

Proceedings

ASPE 2007 Annual Meeting

October 14-19, 2007



Proceedings of:

The Twenty-second Annual Meeting

The American Society for Precision Engineering

October 14-19, 2007

The Fairmont Dallas Hotel

Dallas, Texas

The American Society for Precision Engineering (ASPE) is a multidisciplinary professional and technical society concerned with research and development, design, manufacture and measurement of high accuracy components and systems. ASPE activities encompass relevant aspects of mechanical, electronic, optical and production engineering, physics, chemistry, and computer and materials science. Membership is open to anyone interested in any aspect of precision engineering.

Founded in 1986, ASPE provides a new focus for a diverse but important community. Other professional organizations have covered aspects of precision engineering, always as a sideline to their principal goals. ASPE is based on the core of generic concepts necessary to achieve precision in any application; independent of discipline, ASPE intends to be the focus for precision technology — and to represent all facets from research to application.

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Preface

This book comprises the proceedings of the 2007 Annual Meeting. The contributions reflect the authors' opinions and are published as presented to ASPE, without change. Their inclusion in this publication does not necessarily constitute endorsement by the ASPE, or its editorial staff.

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2007

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Raleigh, NC 27603*

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Welcome Note

Welcome to Dallas for the Twenty-second Annual Meeting of The American Society for Precision Engineering. The growth and success of the Society reflects the increasing importance of precision engineering in a wide variety of fields, from manufacturing to microelectronics to basic science. The Society serves as a focus for precision engineers across all of these fields. The Annual Meeting has evolved into a premier international forum for the exchange of ideas and presentation of research results relating to precision engineering, metrology, controls, and system integration. Precision engineers and scientists from private industry, government laboratories, and universities meet to learn about the latest developments and to exchange ideas about the future directions of these technologies.

This year's meeting continues the tradition of offering two full days of tutorials presented by some of the foremost precision engineers and scientists in the world. The technical sessions and poster presentations offer the latest research results in the areas of ultraprecision machining, metrology, controls, precision grinding, micro-positioning, material processing, design, precision transducers, surface profilometry, and error compensation. The commercial exhibits will provide attendees with the opportunity to view and discuss the latest precision engineering equipment, products, and services that are commercially available.

The conference organizing committee is proud to present the program for the Twenty-second Annual Meeting of the ASPE. We welcome your participation and your feedback on how to make next year's meeting even better.

2007 Organizing & Technical Program Committee

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North Carolina State University, Conference Chair

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2007 Scholarship Recipients

*Mr. Abdallah H. Alkhaleel, University of Nebraska-Lincoln
R.V. Jones Memorial Scholarship*

Mr. Nicholas Jay Ferrell, The Ohio State University

Mr. Nathan A. Mauntler, University of Florida

Program

2007 ASPE Annual Meeting

Time	Sun., Oct. 14	Mon., Oct. 15	Tues., Oct. 16	Wed., Oct. 17	Thurs., Oct. 18	Fri., Oct. 19
8:00	Registration		Early Coffee and Registration			
9:00	Tutorials	Tutorials	Technical Session I	Technical Session III	Technical Session VI	Technical Tour #1
10:00			Break	Break	Break	
11:00			Technical Session II	Technical Session IV	Technical Session VII	
12:00			Lunch and Committee Meetings	Awards Lunch and Business Meeting	Lunch and Open Forum	
1:00						
2:00	Tutorials	Tutorials	Commercial Session	Technical Session V	Technical Session VIII	Technical Tour #2
3:00			Break	Break		
4:00			Poster Session	Poster Session		
5:00			Hospitality Hour	Hospitality Hour		
6:00		Welcome Reception				
7:00		Keynote Address		Open Evening		
8:00			Dinner Banquet at American Airlines Museum			
9:00						

 **Exhibit Open Hours**

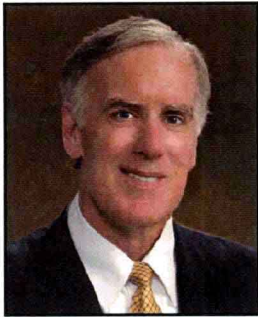
Keynote Address

C. T. "Tom" Burbage

Lockheed Martin Aeronautics Company

Monday, October 15, 7:00 p.m.

