DURIP: Comprehensive Laser Digitizing System for the Creation of Large Scale, Three-Dimensional Data for Simulation, Analysis and Digital Mock-up

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1. Abstract:

As industry and academia continue to use three-dimensional data to facilitate construction of digital geometry and product inspection and validation, methods of rapidly creating this data are becoming more common. The current state-of-the-art machine for the creation of three-dimensional data is known as a laser digitizer. Recent advances in laser digitizing methods have yielded the capability to capture large-scale regions with extremely high fidelity. This data is currently being used for many applications, ranging from forensic investigation, to very large-scale quality control such as investigation of geometrical deviation on objects such as ships and airplanes.

This DURIP seeks to purchase a comprehensive, large-scale, mobile laser digitizing system to support the mission of the Air Force and DoD through research, industrial, and academic applications. The digitizer will be used by researchers at Mississippi State University to facilitate the rapid creation of virtual environments for digital human modeling applications in support of the Virtual Soldier Research Program. The same environments will be used for local and national law enforcement research efforts to simulate hostile environments and to evaluate and improve officer training. Within the aerospace industry, companies such as Aurora Flight Sciences will have access to this digitizer, allowing them to rapidly validate as-built geometry against three-dimensional design data. This digitizing system will allow academic courses to provide authentic education experiences through hands-on demonstration of large scale laser digitizing, post possessing and data analysis. For example, Architecture students will be able to rapidly digitize plots of land, prior to the design of their buildings. Mechanical Engineering and Industrial Technology students will use the system for large-scale industrial metrology applications, and Industrial Engineering will use the device to digitize manufacturing environments for applications such as discrete event simulation and ergonomics analysis.

2. Budget:

2.2.1 Hardware:

Comprehensive laser digitizing system hardware required to process collect data: $147,750

1. Faro Laser Scanner LS 880
   This system contains the laser, rotating prism, laser phase shift measuring hardware and is the device that performs the measuring.
2. Transport Case and Rucksack for the Laser Scanner LS
   This is a rugged case for safe transportation of the FARO LS 880 system for air or ground transport to remote digitization sites to ensure protection of the hardware.
3. Starter Kit (5 Spheres with magnetic mounts and case)
   These spheres are data points to be included within the scans, allowing the operator to line up scans from different angles to acquire geometry that might be occluded during the initial scan.
4. 5 Year Warranty
   This system is offered with a five year warrantee and protection guarantee. This includes yearly calibration of the system covers parts, machine damage and labor to fix the system.
5. Inclination Sensor
   The inclination sensor automatically levels the scans within 15 degrees. This feature will be very handy while scanning outdoor activity.

6. Carbon Fiber Tripod Set

   A tripod is required to allow the system to rotate to capture a three-hundred and sixty degree scan. A light weight tripod is required to make the system portable.

7. Upgraded Power-User Notebook Computer for Scanner LS

   This laptop workstation has been custom configured by Faro and optimized for FARO Scanner LS products.

8. Battery Kit for LS880, LS Battery and Case, 24V, (approximately 8 hours of battery time).

   This kit is designed to run the FARO Laser Scanner LS 880 without a power network. Additionally, a 24V power outlet, and car adapter according ISO 4165 is included. This system has been designed to facilitate field charging and operation of the system.

9. Mobile LS PDA set, Pocket LOOX N560 from Fujitsu Siemens

   The WiFi interface to remotely control the Laser Scanners LS Windows Mobile®, via wireless LAN / WiFi (802.11 b/g), or Bluetooth V1.2. This will allow the person conducting the scan to stand out of the field of view of the scanner, so that their geometry is not accidentally captured, thus increasing post-processing time.

10. Camera (NIKON D200) and mount for the digital camera.

    This addition will enable the Faro LS 880 to capture parallax free colored laser scans. Color is required to create high fidelity visualizations required for our research applications. Included is the Camera (NIKON D200) with an AF DX Fisheye 10.5mm lens and a 1GB CompactFlash Card Ultra II and a rechargeable battery, transport Case and bracket to mount the digital camera to the FARO Laser Scanner LS.

