Abstract Submission for
The Ninth Triennial International
Aircraft Fire and Cabin Safety Research Conference

Sponsor: Fire and Cabin Safety Research Group (FCSRG)
Venue: Resorts Hotel, Atlantic City, New Jersey
Dates: October 28-31, 2019

Abstract Title: Smoke Detection System Performance Modeling

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To design and certify smoke detection systems in cargo compartments, tests are conducted on the ground and in-flight, and involve assessing the performance of the detection system with an oil-based smoke generator in a cargo bay simulator and on the aircraft. For a fixed set of smoke generator settings (heater power, carrier gas pressure, oil flow rate), the generator can be positioned in any location in the aircraft cargo compartments, and the ventilation schedule can vary as prescribed by the air-framer for different points in the flight cycle. These parametric variations can lead to hundreds of costly tests that could span over the course of many months.

Computational Fluid Dynamics (CFD) tools offer an opportunity to augment the certification process with virtual tests that assess the performance of the smoke detection system. The aviation community has explored the application of CFD to develop and validate simulation methodologies to predict the transport of smoke from fire sources. However, the development of a simulation methodology that can assess the performance of a smoke detection system for certification test purposes has not been widely reported.

Over the past year, our team has worked toward developing a validated CFD simulation methodology to assess the performance of a smoke detection system in cargo bays with an oil-based smoke generator. The Fire Dynamics Simulator (FDS) from NIST was used to simulate the transport and detection of smoke from the generator. Data sets were acquired in a controlled laboratory setting to validate the buoyant plume velocities and temperatures from the generator as well as the detector alarm time. The validated model was extended to simulate a cargo bay geometry to predict the alarm times from a detection system. The sequence of smoke arrival time at each detector compared well with the simulation predictions. A demonstration of extending the tool to study variations in the smoke generator output, flight cycle operating conditions, and the presence of bulk items will also be presented.