

Aerodynamic Measurement Technology

Papers Presented at the AIAA SciTech Forum and Exposition
2020

Orlando, Florida, USA
6-10 January 2020

ISBN: 978-1-7138-1074-2

Printed from e-media with permission by:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571



Some format issues inherent in the e-media version may also appear in this print version.

The contents of this work are copyrighted and additional reproduction in whole or in part are expressly prohibited without the prior written permission of the Publisher or copyright holder. The resale of the entire proceeding as received from CURRAN is permitted.

For reprint permission, please contact AIAA's Business Manager, Technical Papers. Contact by phone at 703-264-7500; fax at 703-264-7551 or by mail at 34922 Uwytkug'Xcmg{'Ftkxg.'Uwky'422, Reston, VA 20191, USA.

TABLE OF CONTENTS

DATA PROCESSING, DATA ANALYSIS, DATA DRIVEN MODELING, AND MODEL VALIDATION TECHNIQUES

ASSESSMENT OF TEMPERATURE-DEPENDENT REGRESSION MODEL TERMS OF A RUAG SIX-COMPONENT BLOCK-TYPE BALANCE.....	1
<i>Norbert M. Ulbrich, Claus Zimmermann</i>	
DEVELOPMENT OF A NON-ITERATIVE BALANCE LOAD PREDICTION ALGORITHM FOR THE NASA AMES UNITARY PLAN WIND TUNNEL.....	16
<i>Norbert M. Ulbrich, Max A. Amaya, Alan l'Esperance</i>	
TOMOGRAPHIC RECONSTRUCTION FROM SCHLIEREN IMAGES OF SLENDER BODY WITH ASYMMETRIC PROTUBERANCES	35
<i>Masahito Akamine, Satoshi Yamauchi, Satoshi Nonaka, Yuya Takagi, Hiroyuki Takimoto, Keiichi Kitamura</i>	
COMPARISON OF A PHYSICAL MODEL AND A MACHINE LEARNING APPROACH FOR A MORE ACCURATE ASSESSMENT OF FUEL EFFICIENCY MEASURES.....	50
<i>Franz Enkelmann, Robert Heigl, Kai C. Pfingsten</i>	
SDSU WATER TUNNEL TEST SECTION FLOW QUALITY CHARACTERIZATION	62
<i>Jose R. Moreto, Xiaofeng Liu</i>	

PRESSURE SENSITIVE PAINT I

DIFFERENTIAL PRESSURE-SENSITIVE PAINT METHOD	72
<i>Tatsunori Hayashi, Suguru Hase, Hirotaka Sakaue</i>	
DEVELOPMENT OF UNSTEADY-PSP DATA PROCESSING AND ANALYSIS TOOLS FOR THE NASA AMES UNITARY 11FT WIND TUNNEL	85
<i>Jessica M. Powell, Scott M. Murman, Christina Ngo, Nettie Roozeboom, David D. Murakami, Jennifer K. Baerny, Ji Lie</i>	
PARAMETRIC INVESTIGATIONS FOR FREQUENCY-DOMAIN LIFETIME PSP TECHNIQUE (FLIM).....	102
<i>Hitomi Sato, Daisuke Yorita, Michael Hilfer, Ulrich Henne, Christian Klein, Yuji Saito, Taku Nonomura, Keisuke Asai</i>	
MEASUREMENT OF BOUNDARY LAYER TRANSITION ON OSCILLATING AIRFOIL USING CNTTSP IN LOW-SPEED WIND TUNNEL.....	115
<i>Tsubasa Ikami, Koji Fujita, Hiroki Nagai, Daisuke Yorita</i>	
SKIN FRICTION MEASUREMENT ON NASA COMMON RESEARCH MODEL USING OIL FILM IN JAXA	131
<i>Hidetoshi Iijima, Takahiro Uchiyama, Hiroyuki Kato</i>	
TRANSITION DETECTION METHODS IN A PITCH-SWEEP TEST BY MEANS OF TSP USING LIFETIME AND INTENSITY MEASUREMENTS	141
<i>Daisuke Yorita, Jonathan Lemarechal, Christian Klein, Koji Fujita, Hiroki Nagai</i>	