Session Chair: Alex Sohn, North Carolina State University



C. T. "Tom" Burbage

Tom Burbage is the Executive Vice President and General Manager, Joint Strike Fighter Program Integration. He is responsible for developing and implementing the multi-national F-35 Production and Global Sustainment elements of the JSF Program. He was the Executive Vice President and General Manager, Joint Strike Fighter from August of 2000 until assuming his current assignment in November Of 2004.

Mr. Burbage joined Lockheed Martin in 1980 in the business development branch and later became manager of business development for U.S. government programs at the Lockheed California Company operations in Burbank, California. In December 1987, he was appointed vice president for Washington operations and coordinated the company's relationships with the Department of Defense and the U.S. Congress, as well as the embassies of foreign governments. He restructured and streamlined the Washington Operations group and recorded the highest annual performance in the Congressional budget cycle in the history of LM Aeronautics. He then moved to Marietta, Georgia, in 1990 as vice president for Business Development and Product Support at Aeronautical Systems. During his tenure, LM Aero launched several new initiatives including C-130J, C-27J, C-5AMP and RERP.

After receiving a bachelor's degree in aerospace engineering from the U.S. Naval Academy in 1969, Mr. Burbage served on active duty in the United States Navy until 1980, achieving the rank of lieutenant commander. After completing the U.S. Navy Test Pilot School in 1975, he accumulated more than 3,000 hours in 38 different types of military aircraft. On October 31, 1994, he retired from the Navy Reserves as a captain. Mr. Burbage also holds master's degrees in aeronautical systems and business administration.

F-35 – A Product of Precision Engineering

F-35 is a 5th generation fighter with mission requirements generated by three U. S. Military services and eight International partners. Its stealthy design dictated a higher level of external surface smoothness than legacy aircraft which required increased precision in tooling and detail part fabrication. In addition, parts, components and systems are designed and produced by a global supply chain which also demanded precision in design and manufacturing to insure assembly ease and accuracy. When we reach rate production, we will be moving parts throughout the world with multiple sources of major subassemblies feeding multiple Final Assembly lines overlayed by a Performance Based Logistics Sustainment environment. Also, with affordability being a pillar of the program, product cost was a driver in design and manufacturing. In order to meet all of these requirements we use:

- A common digital database shared among all partners and subcontractors
- Automated processes for part fabrication
 - Auto drillers
 - Auto machining
 - Laser control
 - Automated Fiber Placement
 - Precision milling machine
 - Laser ultrasonic inspection
- Automated aircraft finishing
- Automated precision assembly
- Moving Line Assembly Process
- Electronic Mate and Assembly System (EMAS)

The result of using these increased precision tools and processes has already been shown in the design, fabrication and assembly of the first F-35 aircraft.

- Part quality is significantly improved over legacy programs
- Part non conformances are greatly reduced over legacy programs
- Major assembly span time is significantly reduced over legacy programs
- Affordability of part fabrication and assembly is significantly improved

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<i>AMETEK Precitech, Inc.</i>	<i>Moore Tool Company, Inc.</i>
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<i>MicroFab Technologies, Inc.</i>	<i>Veeco Instruments, Inc.</i>

Commercial Session

Tuesday, October 16, 1:30 - 3:00 p.m.

*Session Co-Chairs: John Casstevens (Dallas Optical Systems, Inc.)
and Jerald L. Overcash (University of North Carolina at Charlotte)*

The Commercial Session will take place early in the week on Tuesday afternoon. This is a special session where companies and participants are free to open discussions on a less-formal basis and to promote interaction on a variety of topics. In the first part of this session, company representatives are invited to make brief presentations (five minutes) on new products associated with precision engineering. This provides participants with the opportunity to receive timely information on new technologies that have been commercialized into products and services, as well as information on advances that can be expected in the near future.