2.2.2 Software:

Software and Integrations required to process data collected: $28,490

The custom FARO Technologies software provides powerful tools for administration for the LS system and for displaying, analyzing, and editing of the 3D measurement data collected as huge point clouds. The software also includes capabilities for registration of multiple point clouds for LS systems, which is useful for digitizing very large environments.

1. FARO Scene Software

   This is the software that the Faro LS 880 laser digitizer uses to quickly capture three-dimensional environment data.

2. FARO Record Recording software

   Faro Record allows the user to measure between points in the scan, apply color to the scan and apply advanced features of the scanner, such as partial angle scans.

3. Faro Cloud for AutoCad Interface for AutoCad for LS systems.

   Faro Cloud is an AutoCAD interface allowing the researcher the capability to interface with the industry standard CAD package, AutoCAD.

4. 5 Years - licensing for FARO Scene
   Faro has included five years of licensing support for the LS 880, to accompany the included five years of hardware warrantee.
5. Onsite Training for up to 10 People
   Included in this price is training for up to 10 people to use this comprehensive digitizing system. This training will ensure that operators of this equipment do so in a manner that is safe and appropriate for the equipment. Training will also ensure that researchers use the system efficiently and appropriately. Our collaborators will be included in this training.

2.2.3. *University Discount -* $29,450

To support this DURIP, Faro Technologies has agreed to discount the system by 29,450.00, which is slightly more than the cost of software and training.

2.2.4. *Total funding this DURIP seeks:* $146,790

Subtotal before discount: $176,240

Other funds to be used: $0

Discount: ($29,450)

Subtotal after discount**:** $146,790

Shipping and Handling: $0

3. Supporting Information:

Researchers within multiple departments and colleges will use this digitizing system to assist with their research. Mississippi State University has a rich history of three-dimensional simulation, as evident with our highly successful Engineering Research Center, established by The National Science Foundation in the late 1980s with a focus in computational fluid dynamics. This research center has expanded into the High Performance Computing Collaboratory (www.hpcc.msstate.edu), with a broader mission of computing support, simulation and analysis as it applies directly DoD, industry and academia through its rapidly expanding member centers.

3.1. Interfacing with Existing Facilities and Upgrading Capabilities:

There are currently two laser digitizing systems (A Creaform Handiscan, and a 6 foot, Faro Arm Platinum, augmented with a laser line probe) at Mississippi State University. Each is located within the Center for Advanced Vehicular Systems, each of which has limitations. The Faro Arm with its laser line probe is very accurate but slow, and studies have illustrated poor ergonomics while using the system (Littell, 2007). The Creaform Handiscan is faster (marginally), but its effective capture volume is the same as the Faro Arm. Each of these digitizers is useful for scanning small objects at very high resolution, that is, to 30 microns. However, efficient and effective large scale digitizing is far beyond the capabilities of these devices. The amount of effort and training required to use each of these systems seriously handicaps academic use of this equipment. The proposed laser digitizing system augments these digitizers by allowing researchers, students and industry professionals to capture areas in minutes that would literally take months to digitize by one of these other methods.

While these digitizers utilize camera triangulation to capture points (~250 per second under optimal conditions) as a laser stripe is dragged across the surface of the geometry of interest, the system we are requesting digitizes much more efficiently. A single, eye-safe, laser beam is shot at a rotating prism which directs the laser beam outwards towards the environment or object to be digitized. As the prism rotates along the X-axis of the machine, three-dimensional points are calculated as the laser hits the surface of an object, bounces back and the distance is recorded. The entire scanner automatically rotates about the Z-axis of the machine, allowing the scanner to digitize three-hundred and sixty degrees, truly capturing the volume of an area. The proposed system has an effective radius of 76 meters, a worst case accuracy of +- 3 mm, and is capable of accurately measuring and capturing 120,000 points per second. The system works by calculating the three-dimensional coordinates of points through the accurate combining of three different measured laser phase shifts (1.2m, 9.6m and 76m) with respect to prism and device rotation as illustrated in figure 1. When used with a digital camera (NIKON D200), the end result is a full color, 8 megapixel, three-dimensional environment, suitable for multiple applications, including simulation, analysis, and digital mock-up.

