16th Automotive Research Center Conference
May 10-11, 2010

Day 1: Monday, May 10, 2010

7:30 am Check-in and Continental Breakfast
8:00 Welcome & Introductions: Prof. Anna Stefanopoulou, ARC Director
- Dr. David Gorsich, Chief Scientist, TARDEC
- Prof. Dave Munson, Dean of Engineering, University of Michigan
8:20 Plenary: Dr. Grace Bochenek, Director, TARDEC
- Dr. Thomas H Killion, Chief Scientist, U.S. Army
9:30 Break
9:50 Keynote: ARC & Research Education
- Dr. Paul Rogers, DPEO Ground Combat Systems
- Dr. Scott Fiveland, Manager, Comb. & Air Syst. Tech., Caterpillar
- Mr. Sam Homsey, Director, Army Programs, Navistar Defense LLC
- Dr. Joe Lin and Dr. Vasilios Tsourapas, Eaton
- Mr. Hakan Yilmaz, Director, Sys & Adv Engr, Bosch Gasoline Syst.
12:00 pm Lunch
1:30 Research Highlights 1: Maximizing Power & Energy under Constraints
2:15 Research Highlights 2: Optimizing Reliability & Survivability under Uncertainty
3:00 Break
3:30 – 5:00 Technical Sessions Part 1
- 1A: Mobility
- 1B: Survivability
- 1C: Alternative Fuels

Day 2: Tuesday, May 11, 2010

7:30 am Check-in and Continental Breakfast
8:00 Opening: Dr. Peter Schihl, ARC Technical Leader, TARDEC
8:05 Plenary: Maj. Gen. Kurt J. Stein, Commanding General, TACOM
8:35 Keynote: ARC & Industry
- Mr. Paul Skalny, Director, National Automotive Center
- Mr. Sharad Kumar, Senior Director, Systems. Engineering, GDLS
- Mr. Christopher Yakes, Director, Adv Products Grp, Oshkosh
- Mr. Mark Groeneweg, Director, DDC, Daimler
- Mr. Haukur “Hawk” Asgeirsson, Manager, Power Syst Tech., DTE
10:45 Break
11:00 Technical Sessions Part 2
- 2A: Tire-Terrain
- 2B: Reliability
- 2C: Advanced Powertrains
12:30 pm Lunch
1:30 Technical Sessions Part 3
- 3A: Vehicle Design & Validation
- 3B: Fuel Economy Demonstrator
- 3C: Thermal Management
The Conference Flyer (pdf) contains the conference schedule and other details.

**Venue:** The 16th Annual ARC Conference will be held at

Four Points by Sheraton Ann Arbor
3200 Boardwalk
Ann Arbor, MI 48108

Phone: 734-996-0600 or 1-800-325-3535 or 1-800-858-2770
Fax: 734-996-8136

Click here for hotel web-site (external link)

**Registration:** Online registration is closed. Registration is compulsory due to space limitations. For late, on-site or non-U.S. registration, please email: arc-conference-inquiries@umich.edu

**Fees:** There are no fees for this year’s conference.

**Lodging:** Rooms are available at the venue. Attendees who wish to book rooms should identify themselves with the ARC Annual Conference for the special rate or use the hotel's web-link. The special rate expires on April 9th 2010.

**Parking:** There will be ample free parking at the venue, as well as at an adjacent overflow lot.

For more information, please email arc-conference-inquiries@umich.edu
### ARC Conference Day 1 Schedule
**Monday May 10th 2010**

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Dr. Grace M. Bochenek
Director, TARDEC

Dr. Grace M. Bochenek was appointed Director of TARDEC in August 2006. TARDEC is recognized as the Department of Defense (DOD) Ground Systems Integrator and the premier laboratory for advanced military automotive technology for ground vehicle systems and logistics support equipment. She is a member of the Senior Executive Service.

Bochenek brings more than 23 years’ scientific, technical and managerial experience to TARDEC. She creates and leads all research, development and engineering strategies for DOD ground vehicle, manned and unmanned, systems. Bochenek manages a workforce of more than 1,200 civilian, military and contractor employees and sets strategic direction for a full range of investments that affect more than 270 Army systems. She is a 2008 Meritorious Executive Presidential Rank Award recipient.

Bochenek previously served as Deputy Program Executive Officer for Program Executive Office Combat Support and Combat Service Support, where she led more than 400 civilian personnel, the Project Management Offices, 18 managers and 250 Acquisition Category III programs in five geographically distributed sites supporting the Army’s tactical wheeled vehicle fleet and force projection commodities. There, she led programs to align ground-based systems science and technology research objectives to meet the Army’s future needs.

Bochenek has a bachelor’s degree in electrical engineering from Wayne State University, a master’s degree in engineering from the University of Michigan and a Ph.D. from the University of Central Florida. She is a member of the Army Acquisition Corps, the NATO Research and Technology Organization, and an active participant in several defense and academic associations.

Dr. Thomas H. Killion
Deputy Assistant Secretary of the Army for Research and Technology and Chief Scientist

In March 2004, Dr. Killion was designated as the Deputy Assistant Secretary of the Army for Research and Technology and Chief Scientist. He is responsible for the entire Army Research and Technology program, spanning 21 laboratories and research, development, and engineering centers, more than 10,000 scientists and engineers, and a 6-year budget of more than $11 billion. He is responsible for developing a science and technology (S&T) strategy responsive to Army needs from the near-term (5 years) stretching out through the far-term (>20 years). The Basic Research, Applied Research, and Advanced Technology Development programs and budgets that Dr. Killion builds for this strategy must be defended within the Army, to DOD, and to Congress. He is also the principal scientific advisor (PSA) to both the Secretary of the Army and the Assistant Secretary of the Army (ASA) for Acquisition, Logistics, and Technology. As an example of the latter role, Dr. Killion is responsible for providing independent assessments on the readiness of critical technologies for weapon systems programs approaching key program decision points (Milestones B and C), both to the Army leadership and to DOD decision makers.

Prior to his designation, Dr. Killion served as the Director for Technology under the Deputy ASA for Research and Technology (DASA(R&T)). In this position, he was responsible for oversight and coordination for most of the Army’s Applied Research (6.2) Program and its Advanced Development (6.3) Program. He also co-chaired the Warfighter Technical Council and managed the S&T Objective and Advanced Technology Demonstration approval process.

Prior to this assignment, Dr. Killion served as the Director for Personnel Technologies in the Office of the Deputy Chief of Staff (DCS), G-1, where he was responsible for policy, guidance, oversight, and advocacy of the Army’s MANpower and PeRsonnel INTegration (MANPRINT) and Soldier Oriented Research and Development in Personnel and Training Programs. Dr. Killion also served as the PSA to the DCS, G-1.

Previously, Dr. Killion served as the U.S. Army Research Laboratory (ARL) Liaison to the Office of the DASA(R&T), where he assisted in shaping, advocating, and defending Army S&T program investments and priorities to senior leaders in the Army, DOD, and Congress. He also served as the Acting Deputy Director for Research, with responsibility for overseeing the Army’s Basic Research (6.1) Program and substantial portions of the Applied Research (6.2) Program. He also served as the manager for the Army’s Dual Use S&T Program.

Dr. Killion’s other key assignments include Technical Advisor in the Advanced Systems and Concepts Office at the Defense Threat Reduction Agency, ARL Liaison to the MANPRINT Directorate, Executive Assistant to the Director of ARL, Technology Team Leader for the Unmanned Aerial Vehicles Joint Project, and Principal Scientist for Electronic Combat Training at the Air Force Human Resources Laboratory.

Dr. Killion earned dual B.A.s in psychology and English from Saint Mary’s College. He received his M.S. and Ph.D. in experimental psychology from the University of Oregon. Dr. Killion also graduated with highest distinction from the Naval War College.
Major General Kurt J. Stein
Commanding General, US Army TACOM Life Cycle Management Command

Major General Kurt J. Stein assumed command of the US Army TACOM Life Cycle Management Command on 29 January 2010 following his recent assignment in Iraq where he served as the Deputy Chief of Staff, MNF-I Combined Joint 1/4/8.