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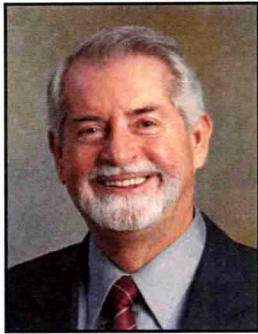
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2007 Annual Meeting

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2007 ASPE Lifetime Achievement Award



E. Clayton Teague

Clayton earned B.S. and M.S. degrees in physics from the Georgia Institute of Technology and a PhD, also in physics, from the University of North Texas. His doctoral work was completed at the National Bureau of Standards (now the National Institute of Standards and Technology), which Clayton joined in 1972. Clayton's PhD thesis on metal-vacuum-metal electron tunneling was groundbreaking work, demonstrating for the first time several basic phenomena that underlie the present widespread use of scanning tunneling microscopes. His thesis provided some important physical concepts that lead to the realization of atomic resolution via the Scanning Tunneling Microscope for which G. Binnig and H. Rohrer received the 1986 Nobel Prize.

At NBS/NIST, Clayton made major contributions to surface microtopography measurement, including the development of a new series of sinusoidal profile roughness artifacts, available today as NIST Standard Reference Materials. He also developed new experimental and theoretical techniques for the measurement of surface roughness using light scattering. Clayton's long interest in, and deep understanding of, the fundamental concepts that underlie the design of precision instruments culminated in the building of the NIST Molecular Measuring Machine. This machine has demonstrated the ability to image atoms and to reposition and measure coordinate positions to nanometer-scale uncertainties over areas of square centimeters - a combination of capabilities achieved by few other instruments in the world.

During his years at NBS/NIST, Clayton assumed positions of increasing technical leadership and responsibility, serving as Group Leader in Nanoscale Metrology and subsequently as Chief of the Manufacturing Metrology Division in the Manufacturing Engineering Laboratory. His technical efforts in nanoscale science and technology, precision engineering and surface metrology have resulted in more than 70 authored or coauthored papers, over 75 invited talks, and 12 keynote lectures.

In 2003, Clayton Teague was appointed as the Director of the National Nanotechnology Coordination Office (NNCO). The NNCO provides technical and administrative support to the Nanoscale Science Engineering and Technology Subcommittee and serves as the point of contact on Federal nanotechnology activities for regional, state and local nanotechnology initiatives, government organizations, academia, industry, professional societies and others.

Clayton Teague is a Charter Member of ASPE and played a leading role in the founding of the Society in 1985. He served as first Chairman of the Board of Directors and later served a term as President. He was instrumental in the development of ASPE's Annual Meeting tutorial series and for many years taught a highly-successful, very well attended tutorial on the basic concepts of precision instrument design. For ten years Clayton was Editor-in-Chief of the international journal Nanotechnology. For this service, and for his technical contributions to the field of nanotechnology, he was elected a Fellow of the UK Institute of Physics. Among his many awards are US Department of Commerce Gold and Silver Medals and the DOC/NIST Allen V. Astin Measurement Science Award. In addition, Clayton received the Kilby International Award from the Kilby Awards Foundation, and an IR-100 Industrial Research and Development Award.

Technical and Poster Sessions Index

The technical program of the 2007 ASPE Annual Meeting contain 123 papers on precision engineering advances. Papers that lent themselves to significant verbal interaction, concise but important discoveries, or strongly visual or tactile subjects have been selected for the poster presentation. Authors will be in attendance to discuss their work on Tuesday, October 16, and Wednesday, October 17, from 3:30 to 5:00 p.m.

Session I

Machine Design I

Tuesday, October 16, 2007, 8:30 am - 10:00 am

Session Chair: Keith Carlisle (Lawrence Livermore National Laboratory) and Eberhard Bamberg (University of Utah)

- 1. Water Hydrostatic Bearings for Precision Machine Tools and Industrial Machinery (Invited Paper)**
Slocum, A. H. (Massachusetts Institute of Technology) page 13
- 2. Comparing the Thermo-mechanical-behavior of Machine Tool Frame Designs Using a FDMFEA Simulation Approach**
Mayr, J.; Weikert, S.; Wegener, K. (Swiss Federal Institute of Technology) page 17
- 3. Instrumented Crank Slider Mechanism for Validation of a Combined Finite Element Wear Model**
Mauntler, N. A.; Kim, N.-H.; Sawyer, W. G.; Schmitz, T. L. (University of Florida) page 21
- 4. Prediction and Control of Acoustically Induced Vibrations of High-precision Equipment**
Roozen, N. B.; Vervoordeldonk, M. J. (Philips Applied Technologies) page 24

