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Professor Frediano V. Bracco – In memoriam

Rolf Reitz, John Abraham, Franco Grasso, Tang-Wei Kuo, Dimitrios Kyritsis and Luigi Martinelli

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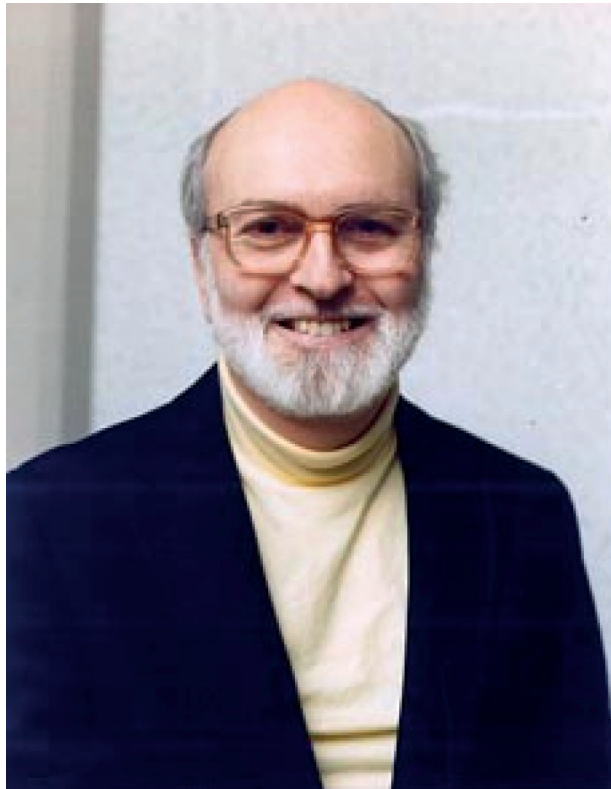
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Frediano V. Bracco passed away on September 3rd, 2013. He was a pioneer in internal combustion engine research. His accomplishments within and outside the Mechanical and Aerospace Engineering Department at Princeton University, New Jersey, were seminal, and they helped lead to significant improvements in the design of transportation engines.

Born in Genova, Italy in 1937, Professor Bracco received a Master's of Science in Mechanical Engineering from Bologna University, Italy in 1961. After a short stint in Industry, Professor Bracco completed a second M.S. degree in Aerospace Engineering at the University of Oklahoma in 1964, thereafter joining Wyle Laboratories in Huntsville Alabama as a "Special Investigator" in gas dynamics involving air shocks, shock wave focusing, shock interactions, and nonlinear acoustics. Professor Bracco came to Princeton in 1966, joining the then Aerospace and Mechanical Sciences Department as a graduate advisee

of Prof. Luigi Crocco. Upon completing his Ph.D. degree in 1970, Professor Bracco joined the Professional Research Staff of the Department, transferred to the faculty in 1973 as an Assistant Professor, and was promoted to full Professor in 1983.

As early as about 1971, Prof. Bracco began to devote the majority of his research efforts to internal combustion engine related research, and became a pioneer in the field. As an Assistant Professor, he established the Engines and Sprays Laboratory in the Mechanical and Aerospace Engineering department at Princeton, which he led until June 1996. Over the 25 years of its operation the Princeton Laboratory became internationally renowned for its original and groundbreaking contributions to sprays and combustion research and for the development of advanced measurement and computational tools to investigate in-cylinder processes in engines.

Professor Bracco introduced to the engine combustion community *in situ* laser diagnostics to investigate the details of in-cylinder flows, high pressure spray atomization, turbulent combustion, and transient processes inside motored and firing internal combustion engines. He also pioneered the use of multidimensional computer models to describe complex flows, sprays, and combustion in internal combustion engines. Professor Bracco, and under his leadership, his graduate students and professional and technical staff, made seminal contributions to advances in engine design, atomization and sprays, and to fundamental research on Wankel engines, stratified charge spark ignition engines, and diesel engines in a unique manner that introduced the fundamentals of the physical and chemical sciences to internal-combustion-engine technology.

His group's pioneering contributions included Boltzman-equation-based spray modeling, the development of spray atomization and drop collision and coalescence models, the experimental establishment of the fractal properties of in-cylinder flames, the achievement of two-dimensional spontaneous Raman imaging in an optical engine, and detailed characterization of flow turbulence and its effect on flame speeds and combustion rates in engines. The coupling of detailed and informative measurements with detailed computations and a rigorous theoretical foundation provided substantial insights, which formed the basis for

high-fidelity models that improved the understanding of engine sprays and combustion. That these models are widely employed by the engine industry today to design and optimize engines is in no small measure a testimony to the impact of the work of Prof. Bracco and his students.

Professor Bracco was also instrumental in starting the Direct-Injection Stratified Charge (DISC) engine combustion workshops organized by the US Department of Energy. Through these workshops, a strongly collaborative research environment was developed involving industry, national laboratories, and academia, and the work from the Princeton Laboratory was disseminated to the wider engine research community. The DISC workshops were often lively and were marked by highly stimulating discussions in large part because of Prof. Bracco's highly reputed ability to raise pointed, incisive and critical questions. The workshop became a model for similar workshops in other fields.

Professor Bracco played an integral role in sustaining, nurturing, and growing Princeton's internationally recognized eminence in combustion and the thermal sciences. Over his career at Princeton, he advised 37 graduate students, and provided a strong academic research environment that included 12 Professional Research and Technical staff. Several of his former PhD students currently hold academic positions in

leading universities in the USA and abroad. His students remember his ability to think deeply about research questions and ask the critical questions, which would lead to the solution of fundamental and applied problems. He created a challenging and stimulating environment for his students and staff where high-quality research could flourish.

Professor Bracco authored or co-authored over two hundred publications in the fields of liquid propellant rocket combustion, non-linear acoustics, detonations, steady and unsteady spray combustion, liquid jet atomization, formation of pollutants in combustion processes, numerical analysis, advanced instrumentation and optical diagnostics, catalytic combustion, and modeling and measurements of combustion in spark ignition, compression ignition, and stratified charge reciprocating and rotary engines. He received numerous awards for his technical contributions to the Society of Automotive Engineers, including the Colwell Merit Award, 1984 and 1985, the Harry Horning Award in 1986 and 1987, and he was elected an SAE Fellow in 1988. He also served as Associate Editor of the Combustion Science and Technology journal from 1972-77, and was a member of the ASME and AIAA.

**Rolf Reitz, John Abraham, Franco Grasso,
Tang-Wei Kuo, Dimitrios Kyritsis and Luigi Martinelli**