MG Stein entered the United States Army as an enlisted soldier in October of 1976 and achieved the rank of Staff Sergeant. In 1982, he was commissioned as an Ordnance Officer from the Officer Candidate School at Fort Benning, Georgia. His military education includes the Ordnance Officer Basic and Advanced Course, Combined Arms and Services Staff School, the Army Command and General Staff College, and the Army War College.

Major General Stein’s previous assignments include; Maintenance Division Chief, APG, MD; Maintenance Platoon Leader and Shop Officer, C Company, 123rd Main Support Battalion, 1st Armored Division; Battalion Adjutant, 123rd MSB, 1st AD; Commander, D. Co. 123rd MSB, 1st AD; Ordnance Assignment Officer, PERSCOM/HRC, Alexandria, Virginia; Executive Officer, 610th Ordnance Battalion, Fort Belvoir, Virginia; Support Operations Officer, 782d Main Support Battalion, 82d Airborne Division, Fort Bragg, N.C.; Executive Officer, 407th Forward Support Battalion, 82d Airborne Division; S-3, 82D DISCOM; Deputy Commander, 20th Support Group, Taegu, Korea; Executive Officer, 82D DISCOM; Commander, 82D Forward Support Battalion; G-4 82D Airborne Division; Commander, 21D DISCOM, Deputy Director for Power Projection, Joint Staff, J-4, Executive Officer to the J-4, Joint Staff, Washington D.C. Assistant Chief of Staff, J4, Headquarters, United States Forces Korea (USFK), Deputy Assistant Chief of Staff, C4, Combined Forces Command (CFC), Deputy Commanding General for Support, Eighth United States Army (EUSA), Yongsan, Korea, Deputy Commanding General of USFK (Advanced Element), Camp Humphreys, Korea and MNF-I CJ 1/4/8, Baghdad, Iraq.

Major General Stein’s personal awards and decorations include the Defense Superior Service Medal, the Legion of Merit, the Bronze Star, the Meritorious Service Medal, the Army Commendation Medal, the Joint Staff Achievement Medal, the Army Achievement Medal, the Army Good Conduct Medal, the Iraq Campaign Medal, the Global War on Terrorism Medal, the Korean Defense Service Medal, the Armed Forces Service Medal, the National Defense Service Ribbon, the NCO Development Ribbon, the Army Service Ribbon, the Overseas Service Ribbon (5 tours), the Master Parachutist Badge and German Jump Wings.

Dr. Paul Rogers
Deputy Program Executive Officer for Ground Combat Systems

Selected to the Senior Executive Service in June 2007, Dr. Paul A. Rogers is currently the Deputy Program Executive Officer for Ground Combat Systems. Prior to this He served as the Executive Director of Research and Technical Director, U.S. Army Tank-Automotive Research, Development and Engineering Center. The Center is the lead organization for Army research and development in Ground Vehicle Power and Mobility, Survivability, Intelligent Systems, Vehicle Electronic and Architecture Systems, and Platform Concept, Analysis, and System Simulation. As Executive Director, he manages the technology base programs and leads a 480 person workforce through six technical business area associate directors. He is also responsible for executive oversight for the Joint Center for Robotics. As Technical Director, Dr. Rogers serves as the key executive responsible for the Center’s science and technology strategic planning, program selection, funding allocation, execution and transition to acquisition programs. Dr. Rogers leads programs to align ground-based systems science and technology research objectives with the Army’s future war fighting and logistic needs.

Prior to this assignment, Dr. Rogers was the Deputy Associate Director for Mobility Research in TARDEC. He provided scientific and technical leadership and expertise for three Army Technology Objectives, 8 technical teams and over 90 associates. Dr. Rogers was largely responsible for transforming the subordinate teams and S&T programs to align more directly with customer needs and TARDEC executive guidance. Dr. Rogers led the formation of a Hybrid Electric Vehicle Experimentation and Assessment program to support future Tactical Wheeled Vehicle acquisition strategy.

Prior to joining Mobility, Dr. Rogers was activated and served in Iraq as the Battalion Commander for the 507th Engineer Battalion. His command included twelve separate companies/detachments at Balad, Iraq in support of Operation Iraqi Freedom 04-06. The 507th Eng Bn was a joint force consisting of deployed forces from the Active Army and Air Force, Army National Guard, Army Reserve, and Marines. He commanded a total of 823 soldiers, 139 marines, and 114 airmen in combat operations during the deployment. His mission responsibilities included military fixed bridging, offensive assault float bridging, rafting operations, riverine operations, vertical and horizontal construction, well drilling, and asphalt production/paving. He also organized, trained, and deployed an armored D9 dozer task force in support of division offensive operations. The 507th Eng Bn served in Iraq from 1 January 2005 to 6 December 2005. Dr. Rogers military awards and decorations include the Bronze Star, Army Meritorious Service Medal, Army...
Dr. Rogers has initiated multiple collaborative programs internal to TARDEC and external to DoD. Dr. Rogers served as Chief Research Engineer to the Associate Director for the Integrated Survivability Advanced Technology Demonstrator (ISATD). He formulated and lead a broad scale collaboration to demonstrate FCS integrated survivability. The IS ATD was the preeminent Army program for survivability and included participants from across the Army technology base. Dr. Rogers guided the efforts of four TARDEC product teams, multiple Army agencies (ARL, ARDEC, CERDEC) and numerous principle contractors supporting the IS ATD. Nationally, he has initiated collaboration with scientists from the National Aeronautics and Space Administration’s (NASA) Goddard Space Flight Center (GSFC) and Clemson University. He was an invited member of a Joint National Aeronautics and Space Administration (NASA)/European Space Agency (ESA) Two-Phase Thermal Management Workshop, an Army research lead for the Office of the Secretary of Defense - Electric Force Transformation Initiative, and a TARDEC Assistant Technical Project Officer for Data Exchange Agreements with Germany, the United Kingdom, and France. He previously served for six years as the ATPO for DEA 1182 with the Netherlands. Dr. Rogers is currently serving the External Advisory Boards for the Mechanical Engineering Departments at Michigan Technological University and the University of Michigan. He has served as an invited member of the Lawrence Technological University Mechanical Engineering Industrial Advisory Committee and an Adjunct Professor of Mechanical Engineering at LTU.

Dr. Rogers holds a Ph.D. in Mechanical Engineering-Engineering Mechanics from Michigan Technological University (MTU), a Masters of Strategic Studies from the U.S. Army War College, a Masters of Science in Engineering – Mechanical Engineering from the University of Michigan – Dearborn, and a Bachelors of Science in Mechanical Engineering from MTU. He is a graduate of the Army Engineer Officer Basic Course, Engineer Officer Advance Course, Combined Arms Services Staff School, Army Command and General Staff College and the U.S. Army War College.

Dr. Rogers is married to his wife Sally of 19 years and has three children Tim, Katie and Nicholas.

Mr. Paul F. Skalny
Director, National Automotive Center

Paul F. Skalny is currently the Director of the National Automotive Center. In this role, Mr. Skalny leads all of the Center's activities in the areas of Advanced Commercial Automotive Technologies and Program Development, Budget, Assessment & Evaluation. The National Automotive Center, chartered by the Secretary of the Army in 1993 to serve as the Army focal point for the leveraging and development of dual-use automotive technologies and their application to military ground vehicles, is an organization under the Research, Development and Engineering Command's (RDECOM), Tank-Automotive Research, Development and Engineering Center (TARDEC).

Mr. Skalny's tenure for the Army spans over thirty-one years and covers the full spectrum of the Army military vehicle acquisition process, from vehicle inception to support in the field. His first seven years were spent in support of major weapon systems that included the M60 series and M1 Abrams tanks.