SPECTROSCOPIC TECHNIQUES I

100-KHZ INTERFEROMETRIC RAYLEIGH SCATTERING FLOW DIAGNOSTICS AT 266 NM	150
<i>Andrew D. Cutler, Naibo Jiang, Sukesh Roy, Paul M. Danehy</i>	
LASER ABSORPTION OF CARBON DIOXIDE AT THE VIBRATIONAL BANDHEAD NEAR 4.2 μ M IN HIGH-PRESSURE ROCKET COMBUSTION ENVIRONMENTS.....	165
<i>Daniel D. Lee, Fabio A. Bendana, Anil P. Nair, Raymond M. Spearrin, Stephen A. Danczyk, William A. Hargus</i>	
VALIDATION AND DATA PROCESSING OF A FIXED WAVELENGTH ABSORPTION SPECTROSCOPY SYSTEM FOR HIGH-DATA-RATE COMBUSTION MEASUREMENTS.....	172
<i>John B. Middlebrooks, Levi Thomas</i>	
PROGRESS IN INTERFEROMETRIC RAYLEIGH SCATTERING TO MEASURE FLUCTUATIONS SPECTRA OF VELOCITY AND TEMPERATURE IN HIGH SPEED FLOWS	182
<i>Jayanta Panda, Matthew P. Nguyen</i>	
WAVELENGTH-MODULATION-SPECTROSCOPY DIAGNOSTICS FOR CHARACTERIZING METALLIZED AND HALOGENATED FIREBALLS OF ENERGETIC MATERIALS	198
<i>Garrett C. Mathews, Christopher S. Goldenstein</i>	

PRESSURE SENSITIVE PAINT II

AEROACOUSTIC NOISE SOURCE IDENTIFICATION USING UNSTEADY PSP AND MICROPHONE CORRELATION MEASUREMENT	209
<i>Kazuyuki Nakakita, Hiroki Ura</i>	
DYNAMIC CHARACTERIZATION OF PYRENE-BASED POLYMER CERAMIC PRESSURE-SENSITIVE PAINT	219
<i>Steve Claunchery, Hirotaka Sakaue</i>	
SURFACE PRESSURE MEASUREMENT OVER ROTATING BLADE USING MOTION-CAPTURING PSP METHOD.....	228
<i>Daiki Kurihara, Tatsunori Hayashi, Hirotaka Sakaue</i>	
RECENT DEVELOPMENTS IN NASA'S UNSTEADY PRESSURE-SENSITIVE PAINT CAPABILITY	235
<i>Nettie Roozeboom, Jennifer K. Baerny, David D. Murakami, Christina Ngo, Jessica M. Powell</i>	

SPECTROSCOPIC TECHNIQUES II

ULTRAFAST LASER ABSORPTION SPECTROSCOPY IN THE MID-INFRARED FOR MEASURING TEMPERATURE AND SPECIES IN COMBUSTION GASES	244
<i>Ryan J. Tancin, Ziqiao Chang, Vishnu Radhakrishna, Mingming Gu, Robert P. Lucht, Christopher S. Goldenstein</i>	
BURST-MODE SPONTANEOUS RAMAN THERMOMETRY IN A FLAT FLAME.....	253
<i>Caroline Winters, Timothy Haller, Justin L. Wagner, Sean P. Kearney, Philip Varghese</i>	

POST-DETONATION FIREBALL THERMOMETRY VIA 1D ROTATIONAL CARS..... 267
Daniel R. Richardson, Sean P. Kearney, Daniel R. Guildenbecher

