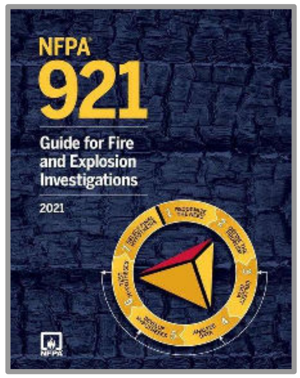
FireWise
CONSULTING
LEARNING ACADEMY

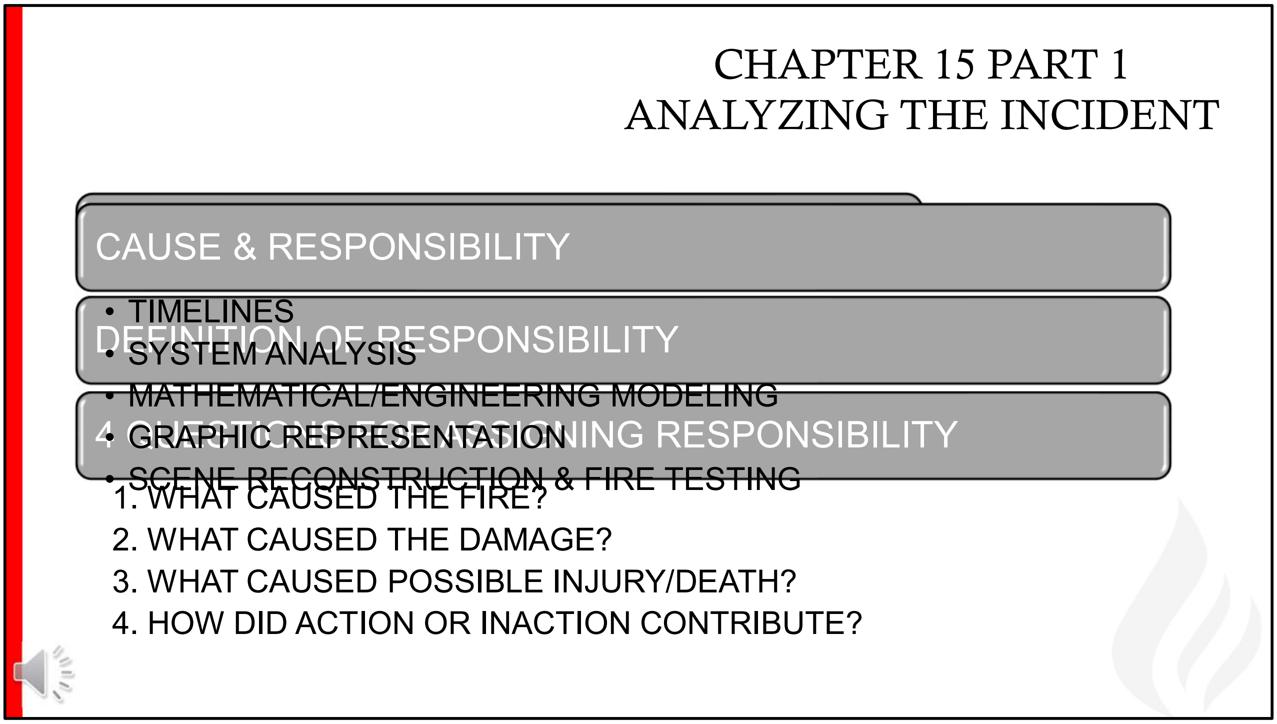
CHAPTER 15 PART 1
ANALYZING THE INCIDENT



CH. 20 & 21

Welcome to **Part 1 of Chapter 15, Analyzing the Incident**.

If you are following our presentation in NFPA 921 - 2021 Edition we are covering Chapters 20 and 21.



In this chapter we will discuss:

- The definition of responsibility as it pertains to a fire or explosion incident,
- The relationship between cause and responsibility for a fire and
- The four questions investigators may need to think about in order to address the issue of responsibility:
    1. What caused the fire?
    2. What caused the damage to the property,
    3. What caused any possible injury or death and
    4. How and to what degree did a person's actions (or inaction) contribute to any of the above.
- We will also discuss failure analysis and its various analytical tools including:
    - Timelines,
    - System analysis,
    - Mathematical/engineering modeling,
    - Graphic representations and
    - Scene reconstruction and fire testing

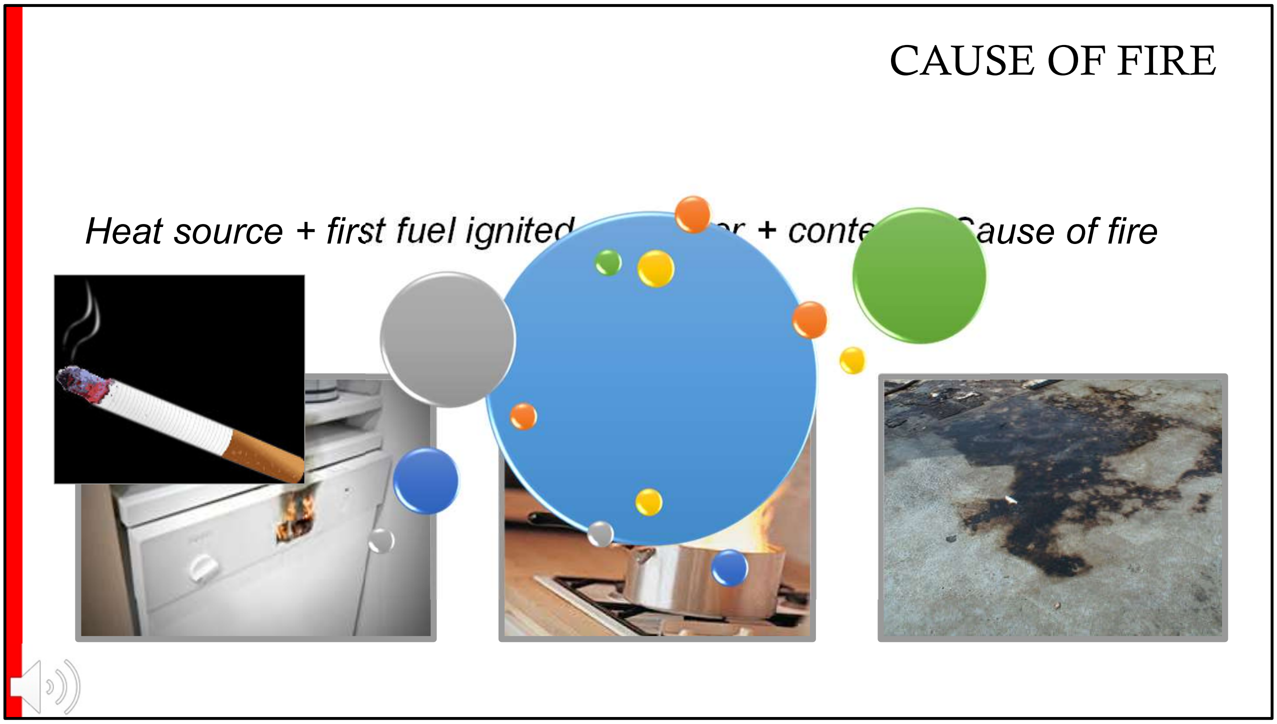
Determining the cause involves identifying the **4 elements of the fire,** while classification focuses more on gathering data, completing reports and assigning responsibility. But what is meant by responsibility in a fire incident?

Responsibility refers to the degree to which a person or entity's actions are accountable and/or contributed to the event or chain of events that led to:

- The fire incident,
- The damage to property, and/or
- Any possible injury or death.

And

- The degree to which human involvement contributed to the fire.



When fire investigators refer to the “cause of fire” they are not just referring to the ignition or heat source (for example a lit cigarette) but to the perfect storm of elements that come together to make conditions for a fire possible.

As we saw in Chapter **14** a fire needs a heat source, a fuel to ignite, an oxidizer and circumstances that encourage the fire to spread. For example, these circumstances might include:

- a defective product,
- negligence – for example, someone forgot about a pot boiling on the stove or
- it might be intentional. For example, someone deliberately pouring fuel throughout a building and then lighting it on fire.

CAUSES OF PROPERTY DAMAGE & INJURIES

FACTORS TO CONSIDER:

CODE VIOLATION

COMPARTMENTA

FIRE SEPARATIONS:
FLOORS, WALLS, CEILING, DOORS, FIRE RATED GLASS, FIRE WALLS, LOUVERS & DAMPERS

How fast a fire develops and how far the flames and smoke reach greatly influence how much damage, injuries and loss of life will occur.

As a fire investigator, here are some contributing factors you should consider:

- Were there any code violations? For example, were any fire doors kept propped open?
- Was compartmentation included in the design of the building? Compartmentation refers to dividing a building into compartments by fire separations which slow or prevent the spread of heat, smoke and fire from one compartment to another. Fire separations are construction assemblies which may include floors, walls, ceilings, doors, fire rated glass, fire walls, louvers and dampers. Did these items work as designed?

CAUSES OF PROPERTY DAMAGE & INJURIES

FACTORS TO CONSIDER:

FIRE PROTECTION SYSTEMS

FIRE SUPPRESSION SYSTEMS

FUEL LOAD AND GEOMETRY

- Did the fire alarm system go off? If so, did it go off in a timely manner?
- Did the fire suppression systems work effectively? For example, did the sprinkler system engage in time?
- What was the influence of the fuel load and geometry? (You can refer back to Chapter 4 Fire patterns for more detail)

CAUSES OF PROPERTY DAMAGE & INJURIES

FACTORS TO CONSIDER:

MAINTENANCE & HOUSE KEEPING

RENOVATED BUILDING

OVER CAPACITY

HUMAN ACT

EFFECTS OF VENTILATION

- Was the building properly maintained? Was it kept clean? A poorly kept building could result in the fire spreading quicker as well as hinder fire fighting efforts.
- Did a human act, or lack thereof, contribute to the fire spread? For example, did a person store a highly flammable substance near a heater?
- Was the building renovated in a manner that made the fire suppression systems inadequate?
- Was the building's occupancy over capacity?
- What were the effects of ventilation on the fire spread?

CONSEQUENTIAL DAMAGE

Damage that results from secondary effects of the fire

LOSS OF ELECTRICITY, WATER OR GAS
RUST, CORROSION, WATER DAMAGE OR
MOLD
WEATHER DAMAGE
THEFT

CONTAMINATION

Consequential damage refers to damage that was not directly caused by the fire, smoke or the fire fighting interventions but by secondary factors. These could include:

- A loss of electricity, water or gas to the building,
- Weather damage to a building whose structural integrity was compromised by the fire incident,
- Rust, corrosion, water damage or mold,
- Theft and
- Contamination

An example of consequential damage is a fire in a cold storage food distribution warehouse. The fire did significant damage to the electrical system and vault but before this could be repaired, large quantities of food was lost causing the overall dollar loss to the owner to increase from hundreds of thousands to millions of dollars.

BODILY INJURY/DEATH

ESCAPE ROUTES? UNOBSTRUCTED
HAZARD RECOGNITION?

AGE OF VICTIMS?
BEHAVIOR?

