATORS

Industrial collaborators help provide direction and support to the specific research projects undertaken. They also participate directly in research projects by providing access to industry facilities for data collection and systems testing and contributing in-kind and cash support on an “as needed” basis.

“Smart” Deboning System

Pilgrim’s Pride Corporation
Tyson Foods, Inc.

Intelligent Transfer System (Post-Chiller Rehang)

Gainco, Inc.
Mar-Jac Poultry, Inc.
Pilgrim’s Pride Corporation

Automated Live Bird Transfer System

Banner Engineering Corp.
Danfoss Bauer
inControl, Inc.
Turck Inc.
U.S. Poultry & Egg Association
Other Collaborators:
University of Georgia
USDA/ARS Russell Research Center

Chlorine Sensor Technology

Pilgrim’s Pride Corporation
Tip Top Poultry, Inc.
Wayne Farms LLC

Automated Missed Bone Screening System

Chick-fil-A
Wayne Farms LLC

Advanced Disinfection, Biofuels, and Water Research

Air Products and Chemicals, Inc.
American Proteins, Inc.
Mar-Jac Poultry, Inc.
Perdue Farms Inc.
Wayne Farms LLC

Augmented Reality Overline Laser Projection System

Gainco, Inc.
North Side Foods

Worker Safety Technology

Various poultry processors throughout the State of Georgia
Liberty Mutual Research Institute for Safety
Other Collaborator:
McMaster University-Ontario, Canada

ATRP POULTRY ADVISORY COMMITTEE

ATRP’s Poultry Advisory Committee is composed of poultry industry leaders who give their time to help the program identify research topics that best address priority industry needs. The committee meets annually to hear updates on program research efforts and to discuss challenges and future direction with program personnel.

Richard Jamison	Perdue Farms Inc. (<i>Chair</i>)
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J. Craig Wyvill	Georgia Tech Research Institute
Michael Lacy	University of Georgia

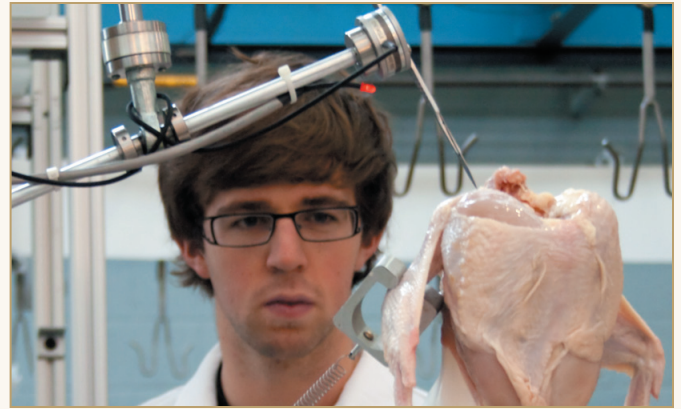
Building “Smart” Deboning Systems

In an effort to address the challenge of automating poultry deboning processes, ATRP researchers are developing a “smart” deboning system. The system uses computer vision and other sensing technologies to recognize and react to size and shape differences of a carcass in order to perform precision cuts that optimize yield (the amount of meat removed from the bone) while reducing the risk of bone fragments in finished product.

“Currently, no cutting systems are available with the capability to ‘react’ to differences in bird size and body deformation,” says Gary McMurray, project director. “By studying the anatomic structure of the chicken shoulder, we were able to identify the cutting locations and develop a prototype intelligent or smart device.”

The smart deboner is comprised of a vision system, a cone line, and a cutting system. The vision system identifies the correct starting position for the cut and a nominal cutting trajectory based on the size of the bird. A standard cone line moves the bird through the work cell. The cutting system employs a 2-degree-of-freedom device that is capable of adapting to changes in the internal bird anatomy while compensating for any body deformations. Thus, as the knife makes strategic cuts on each bird, the computer automatically adjusts the cutting path in response to the particular geometry of the bird coupled with force feedback to perform a near optimal cut.

“The concept is to use the flexibility of a robotic cutting arm to allow the system to automatically adjust to the natural size variations of the bird and thus eliminate the need for any sorting based on weight,” explains McMurray. The elimination of weighing and sorting systems for process control could also have a big



impact on the industry as far as cost savings and minimizing operational floor space demands.

Researchers have developed a prototype for testing and evaluation of some of the cutting concepts. According to McMurray, the project team has conducted extensive testing and modeling to support refining the system design. A thorough kinematic analysis of various cutting paths for the shoulder cut was performed in order to select the best cutting motion for the system. Mathematical models were developed to study the cutting process and understand the impact of the material properties, sharpness of the blade, cutting velocity, and angle of the cut on the cutting force. Initial tests of a first-generation prototype system, including cutting experiments, demonstrated the system’s ability to recognize bone during a cut and modify its path to avoid bone chips. The team’s next steps are to refine the prototype to allow more integrated control testing including the use of 3D imaging technology.

Although the smart deboner has been designed with poultry in mind, McMurray says it could easily be modified to perform deboning cuts on other meat products, such as beef, fish, pork, and turkey, all of which have inherently natural variability similar to poultry products.

Ultimately, researchers anticipate that the concept could be used on new machines or retrofitted to existing machines, adding more capability to adapt to product variability and thereby improve yield.

“As the industry moves to higher throughputs and increased focus on product quality, the need to automate the cutting tasks increases. Our work is very unique for it is analytically based and seeks to leverage emerging automation technology. The potential impact of this work on the poultry industry is huge. Not only will this help them move away from labor-intensive and challenging cutting tasks, but it will also help to improve yield, product quality, and product safety,” says McMurray.



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Industrial Collaborators: Pilgrim’s Pride Corporation; Tyson Foods, Inc.

Automating Post-Chiller Rehang

Researchers are developing a sensor-guided, automated transfer system for transferring carcasses exiting an immersion chiller to a moving shackle line for second and further processing. Currently performed by four to eight plant workers per line, the task is labor-intensive. Automating the process will not only move workers away from a mundane task but save the poultry industry millions of dollars in related labor costs.

The system ATRP researchers are developing, however, takes a slightly different approach to conventional automation. Instead of using traditional mechanical automation concepts or more sophisticated robotics, the so-called Intelligent Transfer System employs a combination of simple mechanisms networked together in conjunction with advanced sensor feedback for command and control decisions.