GAS FLOW VELOCITY AND DENSITY LIMIT ESTIMATES FOR SINGLE SHOT
COHERENT RAYLEIGH-BRILLOUIN SCATTERING 271
Alexandros Gerakis, Mikhail N. Shneider

HYDROGEN THERMOMETRY IN ALUMINIZED PROPELLANT BURNS BY HYBRID
FS/PS COHERENT ANTI-STOKES RAMAN SCATTERING..... 276
Jonathan E. Retter, Daniel R. Richardson, Sean P. Kearney

COMBUSTION DIAGNOSTICS

SINGLE-SHOT DETECTION OF 2-D CHEMILUMINESCENCE EMISSIONS BY
COMPRESSED HYPERSPECTRAL IMAGING 285
Zichen He, Nathan Williamson, Cary Smith, Mark Gragston, Zhili Zhang

INVESTIGATION OF FLOW-FLAME INTERACTIONS IN KEROSENE PILOTED LIQUID-
SPRAY FLAMES USING SIMULTANEOUS OH AND PAH PLIF 294
Ayush Jain, Yejun Wang, Christian Schweizer, Waruna D. Kulatilaka

IMAGING AND EMISSION SPECTROSCOPY IN OPTICALLY DENSE METAL CLOUD
COMBUSTION..... 302
Fynn Reinbacher, Keke Zhu, Travis R. Sippel, James B. Michael

SPECTROSCOPIC TECHNIQUES III

DEVELOPMENT OF CHIRPED-PROBE-PULSE FEMTOSECOND CARS TECHNIQUE FOR
CO₂..... 314
Mingming Gu, Aman Satija, Robert P. Lucht

TIME-RESOLVED MEASUREMENTS OF KEY INTERMEDIATE PRODUCTS DURING
CYCLOPENTANONE PYROLYSIS IN A SHOCK TUBE 324
Erik M. Ninnemann, Andrew Laich, Jessica Baker, Robert Greene, Subith Vasu

DIMP PYROLYSIS AT HIGH TEMPERATURES BEHIND REFLECTED SHOCK WAVES 330
Jessica Baker, Ramees Rahman, Erik M. Ninnemann, Sneha Neupane, Samuel Barak, Subith Vasu

IMAGING OF PROPELLANT FLAME STRUCTURE WITH FEMTOSECOND TWO-PHOTON
LASER-INDUCED FLUORESCENCE OF CN 334
Keke Zhu, Stuart J. Barkley, Anthony C. LoCurto, Travis R. Sippel, James B. Michael

SIMULTANEOUS TEMPERATURE/PRESSURE MONITORING IN COMPRESSIBLE FLOWS
USING HYBRID FS/PS PURE-ROTATIONAL CARS 342
Sean P. Kearney, Daniel R. Richardson, Jonathan E. Retter, Chloe E. Dedic, Paul M. Danehy

VELOCIMETRY TECHNIQUES I

EXTENDING THE FREQUENCY LIMITS OF "POSTAGE-STAMP PIV" TO MHZ RATES 350
Steven J. Beresh, Russell Spillers, Melissa Soehnel, Seth Spitzer

100-KHZ PLEET FOR HYPERSONIC FLOW VELOCITY MEASUREMENTS IN A MACH 6 LUDWIG TUBE.....	364
<i>Paul S. Hsu, Naibo Jiang, Joseph S. Jewell, Josef Felver, Sukesh Roy, Matthew P. Borg, Michael Rynders, Anthony Ciccarello, Roger L. Kimmel</i>	

TAILORING FLEET FOR COLD HYPERSONIC FLOWS	373
<i>Yibin Zhang, Steven J. Beresh, Katya M. Casper, Daniel R. Richardson, Melissa Soehnel, Russell Spillers</i>	

INVESTIGATION OF DOPPLER LIDAR FOR VELOCITY MEASUREMENTS IN WIND TUNNELS.....	387
<i>Samuel A. Barnhart, Sidaard Gunasekaran</i>	