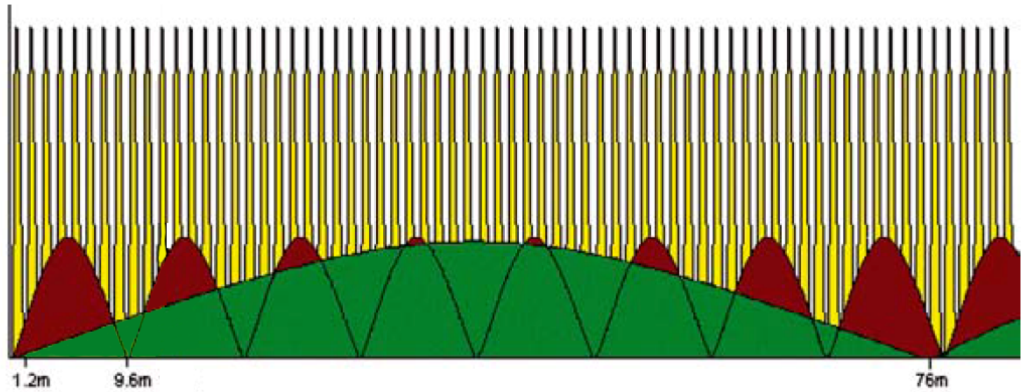

Figure 1: The Faro LS 880 Scanner calculates 120,000 three-dimensional points per second over 152 meters by combining three different phase shifts measured from the reflected laser.

The traditional use of this laser scanner is for creating high fidelity computer models for inspection, reverse engineering, or analysis. Nuclear power facilities use this scanner to digitize pipes to compare against datum scans. Through comparing scan data to this datum, weak pipes can be identified and repaired before they break. Cruise ship companies typically purchase their ships already built. As such, they are not provided blueprints of their ship. Through use of a digitizer such as this, they are able to scan their ships so that they can reverse engineer the existing geometry for future customization. A few privileged law enforcement agencies have used this scanner to digitize crime scenes for investigation and litigation purposes. The funding of this DURIP will allow agencies near Mississippi State University access to this resource to assist with the successful prosecution of criminals.

The Center for Advanced Vehicular Systems has a well established track record for small scale, accurate laser metrology. Laser digitzers are used at the center weekly in support of multiple projects. The faculty staff and students at Mississippi State University have used both of these systems in the past for special projects within academic courses (EG 3113 CATIA V5 Solid Modeling, TKI 3343 CAD/CAM, and various independent projects). However, the current available systems are not fast enough to allow each student to access them within the time span allotted to a typical academic course. The proposed system is fast enough to allow students the opportunity to explore state-of-the-art laser metrology, the data that is produced, and application of that data for visualization, analysis and simulation during one academic semester. Additionally, as this system is portable, and compact. Space provisions have already been made to house this digitizing system, workstation and accessories within the PI’s office at the Center for Advanced Vehicular Systems. The estimated useful life of this equipment is between 10 and 12 years according to the equipment manufacturer: Faro.

3.1.1. HPCC Research: (www.hpcc.msstate.edu)

Research within the Computational Simulation and Design Center at the High Performance Computing Collaboratory is focused on high-resolution dynamic simulation of complex flow fields for real-world physical systems. The comprehensive digitizing system proposed within this DURIP will complement this research by enabling the rapid, high quality capture of three-dimensional geometry and eliminating or greatly reducing the amount of pre-processing required to format three-dimensional geometry in a manner that is suitable for simulation and analysis.

Research within the Center for Advanced Vehicular Systems will be facilitated by allowing researchers to rapidly capture geometry of vehicles such as cars for applications such as virtual crash test (via finite element analysis), and analysis of weight-reducing designs for military vehicles through computational optimization.