“This system is a true departure from conventional automation techniques in use in the industry and from much of our ongoing research in robotics. For this application, we have shown the ability to develop an adaptable solution to a rather complicated problem. While we do not have an exact cost estimate yet for the system, we anticipate the potential payback period for the end user could be well under one year,” says Gary McMurray, project director.

The Intelligent Transfer System consists of three key components: an imaging cell, a flipping/orientation mechanism, and a box-to-shackle transfer mechanism. In a plant setting, the complete system would be located at the exit of the immersion chiller where current manual rehang operations take place. From the chiller, the Intelligent Transfer System is able to identify the orientation of carcasses and manipulate the carcasses in order to hang them on a moving shackle line.

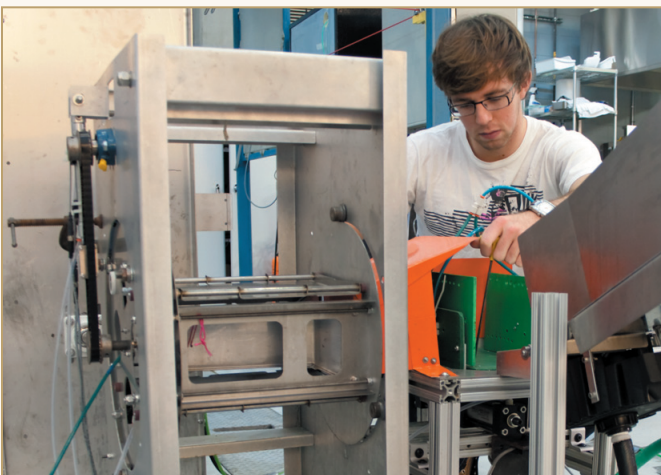


The team has completed initial laboratory testing of the system, with the system successfully demonstrating the placement of a randomly positioned and oriented bird into a box that was then used to automatically transfer the bird onto a moving shackle.

The team is now working on refining the orientation element of the design to make it more robust before moving to limited field testing in preparation for final product commercialization. For these tests, the system will be constructed with a single flipping/orientation mechanism and box-to-shackle transfer mechanism with an anticipated throughput of 60 carcasses per minute. A commercial singulation system will be integrated into the system to accurately represent a fully automated solution. Once those tests are completed, explains McMurray, the team will work on developing a commercial-scale system capable of meeting the required full production volume of 180 carcasses per minute. This final design will consist of multiple flipping/orientation mechanisms and a single box-to-shackle transfer mechanism.

McMurray says there are other features that can be integrated into the system to add benefits beyond simple labor reduction.

A special thanks is extended to Georgia's Traditional Industries Program for Food Processing for providing bond funds to help fabricate the rehang prototype system.

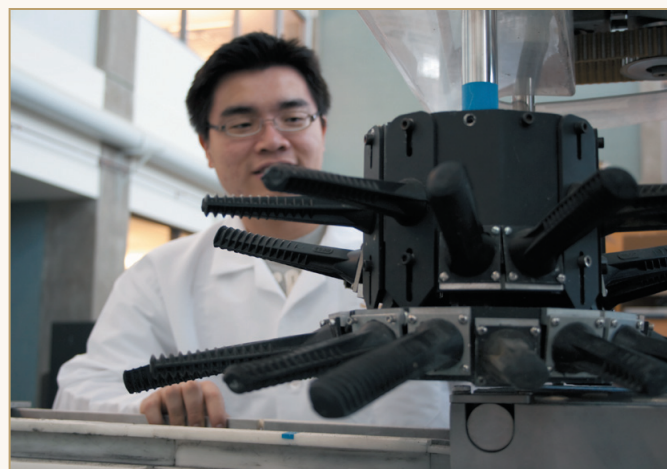


Intelligent Automated Transfer of Live Birds to Shackle Line

Live hang, the initial process in poultry plants where workers manually transfer live birds from a conveyor to a moving shackle line for processing, is considered a prime needs area for automated technology. In addition to its labor-intensive nature, the process is highly repetitive and generates dust. The manner in which workers handle the birds can impact product quality. ATRP researchers are attempting to address these challenges by developing an automated transfer system.

The goal of this research project is to design and develop a computer-controlled, live-bird transfer system that singulates the birds, detects and removes cadavers, and grasps the remaining birds for transfer to a moving shackle line. The mechanical aspects of the system can be broadly organized into three primary operations, explains Kok-Meng Lee, project director. The three operations are preliminary handling, inverting, and transferring to the kill line.

The preliminary handling portion of the operation begins with the current process of unloading broilers from cages onto a moving conveyor belt. The belt-conveyed birds are then sent through a singulator module that puts the birds in a single file. Cadavers are then removed from the singulated feed. The secondary handling operation begins with each bird being grasped individually and its legs inserted in a shackle mechanism. The bird is then stunned and inverted. The transferring operation synchronizes the motions of the inverter shackling mechanism with that of the kill line to ensure a smooth transfer to the first processing line.



In FY 2008, researchers modified the design of the preliminary handler to singulate birds into single file for loading on equally spaced perches. The research focused on developing sensing methods and a sensor-based control system that synchronizes the moving grasper of the singulator with the bird's arrival. This active singulation, explains Lee, requires only a small number of finger-sets, which eliminates excess movement when the bird is not completely in the specified region or when there are not birds to be singulated. In addition, birds can be more accurately singulated and equally spaced on the next conveyor as contact forces on the birds can be more consistently predicted. "More importantly, in handling live birds, active singulation effectively minimizes visual stimuli of the rotating fingers and thus could drastically reduce possible injuries due to unpredictable escape behaviors," adds Lee.

Researchers are currently working with industrial partners to design and fabricate a prototype system for experiments at the Poultry Processing Lab at the University of Georgia and at a selected poultry processing plant. Unlike previous experiments that focused on the birds' reactions to a single mechanical process, these experiments will test the birds' reactions to a sequence of handling processes.