For the last twenty-three years, Mr. Skalny has been an associate of TARDEC. During this tenure, he has held a number of key acquisition positions, to include his present assignment. He has served as the core Acquisition Logistics Engineer for all of TARDEC's emerging systems, the Chief of Logistics and System Engineering for the Advanced Technology Program, and as the Deputy Product Manager for the Advanced Technology Program. For his role as the Chief of the Technical Area of the Advanced Technology Program Source Selection Evaluation Board, Mr. Skalny was awarded the Army Achievement Medal for Civilian Service.

Mr. Skalny's last sixteen years at TARDEC have been as a member of the National Automotive Center. Prior to his current position in the National Automotive Center, Mr. Skalny held the roles of Associate Director for Operations; Associate Director for Innovative Technology; Associate Director for Advanced Technologies; and the Deputy Director/Director of Strategic Initiatives.

In 1997, Mr. Skalny, as the Department of Defense focal point, was asked to lead the Government's 21st Century Truck Initiative, an Initiative geared to make the Nation's military and commercial truck fleets more fuel efficient, safer, more reliable, better performing and more environmentally friendly. The Initiative was announced as a National Initiative in April of 2000 by the Administration. The 21st Century Truck Initiative included major truck manufacturers, tier one suppliers and the Departments of Energy and Transportation and the Environmental Protection Agency. Mr. Skalny was given a second Medal of Achievement for his leadership of the Initiative and was recognized by the White House for his efforts.

In 2002, Mr. Skalny assumed leadership of the Future Tactical Truck System (FTTS) Advanced Concept Technology Demonstration (ACTD) program. The FTTS ACTD, was a sixty-four million dollar program geared to deliver future light and medium/heavy prototype trucks for assessment by the Army. It became the critical data source for both the Army and Marine Corps decisions regarding Tactical Wheeled Vehicle transformation and ultimately the Joint Light Tactical Vehicle. The FTTS ACTD is the first and only ACTD in TARDEC's history. For his efforts, Mr. Skalny was awarded the Medal of St. Christopher by the Army Chief of Transportation, the highest award given for Transporters.
Mr. Skalny, a member of the Army Acquisition Corps, is a Phi Beta Kappa graduate from Wayne State University. He received his Bachelor of Arts degree in Economics in May 1979. In December 1993, he received his Master of Science degree in Industrial Engineering/Operations Research from Wayne State University's College of Engineering.

Mr. Skalny has served or currently serves on several Executive Boards and Scientific Committees. He is also currently a Director for the 2nd Bombardment Association, an Association composed of World War II veterans of the Army Air Force's 2nd Bombardment Group, 15th Army Air Force.

Dr. Scott Fiveland
Manager, Combustion and Air Systems Technology, Caterpillar

Scott Fiveland is the manager of Caterpillar’s Combustion and Air Systems Technology group, leading efforts for Advanced Diesel Technology, and Military Advanced Propulsion System Technology - high-power density concepts. He joined Caterpillar in 2000 as the technical leader of Gas Engine & Large Diesel Research, responsible for the development of a suite of Caterpillar in-house simulation tools. Simultaneously, he obtained his PhD from the University of Michigan in 2002 in advanced simulations of low-temperature combustion, pioneering methodology for transient heat-release analysis and new ignition delay correlation for advanced diesels. Dr. Fiveland held the post of assistant professor at the Merchant Marine 2004-2005 teaching Thermodynamics, Marine Engineering Design, Marine Engineering II and Advanced IC Engines. He currently holds the post of Adjunct Professor in Thermo and Computational Dynamics at Bradley University since 2006..

LTC (Retired) Samuel C. Homsy
Director, Army Programs, Navistar Defense LLC

Samuel C. Homsy was commissioned in the Corps of Engineers upon his graduation from the United States Military Academy (USMA) at West Point in 1987. Since his graduation, Sam’s career assignments have included a variety of command and staff duties.

He first served as a Sapper Platoon Leader and Executive Officer in Bravo Company of the 13th Engineer Battalion, 7th Infantry Division in Fort Ord, California. It was in the 7th Infantry Division where he first grew to admire the HMMWV as he was the only 2LT with a vehicle in the Infantry Task Force. He also participated in Operation Just Cause in Panama in 1989. Appointed “mayor” or “El Hefe” of Aguadulce (Sweet Water) in Panama, he left an indelible mark on the city, by teaching a generation of local Panamanians the proper (Boston) way to speak English.

After completing the Engineer Officer Advanced Course, Sam served as Assistant Operations Officer and then Engineer Company Commander, in Alpha Company of the 40th Engineer Battalion, 1st Armored Division, in Baumholder, Germany. He then moved to the Combat Maneuver Training Center in Hohenfels, Germany where he was the Engineer Observer/Controller (O/C) on the Grizzly Team. As an O/C, his admiration for the HMMWV continued as he continually made the unauthorized mods to his truck (in which he lived) about which he now decries.

In 1997, Sam spent three years as an Instructor and Assistant Professor in the Department of Civil and Mechanical Engineering at USMA. Teaching vehicle dynamics and internal combustion engines, he finally learned why all those mods were unauthorized. Joining the Army Acquisition Corps in 2001, Sam was an Assistant Product Manager in the Office of the Product Manager, Construction Equipment/Materiel Handling Equipment (PM CE/MHE) in the Program Executive Office, Combat Support & Combat Service Support in Warren, MI. As an APM, he brought the High Mobility Engineer Excavator through its first program phases. His last assignment before becoming the PM, Light Tactical Vehicles (LTV) was as a staff officer for the Director of Acquisition and Industrial Base Policy, in the Office of the Assistant Secretary of the Army for Acquisition, Logistics and Technology (ASA(ALT)). Sam became PM LTV in August 2006. As PM LTV, he had the distinct honor of working with the heroes in LTV, TACOM LCMC and industry who continue to tirelessly support the War Fighter engaged in battle.

Sam retired from active duty in November 2009. He now is the Director of Army Programs with Navistar Defense. He now works with another set of great Americans dedicated to support of the War Fighter.

Sam holds a Bachelor’s degree in Mechanical Engineering from USMA and a Master’s of Science in Mechanical Engineering from the University of Michigan, Ann Arbor. His military education includes Engineer Officer’s Basic and Advanced courses, Combined Arms Service Staff School, Command and General Staff. Sam is Airborne, Air Assault, and Ranger qualified, and Level III certified in Program Management.
Vasilis Tsourapas received his Ph.D. degree from the University of Michigan, Naval Architecture and Marine Engineering in 2007, his M.Sc. degree from the University of Michigan, Mechanical Engineering in 2005 and his B.Sc. from the National Technical University of Athens, Naval Engineering in 2003. Dr. Tsourapas was a recipient of the Department of Defense Graduate Fellowship and his Ph.D. research was funded by the Office of Naval Research (ONR), the National Science Foundation (NSF) and the Automotive Research Center (ARC) of the University of Michigan.

He currently holds the position of Lead Engineer with the Innovation Center of Eaton Corporation, Southfield, MI, and leads R&D programs for future technologies. His current research focus is on optimal controls for alternative and hybrid power systems, drivetrain dynamics, vehicle stability controls and engine emission aftertreatment systems for commercial and military applications.

Hakan Yilmaz is Director of System and Advanced Engineering at Robert Bosch LLC, Gasoline Systems North America. He is also the Principle Investigator of Bosch & US - Department of Energy joint research projects on Advanced Flex-Fuel Systems and the recently awarded ACCESS - Advanced Combustion Concepts, Enabling System and Solutions Project. Prior to his current position, Hakan was responsible for control system development and system design teams for engine management system applications.

Before joining Bosch, Hakan has held several research and advanced engineering positions at the University of Michigan – Advanced Powertrain Control Laboratory; Volvo Car Corporation – Advanced Engineering, Sweden; Invent Flow Control Systems GmbH – Engine Research Center, Germany; and Lockheed Martin & Tusas Aerospace Industries - R&D Department, Turkey

Hakan holds two Master degrees from the University of Michigan, Ann Arbor, in Engineering Management and Mechanical Engineering, and a Bachelor degree from the Middle East Technical University, Ankara, Turkey in Mechanical Engineering.