3.1.2. Architecture and the Design Research and Informatics Lab Research:

Educators and students within the department of Architecture which is located in the College of Architecture, Art and Design (http://www.caad.msstate.edu/sarc/) will have access to this rapid digitizing system to assist with research within the Design Research and Informatics Lab (DRIL) and for their design projects. For example, three-dimensional scans of plots of land could be provided for students to use when designing their buildings. Researchers within DRIL (http://www.dril.sarc.msstate.edu/home.html) will use this system to digitize existing large scale geometry, such as buildings within neighborhoods to assist with their research.

3.1.3. Education:

The educational applications of this DURIP are multifaceted, spreading across three colleges within Mississippi State University, and multiple departments. The academic need for three-dimensional data is growing, as universities strive to provide authentic education experiences to students using state-of-the-art technology. As industry and the military advance towards a digital mock-up methodology for product design and evaluation, the need becomes ever more pressing to imprint these methodologies on students. Considering the extensive applications of three-dimensional data, many students, researchers and educators will use this system or data generated from this system to provide hands-on educational experiences for real-world applications.

3.1.3.1. Industrial Engineering:

The department of Industrial Engineering at Mississippi State University uses three-dimensional data for manufacturing analysis and simulation. Examples of this include discrete event simulation, and ergonomics analysis. Discrete event simulation is the statistical modeling of the manufacturing process and variations associated with that process. These simulations are used by industry to predict problems with manufacturing processes as they occur over a long period of time, or to manipulate the manufacturing process to make it more efficient. Ergonomics analysis is used to evaluate how dangerous a particular manufacturing task is to the human performing the task over time. Both of these types of analysis require the construction of a digital model of the manufacturing facility. Traditionally, this model has been greatly simplified; however, the equipment requested in this proposal will allow researchers to perform their simulations within high fidelity digital environments captured directly from the actual working conditions that are being studied. This increase in simulation resolution will facilitate future advances in human centered research, and empower U.S. manufacturers to stay competitive within a global economy.

3.1.3.2. Industrial Technology:

The Industrial Technology department in the College of Education also works with three-dimensional models and undertakes motion and time studies for industry. This tool will greatly enhance the education of technologists especially in plant layout and areas of workstation design. Also, the department works with manufacturers on cost modeling and CNC machining. This tool will help in the reverse engineering of large parts for part programming and for reducing costs by developing unique tooling solutions for these components to enable single set-up machining. This is part of the CADCAM course TKI 3343 taught in the department. This tool will also benefit new local industry such as Paccar who manufacture large truck engines for companies such a DAF, Peterbilt and Kenworth. This facility will enable the company to see how their expensive castings are deforming through both age and vibratory stress relief processes as they transported from the foundry to their machining plant. This links in with Industrial Technology’s research area of residual stress determination and how to alleviate the manufacturing problems caused by these stresses. It will also enable work to be undertaken in the area of work holding as this will enable the jigs and fixtures to be designed to compensate for any detrimental deflections which could cause possible workpiece distortion.

The comprehensive digitizing system proposed will not only impact research and academia, but industry in and around Starkville, MS will have access to the equipment for their purposes as well. As manufacturers develop goods with advanced features with compressed timelines for production, inspection becomes of vital concern.

3.1.4. Aurora Flight Sciences:

Aurora Flight Sciences is a Department of Defense contractor, who specializes in the design, prototyping and manufacture of specialized unmanned aircraft. Aurora will have reasonable access to this digitizing system to digitally inspect their as-built geometry against design geometry. Students at Mississippi State University could be used to assist with this, or a representative of Aurora could request use of the system based upon their requirements which would be met according to the availability of the system. Aurora has been very responsive to working with Mississippi State University in the past, and the funding of this DURIP will extend this relationship.

3.2. Enhancing Current DoD Research:

3.2.1. Project: Human Performance Modeling for the Virtual Soldier

Source: **US Army/TARDEC**
Contract Number: **Prime Award No. DAAE07-03-D-L003/002, UI Award No. W000060722 07060578**
PIs: **Zack Rowland (PI), John McGinley, Daniel Carruth, Gary McFadyen, Kari Babski-Reeves**

The Center for Advanced Vehicular Systems is currently working with the University of Iowa and TACOM on the Virtual Soldier Research (VSR) program. Computer-aided design and computer-aided engineering software have provided product designers and engineers with powerful tools for constructing and evaluating the physical characteristics of products. Today's commercially available tools have limited capabilities to consider the role of the human user in the evaluation of new products and workspaces. The VSR program intends to give the US Army improved capabilities through the development of a next-generation digital human model capable of simulating physical and cognitive aspects of human performance in virtual environments.