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Industrial Collaborators: Banner Engineering Corp.; Danfoss Bauer; inControl, Inc.; Turck Inc.; U.S. Poultry & Egg Association
Other Collaborators: University of Georgia; USDA/ARS Russell Research Center

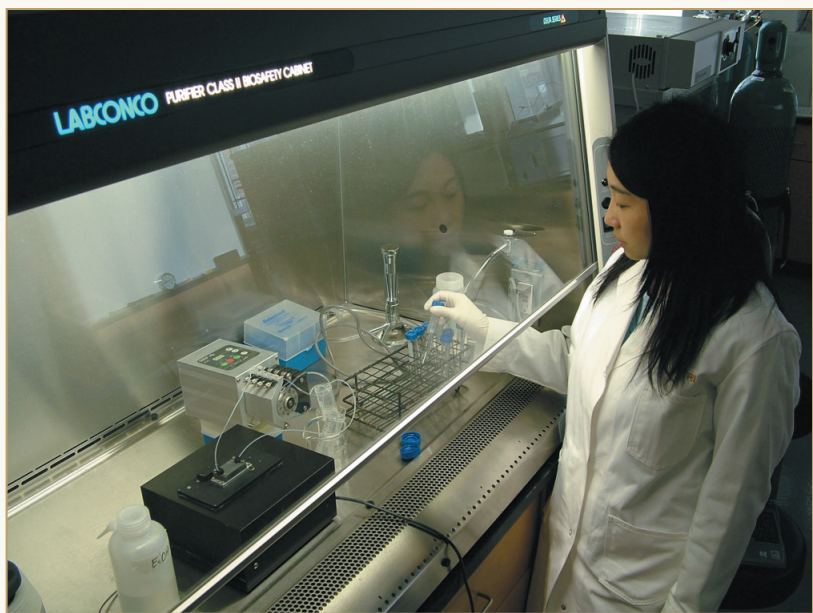
Optical Sensor for Chlorine Detection in Poultry Chiller Water

Last year the U.S. poultry industry processed more than 50 billion pounds of chicken. In one of the closing steps in first-processing, eviscerated and defeathered carcasses are dropped into an immersion chiller, which rapidly chills the carcasses to 40 °F or below. To further ensure microbiological safety, processors also add chlorine to sanitize and disinfect the chiller water. Because varying levels of chlorine can affect product quality and disinfection efficiency, the chiller water must be regularly monitored. Chlorine levels are typically measured by colorimetric analysis. The most commonly used method is based on a chemical reagent known as DPD (N, N-diethyl-p-phenylenediamine). However, the current DPD-based method has a narrow working range and suffers from interferences by organic material present in the chiller water and chloramine formation. As a result, the concentration measured by the DPD method can be inaccurate, potentially leading to either a marginal disinfection process or off-gassing associated with surplus chlorine.

In response, ATRP researchers are developing a sensor that they believe will more accurately track chlorine compounds and their concentrations in poultry chiller water.

“Our research is focused on developing an accurate, cost-effective, and field-deployable approach capable of replacing or complementing the current DPD method for the measurement of free and total chlorine concentrations in process waters, particularly red-water chillers,” says Jie Xu, project director.

The prototype sensor uses an interferometric optical measurement principle previously deployed by the program for rapid microbial detection. The sensor platform was designed for mobile, on-site field analysis with real-time results. In place of the microbial sensing elements, researchers have incorporated novel reactive sensing films for rapid, on-line quantification of various

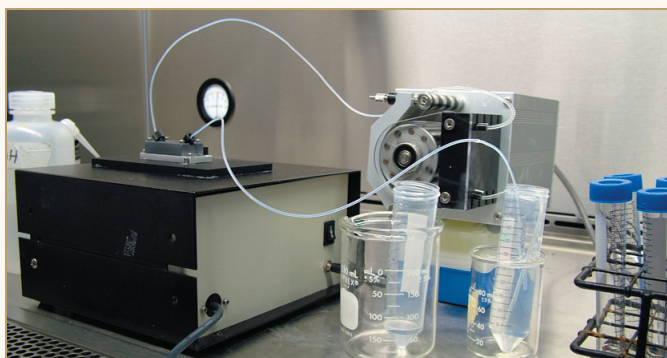


chlorine compounds. Part of this research focused on free chlorine detection is being conducted under a companion research program.

Under ATRP funding this past year, researchers developed sensing chemistries for monochloramine (which measures combined or total chlorine levels). “Monochloramine has become a disinfectant with widespread acceptance due to its biocidal capability, persistence in water, and lower formation of disinfection byproduct trihalomethanes,” explains Xu. Several sensing chemistries were investigated based on the specific reactivities of monochloramine, and initial results on the selected film indicate a sensitive, reversible measurement for monochloramine.

The team also introduced design enhancements to the sensor box (see Special Projects, page 13), and designed and fabricated a waveguide chip with four interferometers. With this new design, simultaneous multiple detection becomes achievable.

Researchers plan to ultimately integrate sensing chemistries for free chlorine, combined chlorine, and pH on a single chip, to provide real-time measurement for each. “A well-managed chiller will provide an important step in helping control bacterial counts and prevalence. This sensor, which provides near real-time information on chiller killing power, should be able to help a plant more dynamically track and control chiller management,” says Xu.



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Industrial Collaborators: Pilgrim's Pride Corporation; Tip Top Poultry, Inc.; Wayne Farms LLC

Automated Missed Bone Screening System to Aid in Quality Control

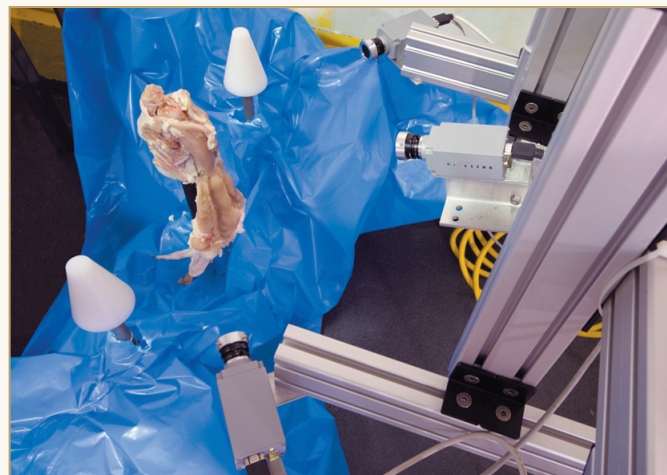
Further processed products are the mainstay of the poultry industry, with the key player usually being deboned breast fillets. However, missed bones, particularly the clavicle and fan, in these fillets continue to be of concern to processors. Current screening techniques for finding missed bones are labor-intensive and expensive, not to mention, they are not as accurate as desired.

