# 2009 BFRL Project Description

## **Project Title:** Model Verification for VCBT

September 5, 2008

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**BFRL Program:** Cybernetic Building Systems

**Objective:** To develop and validate the fire simulation capability for the Virtual Cybernetic Building Testbed that will be used to test the performance of information displays and decision support tools for responding to building fire emergencies.

**Problem:**

***What is the problem?*** BFRL research and demonstrations have shown the feasibility of combining real-time sensor information with computer models to deliver critical decision support information to first responders. Developing decision support systems that operate in real-time with demonstrated accuracy and information outputs acceptable to the emergency response community requires rigorous validation tools that do not exist. Two recent papers in Fire Technology provide insight to the need for this project.[1, 2]

The size of the problem is demonstrated by data from NFPA showing that in 2006 there were 524,000 structure fires, 2705 civilian deaths and $9.6 billion in property damage.[3] The decision support models developed and demonstrated with the VCBT are expected to reduce both the number of civilian deaths and property losses.

***Why is it hard to solve?*** The problem is hard because of the difficulty in developing a realistic building simulator for fire and decision support tools that operate in real time. The tools must be usable for a wide range of building sizes and types, and for many different incident scenarios. In fires, there can be complicated interactions with building systems such as operating HVAC systems, wind effects, and unknown window and doorway openings. First responders are reluctant to adopt new technology without a high level of confidence that it will work when needed and overcoming this obstacle is hampered by the lack of a way to demonstrate new concepts and test prototype products in a realistic manner for the wide range of conditions in which responders must operate.

[1] Craig Weinschenk, Ofodike A. Ezekoye and robert Nicks (2008) Analysis of Fireground Standard Operating Guidelines/Procedures Compliance for Austin Fire Department, Fire Tech 1:39-64

[2] Primoz Podrzaj and Hideki Hashimoto (2008) Intelligent Space as a framework for Fire Detection and Evacuation, Fire Tech 1:65-76

[3] Karter, M. J., Fire Losses in the United States during 2006 (2007) National Fire Protection Association

***How is it solved today, and by whom?*** A solution of the problem does not exist but parts of the solution have been developed at NIST. The Virtual Cybernetic Building Testbed (VCBT) and Sensor Driven Fire Model (SDFM) represent a testbed and the first of its kind decision support system for first responders. The VCBT simulation tool set includes ZFM-HVAC which has recently been developed to simulate building fires with interacting HVAC systems but the simulation results have not been validated by laboratory experiments and measurements from full-building fires. The National Electrical Manufacturers Association has begun developing standards for symbology for use in emergency responder displays. The NEMA SB30 standard is being revised as additional features are added to the SB30 panels. For example, the new enroute screen will need additional icons and the use of the remote interface

***Why NIST?*** Industry does not have the modeling sophistication or laboratories needed to develop future decision support tools such as the Sensor Driven Fire Model (SDFM), which can extract heat release information from sensor signals. NIST has already been approached by a large manufacturer to establish a CRADA to help develop and test a decision support system. This work falls within the BFRL mission to meet the measurement science needs of the building and fire industry and builds on the core competency Fire Protection and Fire Spread within Buildings and Communities.

**Approach:**

***What is the new technical idea?*** A suite of simulation cases will be developed that enable the VCBT to emulate realistically sized buildings with complex automation systems under a variety of incident scenarios. Emulation results will be compared with actual fire data (where possible) and with accepted results from other simulation tools. These test cases will be used to investigate new concepts and identify roadblocks to the development of decision support tools. Virtual controllers will also be developed to represent systems that are not part of the current VCBT hardware capabilities.

***Why can we succeed now?*** Communities around the country are developing sophisticated centers for emergency management that have need for building specific information. Industry has already begun to use the early results from this project to develop new products and standards for next generation fire panels and onsite emergency response centers. With the NEMA SB30 standard that is included in an NFPA72 annex, the stage is set to develop and move this technology into the emergency response community.

***What is the research plan?*** The focus will be on testing and verifying the software suite currently in use by simulating one full-scale building fire that has sufficient data to permit the predictions of the VCBT to be verified; enhancing the VCBT/SDFM to include smoke and CO alarm analysis; developing a method for the VCBT to check its predictions with building sensors in order to develop a method to inform an incident commander about the accuracy of the simulation; and adding virtual controllers for one system, such as elevators, that is not currently emulated by the VCBT.

Validation issues for the VCBT will focus on the impact of operating HVAC systems in fire scenarios in buildings. Either an actual building or a building constructed in the large fire laboratory will be used to provide a set of validation data on smoke movement in fire situations.

Prior to being conducted, the experiments will be modeled in order to define detector locations and fire sizes. Documentation will be developed to make the VCBT system useable for experimentation by outside groups. In addition, a non-fire building example will be set up for both the VCBT and COMTAMW in order to compare the computational results for HVAC systems.

The HVAC system in the VCBT will be tested for the transport of smoke particles in fire scenarios. Additional building scenarios for fire will be developed that include elevators and stairwells and will be used to study pressurization effects on smoke movement to support standards development in this arena. This experimental set will complement the experiments in that smoke movement on a single floor will be studied while the complexity of vertical smoke movement. The addition of these building systems to the VCBT will require additional enhancement of the decision support model (SDFM) and perhaps the development of additional models.

A study of the remote control of building systems in a fire scenario will be conducted as a test for both the control methods and the capability of the decision support system (SDFM) to provide accurate feedback. .

**Recent Results:**

A six-story 31 zone building scenario was developed for the VCBT using a combination of virtual and real HVAC system controllers, the largest building simulated in the VCBT.

**Outcome:** The differential equation set in ZFM was replaced providing a more robust implementation that allows the upper layer to vanish without causing numerical difficulties.

The ZFM/SDFM was used to develop the scenarios used in the Wilson N. C. demonstration.

Completed a set of smoke detector experiments to be used as verification for algorithms developed for SDFM. Currently, these results are being analyzed with the predictive zone fire model JET.

A set of full-scale experiments in a Toledo school modeled using heat detectors with the SDFM and actual measurements were obtained using calibrated smoke detectors.

**Output:** Davis William D., et al. “Predicting Smoke Alarm Response to Fires using the Fire Model JET,” WERB approved, submitted to Fire Technology.

**Standards and Codes:**

NEMA Standard SB 30-2005, Fire Service Annunciator and Interface. An upgraded version that includes the en-route screen demonstrated at Wilson N. C. is in final review and will be included as both a NEMA standard and in the annex of NFPA 72.