PHYSICAL OR MENTAL IMPAIRMENTS?
EMERGENCY SITUATION TRAINING?

OVER CROWDING?

In the case of injury or death, the investigator will want to consider:

- If the escape routes (or means of egress) were well-designed, well marked and unobstructed,
- What was the age of the victims and
- Were they mentally or physically impaired or intoxicated,
- How long did it take the victims to recognize there was a fire and
- How did they behave once they did,
- Was there a person trained in how to behave in emergencies and finally,
- Were there more people in the building than the building code allowed?

Many of these factors **will be discussed in greater detail in Part 3 of Chapter 15.**

DETERMINING RESPONSIBILITY

ARSON:

DETERMINING REPSONSIBILITY ALLOWS FOR LITIGATION

Responsibility can be a ned to certain aspects of the in even if the cause has been cla as undetermined.

ACT OR OMISSION?

After the cause of the fire has been determined, the process of figuring out who or what is responsible begins. Determining responsibility is important because that is what allows for policies, codes, and standards to be changed in order to prevent the same type of incident from happening again. In the case of arson or negligence, it is also what allows criminal or civil litigation to proceed.

The nature of responsibility may take the form of an act or an omission and can either be intentional or unintentional. In other words, did somebody do something or omit to do something that resulted in the fire? In some fires both an act and an omission resulted in the fire. For example, the occupants of a home turned the stove top element on to cook breakfast, act. They forgot to turn the stove off, omission, before leaving for work. A kitchen fire resulted.

Responsibility can be assigned to certain aspects of the incident even if the cause has been classified as undetermined. One person or many can be deemed responsible for one fire incident.

DETERMINING RESPONSIBILITY

INVESTIGATING RESPONSIBILITY MAY INVOLVE:

INTERVIEWING WITNESSES

COLLECTING DOCUMENTARY EVIDENCE

CONSULTING WITH EXPERTS

CONDUCTING FAILURE ANALYSIS

Investigating responsibility may involve:

- Interviewing witnesses,
- Collecting reports, records and other documentary evidence from a variety of sources,
- Consulting with experts

and frequently

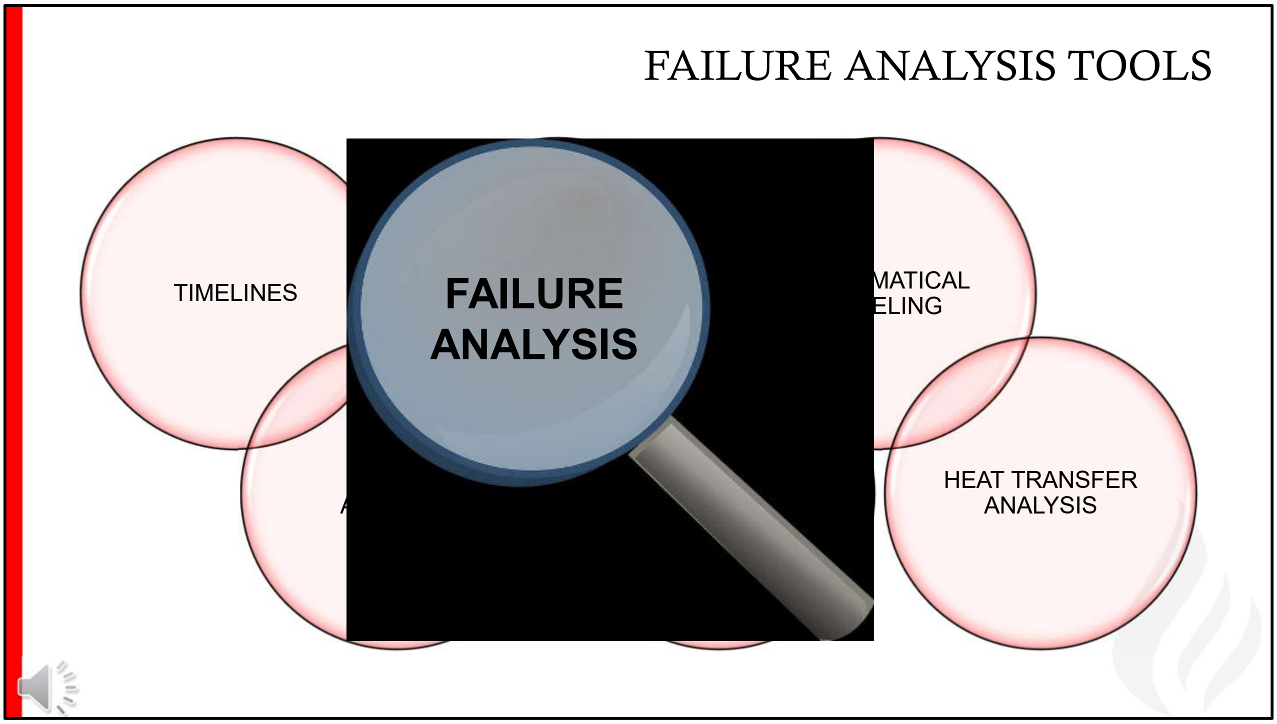
- Conducting failure analyses.

FAILURE ANALYSIS

What factors contributed to the damage caused by the fire?

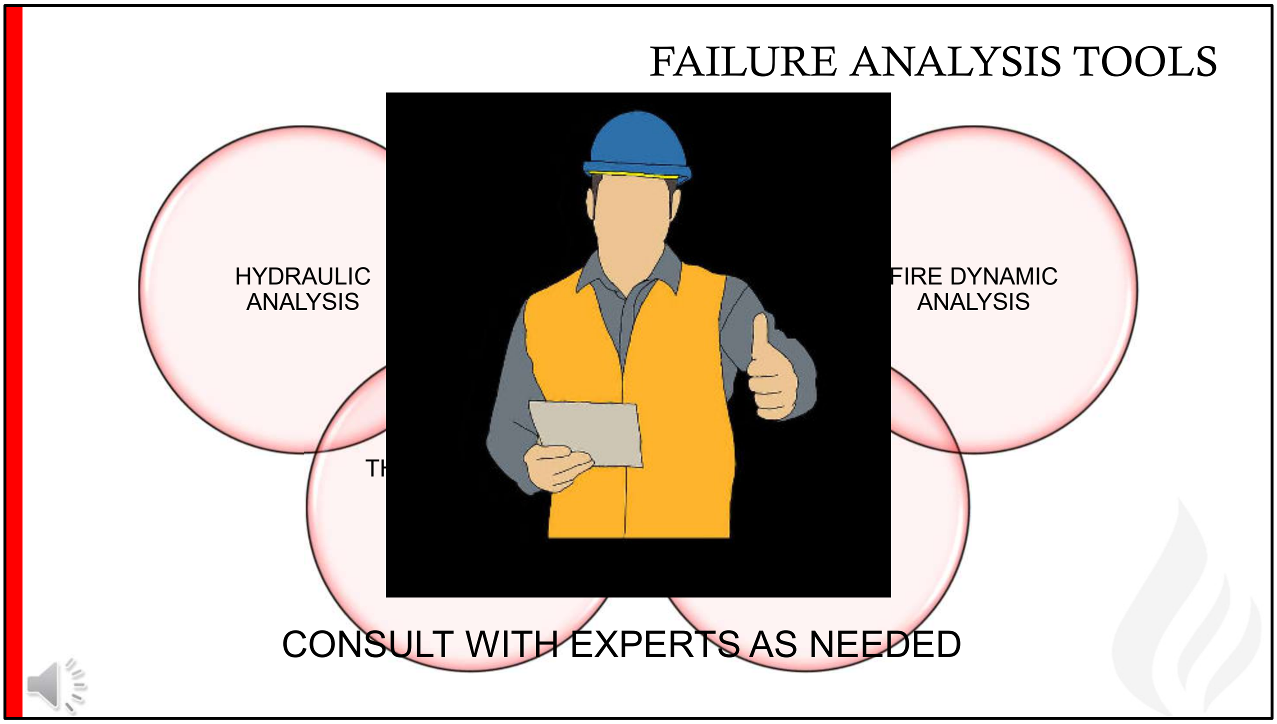
A failure analysis is what its name suggests: it is an attempt to establish the factors that contributed to any property damage, injuries or loss of life caused by the fire incident.

The findings in a failure analysis are vital in that they help make sure the type of incident does not happen again.



When looking at a fire through the failure analysis lens, a fire investigator is seeing the incident as a chain of events that ultimately led to the damage. With that in mind, the failure analysis tool kit includes:

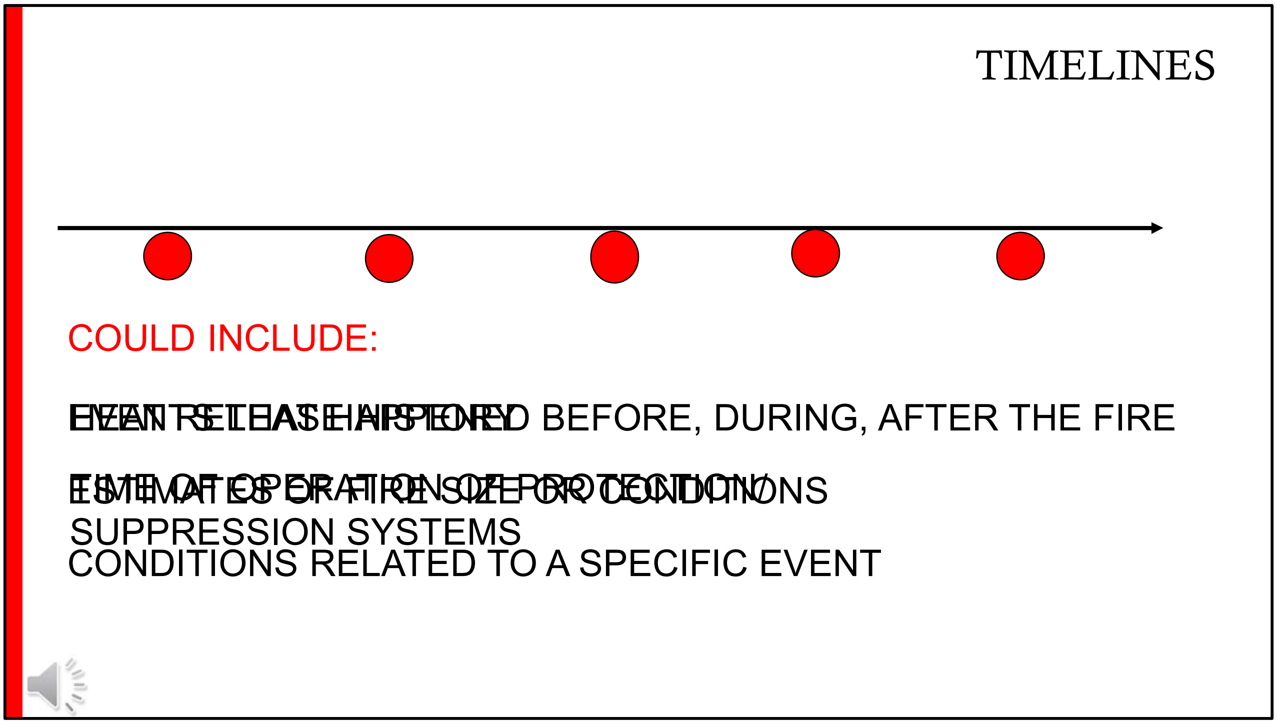
- Timelines,
- Systems analysis,
- Failure mode and effects analysis,
- Fault trees,
- Mathematical modeling
- Heat transfer analysis,



- Hydraulic analysis,
- Thermodynamic chemical equilibrium analysis,
- Structural analysis,
- Egress analysis, and
- Fire dynamics analysis,

All of which we will explore in the following slides.