ATRP researchers have developed a prototype automatic screening system to identify the presence of bone on the cone line providing an opportunity not only to assist in avoiding missed bones in product but also providing real-time monitoring of product yield.

Currently, one of two methods is used to inspect the product for bones. Plant personnel manually screen the product through sight and feel, or the processing plant uses sophisticated x-ray systems to inspect the product. However, neither method fully addresses the missed bone challenge, and missed bones still manage to end up in the final product.

“Because of this, deboned product customers are now placing additional pressures on suppliers to further reduce the incidence of missed bones,” explains Wayne Daley, project director. In addition, he notes, current bone detection methods are reactive as opposed to proactive, allowing little opportunity for process control. Complicating the problem is the fact that some bone types are extremely difficult to find at inspection stations after deboning.

“From a quality control perspective, the ability to detect these bones early in the process could improve production efficiencies by helping to reduce the amount of rework needed while optimizing yield. We set out to



develop an approach that allows for detection of missed bones where the information can be used to control the process because the problem is more tractable,” says Daley.

The prototype system functions by scanning for missed bones on the debone line immediately after the fillets have been pulled from the cage or frame. This allows for a timely response to observe if bone pieces are missing from the cage and check suspect fillets before they are mixed through general transfer mechanisms.

The approach uses a specially designed cone with internal illumination that has the effect of backlighting the cage (skeleton) so that it appears like an x-ray image. This image provides a clear view of the bone structure that makes up the cage. The system then analyzes the image to determine if the fan bone or clavicle bone is present. If these bones are absent, the potential exists for them to be in the meat that was just removed from the cage. These suspect fillets can then be removed for closer examination. Daley says the approach reduces the screening effort and will work on both automated and manual deboning lines.

In addition to missed bone, it would also be possible to monitor the frame for excess meat so that a measure of yield could be tracked and fed back into the process so as to maintain acceptable levels of performance, adds Daley. The team plans to continue conducting more extensive testing of this approach.

A special thanks is extended to Georgia’s Traditional Industries Program for Food Processing for providing bond funds to help fabricate the missed bone prototype system.



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Industrial Collaborators: Chick-fil-A; Wayne Farms LLC

Advanced Disinfection, Biofuels, and Water Research

Environmental systems-based research efforts continued to address product safety, water management, and byproduct recovery challenges. Key focus areas include advanced UV disinfection technologies, biofuels production, and water conservation and wastewater treatment operations.

ATRP researchers continued development efforts on a prototype high-efficiency ultraviolet (UV) disinfection system. Built on the Taylor vortex concept, the prototype has already proven effective at enhancing the UV disinfection of process wastewaters and marination fluids, offering the promise of more efficient recycle options. This past year researchers investigated design issues related to disinfecting opaque fluids under higher volumetric flow rates (laminar to transition flow) using both bench- and pilot-scale systems. Preliminary studies showed that single pass disinfection efficacy on the pilot unit exceeded design volumetric flow rates established in bench-scale studies by at least 50%. “Moving to our pilot-scale system has helped us to not only confirm bench-scale performance estimates but also investigate methods for achieving higher volumetric flow rates by studying fluid hydrodynamics resulting from various Taylor number and rotor surface changes,” explains John Pierson, project director.

On the biofuels front, researchers finalized preliminary performance parameter studies on new processes designed to enhance the conversion of low-quality waste oils and grease to high-grade fuels. ATRP studies focused both on improved methods for separating value-added fractions from waste oil and the subsequent conversion of these fractions into biodiesel alkyl esters. Their work indicates that traditional refining typically used for degraded feedstocks may reduce the biodiesel yield if steam treatment is used as a polishing step.



In the water conservation area, researchers worked closely with the Georgia Poultry Federation and a broad range of industry and trade partners to draft a Water Conservation Implementation Plan for the industrial/commercial sectors. The plan seeks to produce regional water plans that identify practical water management practices, following state policy and guidance, which will ensure that the anticipated future water demands can be met. As part of this focus, ATRP researchers teamed with colleagues from the University of Georgia in organizing a water conservation and reuse workshop. More than 70 individuals from throughout the Southeast attended the workshop.

Research in the wastewater operations area focused on the use of sanitizing chemicals, particularly quaternary ammonium compounds or QACs, and their impact on wastewater treatment systems. Pierson notes that QACs can present significant difficulties for biological treatment systems resulting in insufficient COD (chemical oxygen demand) destruction, accumulation of volatile fatty acids (VFAs), and nitrate reduction inhibition. To address this challenge, researchers developed an analytical testing method that has significantly aided in the assessment of potential wastewater impacts from QACs usage as well as allowed for development of remedial action plans for wastewater pre-treatment operations when required by publicly owned treatment works (POTWs) officials.



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Industrial Collaborators: Air Products and Chemicals, Inc.; American Proteins, Inc.; Mar-Jac Poultry, Inc.; Perdue Farms Inc.; Wayne Farms LLC

Augmented Reality Overline Laser Projection System

Although a number of technologies have recently been developed or are under development to inspect product as it moves along conveyor systems in food processing plants, relaying the information from the inspection systems to human technicians working on the conveyor lines is not easy. Normally this would be done by placing an LCD screen next to the conveyor line, but relating the information on the screen to the corresponding physical product can be difficult.

To address this issue, ATRP researchers are using a high-speed Augmented Reality (AR) Laser Projection System to overlay the inspection system defect information directly on the product as it moves on the conveyor line. “The goal of the AR Overline Laser Projection project is to create a plant-ready prototype to point out defective product exiting cooking operations in a food processing plant. The laser projector tells line workers if a product needs to be removed from the line and why,” says Sim Harbert, project director.

According to Harbert, the prototype laser projection system has actually been integrated with an Automated Midline Inspection System being developed under other funding. The integrated system consists of a plant-ready enclosure containing the laser, high-speed laser pointing mirrors, and a small camera; another enclosure to house the controller and power systems; and software to control the system. The high-speed, two-axis galvanometer-mounted mirror points the laser at locations on the conveyor belt quickly enough that symbols can be “drawn” on the product. The laser projection hardware is driven by software with several modules: a product list module that keeps a list of multiple product items in the laser projection area; a tracking module that uses the built-in camera to track locations of product in the laser projection area; a laser projection control module that translates the product list information into laser projection symbols on the product; and a computer server that waits for product defect information to be relayed by the inspection system.

