EXECUTIVE SUMMARY

Multiple organizations, agencies and companies are involved in cooking fire mitigation from the perspective of technology development and standards development. As part of this work, the National Fire Protection Research Foundation (FPRF) has funded Hughes Associates to develop standardized cooking fires for evaluating cooking fire mitigation technologies. Hughes conducted fire tests to assess the pre-ignition conditions for cooking oils in pans on electric elements. Oil temperatures and pan temperatures were measured continuously from the start of heating until oil ignition occurred. Tests were conducted for different oil types, oil depths, pan materials, pan sizes and thicknesses, and heating element wattages.

In an effort to identify "challenging" test conditions that could be considered for a fire mitigation performance test standard, Primaira, LLC developed a mathematical model of the pan and oil heating processes. This model can be used to compare the oil ignition data collected at different testing labs that use different pans, oils, cooktops, and other test parameters. The model can also be used to fill gaps between test points to define worst case test scenarios, test sensitivities, and areas for additional testing.

The objectives of this modeling work support both standards development and technology development. Specifically, this modeling work:

- Provides a platform for unifying the test results of oil ignition tests conducted at Primaira and Hughes:
    - Characterizes differences and commonalities of results
- Extrapolates from and interpolates between experimental results:
    - Are there conditions not tested that might represent higher risk or worst case detection for fire?
- Offers insights into the sensitivities of oil ignition to key test variables: Pan size, Pan material ; Pan weight; Oil amount; Heating rate
- Can be used to define alternative utensils that would simulate a pan/oil system that could be used for pan-bottom temperature sensing technology development.

The deliverables of this project are as follows:

1) A trade-off analysis of pan characteristics (not yet tested at either Hughes or Primaira) that could represent a worst case with respect to cooktop fires, for example:

- Pan characteristics that are different from those used in the current ignition test database, such as pan material, diameter, and thickness.
- Correlations between specific pan material properties (heat capacity, thermal conductivity, pan diameter, pan thickness) and ignition characteristics (time to ignite and pan temperature at ignition).

2) An analysis of the effect of element input power, to identify a potential worst case scenario with respect to cooktop fires, for example, examining the impact of heating rate as a function of pan types (diameter and thickness)

3) An analysis of the impacts of oil amount and depth on ignition characteristics.

4) A specification of a pan design with temperature sensors (no oil) that could be used to test pan temperature limiters without the use of a fire facility. The specification will be for a material type, "pan" diameter, and "pan" thickness that would respond to heat input in a manner that is similar to identified "worst case scenarios" of pans containing oil.

Fire testing will always be required in the development of cooktop fire mitigation control technologies and standards. On the other hand, fire testing is costly and time-consuming, requiring the use of a dedicated fire test facility, as well as a team of experienced professionals. This work has shown that an analytical approach can be used in support of and in parallel with actual fire testing work. The analytical model allows for a much more rapid and cost-effective exploration of the impacts of test variables on ignition characteristics. The key to developing a useful model is (a) to incorporate all appropriate physics correctly and (b) to calibrate and validate such a model against real ignition test data.