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MARKET ANALYSIS OF COMPUTER FIRE MODELING SERVICES FOR CSIRO

00-JRB9901

FPE

April 28, 1999

This project proposal is submitted in partial fulfillment of the requirements of the Interactive Qualifying Project for Worcester Polytechnic Institute.

ACKNOWLEDGEMENTS

We would like to thank the following people for all there assistance with this project: Our sponsors (Vince Dowling, Neville McArthur, Justin Leonard, Alex Webb, Paul Bowditch, and Glen Bradbury), Our advisors (Prof. Jonathan Barnett and Prof. Matthew Ward), our families and friends.

These are our memories: "Take a look around…", throwing rice, VB, Carlton, Metro, Casino, Mercury Lounge, Odeon, getting our wings, Briedy O'Reillys, tram training?, Sydney, zoo, guy with Scream mask, a weirdo a day, Rhino Bar, late night cabs in Sydney, the unspeakable, the hostel, the bus ride, Barbie, $1000 keychain, the idiot, walking 2 kilometers and no one there, walking in the rain, drying off at McDonalds, girl in sauna, pool on roof, laundry…or not, Kara making table of contents, "Far superior to all before it", neighbors, one space…two L's, school girls, Vsmith, business women and the rest, those pants Stephen hates, McD for breakfast, McD for lunch, McD for dinner, McD for after the clubs, never on time for interviews, passing out in the bathroom, jugs, pots, Aussie Burger, Footy Burger, sauce?, salad, tea time, the Big M chunks, morning paper and donut, the train ride, the burn at CSIRO, ICQ, AOL, Netmeeting, the wall, "Keep walking, it's not our country", the 109, VB Award, like a puppy dog waking up, the infamous yawn, searching the ceiling, interview early to go to Manly, "I don't want to go through all these", "Oh well", getting wet?, East BumF***, West BumF***, and West of East BumF***, Seth never on time, wear your raincoats.

Abstract

The Commonwealth Scientific Industrial Research Organization (CSIRO), an Australian governmental research company, wished to define a potential market in fire modeling services. Interviews and surveys conducted provide insight gathered from fire engineering practitioners as to the fire models they use, the experimental data that is needed, and any features found desirable or undesirable. This information has been analyzed to help direct CSIRO towards a service-oriented market in computer fire modeling. This document presents the completed project for CSIRO.

Executive Summary

The Commonwealth Scientific and Industrial Research Organization (CSIRO), a government supported research company in Australia, wished to explore potential markets in computer fire modeling. Fire models are computer programs that simulate the conditions in a room during a fire. This is done by simultaneously calculating the numerous algorithms involved with the phenomenon of fire. Fire modeling is in its infancy and will be the groundwork for expansion in fire protection engineering.

This project's goal was to interview and survey the fire protection field of Australia to determine the best possible market for CSIRO services in fire modeling. Interviews were conducted over the first four weeks of the project. Over 25 fire engineers, practitioners, and fire model users were contacted for this project.

The goal of the interviews was to determine which fire models were in use, what fire model characteristics were desirable or undesirable, and what experimental data was needed. Also, information was elicited on the interviewees' opinion of validation services, CSIRO's role within the market, and how CSIRO should market its products. The interviewees' background regarding fire models was established at the beginning of the interview. A Priority Table was also completed to determine a trend as to which fire model characteristics were most important.

The analysis of the information elicited during these interviews was completed as the interviewing stage of the project ended. To correctly analyze the results, the interviewees' results were separated by their role in the commercial market. Consultants, who generate their own profit, had a different insight into the field as compared to a research organization. Universities and government funded research organizations do not

need to generate its own profit, so it would not have the same competitive attitude as a consultant would.

Analysis of the results yielded a variety of services required in the fire protection field. The results determined that services should be provided in validation, experimental data, courses or training with models, barriers, and technical support. A database of experimental data was the most desired service. Currently there is not a centralized database, and users must look for the data required, often failing in their search. CSIRO could form a database containing all of its experimental data as well as any other data it could collect and organize. The above are all services that CSIRO could potentially offer to its customers.

Along with services, user expectations of models as well as model characteristics were defined through interview questions and the Priority Table. The interviewees filled out a Priority Table that focused on seven model characteristics. These characteristics were rated from 1 to 7, with 1 being the most important. The Priority Table revealed that accuracy and the capabilities of the model were most important, while speed and cost were least important. Most users felt that a model should be reliable, accurate, robust, and validated for the scenarios it models. The undesirable characteristics of models include performance failures, limitations, and other model specific shortcomings.

The marketing strategy that CSIRO should use, according to the fire protection field, should emphasize personal interaction with the client. CSIRO should conduct face-to-face presentations of its product. This would develop a personal connection with the consumer and in turn will sell more products. Other forms of marketing could include presentations at conferences, as well as articles in journals and magazines. CSIRO's most potential client would be the universities of Australia. By developing student fire engineers' knowledge of the use of a CSIRO model, the student will be more comfortable with this model after graduation and would continue to use it as they enter the fire protection field. Models could be sold to universities on a large-scale amount at a reduced price.

This project has determined that the best product for CSIRO to produce would be a fire modeling package. This package would include a CSIRO developed fire model, all of the support services necessary, as well as access to all of the experimental data CSIRO has developed and will develop. This will also create the centralized database of information needed by the industry. These services could be provided as a membership-based web site. This web site could also provide a forum or newsgroup to perform as a peer review. This would allow users to post questions and answers as well as easily communicate with other fire engineers. Other services that could be useful are training and certification courses. These services should be offered as a complete package that could be marketed as one tool that has all of the necessary requirements for fire modeling.

Extensions of this project could include the collection of the experimental data. This data must be located, collected, and then organized. Another extension could be to design a technical support web site. The project goal should focus on designing a user friendly web site that would attract users. Research into what support is desired would also be required.

These recommendations are based upon numerous interviews conducted throughout the duration of this project. The results analyzed are a good representation of the needs expressed by the fire protection field. This project has resulted in a better understanding of the relation between technology and society. It is hopeful that CSIRO can use this project for its benefit as well as that of the fire protection field.

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1.0 Introduction

Fire fighters, engineers, consultants, and designers continually work to learn new methods of fighting and preventing fires. Fire protection engineers specialize in determining the dynamics of a fire using modeling, experimentation, and field-testing. The purpose of learning more about fire and its behavior under certain conditions plays a great role in the fire protection field. The processes of modeling and experimentation are just some of the actions that are being taken to prevent the loss of life and property due to fires.

Australia's Commonwealth Scientific and Industrial Research Organization, CSIRO, works to cover a broad range of areas of economic or social value to the nation including agriculture, minerals and energy, manufacturing, communications, construction, health and the environment. The vision of CSIRO is "To be a world-class research organization vital to Australia's future" (www.csiro.au). By doing so, CSIRO hopes to benefit Australia's industry, economy, environment, and society as a whole while supporting Australia's national and international objectives.

As a research organization, CSIRO gathers information to produce a product that will best suit the developing needs of industry. It is up to the organization to decide to whom to market its product. CSIRO must first evaluate what type of product it will produce, who will be interested in it, what the product will be used for, and how much customers are willing to pay for the information. This project assists CSIRO to evaluate the current use of fire models and proposes fire modeling services that can be offered.

Computer modeling is designed to simulate actual fire conditions, this leads to fire prevention and safer building design. The models result in valuable information that can be used to protect the safety of the Australian population. In this project, a market analysis was completed for computer fire modeling services. These services include:

- Determining which model features are desirable and undesirable
- Providing fire data that customers are likely to require as input into their models for analysis
- Analysis of fire models for validation
- Consultation

The objective of this project was to survey the fire protection field in Australia and propose a possible market for CSIRO in fire modeling. The initial task was to identify key characteristics of fire models used in Australia. The complexity level varies among different models. Some models work very well at modeling the temperature in a room, while others model the spread of smoke. Our goal was to understand the demands and future of the market and how it can be fulfilled while contributing to Australia's industry, economy, and society.

There are several questions that were answered in developing a successful recommendation for CSIRO. Why does one company choose a certain model over a different one? Does the company use a model that focuses its use on a certain result? Answers to these questions any many more like it have been addressed in the final analysis from several interviews of individuals of the fire protection industry.

Another aspect of the project provides a conclusion as to which features of fire models are desirable and undesirable. Because of the diversity among models, some characteristics might not be useful to one user but required for another. As part of the research, the characteristics that are desirable and undesirable have been recorded and evaluated.

Validation of fire models also plays an important role in the recommendation to CSIRO. The current status of modeling has presented the industry with the dilemma of proper validation of model use and results. The simplicity of attaining and using models without the proper training and education has lead to misuse and improper exploitation. The comparison of experimental versus actual results of a fire provides another area of validation that has been inspected.

Having completed the research and documentation, CSIRO now has an understanding of its customers needs. It will then have more information available to produce a product that it feels will best suit the industry. A complete analysis of the fire safety field has resulted in a recommendation as to what CSIRO should produce based on the fire protection industry's desires and opinions of the future of fire protection, as well as CSIRO's goals and objectives.

Due to the expanding needs of the industry, CSIRO continually develops improved services to benefit Australia. In offering a product that is appropriate for the market, the fire protection field will be able to better predict fire spread and how to control damage and loss of life. Having completed the market study in the Interactive Qualifying Project, insight was gained into how technology fits into society.

2.0 Literature Review

2.1 What is Fire?

Fire is a complex series of chemical reactions involving the oxidation of fuel that contains carbon. Physically, visible flame, heat, and smoke characterize fire. When an object in a room starts to burn, it burns for some time after ignition in much the same way as it would in the open. After a short period of time, room confinement begins to influence the fire development. The smoke produced by the burning object rises to form a gas-layer below the ceiling and this layer heats the ceiling and the upper walls of the room. Thermal radiation from the hot layer, the ceiling, and upper walls begin to heat all the objects in the lower part of the room and may enhance both the burning rate of the original object and the rate of flame spread over its surface. At this point the fire may go out if, for example, the first object burns completely before other objects start burning, or if sufficient oxygen cannot get into the room to keep the object burning. Sometimes, however, the heating of the other combustibles in the room continues to the point where they reach their ignition temperatures more or less simultaneously. If this occurs, flames suddenly sweep across the room, involving most combustibles in the fire. This transition from the burning of one or two objects to full room involvement is referred to as 'flashover'. Usually at the time of flashover, windows in the room will break, allowing the entry of fresh air. The fire burns vigorously for some time until the combustibles are mostly consumed. Flaming eventually ceases, leaving a mass of glowing embers (Working Party of Engineers, 16-17).

2.1.1 The Aftermath of a Fire

In comparison with other countries Australia has a good record with respect to fatalities and property loss due to fire related accidents. About two thirds of property losses due to fire occur in non-domestic buildings. In Australia, fires in dwellings account for 90 percent of all fire fatalities in buildings. A large proportion of the fatalities are associated with incapacitated people such as the aged, young children, the infirm, and the intoxicated. The loss of life and property can be considerably reduced if building fires are confined to the area of their origin. Active fire protection has been extremely effective in preventing loss of life and property. There are some 150 fatalities related to fire in Australia per year. Direct property losses resulting from these fires cost approximately 300 million per year. The broad objectives for the installation of fire protection in buildings are to ensure adequate levels of safety for the occupants and protection of the property. The cost of testing and installation of these systems is greatly reduced by the use of computers (Working party of engineers, 16-17).

2.1.2 Fire Safety

In case of a building fire the objective is to achieve an acceptable level of risk for occupants, firefighters, occupants of adjoining buildings, and the property itself. The provision of acceptable levels of risk to safety for occupants is the result of a complex interaction between fire growth and spread, building design, and occupant mobility and behavior. The loss of life and property can be reduced by controlling one or more of these variables. The application of fire engineering principles to the building structure is an important aspect in the provision of acceptable levels of risk for occupant safety.

2.1.2.1 Improving Fire Safety

There is a need for improved understanding of fire behavior and engineering design techniques. This understanding can be achieved through use of computer models and can lead to the development of more cost-effective designs for buildings, such that acceptable levels of risk to occupants are achieved. The provision of fire safety in buildings is a reflection of complex interaction between the social, economic, and legal aspects of society. Attention is drawn to the Code of Ethics of the Institution of Engineers, Australia, IEAust. IEAust emphasizes the responsibility of engineers for the welfare, health, and safety of the community. IEAust accepts that all human activity involves a level of risk, and that a complete absence of risk is impossible to achieve (Working party of engineers, 1).

2.1.2.2 Building Regulations

Fire safety in buildings is largely controlled by building regulations, many of which are based on experience gained from major fires in history. Building regulations tend to place emphasis on prescriptive requirements for design. As a response to recent advances in fire technology, consideration is being given to introduce performance based design procedures. In the past, the performance of structural elements under fire conditions has been assessed by experimental means. Emphasis has been placed on the use of tests conducted under standard temperature-time conditions. In recent times, techniques have been developed that permit the performance of structural elements and assemblies, under various fire conditions, to be assessed by analytical means. Computer models have used the analytical calculations to create more accurate models.

2.1.3 Fire Engineering

Fire engineering is a technological discipline that has been explored and developed significantly, but there are still many advances that can be made to save lives and reduce property damage. It is essential that there is an improved understanding of both fire behavior and existing fire engineering techniques, in order to develop more cost-effective designs against fires in buildings. The use of computer models is beginning to expand and the reliability of these models is growing.

2.2 Fire Models

Fire models have been around since the 1960's. Development began by devising mathematical formulae to describe phenomena observed during fire growth and spread. When these formulas are combined, it creates a complex fire model that can be used to predict the effects of a fire based on the user's input. Models have evolved to the point that they are accurate enough to be used in engineering applications. Two questions must be considered when selecting a model for engineering calculations:

- How good do the inputs need to be (How do changes in the model affect the model outputs)?
- How good is the output of the model (How close are the actual conditions to those predicted by the model)?

To answer these questions, one must conduct a *sensitivity analysis* into the particular model that they are intending to use (Peacock et al, 104).

In an international survey, over 60 models are in active use and probably many more exist. Each model has is own characteristics and a variety of features that make it different from other models. Some of the major categories include models that predict the fire-generated environment, fire endurance, detector or sprinkler response, and evacuation times. Most of the models are for a single room. Models such as CFAST can handle situations involving multi-rooms. Sometimes rooms are referred to as compartments within the models (Peacock et al, 105).

2.2.1 Theory or Experimentation

A detailed review of the underlying physics of fire models place them into two categories. One type of models use the principle of conservation of mass, momentum, and energy. The others apply data from a series of experiments to graphs. The graphs are used to visualize the relationship between a pair of parameters. Errors in the models can be contributed to the absence of some important fire phenomena that is not included within the calculations of the model.

2.2.2 Two Classes of Fire Models: Probabilistic and Deterministic

Generally it is considered that there are two classes of computer models for analyzing fire development: (1) Probabilistic and (2) Deterministic.

2.2.2.1 Probabilistic Models

Probabilistic models track fire growth as a series of sequential events. These models are also referred to as state transition diagrams. Each event is connected to other events. The links between events are rules that specify how a transfer is made from one event to another. Probabilities that are determined by experimental data are arranged on each event. This indicates that each event has a certain probability of occurring. Probabilistic models usually do not take into account physical or chemical equations.

2.2.2.2 Deterministic Models

Combining numerous physical and chemical equations into one complete model forms the other class of models: deterministic. The expressions in the model are more mathematical as opposed to the graphical approach by the probabilistic class. The main purpose of deterministic models is to be able to change input data so that it can be seen how it affects fire growth and other results. Zone models and computational fluid dynamics, CFD, models or field models are the main categories of deterministic models (Walton, 53).

2.2.3 Control Volumes

Every mathematical fire model involves a collection of equations and formulae. Due to constantly changing conditions during a fire, models must use differential equations to properly calculate the variations during a fire. A group of equations can predict conditions during a fire in any volume of air known as the control volume. It is assumed that conditions in the control volume are homogeneous at any time. This permits the control volume to have one set of measurements. Measurements include but are not limited to temperature, smoke density, and gas concentration. Complex models break up control volumes into smaller control volumes to get more precise calculations of certain conditions of a specific location in a room. In zone models hot gas collects at the top of the ceiling creating two distinct levels of hot and cool air. Variations within a layer are insignificant when compared to the differences between levels. Zone models can be used for most fire conditions (Peacock, 106).

2.3 Models

2.3.1 Basic Fire Modeling

Basic fire modeling can be done by anyone with basic mathematical literacy. Some models are more complicated and require specialized training and research into fire modeling. The simplest type of fire models can be done with a calculator because it involves simple algebraic equations. The ability to display data comparisons among parameters makes spreadsheets another way to model fires. Spreadsheets are an easy way to organize data and to quickly convert it into graphs.

2.3.2 Zone Models

Depending on the level of detail desired, certain models divide a building into a number of control volumes. The zone model is the most common fire model because it uses two control volumes, the upper layer and the lower layer, to describe a room. More complex zone models may include additional levels to take measurements on the fire plume and the ceiling jets. This improves the accuracy of the model.

2.3.3 Example 1: FIRECalc

The Division of Building, Construction, and Engineering at CSIRO has developed a suite of computer fire modeling programs, Firecalc, that can calculate numerous factors. These include the likely response of sprinklers and detectors, how the flames will spread laterally, how and when adjacent combustible material will ignite from radiation, and the amount of time needed to evacuate a building before it is filled with smoke. This information makes it possible to design or adapt a building to enhance its safety features against the effects of fire (ECOS No. 77, Spring 93). The current upgraded version of Firecalc is now known as Firewind. It includes calculations for smoke control and ventilation.

2.3.4 Example 2: WPI/FIRE – Single Room Zone Model

There are many zone models in existence. Each model has its own set of prescribed inputs and detailed outputs. Many newer zone models are extensions of older models. The WPI/FIRE model developed by J. R. Barnett and D. B. Satterfield, for instance, adds features such as improved input routines, momentum-driven flow through ceiling vents, etc., along with the features included with the HARVARD and FIRST models. New models are created based on need for certain features. If one needs a model to describe a certain fire and one does not currently exist, then a new model is created. The process of evaluating a current model and deciding if a new model is needed is determined during *model validation*.

2.3.5 Example 3: CFAST – Multi-room Zone Model

CFAST, Consolidated model of Fire growth and Smoke Transport, is an extension of the zone model FAST. CFAST can handle up to 15 compartments, 30 ducts, and 5 fans. It is one of the multi-room models available. A majority of the zone models handle one room and have a defining special capability that sets it apart from other model (Walton, 55).

2.3.6 FASTLite: Online Fire Model

National Institute of Standards and Technology, NIST, has developed a DOS based software package, FASTLite, which runs computer simulations of different fires under different conditions. FASTLite combines the routines of FPEtool and the computer model CFAST. It provides calculations of fire phenomena for use by building designers, code officials, fire protection engineers, and fire-safety-related practitioners. FPEtool was one of the earlier programs that were favored by fire protection engineers. CFAST is a zone model that predicts the effect of a specified fire on temperatures, various gas concentrations, and smoke layer heights in a multi-compartment structure. FASTLite has many applications and is readily available. It can be downloaded for free on the World Wide Web at NIST's web site. (http://www.nist.gov)

2.3.6.1 FASTLite: Typical Zone Model Features

One of the many attractions of FASTLite is the variety of tools it has available for modeling. It is a good example of the typical features that may be included in a zone model. FASTLite can simulate a fire involving up to three rooms. The user can also specify the size of the rooms, place fire detectors or sprinklers anywhere, and indicate building materials. Many other parameters can be customized allowing for flexible simulations. Once all of the data required to test a fire has been entered, a simulation can be done which calculates certain measurements for each increment of time. Results can be printed in a detailed report that includes measurements of upper and lower layer temperatures of the room, fire size, and pyrolysis rate among others at a certain time increment. The user can also display graphs that show upper layer temperature, layer height, and the heat release rate. With all this information combined, the user has a detailed mathematical description of how the fire evolved as time passed.