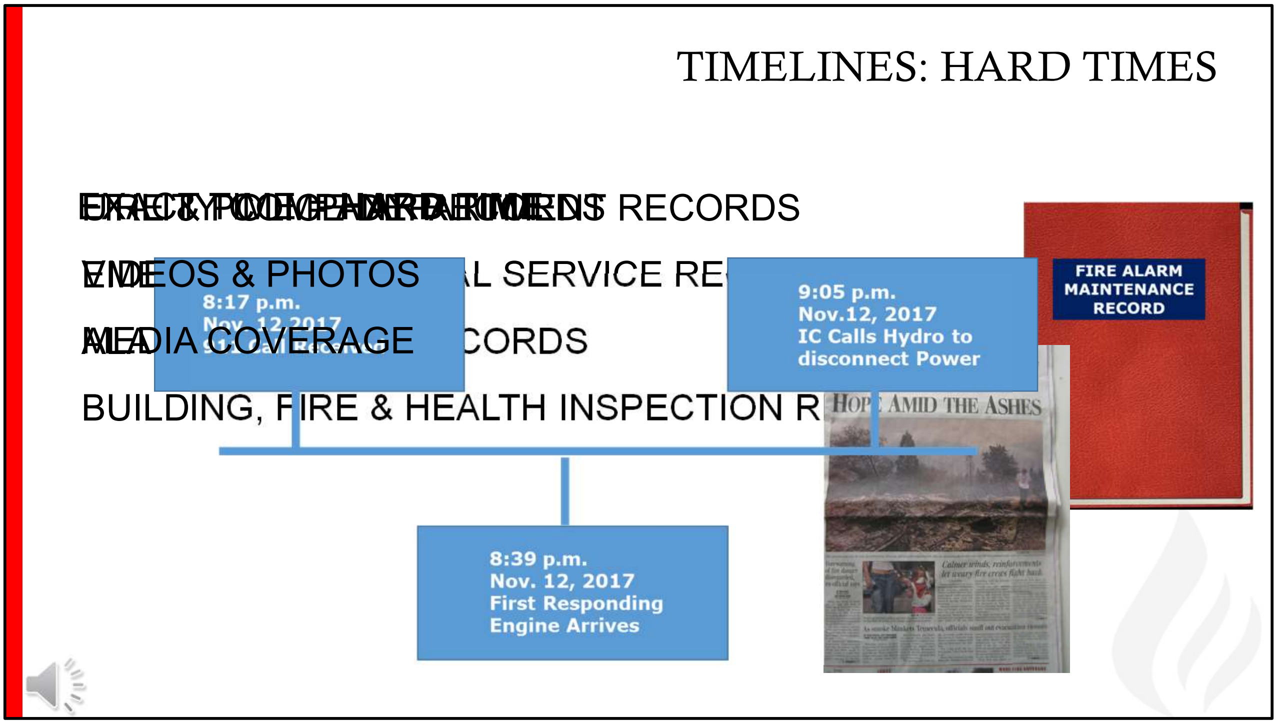
Before we do however, it is important to note that the proper use of failure analysis often requires certain specialized expertise and education (for example, electrical, mechanical or fire protection engineering). If you need to use one of the tools above and do not have the expertise, you should always consult with someone who does.



A timeline refers to a graphic or narrative outline in chronological order of the events related to the fire.

A timeline could include events that happened before, during and after the fire. Estimates of fire size or fire conditions are frequently valuable in developing time lines. Fire conditions can be related to specific events. It may be possible to develop an estimate of the heat release history for at least the early stages of a fire by observing the height of flames relative to the height of known objects.

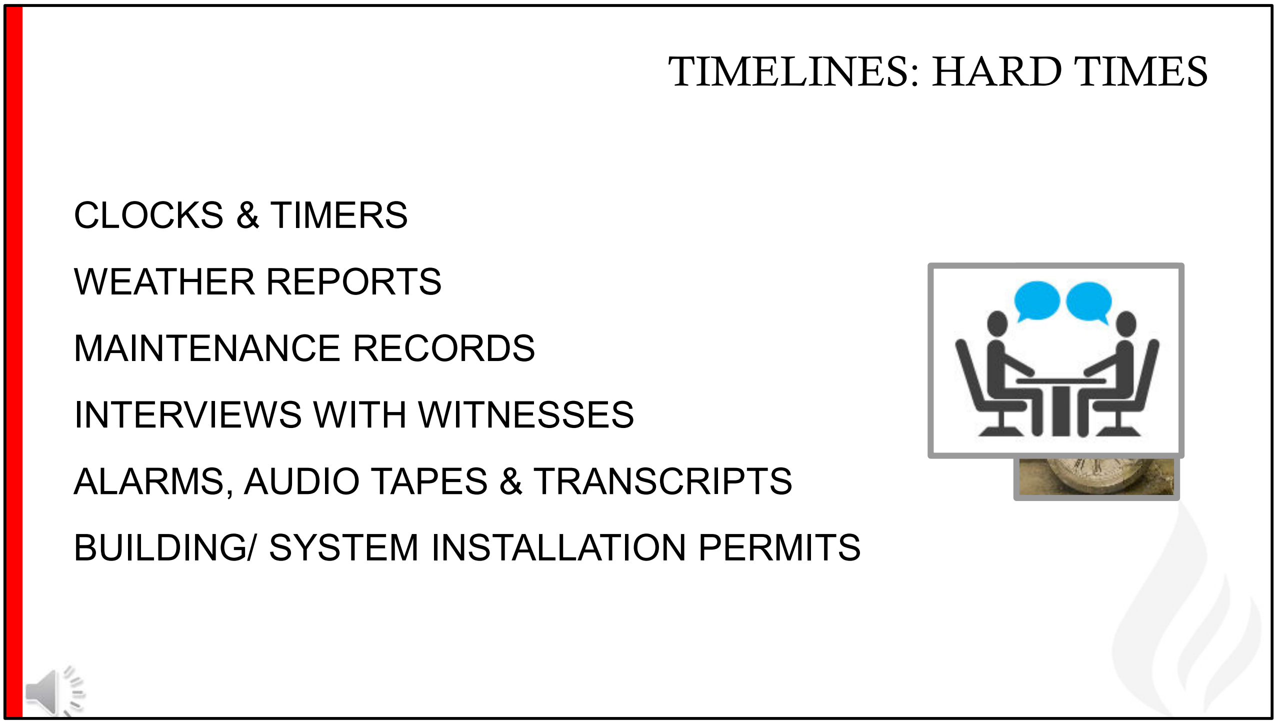
The time of operation of fire detectors and sprinklers can indicate the estimated size of the fire in the area where the alarm occurred. If there are multiple zones the spread of the fire can be tracked through the building and added to the time lines. If the heat release can be estimated for several points, a possible heat release history may be postulated and used as a means to assist in testing various hypotheses for the cause and growth of a fire.



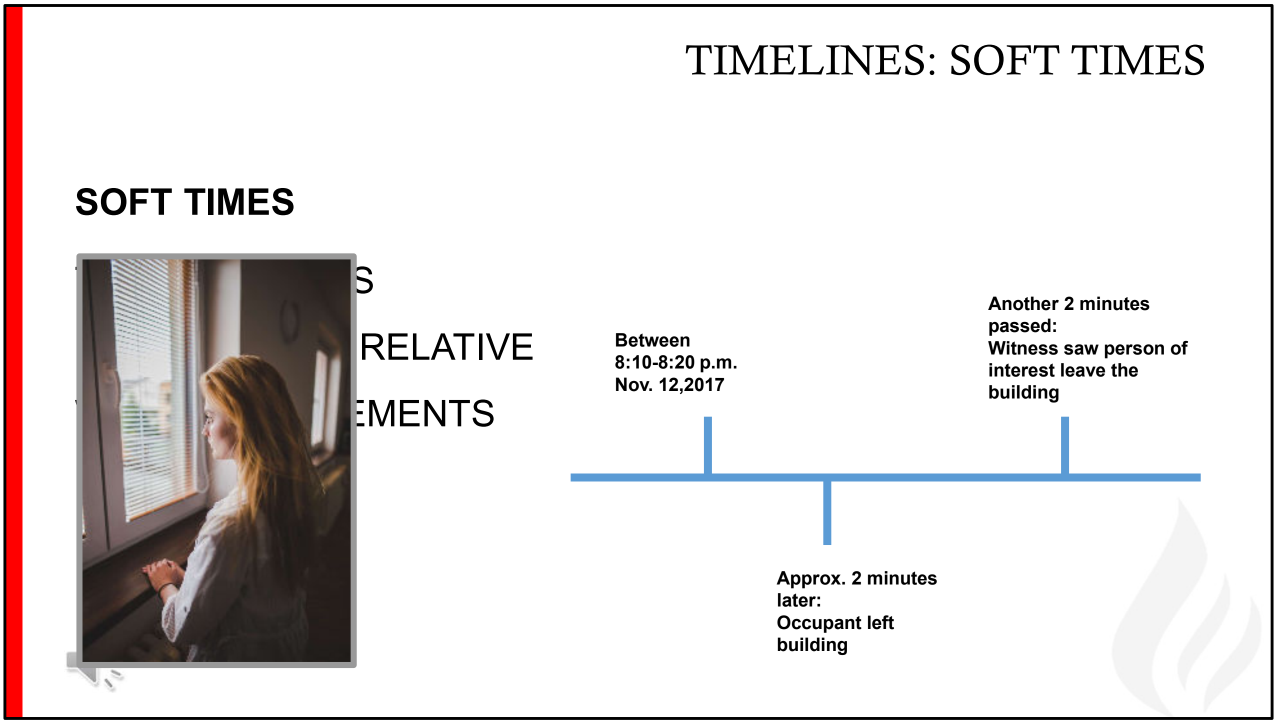
A timeline is only as reliable as the accuracy of the data used to construct it. When an exact time can be determined, it is referred to as a hard time.