As part of the VSR program, CAVS researchers are developing computational models that will allow human factors designers and ergonomists to computationally predict and evaluate human interaction with virtual prototypes of products and workspaces. The models under development at CAVS integrate state-of-the-art models of human posture and motion from the biomechanics and ergonomics domains with models of human cognition from the cognitive science and computer science domains. These integrated models allow a digital human model to predict the physical and mental aspects of human interaction with virtual prototypes. When simulating human performance, it is not enough to have an accurate model of human motion or cognition. Human performance is a function of a human’s physical and mental capabilities and the environment in which the human is performing the task. In order to accurately model human performance, the environment must be represented as accurately as possible.

To date, environments for the Center for Advanced Vehicular System's efforts for the VSR program have been generated from AutoCAD drafts of buildings, manual measurements of buildings, and 2D blueprints. Objects within the environments are modeled from manual measurements or 3D scans using the two currently available laser digitizing systems (a Creaform Handiscan, and a 6 foot, Faro Arm Platinum, augmented with a laser line probe). Construction of virtual environments from real-world environments can be slow and tedious, especially when manual measurements of the environment are required. The accuracy of 2D blueprints and AutoCAD drafts are questionable as changes are often made during or after the construction process and may not be reflected in the source materials.

The Faro LS scanner will significantly reduce the time required to generate accurate 3D geometry in comparison to any of our current methods. Researchers will use the Faro LS Scanner to create 3D geometry of real-world industrial, military, and general locations for use with the digital human model. By easing the process of environment generation, many complex and realistic environments can be created. The digital human model can be developed and validated for a wider range of tasks and environments improving its usefulness for both military and industrial uses.

3.3.1. Project: Video Game Environments for Spatial Training

Source: **Internally Supported**
PI: **Daniel Carruth**

In addition to directly supporting DoD research activities, this digitizing system will support current efforts in human factors and ergonomics research for the law enforcement community. Researchers at CAVS are currently exploring the possibility of using video game environments as a tool for patrol and tactical team officers to learn the spatial layout of public buildings that may be potential targets for active shooters. The goal of the project is to determine whether digital recreations of real-world buildings can be used to give police officers detailed knowledge of the size and positions of hallways, rooms, doors and windows. This type of tactical knowledge could be very beneficial if officers were required to respond to an active shooter event. In many cases, the locations that are most vulnerable to active shooters are the locations that law enforcement and special weapons and tactics teams are least likely to have access to for practice. Recent infamous examples include the Virginia Tech, Pearl high school, and the Utah Mall Shooting. These public locations are not often accessible to law enforcement officers for intensive, realistic training. By recreating these types of locations in video game environments we hope to allow law enforcement officers to gain some of the benefits without the disruptions of on-site training. These virtual environments will be available for solo and team training 24 hours 365 days a year. No real-world training can match this availability.

However, for training to be effective, the virtual environments in the video game must accurately represent the real-world locations. Currently, the researchers at CAVS are constructing environments through one of two methods: hand-measuring real-world locations and manually re-creating the geometry in a game editor or constructing geometry in a CAD editor from 2D blueprints. Both methods have significant issues. While measuring the real-world location by hand ensures that the model accurately represents the site, the effort is time consuming and requires free access to the location for many days. Due to human error, the site must often be revisited during the geometry construction process to verify or correct measurements. Working from blueprints allows researchers to avoid disrupting normal operations at the real-world location but blueprints are often not true representations of the physical reality at the site. Especially in older public buildings, modifications that would impact law enforcement movements may have been made without updating the available blueprints for the location.