2.3.6.2 System Requirements

Probably the most important reason why FASTLite and zone models in general are so popular is that it can be executed on virtually any PC. The recommended system requirements are very low, which is good for use on older systems. Many other models require huge amounts of processing power and memory. The cost of such equipment is expensive and therefore an unlikely choice among fire modelers with a limited budget.

2.3.7 Zone Model Limitations

Limitations to the zone model include being unable to accurately simulate rooms that are very high or too long. Non-homogeneous heat layers are formed instead of the homogenous layers formed in reasonably rectangular rooms that the zone model requires. Other external factors can affect results and cause the zone model to fail. Extreme outside temperatures causes variation in the layers. In zone models, like all other fire models, it does not predict fire. Fire models are only meant to be used as a tool to accurately model the phenomenon of fire.

2.4 Network Models

Other categories of models include the network model and the CFD model. Network models predict conditions in rooms that are far away from the fire. In these instances layering does not occur and temperatures are only slightly affected by the fire.

2.5 Computational Fluid Dynamics (CFD)

The most complicated category of fire models is the Computational Fluid Dynamics model, CFD, or field model. CFD models divide the fire room into many separate control volumes. Each control volume has its own set of internal conditions, which provides for highly accurate results of the overall conditions in the room. Typically the model solves the equations of mass, momentum, and energy for each separate control volume. The model can then determine the conditions at any point in the room. Because there is so much data that the model must consider and then calculate, CFD models typically are very intensive and require lots of computing power to run in a reasonable amount of time.

2.5.1 CFD System Requirements

Personal computers are not powerful enough to perform the numerous calculations needed in a model. Most CFD models require powerful desktop workstations, minicomputers, or mainframe/super computers to perform calculations efficiently. For example, if a CFD model is computed on a current workstation where the calculation involves 514,000 control volumes and at time increments of 0.2 seconds, then it will require 18 days until the model has finished computing! Cost for sufficient hardware and software to run typical CFD models can range from $10,000 to $100,000 or more (Walton, 53). Therefore these models are only used when detailed calculations are necessary. Typically a room is subdivided in up to 20,000 or more control volumes. To compute turbulence in a room, control volumes would have to be 1 cm^3. This volume is far too small to be applied to any CFD model until computer hardware becomes faster and less expensive. This is a limitation to the CFD model.

2.5.2 Advantages vs. Disadvantages

Despite the limitation of cost of a CFD model, it is growing in popularity based on its detailed results. It has been assumed that only zone models can be used to generate real-time fire predictions. The problem is that zone models do not provide enough information for understanding fire growth and spread. The high resolution of a CFD model resolves this conflict. The problem with CFD models is the large time consumption and the high degree of skill required developing a CFD simulation (Barnett, 13). Validation of current CFD models is still continuing. The experimental data must confirm the simulation data obtained for the model before it will be adopted.

2.5.3 Example: JASMINE

JASMINE for the Fire Research Station in the U.K. is an example of a CFD model. The model provides three-dimensional solutions for heat and mass transfer. The mathematics includes differential equations to solve conservation of mass, momentum, energy, and species. The models main purpose is to analyze smoke movement in a room. The required computer hardware must be either a mini or super mini computer. In general, this model can only be used through the Fire Research Station, although WPI students have been extensive users of the program. Another popular CFD model used in

Australia is Phoenix. Phoenix is the general CFD model which forms the basis for JASMINE. However, JASMINE's modification of Phoenix provides a vastly superior fire model.

2.6 Experimental Fire Data

Research companies such as CSIRO often gather experimental fire data. Full scale test facilities provides the means of gathering valuable measurements of conditions during a fire such as heat release rate, carbon dioxide content, carbon monoxide content, and many more. This data is acquired by performing a "burn" which entails burning an object in a controlled enclosed environment where these measurements can take place. The acquired data can then be used as input into computer fire models. Full scale testing can be expensive, therefore several companies do not have the access to all the experimental data that is available. The companies that do conduct full-scale tests do not release this information because it gives them a competitive advantage. Also, the companies that do pay for the data do not want the information released because they can afford to pay for the data and this also gives a competitive edge. Without the proper experimental data available it is common for the modeler to make assumptions in the model.

2.7 Fire Model Validation

There are four areas of importance for evaluating the predictive capability of fire models:

1. Model and scenario definition
2. Theoretical basis and assumptions in the model
3. Mathematical and numerical robustness of the model
4. Quantifying the uncertainty and accuracy of the model (Mowrer, 2)

There are many questions that must be considered before a model is adopted. Fire model validation includes verifying if the results that are computed by the fire model are consistent with the data accumulated through experiments. The questions to answer are:

- How complete is the model in terms of the phenomena being modeled?
- What is the effect of incomplete phenomenology on the calculated outcomes?
- How sensitive are the calculated outcomes to the input parameters?
- How accurately are the input parameters known?
- What is the uncertainty in the input parameters?
- How do the calculated outcomes affect the decisions being made?
- What is the uncertainty in the calculated parameters?
- What is the uncertainty in the damage criteria? (Mowrer, 2)

Models that clarify these questions usually have increased capabilities. Input into the model defines the fire scenario. Common inputs of the fire source include location, history, and duration. Also included in the model are material compositions and fire protection devices such as sprinklers and fire alarms. Each model requires its own set of input parameters to adequately describe the fire scenario so that results can be calculated (Mowrer, 2).

Validation is a hot issue in the fire protection field. There are many debates into how to properly validate a model. Models can be validated for certain scenarios. Often it is the responsibility of the model creator to offer validation to their models to prove that it works correctly and so that the limitations of the model are known. Any validation that is done is usually included in the documentation of the model. If a model does not work for a certain scenario then that defines a limitation of the model which must be addressed by documenting it or providing a new version of the model which fixes the bug.

To validate a model, several options are available. An initial step in validation is using knowledge-based judgement. An expert in fire safety engineering knows what a particular model requires and what the outcome should be, just based on experience. Experimental data is another way to test the input data of a fire model. Results from the fire model should confirm the experimental results. Variations in the data must be explained. Inconsistencies could result from estimations and approximations of input data. This information should be included for consideration of model validity (Mowrer, 17). However, there can still be validation problems. One data set may validate a model while another similar data set causes problems. Another validation problem comes in the validation of a user and the model together. Some users are proficient at using one specific model but cannot use another correctly. The same goes for the model itself. A model might be valid in the hands of one user but not in the hands of another. A proper validation must include the model, the user, and all of the data that has been entered during the actual modeling of a fire. These inconsistencies create a problem for both the modeler and user. Currently a solution has not been found but it is the topic of many studies.

2.7.1 Sensitivity Analysis

A sensitivity analysis can study how changes in model parameters affect the results generated by the model. Sensitivity studies are used to determine which models are useful and if it accurately represents the type of fire that is being modeled. Analysis determines the necessary input parameters for a model and how sensitive the outputs are to variations of the inputs.

2.7.2 Validation Protocol

Protocols have been proposed to standardize the way models are evaluated. Here is a summary of a general protocol:

- Peer review of theoretical basis of models
- Usability and practicality of models
- Comparison of model predictions with experimental results
    - Sources and quality of data for comparisons
    - Measurement and measurement system requirements
    - Uncertainty in experimental results
    - Peer review of experimental results
    - Methodology for transforming measured data into values that may be compared with model predictions
    - Sensitivity analysis of the experimentally based "model predictions"
    - Blind runs of the models
    - Statistical and analytical comparisons (Jones, 8)

Experts who are familiar with the physics and chemistry of fire phenomena should be selected to review the theoretical basis of the model and become *AHJs,* Authorities Having Jurisdiction. Their basis for judgement should rely on sufficient scientific evidence to justify the theoretical approaches and assumptions that are used in the model. This peer review should be made up of both modelers and model users. Decisions will have to be made of who sits on the board and if payment for their services are required.

The second element of the protocol, usability and practicality, determines how easily the data can be input and whether the output of the data is appropriate. This is an indication that the model is used correctly. The documentation on the model must be reviewed to determine the level of complexity and what the learning curve may be. A recommendation is made regarding the level of expertise that is needed to properly use different models.

The most important protocol is based on the user's opinion of the model. The user must approve the model and decide if it serves their purpose. User acceptance can be maximized by correctly categorizing the model to the proper expertise level before the user even gets to review the model. User acceptance also depends on whether the predictions of the model match the user's experience or experimentation with actual fire tests (Jones, 9).

2.8 The Future of Fire Modeling?

The next logical sequence as computers get faster, would be a transition from the use of zone models to CFD models that require more computational power. The results from these new models will be much more accurate and precise. It is stated that computer aided drawing, CAD, may also be in the future of fire modeling. The key for CAD would be to keep it simple so that it does not require several hours of training. Using CAD the programmer could implement some error checking into the program to prevent the user from making mistakes. This maximizes productivity and efficiency (Walter, 4).

3.0 Methodology

The objective of this Interactive Qualifying Project was to survey the fire protection field in Australia and to determine the market for CSIRO in fire modeling services. First, a basic understanding of each model used in Australia was necessary. This knowledge was used to devise and conduct interviews and surveys. The insightful surveys and interviews elicited information that characterized the user's interests. The data collected was evaluated in such a way as to accurately sample from all specific aspects of the fire protection industry. The final recommendation suggested fire modeling services CSIRO could offer.

3.1 Research

This project required that diverse research tools be used. Finding related books and magazines was a just a portion of the research that has been accomplished. The topic of computer fire models is a complicated and ever-expanding area of fire protection engineering that commands the use of many resources in order to recommend a proper marketing strategy for CSIRO. A search strategy was developed to prepare for the large task ahead. It also presented goals to achieve. First, a basic knowledge of computer fire modeling was established. A compilation of research from lectures, videos, library references, computers, and expert teaching provided a broad knowledge of the fire protection field needed to complete the analysis. The fundamentals were more easily grasped after consulting an expert, Professor Jonathan Barnett, to focus the search for resources (Barnett, Introduction to WPI and Fire Modeling). Professor Barnett suggested videos that helped develop detailed insight into computer fire models (FP 520, FP 572). In addition, he provided PowerPoint presentations from lectures and web site links to aid the research (www.wpi.edu/~jbarnett/lectures.html). The Web provided consultation to diversify the expansion of sources. From this, FASTLite, a model produced by National Institute of Standards and Technology (NIST), was used to become familiar with the model's interface (www.nist.gov).

The computer search, combined with subject searches in the library, resulted in a variety of articles and books that provided detailed references on the principles involved with computer fire modeling. Magazine articles, research papers, and technical reports presented relevant and useful information. Government documents found at the NIST web site were also very useful. NIST provides online experimental data and a wide variety of models for free downloading. The National Fire Protection Association (NFPA) contributed with many publications of reports and theories written by experts. The Australian counterpart of the NFPA, Fire Protection Association of Australia (FPAA), was also contacted through electronic mail to get current statistics on fire related damage in Australia. Compiling these resources furnished the basic terminology and knowledge needed to continue the market research.

One of the objectives of the project was to survey and interview many of the experts in the field of fire protection to obtain their views on computer fire modeling. The process of interviewing and surveying had to be researched in order to conduct them in a professional manner. This led into the next task, which was to prepare for the interviewing process. Much like the pursuit of knowledge on fire models, a professor was available to give a lecture on the craft of interviews and surveys (Ljungquist, February 8, 1999). Literature from the library was also used to find the proper way to conduct interviews and surveys. The research provided knowledge on how to order and ask questions in such a way that the results would be unbiased and would get sufficient information to conduct an analysis. Practice interviews had given the insight needed to formulate the proper questions and to find the correct wording for this market research in Australia (Beller, February 17, 1999 and Wright and Ierardi). The interview responses helped develop a greater knowledge of computer fire models and an insight into the needs of potential CSIRO clients. The opinions garnered are specifically from an Australian point of view.

While the research was being conducted and the resources were compiling, it became apparent that a detailed record system was needed to aid in the writing process of the project. As interviews were set up, the contacts were kept in an organized database with all the pertinent information of the interview. This made it easier to retrieve the details of all the interviews for a particular day.

An evaluation of the material collected throughout the research process had been performed to determine the credibility of the resource. The evaluation determined if there was an over-reliance on any one source, if there was any dated material, if there were a variety of sources, and what level of complexity the resources used. The writing process began when all these criteria were evaluated and more care was taken to properly credit cited material. Finally, after combining all preparation efforts (the process of producing a strategy, using all the resources available, evaluating the research, and using proper interviewing techniques), the final recommendation became a reasonably accurate analysis of the computer fire modeling services market for CSIRO.

In order to understand the opinions of the companies that were interviewed, a background search was necessary. Most of the larger companies and all of the federally funded and educational contacts can access this information on the Internet. The information provided on the Web was useful in determining the company's goals and their involvement in the fire protection field. Some of the smaller companies that operated out of an owner's home could not be researched before the interview. The majority of the self-employed businesses were consultation services.

3.2 Interviews

The main method of collecting data was from interviews. Many factors had been included when creating questions for the interview and specific studies had been done that explain how to prepare for an interview. Some of the issues faced in using interviews included variation of data, defining the target population, and a means of handling data so it was not affected by extreme differences in opinion (Applied Statistics I, C98).

Every type of data analysis performed in real life conditions consists of variations. Variations occur when responses to interview questions vary. There are several other factors that can cause variation. Not everyone interviewed was of the same skill level or had the same exposure to the topic of computer fire modeling.

3.2.1 Inexperience vs. Experienced

It was determined necessary to divide the interviewees into two categories: experienced and inexperienced. In the fire safety field there are several models that are used by people of different skill levels. The inexperienced user has a basic familiarity with the models. Often these individuals downloaded free models off the Web and are self-taught in modeling. Experienced modelers can be self-taught, but their amount of experience in the fire safety field is the fundamental difference. An experienced modeler can recognize when the output is incorrect and they have the knowledge to find where the error was made. An inexperienced user could create errors or there could be a limitation or assumption that is unknown to them. An experienced and responsible user would be able to recognize limitations and that is the difference between them and an inexperienced modeler.

3.2.2 Commercial vs. Non-commercial

The next task was to divide the experienced users into two more categories: commercial and non-commercial. An interviewee is grouped into the commercial category if their company uses fire models in a way that produces profit. Typical companies are involved with consulting or building surveying. Commercial users usually have more money to buy complex models and faster computer hardware. Their needs and expectations of fire models are different from the next category: non-commercial. The non-commercial category consists of organizations that get partial funding from the government or base their business on offering research capabilities mostly by providing fire data. Examples would be a university such as Victoria University of Technology (V.U.T.) or an organization such as CSIRO or Scientific Services Laboratories (SSL).

Dividing interviewees into separate categories enables a recommendation to be made concerning a certain audience. Often there is a difference in opinion between commercial and non-commercial. The method of dividing the two separates their responses so that an accurate evaluation can be made.

3.2.3 Interview Questions

By definition the project is a sample study. A sampling study is a study in which a sample is drawn from a target population, and the responses observed from the samples are used to draw conclusions about the target population (Applied Statistics I, C98). A combination of open-ended questions and a priority survey were used in the interviews (Appendix B). This elicited responses that helped to evaluate the interests and needs of the interviewees and form ideas on services that are desired for fire modeling. From this information a recommendation has been made on whether there is a need for CSIRO to provide fire modeling services such as validation and consulting.

The target population included fire engineers, building designers, consultants, academia, and researchers. Over 25 personal interviews with professionals in specialized fields were completed. There are several steps in designing a sampling study. First it must be determined what information is required. This was achieved by developing a precise project description and then conducting research into the topic of fire modeling. With this knowledge, intelligent questions were drafted that elicited the best response. The best responses were those that provided the most detail into the question asked.

The third step to designing an interview was to determine how the data would be obtained. This included face-to-face interviews, phone calls, and mailings. Phone, email, and fax extended to locations out of reach of public transportation. This provided information that would be indicative of all Australia and not just specifically for Victoria and New South Wales. By expanding the survey area, the potential market for CSIRO can be expanded to include all of Australia.

Most of the data was collected by in-person interviews in Melbourne and Sydney. It was also the project goal to interview the same organization in several states. For instance, the Fire Brigade has a division in every state. Responses from these organizations were compared among each other to provide an interesting evaluation.

The first step to the actual interview process was to find potential interviewees and set up times to meet. A short list of contacts was devised by CSIRO, but that list had to be expanded. The *Yellow Pages* on the Internet (http://au.excite.com/yellow_pages) was the most useful source for determining contacts. Using the two search phrases *Fire Protection* and *Consultants*, over 200 possible contacts were found. Possible contacts were selected and contacted for a potential interview if they were reachable by public transportation. Each contact was called to determine if they had or currently used fire models. If they had any experience with fire models, then an interview was set up. At the end of each phone call, the contact was asked if there was anyone else to contact whom had a background in fire modeling. Towards the end of the set up process, interviewees would reference the same possible contacts and therefore it was determined that the majority of model users were already known for the project. Refer to Appendix H for a complete list of the contacts.

The questions posed to the interviewees were grouped to show separate main themes.

How long have you been in the fire safety field?
Which models do you prefer to use and why?
What training have you received?
Is there any training or course you would have liked to participate in?
How often do you use computer fire models and for what reasons?

These were the first five questions asked in all of the interviews. Their purpose was to get a basic understanding of the background of the interviewee. It also started the interview with easy questions that did not require complex answers and relaxed the interviewee.

What expectations does your company have in computer fire modeling?
Are there any specific circumstances that you can recall, when your

models did not perform correctly?
What are some of the undesirable characteristics of the models you use?
How could these be improved?
What limitations do you find with models?

These next five questions were used to determine the company's standpoint with computer fire models. The last three questions of these five were asked exclusively to determine the characteristics that the interviewee would like to have improved if a new model were to be produced.

Do you find there is a lack of experimental data?
What type of experimental data do you feel is necessary?
Would this information be worth purchasing and for how much?

Experimental data is required to use fire models correctly. The more accurate the data, the more accurate the model outputs. Due to the necessity of this information, the three questions listed above were formatted to find out what would be most useful to the field. How much companies might pay for this information was an important question to ask because it provided CSIRO with knowledge of profit potential in data services.

Should there be barriers to limit the risk of misuse of inexperienced operators?
Should there be a validation service for each model?
Do you feel CSIRO should offer services for modeling?
What types of services do you feel are necessary?

The scope of these questions was to find out what the fire protection field felt about different services that CSIRO could potentially offer. It was also to determine if they felt that it fell under CSIRO's responsibility to offer these different types of services.

How do you plan to use fire modeling in the future?
Do you have a reference if there are problems with a model? Someone that you can ask questions.
How do you think models should be marketed? I.e. through the Internet, catalogs, conferences, or others?
What do you think the future of computer fire modeling is?
Do you know of anyone else that we can contact for more information?

These were the final miscellaneous questions that were asked to conclude the interview. Interviewees were asked if they knew anyone else who could be of help to the project. This would provide a contact list that included as many fire model practitioners as possible.