Here are a few ways in which hard times can be determined:

- Fire and police department records,
- Emergency medical service records,
- Alarm systems records that come from on-site, central station, fire dispatch and others,
- Building, fire and health inspection reports,
- Utility company maintenance, emergency and repair records,
- Private citizen videos and photos,
- Newspaper photographs, radio, television and magazine media coverage,



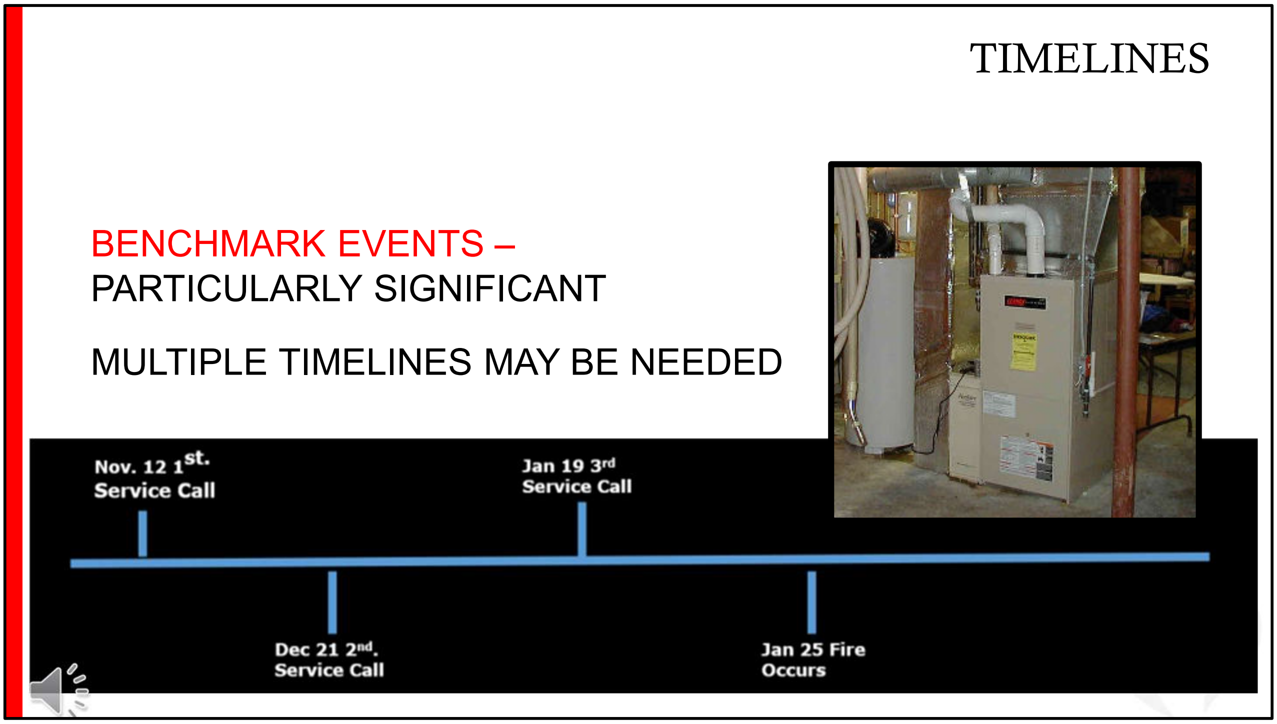
- Clocks, time clocks, security systems, water softeners, and lawn sprinkler systems with timers,
- Weather reports from provincial, state and federal agencies, and lightning tracking services,
- Maintenance records from current and/or prior owners and tenants,
- Interviews with witnesses,
- Computer based fire department alarms, communications audio tapes and transcripts, and
- Building or systems installations permits.



However, it is not always possible to pinpoint the exact times for every event, in which case, they need to be listed as **time intervals**. These events are estimated or relative and are usually pieced together by witness statements. These are referred to as **soft times.**

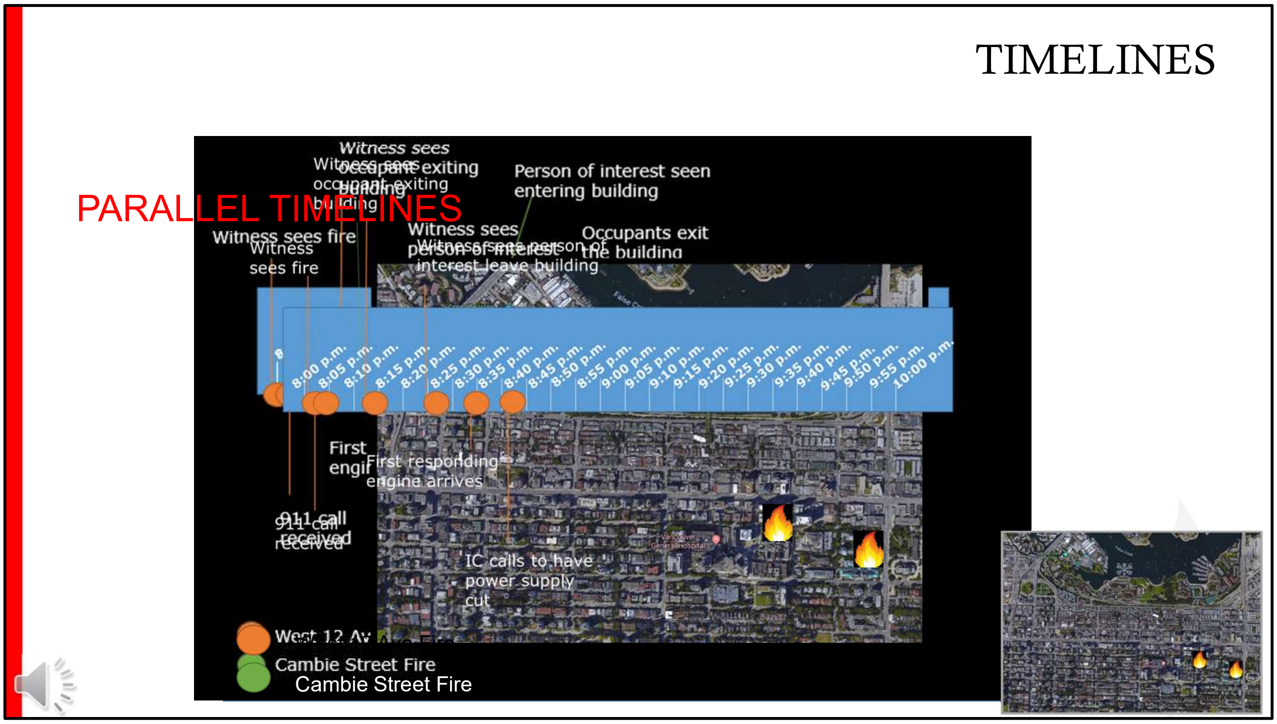
When dealing with a soft time, an investigator may be able to narrow it down to a relative time period by putting together witness statements in relation to other known facts. For example, even if a witness cannot pinpoint the exact time a certain event occurred, they might be able to remember that when that event was occurring, a bus was going by or a certain show was playing on TV.

By taking all the witness statements and known facts and putting them together, an investigator can narrow down the time interval for a specific event to an **estimated time**.



Though every detail is important in a fire investigation, there are certain events that are particularly significant in the cause or spread of the fire and/or valuable in establishing an accurate timeline. These are called **benchmark events**. Remember to make sure all hard time sources are synchronized and double-checked to make sure they are accurate and there are no discrepancies.

It is also possible the investigation requires not one but multiple timelines in order to get a more accurate picture of the fire incident. For instance a larger scale, or macro timeline that covers weeks or months might be needed in order to understand how a fire propagated as well as a timeline that deals with a specific event, or a micro timeline. For example, investigators determine the cause of the fire to be a faulty furnace. During an interview the building manager said that he had trouble with the furnace several times over the last 6 months. It was making funny noises and he called the repair technician who worked on it but said the unit should be replaced. Another time the furnace would not come on so he called the repair guy again and he got it working again but said again that the unit should be replaced. The building manager talked to the building owner who said spring was on the way, so he decided to leave it until the summer to replace the faulty furnace. Consider the significance of the timeline if people had been injured or died as a result of not replacing the furnace.



Parallel timelines are also useful when dealing with multiple, simultaneous events. They can demonstrate whether or not two or more events are related. Displaying these graphically can be very helpful in order to determine the relationship of seemingly separate events. (Julie please make up parallel timelines for 2 or more fires that occur within minutes of each other – may want to use google earth to show locations and then a timeline for each fire)

Creating a timeline can be as simple as drawing it with a pen and paper or as sophisticated as using specialized software, depending on the complexity of the analysis.

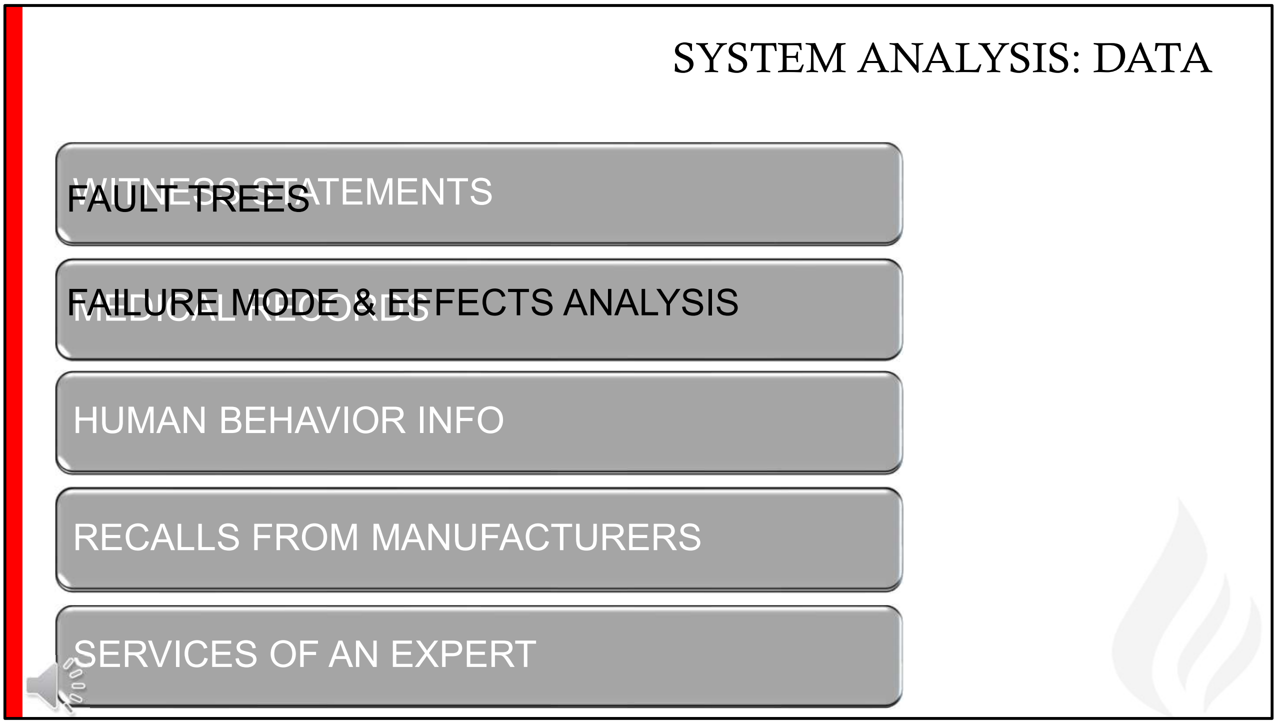
A scaled timeline that shows each event and the time in between them, as well as the **soft times above and the hard times below** is an excellent way to create a comprehensive visual of the event.

This is especially useful when dealing with serial or spree arsonists, which will be discussed later in more detail in the Chapter on Incendiary Fires.

System analysis is a tool used to incorporate all the different aspects of a case—for example human behaviour, the different characteristics of a fire incident's location, the mechanical features of any equipment involved—to form as comprehensive an understanding of the events surrounding a fire as possible.