The comprehensive environment scanning system proposed will allow the researchers at CAVS to swiftly scan public buildings to construct accurate 3D models that can easily be imported into video game software as training environments. The scanner system will improve our ability to test the effectiveness of video game software as a training tool for law enforcement and may ultimately improve law enforcement’s ability to respond to active shooter and terrorist events. This same training capability may be of interest to DoD for use in training shipboard firefighting techniques, MOUT operations, and more.

4. Additional Notes:

The instrumentation of the Faro LS scanner will enable researchers, educators and students at Mississippi State University to rapidly reproduce three-dimensional geometry. The uses of this comprehensive three-dimensional laser digitizing system are many, and the impact of this DURIP will be felt by many people, including faculty, staff and students within Mississippi State University, the local community and, hopefully, the nation as a whole. Faculty will use the data generated by this scanner to perform ergonomic validation of task, authenticate geometry through advanced analysis such as CFD and FEA, and create digital environments to validate the performance of next generation digital human models. Industry will have access to this system to validate as built geometry against their design geometry, and local law enforcement will be able to digitize crime scenes for analysis and litigation. Students of Mississippi State University will work side by side with professionals armed with state-of-the-art hardware and software to experience modern methodologies of inspection and visualization while they develop an appreciation for virtual analysis and simulation that is involved large scale product design and evaluation.

5. Reference:

1. Littell, N., Babski-Reeves, K., McFadyen, G., & McGinley, J. (2007). Musculoskeletal and performance effects of monocular display augmented, articulated arm based laser digitizing. *Human Computer Interaction International 2007*, Bejing, China: LNCS Digital Library (LNCS, http://www.springer.com/lncs).

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A. Education

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Bachelor of Science, Industrial Technology, Mississippi State University, 2003
Bachelor of Science, Trade and Technical Studies, Mississippi State University, 2003
Associate of Applied Science, Drafting and Design, Holmes Community College, 2001

B. Positions and Employment

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06/03 – 06/04	Graduate Research Associate, Center for Advanced Vehicular Systems, at Mississippi State University, 200 Research Boulevard, Starkville MS 39759
06/03 – 06/04	Graduate Teaching Assistant, Department of Instructional Systems, Leadership and Workforce Development, Mississippi State University, PO Box 9730 MS 39762
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C. Publications & Patents

1. Littell, N., Babski-Reeves, K., McFadyen, G., & McGinley, J. (2007). Musculoskeletal and performance effects of monocular display augmented, articulated arm based laser digitizing. *Human Computer Interaction International 2007*, Bejing, China: LNCS Digital Library (LNCS, http://www.springer.com/lncs).
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2002 – 2003	Research Assistant, Skill Acquisition Lab, Department of Psychology, Mississippi State, MS 39762

C. Publications

1. Carruth, D.W., & Littell, N. (2007). Leveraging CATIA V5 and Virtools for Environment Simulation . COE 2007 Annual PLM Conference & TechniFair, Las Vegas, Nevada.
2. Carruth, D.W., Thomas, M., Robbins, B., & Morais, A. (2007). Integrating Perception, Cognition, and Action for Digital Human Modeling. Proceedings of HCI International 2007, Beijing, China.
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D. Research Support

Human performance modeling for the Virtual Soldier
U.S. Army NAC-TARDEC
2006-2007
Role: Co-Principal Investigator

Law Enforcement Research Initiative
Center for Advanced Vehicular Systems (Internal Funding)
2006-2007
Mississippi State University
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A. Education

10/94 – 03/02 PhD Awarded Southampton Institute College of Technology
High Speed Face and End Milling of Stainless Steel Grades

10/94 – 06/95 Post Graduate Diploma in Research Techniques
Southampton Institute College of Technology
The PGDip Res is a prerequisite preparation for PhD research in the UK. The curriculum included an appreciation of other research techniques including quantitative and qualitative research methodologies.

09/91 – 06/94 BEng (Hons) Engineering & Business Southampton Institute College of Technology
This curriculum combined aspects of manufacturing engineering with business activities such as marketing, law and accountancy. My final year project was a company based analysis of how cellular manufacture and group technology could help to improve the way a valve actuator company manufactured its products.

