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<th>Faculty</th>
<th>Research Areas</th>
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<td>M. di Marzo</td>
<td>suppression, detection</td>
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<td>M. Gollner</td>
<td>wildfires, flammability, sustainability</td>
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<td>K. E. Isman</td>
<td>suppression systems</td>
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<td>A.W. Marshall</td>
<td>fire flows, combustion, suppression</td>
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<td>J. A. Milke</td>
<td>structures, detection, egress</td>
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<td>S. I. Stoliarov</td>
<td>pyrolysis, flammability, fire growth</td>
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<td>P. B. Sunderland</td>
<td>fire dynamics, diagnostics, refrigerant fires</td>
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<td>J. L. Torero</td>
<td>smoldering, structures, fire dynamics</td>
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<tr>
<td>A. Trouvé</td>
<td>turbulent combustion, fire modeling</td>
</tr>
</tbody>
</table>
Faculty: M. Gollner, A. Trouvé

M.S. Students: Lana Benny, Evan Sluder

Ph.D. Students: Xingyu Ren

Title: Buoyant instabilities in inclined fires

Sponsor: USFS RMRS Decision Support Center

Collaborators: M. Finney, S. McCallister (USFS)

Objectives: Determine the mechanisms responsible for wildland fire spread. Current work on adding grid-generated turbulence, understanding flame attachment and intermittent heating on fuels.

**WIFIRE – Real Time Wildfire Predictions**

- **Faculty:** M. Gollner, A. Trouvé
- **Ph.D. Students:** C. Zhang
- **Title:** Real-time wildland fire modeling
- **Sponsor:** National Science Foundation
- **Collaborators:** UC San Diego
- **Objective:** NSF-funded Development of a cyberinfrastructure for real-time wildfire monitoring and prediction

Example of a test simulation performed with FIREFLY showing the time evolution of the burnt area (in blue) on a complex terrain. (a) $t = 225$ s; (b) $t = 1275$ s (Trouvé)
**Faculty:** M.J. Gollner

**Students:** H. Salehizadeh (M.S.), R. Hakes (Ph.D.), A. Davis (B.S.), E. Griffith (B.S.)

**Title:** Understanding Ignition Susceptibility of Wildland Urban Interface (WUI) Fuels to Firebrand Attack

**Sponsors:** NIST EL Fire Grant Program

**Objective:** Understand ignition by firebrands of wood, plastic and composite assemblies attached to structures, such as decks, fences, porches, etc.

![Image of flaming ignition of a Redwood decking assembly](image_url)

Flaming ignition of a Redwood decking assembly due to firebrand accumulation (Manzello and Suzuki, 2014).

Different possibilities for the ignition process conceived as a result of a single brand or pile of smoldering embers placed on a wooden substrate. The possible locations for ignition will be determined by experiments and then incorporated into analyses.
Wildland Fires

Generation of Firebrands

- **Faculty**: M.J. Gollner
- **Title**: Fire Ember Production from Wildland and Structural Fuels
- **Sponsors**: Joint Fire Science Program (USFS)
- **Objective**: (1) Understand how firebrands are generated by vegetation using simple laboratory experiments and scaling. (2) Perform large-scale experiments at IBHS to characterize firebrand generation.
Faculty: M.J. Gollner, A.W. Marshall

Ph.D. Students: P. Maisto

Title: Characterizing smoke transport in naturally-ventilated green buildings

Sponsors: Department of Homeland Security, Fire Grant

Collaborators: B. Meacham

Objective: Apply PLIF, PIV, and other non-intrusive diagnostics to model smoke transport in green buildings. Focusing on double-skinned facades and sloped ceilings.
Risk Management

Fire Safety in Commercial Spaceports

- **Faculty:** M.J. Gollner
- **B.S. Students:** S. Lattner, E. Griffith, A. Fitzpatrick
- **Title:** Literature Review on Fire Safety in Spaceports
- **Sponsors:** NFPA Fire Protection Research Foundation
- **Objective:** Perform a literature review of fire safety hazards present in spaceports, review recent incidents, understand the current hazards, and document gaps in current safety standards.
Risk Analysis in WUI Communities

- **Faculty:** M.J. Gollner
- **M.S. Students:** Samiyah Mustafa
- **Title:** A framework for risk analysis in wildland-urban interface communities
- **Objective:** Apply current tools for hazard analysis in disasters to a new, multi-hazard analysis focused on fire risk to homes and communities in wildland-urban interface fires. A key is incorporating the combined influence of embers, wildfire flames, and interactions between homes into the risk framework.
Faculty: Marshall, Trouvé, Sunderland, Baum
Ph.D. Students: Zheng, Vilfayeau, White, Myers, Jordan, Link
Title: Quantifying Fire-Spray Interactions
Sponsors: NSF MRI, NSF GOALI, FM Global, UTRC
Objective: Characterization and Model development for fire suppression spray interactions with fire plumes (kinematic), flame sheets (cooling and dilution), and flame radiation (scattering and absorption).
Faculty: Marshall
Ph.D. Students: S. Jordan
Collaborators: Custom Spray Solutions (CSS)
Title: Spatially-resolved Spray Scanning System (4S)
Sponsor: NSF MRI
Objective: Develop next-generation spray characterization technology to support advanced suppression analysis.
Faculty: J.A. Milke
Student: I. Lemberos and N. Schraffenberger
Title: “Improvements in Aircraft Fire Detection”
Sponsor: FAA
Objective: provide an initial study into potential fire detection improvements for passenger and cargo compartments and hidden spaces on aircraft. Improvements are sought to provide prompt detection given the contemporary fuel loads and arrangements of cargo while ignoring nuisance sources.
**Faculty:** Stoliarov