Fire investigators are involved in informal system analysis everyday. Take the example of a forest fire that started from the improper disposal of a cigarette butt. One factor in the fire is the human behaviour (throwing the lit cigarette butt out the car window). Another would be the dry weather conditions as well as the geography. A cigarette will only cause a wildland fire if the relative humidity is less that 25%. Put it all together and you have a system that led to the fire.

Two examples of system analysis are Fault Trees and Failure Mode and effects analysis.

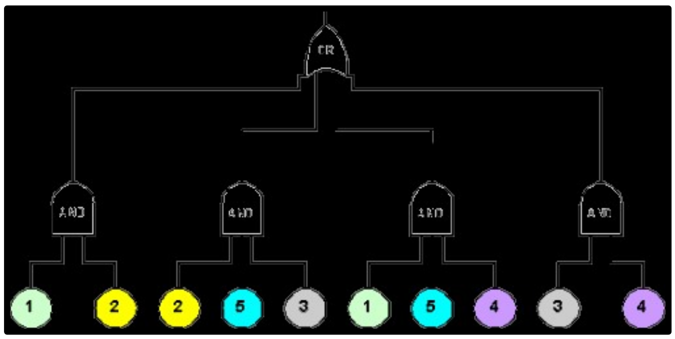


For both fault trees and failure mode and effects analysis, the data to be analysed can be found in:

- Operations and maintenance manuals,
- Maintenance records,
- Parts replacement and repair records,
- Design documents,
- Services of expert with knowledge of the system,
- Examination and testing of exemplar equipment or materials,
- Component reliability databases,
- Building plans and specifications,
- Fire department reports,
- Incident scene documentation,
- Witness statements,
- Medical records of victims,
- Human behaviour information and
- Recalls from manufacturers

FAULT TREES

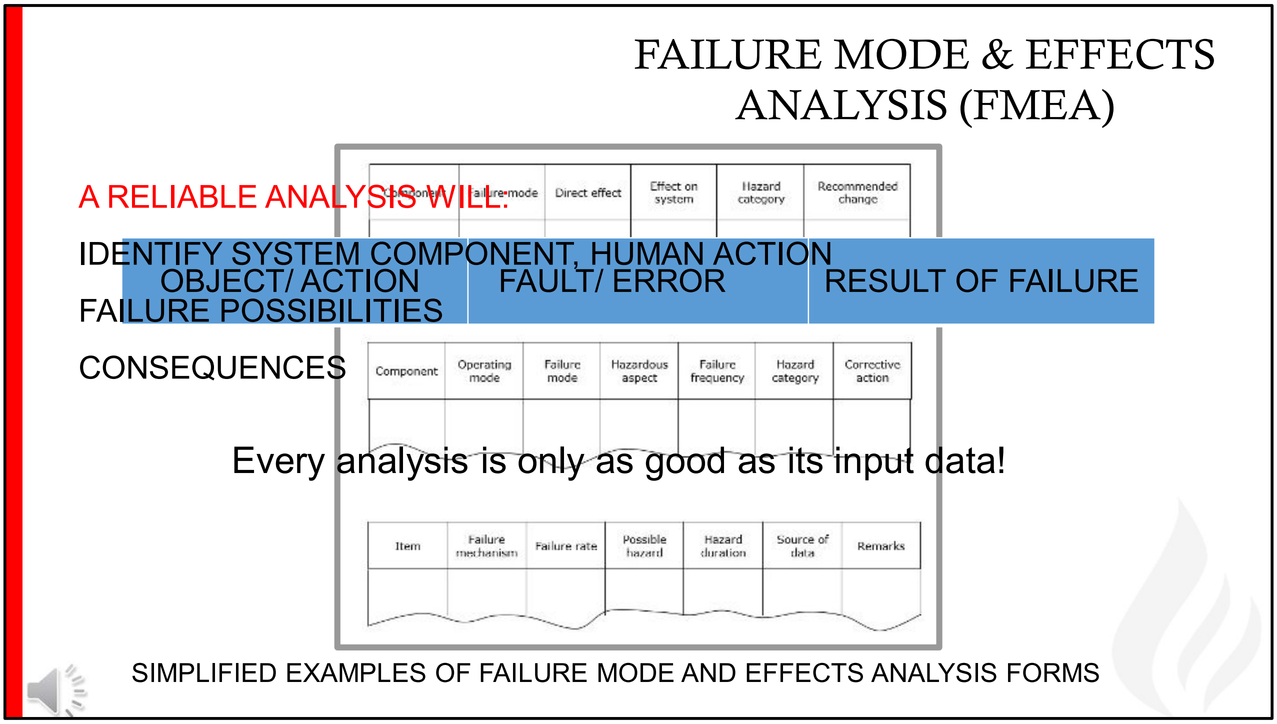
RELIES ON THE “**AND**” “**OR**” POINTS OF ENTRY



A fault tree, or decision tree, is a graphic representation based on deductive reasoning and illustrated in logical sequence of the decisions or events that had to happen in order for the fire incident to take place.

The logic used to create a fault tree is the same used in computer programming. It relies on the “and” ”or” points of entry. Using the “and” gate, means all of the events and conditions have to be present in order for that scenario to occur. The “and” narrows down the tree considerably. If you use the “or” gate, any of the conditions could be possible, which considerably widens the branches of the tree. If the events and conditions did not happen in the right order, then the fire would not be possible. Thus certain scenarios can be eliminated.

In this way fault trees quickly identify the multiple scenarios where the conditions needed for a fire to have occurred were present and in the right order.



Failure mode and effects analysis is also a graphical representation tool, but one which deals with only one event or subevent that led to a fire. It is used to identify specific components that may be associated with the ignition source or the spread of the fire. This will then help to identify past events or activities leading up to an incident.

To complete a Failure Mode and Effects Analysis the investigator draws a table with appropriate column headings. These can vary, though every failure mode and effects analysis should include the following:

- the object or action being analysed
- The basic fault or error that led to the hazard, and
- Result of that failure

Depending on the incident under analysis, the failure mode and effects analysis can be very simple or incredibly complex. However, it bears repeating that every analysis is only as good as its input data. A reliable analysis will have identified each system component and human action pertaining to an incident, the possible ways in which they failed, and finally the consequences of those failures. Remember to include any relevant environmental conditions as well as the process status of each object.

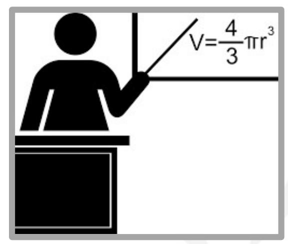
MATHEMATICAL/ ENGINEERING MODELING

SIMPLE FORMULAS TO COMPLEX FIRE DYNAMICS AND PROGRESSION

PICTURE OF EVENTS THAT **MAY** OR **MAY** NOT HAVE OCCURRED

SHOULD **NOT** BE USED AS THE SOLE PIECE OF EVIDENCE IN CAUSE DETERMINATION

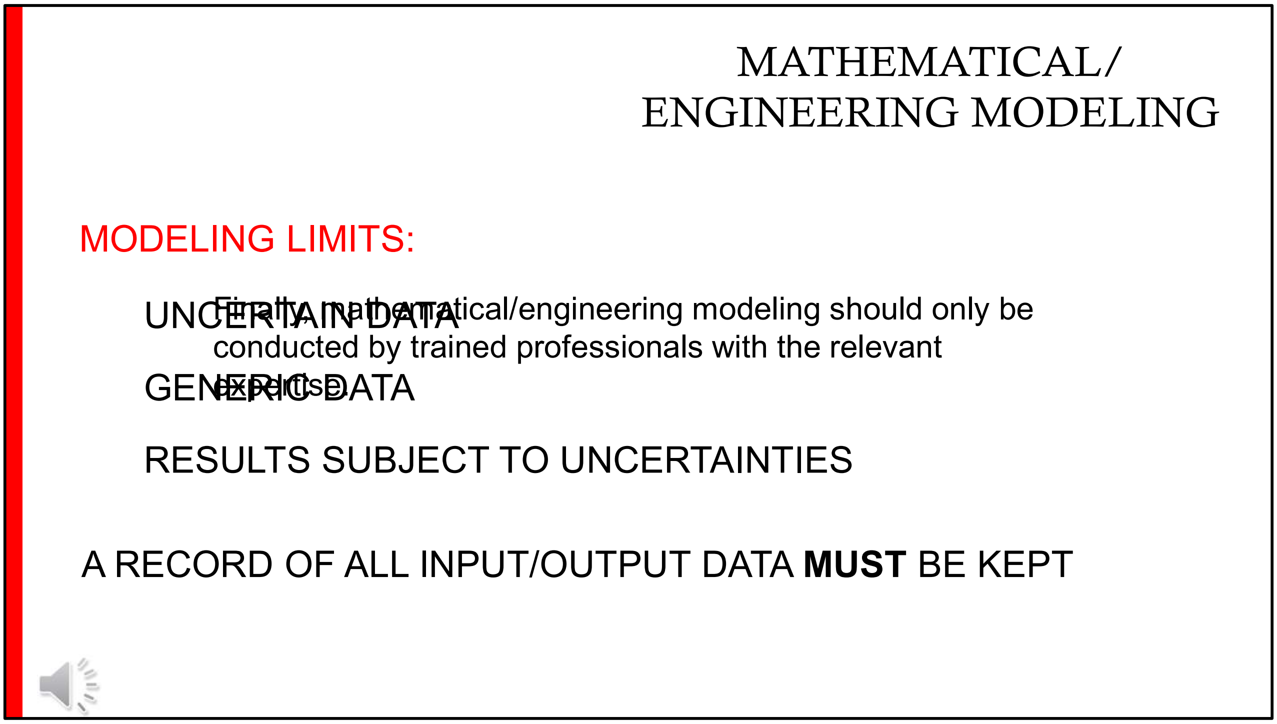
ENGINEERING MODELS INVOLVE "**FACT SETS**" AKA "**MODELING INPUT DATA**"



Mathematical, or engineering models are used by experts to assess specific, quantifiable issues. These can range from simple formulas to more complex fire dynamics and fire progression issues which require the aid of a computer program.

Engineering models involve "fact sets", also known as "modeling input data". These are the known properties of the materials, features, components and systems involved in the fire incident as well as their approximated properties. When the fact set is established, experts apply generally accepted engineering and analytical techniques to develop a picture of events that may or may not have occurred given a certain set of conditions.

It is important to remember that these models are only tools used to test a hypothesis or possible scenario and should be taken in relation with all of the other data and evidence. They should never be used as the sole piece of evidence in cause determination. However, they can be used to support the other available evidence as well as shed some light as to the cause of the damages or injuries.