Sharad Kumar is the Senior Director for Systems Engineering in the General Dynamics Land Systems (GDLS) Division. In this role, he is responsible for strategic direction, leadership, execution and revitalization of Systems Engineering across all of GDLS.

General Dynamics, headquartered in Falls Church, Virginia, employs approximately 91,700 people worldwide and had 2009 revenues of $31.98 billion. The company is a market leader in business aviation; land and expeditionary combat systems, armaments and munitions; shipbuilding and marine systems; and information systems and technologies.

Mr. Kumar began his career at General Dynamics in 1970 as a Design Engineer. Since then, he has held a variety of positions with increasing responsibilities. Prior to his current assignment, he was the Senior Director of Engineering, responsible for product development.

Mr. Kumar holds Masters Degrees in Mechanical Engineering (1967) and Business Administration (1970) from the University of Windsor and a Bachelor of Science Degree in Mechanical Engineering from Banaras Hindu University (1965).

Chris Yakes is Director, Advanced Products at Oshkosh Corporation. He has been with Oshkosh Corporation for the last 13 years and has been involved in various forms of advanced vehicle research, designs and development activities.

As Director of the Advanced Products Group, Yakes is currently responsible for all commercial and military programs, and engineering efforts associated with Oshkosh Corporation’s hybrid vehicle developments and autonomous vehicle development activities, along with many other advanced technology development efforts, tools and techniques.

Recently, Yakes led the engineering for the company’s successful win of the Department of Defense’s M-ATV
(MRAP All Terrain Vehicle) program. He continues to lead engineering teams focused on developing some of the next generation platforms for Oshkosh Corporation.

Yakes was instrumental in developing a production-intent hybrid system design and architecture for Oshkosh Corporation. He continues to lead the team of engineers and scientists in the development of Oshkosh Corporation’s autonomous vehicle, TerraMax™. TerraMax™ was one of only five vehicles to complete the 132-mile off-road Defense Advanced Research Projects Agency Grand Challenge in 2005.

Yakes currently has nine patents related to hybrid systems and autonomous vehicles. He has been a leader in Oshkosh Corporation’s vehicle development efforts including: MRAP All Terrain Vehicles, Joint Light Tactical Vehicle, various DARPA activities, Department of Defense ProPulse Phase I and Phase II, the Future Tactical Truck System and the Family of Medium Tactical Vehicles; the United Kingdom Wheeled Tanker and the Support Vehicles; and the National Renewable Energy Laboratory Advanced Heavy Hybrid Propulsion System.

Yakes graduated from Michigan Technological University with a Bachelor of Science degree in mechanical engineering.

Mr. Mark Groeneweg
Director, DDC, Daimler

Mr. Groeneweg is the Director of Truck Engine Product Engineering for Detroit Diesel. In this capacity he is responsible for Management and Technical Lead for all of Daimler Trucks North America’s Detroit Diesel engine engineering activities in North America, including management of the engineering groups responsible for Design, Component, Performance/ Emissions, and Aftertreatment development of commercial vehicle engines. He also is responsible for collaboration with engine development activities in Stuttgart Germany, engine manufacturing operations in Detroit Michigan, and vehicle engineering in Portland, Oregon. Mr. Groeneweg was the Senior Manager responsible for the engineering development of the new Detroit Diesel Heavy Duty Platform engines introduced to the North American market in 2008. Since joining Detroit Diesel in 1984 as an engineer responsible for structural and thermal design analysis and verification testing of on and off highway heavy duty diesel engine components, Mr. Groeneweg held many positions with increasing levels of responsibility in the areas of Analysis, Design, Engineering Technologies, and Performance and Emissions. Mr. Groeneweg holds a Bachelor of Science in Mechanical Engineering from The Ohio State University and a Masters of Science in Mechanical Engineering from Case Western Reserve University.

Mr. Haukur (Hawk) Asgeirsson, P.E.
Manager, Power Systems Technologies, Detroit Edison – DTE Energy

Haukur (Hawk) Asgeirsson is the Manager of Power Systems Technologies at Detroit Edison, a DTE Energy Company. In his current position, he is managing number of grants related to plug-in electric vehicles, energy storage and solar integration, and the effect of distributed energy resources (DER) connecting to the grid. Hawk is also responsible for managing a mobile fleet of Distributed Energy Resources (DER) for supporting distribution circuits and managing all DERs interconnecting to the Detroit Edison electric system.

Hawk is a member of GridApp, a consortium of utilities whose mission is to transition best smart grid technologies and best practices into broader use by member utilities. He is also an Electric Power Research Institute (EPRI) Advisor on the Energy Storage program, the Electric Transportation program and the industry chair of the Integration of Distributed Renewable program. Hawk was responsible for the EPRI “Best Practices Guide Book for Integration of DER into the Utility System Planning” and “Using Aggregated Distributed Energy resources for Economic Dispatch to an Independent System Operator”.

Mr. Asgeirsson is a member of the NIST Priority Action Plan 7 Electric Storage Interconnection Guidelines and was instrumental in bring the 2011 IEEE PES General Meeting to Detroit and sponsoring the IEEE P2030 Smart Grid Interoperability meeting that was held in Detroit in January 2010.

Mr. Asgeirsson is a member of the board of directors of DTE Engineering Services, Inc., the University of Michigan Transportation Research Institute Advisory Board, the Institute of Electrical and Electronics Engineers EEE and a is registered engineer in Michigan.
### Technical Sessions Part 1

#### Day 1

**1A: Mobility**
- Session Chair: Dr. P. Jayakumar
- 3:30pm - Effect of Coupling Point Selection on Internet-distributed Hardware-in-the-loop Simulation
  - PI: Hosam Fathy

**1B: Survivability**
- Session Chair: Dr. Sudhakar Arepally
- 4:00pm - The Virtual Driver: Integrating Physical and Cognitive Human Models to Simulate Driving with a Secondary In-Vehicle Task
  - PI: Matthew Reed

**1C: Alternative Fuels**
- Session Chair: Patsy Muzzell
- 4:30pm - Estimation Techniques for Mass and Center of Gravity Location of Military Vehicles
  - PI: Jeffrey Stein, Hosam Fathy, Corina Sandu

#### Day 2

**2A: Tire-Terrain Interactions**
- Session Chair: Dr. Al Reid
- 11:00am - A Fatigue Damage Formula and A New Definition of Roughness of Terrain Profiles
  - PI: T.C. Sun

**2B: Reliability**
- Session Chair: Dr. David Lamb
- 11:30am - Mobility, Handling, and Traction Efficiency of Wheeled Off-Road Vehicles
  - PI: Corina Sandu

**2C: Hybrid/Advanced Powertrains**
- Session Chair: Erik Kallio
- 12:00pm - Implication of Terrain Topology Models on Ground Vehicle Reliability
  - PI: John Ferris

### Technical Sessions Part 2

#### Day 1

**3A: Vehicle Design and Validation**
- Session Chair: Dr. Mark Brudnak
- 1:30pm - Multilevel Vehicle Design: Fuel Economy, Mobility and Safety Considerations, Part A
  - PI: Panos Papalambros, Michael Kokkolaras

**3B: Fuel Economy Demonstrator**
- Session Chair: Mike Pozolo
- 2:00pm - Multilevel Vehicle Design: Fuel Economy, Mobility and Safety Considerations, Part B
  - PI: Panos Papalambros, Michael Kokkolaras

**3C: Thermal Management**
- Session Chair: Dr. Matt Castanier
- 2:30pm - Multilevel Vehicle Design: Fuel Economy, Mobility and Safety Considerations, Part B
  - PI: Panos Papalambros, Michael Kokkolaras

### Technical Sessions Part 3

#### Day 1

**3A: Vehicle Design and Validation**
- Session Chair: Dr. Mark Brudnak
- 1:30pm - Simulation-based Validation and Certification of Vehicle Tests and Designs
  - PI: Michael Kokkolaras, Greg Hulbert