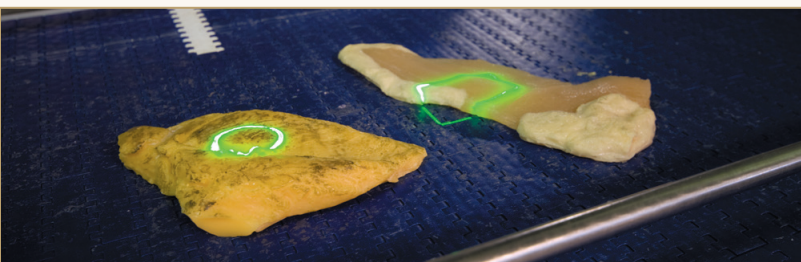
The enclosure and the AR laser projection software as a stand-alone system was created and tested as the



software and hardware systems were developed. This included tracking product with the built-in camera and projecting random “defect” symbols on the product in the laser view on a moving conveyor belt. Harbert notes that integration of the AR Laser Projection System with the Automated Midline Inspection System was achieved in the laboratory, with a basic version of the Midline Inspection System relaying product locations to the Laser Projection System. Test results indicated that the highly visible green laser symbols (which identify a defect) as specified by the inspection system were displayed in the center of each test piece as it continued down the moving conveyor belt.

Although the AR Laser Projection project is not continuing as a stand-alone development, further integration and testing of the system is being supported in FY 2009 by the continuation of the Automated Midline Inspection System’s other funding. The integrated inspection and laser projection system will be tested on a plant sausage patty cook line as the final version of the inspection system prototype is completed in FY 2009. “Once in place for testing the AR Laser Projection System will allow the inspection system to be installed and fully function without the need for an expensive kick-off mechanism by relaying the product defect information directly and quickly to conveyor technicians,” says Harbert.

A special thanks is extended to Georgia’s Traditional Industries Program for Food Processing for providing bond funds to help fabricate the AR Laser Projection prototype system.



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Industrial Collaborators: Gainco, Inc.; North Side Foods

Improving Worker Safety Through Advancements in Ergonomics Research

ATRP researchers in conjunction with member companies of the Georgia Poultry Federation have been working together to develop an instrument to assess musculoskeletal injury risk to workers in situ. The initial focus has centered on the cutting tasks associated with the deboning process and their impact on musculoskeletal activities of the upper and lower arm. The specific ergonomic factors related to these cutting tasks include grip force, posture, and repetition.

“The ultimate goals for this research program are to assist plants and ergonomists in developing effective worker rotation schemes and training programs for new and inexperienced workers to minimize the risk of injury,” says Doug Britton, project director.

To accomplish these goals, the research team modified a cutting edge measurement tool, developed several years ago by ATRP, known as EWAS or Ergonomic Work Assessment System. This new and improved version uses biomechanical measurements and position-tracking technology to measure the fore- and upper-arm muscle stress/strain associated with the poultry deboning cutting tasks. A ShapeTape fiber optic position measurement system is integrated with EMG sensors and an instrumented knife handle, developed at the Liberty Mutual Research Institute for Safety, to collect data from workers on an actual processing line in a plant. As a worker wearing the system cuts poultry, the aggregate data of the back and arm position, muscle response, and grip force is transmitted wirelessly to a laptop computer allowing researchers to study relationships among force, exertion, posture, and repetition. The information can be used both to boost work efficiency on the deboning line and to correct inefficient movements by workers performing the cutting task.



Researchers recently conducted an in-plant pilot test of the system with data being collected from five volunteer subjects that included both experienced and inexperienced workers as well as non-fatigued and fatigued workers. According to Britton, an initial analysis of the data reveals several interesting observations regarding worker actions associated with the wing cut.

- Experienced workers exhibit a larger yaw motion of the back in the coronal plane when compared with inexperienced workers.
- Experienced workers exhibit a much smoother cut trajectory in the z-plane when compared with inexperienced workers.
- Experienced workers exhibit less rotation or twist of the upper body in the transverse plane when compared with inexperienced workers.
- When experienced workers become fatigued, their work patterns tend to become more like those of the inexperienced workers.

While these are only preliminary results, Britton explains that they do indeed provide insight into some of the differences between experienced and inexperienced workers and fatigued and non-fatigued workers.

“Given that the sample of workers is relatively small, a larger study is being planned that should provide an even better insight into the musculoskeletal activities associated with doing these cutting tasks,” adds Britton.

Researchers also anticipate that developments in this area will be expanded to include assessments of the back and other tasks within the poultry processing environment.



Project Director: Doug Britton | 404-407-8829 | doug.britton@gtri.gatech.edu

Industrial Collaborators: Various poultry processors throughout the State of Georgia; Liberty Mutual Research Institute for Safety

Other Collaborator: McMaster University-Ontario, Canada

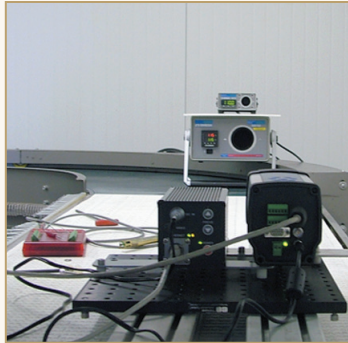
Special Projects

In addition to its many major research focuses, the program conducted the following special projects in FY 2008. These projects addressed design challenges related to prototype systems under development or evolution.

IR CAMERA RELIABILITY STUDIES

This project focused on addressing performance issues related to two competing commercial infrared (IR) camera systems being used in thermal scanning development studies. In processing plants the ambient temperature and humidity can change rapidly causing a thermal measurement system to also change temperature rapidly. The combination of these changes can lead to measurement errors. Researchers tested the FLIR A40 and Mikron M7500 to determine how they performed in measuring product surface temperatures while ambient temperature underwent fast changes. Tests showed residual temperatures for cold objects are higher than they are for warm objects. Despite the better performance of the FLIR A40 relative to the Mikron M7500 in a non-windowed test, both cameras have a similar $\pm 3^\circ\text{F}$ residual error when looking through a plastic window.