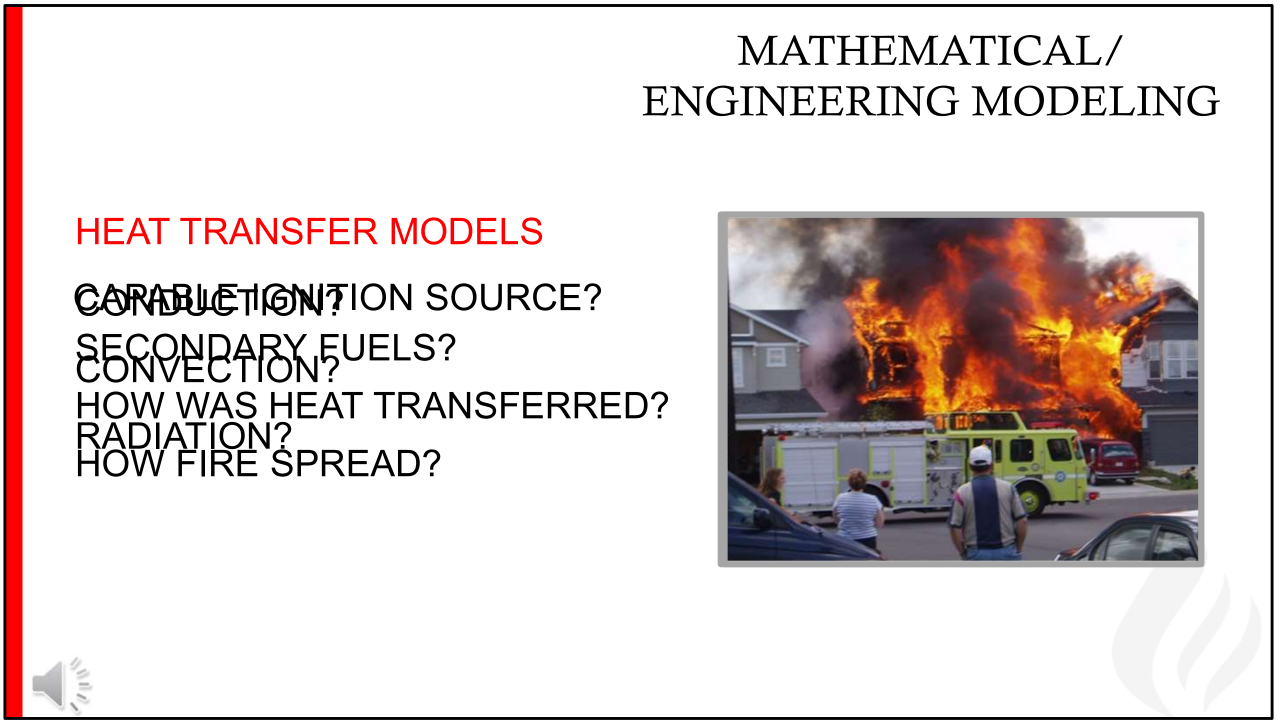


There are also limits to the usefulness of these types of models:

1. As always the input data can contain uncertainties, though the use of standardized data can minimize these.
2. Generic data taken from the fire science literature can also cause some uncertainties, and finally
3. Because of the uncertainty of the data, especially any data that has been approximated, the results will consequently also be subject to uncertainties.

If this type of modeling is incorporated into the investigation, a record must be kept of all the input and output data for the sake of transparency.

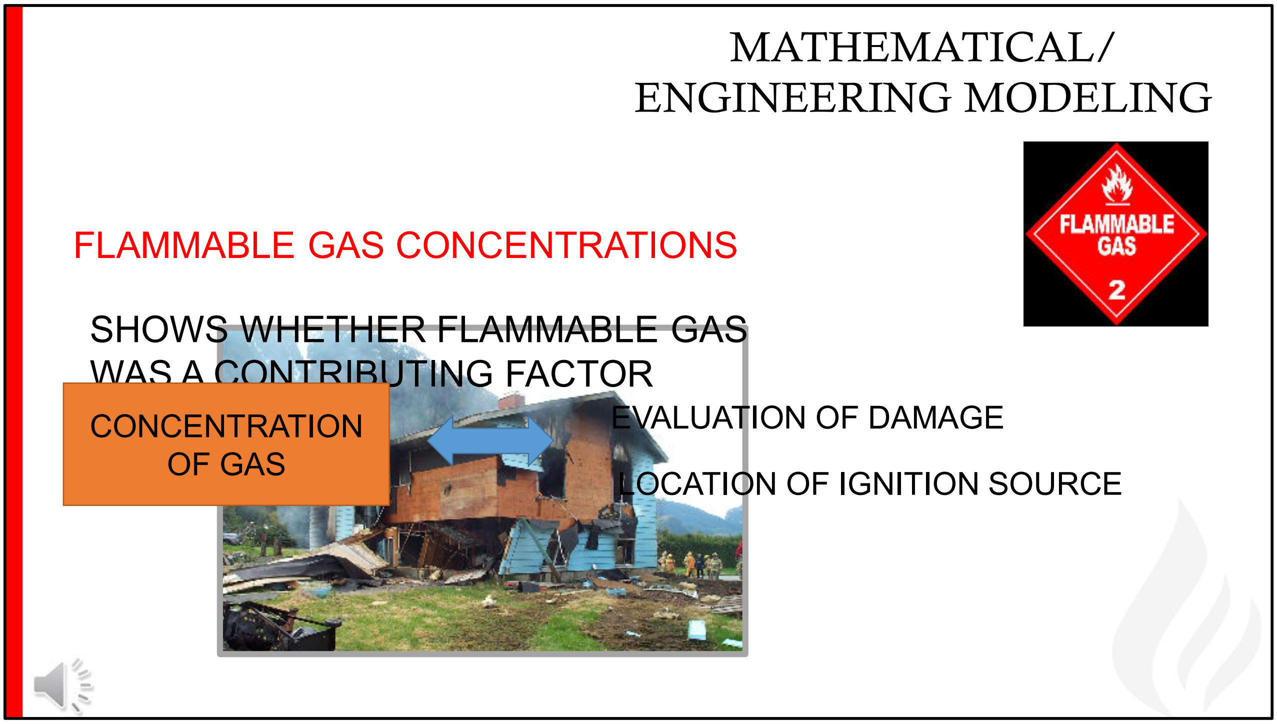
Finally, mathematical/engineering modeling should only be conducted by trained professionals with the relevant expertise.



The following are a few examples of the kind of mathematical/engineering modeling analysis techniques used in fire investigation:

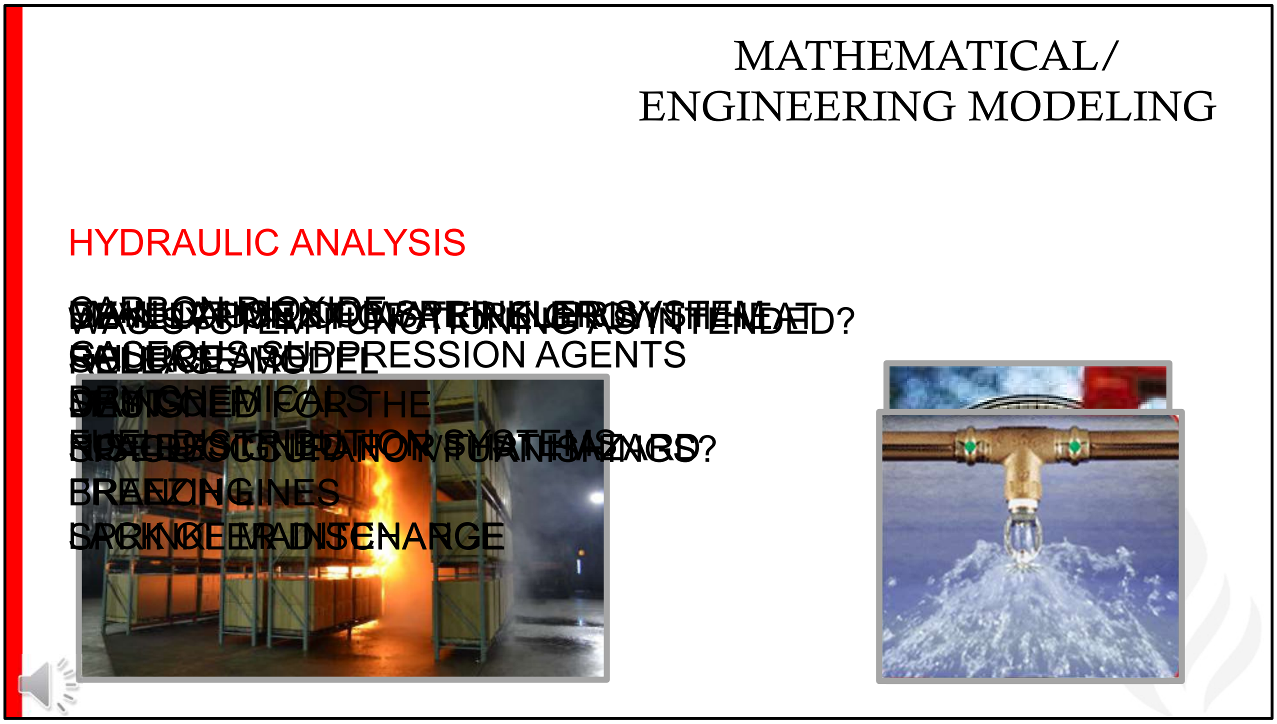
Heat Transfer models attempt to determine what kind of heat transfer took place in order for the fire to have ignited and then to propagate. Was it by conduction, convection or radiation?
This kind of analysis is useful in determining whether or not a possible ignition source was actually capable of starting the fire. It can also help explain how secondary fuels ignited, how the heat was transferred through the building, and how the fire spread to another building.

These photos show the start of a fire that eventually destroyed a number of homes in a new neighborhood.



Flammable Gas concentration analysis can show whether or not flammable gas was a contributing factor in the chain of events that led to the fire or explosion. This is done by calculating the concentration of gas within a given space combined with an evaluation of the fire or explosion damage and the location of possible ignition sources. The source of the gas or fuel vapour must be identified and if a leak is suspected where the leak is located in relation to ignition sources.

The vapour must be within the flammable limits to ignite. In this case, ten pounds of propane was released into the basement and ignited resulting in the damage seen in this photograph.



Hydraulic analysis comes into play when a building is equipped with a sprinkler system. Was the system functioning as intended? Was the design tailored to the space, the occupancy classifications and the building contents? In order to answer these questions, an analysis of the sprinkler system and its water supply is required. This involves a detailed examination of the system to see whether everything was working as it should as well as evaluating why the sprinkler system did not control the fire as it was intended.

It also requires an evaluation of the water supply, from the source, through the mains, risers, and branch lines to the sprinkler discharge.

It could also include the development of a fire growth or heat release model to see whether or not the sprinkler was effective in dealing with certain scenarios.

The main causes of sprinkler system failure are the system was shut off, the system was not designed for the hazard being protected, freezing, and lack of maintenance.

Hydraulic analysis is not limited to water systems; it can also be used for carbon dioxide, gaseous suppression agents, dry chemicals and fuel distribution systems.