EXPERIMENTAL ASSESSMENT OF WAVELET-BASED OPTICAL FLOW VELOCIMETRY (WOFV) AS APPLIED TO TRACER PARTICLE IMAGES FROM FREE SHEAR FLOWS.....	400
<i>Wayne E. Page, Bryan E. Schmidt, Jeffrey A. Sutton</i>	

AN IMPROVED VIEW REGISTRATION METHOD AND ITS APPLICATION IN LASER IMAGING MEASUREMENTS.....	412
<i>Boyao Hu, Lin Ma</i>	

VELOCIMETRY TECHNIQUES II

DEVELOPMENT OF LONG DISTANCE 2D MICRO-MOLECULAR TAGGING VELOCIMETRY (μ MTV) TO MEASURE WALL SHEAR STRESS.....	419
<i>Charles Fort, Matthieu Andre, Philippe Bardet</i>	

TOWARDS VIBRATIONALLY EXCITED NITRIC OXIDE MONITORING (VENOM) IN A LAMINAR, HYPERSONIC BOUNDARY LAYER.....	429
<i>Zachary D. Buen, Casey Broslawski, Madeline Smotzer, Jason E. Kuszynski, Simon North, Rodney D. Bowersox</i>	

FLEET VELOCIMETRY IN THE COMMON RESEARCH MODEL'S WING WAKE	453
<i>Daniel Reese, Paul M. Danehy, Eric L. Walker, Melissa B. Rivers, William K. Goad</i>	

PRELIMINARY EXPERIMENTS FOR VISUALIZATION OF DETONATION WAVES PROPAGATING INSIDE A ROTATING-DETONATION ROCKET ENGINE BY USING POINT-DIFFRACTION INTERFEROMETRY	462
<i>Toshiharu Mizukaki, Daiju Numata, Iwasaki Fumihiko, Misato Mori, Makoto Kojima, Hideto Kawashima, Shingo Matsuyama, Hideyuki Tanno</i>	

IMPLEMENTATION IN FACILITIES WITH UNIQUE MEASUREMENT CHALLENGES

HIGH-SPEED X-RAY STEREO DIGITAL IMAGE CORRELATION FOR FLUID- STRUCTURE INTERACTIONS IN A SHOCK TUBE.....	468
<i>Jeremy James, Elizabeth M. Jones, Enrico C. Quintana, Kyle P. Lynch, Benjamin R. Halls, Justin L. Wagner</i>	

FLOW VISUALIZATION WITH COMMON PATH INTERFEROMETRY IN HIGH- ENTHALPY SHOCK TUNNEL.....	480
<i>Hideyuki Tanno, Katsuhiro Itoh, Yamada Kento, Koji Yamada, Mariko Kobayashi, Kohei Shimamura, Ginji Uchibe</i>	

FOCUSED LASER DIFFERENTIAL INTERFEROMETRY FOR HYPERSONIC FLOW INSTABILITY MEASUREMENTS WITH CONTOURED TUNNEL WINDOWS	486
<i>Elizabeth K. Benitez, Joseph S. Jewell, Steven P. Schneider</i>	

SPATIALLY-RESOLVED SURFACE TEMPERATURE MEASUREMENTS OF A ROCKET MOTOR NOZZLE USING AN ACOUSTO-OPTIC MODULATOR	508
<i>Yi C. Mazumdar, Justin L. Wagner, Donald J. Fredrick, Daniel R. Guildenbecher, Terry L. Hendricks</i>	

MODELING AND SIMULATION OF AIRCRAFT SYSTEMS

REAL-TIME OPTICAL TRACKING FOR STORE SEPARATION TESTING IN WIND TUNNEL	514
<i>Youssef Mebarki, Sador Brhane, Stuart Rutherford</i>	

