Computer Models
For
Fire and Smoke

Model Name:	CRISP
Version:	2.4
Classification:	Monte-Carlo Simulation for Risk Assessment. (It can also be used as stand-alone egress model or fire zone model)
Very Short Description:	CRISP is a Monte-Carlo model of entire fire scenarios. The sub-models representing physical 'objects' include rooms, doors, windows, detectors and alarms, items of furniture etc, hot smoke layers, and people. The randomised aspects include starting conditions such as various windows and doors open or closed, the number, type and location of people within the building, the location of the fire and type of burning item.
Modeler(s), Organization(s):	Jeremy Fraser-Mitchell, FRS, BRE
User's Guide:	Yes, with model
Technical References:	Phillips, WGB, 'Simulation Models for Fire Risk Assessment', Fire Safety Journal vol.23 no.2 p.159-169, 1994 Fraser-Mitchell,JN & Pigott,BB, "Modelling Human Behaviour in the Fire Risk Assessment Model CRISP 2", Proc. Int. Symp. CIB W14: Fire Safety Engineering, part 3, p.1 (1993) Fraser-Mitchell,J, "An Object-Oriented Simulation (CRISP 2) for Fire Risk Assessment", Fire Safety Science, Proc 4th Int Symp IAFSS, p.793 (1994) Pigott,,BB & Fraser-Mitchell,JN, "An Approach To Risk-Based Fire Safety Engineering Design", Fire Safety by Design Conference, University of Sunderland, 10-12 July 1995; Proceedings, Vol.3 p.103-110 (1995)

Fraser-Mitchell,JN, "Lessons Learnt During The Development Of CRISP2, A Monte-Carlo Simulation For Fire Risk Assessment", Proc 7th Intl. Fire Conf., INTERFLAM '96, ed. Franks,C, Interscience Communications Ltd, London, p.631-639 (1996)

Fraser-Mitchell,JN, "Risk Assessment Of Factors Relating To Fire Protection In Dwellings", Fire Safety Science, Proc 5th Int Symp IAFSS, p.631 (1997)

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Boyce,KE, Fraser-Mitchell,JN, & Shields, TJ, " Survey, analysis, and modelling of office evacuation using the CRISP model ", Human Behaviour in Fire, Proc 1st Int Symp, ed. Shields,TJ, University of Ulster, p.691-702 (1998)

Validation References: Some validation results are included in the above references

Availability: The model is used for in-house consultancy by BRE. It is currently not available “off the shelf”

Price: N/A

Necessary Hardware: Pentium PC

Computer Language: Fortran

Size: Executable program 0.75MB, Input data files up to ~ 2MB, Output data size depends on options chosen – can be huge.

Contact Information: Jeremy Fraser-Mitchell, FRS, BRE, Bucknalls Lane, Garston, Watford, Herts, WD25 9XX, UK. Email fraser-mitchellj@bre.co.uk

Detailed Description:

CRISP is a Monte-Carlo model of entire fire scenarios. The sub-models representing physical 'objects' include rooms, doors, windows, detectors and alarms, items of furniture etc, hot smoke layers, and people. The randomised aspects include starting conditions such as various windows and doors open or closed, the number, type and location of people within the building, the location of the fire and type of burning item.

The basic structure of CRISP is a two-layer zone model of smoke flow for multiple rooms, coupled with a detailed model of human behaviour and movement. All the physical 'objects' are supervised by the Monte Carlo controller, making each one perform for each timestep. The Monte Carlo controller also handles all the input and output, initialisation for each run, and starts each run automatically. Functions are included to generate random numbers from any distribution. The calculations for each run are carried out iteratively, with variable time intervals to ensure the program's efficiency, accuracy and stability.

The combustion process assumes that flames spread radially at a constant rate across a horizontal surface. Other configurations are accounted for by modifying the variable parameters. The radiant heat flux from the flames and hot smoke layer determines the pyrolysis rate per unit area. Oxygen entrained into the plume from both the cold and hot gas layers affects the combustion efficiency, and hence the heat output rate to be used in the next iteration. The initial conditions are a heat release rate of 1kW, and a fire radius chosen to give zero flame height. The burning item parameters are all variables which may be adjusted to reproduce experimental observations. Predicted heat release rates for items burning in fully ventilated conditions give satisfactory agreement. An alternative mode of program operation allows experimental values to be used directly, however in this mode the influence of varying oxygen availability is neglected.

Smoke moves between rooms by means of vent flows, driven by pressures arising from buoyancy differences. These flows may form vent plumes, which may cause further mixing of the gas layers in the room they flow into. The geometry of the room determines how quickly a growing smoke layer will descend. Combustion products are transported between the various cold air and smoke layers by plumes and vent flows. Heat may also be lost by radiation and conduction through the walls of the compartment. The buoyancy of the hot and cold layers determines whether plumes and vent flows rise or sink.

Vents are defined as doors and windows, or any other opening which smoke may move through. They may open or close during the simulation as people move through them. However, doors can be specified as self-closing. The traversal difficulty includes physical and psychological aspects.

CRISP does not explicitly model fire resistance, all barriers are assumed to retain their integrity for the duration of the simulation. The great majority of scenarios are resolved in a few minutes, so this assumption may not be too bad. It is also assumed there is no smoke spread through cavities.

People are assumed to adopt distinct behavioural roles, either naturally or due to training. Their behaviour can be described in terms of actions, which may be abandoned, and substituted by new ones, depending on the state of the environment. Rational decisions are made based on current knowledge (which may be limited and/or incorrect). People never ‘panic’ (in real life, ‘panic’ behaviour is actually extremely rare).

Movement of people through a building firstly requires a route to be planned through the network of rooms. The choice of route is influenced by the doors' transit difficulty (modified for the presence of smoke) and the distance. Within each room, movement to the next door on the route is directed by means of a ‘contour map’ of distance to go. This enables any obstacles to be avoided. Movement speed is affected by local crowd density. Deviations from the minimum distance path through a room may be made to avoid areas of high crowd density.

The model attempts to calculate ‘pre-movement time’ (rather than use an empirical distribution) in terms of the time delays associated with various actions performed by the occupants in response to the early fire cues. The occupants may perform a number of actions (eg. investigate, warn others) before actually starting to escape (thus the term ‘pre-movement time’ is not strictly accurate). If the occupant’s ‘pre-movement’ actions do not actually require him to move, then all these actions can be lumped into a single delay in reacting to the alarm.

As the people move around, they are exposed to smoke and acquire a fractional effective dose (FED). When the FED reaches 100%, the person is assumed to be ‘dead’. The risk is expressed simply in terms of the fraction of people originally present who end up ‘dead’, averaged over a sufficiently large Monte-Carlo sample.