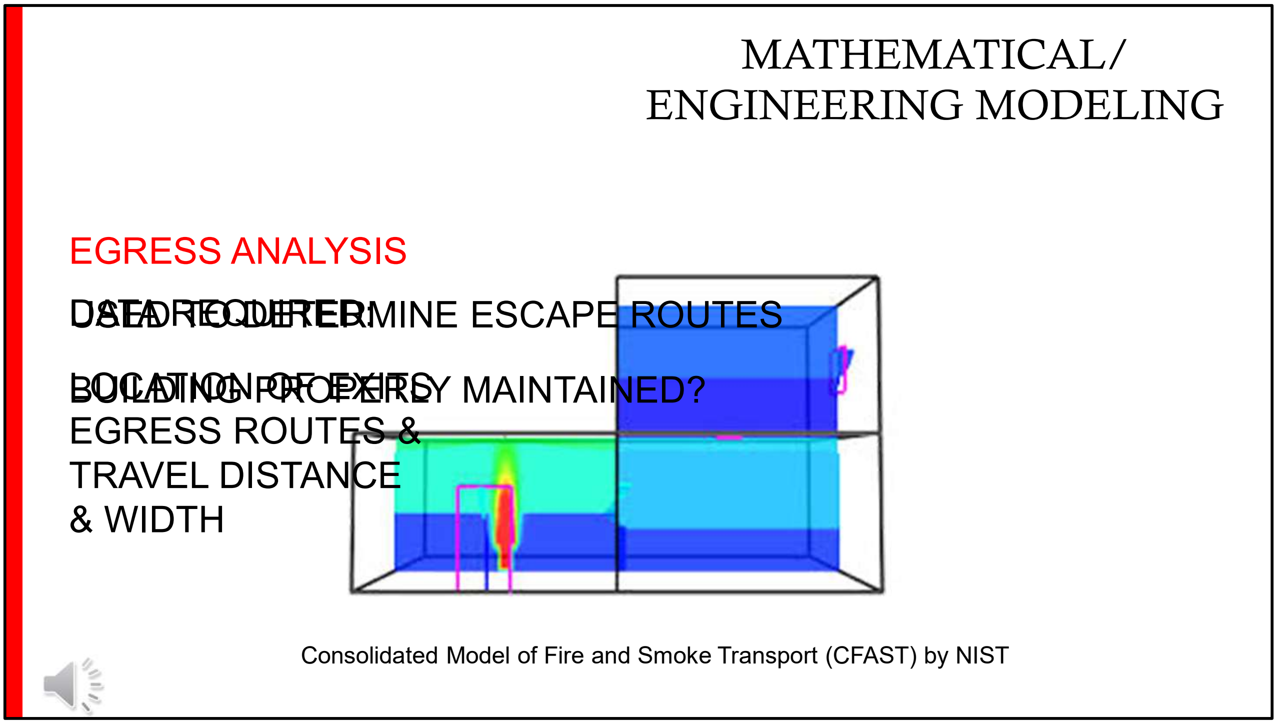
MATHEMATICAL/ ENGINEERING MODELING

STRUCTURAL ANALYSIS

THE STUDY OF THE BUILDING

MAY PINPOINT POINT OF IMPACT

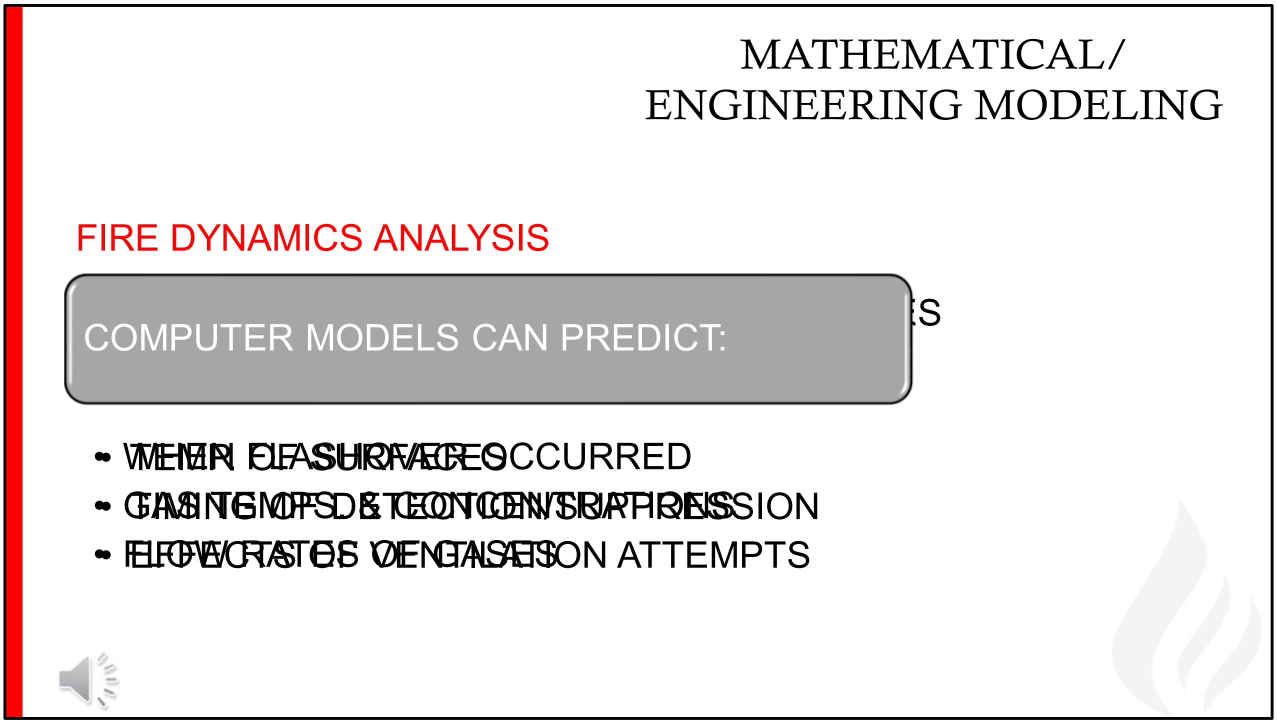
Structural Analysis refers to the study of the actual building. This is very useful in shedding some light on why it might have collapsed at any given point during the fire or explosion. It can also help pinpoint where the fire had the most impact on the structural integrity of the building, thus causing it to collapse.



Egress analysis is used in the case of bodily injuries and death to determine at what point the escape routes and fire safety plans of the building failed. Was the building properly maintained and the fire exits kept clear, well marked and accessible? In order to conduct an egress analysis a fire investigator needs the following data:

- The location of exits,
- Egress routes and
- Their travel distance, as well as
- Their widths

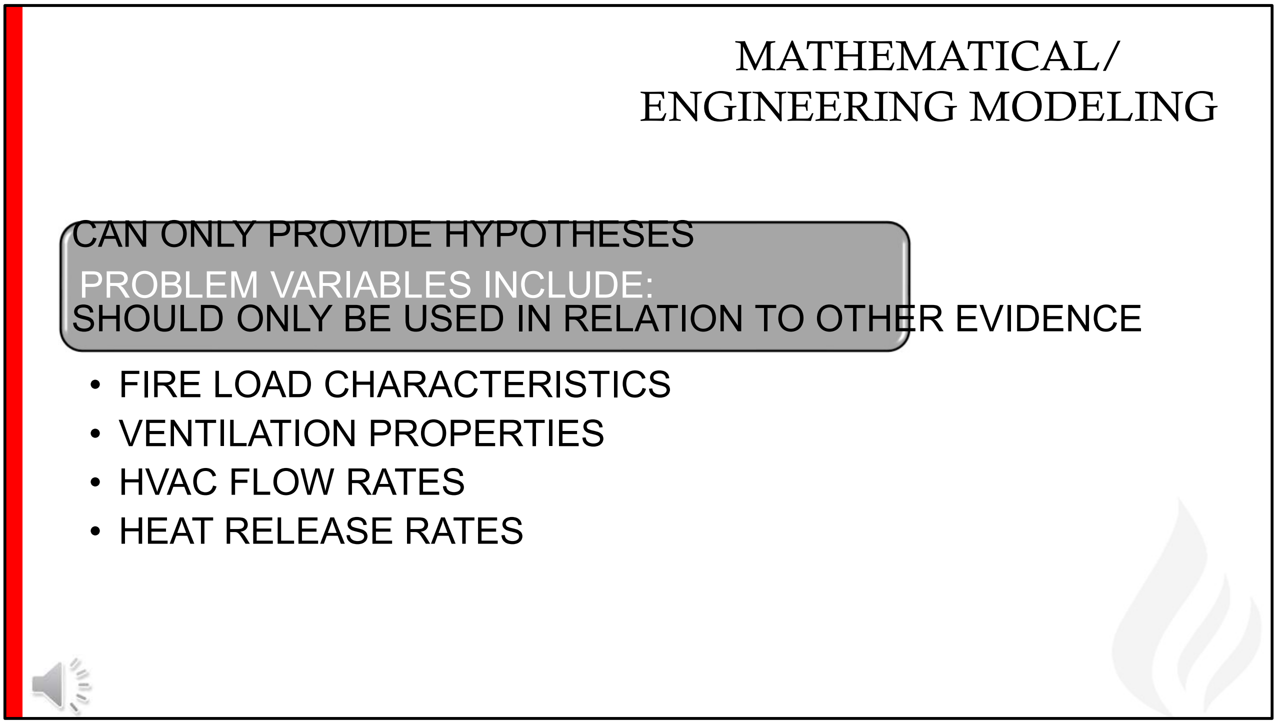
The National Institute of Standards and Technology (NIST) has computer programs like the Consolidated Model of Fire and Smoke Transport (C-FAST) to help model the egress data.



Fire dynamics analysis assesses fire origin and cause hypotheses. As part of the process it can also assess the validity of physical and eyewitness evidence. There are a number of ways fire dynamics analysis can take place, from hand calculations to computer models.