Project Director: John Stewart | 404-407-8834
john.stewart@gtri.gatech.edu

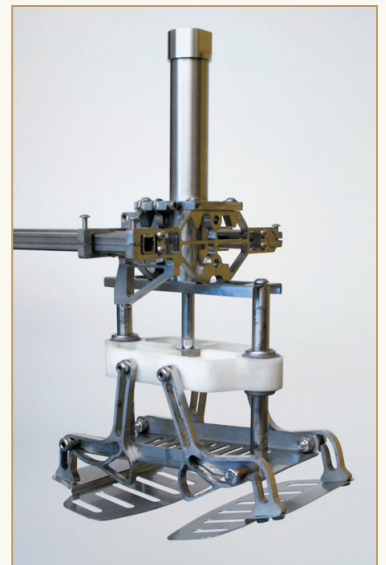


potential damage due to flow cell leaks and being bumped while lifting the unit in and out of the sensor box. It was repositioned and better protected for these concerns. Finally, the adjustment bracket for the laser proved too restrictive in allowing it to be aligned for a range of waveguide designs. The bracket was modified to expand the adjustment angle range. All three revisions resulted in a revised sensor box design which is performing very well.

Project Director: Vince Camp | 404-407-8087
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ROBOTIC GRIPPER DESIGN

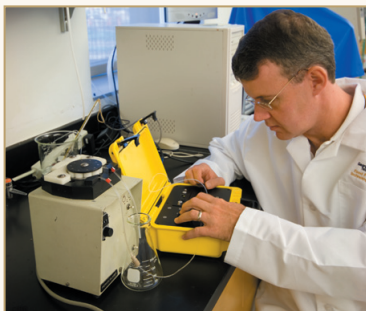
This project focused on refining the design of the gripper, being used to handle pork chops on the washdown robot project, to allow it to handle poultry products. Previous testing efforts highlighted handling issues on poultry products because of the higher surface tension of the membrane on deboned poultry products. In addition, the larger range of meat thickness meant thick pieces of poultry would jam the closing motion of the gripper and prevent a successful cycle. The redesign addressed these issues successfully by modifying the stop plate and travel of the gripping mechanism to better adjust to the difference in friction and wider variety of thicknesses.



Project Director: Jonathan Holmes | 404-407-8845
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INTEGRATED OPTIC SENSOR PLATFORM REDESIGN

This project focused on making changes to the box design of the program's chemical/biological sensor. Engineers redesigned several elements of the new sensor box built last fiscal year to address performance problems encountered in preliminary testing. First, the waveguide/flow cell snap-in mount had to be redesigned to address leaking problems with the flow cell and play in the waveguide securing mechanism. A new single pin securing mechanism proved the perfect solution to the problem. Next, the camera chip had a problem, both from the standpoint of ambient light interference and



Technology Transfer

ATRP continued an active technology transfer program. *PoultryTech*, the program's newsletter, received two awards for its Summer 2007 Environmental issue: 2008 APEX Award of Excellence in the Newsletters-Print category and a 2008 MarCom Gold Award in the Writing/Newsletter category. In all, three issues (Environmental, Safety, and Automation) of *PoultryTech* were published in FY 2008. Several articles were reprinted in the trade press. Subscriptions to the newsletter totaled more than 1,500 subscribers, including more than 200 subscribers from foreign countries.

A full-length cover article on "Emerging Technology Trends: Integrating the Processing Plant," highlighting some of the program's automation work, appeared in the August 2007 issue of *WATT PoultryUSA* magazine. Research staff also produced 45 articles/technical presentations and generated 3 records of invention.

ENGINEERING TOMORROW'S POULTRY INDUSTRY

PoultryTech

VOLUME 19 NUMBER 2 SUMMER 2007 ENVIRONMENTAL ISSUE

Gaining New Ground on Biodiesel Conversion Efficiency

Growing concerns over global warming coupled with increasing crude oil prices have sparked national interest in alternative fuel sources. Many think that a biofuels boom-and-bust scenario is under way because so many start-ups have entered the market and oil prices are volatile. But any breakthrough in one of three areas will dramatically enhance the viability of biofuels. Those areas are identifying feedstock materials that do not compete with food processing needs, improving conversion efficiencies, and finding better ways to get more energy out per pound while using less energy. Researchers at Georgia Tech are focusing on improving conversion efficiencies.

"We are interested in improving conversion and producing higher yields from valuable but problematic feedstocks, specifically poultry processing byproducts," says John Pierson, a principal research engineer in Georgia Tech's Food Processing Technology Division and head of the division's Food Safety, Environment, and Energy Technology group.

"We are working to develop a one-step process for converting feedstocks that contain high levels of free fatty acids into biodiesel, and

Chemist Robert Wallace determines the energy content of a sample of biodiesel using a state-of-the-art calorimeter.

hopefully, 'drop-in' diesel or a kerosene equivalent," adds Pierson.

Currently, the most common feedstock materials for biodiesel production in the United States are refined soybean oil and yellow grease (primarily recycled cooking oil from restaurants). Unrefined and waste oils are targeted as feedstocks for biodiesel production, but each contain

free fatty acids (FFA), and each percent of FFA decreases the yield of biofuel production by an equal amount. Used and/or degraded sources such as yellow grease require filtering followed by water and FFA removal to prevent soap formation that occurs under conventional processes. A two-step process employing acid catalysts prior to base-catalyzed transesterification is used to reduce FFA levels.

"Water is chemically produced during most production processes, but it really slows the conversion of free fatty acids," says Pierson.