> *Rate these in order of importance to your company from 1 to 7. 1 being the most important:*
> 1) *Accuracy of the model (physics of the model)*
> 2) *Capabilities*
> 3) *Cost of the model*
> 4) *Documentation*
> 5) *Experience/Training*
> 6) *Speed*
> 7) *Usability*

The Priority List was the last thing that the interviewee was asked to complete. The table listed seven characteristics that are included in all models. This information was used to form a trend representing what the fire protection field feels is most important in computer fire modeling. It was understood that each characteristic has importance to the model user, therefore, this rating system was not an "end all" evaluation on the characteristics of a model. Its basic purpose was to find one or two characteristics that are most important to the model user.

Before interviewing any of the professionals in the fire protection field, an employee of CSIRO volunteered to be interviewed to test the format of the interview questions. The interview went well and questions were finalized after comments were made.

Accurate reports of the interviews were taken by tape-recorded them. The interviewee was first asked if they were uncomfortable with tape recording. Most interviewees had no objections. After the interview, a summary of all of the responses was made. This way there was an accurate account of each interview, leaving less risk for misinterpretation.

3.3 Evaluating the Results

Evaluating the results of the interviews and surveys was involved. To propose services that will fulfill the needs of the Fire Protection field, it was first necessary to know what it desires. A series of questions focusing in on the advantages and disadvantages of each model was asked. To obtain information that is still applicable to the project, interviewees then prioritized a list of characteristics common to all models. Finally, by combining the results, a recommendation was made that was designed to fulfill the needs of the fire protection industry.

The first method of evaluation began with separating the interviews by the categories previously discussed: inexperienced vs. experienced and commercial vs. non-commercial. This divided up the number of interviews into manageable sizes.

Similarities were searched for within each of the categories and the observations made were recorded. Observations included what model features are desirable, the future of fire modeling, and opinions on the potential for CSIRO to offer modeling services. For each question a response was developed which reasonable describes an overall response given by the interviewees.

An evaluation of the differences within each category was also achieved. Differences were determined to be responses that were far from the norm of typical responses from interviewees. Possible reasons for the differences were proposed to explain why the interviewee responded the way he/she did. Oftentimes differences among interviews brought up good points that were included in the evaluation.

It was necessary that biases were not shown with any model. With a lack of experience in the field a true understanding of all models was nearly impossible. Caution was taken to avoid relating all models to a single model that was understood better. Instead, an understanding of underlying material of each model was achieved. Knowledge of actual fire modeling was not necessary. Actual model use was avoided since the scope of this project was to just interpret what characteristics were useful or not.

A list of advantages and disadvantages, along with any suggestions for improvement to fire models were determined. We collected reports on several different models and all of them have been included. If two companies use the same model, another comparison was made to relate the two reports to see if they were consistent.

The last portion of the interview was for the interviewee to complete a Priority List of common characteristics found in models. The seven issues that were evaluated were *Accuracy of the model, Capabilities, Cost of the Model, Documentation, Experience/Training, Speed, and Usability*. Many of these are interrelated and precautions were taken in the evaluation of the results.

By asking the interviewee to prioritize the importance of key issues, it eventually produced a trend among fire engineers. A list prioritizing the key issues was ordered from most important to least important. A rating of one was defined as most important and a rating of seven was defined as least important. Each company rated these issues which were then reversed for the purpose of analysis. The issue that finished with the greatest total sum of ratings was considered the first priority of the fire protection field. This evaluation helped to determine and confirm what is believed to be the most important model features desired by potential CSIRO clients.

3.4 Conclusion

At the conclusion of the interviews, the priority table was completed. This provided a means to compare questions asked regarding the satisfaction of the company with the models it uses and what they desire in a model. Does the model the company uses fulfill all of its needs? If not, what improvements would the company most like to see? These answers were influenced by the information provided at the beginning of the interview. It was determined if the models in use are consistent with user's needs.

4.0 DATA PRESENTATION AND ANALYSIS

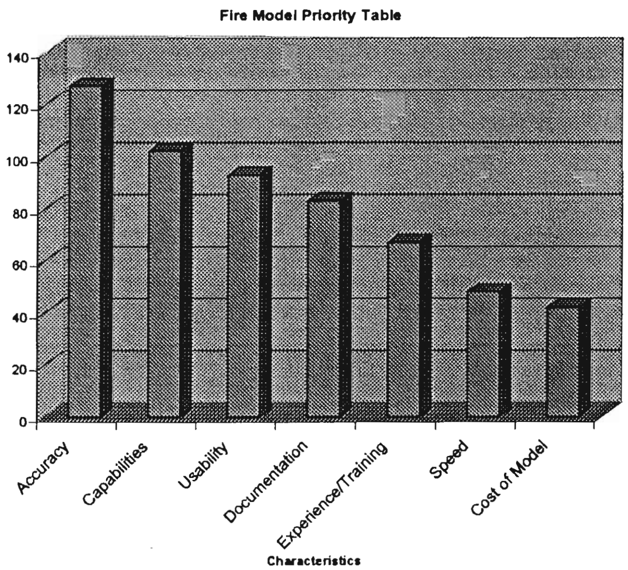
This section of the project presents the process of data presentation and analysis. In detail, the data collected throughout the interview process is presented. This data was then analyzed and a description of that process is also provided.

Figure 1

4.1 Priority Table

	Totals
Accuracy	127
Capabilities	102
Usability	93
Documentation	83
Experience/Training	67
Speed	48
Cost of Model	42

Figure 2



4.1.1 Reading the Graph

To generate a graph representing the priority of model characteristics, the interviewees had to rate the above seven characteristics from 1 to 7. One (1) was considered the least important characteristic. All of these totals were added up to produce the numbers above. Accuracy totaled 127 points and is considered the most desired characteristic. The bar graph on the right shows how each of the characteristics compared in relation to each other. All of the model characteristics are important and it was difficult for some of the interviewees to complete the survey.

4.1.2 Top Model Characteristics

The first analysis of the data collected was through the priority table the interviewees filled out. A general trend established which two characteristics stood out amongst the rest. The characteristic that the fire protection field felt was most important was the *accuracy* of the model. The degree of accuracy of a model relates to the proximity in which the model can generate a resemblance to a fire. The interviewees thought that accuracy, of all the other characteristics, could not be compromised.

As Australia moves toward a performance-based code, there is going to be flexibility in the design of buildings. Where one aspect of the building may be lacking certain fire safety requirements, a fire engineer can compensate in other areas. This creates flexibility in requirements. If the computer models that they use to design and evaluate these new buildings are not accurate, then it may cost lives. Realizing that model results are not fact can prevent this.

A company will not pay for a model that it cannot use because of its inaccuracy. Because the fire engineer's job affects the safety of people, it is important that their job is done correctly and as accurately as possible.

The second most important characteristic is the *capability* of the model. A major problem with current fire models is their limited capabilities. Fire protection engineers often must manipulate the inputs of a model to extend its capabilities. This is because the models are limited in the range of inputs that they are valid for. If broadening the capabilities can reduce the manipulations, then the model would become a more useful tool to the companies.

To correctly use a model a fire engineer must have knowledge within the field and a solid understanding of the ranges of inputs that the model can handle. If a model is to be exploited the user must have an understanding of what the limitations of the model are. Some models produce results for any set of inputs that are used. This result may be harshly inaccurate, but an inexperienced user would not be aware of that. Although increasing the capabilities may not cure the problem of inaccurate users, having a model that limits the assumptions will be beneficial to inexperienced users. This, however, may limit the expert users of the models.

Along with the reduction of limitations, a model that has more capabilities gives consumers a better product for their money. Unless the engineer's task is very specific, a model that can only model one scenario is useless. A single model that can cover the whole range of applications needed is more valuable than if a multitude of models are needed to do the same tasks.

4.1.3 Less Desirable Characteristics

Along with the analysis for most desirable characteristics, the less important characteristics were established as well. The least influential characteristic was the *cost of the model*. Some models are given away for free over the Internet while others cost upwards of a $100,000. The more accurate and versatile the model, the more it is going to cost.

There is a slight misrepresentation of the results though. For well-established commercial businesses, it is easy to justify spending large amounts of money on a CFD model. Their clients are paying well for the information they produce, therefore absorbing the cost of the model. On the other hand, a publicly run organization might not have the profitability to afford an expensive model. They cannot justify paying a large sum for a CFD model. Smaller companies must maintain profitability, therefore, they work with the limited models they can afford.

The other less important characteristic was the *speed* of the model. Its importance was almost equal to that of cost. CFD models run much slower than zone models due to the complexity of the mathematics coded within them. The final output from the CFD model better represents the fluid flow within a fire. Unfortunately, zone models do not have these capabilities and must be run several times to get a good understanding of the fire. Because so many runs must be made, time is a critical issue. Some CFDs take days to go through one run. During this time the computer is tied up and unable to be used for other tasks.

Commercial businesses can afford these long computational times because their consumers desire the CFD results. Computer hardware is also better updated. Some small companies cannot sacrifice their time to use a CFD model when they can use a faster zone model. Another advantage for commercial businesses is the capability to have a large staff working on one project. Again, the smaller companies cannot afford this.

4.2 Commercial vs. Non-commercial

The major differences in opinions within the fire protection field come from the commercial aspect of their occupation. The needs of a commercial business are different than the needs of a non-commercial business. In evaluating the needs of the fire protection field, these differences were taken into account.

4.2.1 Company Description

Companies are considered commercial businesses. These are the organizations that do most of the fire safety consulting. Their source of income depends on the number of clients they service and the scale of the projects brought to them. A description of each of the interviewed companies is provided in the appendices.

4.2.2 Organization Description

These organizations do not receive money for the work they do. This group consists of organizations that get funding from the government for research or offering courses or training in fire safety. This group will offer a different perspective on the fire safety field because they come from a non-commercial standpoint. A list of these organizations is also provided in the appendices.

4.2.3 Inexperienced Users

During the interview process it was determined that some users of fire models do not have the educational background needed to use fire models correctly. The most common stereotype of these users is a person who has downloaded a computer fire model off of the Internet. They then used these models in their own consulting businesses. They continue to use the models without any proper training or any knowledge of limitations of the models. Some even disregard the manual that comes with the model. Interviewees felt that professional ethics should limit the misuse of models, but this is often not the case.

4.3 Contact Information

Interviewees differed in their backgrounds within the fire protection field. Below is a description of the background and the qualifications of some of our interviewees.

4.3.1 Background

Some interviewees have had college education directly in fire engineering but in most instances an interest in fire safety came after being hired for a job. They were trained on-the-job to supplement their college studies. Some participated in training courses and conferences on the use of fire models. This education enabled them to establish themselves in the fire protection field and work with fire models.

Other interviewees research the fire protection field and are on the cutting edge of developing new methods and tools for fire engineers and consultants.

4.3.2 Model Preference

In the following sections are the model preferences as expressed by the interviewees.

4.3.2.1 Zone Model Preferences

The most common inexpensive models are CFAST and FAST part of the HAZARD package. These models are used because of their solid physics and algorithms within the program. Unfortunately, it is difficult to model HVAC systems using these models. Also some users desire a delay before the start of fans for ventilation until after ignitions but this is not possible with these two models. FAST does allow you to model several compartments at once.

FIRECalc a commonly used model in Australia. FIRECalc is a model developed by CSIRO in Australia. FIRECalc has undergone many validation studies. Australian companies prefer FIRECalc because of the technical support that can be offered by a company as close as CSIRO. FIREWind has since replaced FIRECalc, a windows based version of FIRECalc.

In general, the feelings regarding zone models are mixed. Although they are an early stepping stone in the development of fire models, they need to be improved. Zone models are unfortunately easy to manipulate. Models have limitations such as the ability to only run with small fire loads and finish at flashover. Some models are not user friendly and often limitations are not documented. This creates a lack of guidance on the inputs of fire models. Because the models assume there is a uniform and homogeneous hot gas layer and a corresponding lower layer great care must be taken to model large areas and long corridors. Assumptions must be made to avoid the limitations.

4.3.2.2 CFD Preferences

Computational Fluid Dynamic or CFD models are more accurate at modeling the fluid flow of a fire than Zone models. Two of the most common models used among our interviewees are Phoenix and Exodus. Because of their fine mesh they require long computational times. Although the information is very accurate, it is only a snapshot of what is happening during a fire. This snapshot shows the conditions in the room at one specific instance. Exodus is used mainly for egress times.

Other Fire Models that are in use by the fire protection field include Evacnet, TASEF, Wayout, and FPETool. Another way to develop a model is to use an Excel spreadsheet. This model is based on basic fire engineering principles and equations.

4.4 Services

There is still confusion about what services are needed in the fire protection field. Since performance design and the application of modern scientific principles to fire protection engineering is, relatively speaking, new it is difficult to determine what services should be offered that will still be useful in the future. It is more cost effective to continue offering the same services than to continually change the objective of a company to accommodate the industry. This requires careful planning and good forecasting to predict where the fire protection industry is headed in the coming years. Fire model practitioners have expressed the type of services they feel are necessary to assist in fire modeling. This is a good start in determining the potential market for CSIRO.

4.4.1 Necessary Services

Each company has its own agenda and a plan to increase profit. Because of this, there were several services that were deemed necessary. There were also specific services that would only benefit certain companies, such as services in verification of building design to building codes. This type of service requested is very specialized to those companies involved with building design. Most of the interviewees did not fit this category and requested the typical services: more validation, more research, and more data. Again, this response is due to the infancy of the industry. As fire modeling develops, validation, research, and data will naturally follow with the progression of the industry. Until there is such a time when validation, research, and data are plentiful, the potential for services in these areas is enormous. One comment that was made was that if the industry wants the best possible services available, then they must be willing to pay for them. Evaluating the current state, the industry is not ready to do that in all instances.

4.4.2 Validation Services

The largest conflict involved with the scope of this project was found when interviewees expressed where they believe the responsibility for validation services lies. Responses to the question "Should there be a validation service for each model?" divided the fire model practitioners. Several individuals were for a validation service and several were not. What was interesting were the reasons given for not having a validation service.

First we have considered the side that supports validation services. Some interviewees were puzzled about who would be the proper organization to offer services in validation. There are many models and situations that need to be validated; it is unlikely that one organization could possibly have enough expertise to support every company's validation needs. Despite this limitation, there is still potential for offering validation services.

One company for instance would like to see more correlation between small enclosures versus large enclosures. The reason for this is because the company wants to extrapolate the models and test its versatility upon different sized rooms. This kind of validation should be done because it defines the limitations of the model. By defining the maximum and minimum sizes of a room compared to fire sizes, the model user can begin to understand the limitations. Some concerns have been expressed that validation within the model documentation is not descriptive enough. If a definite number had been provided, it would then be the responsibility of the model user to validate instances where they choose to exceed the boundaries. This scenario would require a validation service to determine the accuracy of the tested models.

Users also need validation to check for instabilities in the model. Oftentimes the model may be slow to produce results. Graphs would be displayed at a very slow rate and sometimes would appear to have stopped, leaving the user to wonder if the program crashed or if it was just really slow. This is a task that should be done with any software program and should be conducted before marketing. Under circumstances where a client buys a fire model, it is expected that 1) the model works as advertised, and 2) that it will operate on the client's current hardware. Instabilities also include conformation of the physics of the model to determine that the algorithms are performing correctly.

Some interviewees were very supportive of the idea of having any type of validation service that will make models easier to use correctly. Models that are gotten off of the Web do not provide enough information about the physics of the model. This was referred to as a "black box." Black boxes refer to models that lack documentation or are not properly documented and therefore the mathematics within the model remains unknown. The user cannot easily determine how the models get the results they do. Therefore, the credibility of the model cannot be determined and this makes the experienced users wary of using a model that they do not understand. In some instances of the more complicated CFD models, a black box may exist since some of the physics may be too detailed. In this case, a validation should be done that would provide enough proof that the model is accurate.

Users want to know about the model validation work that has been done. This information makes them better fire modelers. Oftentimes the most recent validation work does not reach the user. Without this information the user could waste time and money trying to find a solution to a problem that has already been solved. Frequent updates of validations with new data and new scenarios are desperately needed in the fire protection field.

In opposition, several fire model practitioners have suggested reasons why a validation service should not be offered. The most common answer is that validation should come from the model creators before it is released for public use. This opinion places the responsibility of validation on the creators. Lack of validation is lack of proof that the model actually works correctly. No model can be fully validated. It is argued that if a service is offered to validate models and scenarios, then the model creators will avoid the costs of validation and place the burden of validation on the user. Clearly the user does not want to pay for an incomplete model. It is common belief that validation should come with the model as a package. More recently it has been expected as users want to model more complicated scenarios. Validation has costs such as time, money, and training.

Another reason not to offer validation services is that it already has been done in the form of peer review. Associate engineers validate each other's work checking to see if the model produced the correct results for a particular scenario. A third party, to keep the evaluation unbiased, should almost certainly do validation. The peer reviewer should be knowledgeable of the potential model limitations and be adequately experienced in modeling.

It has also been expressed that one organization cannot exclusively validate models created by others. Validation of models should be "bureaucratic" and validation should come from the creator and peer reviews. The reason is so that one company does not define the future of validation. In time, the industry will determine a standard by which models can be validated. Until then, different methods are being explored and what has been expressed is that it is good for the industry to find its own future.

4.4.3 Courses or Training Services

There are several methods for learning how to use fire models. Commonly our interviewees participated in short courses, seminars, and conferences. Still others had formal training at Victoria University of Technology in Fire and Risk Management or possibly other disciplines. Then there are those who have had no training except what has been offered on the job.

Of all the people interviewed, nearly two-thirds still desire more training in fire modeling. Even those who have had extensive training in the form of seminars and post-graduate schooling still desire to learn more. An interesting analysis is that most who do not have any courses or training were the individuals who had the least interest in training or courses. This is an issue in professional ethics.

There were no significant differences between commercial and non-commercial training. Both sides, in general, wished to have more training available. Some companies expressed specific courses that they wish were made available. Training is desired on specific models such as Hazard, FAST, Exodus, Evacnet, and FIRECalc.

There were many suggestions as to how the training should be administered. One belief was that training should be offered with the model as a package. This method would provide assurance that every copy of the model that has been sold is being used as the creators had intended. Ultimately it is the professional responsibility of the users to get the proper training, but requiring a course to go with the package provides an easy way to receive that training.

4.4.4 Experimental Data Services

When it comes to fire data there is a small difference between commercial and non-commercial users, but both are in agreement that there is a lack of fire data. When asked if there is a lack of experimental data, the answer was almost always "yes." The most common problem was that the interviewees were aware that the data they need is available; they just do not know where to find it. A suggested solution is to collect the fire data into a well-formatted database. Non-commercial organizations do not have the funds to buy specialized full-scale experimental fire data since most of their work is for academic research or as a favor to other companies.

Only a couple of companies would be willing to pay for experimental data. One price quoted was $200 to $500 for data on a typical office or patient ward. Others desired a library of data that could be easily referenced for input into models and for testing model limitations. A few interviewees did state that the creator of the model has the responsibility to get the experimental data for themselves and to validate their models with it. This would save the company money if they do not have to thoroughly check their output on a situation that has already been validated with actual experimental data.

Since often this is not the case, companies need fire data to validate their own results. Heat release is most needed, according to our interviews. Other data desired includes toxic gas concentrations, dimensions of objects, smoke, and details as to the percentages of materials such as timber and stuffing within the objects. More data is needed on complicated objects made of composite materials. Without this type of data the user is left to make assumptions. Data was also requested for specific situations such as car fires, work stations, offices, and patient wards. This data will be indirectly used for the purpose of consulting and for determining compliance with building codes.