NOVEL AERODYNAMIC MEASUREMENT TECHNIQUES I

A NOVEL MULTI-BAND PLENOPTIC PYROMETER USED FOR TEMPERATURE MEASUREMENTS OF STRAND BURNER PLUMES	529
<i>Dustin L. Kelly, Matthew A. Phillips, Brian S. Thurow, David E. Scarborough</i>	

INFLUENCE OF MIE AND GEOMETRIC SCATTERING CONTRIBUTIONS ON TEMPERATURE AND DENSITY MEASUREMENTS IN FILTERED RAYLEIGH SCATTERING	538
<i>Matthew T. Boyda, Gwibo Byun, Ashley J. Saltzman, Todd Lowe</i>	

SLOW LIGHT IMAGING SPECTROSCOPY	554
<i>Richard Miles, Arthur Dogariu</i>	

PRELIMINARY DEVELOPMENT OF A SINGLE CAMERA ROTATING VOLUMETRIC VELOCIMETRY TECHNIQUE	564
<i>Abhishek Gururaj, Mahyar Moaven, Zu Puayen Tan, Brian S. Thurow, Vrishank Raghav</i>	

TRIP COMPARISON FOR TAILORING TRANSITION IN REYNOLDS-SCALED EXPERIMENTS	574
<i>Jaslyn E. Gray, Jonathan Lakkis, Reza Aliakbari, Danielle Vasiljev, Alejandro Pastore-Rodriguez, Christopher Purser, Pier Marzocca</i>	

PLASMA DIAGNOSTICS

APPLICATION OF A PULSE-BURST LASER FOR 10 KHZ THOMSON SCATTERING	590
<i>Zhili Zhang, Cary Smith, Theodore Biewer, Mark Gragston, Naibo Jiang, Paul S. Hsu, Josef Felver, Sukesh Roy</i>	

FILTERED RAYLEIGH SCATTERING AND DISPERSION FILTERS IN BETWEEN 380 TO 420 NM FOR ATMOSPHERIC TEMPERATURE PROFILING	598
<i>Anuj Rekhy, Mikhail N. Shneider, Richard B. Miles</i>	

NOVEL AERODYNAMIC MEASUREMENT TECHNIQUES II

EXPERIMENTAL INVESTIGATION OF OPTICAL DISTORTION IN HYPERSONIC FLOWS AT MACH 6.....	622
<i>Michael Winter, Ricky W. Green, Eswar Josyula, Benjamin Hagen, James Hayes, Joseph S. Jewell</i>	
DIGITAL PHASE-SENSITIVE HOLOGRAPHY FOR NUMERICAL SHOCK-WAVE DISTORTION CANCELLATION	639
<i>Tyrus M. Evans, Andrew Marsh, Jaylon Uzodinma, Daniel R. Guildenbecher, Yi C. Mazumdar</i>	
APPLICATION OF FOCUSED LASER DIFFERENTIAL INTERFEROMETRY (FLDI) IN A SUPERSONIC BOUNDARY LAYER.....	651
<i>Andrew Ceruzzi, Braeden Callis, Daniel Weber, Christopher P. Cadou</i>	
TWO-PHASE MULTIPLEXED STRUCTURED IMAGE CAPTURE	662
<i>Walker McCord, Cary Smith, Mark Gragston, Zhili Zhang</i>	

NOVEL AERODYNAMIC MEASUREMENT TECHNIQUES III

INCIPIENT STALL DETECTION USING THE REAL-TIME AERODYNAMIC LOAD ESTIMATION FROM A DISTRIBUTED FADS SENSOR NETWORK	670
<i>Ruchir Goswami, Atul Kelkar, Jerald Vogel</i>	
STATISTICAL ENGINEERING FOR WIND TUNNEL TESTING OF MARS PARACHUTE DESIGNS	688
<i>Drew Landman</i>	
DESIGN OF FLUSH AIR DATA SYSTEMS INSENSITIVE TO MANUFACTURING VARIANCE	700
<i>Grant T. Dunbar, John A. Farnsworth</i>	
MEASURING ATMOSPHERIC BOUNDARY LAYER PROFILES USING UAV CONTROL DATA.....	731
<i>George Loubimov, Michael P. Kinzel, Samik Bhattacharya</i>	
DEEP LEARNING IMAGE ANALYSIS FOR ANGULAR MEASUREMENTS IN WIND TUNNELS.....	743
<i>José Pedro d. Ferreira, James Bell</i>	