09/85 – 06/87 Southampton Institute
Higher National Certificate Mechanical & Production Engineering

09/83 – 06/85 Southampton Technical College
Ordinary National Certificate Mechanical Engineering

B. Employment History

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06/98 – 07/02	Research Associate Aerospace Manufacturing Research Centre (AMRC), University of the West of England, Bristol, BS16 1QY
10/94 – 03/2	Research Student PhD High Speed Face & End Milling of Stainless Steel Grades Southampton Institute, Systems Engineering Faculty, Southampton, SO14 0YN
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C. Publications & Patents

1. Wyatt J.E. Berry J.T. Westfall A.H. (2007) Residual Stress Mapping of Abusively Machined Surfaces, Submitted to the ASME Journal of Engineering Materials and Technology

2. Wyatt J.E. Berry J.T. Williams A.R. (2007), Residual Stresses in Aluminum Castings, Journal of Materials Processing Technology, (191) pp. 170-173

3. Wyatt J.E. Berry J.T. Williams A.R. (2007) Measurement of Superficial residual Stresses In The Casting Of Aluminum Alloys Using a New Low-Cost Technique, Transactions of the American Foundry Society, Vol. 115 May

4. Wyatt J.E. Trmal G.J. (2006) Plunge Cut Grinding Simplified: An Illustrative Student Experiment, Journal of Industrial Technology, Volume 22 No. 3, July through September

5. Wyatt J.E. Trmal G.J. (2006) Machinability: Employing a Drilling Experiment as a Teaching Tool, Journal of Industrial Technology, Volume 22 No. 1, January through March

6. Wyatt J.E. Berry J.T. (2006) A New Technique for the Determination of Superficial Residual Stresses Associated with Machining and Other Manufacturing Processes, Journal of Materials Processing Technology, Vol. 171, pp. 132 – 140

7. Smith G.T. Wyatt J.E. (1999) Ultra High Speed Face Milling, Metalworking Production, May, pp. 37 & 38

8. Berry J.T. Wyatt J.E. (2005) A Low Cost Method for Determining Superficial Residual Stresses as Applied to Machined Surfaces, US Patent No. 6,934,642, Issued August 23rd

Aurora FLIGHT SCIENCES

August 21, 2007

Gregory A. Stewart
General Manager
Aurora Flight Sciences, Mississippi
2502 Airport Road
Columbus, MS 39701

Dr. Spencer Wu and reviewing panel members
AFOSR
875 North Randolph Street
Suite 325, Room 3112
Arlington, VA 22203 -1768

Dear Dr. Wu and reviewing panel members,

The laser digitizing system outlined in the DURIP "Comprehensive Laser Digitizing System for the Creation of Large Scale, Three-Dimensional Data for Simulation, Analysis and Digital Mock-up" would significantly augment the capabilities of Aurora Flight Sciences, Mississippi.

The abilities to rapidly inspect both as-built aerospace components against three-dimensional design geometry and inspect existing hardware to create representative three-dimensional models are fundamental to our mission of supporting DoD and aerospace contractors through the design, prototyping and building of next generation unmanned and manned aircraft.

If this DURIP is successful, The Center for Advanced Vehicular Systems has agreed to provide us with both training for and access to this system to help fulfill our three-dimensional inspection needs if the system is not in use by the university.

We see this as a key opportunity to further build the relationship between Aurora Flight Sciences, the students of Mississippi State University and the Center for Advanced Vehicular Systems.

Regards,

Gregory A. Stewart

General Manager

Mississippi State University

DEPARTMENT OF INSTRUCTIONAL SYSTEMS, LEADERSHIP, AND WORKFORCE DEVELOPMENT
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Dr. John Wyatt
ISLWD
Box 9730
Mississippi State University
MS 39762
August 21, 2007

Dr. Spencer Wu
Suite 325, Room 3112
875 N. Randolph St.
Arlington, VA 22203.

Dear Dr. Wu

I am writing to you in support of the DURIP proposal from Mississippi State University's Center for Advanced Vehicular Systems (CAVS). As the coordinator for the Industrial Technology program I feel that the addition of the FARO LS 880 laser scanning system will be of tremendous benefit not only to the research community here at MSU but to the teaching area and local industry.