Specific types of data was not of utmost importance to the non-commercial group. These organizations mostly need large databases of information to base their research upon. The major complaint was that the data currently available is too simplified. This includes the commercial desire to have more data on composite material. Since most objects are not made of just one material, the data should be more detailed than just information on timber. There is also fabric, paint, metal, and other materials to consider. More data is also desired on real fires in real fire layouts. This type of data requires a large test facility with the ability to handle a whole room situation such as a typical office with desk, chairs, paper, computer, and any additional objects that are found in an office.

4.4.5 Support Services

There are many ways for a company to receive support for a model. The problem is that this support is not always helpful and timely. Also this support often only comes from the creator of the model or through in-house training. This support is not bad, but the more references that are available, the better the results can be. The references commonly used are colleagues, professors, surveyors, manuals, and those in the Society of Fire Protection Engineers.

Usually the manual is the first to be referenced. This is why documentation is important. Oftentimes these references are worldwide and only reachable by e-mail. The difficulty with this method is that a response by e-mail may take a few days until a response is received and then it is possible that the responder did not interpret the user's question correctly, thereby answering incorrectly. This can waste time that is needed to meet deadlines for a client. Since CSIRO and SSL are located in Australia, they are logical organizations capable of providing support services.

Personal service is almost always desired over informal e-mail. Site visits and phone calls provide quick responses to troubles with a model. In one instance, a company chose not to purchase a model because the support was so poor. This was due to the location of the company in Europe. An Australian organization is best suited to provide for an Australian company.

One way this can be accomplished is by an affiliation with a local university such as V.U.T. The backing of a university has the potential to promote CSIRO's interests to the academic community.

Interviewees often look through journals, magazine, and papers when they need information. This is a good target for common questions that have been brought forward by other model practitioners. It also provides a way to report any updates to the model that have been made or any newly found limitations. Another potential way of providing support is through an Internet forum or newsgroup. Questions can be posted at anytime and anyone can answer. This will provide faster response time if several people frequently go to the forum to ask and answer questions. This method will help those model practitioners who only have the manual as their reference.

4.4.6 Barrier Services

There is controversy as to whether there should be ways to prevent users from making fundamental mistakes with fire models. Those who agreed that barriers should be implemented often did not have a suggestion to how that should be done.

The idea of having a central jurisdiction to determine that a person is knowledgeable enough to use a model was almost unanimously opposed. The fire protection industry would not go for a service that would explicitly label someone as competent or incompetent to use a model. It was expressed that there is the possibility of a course that would informally certify someone as having taken a course in a certain model and has the tools to use it correctly. This type of course would be totally voluntary but could only benefit the model user.

Other types of barrier services that could be offered may be adding cautions or warnings into the code of the model. By using this method the limitations of the model would have to be clearly defined so that when a warning is ignored, the user knows the model is being extended past its limitations and should realize that the results may be invalid.

There was opposition to this idea too because it adds a limiting factor to the model the experienced users did not like. If a service is to be added directly to the model, both types of users must be accommodated so that one group of users does not choose a different model based on the barriers it imposes. Overall the intention should be to guide inexperienced users but clearly state that the experienced users should still validate their work.

4.4.7 CSIRO and Services

Nearly everyone interviewed thought that CSIRO should offer services. Since most of those interviewed were in fact consultants, there was an overwhelming opposition to CSIRO becoming involved with consultation. This does not mean that consultation is not an option for CSIRO, it does mean it needs to offer a consultation service that do not hinder their other fire related services. The consultation can not undercut other commercial services and should not be associated with the other fire related services.

Since CSIRO is a research-based organization, our interviewees believed that CSIRO would be better suited to offer research-based services rather than to go into consultation. It was suggested that CSIRO could offer specialty services that only CSIRO can provide. The obvious service would be to supply full-scale data from the test facilities. Interviewees desired more data and by expanding research, the needs of fire protection engineers would be met.

One interviewee proposed that CSIRO separate into two divisions. This would allow CSIRO to have two independent divisions that could perform two separate services. This may be an acceptable way to combine research and consultation within one organization.

4.5 Models

In the following sections the expectations of computer fire modeling are described. This is followed by shortcomings of the models currently used. These shortcomings include performance failures, undesirable characteristics, and the limitations of the models. The two sections are appropriately paired together to first analyze the expectations of fire models. Expressing these expectations will lead to the elimination of the shortcomings that are in the following section. Improvements will be incorporated into the future expectations of the models. These are then followed by possible marketing options and barriers to limit the amount of misuse by inexperienced users.

4.5.1 Expectations

User expectations regarding computer fire models play a vital role in the direction and future of the fire industry. These expectations are based upon the acceptance of fire modeling along with improvements that need to be made.

The current users of fire modeling expect that there will be a high emphasis placed on modeling, making it a profitable industry. They also believe the role of fire modeling in engineering will greatly expand. The companies expect the model to accurately and consistently simulate the phenomenon of fire. They also anticipate that the models will give efficient solutions and will be accompanied by a wide range of validation. Users depend on the limitations and assumptions being clearly stated within a comprehensive technical manual that includes the data used and references to find that data, therefore, eliminating the notion of a “black box”. The interviewees want validation against experimental data that is highly comprehensive. The users anticipate having confidence in a validated model and expect the results will not vary from model to model assuming the other models are validated as well. This limits manipulation of models and the input data. They hope to see more user-friendly models in the future, but they do not want to see the uneducated using the models because they lack knowledge in fire phenomenon.

4.5.2 Shortcomings

Engineers using fire models face many problems. These shortcomings include performance failures, undesirable characteristics, and limitations within the models. These shortcomings limit the use of the fire models and can cause serious errors in the modeling procedure.

4.5.2.1 Performance failures

Performance failures of the models are a great concern to the fire engineering community. These performance failures can limit the use of the fire models or in more drastic cases cause the loss of life if not noticed by the operator. Concern is expressed because of the fact that many would not know if their models were working incorrectly. Other companies are fortunate enough to test the model results against actual fire conditions. It has been expressed that it is not the model that has to be questioned, but the user of the model. One should know what the approximate outcome should be and generally every result should be questioned. However, even the most experienced user may not know the outcome of a particular fire.

There are many situations where models do not perform correctly because of limitations. In one model if there is a high fire load in a small compartment, the temperature can reach 7000 degrees, which is wrong. It is also possible that a fire can be modeled with four different models and four different results produced. How does one determine which is correct, if any? Under crosswind conditions design models cannot handle the complex mathematics, so a CFD model might need to be used. FASTLite fails in low-pressure situations, and when the position of the sprinkler head is too close to the ceiling, the reaction time of the sprinkler is significantly delayed. These are some of the many problems that still occur with fire modeling.

4.5.2.2 Undesirable Characteristics

Limitations and assumptions are generally considered to be undesirable characteristics. This is due to the large amount of time needed to check the documentation for these limitations and assumptions. However, limitations and assumptions are expected and are context dependent. Many find the models not user friendly and the instability of results given by the model resulting in a lack of confidence is undesirable.

Some additional undesirable characteristics include the strange parameters, limited validation, documentation, or lack of internal verification of numbers. Models limit their inputs and provide little guidance as to what inputs would be valid. There is not enough experimental data available and the data that is available lacks sufficient detail. Therefore, assumptions are made. Manipulation of data and multiple assumptions result in what the fire protection field commonly refers to as "garbage in garbage out."

Some of the models do not account for drastic changes in fire conditions because of the simplicity that has to be maintained. They have limitations such as lack of data for heat release rates and the decay of the cooling rate of sprinklers. All the models are based upon cubic enclosures that are reasonably small. These rectangular shapes represent simplistic buildings that do not need fire engineering as much as the unique shapes of some of the more modern buildings. The fires are modeled with small fire loads and stop at the point of flashover. Subsequently with all the undesirable characteristics listed they are used as a research tool rather than an engineering tool.

Some more specific examples of undesirable characteristics can be seen in Evacnet, where the user can only define one unvarying person in the program, or Hazard, that has a complicated ventilation scenario. FIRECalc has limits on the variables used, which are not stated in the reference material provided. Therefore, users may not know that they have exceeded a limitation. FIRECalc also has errors in model evacuation, as well as some numerical problems. Interviewees state that CFAST's user interface is inept, unfriendly, and contains limitations in the form of output. FASTLite gives options for experimental data inputs but not the details of contents of the experimental data. CFD models remain time consuming and costly.

4.5.2.3 Limitations of the Models

Models are limited by their lack of capabilities. Lack of capabilities causes irritation to the users. This irritation is caused by the validation that must be done to ensure that the fire is being properly modeled. This examination process can be done by the model maker, a third party peer review, or an Authority Having Jurisdiction (AHJ).

Limitations can be in the form of software references that are hard to find. This forces the user to search and find the proper documentation. Some models do not produce results on toxicity or have temperature predictions that vary greatly between real and calculated results. Modeling becomes time consuming especially when the output does not make sense. The input must then be tweaked. There are limitations with validation and assumptions when compared to sources of suitable data.

Most models are user unfriendly, time consuming, costly, and require too much computer power. Some runs of a model take days, which ties up the computer and delays other work. Zone models are limited to variations of the base model of a square room. If there is a long corridor to model, then they break up the corridor into smaller boxes, which does not show that the gases flow down the corridor. Instead each room fills up and then spills over into the other rooms. CFAST is difficult; one mistake and the user can throw away the results. It is very difficult to find where the mistake lies. Evacnet is difficult to use. If a mistake is made, the model must be run again from scratch. In terms of operational limitations, validation must prove itself under real fire conditions. Limitations exist in area crosswinds of large open spaces.

4.5.3 Marketing Preferences

There are numerous ways in which to market the product of computer fire models to the commercial industry. Word of mouth tends to be the most popular in the close-knit fire protection industry. Through demonstrations or presentations the model can be introduced and the main features shown. Human contact is always better than a brochure. It is also important to advertise through literature, Internet, conferences, University providers, and large organizations such as FPAA. CSIRO is in a good position for marketing and could be more pro-active than it currently is. The consumers want a realistic cost. Shareware can solve this problem by letting the consumer test the model. The shareware version can be restricted so it cannot be used for final results. Warnings can appear if it is not properly registered. The models should also be marketed as a reliable tool, showing the new improvements.

The models can be marketed as a total package with training and clear communication of the limitations and assumptions. It should be marketed by showing the validation and stating exactly where the numbers are coming from. Like any commercial product, the models should be marketed competitively. One or two models will become the accepted standard after a competitive market has weeded out the inferior models. A model should be sold to engineering companies with limitations and assumptions clearly identified, handbooks, internal number verification, and acceptance by an Authority Having Jurisdiction or third party review. Its intent should be as a tool that is part of fire engineering.

4.5.4 Model Barriers

The danger of an inexperienced modeler is that the answers produced, regardless of how they are attained, are taken as fact. This may result in dangerous building designs. How barriers will be enforced and what they will entail are very controversial questions. Should regulations be enforced through supervision of a governing party, should the models themselves indicate inappropriate data, or should professional ethics remain the barrier for inappropriate use?

The user has a responsibility to follow a code of ethics. Barriers should not replace these professional ethics. Users should be counted upon to act in a professional manner and model producers should publish the model's limitations in its documentation. Documentation assists the user to properly validate the models with out ethical dilemmas.

Computer fire models should contain cautions and warnings in the code of the model. This is referred to as trapping or, as it more commonly known, flagging. Flagging is beneficial to both the experienced and inexperienced users of the models. These barriers help to stop mistakes by giving the user an opportunity to catch errors in the data. Flagging, although beneficial, would have to be user friendly and could not stop the modeler from testing the limits of the model. This type of barrier would not solve every problem. The input data could still be incorrect, leading to, "Garbage in, Garbage out."

The most severe case of barriers would be government intervention. The government would restrict who is a practitioner and how the models are used. Some requirements may be a post-graduate education or a standardized test to determine the ability of the users. The professionals of the field should feel not only the ethical pressure but also a governmental influence to present their expertise and experience honestly and scrupulously.

4.6 Future of Modeling

4.6.1 Usage

The future of fire modeling is unlimited because of its infant stage. Many of the interviewees compare this stage of growth to that of structural engineering in the late 60's. Many of the users plan to continue using the models as they currently do, while a few plan to expand their operations to encompass a greater range of services. It is the hopes of the fire engineering community that as computer power grows, limitations of current computer programs will disappear. These engineers also hope to see a wider range of services being offered in the areas of validation and generation of experimental data.

Many use modeling for the purpose of consulting on office buildings and institutions. They use it as a design tool for the risk assessment of buildings and to limit the amount of wasteful construction in buildings. They plan to use the models along with the performance-based codes and faster, more powerful computers. This will maintain the safety of the building while increasing the amount of options a designer has. Operators also hope to accurately model large-scale applications such as a stadium with the increased power and speed of computers. This increase in speed would also evoke a movement to the more detailed CFD models.

4.6.2 Modeling

As experimental data available increases, there will be greater validation of both model usage and the model's numerical calculations. Also, with proper documentation this will bring about greater confidence in models as an engineering tool instead of a research tool. A plentiful supply of experimental data will increase the variety of input data, making a more accurate account of the real fire conditions possible. The models will increasingly fit into risk assessment and risk management frameworks. Human behavior during egress situations will advance evacuation modeling, making it possible to predict the actions of human response during a real fire situation. Gross assumptions will disappear leading to greater accuracy of output data that will be comparable between similar models. Work on combining CFAST and architectural packages is underway and the ability to use computer aided drawing for input will increase the usability by generating specific door, window, and room sizes from the single computer file. Eventually, virtual reality graphics will simplify user friendliness by making it possible to walk though a fire scenario in real time to "see" evacuation, smoke spread, and flame movement. This will assist in fire fighter training and court cases. The acceptance of the computer fire models will cut the cost of building design and safety systems, bringing about a new era in performance based codes. Models will no longer be limited to rectangular rooms but expanded to multi-purpose, unique, and large area rooms with diverse geometry. Advances in computer technology will bring upon a change from zone modeling to CFD models such as Exodus and Phoenix.

There is an extreme point of view among the industry that the future of fire modeling is limited. This point of view refers to buildings that are of a standard design. Building regulations have acceptable solutions already in place. So unless it is, for example, a large arena that does not fit into the building regulation, it does not need to be modeled.

5.0 CONCLUSIONS

The purpose of this project was to conduct an analysis of the fire protection field to determine a possible market for CSIRO in computer fire modeling. This was accomplished by interviewing a sample of the fire protection community. Through the analysis of these results, conclusions have been formed and recommendations have been made.

5.1 Marketing

An important aspect of CSIRO's ability to offer services will be through marketing. Marketing is the one variable that can determine how successful a business is. If new products or services offered by CSIRO are marketed correctly, it has the potential to be very successful.

The interviewees contacted had very strong feelings towards the method that a product or service should be marketed. CSIRO must make sure that it markets the capabilities, documentation, validation, limitations, and assumptions, of any new product. The fire protection field would most benefit from a product that is marketed honestly and without all of the bells and whistles that divert attention away from the main functionality. Clients are interested in what these services or products will do for them.

Through interviews, the most effective ways to sell products to the fire protection field of Australia has been determined.

5.1.1 Personal Marketing

The most difficult but also the most effective way to market CSIRO's product is through personal meetings at the client's company. If an individual visit is conducted by an on-site meeting, the consumer feels important and a personal connection is made. On a more personal level, the feelings of both the consumer and CSIRO can be expressed. The client will feel the privilege of having its own opportunity to hear what CSIRO has to offer them. In the presentation of CSIRO's product, CSIRO will have to make sure that it clearly states how the product will be useful to this specific client.

Through on-site presentations CSIRO can give the client security and peace of mind before purchasing a product. Some products carry a warranty that ensures that the product will perform to a certain standard, and if it does not, then it will be fixed or replaced. CSIRO should offer the same type of security. This security may be in the form of future model versions to prevent the model from becoming obsolete, and offering technical support for the current model's features. CSIRO should continue to offer services to this client to make sure that they are happy with the product. This will not only make the client want to come back to CSIRO, but also recommend CSIRO to someone else.

In general, if a product is marketed in journals or reports only, many potential clients may not notice it. Several papers pass by the desk of potential clients every day and most get thrown away without even a glance. The fire protection field will never know what CSIRO has to offer unless a proactive stand is taken. CSIRO should not depend on word getting out that it has a particular service to offer, nor should it wait for potential clients to come to them. In the end, it is the quality of service offered that will dictate CSIRO's success.

5.1.2 Other Forms of Marketing

At conferences, CSIRO should make the fire protection field aware of the products and services it is going to offer. These presentations should be widespread so that a large market can be reached. It is then up to CSIRO to pursue these people on an individual level. These conference presentations should be short and concise but long enough to spark the potential client's interest.

Another way for CSIRO to market its services and products is through journals and organizations such as the FPAA and the NFPA. These organizations reach a large range of the fire engineering practitioners that make up a large portion of the market for CSIRO. CSIRO should also market its product and services to practicing universities and colleges. There, its products would reach future fire safety engineers, which would lay the groundwork for a solid client base. This could potentially be the largest client base because the users will leave the university and continue to use CSIRO's models. These users would be comfortable with the use of this model and would continue to use this model because of their understanding of it. If CSIRO continues its interaction with the universities, then eventually the majority of the fire protection field will have experience and be comfortable with the model.

5.1.3 Shareware

Along with presenting a product to the fire protection field, CSIRO should give its potential clients a chance to test the product. Putting a copy of a model on the Internet can achieve this objective. This would give clients an opportunity to see what is incorporated within the model. Seeing the type of inputs and outputs that a model produces would give clients a chance to see the actual capabilities of the product. This, in turn, would create confidence in the models and result in sales.

There should be precautions to giving out this information though. These programs could be used on a consulting level without the user paying for the model.

There are a few options to protect CSIRO from losing money or information this way. First, CSIRO can give out a version of the model that clearly states that it is a restricted/constrained version of the program. It must be stipulated that results from the version cannot be used in consulting or for any commercial use. There could even be a warning printed out along with the results from the model. This would insure CSIRO that a model given out could not be stolen. The advantage to giving out this type of model is that the consumer can use the model and clearly see the capabilities and limitations of the model.

The other option is to restrict the use of the model and only give out the results of a few runs of the model. This would include what variables were input into the model and the type of data that was elicited from the model. Then CSIRO could compare these results to experimental data showing the validity of their model in certain instances. This is the only way currently available to validate a model correctly. A disadvantage to this is that the users could not input their own data and use the model for themselves.

Finally, before the model is downloaded the consumer should be required to fill out a survey including their name and contact information, as well as the purpose for downloading the software. This would also give CSIRO a database of potential customers. It is proposed that CSIRO produce a restricted version of the program that clearly states that the model cannot be used for anything besides testing the product.

5.2 Services

Under the current structure of the Division of Building, Construction, and Engineering, there is the potential to offer services in model support, experimental data, and in validation. These services should include a database of experimental data, validation services, forums and newsgroups to consult with other engineers, and other services that CSIRO could offer in the future.

5.2.1 Forums and Newsgroups

Since the Internet is used commonly throughout businesses, it should be a target for offering services. Many models are offered for free over the Internet. Some model practitioners search for data this way as well. CSIRO can use the Internet to offer technical support for its models and data through Internet forums and newsgroups. Model users can post messages and questions on this Internet site and other users can help by answering those questions. An expert in CSIRO fire models can easily maintain these sites. It would require checking the site occasionally for posts and making sure that there have been responses to all questions. This way users know that when they log onto the site they will get a response. Costs would be really inexpensive. These costs would only include the price of a computer to run the site from, the necessary computer memory to store the data , and maintenance. Initially CSIRO would be in a good position to offer support for the models it helped create: FIRECalc and FIREWind. Users of the forum could still post questions about other models, but CSIRO models should be emphasized.