**3B: Fuel Economy Demonstrator**
- Session Chair: Mike Pozolo
- 2:00pm - Engine Modeling for the System Analysis Tool in GT-Drive Framework
  - PI: Dennis Assanis

**3C: Thermal Management**
- Session Chair: Dr. Matt Castanier
- 2:30pm - Packaging or Layout Optimization Methodologies Considering Thermal Aspects
  - PI: Georges Fadel
Technical Session 1A – Mobility
Session Chair: Dr. Paramsothy Jayakumar

1A1: Effect of Coupling Point Selection on Internet-distributed Hardware-in-the-loop Simulation
Tulga Ersal/UM (Presenter), Hosam K. Fathy (PI), Brent Gillespie, Zoran Filipi, Jeffrey L. Stein, University of Michigan
Mark Brudnak, TARDEC; Marcella Haghgooie, Applied Dynamics International

As highlighted by our previous integration of TARDEC’s ride motion simulator with UM’s engine-in-the-loop simulator, the Internet-distributed hardware-in-the-loop (ID-HIL) simulation presents unique opportunities for geographically-dispersed concurrent systems engineering. By enabling the Internet-based integration of distributed HIL setups, ID-HIL can offer significantly higher fidelity experiments significantly earlier in the design stage. Thus, alternative designs can be evaluated with unprecedented speed, effectiveness, and with significantly less investment of resources than full physical hardware integration.

These benefits come, however, with unique research challenges. In our previous work we showed that Internet’s delay, jitter, and loss, and distributed simulation affect an ID-HIL setup’s stability, robustness, and transparency, and developed a statistical method to quantify their respective effects. In this talk we will present ID-HIL experiments to show that another important consideration is the coupling point selection. We will also discuss a rigorous control-theoretic analysis to explore some of the factors affecting the ID-HIL performance.

1A2: The Virtual Driver: Integrating Physical and Cognitive Human Models to Simulate Driving with a Secondary In-Vehicle Task
Helen Fuller (Presenter), Matthew Reed (PI), Yili Liu, University of Michigan

Models of human behavior provide insight into people’s choices and actions and form the basis of engineering tools for predicting performance and improving interface design. Most human models are either cognitive, focusing on the information processing underlying the decisions made when performing a task, or physical, representing postures and motions used to perform the task. Many tasks have both cognitive and physical components, which may interact in ways that could not be predicted using a cognitive or physical model alone.

This research proposes a solution by combining a cognitive model, the Queuing Network – Model Human Processor, and a physical model, the Human Motion Simulation (HUMOSIM) Framework, to produce an integrated cognitive-physical human model that makes it possible to study complex human-machine interactions.

The Virtual Driver is the application of the integrated model to driving with an in-vehicle task. A driving simulator experiment was used to tune and evaluate the integrated model. The Virtual Driver replicates basic driving, in-vehicle task, and resource-sharing behaviors and provides a new way to study driver distraction. The model has applicability to interface design and predictions about staffing requirements and performance.

1A3: Estimation Techniques for Mass and Center of Gravity Location of Military Vehicles
Jeffrey Stein (PI, University of Michigan), Hosam Fathy, Benjamin Pence (PhD Student), University of Michigan
Corina Sandu (PI, Virginia Tech), Joseph Hays (PhD student), AVDL, Virginia Tech
David Gunter, U.S. Army TARDEC; Gary Witus, Founder & President, Turing Associates

Frequently, physical parameters of a dynamic system---such as a vehicle's mass and center of gravity location---are unknown or difficult to measure directly. Such uncertainties inhibit engineering analyses, such as those related to active suspension performance and vehicle rollover risk. This project aims at developing new methods to estimate uncertain parameters of on-road and off-road, military and commercial vehicles. The novel estimation techniques introduced in this presentation are based on polynomial chaos theory within the maximum likelihood, Bayesian, Extended Kalman, and Ensemble Kalman filtering frameworks. This project applies these techniques on vehicle dynamics models in order to estimate physical parameters, such as mass and center of gravity location. The first part of the study aims to estimate the vehicle mass in real-time. To do this, the estimation techniques are combined with a vehicle ride model that treats the unsprung mass accelerations, instead of the terrain profile, as the model input. The purpose for using such a model is based on the assumption that one can more readily/inexpensively obtain real-time measurements of the unsprung mass accelerations than of the terrain profile. The method is demonstrated on a complex, multi degree-of-freedom vehicle model. Further validation of the mass estimation technique will be performed based on real test data, to be obtained with support from our quad members. The second part of the study relates to future work and aims at extrapolating the techniques developed for the mass estimation to the estimation of the location of the center of gravity.

Technical Session 1B – Survivability
Session Chair: Dr. Sudhakar Arepally

1B1: Structural Dynamic Modeling and Analysis of Damaged Vehicles
Sung Kwon Hong (Graduate Student), Bogdan Epureanu (PI), The University of Michigan
Matt Castanier and Wesley Bylsma, U.S. Army TARDEC

The objective of this work is to develop new, advanced modeling, simulation, sensor placement and damage detection capabilities for structural dynamic analysis of vehicles that have suffered damage or have design changes in one or more components. These capabilities aim to enable reliability analyses and the development of innovative designs through novel, extremely computationally efficient methods of structural (re-)analysis. These capabilities aim to directly contribute to health monitoring,
1B2: Multi-Scale Simulations for Developing Light Weight Vehicles with Increased Survivability from Impulsive Loads
Nick Vlahopoulos (Presenter & PI), John Kim (GSRA), University of Michigan
Krishan Bishnoi, Farzad Rostam-Abadi, James Sheng, TARDEC
Bachar Aljundi, First Technology, Safety Systems, Inc.

The U.S. Armed forces face the need for rapid deployment from the United States in order to engage regional threats decisively on a global basis. Size and weight are paramount factors for Army vehicles supporting this force projection structure. Composite materials provide some of the most viable options for manufacturing such lightweight vehicles provided that they can offer the desirable level of protection. Multi-scale simulations can be engaged for designing such materials and for evaluating the overall vehicle survivability. The objective of this project is the development of a process that combines the FEMAC code (part of the ImMAC suite of codes from NASA Glenn) with a commercially available code for simulating the loads applied on a structure from explosion/fragmentations in order to develop a new multi-scale simulation method suitable to Army vehicle analysis. The new process will be used within an automated design environment for determining the micro-structure of the composite material for achieving survivability objectives at reduced weight. The progress towards the project’s objectives will be presented.

1B3: Fundamental Multidisciplinary Structure Technology with Application to an Innovative Restraint System for Improved Safety of Military Vehicles
Guang Dong (Presenter and PhD student), Zheng-Dong Ma (PI), Gregory Hulbert, Noboru Kikuchi (Co-PIs), University of Michigan
Sudhakar Arepally, Karrie Hope, Madan Vunnam, and James Sheng, U.S. Army TARDEC
Ken-An Lou (ArmorWorks, LLC), Hui Wang (AM General, LLC)

The objective of this research is to develop a new and general multidisciplinary design methodology that can optimize geometrically nonlinear, time dependent (and timing dependent) structural/multibody systems. The motivating problem and Army application is to support development of an innovative and optimally combined structural and material system for Gunner Restraint Systems, which could include passive, active, and reactive members in a multibody dynamics model, and which can satisfy various operating conditions and battlefield scenarios. A new topology optimization method has been developed for the time dependent, geometrically nonlinear design problem. A representative G-force element was also developed to represent a wide range of passive, active, and reactive members in the multibody dynamics model for the optimal design problem. The new optimization algorithm is further developed to deal with the multi-disciplinary and multi-objective design problem, and advances the current state-of-the-art by new methods to efficiently calculate the design sensitivities.