Session II

Machining

Tuesday, October 16, 2007, 10:30 am - 12:00 pm

Session Chair: Deming Shu (Argonne National Laboratory) and Eric S. Buice (University of North Carolina at Charlotte)

- 1. A Novel Micromilling Technology Based on Single-point Tool Tip Geometry**
Bamberg, E.; Heamawatanachai, S. (University of Utah) page 28
- 2. A Novel Method for the On-center Turning of Tightly Toleranced Micro Arrays**
Gill, D. D.; Hsu, A.; Keeler, G. A.; Sweatt, W. C. (Sandia National Laboratories) page 32
- 3. Micro Electrical Discharge Machining Using a 5-DOF Controlled Maglev Actuator**
Zhang, X.; Shinshi, T.; Endo, H.; Shimokohbe, A. (Tokyo Institute of Technology); and Imai, Y.; Miyake, H.; Nakagawa, T. (Mitsubishi Electric Corporation) page 36
- 4. Study of Gap Control and Electrostatic Force in Nano Electro Machining**
Alkhaleel, A. H.; Sundaram, M. M.; Rajurkar, K. P. (University of Nebraska-Lincoln); and Malshe, A. (University of Arkansas) page 40

Session III

Metrology I

Wednesday, October 17, 2007, 8:30 am - 10:00 am

Session Chair: Hans-Jochen Trost (MicroFab Technologies, Inc.) and Eric R. Marsh (The Pennsylvania State University)

1. **NIST Standard Bullets and Casings Project**
Song, J.-F. J.; Vorburger, T. V.; Ballou, S.; Renegar, T. B.; Ma, L.; Whitemont, E. P.; Kelley, D.; Clary, R.; Zheng, A. (National Institute of Standards and Technology); and Ols, M. (Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF)) page 44
2. **CMM Dynamic Error Analysis, Control and Compensation**
Chang, D. W.; Spence, A. D. (McMaster University) page 48
3. **Direct Measurement of Spindle Error Motion with 10-picometer Resolution Using Regular Crystalline Lattice and Scanning Tunneling Microscope**
Aketagawa, M.; Patamaporn, C. (Nagaoka University of Technology); and Okuyama, E. (Akita University) page 52
4. **High Resolution Computed Tomography for Metrology**
Lehmann, D. K.; Brockdorf, K. (phoenixlx-ray Systems + Services Inc.); and Neuber, D. (phoenixlx-ray Systems + Services GmbH) page 56

Session IV

Optics Fabrication

Wednesday, October 17, 2007, 10:30 am - 12:00 pm

Session Chair: Jeffrey W. Roblee (AMETEK Precitech, Inc.) and Tony L. Schmitz (University of Florida)

1. **Optical Effect of Surface Finish by Single Point Diamond Machining**
Li, L.; Collins, Jr., S. A.; Yi, A. Y. (The Ohio State University) page 61
2. **Development of Large Ultra-precision Diamond Turning Machine for Making Next Generation Hard X-Ray Telescopes**
Namba, Y.; Shimomura, T.; Shimizu, T. (Chubu University); and Kunieda, H.; Ogasaka, Y.; Yamashita, K. (Nagoya University) page 65
3. **Rapid Manufacturing of Fast Aspheres**
Subrahmanyam, P. K.; Gardopee, G. (RAPT Industries, Inc.) page 69
4. **Manufacture and Metrology of 300 mm Silicon Wafers With Ultra-low Thickness Variation**
Hall, C.; Tricard, M.; Dumas, P. R. (QED Technologies, International) page 73

Session V

Metrology II

Wednesday, October 17, 2007, 1:30 pm - 3:00 pm

Session Chair: David D. Gill (Sandia National Laboratories) and Mark A. Stocker (Cranfield Precision)

1. **Tribology and Corrosion Evaluation Using White-light Interferometry**
Novak, E. L.; Blewett, N. R.; Stout, T. (Veeco Instruments, Inc.) page 77
2. **Intelligent Shape Sensor**
Merritt, J.; Mostafavi, M. T. (University of North Carolina at Charlotte); and Sayeh, M. (Southern Illinois University Carbondale) page 81
3. **First and Second Order Periodic Error Measurement Under Non-constant Velocity Conditions**
Kim, H. S.; Schmitz, T. L. (University of Florida); and Chu, D. C. K.; Lee, H. (Agilent Technologies, Inc.) page 85
4. **Roundness Measurements Using the NIST Fiber Probe**
Muralikrishnan, B.; Stone Jr., J. A.; Stoup, J. R. (National Institute of Standards and Technology) page 89