Initially the Internet site should be offered for free. The intent would be to build up a reputation for CSIRO that it offers excellent technical support with its models and services. When the Internet site becomes more established, then CSIRO might want to consider charging a fee. Other services that could be included are described in detail below.

5.2.2 Database of Experimental Data

Fire model users are most concerned with the lack of experimental data, especially those involved with research. There is a desire for an organized collection of data. CSIRO could form a membership service to access a centralized database of this data. This centralized database would contain all of the data collected by CSIRO and make this material available to the fire protection field. Members would pay a fee, possibly annually, to have access to current data as well as data collected in the future. There was reluctance among interviewees to pay for experimental data. A way to avoid this reluctance is discussed later in Chapter 6 Recommendations.

For those who require experimental data, the database would be helpful. The database should be properly formatted so that it is easy to understand and to incorporate into models. The data would have to incorporate what the users desire such as heat release rates, composite materials, and optical density. The service could also include an expansion upon the database as more data was obtained. In order to charge a rate the data would have to be what the client needs. This is why it would be beneficial for CSIRO to continue to gather input from its clients as to what they would like offered.

5.2.3 Validation Services

The view on validation services is mixed among the fire safety industry. Some companies desire more validation while others believe that proper validation should be included within the model. Unfortunately it is impossible to validate a single model. There are too many variable involved in the validation of a model. These variables include the model, the modeler, the data set, the complexity of the model, and many others. There are scenarios where the model may be valid and these scenarios must be identified. Validation will only be correctly reached by validating a model and user together. It is true that validation should be included with the model, but there are always scenarios that may be overlooked during the initial validation of the model. In this case there should be a service that validates or reviews the instances not previously modeled. It would be difficult to offer validation services for a larger range of models.

To offer the validation of these other models CSIRO would have to employ the best professionals in the field. These professionals would have to have extensive knowledge of a model for them to consult on the validation of that model. This could be a potential market for CSIRO to go into, but solid understanding of the models is required within the staff.

5.2.4 Computational Services

Since CFD models take so long to run, CSIRO could offer to run the models on its computers. This would allow CSIRO's clients to continue working while the CFD model is running at CSIRO. A CFD model can run between 12 to 18 hours and can render a computer useless until the CFD model is finished. This service could be very valuable to CSIRO's clients until there is a time when personal computers can easily handle CFD models.

5.3 CSIRO Fire Models

An option for CSIRO is to produce its own models. The development of a fire model would place CSIRO on the expanding market of computer fire model use. CSIRO would have to offer services and characteristics that are unique to its model but also enticing to its clients. Some options are provided below.

5.3.1 Modeling Features

The features the model contains should assist the modeler, making it easier to run through multiple scenarios and to obtain the most accurate model of the fire phenomenon. These features should be user friendly and not prohibit the operator from completing their runs of the system. An example of this would be the use of flagging within the code of the program. Flagging would warn the operator of limitations in the system, but it would not stop the operator from continuing the run.

5.3.2 CFD and Zone Models

The fire engineering community uses zone models daily for many applications. Every company uses a multitude of models to fulfil its needs, fitting the model to the fire phenomenon. If a zone model were to be developed by CSIRO, it would have to offer a multitude of modeling options or contain unique features. These features could contain documentation and a user-friendly interface. Additional services could also promote the sale of a model. CFD models are becoming more common as computer speeds increase and more models are developed. These types of models give a detailed snapshot of the fire dynamics. Its acceptance is increasing and although it may never completely replace zone models, it will be widely used in the future. The use of CFD models, however, is still very limited, due to the expenses of models and the time needed to run the model. Also, to currently use a CFD model correctly, certain scenarios should be tested along with sensitivity studies. This creates a great opportunity for CSIRO to expand into this area of modeling. It would be beneficial for CSIRO to develop and market either type of model in a long-term scenario.

5.4 Separation of Divisions

Along with research into the providing of services to the fire protection field, CSIRO's role within the fire protection field was examined. It was the general feeling that because CSIRO is federally funded, it should not be in competition with other commercial consultants. Companies feel that the taxes they pay to the government should go into research for the fire safety field.

Unfortunately for CSIRO, the government cut its funding. To continue its research, CSIRO was forced to produce its own funding through commercial competition. This placed CSIRO in a difficult position within the consulting field. CSIRO could not continue as it was without producing its own funds, but they are losing customers because of competition it creates within the industry.

One option is for CSIRO to split its Fire Science and Technology Laboratory and become two independent organizations. One organization would deal only with research and the other would focus on only the commercial consulting activities. This would provide income from the consulting division, but it would also provide the fire protection field with data from the research division. This would also separate the two disciplines and put CSIRO in a respected position within the fire community. This split and independence of the research lab from consulting would have to be highly publicized to promote confidence in CSIRO.

5.4.1 Research

The Fire Science and Technology Laboratory of the DBCE would deal exclusively with research into the fire protection field. Its obligation would be to conduct experimental fire tests. This data would be available to industry through CSIRO's service of a centralized database. There are several experimental tests left to be done.

Each of these provides more information that could be provided to Australia and even a worldwide market. Other foreign modelers have similar complaints of the lack of organized experimental data. Money raised from targeting these markets could be put into further research that is necessary.

5.4.2 Commercial Consulting

CSIRO should continue consulting and providing the commercial services that it currently does. Additional services could potentially open a larger consumer base for consulting. If CSIRO develops a model, its expertise with the model will lure commercial projects. Even though the model will be available to the fire protection field, CSIRO will have the best understanding of the software. Potential customers will want the best consultants, generating greater opportunities for CSIRO in the fire protection field.

6.0 RECOMMENDATIONS

As the power of computers increases and the acceptance of performance based codes grows, the future of computer fire modeling is expanding. Zone models are becoming more reliable while CFD models are quickly becoming more of a day to day tool of fire protection engineers. The fire protection industry is moving forward and needs a more comprehensive modeling package.

6.1 Modeling Package

It is in the best interest for CSIRO to produce its own models. The development of a fire model would create a market for CSIRO to offer services that are needed by the fire protection field. CSIRO would have to offer services and characteristics that are unique to its model but also enticing to its clients. Clients desire the most out of a model and if many services are offered by CSIRO along with its models, then this could persuade the consumer to buy CSIRO's product.

The models produced should be included in a total package containing experimental data, forums and news groups, and validation services. The limitation and assumptions of the model should also be included in a comprehensive technical manual. The model should also be sold with the proper training and certification, which would give the user access to membership privileges. This total package would promote the sale and acceptance of the model into the fire protection field.

6.1.1 Membership Access

As part of the modeling package, CSIRO should include a membership to its services. Access to the membership benefits would promote the sale of the model. The membership should give the model users access to validation services, forums, newsgroups, and updates of experimental data. More importantly it will present them with the problems that other colleagues are facing and the updated solution to that problem.

The forums and newsgroups as well as the centralized database could both be offered through the Internet. Members would have a login name and password and would be able to access the features whenever desired. As mentioned before, the forums and newsgroups would provide CSIRO's clients with an opportunity to ask questions in a peer review style. The web page should also include a section that includes previously asked questions along with their answers. This would prevent users from having the same problems. The information would allow users to update their systems to contain the most updated information on the package.

The experimental data section should contain all of the data that CSIRO has produced along with any additional information that can be found. As more experimental data is obtained, it should also be added to the database. This would provide CSIRO's clients with the most up to date information available. Also, a centralized database is highly in demand within the fire protection industry.

It is proposed that as part of a membership, the member can at anytime have their scenario validated. This helps CSIRO identify limitations previously overlooked. Validation results should be published and distributed to other members to prevent an overloading of validation requests. The forum or newsgroup would be a good way of informing members. Occasionally additional pages of recent validation work should be sent to the members for the purpose of updating their manuals.

6.2 Other Modeling Package Features

Along with the features recommended above, CSIRO should also include the following ideas in a modeling package. The interviewees contacted throughout the completion of the project desired both of these features. Other features that were not included but could be added at a later time are found in chapter 5: Conclusions.

6.2.1 Limitations and Assumptions

The limitations and assumptions of the model must be properly recorded. Many of the model limitations are caused by the experience of the user. An engineer with more experience will have a better idea of when the limitations are reached and when they are breached. Along with the ethical implications of professionalism, the users must be able to examine the algorithms used in the model. This creates confidence in the model and resolves possible problems that the user may face. It informs the users when the boundaries of the model are being challenged or even exceeded.

The comprehensive technical manual should include limitations and assumptions along with the specifics of the operating system. This would limit the misuse of the program and provide guidance to the users.

6.2.2 Training and Certification

Once the program has been purchased, the users of the program should participate in an inclusive training program to receive certification for the particular model. This training would include insights into not only the model features, but also the advantages of the membership program. This training and certification would also eliminate the misuse of the model by inexperienced users.

6.3 Conclusion of Recommendations

These recommendations are based upon numerous interviews conducted throughout the completion of this project. The results analyzed are a good representation of the needs expressed by the fire protection field. This project has resulted in a better understanding of the relation between technology and society. It is hopeful that CSIRO can use this project for the benefit of the fire protection field.

6.4 Extending the Project

There are several ways this project can be extended. All of the services proposed need to be implemented. Since the most useful resource to fire modelers is experimental fire data, a project could be to locate, collect, and organize data into a well-formatted data base. The project team would need to determine specific data types that are desired by the field. Also the project team must find a good data format so that it can easily be input into models. Since ease of input was a problem among this projects interviewees, this must be taken into account.

There is also the opportunity for a project in developing a technical support web site. This project would require research to determine the best method to attract model users to the web site. Implementation would be based upon what model users need for technical support. Study into user interfaces and computer and human-interaction would be helpful.

APPENDIX A

Appendix A
CSIRO: Commonwealth Scientific and Industrial Research Organization

Commonwealth Scientific and Industrial Research Organization, CSIRO, has a history that extends as far back as World War I. In 1916, Prime Minister Hughes established the Advisory Council of Science and Industry to improve science and research and to bring it to a national level. In order to form a permanent body, the government created an Act to establish the Commonwealth Institute of Science and Industry in 1920.

Soon after, in 1926, the Commonwealth Institute of Science and Industry was reorganized. New legislation was passed and the Council for Scientific and Industrial Research, CSIR, was established. CSIR's initial purpose was to conduct research that would benefit Australia's primary and secondary industries. Its focus was on agriculture and the economic value of forest products.

After World War II ended in 1945, research expanded to include areas such as building materials, wool textiles, coal, atmospheric physics, physical metallurgy and assessment of land resources. At this point, the CSIR was renamed to CSIRO, the Commonwealth Scientific and Industrial Research Organization. Since then, CSIRO has gradually expanded its research to include almost every field in industry today. Many other areas affecting a majority of the community are also covered -- such as the environment, human nutrition, conservation, urban and rural planning, and water supplies.

In 1971, CSIRO relocated its headquarters from Canberra to Melbourne. The current structure, which was implemented in 1996, divided CSIRO into semi-autonomous divisions that report to the Deputy Chief Executives. In the summer of 1998, CSIRO employed 6,600, which included almost 4,000 researchers. This is a clear indication of CSIRO's dedication towards research and development in Australia.

Employees work in a variety of different environments. Some of these environments include laboratories and field stations located in all regions of Australia. Each region contributes to one or more of the following fields: agriculture, minerals and energy, manufacturing, communications, construction, health, and the environment. This broad spectrum of scientific fields is part of CSIRO's emphasis on bringing together scientists of different backgrounds to work on solving the major challenges that face Australia.

CSIRO's vision is "to be a world-class research organization vital to Australia's future (CSIRO 1998 Annual Report)." CSIRO plans to achieve this goal while serving the Australian community by offering support for Australia's national and international goals. It strives towards providing social and environmental benefits to secure the future of Australians and to develop international recognition. Local and international industry and economy will benefit from CSIRO's commitment towards superior quality work in research and development. Parliament, competitive grants, and industry funds combined for CSIRO's 1998 total external income of $266 million, which is slightly above the government mandated target of 30 per cent of total income.

CSIRO divides its resources among these fields:

- Agribusiness
- Environment and Natural Resources
- Information Technology, Infrastructure, and Services
- Manufacturing
- Minerals and Energy
- Others

Some of CSIRO's recent achievements in these fields include a vaccine that is expected to enhance cattle health, a face recognition system used for security, and biological control techniques developed to eliminate or repel animal pests such as rabbits, foxes, and mice. It also has developed a new method for x-raying that gives sharper images of softer tissue while reducing the amount of x-rays that the patient is exposed to. Each development demonstrates the broad range of fields that CSIRO is capable of providing benefits towards. (www.csiro.au)

CSIRO's Division of Building, Construction and Engineering, operates the most comprehensive fire research, consulting, and test facility in Australia. The Fire Safety Division of the DBCE, which is under the supervision of Senior Research Scientist Vince Dowling, uses a combination of expertise and full-scale fire test capabilities to provide a unique facility to industry, capable of simulating a wide range of fire scenarios. The staff supervised by Vince Dowling includes the Senior Experimental Scientist Neville McArthur, Experimental Scientists Justin Leonard and Alex Webb, and Senior Technical Officers Paul Bowditch and Glen Bradbury. This staff is responsible for all of the work done within the Fire Safety Division of the Division of Building, Construction and Engineering.

The Fire Safety Division of the DBCE has participated in smoke control design for several of Melbourne's buildings. An innovative approach to computer, zone and field, modeling techniques are utilized to meet the client's requirements. The division has also developed comprehensive testing facilities to undertake a wide range of tests for industry based on international, Australian, British, American, and other standards. The range of test include fire resistance, flame spread, smoke development, combustibility, fire behaviour, hot smoke test, rate of heat release, room fire test, and many more. These tests can be conducted using their major test and research equipment. This includes, but is not limited to, wall and floor furnace, pilot furnace, column loading furnace, flammability apparatus, cone calorimeter, room fire test facility, and room and corridor fire test facility (Fitzgerald, 1,2).

CSIRO assesses the needs of the fire protection industry and supplies its customers with products that will most benefit the needs of the field. Because of its understanding of the business and the world markets their customers operate under, CSIRO can sponsor research that potentially could open new markets of business for the organization.

As a means of enhancing communication among industry officials, CSIRO participates in media releases in the form of scientific papers, conference reports, newsletters and promotional brochures. CSIRO also holds days where community groups and researchers are given the opportunity to learn more about its direction in industry research. The Internet has become an important means through which CSIRO publishes its organizational news all around the world. Through efficient communication, CSIRO can determine a standard of engineering excellence by researching and developing a product necessary through which all fields can benefit.

APPENDIX B

Survey/Interview Questions

- How long have you been in the fire safety field?
- Which models do you prefer to use and why?
- What training have you received?
- Is there any training or course you would have liked to participate in?
- How often do you use computer fire models and for what reasons?
- Rate these in order of importance to your company from 1 to 7, 1 being the most important:

1) Accuracy of the model (physics of the model)
2) Capabilities
3) Cost of model
4) Documentation
5) Experience/Training
6) Speed
7) Useability

- What expectations does your company have in computer fire modelling?
- Are there any specific circumstances that you can recall, when your models did not perform correctly?
- What are some of the undesirable characteristics of the models you use?
- How could these be improved?
- Do you find there is a lack of experimental data?
- What type of experimental data would be worth purchasing and for how much?
- What limitations do you find with models?
- Should there be barriers to limit the risk of misuse by inexperienced operators?
- Should there be a validation service for each model?
- Do you feel CSIRO should offer services for modelling?
- What types of services do you feel are necessary?

- How do you plan to use fire modelling in the future?
- Do you have a reference if there are problems with a model? Someone you can ask questions.
- How do you think models should be marketed? ie. through the Internet, catalogue, or other ways.
- What do you think the future of computer fire modelling is?
- Do you know of anyone else that we can contact for more information?

APPENDIX C

APPENDIX C
Interview Transcripts

The following documents are the transcripts directly from the interviews conducted throughout the completion of this project. The identity of the interviewee has been kept confidential.

Appendix C
Interview Summeries

Survey/Interview Questions

- **How long have you been in the fire safety field?**
  20 years been engineering since 92

- **Which models do you prefer to use and why?**
  CFAST part of HAZARD, EVACNET, FIRECalc

- **What training have you received?**
  Work shop on CFAST

- **Is there any training or course you would have liked to participate in?**
  None

- **How often do you use computer fire models and for what reasons?**
  Daily, for validation and fire engineering assessments

- **What expectations does your company have in computer fire modelling?**
  N/A

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  No, How would you know?

- **What are some of the undesirable characteristics of the models you use?**
  Input complicated and the user friendliness could be improved

- **Do you find there is a lack of experimental data?**
  Yes

- **What type of experimental data would be worth purchasing and for how much?**
  The typical office, patient ward typical situation for fire size. 200-500 dollars.

- **What limitations do you find with models?**
  How real is it compared to fire BHP office there is a full scale test

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**
  Yes

- **Should there be a validation service for each model?**
  Yes

- **Do you feel CSIRO should offer services for modelling?**

Yes useful

- **What types of services do you feel are necessary?**
  More services in large scale building applications.

- **How do you plan to use fire modelling in the future?**
  Currently office buildings and institution difficulty with large-scale stadium don't know accuracy. CFD

- **Do you have a reference if there are problems with a model? Someone you can ask questions.**
  No, personal reference

- **How do you think models should be marketed? ie. through the Internet, catalogue, or other ways.**
  As a total package with training and understanding of the limitations and assumptions

- **What do you think the future of computer fire modelling is?**
  Even more important every day tool

Survey/Interview Questions

- **How long have you been in the fire safety field?**
  3 years.

- **Which models do you prefer to use and why?**
  I use Exodus and Evacnet. I use them because they model all types of occupants. It provides a variation of age and mobility. We also use Phoenix, FIRECalc, and CFAST.

- **What training have you received?**
  One of our employees is trained for each model. He was trained at University of Technology, Sydney, and has a degree in Fire Safety Engineering.

- **Is there any training or course you would have liked to participate in?**
  None

- **How often do you use computer fire models and for what reasons?**
  I use fire models for approving construction. How often I use them depends on the job.

- **What expectations does your company have in computer fire modelling?**
  I expect that the results will be reliable with performance and also with the reaction of occupants.

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  For one project the ceiling did not contain smoke the way it was perceived.

- **What are some of the undesirable characteristics of the models you use?**
  N/A

- **Do you find there is a lack of experimental data?**
  N/A

- **What type of experimental data would be worth purchasing and for how much?**
  N/A

- **What limitations do you find with models?**
  N/A

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**
  Yes, the barriers should be contained within the accreditation service.

- **Should there be a validation service for each model?**
  There should be a Q/A validation for each model.

- **Do you feel CSIRO should offer services for modelling?**
  N/A

- **What types of services do you feel are necessary?**
  Services that are needed are Research, Peer Reviews, Publication of research methods, Validation of models, and Alternative products.

- **How do you plan to use fire modelling in the future?**
  Our use of fire models in the future will include alternative proposals to design.

- **Do you have a reference if there are problems with a model? Someone you can ask questions.**
  Peer reviews

- **How do you think models should be marketed? ie. through the Internet, catalogue, or other ways.**
  Models should be marketed through the Australian Building Code Board or the Building Codes of Australia. Another way that a model should be marketed is to obtain a professional certification of the model.

- **What do you think the future of computer fire modelling is?**
  Fire models will become more accurate and also become the basis of all math validation.