Technical Session 1C – Alternative Fuels
Session Chair: Patsy Muzzell

1C1: Opposing Effects of Recycled Gases on the Cold Start of Diesel Engines
Naeim A. Henein (PI & Presenter), Walter Bryzik, Rajik Rafail (GRA), Wayne State University
Peter Schihl, U.S. Army TARDEC; Inderpal Singh, DDC

Recycling of the engine out gases during cranking improves the cold staring of direct injection diesel engines as it reduces the cranking period and combustion instability. These effects have been observed in an experimental investigation on the cold starting of a 4-cylinder, turbocharged, diesel engine when the products are recycled at low back pressures. But by applying high back pressures to increase the recycling rate, opposite effects have been observed and the cranking period increased. A preliminary analysis pointed out to the possible role of the recycled aldehydes. This role has been investigated using two approaches. The first is by modeling the autoignition and combustion processes using ChemKin simulation. The second is by using high speed imaging in an optically accessible engine and detailed analysis of the rate of heat release. The results of the two approaches supported the experimental results that an increase in the aldehydes concentration in the fresh charge slows down the autoignition and combustion reactions, and reduces the combustion efficiency of the injected fuel. A detailed analysis of the mechanisms of autoignition and combustion of different fuels in the presence of aldehydes is in progress. This should lead to a better understanding of the basic phenomena that impact the cold starting process and point out to the strategies that can be implemented to improve the cold starting ability of commercial and military diesel engines.

1C2: Multi-Fuel Operation of Advanced Diesel Engines; On Board Fuel Identification
Dinu Taraza (Presenter, PI), Naeim A. Henein and Florin Mocanu, Wayne State University

The increasing use of alternative fuels requires the engine controls to adapt the operation of the engine to the fuel existing in the tank. The identification of the fuel properties directly on the running engine becomes extremely important. This is especially critical for military engines that must run safely and efficiently on any fuel available in the field. The technique used to accomplish this goal is based on the measurement of the crankshaft instantaneous speed by a shaft encoder and converting this information in the cylinder pressure variation over an engine cycle. Two approaches are used. The simplified approach uses the speed to determine the crankshaft acceleration and, considering the crankshaft rigid, to engine torque is estimated, which is then converted into the cylinder pressure. The model based approach uses a detailed dynamic model of the crankshaft to convert the measured speed into the engine torque. The technique is applied first on a single cylinder diesel engine and then transferred to a four cylinder diesel engine. Results
show the possibility to identify the fuel properties by the comparing the peak cylinder pressures and the shape of the pressure trace around TDC.

1C3: JP8 Engine Combustion Modeling
Janardhan Kodavasal (Presenter), Seung-Hwan Keum, Dennis Assanis (PI), Aristotelis Babajimopoulos, University of Michigan

Jet Propellant 8 (JP8) has been chosen by the Department of Defense as the single fuel for the battlefield to facilitate efficient logistics. The effect of using JP8, which is primarily a jet fuel, in military diesel engines is thus an important area of study. Of particular interest to the army is the impact on fuel economy, performance and reliability of equipment running JP8. The differences in the physical and chemical properties of JP8 as compared to diesel (DF2) result in different combustion characteristics which in turn affects fuel economy and performance. The current work is a three dimensional in-cylinder KIVA-3V CFD simulation study on the impact of using JP8 in a typical diesel engine. As a first step, the effect of different physical properties of the two fuels on combustion was studied. Potential chemical kinetic mechanisms and chemical kinetic surrogates for JP8 were also identified and evaluated in CHEMKIN.

Technical Session 2A – Tire-Terrain Interactions
Session Chair: Dr. Al Reid

2A1: A Fatigue Damage Formula and A New Definition of Roughness of Terrain Profiles
T. C. Sun (Presenter & PI), M. Chaika, S. Qiu, K. Alyass, Wayne State University
D. Gorsich, U.S. Army TARDEC; Jinfeng Wei, Maryville University

There have been complaints that the root mean square (rms) does not describe well the roughness of terrain profiles. In this talk we shall first derive a fatigue damage formula using the idea from the linear damage theory in fracture mechanics and the concept of rainflow counts of the oscillation cycles in a terrain profile. We shall use this formula to check how close a simulated profile of a terrain is to the original measured profile of this terrain in regard to the sizes of the oscillations and the number of oscillations. And then we shall use this formula to define a new measure of roughness of a terrain profile which seems to be more sensitive to the number and the size of the oscillations in the road profile. We believe that this new definition can be used in parallel to the root mean square method as measures of roughness of terrain profiles.

2A2: Mobility, Handling, and Traction Efficiency of Wheeled Off-Road Vehicles
Corina Sandu (PI), Carmine Senatore (PhD candidate), AVDL, Virginia Tech
Alexander Reid, U.S. Army TARDEC; Tim Rooney, The Goodyear Tire & Rubber Company

Mobility, handling, and energy efficiency of off-road vehicles are deeply influenced by the tire-soil interaction mechanism. In this study, a tire model able to predict the performance of rigid wheels and flexible tires is developed. The model follows a semi-empirical approach for steady-state conditions and predicts basic features, such as the drawbar pull, the driving torque and the lateral force, as well as complex behaviors, such as the slip-sinkage phenomenon and the multi-pass effect. The tractive efficiency of different tire-soil configurations is simulated and discussed. To investigate the handling and the traction efficiency, the tire model is implemented into a four-wheel vehicle model. Several tire geometries, vehicle configurations (FWD, RWD, AWD), soil types, and terrain profiles are considered to evaluate the performance under different simulation scenarios. The simulation environment represents an effective tool to realistically analyze the impact of tire parameters (size, inflation pressure) on the energy efficiency. It is verified that larger tires and decreased inflation pressure generally provide better traction and energy efficiency (under steady-state working conditions). The torque distribution strategy between the axles deeply affects the traction and the efficiency: the two variables can't clearly be maximized at the same time and a trade-off has to be found.

2A3: Implication of Terrain Topology Models on Ground Vehicle Reliability
Sujay Kawale (Presenter), John B. Ferris (PI), Heather Chemistruck, Ma Rui, Virginia Tech
Alexander A. Reid, U.S. Army RDECOM-TARDEC; Eric Tseng, Ford Motor Company

Accurately predicting ground vehicle performance, such as durability and reliability, through modeling and simulation requires accurate vehicle models and excitation of these models. This work addresses the primary excitation to the ground vehicle, the terrain, for which a modeling and simulation software package is developed. TerrainSim© is terrain topology modeling and simulation software developed by the Vehicle Terrain Performance Laboratory (VTPL) at Virginia Tech. The software analyzes the statistical properties of measured terrain profiles, identifies the optimal parameters for an Autoregressive (AR) model of the empirical terrain profile, and generates a synthetic terrain profile having the same statistical properties. The appropriateness of the AR representation is then evaluated in terms of the ability of the synthetic profile to match the important statistical properties of the empirical profile. This ability to analyze and simulate terrain will serve as a valuable tool to excite vehicle models, improving the ability to predict durability, reliability, and ride quality through simulation. In turn this will reduce dependence on expensive and time-consuming physical tests for ground vehicle development and allow physical testing to be used for validation and verification of designs.
2B1: A Metamodeling Method Using Dynamic Kriging and Sequential Sampling
Liang Zhao (Presenter), K.K. Choi (PI), and Ikjin Lee, The University of Iowa
David Gorsich and David Lamb U.S. Army RDECOM/TARDEC

In engineering design, metamodeling has been widely applied to design problems to build a surrogate model of computationally-intensive engineering problems. The Kriging method has gained significant interest for developing the surrogate model. However, traditional Kriging methods, including the ordinary Kriging and the universal Kriging methods, use fixed polynomials basis functions to generate the mean structure. In this paper, a new method, the so-called Dynamic Kriging (DKG) method is proposed to fit the true model more accurately. In this DKG method, the optimal mean structure is obtained using the basis functions that are selected by a genetic algorithm from the candidate basis functions based on a new accuracy criterion. In addition, a sequential sampling technique based on the prediction interval of the surrogate model is used and integrated with the DKG method. Numerical examples show that DKG generates significantly more accurate results compared with traditional Kriging methods and other metamodeling methods.