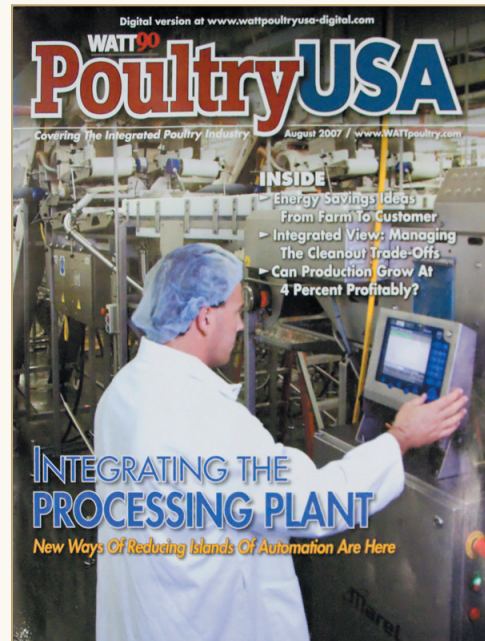
at ways to replace and improve the process.

page 2 - The Economics of Biofuels
page 3 - Georgia Tech Students Study Biodiesel Production Using Algae
page 4 - Homebrewed Biodiesel Using Restaurant Fryer Oil
page 5 - Cool Storm Water Runoff from Poultry Processing Facilities
page 6 - How to Recover Eggshell Waste for Alternative Uses
page 7 - How Homeland Security's Chemical Facility Anti-Terrorism Standard Process and Controls
page 8 - How Energy Climate Creates New Opportunities for Electric Boilers
page 9 - The Classroom

IN THIS ISSUE

2008 APEX AWARDS FOR PUBLICATION EXCELLENCE

2008 MarCom Gold Winner



The FY 2007 Annual Report was published, and the ATRP website was updated.

Georgia Tech Research Institute

Agricultural Technology Research Program

ENGINEERING TOMORROW'S POULTRY INDUSTRY

Updated October 2008 | Questions | Press Kits | Publications | Archives | Facilities | Milestones |

CURRENT PUBLICATIONS	RESEARCH NEWS
The current issue of <i>PoultryTech</i> is online. The topic of this issue focuses on Environmental Research. ATRP's 2007 Annual Report PDF 16.0 Mb ATRP's Program Brochure PDF 1.3 Mb UPCOMING EVENTS International Poultry Exposition January 28 - 30, 2009 Georgia World Congress Center, Atlanta, GA SPECIAL INTEREST Butcher Industries Donates \$250,000 to Georgia Tech Research Institute's Food Processing Technology Building Butcher Industries, Inc., an innovative world leader in the design and manufacture of food processing equipment and cutting tools, has made a donation of \$250,000 to the construction of Phase II of the Georgia Tech Research Institute's Food Processing Technology Building. Butcher Industries is the first company to donate to the \$3 million food-rising campaign that will add 10,000 square feet of laboratory and office space.	ENVIRONMENTAL RESEARCH Researchers Take A Closer Look at the Impact of Sanitizing Chemicals on Waterstar Treatment Systems In early 2007, after a relatively long period of sustained low temperatures a number of poultry processing facilities in the U.S. Southeast experienced increased ammonia levels in effluent wastewater. These facilities all employed biological treatment processes for nitrogen, and in some cases, phosphorus removal. Limited analysis and testing with wastewater samples collected at one plant showed that the chlorination process used was causing sustained low temperatures (below 15 °C) and more than likely exacerbated by the presence of disinfectants in the waste stream. These events point out that although product quality and safety are paramount in the poultry industry, intervention treatments used to control foodborne pathogens can cause upsets downstream in the effluent treatment area. Optimizing plant direction with wastewater treatment is more challenging in that chemistries designed to disinfect foodborne pathogens can also impact useful wastewater treatment bacteria. University Researchers Team Together to Establish Water Conservation Strategies for Poultry Processing Georgia Tech researchers together with colleagues from the University of Georgia have launched a joint university project aimed at establishing a consistent methodology for assessing water conservation and reuse options in processing plants. Working with poultry processing and other agribusiness industries, the team plans to identify short-term best management practices (BMPs) that will position these industries to meet the requirements of emerging water conservation measures, such as Georgia's Comprehensive Statewide Water Management Plan (Water Plan). A Look at the Importance

Technology Transfer

ATRP once again participated in the International Poultry Expo, the Georgia Poultry Federation Spring Meeting, and the Night of Knights, preparing exhibits for all three.



Working with the Georgia Poultry Federation, Georgia Tech helped coordinate the Poultry World exhibit at the Georgia National Fair, in Perry, Georgia. Staffed by over 150 knowledgeable volunteers from poultry companies, allied industry companies, universities, the Georgia Poultry Laboratory Network, and the Georgia Poultry Federation, Poultry World continues to be one of the most popular exhibits at the Fair, drawing more than 40,000 visitors during the 10 days of the fair, over half of which are school children touring the exhibit as part of the Georgia National School House program.



In conjunction with the Georgia Poultry Federation, the National Chicken Council, and the National Turkey Federation, ATRP hosted the 2008 National Safety Conference for the Poultry Industry in Orlando, Florida, attracting more than 75 safety professionals and vendors from across the United States. Edwin G. Foulke, Jr., Assistant Secretary of Labor for Occupational Safety and Health, served as the keynote speaker for the second year in a row.