Survey/Interview Questions

- **How long have you been in the fire safety field?**
  25 years

- **Which models do you prefer to use and why?**
  CFAST

- **What training have you received?**
  BBS Courses on performance based fire codes at Victoria University of Technology. Some guys taken the fire technology courses

- **Is there any training or course you would have liked to participate in?**
  Keeping an eye on it. Would like to get it into the industry

- **How often do you use computer fire models and for what reasons?**
  N/A

- **What expectations does your company have in computer fire modelling?**
  N/A

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  N/A

- **What are some of the undesirable characteristics of the models you use?**
  N/A

- **Do you find there is a lack of experimental data?**
  N/A

- **What type of experimental data would be worth purchasing and for how much?**
  N/A

- **What limitations do you find with models?**
  N/A

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**
  Yes, has to be barriers to stop mistakes has to be user friendly has to be restricted

- **Should there be a validation service for each model?**
  Yes

- **Do you feel CSIRO should offer services for modelling?**
  Respected name

- **What types of services do you feel are necessary?**
  Checking third party. SSL deemed to be unbiased, some one like that.

- **How do you plan to use fire modelling in the future?**
  To deem if design is satisfactory. Contractors from a commercial point of view want all the systems in the fire industry wants them all in but developers don't.

- **Do you have a reference if there are problems with a model? Someone you can ask questions.**
  N/A

- **How do you think models should be marketed? ie. through the Internet, catalogue, or other ways.**
  On their industry exception. One model has to push to become the industry standard.

- **What do you think the future of computer fire modelling is?**
  Watching. Definitely has a future in the industry. Limit wasteful development.

Survey/Interview Questions

- **How long have you been in the fire safety field?**
  I've been in consulting for two years. I have 4 years experience including projects.

- **Which models do you prefer to use and why?**
  For zone modeling we use CFAST because of its broader capabilities and extensive documentation and validation. It is good for an overview of the scenario.
  We also use the CFD Phoenix No one has training as of yet but we are looking to getting trained. We also use Tasif for heat transfer situations.

- **What training have you received?**
  N/A

- **Is there any training or course you would have liked to participate in?**
  CFD Phoenix No one has training as of yet but we are looking to getting trained.

- **How often do you use computer fire models and for what reasons?**
  Daily. The reason is for the complexity of the problem. Cannot do hand calculations. Can use spreadsheet but models already have them

- **What expectations does your company have in computer fire modelling?**
  Robust, validated for different circumstances, documented limitations, solutions to be accurate, assumptions to be stated, properties. In the manual I expect to see a full technical list of the model. Clear field of application of the model

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  N/A

- **What are some of the undesirable characteristics of the models you use?**
  There is instability in the solutions that are produced. There are also significant errors in many of the components of the models. Robust in the numerical solving capabilities. They have primitive interface. They also need better processing of the output data.

- **How could these be improved?**
  Better coding of the models. A lot of them were just research projects. Rigorous testing and research.

- **Do you find there is a lack of experimental data?**
  Yes, simple well controlled experiments with boundary conditions clearly designated. Heat transfer, material properties are needed.

- **What type of experimental data would be worth purchasing and for how much?**
  N/A

- **What limitations do you find with models?**
  N/A

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**
  How do you do this? Maybe statuary law. Any one can get FIRECalc and you can always get an answer. From a liability point of view than you are going to have do defend your assumptions and calculations.

- **Should there be a validation service for each model?**
  Verifying if what the person has done is correct…yes if you can do this. Models should validate themselves. If it produces an outrageous answer make a warning pop up saying so.

- **Do you feel CSIRO should offer services for modelling?**
  They can, it could be useful. There should not be a model that can do everything. There is too much to be understood. They should understand their role as a research institution.

- **What types of services do you feel are necessary?**
  I think that there is a lot of area of improvement with software. There should be more validation of models and more models dealing with egress times.

- **How do you plan to use fire modelling in the future?**
  N/A

- **Do you have a reference if there are problems with a model? Someone you can ask questions.**
  We can do this in house.

- **How do you think models should be marketed? ie. through the Internet, catalogue, or other ways.**
  CSIRO should use a shareware version first and let the consumer understand the inputs. You would have to make it a bastardized program.

- **What do you think the future of computer fire modelling is?**
  It is going to get better and better. Zone models will disappear. As computers get faster CFDs will come into more effect. The graphics will be better. Possibly regenerate a building just by using inputs.

Survey/Interview Questions

- **How long have you been in the fire safety field?**
  37 years.

- **Which models do you prefer to use and why?**
  FIREWind (by CSIRO) It is user friendly and it has considerable validation. Validation consisted of hot smoke test and a tool for demonstrating the smoke control in buildings. The hot tests also give an indication of the system. FIREWIND was also validated in a custom design system.
  LIMITATIONS: You must know that the inputs you use are good and that the values you use are accurate. I make use of models like Phoenix and other models that I have access to.

- **What training have you received?**
  3 years at VUT. 7 years experience with sprinkler design. Inst of FE in the UK. Bachelor degree in the mid-eighties in materials.

- **Is there any training or course you would have liked to participate in?**
  I would like to get my masters and PH.D.

- **How often do you use computer fire models and for what reasons?**
  Everyday for consulting use or whatever use is needed within the industry. Existing building refurbishment and incorporating new designs under the Performance Based Codes. Also make recommendations in the report of the building itself from the fire safety perspective.

- **What expectations does your company have in computer fire modelling?**
  CSIRO...embarking on a process of R+D to improve the models and to improve on incomplete models. Make models that are better than others in the world.

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  Probably in the earlier stages when the models were being developed. Part of the ironing out of the bugs in the program. Ridiculous results, crashing the computer....but these have been adjusted.

- **What are some of the undesirable characteristics of the models you use?**
  Hot layer increases in depth you can put in a detector...second room you can put in a vent but not a detector. CFD cannot do multi-level departments. Takes three days to get the results.

- **Do you find there is a lack of experimental data?**
  NO I don't. It is on the increase. There should be inputs for the data, but if not you can make assumptions. If not, decide whether you can burn the furniture.

- **What type of experimental data would be worth purchasing and for how much?**
  You might pay for it to get sufficient data to use a model

- **What limitations do you find with models?**
  Tell you how large of a compartment you need. Hot layer will be completely horizontal. Some movement of heat with in the hot layer. Dead spots will drop the smoke to a lower height. Area limitations. Low ceilings.

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**
  There are barriers. NSW fire engineer does an assessment that eventually goes through the local government. They examine and question it. They have been becoming very common to have inexperienced users that are being exposed. The user must be aware of the limitations and know what is a good result.

- **Should there be a validation service for each model?**
  N/A

- **Do you feel CSIRO should offer services for modelling?**
  Consultancy.

- **What types of services do you feel are necessary?**
  Every company wants to be commercial competitors and make more money. Fire engineering to improve the technology so that CSIRO has the best models.

- **How do you plan to use fire modelling in the future?**
  The same as we do now.

- **Do you have a reference if there are problems with a model? Someone you can ask questions.**
  We have access to he code design and the model designer. If we discover a problem we investigate it and fix it.

- **How do you think models should be marketed? ie. through the Internet, catalogue, or other ways.**
  When CSIRO develops it own range of models we will use them to give us an advantage in the fire safety field.

- **What do you think the future of computer fire modelling is?**
  An enormous future because the fire engineering field is growing at a large fast rate. The is an enormous future there but it needs to be coordinated so the fire model users can validate the use of models under certain situations.

Survey/Interview Questions

- **How long have you been in the fire safety field?**
  Since 1979 (20 years)

- **Which models do you prefer to use and why?**
  I use CFD and egress fire models

- **What training have you received?**
  I have my Ph.D. in Fire Training and my project was a research project. I am also a research
  group leader.

- **Is there any training or course you would have liked to participate in?**
  I would like to get my Graduate Diploma from a school that offers FPE.

- **How often do you use computer fire models and for what reasons?**
  As a leader of a research group I oversee the students use of the models.

- **What expectations does your company have in computer fire modeling?**
  I expect that models would model risk accurately and consistently. There are several models that do this. I expect models to compare: human behavior vs. fire model. Then be able to compare the level of accuracy in both.

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  I know of a lot of examples when fire models failed to work.

- **What are some of the undesirable characteristics of the models you use?**
  CFD – time consuming. Limitations, but those are expected and they are context dependent.

- **Do you find there is a lack of experimental data?**
  Yes, there is a lack of reference to real fires in real fire layouts. Also there is too much
  simplified data.

- **What limitations do you find with models?**
  I find that models are not toxic specific or have temperature predictions. There is also a great
  variety between real and calculated results.

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**
  The limitation should come with professional ethics. You would expect professionals to be professionals. Model producers should publish the models limitation in its documentation.

- **Should there be a validation service for each model?**
  A validation services cannot be done by one organization and should only be bureaucratic

- **Do you feel CSIRO should offer services for modelling?**
  Yes I feel that CSIRO should offer services but I don't know in what kind of market.

- **What types of services do you feel are necessary?**
  Services should include trying to get risk assessments and a spread of models that will help. Models should also be self-referencing.

- **What do you think the future of computer fire modelling is?**
  The future is a developing science that will see CFD in more use. Models will both give qualitative and quantitative results.

Survey/Interview Questions

- **How long have you been in the fire safety field?**
  15 years.

- **Which models do you prefer to use and why?**
  Hazard and Evacnet.

- **What training have you received?**
  Training course at VUT. In one course about Hazard he knew more than the lecturers.

- **Is there any training or course you would have liked to participate in?**
  A more advanced level course would be desirable.

- **How often do you use computer fire models and for what reasons?**
  Not often. One use was for the Victoria Racing Grandstand.

- **What expectations does your company have in computer fire modelling?**
  Expectations are that the models are reliable. One must have confidence in the model which is helped by validation.

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  Not aware of any.

- **What are some of the undesirable characteristics of the models you use?**
  Input into Evacnet is difficult. It is also difficult to use faults in Hazard and the newest version won't do some things.

- **Do you find there is a lack of experimental data?**
  Yes. A burn of one object is not valuable.

- **What type of experimental data would be worth purchasing and for how much?**
  No money to buy data. What is needed is more free burn data for example and open shopping center or a fire on a concert stage. These situations are difficult to model.

- **What limitations do you find with models?**
  It is difficult to stop in the middle of a simulation.

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**
  FIRECalc is a bad example. There is a one page output to solve many problems. It is just too simplified.

- **Should there be a validation service for each model?**

Yes.

- **Do you feel CSIRO should offer services for modelling?**
  That would be great.

- **What types of services do you feel are necessary?**
  There should be more access to test information. Most data done for a specific client so the data can not be made available.

- **How do you plan to use fire modelling in the future?**
  If there is a new program then he may change over.

- **Do you have a reference if there are problems with a model? Someone you can ask questions.**
  NIST

- **How do you think models should be marketed? ie. through the Internet, catalogue, or other ways.**
  N/A

- **What do you think the future of computer fire modelling is?**
  There will be more on sprinkler influences on modeling.

Survey/Interview Questions

- **How long have you been in the fire safety field?**
  6 yrs

- **Which models do you prefer to use and why?**
  Occupancy Evacnet, dynamic fire model , excellent modeling tool, FIRECalc. It's from CSIRO and its simplistic. CFAST and FASTLite because the physics and algorithms behind the program seem the most relevant, limitations compared to yardstick used by fire brigade and it produces a color graph.

- **What training have you received?**
  None, I am self taught.

- **Is there any training or course you would have liked to participate in?**
  VUT course building fire risk engineering, 2 day course in CFAST.

- **How often do you use computer fire models and for what reasons?**
  Weekly

- **What expectations does your company have in computer fire modelling?**
  My expectations are for a utopia, development user friendliness for the input of data, and capabilities of evacuation and streamline. It should be not to simplistic so any Tom Dick or Harry can get it and not understand the physics

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  Yes, but have to be aware of the limitations of the area being modeled.

- **What are some of the undesirable characteristics of the models you use?**
  N/A

- **Do you find there is a lack of experimental data?**
  N/A

- **What type of experimental data would be worth purchasing and for how much?**
  N/A

- **What limitations do you find with models?**
  N/A

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**
  N/A

- **Should there be a validation service for each model?**
  N/A

- **Do you feel CSIRO should offer services for modelling?**
  N/A

- **What types of services do you feel are necessary?**
  N/A

- **How do you plan to use fire modelling in the future?**
  N/A

- **Do you have a reference if there are problems with a model? Someone you can ask questions.**
  N/A

- **How do you think models should be marketed? ie. through the Internet, catalogue, or other ways.**
  N/A

- **What do you think the future of computer fire modelling is?**
  N/A

Survey/Interview Questions

- **How long have you been in the fire safety field?**
  I have been in the field for 23 years. Been in the fire investigation unit for 5 years.
  3 years

- **Which models do you prefer to use and why?**
  Just starting so they don't use any models at this time. They are forming a database of information exploring modeling and the impact in fire sciences along with performance based codes.

- **What training have you received?**
  None in fire modeling

- **Is there any training or course you would have liked to participate in?**
  Firewind training

- **How often do you use computer fire models and for what reasons?**
  It is increasing to daily encounters with the models.

- **What expectations does your company have in computer fire modelling?**
  That they will play a great role in the future of Fire engineering.

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  N/A

- **What are some of the undesirable characteristics of the models you use?**
  The limitations and assumptions.

- **Do you find there is a lack of experimental data?**
  N/A

- **What type of experimental data would be worth purchasing and for how much?**
  N/A

- **What limitations do you find with models?**
  N/A

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**
  Yes, one should have to show expertise in the field.

- **Should there be a validation service for each model?**
  N/A

- **Do you feel CSIRO should offer services for modelling?**
  N/A

- **What types of services do you feel are necessary?**
  N/A

- **How do you plan to use fire modelling in the future?**
  N/A

- **Do you have a reference if there are problems with a model? Someone you can ask questions.**
  Universities, They could sell them though a university, interaction in the fire safety science, University of New Castle

- **How do you think models should be marketed? ie. through the Internet, catalogue, or other ways.**
  The cost has to be realistic. Shareware

- **What do you think the future of computer fire modelling is?**
  3 D walk though models and fire fighting training.

Survey/Interview Questions

- **How long have you been in the fire safety field?**
  Been in the fire safety field for 14 years.

- **Which models do you prefer to use and why?**
  Design models, CFD sometimes, but CFD is a snapshot of what is happening. Used CFD for particular designs for example two trucks crashing in an arena. The two trucks producing a huge fire in a large controlled closed space. Besides that, zone models like FIRECalc is used as a quick guide more than anything. Hazard one is also used.

- **What training have you received?**
  Trained in Hazard one seven years ago. The new version FAST is simpler. Doesn't like training and for the most part Bruce (an associate) handles the training.

- **Is there any training or course you would have liked to participate in?**
  No

- **How often do you use computer fire models and for what reasons?**
  When ever they have a job, approximately every other week. They could have a string of five weeks in a row but then have a dry spell.

- **What expectations does your company have in computer fire modelling?**
  He believes the better way of stating the question would be the expectations in fire safety engineering. Their expectations is that it is something the company will have to become more proficient at as well as a marketing opportunity for them. Job opportunities for them

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  No, quite fortunate. They have had the opportunity to test the models against actual fire situations.

  Firecalc, using simple calculation area model worked quite well.

- **What are some of the undesirable characteristics of the models you use?**
  Rectangular shapes, For a simple building there is less of a need for the fire engineering. The unique shapes need the fire engineering. Sometimes you have to manipulate the model for example putting a line across the slant of a roof to make it the typical box it turns out it doesn't give bad results.

- **Do you find there is a lack of experimental data?**
  Yes, starting to get a little information though the cracks now. Starting to get little things like work stations, and cars. The fire authority says they want a five

megawatt fire from zero right to five. In a real situation the fire builds up to it but they want it right away. Were not going to give them a five-megawatt fire. Another example is in a carpark with sprinklers only one car can catch on fire then be contained they want seven cars. Why?

- **What type of experimental data would be worth purchasing and for how much?**
  Fire data, toxins, Heat release rate.

- **What limitations do you find with models?**
  In terms of the functional limitations firecalc is nice. CFAST is difficult, one mistake and you can throw away the results. It is very difficult to find where the mistake lies. EVAC is a real bugger if you make a mistake you must start from scratch. In terms of operational limitations validation must prove itself under real fire conditions.

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**
  The ethics of the user should be the barrier. The attitude that someone is proficient in model use but there is more than that.

- **Should there be a validation service for each model?**
  Yes, Our Company could download the models off the web but chooses not to because they consider it a "black box" They have to know what is behind the model. They also validate and test ever model by comparing for example the results of a CFD to FAST to Hazard one.

- **Do you feel CSIRO should offer services for modelling?**
  Yes, on the basis it stays a CSIRO. Research based. It would be difficult to get into fire engineering as a competitor How can you go to them for services. They have to be a body out at arms length from everyone. Who can use them to validate, peer review, needs to actually be a research area more than a commercial. SSL was assisting and are now competitors. They could split into two divisions research or Authority.

- **What types of services do you feel are necessary?**
  Research services are needed along with research library, facilities such as live fire tests. References to the calculations. CSIRO for example could with FIRECalc.

- **How do you plan to use fire modelling in the future?**
  To continue as we are.

- **Do you have a reference if there are problems with a model? Someone you can ask questions.**
  In house references, or colleagues.

- **How do you think models should be marketed? ie. through the Internet, catalogue, or other ways.**

They should be marketed by showing their validation, where the numbers are coming from.

- **What do you think the future of computer fire modelling is?**

  The future of fire modeling is limited, unless it is a specific rare case. Many times the buildings become very standard repeating so building regulations have acceptable solutions already in place. So unless it is, for example, a large arena that doesn't fit into the building regulation it doesn't need to be modeled and it will fit somewhere.

Survey/Interview Questions

- **How Long have you been in the fire safety field?**
  Fire modeling consulting for 5 years, worked for 30+years and is the most experienced of the three, 3 years

- **What models do you prefer to use and why?**
  They prefer to use models that have Availability, validation and a good computer interface They use FASTLite, CFAST, FIREWind, FIRECalc. They also produce their own models.

- **What training have you received?**
  Limited training a short course, mostly in house training by Peter.

- **How often do you use computer fire models and for what reasons?**
  Weekly if not daily use of the models for consulting purposes

- **What expectations does your company have in computer fire modelling?**
  They expect clear documentation, accuracy, easy use, fast, validation, quicker

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  FASTLite in low-pressure situations, position of sprinkler head to close to the ceiling that goes back to the proper documentation of the models physics and the equations used.

- **What are some of the undesirable characteristics of the models you use**?
  Heat release rates, details in the experimental data given, limitations, user friendly, decay of the cooling rate of sprinkler, lots of assumptions, FASTLite gives options but not the details of the options of experimental data.

- **Do you find there is a lack of experimental data?**
  Yes, generally there is information but it is either not provided or not easy to find. Also the experimental data does not give details as to what is the percentage of materials.

- **What type of experimental data would be worth purchasing and for how much?**
  More detailed experimental data with percentages of such things as timber, stuffing, and the other materials the test object is made of. Along with the dimensions of the object used for experimental data.

- **What limitations do you find with models?**
  N/A

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**

What barriers? How? Regulation though supervision. The user has the responsibility to follow a code of ethics or standard. You couldn't flag because experienced and unexperienced use it to learn and add extreme cases. Flagging is good though.

- **Should there be a validation service for each model?**
  Yes, validation services for models. Who could do it?

- **Do you feel CSIRO should offer services for modelling?**
  Why not?

- **What types of services do you feel are necessary?**
  For models, validation is needed with support and access to the proper literature.

- **How do you plan to use fire modelling in the future?**
  They are the future. Will be using the models with performance-based codes and more powerful computers.