2B2: Sampling-Based Stochastic Sensitivity Analysis Using Score Functions for RBDO Problems with Correlated Random Variables
Ikjin Lee (Presenter), K.K. Choi (PI), Yoojeong Noh, and Liang Zhao, The University of Iowa
David Gorsich and David Lamb, U.S. Army RDECOM/TARDEC

This study presents a methodology for computing stochastic sensitivities with respect to the design variables, which are the mean values of the input correlated random variables. Assuming that an accurate surrogate model – the Dynamic Kriging is used in this study – is available, the proposed method calculates the component reliability, system reliability, or statistical moments and their sensitivities by applying Monte Carlo simulation (MCS) to the accurate surrogate model. Since the surrogate model is used, the computational cost for the stochastic sensitivity analysis is negligible. The copula is used to model the joint distribution of the correlated input random variables, and the score function is used to derive the stochastic sensitivities of reliability or statistical moments for the correlated random variables. An important merit of the proposed method is that it does not require the gradients of performance functions, which are known to be erroneous when obtained from the surrogate model, or the transformation from X-space to U-space for reliability analysis. Since no transformation is required and the reliability or statistical moment is calculated in X-space, there is no approximation or restriction in calculating the sensitivities of the reliability or statistical moment. Numerical results indicate that the proposed method can estimate the sensitivities of the reliability very accurately, even when the input random variables are correlated. Furthermore, the sampling-based reliability-based design optimization (RBDO) using the proposed sensitivity calculation and the Dynamic Kriging also works very well for both mathematical examples and real engineering applications.

2B3: Time-Dependent Reliability using a Random Process Approach in the Design for Lifecycle Cost and Preventive Maintenance of Vehicle Systems
Amandeep Singh (TARDEC, PhD Candidate), Zissimos P. Mourelatos (Presenter, PI), Jing Li, Oakland University

Reliability is an important engineering requirement for consistently delivering acceptable product performance through time. As time progresses, the product may fail due to time-dependent operating conditions and material properties, component degradation, etc. The reliability degradation with time may increase the lifecycle cost due to potential warranty costs, repairs and loss of market share, and also affect maintenance schedules. We will present methodologies considering the cost during the life of the product, to determine 1) the optimal design of time-dependent, multi-response systems, and 2) a preventive maintenance schedule. Examples will highlight the calculation of the cumulative probability of failure and the design for lifecycle cost. A methodology will be also presented to calculate the first-passage probability of failure of a dynamic system, driven by an ergodic input random process. Time series modeling is used to characterize the input random process based on data from a “short” time period (e.g. seconds) from only one sample function of the random process. A quarter car model on a stochastic terrain will demonstrate the proposed methodology. Future research will concentrate on developing an importance sampling method which allows the use of MC simulation with only a small number of sample functions.

Technical Session 2C – Hybrid/Advanced Powertrains
Session Chair: Erik Kallio

2C1: Modeling and Simulation of Series Hybrid Electric Vehicle with In-Hub Motors
Youngki Kim, Tae-Kyung Lee and Zoran Filipi (PI), University of Michigan

Power and energy efficiency of vehicle systems are of strategic importance for TARDEC and as such are receiving increased emphasis in the Automotive Research Center. Advanced models of energy conversion and storage, system integration methodologies, analysis and optimization of complex hybrid vehicle power systems (main and ancillary), and techniques for supervisory control will provide the cornerstone of the new vision. The on-going effort pursues development of the next-generation electrified tactical truck based on the M-ATV specifications. This vehicle is significantly larger and heavier than the HMMWV and it will be equipped with a number of electrified systems. High mobility, packaging and implementation of IED protection favor application of in-hub motors. Our modeling approach emphasizes proper degree of fidelity, i.e. a combination of physics-based models and efficiency maps that
provide sufficient predictiveness and acceptable computational effort for system analysis. As an example, a link is established with the separate activity on physics-based battery modeling and a parameterized electrochemical battery model is integrated within the HEV simulation. The simulation is used to address component sizing based on performance requirements and representative driving schedules. Predicted battery state-of-charge and current time histories indicate frequent transient peaks exceeding 500 Amps and provide impetus for modifications of the supervisory controller. The supervisory strategy considers propulsion requirements, charge sustaining with realistic power limits, and optimization of engine operation. The predictions demonstrate significant fuel efficiency potential and provide definition for on-going work focused on next-generation electric motor modeling and application of optimization algorithms for supervisory control.

2C2: Dynamic Characterization and Analysis of Turbocharged SOFC Engines
So-ryeok Oh (Presenter, co-PI), Jing Sun (PI), The University of Michigan
Herb Dobbs, Joel King, U.S. Army TARDEC

Combining solid oxide fuel cell and gas turbine (SOFC/GT) system is a promising concept for future clean and efficient power generation. An SOFC/GT system exploits the complementary features of the two power plants, where the GT recovers the energy in the SOFC exhaust stream and thereby boosting the overall system efficiency. Through model based transient analysis, however, it is shown that the intricate coupling dynamics make the transient load following very challenging. Power shutdown has been observed when the load is changed abruptly. Our recent work focuses on modeling, dynamic analysis, and control design for the turbo-charged SOFC engines with the goals to understand the dynamic capabilities and performance limitations the system for military APU applications. First, dynamic load following capabilities and issues are examined through model based analysis for two distinct SOFC/GT designs: One is a single-shaft design with the compressor and turbine mounted on the same shaft as the power generator. Another is a dual-shaft design with two turbines, namely one drives a compressor and another is a free power turbine driving a generator. Second, based on control parameter sensitivity analysis of load changes, an optimal load operation strategy which explores the trade-off between the system efficiency and the fast load change capability is developed.

2C3: Measuring Electro-thermal Battery Dynamics
Jason Siegel (presenter), Xinfan Li, Anna Stefanopoulou (PI), Levi Thompson, University of Michigan
Sonya Zanardelli, David Gorsich, Yi Ding, U.S. Army TARDEC
Dyche Anderson, Ford Motor Co; Ray Skinner, A&D Technology

Our ability to control the power and fully utilize the energy from Li-ion batteries depends on physics-based and scalable battery models of the cell spatio-temporal variations in lithium concentration and temperature. These models can then be used for real-time state of charge estimation, efficient cell-to-cell balancing, and active thermal management using nonlinear predictive control techniques. In this presentation we summarize the parameterization process of an electrochemical model of the lithium concentration in the solid electrode using a set of carefully performed experiments. We then discuss the potential and challenges of using neutron imaging for in-situ measurement of the lithium concentration for detailed model validation. The choices of materials and chemistry, and the design of the electrode and the casing for enhancing the contrast between the charged and discharged states are presented. We finally show the neutron imaging facility at the National Institute of Standards and Technology that has allocated beam time in June for our experiments.

Technical Session 3A – Vehicle Design and Validation
Session Chair: Dr. Mark Brudnak

3A1: Simulation-based Validation and Certification of Vehicle Tests and Designs
Greg Hulbert and Michael Kokkolaras (Presenters & PIs), Panos Papalambros (PIs), University of Michigan
Z. Li and Z. Mourelatos, Oakland University; David Gorsich and Mark Brudnak, U.S. Army TARDEC

It is important to quantify the confidence that designs obtained using simulations will perform as expected when realized. However, due to practical limitations of physical testing, it is impossible to assess the validity of designs throughout the design and parameter space. In addition, the object of validation should be the resulting design, not the simulation model. This talk will first discuss techniques for computing simulation confidence and then present a novel methodology for validating designs as they are generated during the simulation-based optimization process.