ADVANCEMENTS IN PLANAR, VOLUMETRIC, AND HIGH-SPEED IMAGING TECHNIQUES

THREE DIMENSIONAL SCHLIEREN USING ITERATIVE PHASE TOMOGRAPHY	757
<i>Nandhini Raju, Manoj Prabakar Sargunraj, Biswajit Medhi, Muruganandam T M</i>	
HIGH-MAGNIFICATION, LONG-WORKING DISTANCE PLENOPTIC BACKGROUND ORIENTED SCHLIEREN (BOS).....	766
<i>Daniel R. Guildenbecher, Marley Kunzler, William Sweatt, Katya M. Casper</i>	
SEEDLESS VELOCIMETRY IN A TURBULENT JET USING SCHLIEREN IMAGING AND A WAVELET-BASED OPTICAL FLOW METHOD	775
<i>Bryan E. Schmidt, Wayne E. Page, Jeffrey A. Sutton</i>	

3D FLAME MEASUREMENTS USING TOMOGRAPHY RECONSTRUCTION INTEGRATING VIEW REGISTRATION.....	786
<i>Ning Liu, Lin Ma</i>	

TOMOGRAPHIC TIME RESOLVED LASER INDUCED INCANDESCENCE.....	793
<i>Elise M. Hall, Benjamin R. Halls, Daniel R. Richardson, Daniel R. Guildenbecher, Emre Cenker, Megan Paciaroni</i>	

**NOVEL CALIBRATION, ERROR ANALYSIS, UNCERTAINTY QUANTIFICATION, AND
EXPERIMENTAL VERIFICATION**

A CALIBRATION SYSTEM FOR LOW-VELOCITY FLOWS AT STRATOSPHERIC CONDITIONS.....	800
<i>Andrew Mahon, Joseph L. Pointer, Dale Lawrence, Brian Argrow</i>	

AERODYNAMIC DESIGN AND VALIDATION OF A CONTRACTION PROFILE FOR FLOW FIELD IMPROVEMENT AND UNCERTAINTY QUANTIFICATION IN A SUBSONIC WIND TUNNEL.....	812
<i>Vidya Vishwanathan, Máté Szoke , Julie E. Duetsch-Patel, Aldo Gargiulo, Daniel J. Fritsch, Aurelien Borgoltz, Christopher J. Roy, Kevin T. Lowe, William J. Deavenport</i>	

STATIC TAP PRESSURE MEASUREMENT BIAS ERROR INTRODUCED BY AERODYNAMIC NOISE	829
<i>Sho Sato, Chen Chuck</i>	

A NOVEL, HIGH-FREQUENCY, RECIPROCAL CALIBRATION METHOD FOR DYNAMIC PRESSURE SENSORS USED IN HIGH-SPEED FLOWS	845
<i>David A. Mills, Tai-An Chen, Stephen Horowitz, William Patterson, Mark Sheplak</i>	

AERODYNAMIC DESIGN AND ASSESSMENT OF MODULAR TEST SECTION WALLS FOR CFD VALIDATION IN HYBRID ANECHOIC WIND TUNNELS.....	858
<i>Julie E. Duetsch-Patel, Vidya Vishwanathan, Jared B. Minionis, Eric Totten, Aldo Gargiulo, Daniel J. Fritsch, Máté Szoke , Aurelien Borgoltz, Christopher J. Roy, Kevin T. Lowe, William J. Deavenport</i>	

Author Index