- **Do you have a reference if there are problems with a model? Someone you can ask questions.**
  No references

- **How do you think models should be marketed? ie. through the Internet, catalogue, or other ways.**
  As a tool as part of fire engineering and though literature.

- **What do you think the future of computer fire modelling is?**
  Evacuation modelling, there is no good ones.

Survey/Interview Questions

- **How long have you been in the fire safety field?**
  I been in the fire safety field for 25 years.

- **Which models do you prefer to use and why?**
  Firelot, Detech…I am just playing around with it. It comes down to designing you own system and fire models will help do this.

- **What training have you received?**
  None

- **Is there any training or course you would have liked to participate in?**
  I don't know of any that are available. If there was I would.

- **How often do you use computer fire models and for what reasons?**
  From what I have seen you have to add areas and measurements. I don't want to know about the temperature. I want to be able to designate how the room is going to be used. (residential, commercial, storage)

- **What expectations does your company have in computer fire modelling?**
  N/A

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  N/A

- **What are some of the undesirable characteristics of the models you use?**
  Right now it seems that having to specify the temperatures during a fire is an undesirable characteristic. How hot does a computer burn?

- **How could these be improved?**
  N/A

- **Do you find there is a lack of experimental data?**
  Yes, I think that there is a lack of the data of materials during a fire

- **What type of experimental data would be worth purchasing and for how much?**
  N/A

- **What limitations do you find with models?**
  Just the temperature limitations

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**
  I would expect that the models have been put together and model experimental data shadows the results of the model test.

- **Should there be a validation service for each model?**
  N/A

- **Do you feel CSIRO should offer services for modelling?**
  I suppose so. CSIRO is a body that the fire safety field trusts.

- **What types of services do you feel are necessary?**
  No. I guess that the governing body should do that.

- **How do you plan to use fire modelling in the future?**
  N/A

- **Do you have a reference if there are problems with a model? Someone you can ask questions.**
  No, I use the manuals. The models are not being used much now but I may use them to model smoke transfer and heat transfer.

- **How do you think models should be marketed? ie. through the Internet, catalogue, or other ways**.
  Models should be marketed through the NFPA, NIST, and FPAA. It should be marketed through them.

- **What do you think the future of computer fire modelling is?**
  If it can be used in a comfortable degree it will eventually be used in the BCA.

Survey/Interview Questions

- **How long have you been in the fire safety field?**
  I have been in the fire safety field for three years.

- **Which models do you prefer to use and why?**
  There are two categories of fire models that we use: Evacuation models and Fire Models. The evacuation models we use are Wayout, Evacnet, and Exodus. We use these interchangeably. Each has their own capabilities and their use depends on the situation. For the most part Exodus has more features than needed and is only used for big jobs when the client wants more for their money. For evacuation models a broad range of evacuation time are used. This usually gives a distribution of time throughout the range of people occupying a building (young, old, handicapped, etc.) Exodus does this automatically and gives a normal distribution curve along with its outputs.

  Along with basic principles and an Excel spreadsheet, our company uses other models. FIRECalc, Hazard, and Fast are the main models in use.

- **What training have you received?**
  I have received no training specifically for fire safety. I have received all of my training at VUT and on the job. Presently, there are a few people in my division who are interested in taking fire courses at VUT.

- **Is there any training or course you would have liked to participate in?**
  I would like to participate in a Fire Engineering course or course of study in the United States. Unfortunately right now that is not possible.

- **How often do you use computer fire models and for what reasons?**
  I use fire models hourly. We use them to comply with performance based solutions for fire engineering purposes.

- **What expectations does your company have in computer fire modelling?**
  I expect to have confidence in the accuracy of a model. The results should be comparable to results with other models. We use FIRECalc as a benchmark for modeling.

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  From a contracting standpoint there has not been a time when the models did not perform correctly. If there is a problem within the calculations, the building design is given back to the designers to fix the problem. But every model has its limitations and when those limitations are reached a different and more accurate model is used.

- **What are some of the undesirable characteristics of the models you use?**

Evacnet: You can only define one homogenous person in the program
Hazard: Tricky for ventilation but more reliable
FIRECalc: The limits on the variables used are not stated in reference material. When do you know that you have exceeded a limitation. Also, a one room hot layer is used and there is not a limit explicitly stated on room size

- **Do you find there is a lack of experimental data?**
  Yes, Fire data that needs to be input has to be collected or made available. A library of real fire scenarios is also needed to justify slow/medium/fast fires. Then compare the models with data.

- **What type of experimental data would be worth purchasing and for how much?**
  Most of this information should be made free but some cost would be understandable. Just not a lot.

- **What limitations do you find with models?**
  Software references are hard to find. You have to search locally to find documentation

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**
  You will never be able to set up barriers. "Garbage in…Garbage out!"

- **Should there be a validation service for each model?**
  The validation service is the responsibility of the software writer. It could be put to approval authorities.

- **Do you feel CSIRO should offer services for modelling?**
  We have had sessions with CSIRO to discuss their role in servicing the fire protection field. They should along with SSL or a manufacturer.

- **What types of services do you feel are necessary?**
  The types of services that are necessary are getting real data and how to model different objects.

- **How do you plan to use fire modelling in the future?**
  I would like it if a model was produced that could model what happens when a sprinkler system is activated in a room. Fire modeling will become much more advanced. The Fire Design business will go elsewhere and fire models will be used everyday. They will become mainstreamed in their use.

- **Do you have a reference if there are problems with a model? Someone you can ask questions.**
  Our references consist of the Commission, Surveyors, Professors, and World Experts.

- **How do you think models should be marketed? ie. through the Internet, catalogue, or other ways.**
  They should be marketed at conferences, on the web, and given out as a shareware so users can see its limitations. It all has to do with money verses time. Market them as user friendly.

- **What do you think the future of computer fire modelling is?**
  The future of computer fire models will be with programs like Exodus and Phoenix. As skills and computational time goes up, more complex models will be designed and used. It will be a progression of fire modeling.

Survey/Interview Questions

- **How long have you been in the fire safety field?**
  4 years

- **Which models do you prefer to use and why?**
  FIREWind the updated version of FIRECalc that is windows based. Other than that we use CFD models.

- **What training have you received?**
  FIREWind users manual and contact is kept with the writer of the program by forwarding stuff that is done.

- **Is there any training or course you would have liked to participate in?**
  No

- **How often do you use computer fire models and for what reasons?**
  Daily with the fire engineering work. Work with egress to smoke modeling, mainly egress.

- **What expectations does your company have in computer fire modelling?**
  Still new to the profession so doesn't expect much. He understands it is still a developing field. Largest concern is the outcome of the results.

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  Under cross wind conditions the design model couldn't handle it so a CFD had to be used.

- **What are some of the undesirable characteristics of the models you use?**
  The limitations of the areas in zone models

- **How could these be improved?**
  Through further research.

- **Do you find there is a lack of experimental data?**
  Yes, there is a lack of experimental data. In Australia not a lot of data on fires that happened and why they happened.

- **What type of experimental data would be worth purchasing and for how much?**
  100 Years of Fire, just fire there is no data on smoke.

- **What limitations do you find with models?**
  There are limitations with the areas, crosswinds, and large open spaces.

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**

Yes, if you don't have the training

- **Should there be a validation service for each model?**
  Yes, but to what extent. The Standards Australia Company should do validation of building codes.

- **Do you feel CSIRO should offer services for modelling?**
  They are not competitive enough in Australia seem to be out of touch with industry offered before but...

- **What types of services do you feel are necessary?**
  CFD research in modeling. There should be deeper research in general.

- **How do you plan to use fire modelling in the future?**
  Wants more use in CFD

- **Do you have a reference if there are problems with a model? Someone you can ask questions.**
  N/A

- **How do you think models should be marketed? ie. through the Internet, catalogue, or other ways.**
  Word of mouth and over the Internet.

- **What do you think the future of computer fire modelling is?**
  Extensive and there is a lot of room to grow. Zone models will catch CFD.

Survey/Interview Questions

- **How long have you been in the fire safety field?**
  I have been in the fire safety field between 15-20 years.

- **Which models do you prefer to use and why?**
  The model that I use the most is CFAST. I use it because it has an understanding of the process during fire development. I also do experimental work instead

- **What training have you received?**
  I am a Civil Engineer and have my Ph.D. in Structural Engineering. In the fire field I have most of my training through research. On models I use Books and training courses and manuals. I also advise students in formal courses.

- **Is there any training or course you would have liked to participate in?**
  Not really.

- **How often do you use computer fire models and for what reasons?**
  I use fire models constantly for big projects. Really for anything that I do

- **What expectations does your company have in computer fire modelling?**
  I have low expectations for fire models. Models do not give good enough material. They are too easy to manipulate. I expect that with well established inputs, it will be the driving force of the outputs.

- **What are some of the undesirable characteristics of the models you use?**
  Some of the undesirable characteristics are that all models are based on cubic enclosures that are reasonably small. Also the fires are modeled with small fire loads and only run to flashover.

- **How could these be improved?**
  Better codification, real building situations, and some non-residential situations could improve these undesirable characteristics.

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  For many situations our models do not perform correctly.

- **Do you find there is a lack of experimental data?**
  Yes, there is always some but it is difficult to understand the use of it.

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**
  There should be cautions and warnings in the codification of the model. Also make sure that only qualified and experienced users use the model.

- **Should there be a validation service for each model?**

No, one company should not be the validation service. The model should be highly validated before it is marketed.

- **Do you feel CSIRO should offer services for modelling?**
  There is no need for CSIRO to offer services in fire modeling.

- **What types of services do you feel are necessary?**
  There should be data on validation vs. experimental data. Also documentation on good and bad conditions with in the model. The number and size of enclosures would also be useful.

- **How do you plan to use fire modelling in the future?**
  The more advanced models will be in use more. Always compare model data vs. experimental data.

- **How do you think models should be marketed? ie. through the Internet, catalogue, or other ways.**
  They should be marketed as reliable and with backup documentation. Also show the new alternatives.

- **What do you think the future of computer fire modelling is?**
  The future of computer modeling will be bigger and better than NIST. There will be a big large development process with large commercialization. Flagging of models might also be an option.

Survey/Interview Questions

- **How long have you been in the fire safety field?**
  9 years. Basically design documentation.

- **Which models do you prefer to use and why?**
  Zone models. Mainly I use CFAST, FASTLite, FIREClac. I do a lot of plume modeling. Single compartment fires. We don't use CFD models in Melbourne but do a little of that modeling in Sydney.

- **What training have you received?**
  Finished post-graduate in fire safety and risk assessment. Attended Victoria University of Technology for undergraduate degree. Building design.

- **Is there any training or course you would have liked to participate in?**
  I wouldn't mind doing a master program. Can't afford it commercially right now in a relevant field of study.

- **How often do you use computer fire models and for what reasons?**
  Company name…we use them administratively. Smoke spread modeling, enclosures, use them for egress some times. Deterministic analysis.

- **What expectations does your company have in computer fire modelling?**
  Heavy emphasis on models and on computer technology overall. Further develop the tools that we have at the moment. They should be more user friendly in terms of their outputs and in its generation of graphs (CFAST) Smoke, temp, and other things. Tie computers into a database. Easier to streamline these data. Also use Evacnet. Twig analysis also for egress.

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  There are certain projects where you should question the results to see how realistic they are.
  We do that for our projects. We do assess each model and if we are not happy with the results than we reassess them until we are satisfied. Also the method of input and trying to interpret the outputs are a major draw back.

- **What are some of the undesirable characteristics of the models you use?**
  See previous two questions

- **Do you find there is a lack of experimental data?**
  Absolutely…I think we need look at fully developed fires. For instance residential, car (with newer cars that have more synthetics) and commercial. Atrium data is also useful, for example, shopping centers. Need heat release rates across the board.

- **What type of experimental data would be worth purchasing and for how much?**
  N/A

- **What limitations do you find with models?**
  The method of input and trying to interpret the outputs are a major draw back.

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**
  N/A

- **Should there be a validation service for each model?**
  Absolutely, Every model has its application and users should be more forward in what they should be used for. Users should know the limitations.

- **Do you feel CSIRO should offer services for modelling?**
  Yes, if CSIRO would take this on. Other research laboratory as well. Models only validated for residential fires should get some kind of correlation between residential fires and other fires (large compartments, malls, atriums)

- **What types of services do you feel are necessary?**
  There needs to be a database of information. Evacuation times should be included. There is a deficiency within the industry for this type of data. Evacuation drills to find out average results (Fire Alarms). Then compare this to evacuation models.

- **How do you plan to use fire modelling in the future?**
  Fire modeling is a huge part of our future plans and we want to use it for risk assessment. Develop models further then be able to use them across the board.

- **Do you have a reference if there are problems with a model? Someone you can ask questions.**
  Manual or industry contacts. It would be good if there was a help desk.

- **How do you think models should be marketed? ie. through the Internet, catalogue, or other ways.**
  Advertised through the main fire safety committees. This is their main source of information. Also advertise through the universities. The designer or the marketer could do door-to-door sales. Show capabilities and limitations.

- **What do you think the future of computer fire modelling is?**
  The future of computer fire modeling is very bright. In particular since Australia has moved to performance based fire designs. Fire modeling is a tool for the fire risk management approach. Particularly in Melbourne.

Survey/Interview Questions

- **How long have you been in the fire safety field?**
  I have been in the fire safety field for a year or two. Most of my experience comes from my graduate research that lasted for 18 months.

- **Which models do you prefer to use and why?**
  Hazard 1 and CFAST. I use them to get the smoke production rate.

- **What training have you received?**
  I have had no specific training, but I did research for my graduate department. I also work with colleagues who help me out. Also consulting manuals have helped me out.

- **Is there any training or course you would have liked to participate in?**
  I would like to have training with the Hazard and CFAST packages. Our company also has Exodus, but we need training. Also it would be helpful to have training in the limitations of a model. We use Evacnet for egress but we no training in that as well.

- **How often do you use computer fire models and for what reasons?**
  We use models in investigation as a basis to support recommendations made for an upgradeable building. We used it once for a project, but it had been used previously in the progress of the report.

- **What expectations does your company have in computer fire modeling?**
  "End all, be all" are some of the opinions. I personally use it for detection.

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  It might have been the function of the computer or with the input of data. Hazard ran for a long period of time. Wasn't sure if the computer had crashed or if it was just slow. My new computer has a faster processor so I have not run into the same problem again.

- **Do you find there is a lack of experimental data?**
  There is a lack of heat release rates. I can get a lot from the NIST web page. Also, CSIRO along with the DHS has done different tests.

- **What type of experimental data would be worth purchasing and for how much?**
  Mainly getting the heat release rates.

- **What limitations do you find with models?**
  Knowing if the information that was used was applicable to the situation.

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**

Yes, that was a concern with myself in modeling. I personally tried to make sure that I had done enough research and had enough modeling experience to do it correctly. I have played around with the effects of doors open/closed, arc ways, flat ceiling, and anything else to help with my knowledge.

- **Should there be a validation service for each model?**
  Reports about validation of a model or situation. Give more information.

- **Do you feel CSIRO should offer services for modelling?**
  If it needed to be done CSIRO should go ahead. But I think that they should not do consulting unless they have to. The CFA is trying to do these services for themselves.

- **What types of services do you feel are necessary?**
  Not consultancy services but a net work of people to bounce questions off of. Evacuation stuff like what is the industry standard is needed.

- **How do you plan to use fire modelling in the future?**
  For first incidences I will try and model what happened and to see what type of fire systems could have prevented the fire or the loss of life.

- **Do you have a reference if there are problems with a model? Someone you can ask questions.**
  I have a few industry contacts. I also have friends I know through the SFPE. There is some support for Exodus who does training with the model.

- **How do you think models should be marketed? ie. through the Internet, catalogue, or other ways.**

  To the consumer? I would want them to know about the assumption and the limitations. Also, the capabilities and area and spaces that can be used are useful. What is the easiest way to reach the consumer? Practitioners Board or the registration board.

- **What do you think the future of computer fire modelling is?**
  The future…Developed. There will be a large potential for progression with the use of the models. Models will also be validated to a specific need.

Survey/Interview Questions

- **How long have you been in the fire safety field?**
  9 years

- **Which models do you prefer to use and why?**
  With performance based codes role has grown looking at the flexibility. A wide rage of models is used and what ever model the consumer used. The company has the program to check the developer. Or they would use a different model to check the developers model. FIRECalc FIREWind, Evacnet, Hazard, Phoenix.

- **What training have you received?**
  Training in booting, surveying. Post graduate at Victoria University of Technology. Two years in fire with numerous seminars and conferences.

- **Is there any training or course you would have liked to participate in?**
  Looking into further short courses or seminars

- **How often do you use computer fire models and for what reasons?**
  Used weekly for checking purposes.

- **What expectations does your company have in computer fire modelling?**
  Knowledge to use the models and why they use the models.

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  Had queries into criteria and input data, questioned the user more than the model.

- **What are some of the undesirable characteristics of the models you use?**
  Limitations which vary in it as long as you are aware of the limitations. User friendly, Time it takes to check.

- **Do you find there is a lack of experimental data?**
  N/A

- **What type of experimental data would be worth purchasing and for how much?**
  N/A

- **What limitations do you find with models?**
  Limitations depend on the model. large scale buildings, often large factory, warehouse. Human behavior. Phoenix has to many variables. Evacnet is to limiting

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**

Yes, How could you limit? Government come in. Very stringent as to whom is a practitioner, building surveyor. In order to approve a building design you have to go though a post-graduate education.

- **Should there be a validation service for each model?**
  Depends on the system. They in sense are a validation service. Peer review.

- **Do you feel CSIRO should offer services for modelling?**
  Yes

- **What types of services do you feel are necessary?**
  Verification of building design to building code. Fire engineering reports. How fire team should be set up. Fire engineering outline briefs.

- **How do you plan to use fire modelling in the future?**
  Checking tool, and possibly to design if the opportunity presents itself.

- **Do you have a reference if there are problems with a model? Someone you can ask questions.**
  No, not really. They point out the problem, they don't fix it.

- **How do you think models should be marketed? ie. through the Internet, catalogue, or other ways.**
  FPAA, CSIRO is in a good position for marketing. They could be more pro-active than they are.

- **What do you think the future of computer fire modelling is?**
  Good future, there are some good models around. Human behavior. Quite reasonable fire models up to date.

Survey/Interview Questions

- **How long have you been in the fire safety field?**
  C- Lincoln Scott Mechanical and Electrical Engineering 2.5 years. Been in FPE and the Fire Brigade for 2 years. Learned fire modelling on the job.
  J- In the Fire Brigade for 6 months

- **Which models do you prefer to use and why?**
  FIRECalc, FIREWind, FAST, CFast, Phoenix. Use is 2-3 times per week. They use Evacnet for evacuation modelling.

- **What training have you received?**
  Training has been received on the job.

- **Is there any training or course you would have liked to participate in?**
  There is only one college that offers courses in FPE.

- **How often do you use computer fire models and for what reasons?**
  About 2-3 times per week. For consulting purposes.

- **What expectations does your company have in computer fire modelling?**
  They use fire models for fire investigation and to help other brigades. If there is a fatality or suspicious fire then they will use modeling to determine how a fire started and compare that result with the assessment done by the investigators.

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  They are incorrect all the time. One should know what the outcome is. The models are used to prove theory. One instance when the model fails is when there is a high fire load in a small compartment. The temperatures in the model reach 7000 degrees which is wrong.