3A2&3: Multilevel Vehicle Design: Fuel Economy, Mobility and Safety Considerations: Parts A & B
Michael Alexander (Presenter, Part A), Steven Hoffenson (Presenter, Part B), Panos Papalambros (PI), Michael Kokkolaras (PI), University of Michigan
David Gorsich, Sudhakar Arepally, U.S. Army TARDEC

Military vehicles are designed and built to perform in a variety of mission environments and scenarios. Their performance requirements under some operating circumstances often compete with other requirements under different, often unpredictable, circumstances. Further, the available technologies and demands placed on these vehicles change over time, and new environments pose new challenges in speed and maneuverability, fuel supply chain logistics and costs, and protection from new modes of attack such as improvised explosive devices (IEDs). Next generation light tactical vehicles (LTVs) must meet these challenges in a collectively meaningful manner. Towards this goal, the present study introduces a framework for the development of a fully-electric ground vehicle based on mathematical design optimization decision making. Part (a) of the study presentation will focus on a
Technical Session 3B – Fuel Economy Demonstrator
Session Chair: Mike Pozolo

3B1: Engine Modeling for the System Analysis Tool in GT-Drive Framework
Kyoung Hyun Kwak, Dohoy Jung, Dennis Assanis (PI), University of Michigan

Engine performance and fuel consumption maps over the entire engine speed-load range are needed to evaluate vehicle performance and fuel economy over driving cycles using vehicle simulation tools. However, complete engine performance and fuel consumption maps are difficult to be obtained from manufacturers. Typically very limited data at several operating points are often available. As the first step to address this issue a methodology to generate engine maps with limited data in the GT-Drive framework using high fidelity engine modeling with GT-Power is developed. For the high fidelity engine combustion model, UM-developed quasi-dimensional multi-zone diesel combustion model is implemented into GT-Power. The model is evaluated in wide ranges of engine operation and sizes with existing experimental data. In addition, an engine map generation strategy to construct virtual full engine model including dual stage turbo-charger is exercised. Using this strategy, a set of virtual engine performance and fuel economy map is generated.

3B2: Modeling and Simulation of a Road-Coupled Parallel HEV System with ISG
Abhishek Bhat, Zoran Filipi, Dennis Assanis (PI), University of Michigan

Improving military vehicle fuel economy is of strategic importance, due to the overall impact of the fuel consumption on cost and logistics. The FED (Fuel Efficient Ground Vehicle Demonstrator) program was recently launched by TARDEC (U.S. Army’s Tank Automotive Research, Development and Engineering Center) with the primary objective to prepare the armed forces for the 21st century by developing and evaluating alternatively-powered fuel efficient military vehicles. The goals include investigating innovative concepts from non-traditional sources by leveraging modeling and simulation capabilities to predict performance, set objectives and establish test criteria. ARC team is providing support with development of modeling and simulation capabilities. The software platform of choice for this effort is GT-Drive, and of particular interest is the ability of GT-Drive to be interfaced with MATLAB-Simulink in order to port custom models or control modules into the system simulation environment. This project pursues development of the simulation for a parallel hybrid electric vehicle with moderately sized Integrated Starter Alternator (ISA - mechanical path) and two in-hub motors (through-the-road coupling). The engine and ISA drive the front axle via the conventional transmission, while the in-hub motors coupled to the rear wheels enable regeneration and greater flexibility in controlling engine operation. This architecture poses a number of unique research questions pertaining to design and control. In order to understand the merits and limitations, vehicle model has been developed within the GT-Drive framework and supervisory control module has been integrated as a self-contained module. Two different supervisory strategies, namely the rule based and equivalent consumption minimization strategy (ECMS) have been implemented to fully understand the potential benefits over specified military driving missions.

3B3: Packaging or Layout Optimization Methodologies Considering Thermal Aspects
Karthik Ravindranath (Presenter), Georges Fadel (PI), Clemson University
Mark Brudnac, U.S. Army TARDEC; Peter Fenyes, GM

Optimal placement of components under the hood is a major design concern for the efficient overall vehicle performance and passenger comfort. This is even more an issue for hybrid vehicles. Current under the hood packing approaches do not consider thermal issues which could play a vital part in the placement of components. Common approaches for 3D thermal modeling are computationally expensive and inflexible. We are evaluating a lumped heat transfer model which can be called iteratively for final changes in design and placement of the components in the vehicle under steady state environment. This packing problem incorporates dynamic behavior, survivability, accessibility and component operational temperature as the objectives subject to collision detection and ground clearance. The Agent-based approach should make the multi-criteria under the hood packing problem simpler and computationally more efficient. Each component under the hood is considered as an agent that interacts, coordinates, cooperates and negotiates with its neighboring components to achieve the ideal placement.

Technical Session 3C – Thermal Management
Session Chair: Dr. Matt Castanier

3C1: Vehicle Thermal Management System of Advanced Vehicles: The Impact of Climate Control System
Sungjin Park (Presenter), Dohoy Jung (PI), Dennis Assanis, Zoran Filipi, University of Michigan
Peter Schidl (U.S. Army TARDEC); Bashar Abdull/Nour (GDLS), Jun Kuang (GDLS)

Bullet proof operation of vehicle cooling system of the powertrain is critical for the survivability of army ground vehicles. In addition, climate control (Air Conditioning) system is also important for reduced fatigue of vehicle operators and thermal damage of on-board electronic equipments. In hybrid powertrain systems, battery pack temperature is cooled by the cabin air managed by the climate control system. In addition, both the powertrain cooling system and the climate control system are major parasitic power consumers. Thrust area IV at the University of Michigan has studied on the design and optimization of the cooling systems for better
performance and fuel economy. This year we expanded our work scope to include the climate control system as a subsystem for vehicle thermal management. A numerical model of climate control system has been developed including the refrigerant system and the heat sources in the cabin. Then the impact of the climate control system on the performance and efficiency of the thermal management system was investigated. The results show that the parasitic power consumption by the refrigerant compressor is considerable and varies depending on driving conditions. It is also observed that the climate control system causes more parasitic power consumption than the cooling system despite relatively smaller heat rejection from the cabin.

3C2: Enhanced Fluid Properties and Minimization of Radiator Fan Power Consumption in Military Ground Vehicle Cooling Systems
Lin Ma (Presenter and PI), John Wagner (PI), David Ewing, Joshua Finn, Clemson University

Internal combustion engines have been applied in mobile and stationary settings, for transportation and power applications. The engine, during its power stroke, generates heat and must be cooled either by air or liquid coolant to maintain an acceptable operating temperature. Engines cooling circuits typically involve a radiator fan, water pump, a thermostat valve, and a heat exchanger/radiator. The water pump and radiator fans can either be mechanical, electrical or hydraulic driven and the thermostat valve is wax based or electric activated. From a power consumption perspective, the radiator fan(s) consume the greatest amount of power followed by the water pump and then the thermostat. In this proposed study, an analytical and experimental analysis will be undertaken to minimize the radiator fan array power usage to improve the vehicle’s fuel economy. In addition, a variety of additive materials may be introduced into the coolant fluid to improve the heat transfer process and overall efficiency. In this second aspect of the study, nano-particles will be added to the ethylene-glycol and water mixture with subsequent evaluation to determine heat rejection improvements.

3C3: Piston-Assembly Dynamics and Frictional Losses in High Power Density Diesel Engines
Nabil G. Chalhoub (PI & Presenter), Mohammad Al-Hakeem (GRA), Naeim A. Henein, Wayne State University
Pete Schihl, U.S. Army TARDEC; Hassan Nehme, Ford Motor Co.

The objective of this work is to determine the instantaneous frictional losses of the piston-assembly, which directly impact engine fuel economy, noise, wear and durability, all of which are critical for the safe and reliable operation of both military and commercial vehicles. The formulation accounts for the piston secondary motions (both piston-slap and piston-tilting), piston contact with the cylinder liner, and the solid-fluid interaction between the piston-skirt and the lubricating oil film. Moreover, given the fact that the piston rings are the major contributors to the piston-assembly frictional losses and engine wear, the derivation considers the rigid and flexible motions of the rings. Accounting for rings’ elasticity is essential to properly formulate the solid-fluid interaction between the rings and the lubricating oil film, which mainly involves longitudinal and in-plane transverse deformations of the rings. The interaction between the rings and the piston dictates the rings’ rigid body motions along with their torsional and out-of-plane transverse deformations. At this stage, results pertaining to the dynamics of the piston-assembly will be presented under both transient and steady-state engine operating conditions. The model will be helpful in designing the piston-assembly for high speed and high power density engines.