**Students:** J. Swann (Ph.D. candidate), Y. Ding (Ph.D. candidate)

**Sponsor:** NSF CAREER

**Objective:** To develop quantitative understanding of char growth dynamics and its relations to the thermal decomposition chemistry and heat transfer in a wide range of polymeric systems including a new generation of biodegradable materials.
Pyrolysis and Oxidation

Modeling Impact of Condensed-phase Active Flame Retardants

- **Faculty**: Stoliarov
- **Students**: Y. Ding (Ph.D. candidate), C. McCoy (Ph.D. candidate)
- **Sponsor**: BASF
- **Objective**: To develop a systematic approach to quantification of the impact of condensed-phase active flame retardants on the rate on pyrolysis and flame spread.

Prediction of mg-scale experiments for a material containing multiple flame retardants
Ignition and Flame Spread

Prediction of Material Performance in Standard Flammability Tests

- **Faculty**: Stoliarov
- **Students**: J. Tilles (M.S. candidate), C. McCoy (Ph.D. candidate)
- **Sponsor**: FAA
- **Objective**: To develop a computational tool for prediction of fire growth in a range of standard flammability testing scenarios, including cone calorimetry, UL-94 and single burning item test, from material properties.

Flame Spread Experiment versus Model Prediction
Effectiveness of Gas-Phase Flame Retardants

- **Faculty**: Stoliarov
- **Students**: F. Raffan (Post-doc), A. Kushner (B.S. candidate)
- **Sponsor**: ICL-IP
- **Objective**: To develop an experimental method for the measurement of the effect of gas-phase-active flame retardant additives on ignitability and burning intensity of solid materials using mg-sized samples.

The UMD Microscale Flame Calorimeter is used to measure the heat release rate (HRR) histories of Polystyrene (PS) and brominated polystyrene (PS-Br). The diagram shows a phosphorus-induced flame extinction.
Faculty: Stoliarov, Marshall

Students: A. Said (Ph.D. candidate), C. Lee (M.S. candidate)

Sponsor: Carrier Center of Excellence

Objective: To conduct an investigation of the processes that drive cascading failure of lithium ion battery packs and examine a spectrum of detection and suppression methodologies with the goal of identifying the most effective and cost-efficient approach to lithium ion battery fire mitigation.
Flame Suppression with Low Frequency Sound

- **Faculty**: Stoliarov
- **Students**: A. Friedman (M.S. candidate), P. Denis (B.S. candidate)
- **Sponsor**: ARL
- **Objective**: To examine feasibility of using a low frequency and high amplitude sound waves for suppression of localized aircraft fires.

Experimental Setup

Sound Pressure Profile at Resonator Opening

Flame Response
Microgravity Fire Dynamics

Burning Rate Emulator

- **FPE Faculty:** Quintiere, Sunderland
- **Ph.D. Student:** Akshit Markan
- **Collaborator:** J. deRis
- **Title:** Experimental Investigation of Emulated Burning Rate at Various Gravity Levels
- **Sponsor:** NASA Glenn
- **Objectives:** Use gases to emulate condensed fuel burning in microgravity. Heat flux gages are embedded in the burner face. Flight tests will occur on ISS.

BRE emulations in normal gravity
Microgravity Fire Dynamics

Flame Design

- **FPE Faculty:** Sunderland
- **Ph.D. Student:** Zhengyang Wang
- **Collaborators:** R.L. Axelbaum, D.L. Urban
- **Title:** Flame Design: A Novel Approach to Clean Efficient Diffusion Flames
- **Sponsor:** NASA Glenn
- **Objectives:** Study microgravity spherical flames to identify the effects of dilution on soot formation and flame extinction. Flight tests will occur on ISS.

Identification of PAH main pathways in premixed flames with varying flame temperature
Objectives: Observe cool diffusion flames in microgravity aboard the International Space Station. Use porous spherical burners fed with propane, $n$-butane, and $n$-pentane. Model the flames with high-fidelity simulations.
Refrigerant Flammability

Ignition of Refrigerants

- **FPE Faculty**: Sunderland
- **Ph.D. Student**: D. Kim
- **M.S. Students**: A. Klieger, P. Lomax, C. McCoy, J. Reymann
- **Title**: Investigation of Energy Produced by Potential Ignition Sources in Residential Application
- **Sponsor**: AHRI
- **Objectives**: Identify and characterize residential ignition sources. Measure their ability to ignite refrigerant mixtures.