- **What are some of the undesirable characteristics of the models you use?**
  Models are limited to their input. There is also no guidance on the inputs and since there is a lack of data then the models are not completely fed with the right information. Some models don't allow for any sudden changes because of the large size of some of the timelines. The details can not be input into any fine degree that brings a simplicity to the model.

- **How could these be improved?**
  These could be improved with validation. They wish NIST would provide a validation with their models.

- **Do you find there is a lack of experimental data?**
  The data is hard to find. There are vast differences in laboratory data and this may be due to the infancy of the industry. Most companies don't want to share

information so they are left to build their own database with data that they find in journals and on the internet.

- **What type of experimental data would be worth purchasing and for how much?**
  The fire brigade doesn't charge for work. They do modeling as a favor to building surveyors so they do not receive any profit so it would be difficult to buy data. However, if there was a database in a good format and at a reasonable price then they could probably convince the Fire Brigade to buy the database. Data of interest would be specific heat release data on composite materials and for desk and chairs individually.

- **What limitations do you find with models?**
  Modeling is time consuming especially when the output doesn't make sense. The input must then be tweaked. Some are user unfriendly, time consuming, costly, and require too much computer power. Some runs of a model take days which ties up the computer for other work. Zone models are limited to variations of the base model of a square room. If there is a long corridor to model then they break up the corridor into smaller boxes which doesn't show that the gases flow down the corridor. Instead on room fills up and then spills over into the other rooms.

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**
  Yes. They don't know how it would be done. But it is unsafe to model when someone does not know the dynamics of fire. The results are then taken as gospel, which is incorrect.

- **Should there be a validation service for each model?**
  N/A

- **Do you feel CSIRO should offer services for modelling?**
  Training yes. There is an understanding that a fee would be involved but industry should start paying for it if fire modeling is to progress.

- **What types of services do you feel are necessary?**
  There are so many methods for calculating. Each organization should publish a paper on the validation of their model.

- **How do you plan to use fire modelling in the future?**
  N/A

- **Do you have a reference if there are problems with a model? Someone you can ask questions.**
  We use material that comes with the model. We also look in journals or papers to compare full scale testing with results of certain models with consultants that use the models frequently. There is a lot of information on the Internet. E-mail is effective but it takes a long time to get a response and oftentimes the response does not answer the question. One example is Taset from Sweden that was not

user friendly. The problem was that the manual was translated from Swedish to English so it was difficult to understand. Therefore the Fire Brigade did not use the model solely based on the fact that there was not enough support. It is good to have CSIRO close for tech support.

- **How do you think models should be marketed? ie. through the Internet, catalogue, or other ways.**
  They should be marketed though presentation or demonstrations. It introduces the model and shows the main features. Human contact is always better than a brochure that just passes by on the desk with barely a look. Flyers don't usually work.

- **What do you think the future of computer fire modelling is?**
  The future is CFD. But, it is to expensive right now because of the hardware. More experimental data will become available where the models produce 0.0001% error. Full scale testing will be non existent. Models will be designed for specific occupancies that will accommodate upgrading. For example a model specifically for an office with a chair and desk with different vent conditions and linings.

Interview/Survey

- **How long have you been in the fire safety field?**
  4 years. Since I got out of school. Just a local high school.

- **Which models do you prefer to use and why?**
  FIREWind, it is simple to use and it is good with the limitations that we have. Other than that we use CFDs.

- **What training have you received?**
  The manual that came with FIREWind and working directly with the writer of the program.

- **Is there any training or course you would have liked to participate in?**
  Not really.

- **How often do you use computer fire models and for what reasons?**
  When I do any fire engineering work. Mainly for fire engineering work. Egress paths mainly.

- **What expectations does your company have in computer fire modelling?**
  They seem to be pretty new so I don't have many expectations.

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  Yes. One instance when we had cross winds in a building. We had to use a CFD so we sent it to another company.

- **What are some of the undesirable characteristics of the models you use?**
  Only the limitation on the areas of zone modeling.

- **How could these be improved?**
  Probably through further research. But that is in the future.

- **Do you find there is a lack of experimental data?**
  Definitely. There is only some that is provided by companies like FM.

- **What type of experimental data would be worth purchasing and for how much?**
  There is a book 100 years of fire and that has most of the information that we need. It just has fire statistics.

- **What limitations do you find with models?**
  Area limitations. Zone models don't work with cross winds and large empty spaces.

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**

Definitely. If people don't have the experience than they should pass the job on to someone who does have the proper experience.

- **Should there be a validation service for each model?**
  Yes there should, but who is going to do it. In Aust a standards corporation should do the validation. Or the BCA. It is the same as the NFPA.

- **Do you feel CSIRO should offer services for modelling?**
  They have in the past. I am not sure what they offer anymore. I don't think that they are competitors anymore.

- **What types of services do you feel are necessary?**
  CFD research and modeling.

- **How do you plan to use fire modelling in the future?**
  Hopefully as I become more experience I will move on to using a CFD package.

- **Do you have a reference if there are problems with a model? Someone you can ask questions.**
  Victor Schestopal...writer of the program.

- **How do you think models should be marketed? ie. through the Internet, catalogue, or other ways.**
  Because the industry is so small it would be easy to do it by word of mouth.

- **What do you think the future of computer fire modelling is?**
  It has a lot further to go. Either Zone modelling will catch up or CFDs will become the only models used.

Survey/Interview Questions

- **How long have you been in the fire safety field?**
  2 yrs Consultant, Four years Doctorate at Victoria University of Technology

- **Which models do you prefer to use and why?**
  CFAST for it fire spread capabilities and broad range of capabilities. It has a lot of validation and large number of design options. FIRECalc is used for small projects and has significant faults. Tasif for it heat release rates.

- **What training have you received?**
  No

- **Is there any training or course you would have liked to participate in?**
  Possibly CFD

- **How often do you use computer fire models and for what reasons?**
  All the time

- **What expectations does your company have in computer fire modelling?**
  Robust, solution efficient, validation for a wide range. Clearly stated where it can't be used by stating the assumptions the model makes. Full technical description, No black box's.

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  None

- **What are some of the undesirable characteristics of the models you use?**
  Instability in solution, FIRECalc has errors in model evacuation and numerical problems. User interface CFAST. One has to use their output form.

- **How could these be improved?**
  Need better coding, more testing, trial versions

- **Do you find there is a lack of experimental data?**
  Yes

- **What type of experimental data would be worth purchasing and for how much?**
  Simple well controlled experiments where the boundaries were well defined. The problem with burns is the changing variables. You have to do it in a controlled experimental situation.

- **What limitations do you find with models?**
  N/A

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**
  How would you create a barrier?

- **Should there be a validation service for each model?**
  Yes, models should be checked for stability…etc.

- **Do you feel CSIRO should offer services for modelling?**
  They can, it could be useful if they could model one aspect of the fire at a time. Research work or commercial work?

- **What types of services do you feel are necessary?**
  More validation, models for human behavior evacuation models

- **How do you plan to use fire modelling in the future?**
  N/A

- **Do you have a reference if there are problems with a model? Someone you can ask questions.**
  In house

- **How do you think models should be marketed? ie. Through the Internet, catalogue, or other ways.**
  Shareware to try and test. Then it could be "bastardized" so it cannot be used. A warning shows up if it is not registered copy. FPAA could distribute.

- **What do you think the future of computer fire modelling is?**
  Modeling will get better. Zone models will disappear and CFD will take over. Gross assumptions disappear, front end better input data will become more complex. The models will be able to generate specific door window sizes. UCLA is working on combining CFAST and architectural package.

Interviews/Survey

- **How long have you been in the fire safety field?**
  30 years.

- **Which models do you prefer to use and why?**
  CFD models (Phoenix) because has a better representation of the true phenomenon. Makes less assumptions of the hot layer, ceiling jets, smoke flow. Make sure it is properly represented.

- **What training have you received?**
  I have not received any training. The people that use them have university background with use of CFD

- **Is there any training or course you would have liked to participate in?**
  Yes we would be interested with training courses of advanced use of CFD. We had one professor who was going to but he was unable to come to Australia.

- **How often do you use computer fire models and for what reasons?**
  Everyday.

- **What expectations does your company have in computer fire modelling?**
  We need to have confidence in the results. This is reached by having reports, validation, and work that has been done. Research data and reports on the comparison between research and the results. 2: what the model does and what goes into them (no black boxes)

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  Zone models have a number of incidences where the phenomenon cannot be shown. Flow in the hot layer.

  CFD: getting the appropriate thermal conditions. Entrainment. We are working to get a model of the plume and then use the plume model in the CFD.
  You don't need to plug in material properties but you can. You can do heat loss, or non. The program can do what you say.

- **What are some of the undesirable characteristics of the models you use?**
  The conversions issues are a problem. As long a proper conversions are done correctly.

- **How could these be improved?**
  Improved by putting in intelligent algorithms.

- **Do you find there is a lack of experimental data?**

There is an adequate amount. There is a lack of a systematic arrangement of the data

- **What type of experimental data would be worth purchasing and for how much?**
  I think that as various needs arise we would be in the position to buy some of the material. We are interested in validation of models with real fires. The value of the code has improved.

- **What limitations do you find with models?**
  Amount of physics represented in a model
  Assumptions are made in a general case but may not be appropriate in others. Flat ceilings versus pitched ceilings. CFD adds a level of complexity.

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**
  I think that it is a regulatory issue. The barrier should be within the individual (professional level). "If I give you a hammer you don't become a carpenter" Do we regulate the hammer? No. But we can regulate who does the carpentry.

- **Should there be a validation service for each model?**
  I think that each model should be supported by validated data. Also warnings where the model tells when a problem has occurred in an event. It is the users responsibility.

- **Do you feel CSIRO should offer services for modelling?**
  I think that CSIRO should develop new models. They should not commercially offer services. They should support and develop new models.

- **What types of services do you feel are necessary?**
  N/A

- **How do you plan to use fire modelling in the future?**
  An integral part of our work. We are looking for the development of more sophisticated models. Models developed that integrate flame spread. Direction of sprinkler spray in the CFD code. Alternatives for Performance Based Codes? CSIRO should support performance based codes.

- **Do you have a reference if there are problems with a model? Someone you can ask questions.**
  The Peer Review. And also people overseas who have written the program (Phoenix).

- **How do you think models should be marketed? ie. through the Internet, catalogue, or other ways.**
  I think they need to be marketed that reflects the value of the program (in the design and also how it is useful to the market) Performance based approach as

well. There is a limit as too how much you could charge. It has to do with the values versus the cost.

- **What do you think the future of computer fire modelling is?**
  I think that it is the future.

Survey/Interview Questions

- **How long have you been in the fire safety field?**
  Fire Safety Field for 30 years. Consulting for 15 years. Fire safety engineer for 12 years.

- **Which models do you prefer to use and why?**
  Fast and Phoenix
  Why: Fast does really large buildings and fast allows you to do a lot of rooms at once. It is also more towards the expectations. Also for the amount

- **What training have you received?**
  Done a weeklong course on Phoenix. A person is coming from New Zealand and will be teaching a course. She (a new employee) will be getting trained in FAST. CFAST and Phoenix

- **Is there any training or course you would have liked to participate in?**
  Has done most of the coursework that he desires. Did a course in FIRECalc. CSIRO dropped the ball and sold the rights to it. The successor made a derivative with FIREWind there was no validation. Just won't use it. With CFAST and Fast inputs can be controlled. In other models like FIRECalc it is a black box where you cannot check or reference what you put in with the right equations.
  FASTLite: FPETool: Don't have much use with these

- **How often do you use computer fire models and for what reasons?**
  Use them daily because it does all of the engineering work for fire effects, smoke, heat, and things like that.

- **What expectations does your company have in computer fire modelling?**
  The use of fire models gives you a better indication of what a model is going to be subjected to. Then it will give the subjective requirements of a room from a consulting point of view. Get certain data and make sure that the room is safe. It doesn't include materials of the room (surface areas). With fire modeling you can look at the development of the fire.
  Give a clear balance and appropriate fire resistance of a building.

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**

  When the people did not know how to use them. FIRECalc: everyone had it. People did not understand what the model was supposed to be and did not use it correctly because of a limited background in fire as well as poor documentation. Documentation: Phoenix does not cover the practical end of it. Written by mathematicians. Can't understand it creating "Garbage in Garbage out"

- **What are some of the undesirable characteristics of the models you use?**

Phoenix: Long computing time could take a month and a half to look at a developing fire. Then with virtual reality in the software, it will give only point conditions. We want to see a broader spectrum. FAST and CFAST are easy to use. They do have a problem with ventilation. They can't start fans later than the beginning of a fire. Lag time is needed between the start of the fire and the start of the fan. One should be able to manipulate time shifts.

- **Do you find there is a lack of experimental data?**
  Less and less as time goes on. Fire Code Reform Center and other organizations are starting to get this information to come through.

- **What type of experimental data would be worth purchasing and for how much?**
  Of course no one wants to pay anything. But what you pay for has to deal with the relevance of what you are doing. FPE is still in the infant age. The field is starting to get accepted because of the change to performance based codes. Don't know...but guess it has to do with the type of work that this project is doing. The variety of data around might not be reasonable until that data is needed. Then you look for specific data once you know what you need. Then if you don't have it, you use other info. For a job that is $4000 you aren't going to pay $5000

- **What limitations do you find with models?**
  Fast: Prints out in excel and then you have to decipher it. CFAST gives these horrible plots that you have to work through. The outputs from models should be easier to interpret.

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**
  Yes, because of the way that FIRECalc was marketed anyone could be a consultant. The documentation was used and everyone was an FPE. It goes back to buying the data. Everyone is trying to consult, research, and do everything else. CSIRO should not be involved in both consulting and research. This information gotten from research should be made available and not used for personal use. Also have to be honest with the inputs as opposed to fucking with the inputs to get the outputs you want. You should also have an expectation of what the results should be. Then if the results are wrong go back and figure out why. This is why people need the proper training. Peer Review is another way to make sure that the models are used correctly. Barriers are good either from an education point or a business point

- **Should there be a validation service for each model?**
  This is what you call a Peer Review. There are two points, should be done by an associate engineer and the program authors should also make sure that the correct limitations are know with their models. FIREWind is a one-man band and any results can be out in and then the model is validated. There is definitely a need for proper validation.

- **Do you feel CSIRO should offer services for modeling?**

CSIRO should do what they are supposed to do. Doing background research and giving us the data and the information: Scientific Investigations and pass this data on. Leave the consulting to the consultants. There is obviously information that they have that they use in house that isn't available to us. Also they do not necessarily have the proper background in fire consulting. They have not been involved with it long enough.

- **What types of services do you feel are necessary?**
  By anyone? The production of data is necessary. The data of test fires. The performance of materials that are not directly in contact with the fire (Radiation). This is only the bread and butter of the stuff that is needed, but someone needs to do it

- **How do you plan to use fire modelling in the future?**
  Pretty much the same ways that I am using it know for the assessment of fires in a compartment. All of these buildings have structural engineering that can withstand a complete burn out but can still stand. In buildings, fire sprinklers only have to be above 25 meters. So sprinklers aren't needed below that but other fire protection needs have to be used.

- **Do you have a reference if there are problems with a model? Someone you can ask questions.**
  Email NIST directly for FAST, CFAST, and FASTLite. For Phoenix I have a local contact.

- **How do you think models should be marketed? ie. through the Internet, catalogue, or other ways.**

  Models should be marketed by a specialist market. There is not enough emphasis on the amount of validation that has been used. Validity of the model for the features it is used for. Some people just buy it and use it. The limitations should be documented. Marketed to the industry as opposed to the way that other models were offered to everyone. Also market with the training that comes with the model.

- **What do you think the future of computer fire modelling is?**
  It is the future. There are going to be buildings that are going to be built on a prescriptive basis and fire engineers are going to be asked to do the work for them. Fire models will be used for anything that goes out side of the normal building code. Also don't forget about all of the new renovations that are going into new buildings. All of these projects are going to require fire engineers.

Survey/Interview Questions

- **How long have you been in the fire safety field?**
  24 years

- **Which models do you prefer to use and why?**
  Compartment fire models, fire growth, fire production of hot gasses, flame spread, and evacuation. CFAST, FASTLite, FPE tool as a fire simulator. FIRECalc and FIREWind for hot layer and roof vent. Spreadsheets based on equation in NFPA 92 B. Simulex TM19. CFD star 3D and Phoenix in NSW office. For egress use Simulex and Evacnet. Detection DETACT few versions DETACT qs and DETACT t2. Sprinkler use FIRECalc

- **What training have you received?**
  Training in the basics of the fire models was part of education. Graduate diplomas, Masters, and doctorate. So the training was part of the education. Some short courses in CFAST as HAZARD one course (Barnett) courses in New Zealand and 2 day to one-week short courses.

- **Is there any training or course you would have liked to participate in?**
  Yes, in Simulex. NFPA 92 B course, one day smoke course with Jim Milky of the University of Maryland which took place in Australia. The work team needs less training because of the educational background.

- **How often do you use computer fire models and for what reasons?**
  Daily for numerous fire safety design purposes

- **What expectations does your company have in computer fire modelling?**
  Hopes the model comes with high degree of validation against experimental data, hand book with data and references to data, clarity in assumptions and limitations. Most models don't have this, many are not well documented or validated

- **Are there any specific circumstances that you can recall, when your models did not perform correctly?**
  They can recall a number of examples. They made calculations with three or four different models that had different results. For example a shopping mall in western Australia which resulted in variations in the results all over.

- **What are some of the undesirable characteristics of the models you use?**
  They are rubbish. Some models are not very user friendly at the front end or back end. They are more research tools than engineering tools. They contain strange parameters, limited validation, documentation, or internal verification of numbers.

- **Do you find there is a lack of experimental data?**
  Yes, and lack of checking model against data. There is more writing of the computer programs than experimentation.

- **What type of experimental data would be worth purchasing and for how much?**
  Wouldn't purchase data unless it could suit purpose. Model makers should get data and verify their models with it.

- **What limitations do you find with models?**
  I find there are limitations with the validation and assumptions with sources of suitable data.

- **Should there be barriers to limit the risk of misuse by inexperienced operators?**
  Yes, How would you do it? Professional ethics not working completely. It would be useful if models had traps or flagging.

- **Should there be a validation service for each model?**
  No, person who produces the model should validate it. If it has not been validated it should not be used.

- **Do you feel CSIRO should offer services for modelling?**
  If they do commercial consulting they should not be using the funds to under cut competitors. Maybe they should stay out and offer specialty services.

- **What types of services do you feel are necessary?**
  Training courses, sources of data, validation of methods, CSIRO could do this.

- **How do you plan to use fire modelling in the future?**
  Continue using it as a consulting and design tool.

- **Do you have a reference if there are problems with a model? Someone you can ask questions.**
  ARUP colleagues world wide, links with universities and research organizations like CSIRO.

- **How do you think models should be marketed? ie. through the Internet, catalogue, or other ways.**
  Like any commercial product, competitively. Sold to engineering companies with the assumptions and limitations. Hand book, guide internal numerical verification, and verification and acceptance by authority, a third party review.

- **What do you think the future of computer fire modelling is?**
  This is a question of why you do fire modelling A) design B) convince fire brigade C) convince client. Different reasons for the use of models fit in overall methodology of design and risk broad fire engineering framework. Coached in risk management and risk assessment. They also need to lend themselves to link to fit in to virtual reality or computer model fit into end packages. Want to be able to run through fire scenario in real time to "see" evacuation, smoke spread, and flame movement. Clients would like that on big projects. Other things fit

into expert systems, Sophie University of Grenache, CFD models. Use simple questions to input data, design community.

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