Session VI

Novel Systems

Thursday, October 18, 2007, 8:30 am - 10:00 am

Session Chair: Thomas M. Crawford (University of South Carolina) and Anthony A. Gee (University College, London)

1. **Spatial and Temporal Measurements of the Field of a Magnetic Recording Head Using a Contact Read/Write Tester (Invited Paper)**
Gokemeijer, N. J.; Kaka, S.; Langzettel, A. K. (Seagate Technology, LLC) page 93
2. **Plasmon Resonance Enhanced Scanning Near-field Optical Microscope Probes for Single Fluorescent Molecule Observations**
Sugimoto, S.; Morii, H.; Nagato, K.; Tsuchiya, K.; Hamaguchi, T.; Nakao, M. (The University of Tokyo) page 97
3. **Design of an Injection-molded Impedance Cell for Measuring the Dielectric Constant and Conductivity of Liquids and Gases Across Adjustable Nanometer Electrode Gaps**
Ma, H.; Slocum, A. H. (Massachusetts Institute of Technology) page 101
4. **Pinpoint Synthesis of Tungsten Oxide Nanowires Using Heat Controlling Layer**
Kojima, Y.; Nagato, K.; Moritani, H.; Nakao, M. (The University of Tokyo); and Kasuya, K. (Hitachi, Ltd.) page 105

Session VII

Biomedical Instrumentation

Thursday, October 18, 2007, 10:30 am - 12:00 pm

Session Chair: Craig R. Forest (Massachusetts Institute of Technology) and Yazid Tohme (Moore Tool Company, Inc.)

1. **Squirt-guns, Syringes and Science: Precise Jet Delivery of Liquid Drug Using Servo-controlled Linear Lorentz-force Actuators (Invited Paper)**
Taberner, A. J.; Hogan, N. C.; Hunter, I. W. (Massachusetts Institute of Technology) page 109
2. **The Design and Dynamic Characterization of a Precision Three-axis, Micro-scale Fast Scanning Stage for Two-photon Endomicroscopy**
Chen, S.-C.; Culpepper, M. L.; Choi, H.; So, P. T. (Massachusetts Institute of Technology) page 111
3. **A Combined Scanned Probe and Confocal Microscope System for Live Cell Spectroscopic Imaging**
Elliott, K. E.; Smith, S. T.; Elliott, G.; Moyer, P. J. (University of North Carolina at Charlotte) page 115
4. **Fabrication Methods for Polymer MEMS**
Ferrell, N. J.; Gallego, D.; Woodard, J. A.; Hansford, D. J. (The Ohio State University) page 119

Session VIII

Machine Design II

Thursday, October 18, 2007, 1:30 pm - 3:00 pm

Session Chair: Thomas A. Dow (North Carolina State University) and Lius A. Aguirre (3M Company)

1. **Hybrid Electromagnetic Air Bearing Systems**
van Beek, A.; Spronck, J. W.; Langen, H. H.; van Ostayen, R. A. J.; Munnig Schmidt, R.-H. (Delft University of Technology) page 123
2. **Hybrid Bi-directional Flexure Joints**
Lee, V.; Ziegert, J. C. (Clemson University) page 127
3. **Model-based Subnano-positioning Control**
van Hulzen, J.; van Eijk, J.; Van den Hof, P. M. J. (Delft University of Technology) page 131
4. **A High-speed Air Bearing Spindle**
Delhaes, G. M. J.; van Beek, A.; van Ostayen, R. A. J.; Munnig Schmidt, R.-H. (Delft University of Technology) page 135

Poster Sessions

Tuesday, October 16, 2007, 3:30 pm - 5:00 pm

Wednesday, October 17, 2007, 3:30 pm - 5:00 pm

Session Chair: Byron R. Knapp (Olympic Precision, Inc.) and Senajith B. Rekawa (Lawrence Berkeley National Laboratory)

BIOMEDICAL

Biomedical

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