R-32 autoignition by a hot plate at 764 °C (left) and AHRI test enclosure (right).
Wildland Fires

Firebrand Pyrometry

- **FPE Faculty:** Sunderland
- **Ph.D. Student:** Dennis Kim
- **Title:** Temperature Measurements of Airborne Firebrands
- **Sponsor:** NIST
- **Objectives:** Develop a firebrand pyrometer with an inexpensive digital camera. Characterize the temperatures of diverse airborne firebrands.

**Equations:**

1. \( y = 4.6 \times 10^{-8}x^2 + 1.3 \times 10^{-4}x - 8.9 \times 10^{-2} \)
   \( R^2 = 1.0 \times 10^0 \)

2. \( y = 6.5 \times 10^{-8}x^2 - 1.5 \times 10^{-4}x + 1.1 \times 10^{-1} \)
   \( R^2 = 1.0 \times 10^0 \)

3. \( y = -1.1 \times 10^{-8}x^3 + 3.7 \times 10^{-5}x^2 - 4.2 \times 10^{-2}x + 1.6 \times 10^1 \)
   \( R^2 = 1.0 \times 10^0 \)

**Graphs:**

- **Blackbody calibration (left) and Sony RX10 camera with burning dowel (right).**
Faculty: A. Trouvé – MS students: S. Vargas-Cordóba, S. Wu; PhD student: S. Verma; Post-doc: A. Marchand

Title: “Towards a Collaborative Research Infrastructure for Fundamental Studies of Turbulent Fire Phenomena”

Sponsor: NSF


Objective: Build a collaborative framework between computational and experimental fire researchers around the topic of the experimental validation of computer-based fire models. Organize a new series of biennial workshops sponsored by IAFSS.


Faculty: A. Trouvé – Post-doc: A. Marchand; PhD students: M. Le, S. Verma, R. Xu

Title: “Modeling of Under-Ventilated Fires and Fire Suppression”

Sponsors: NSF, FM Global

Collaborators: N. Ren, K. Meredith, Y. Wang (FM Global); T. Rogaume, F. Richard, J. Luche (Poitiers, France); A.W. Marshall, P.B. Sunderland (UMD)

Objective: Develop CFD models to describe flame extinction under fire conditions (including effects of mixing times, air/fuel vitiation, evaporative cooling by water spray)

2017 Results: Development of a new flamelet combustion model that accounts for detailed chemistry (CFD solver: FireFOAM)

Faculty: A. Trouvé – Post-doc: A. Marchand; PhD students: M. Le, S. Verma, R. Xu

Title: “Modeling of Thermal Radiation in Fires”

Sponsors: NSF, FM Global

Collaborators: K. Meredith, Y. Wang (FM Global); T. Rogaume, F. Richard, J. Luche (Poitiers, France); A. Collin, P. Boulet (Nancy, France)

Objective: Develop spectrally-averaged (gray) and spectrally-resolved (WSGG, SNB) models to describe gas/soot radiant emissions in fires (CFD solver: FireFOAM)

2017 Results: Coupling of gas radiation models (gray and WSGG) with new flamelet combustion model in order to treat turbulence-radiation interactions (TRI)

Comparison of gray and WSGG radiation models: (Left) 1D column of gas; (Right) turbulent line fire
Faculty: A. Trouvé – PhD student: S. Verma

Title: “Large Eddy Simulation of Flame Spread in Wildfires”

Sponsor: USDA Forest Service

Collaborators: M. Finney, T. Grumstrup (Forest Service); M.J. Gollner (UMD)

Objective: Perform detailed numerical simulations of the dynamics of wildland fire flames; identify origin of organized vortical structures; evaluate relative weight of convective/radiative heat transfer; provide companion computational tool to UMD experimental program (Gollner)

2017 Results: Simulations of line fires in cross-wind and line fires in sloped terrain (CFD solver: FireFOAM). Analysis of simulation results in order to differentiate between attached vs lifted flame regime

Series of FireFOAM simulations of line fire exposed to cross-wind with variable wind velocity
Faculty: A. Trouvé – PhD student: C. Zhang

Title: “Data-Driven Wildland Fire Spread Modeling”

Sponsor: NSF (OCI)

Collaborators: M. Rochoux (CERFACS, France); I. Altintas, J. Block, R. de Callafon (UCSD); E. Ellicott, K. Ide, M.J. Gollner (UMD)

Objective: Demonstrate the feasibility of coupling fire sensor technology with fire modeling software for improved predictions of wildland fire dynamics. Evaluate data assimilation methodologies (as used in weather forecasting applications).

2017 Results: Evaluation of prototype data-driven wildfire model, called FIREFLY, in prescribed fire experiments (FireFlux, RxCADRE) and past wildfires (Rim fire, 2013, CA). Development of an improved formulation for dual parameter/state estimation.