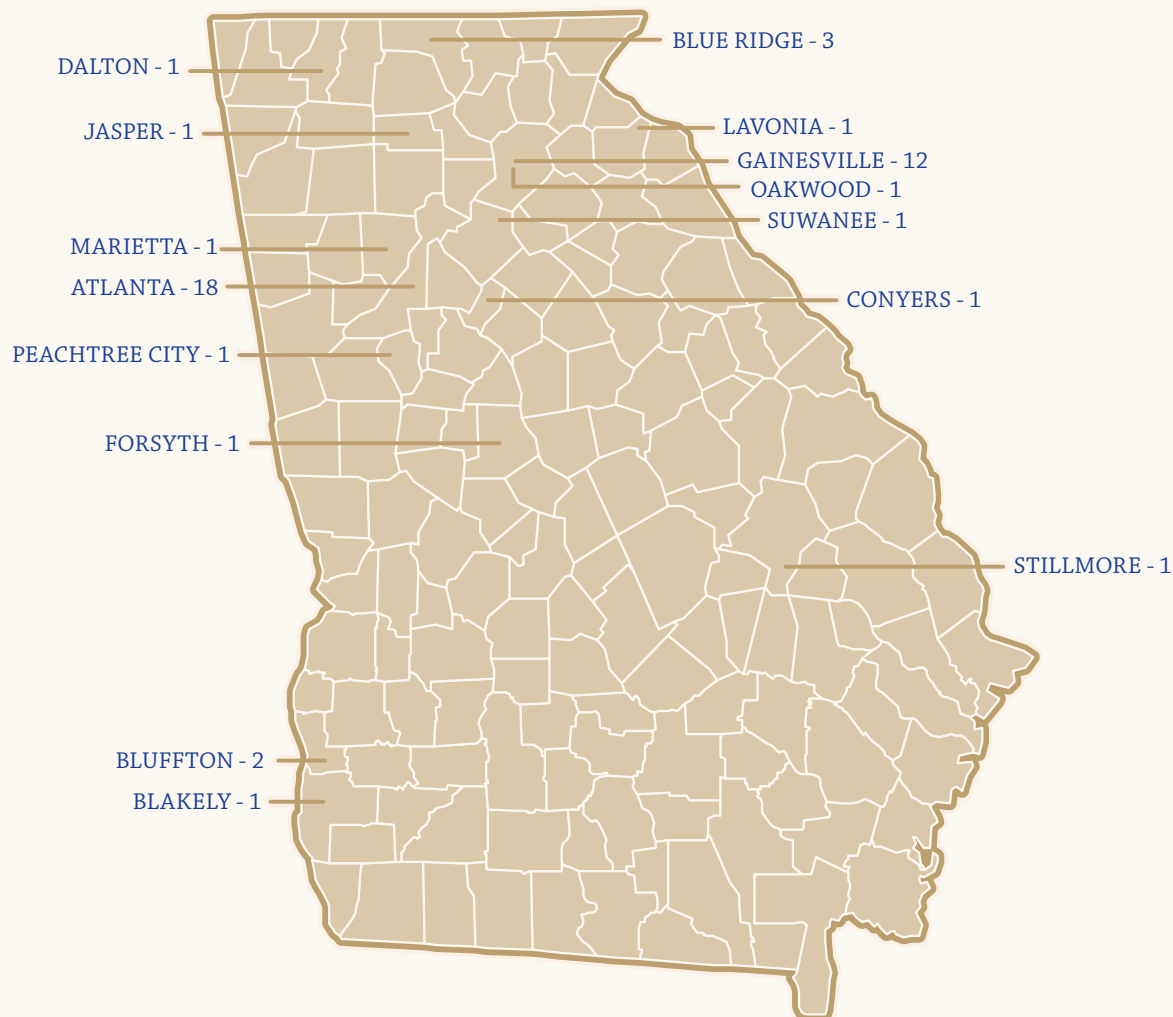


The program also provided tours of the Food Processing Technology Building and demonstrated research projects to seven school groups, totaling 165 students and teachers. In addition, tours and demonstrations of research activities were provided for more than 30 industry and government groups.



Technical Assistance

Forty-six technical assists were provided to firms and individuals in the poultry industry across the state. These assists included simple inquiries regarding information or help needed to address a problem and extensive on-site consultations in which researchers collected data and provided a full report on their findings and recommendations. The program uses input from all assists to gauge situations calling for new research initiatives.



Categories:

Energy: 8

Environmental: 16

Safety: 8

Workplace Efficiency: 2

Other: 12

Publications and Presentations

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- Stewart, J. Spring 2008. 3D computer vision technology promises to revolutionize process control. PoultryTech. 20(1):5, 8.
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Lee, K.-M. and H. Son. 2007. Equivalent voice-coil models for real-time computation in electromagnetic actuation and sensor applications. Proceedings of the 2007 IEEE/ASME International Conference on Advanced Intelligent Mechatronics. Zurich, Switzerland, September 4-7. ON CD-ROM.

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Lectures and Presentations *(continued)*

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Pierson, J. and A. Giorges. 2008. A storm water BMP case study: TSS vs. fecal update. U.S. Poultry & Egg Association Environmental Management Seminar, Atlanta, GA, March 5-6.

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Invention Disclosures

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Holmes, J. Washdown LED assembly.

Pierson, J. and A. Giorges. Throughput-enhanced photolytic apparatus.

ATRP: Five-Year Plan

The five-year goal of the Agricultural Technology Research Program (ATRP) at Georgia Tech is to provide state-of-the-art applied engineering research and service to the poultry industry. The research program will continue to focus on automation, information technology, environmental, and safety areas, while service activities will continue to concentrate on broad information dissemination and one-on-one general assistance.

Automation/electronics research studies over the next five years will focus heavily on integrated, “intelligent” automation systems. These systems offer major opportunities to further enhance productivity in the poultry industry. They incorporate advanced sensors, robotics, and computer simulation and control technologies in an integrated package and tackle a number of unique challenges in trying to address the specific needs of the industry. Research will also continue in the area of computer vision. As a leader in this exciting research field, the program has already introduced several commercially viable designs. Work has also begun focusing on the emerging areas of stereo 3D, IR, and UV imaging concepts. These technologies, perhaps more than any other, offer the potential to revolutionize the way in which processes are controlled and optimized.

Information technology research studies will continue focusing heavily on streamlining the flow of information among machines, people, and the integrated enterprise. Efforts to work with statistical process control and database management concepts will continue, as will studies to develop practical augmented reality tools capable of simplifying the dynamic transfer of information among production workers, databases, and processing equipment.

Environmental research studies will continue to focus on emerging technologies that help to reduce

water usage and waste generation. Improved recycling technologies, in particular, will continue to be pursued to assist not only in recycling water, but also in recycling marinades, brines, etc., thereby reducing their impact on waste treatment operations. Studies will also continue focusing on enhancing the program’s understanding of how waste is generated and how to more effectively remove it from air and water streams. And finally, efforts will expand into the area of value-added byproduct recovery.

Safety research will continue to take two paths. Personnel safety research will focus on finding new ways to reduce the risk of worker injury. The newly activated worker safety thrust will build on research previously conducted into ergonomic risk quantification. The industry needs a more scientific base for assessing and controlling injury, and the program is committed to helping with this pursuit. Product safety research, on the other hand, will continue to focus on technologies to improve control over process and product quality. The program’s efforts to develop an innovative biosensor have been groundbreaking and are transitioning into exploratory studies designed to use it and other such sensing technologies as screening and control systems for microbial intervention and water recycling processes. Studies will also be pursued into developing advanced x-ray and other screening tools for food safety determination and control.

Finally, ATRP will continue to actively support industry needs through its technical assistance program and will use newsletters, seminars, research reviews, topical reports, research reports, technical papers, and articles in industry trade publications to transfer its research findings and expertise. The program will also work to promote a better understanding of and appreciation for Georgia’s dynamic poultry industry and increasing opportunities for engineering and technical careers in the industry.

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