I am currently developing a course in metrology for Industrial Technology students and this equipment will greatly enhance the curriculum. Also, the students undertake time and motion studies for industry which leads to better plant layout and the design of more efficient and ergonomically improved workstations. This equipment will allow for the managers at these plants to see where the changes have to be made in their plants with ease. The LS 880 will also be incorporated into the TKI 3343 CADCAM class taught in the department in the area of reverse engineering.

With regard to local industry this tool will help the new industries coming into Mississippi in allowing for previous plants to be modeled and then built here on green field sites to allow for the simple transition from plant hand off into manufacturing. This tool will also help in the reverse engineering of large parts for part programming and for reducing costs by developing unique tooling solutions for these components to enable single set-up machining.

This tool will also benefit new local industry such as Paccar who manufacture large truck engines for companies such a DAF, Peterbilt and Kenworth. This facility will enable the company to see how their expensive castings are deforming through both age and vibratory stress relief processes as they transported from the foundry to their machining plant. This links in with Industrial Technology's research area of residual stress determination and how to alleviate the manufacturing problems caused by these stresses. It will also enable work to be undertaken in the area of work holding as this will enable the jigs and fixtures to be designed to compensate for any detrimental deflections which could cause possible workpiece distortion.

This piece of equipment is vital to the newly emerging hi-tech companies that are coming into Mississippi and I hope that this proposal comes to fruition. If you have any questions then please contact me.

Yours faithfully

John Wyatt
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e-mail wyatt@colled.msstate.edu

Mississippi State University

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Dr. John Berry
Mechanical Engineering
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August 21, 2007

Dr. Spencer Wu
Suite 325, Room 3112
875 N. Randolph St.
Arlington, VA 22203.

Dear Dr. Wu

I am happy to recommend for funding the DURIP proposal concerning the purchase of a laser digitizing system for creating large 3-D images which will greatly enhance MSU's Center for Advanced Vehicular Systems (CAVS) capabilities in the areas of plant design, human factors design and ergonomics as applied to both industrial and defense related areas.

A particular potential application where this system would be invaluable is to the CAVS effort related to the US Army's Virtual Soldier Research (VSR) program.

A second potential application, which has both research and training ramifications, is the use of such a system in the manufacture of large commercial vehicles, both in terms of in-process inspection and power train installation. This will be especially relevant to the new PACCAR plant currently building near MSU. (PACCAR manufacture Peterbilt and Kenworth brands in the US, and DAF in Holland).

The opportunity for our Mechanical Engineering students to participate in projects related to these topics would be extremely worthwhile and would provide them with hands-on experience involving state-of-the-art imaging equipment.

I make the recommendation without reservation.

Yours sincerely

John T Berry

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COLLEGE OF
ARCHITECTURE
ART + DESIGN

SCHOOL OF ARCHITECTURE

Dr. Larry Barrow, Anijo Mathew, Sarah Pittman
Design Research & Informatics Lab (DRIL)
College of Architecture, Art & Design (CAAD)
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Mississippi State, MS 39762

Dr. Spencer Wu and reviewing panel members
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Dear Dr. Wu and reviewing panel members,

This is a letter of support for the DURIP entitled "Comprehensive Laser Digitizing System for the Creation of Large Scale, Three-Dimensional Data for Simulation, Analysis and Digital Mock-up." The system outlined in the proposal will significantly impact the capabilities of the Design Research & Informatics Lab (DRIL) as well as the School of Architecture. The ability to rapidly digitize large complex geometries will allow Mississippi State University Architecture students to examine digital buildings through realistic simulation, adapt design projects to fit allotted space with respect to surrounding buildings, and evaluate as-built buildings against their designs. This technology will enable advanced visualization for human interaction within virtual environments, and it will allow our students the opportunity to experience state-of-the-art instrumentation, software and methodologies for modern engineering.

Best wishes,

Dr. Larry Barrow
Director Design Research & Informatics Lab (DRIL)

Anijo Mathew
Assistant Professor

Sarah Pittman, M.C.S.E.
Architecture Graduate Coordinator
DRIL Projects Manager