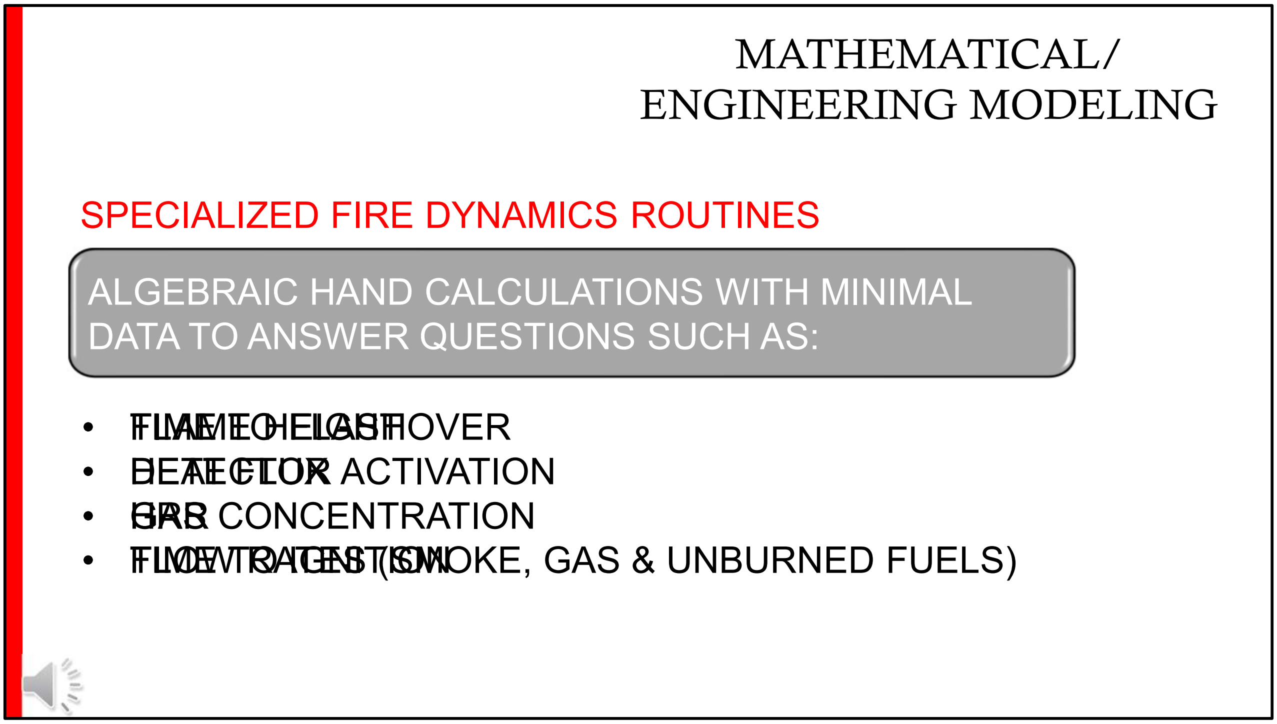
The computer models can help gain a clearer picture of the fire's growth and spread. They use established mathematical equations to predict certain factors related to a fire incident including:

- How long until flashover occurred,
- What were the gas temperatures and/or concentrations, and
- the flow rates of those gases
- How hot were the interior surfaces,
- How long did it take for the fire detection and suppression devices to engage, and
- What were the effects of any ventilation attempts such as opening doors and windows



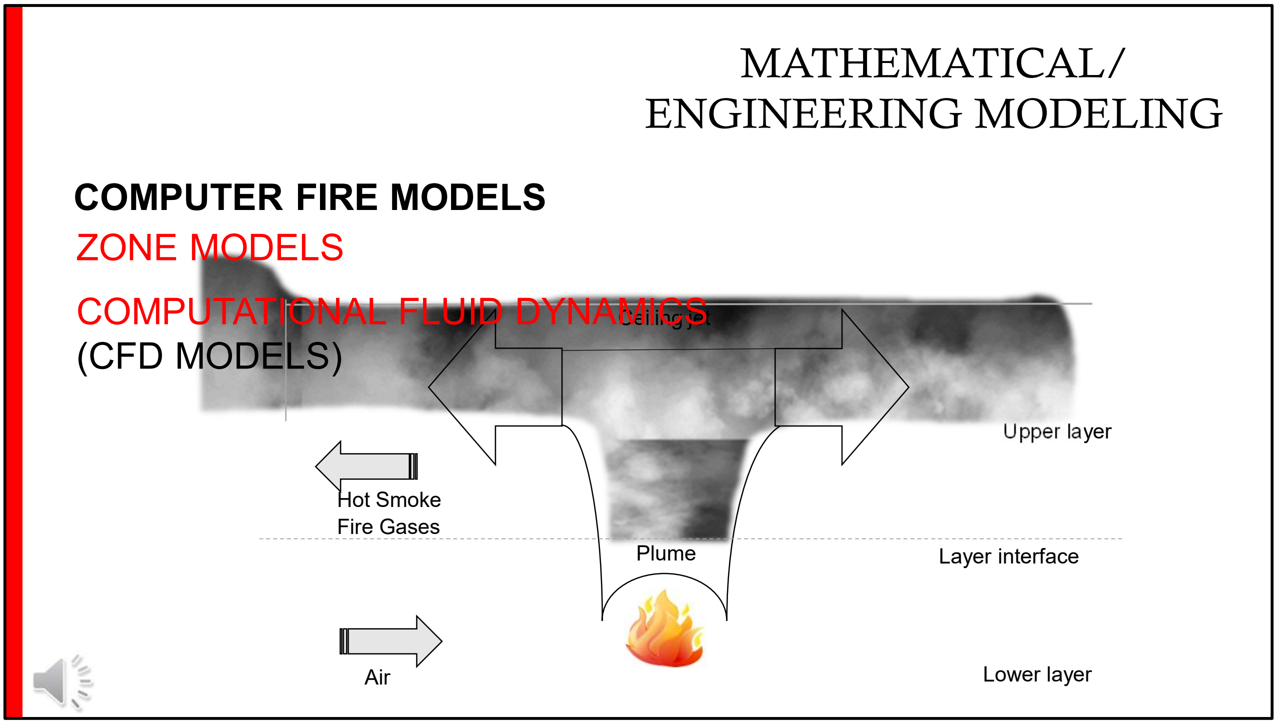
It is important to remember that this kind of analysis can only provide hypotheses and should only be used in relation to other information gathered during the investigation. In fire dynamics there are a number of variables that can cause uncertain results such as:

- Fire load characteristics,
- The ventilation properties and conditions (for example the size of the windows and whether they were open or closed),
- HVAC flow rates and
- Heat release rates.



A specialized fire dynamic routine frequently uses simple, algebraic hand calculations with minimal data input in order to answer a very specific question. These could include:

- Time to flashover
- Heat flux
- Heat release rate
- Time to ignition
- Flame height
- Detector activation
- Gas concentration, and
- Flow rates of smoke, gas and unburned fuels



The two main types of computer models used in fire dynamics analysis are **Zone models** and **Computational Fluid Dynamics or CFD models**. Like all other computer models, they have their limitations— they function using certain assumptions which need to be considered when viewing the results.

Zone models can be run on a personal computer and are generally validated by fire investigation peers. They divide a compartment into a hot upper zone and a cooler lower zone and, assuming universal conditions throughout the zone, trace the expansion of the zones as the fire develops.

Julie- could you find an image like the grey one with red flames or could you make one? I could not find a royalty free one. We could ask the owner for permission to use it.

MATHEMATICAL/ ENGINEERING MODELING

COMPUTER FIRE MODELS

CFD MODELS

MORE COMPLEX

TIME CONSUMING & EXPENSIVE

SEVERAL SMALL CELLS

IRREGULAR GEOMETRIC SPACE

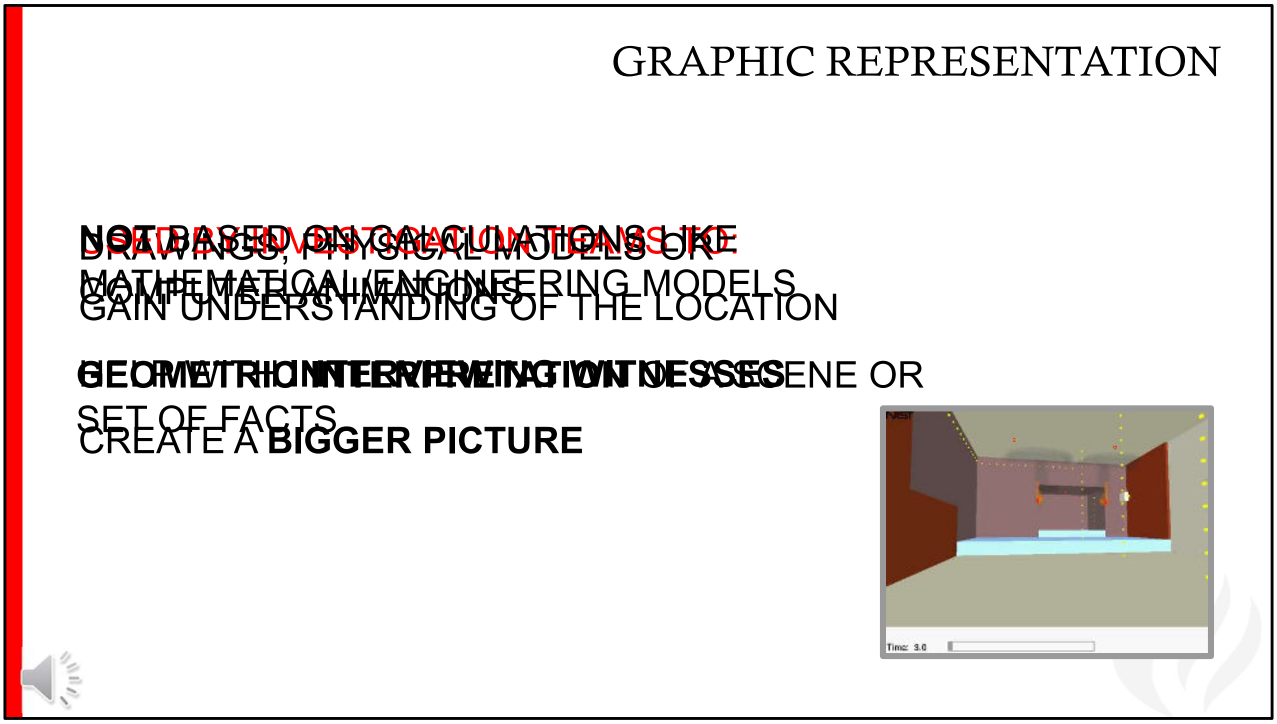
MULTIPLE CALCULATIONS

OR GRANULAR DATA REQUIRED

REQUIRES EXPERTISE

Computer Fire Models are more complex. They take a more granular approach than the zone models, dividing each compartment into several small cells. Many calculations happen in each cell and the results of the calculations in one cell affect the surrounding cells. This provides a more detailed analysis of the fire but also requires more expertise and large capacity computer programs. They are also time consuming and expensive. CFD models are most useful when analysing a fire in an irregular geometric space or where very granular data is required. CFD models are being used more and more frequently. This picture is taken from a NIST computer simulation which are available on their website.

Computer modeling is beyond the scope and resources of most fire investigators but more information on computer modeling is available in Chapter 21 of NFPA 921 which can be viewed at no charge on the NFPA website.



Graphic representations are another tool in the failure analysis toolbox. These can be any sort of drawing, physical models or computer animations (which are becoming more and more popular).

Computer programs like the NIST Fire Dynamics Simulator works with NIST Smokeview to create a visual interpretation of the data from the model results.

Graphic representations are often used by fire investigation teams for various reasons including:

- To gain a better understanding of the location of the fire,
- To help with interviewing witnesses, and
- To create a bigger picture of the materials and systems at play during a fire incident.

Graphic representations are not based on calculations like the mathematical/engineering models we discussed in the previous slides; they are founded on geometric interpretations of a scene or a set of facts.

- https://www.nist.gov/video/non-sprinklered-computer-model-stage-area-fire-dynamics-simulator-fds-and-smokeview

GRAPHIC REPRESENTATION

The following video shows the computer simulation done by NIST of the dynamics of a fire in a one-story restaurant that claims the lives of two firefighters.

https://www.youtube.com/watch?v=VkeiHwW5rCs&t=497s

FIRE TESTING

A WAY TO CHECK THE COLLECTED DATA & TEST HYPOTHESES

HELPS TO EVALUATE WORKING HYPOTHESES

PINPOINT:

CAN BE DONE IN THE FIELD OR A LAB

ORIGIN & CAUSE

SIMPLE OR COMPLICATED

FIRE GROWTH & DEVELOPMENT

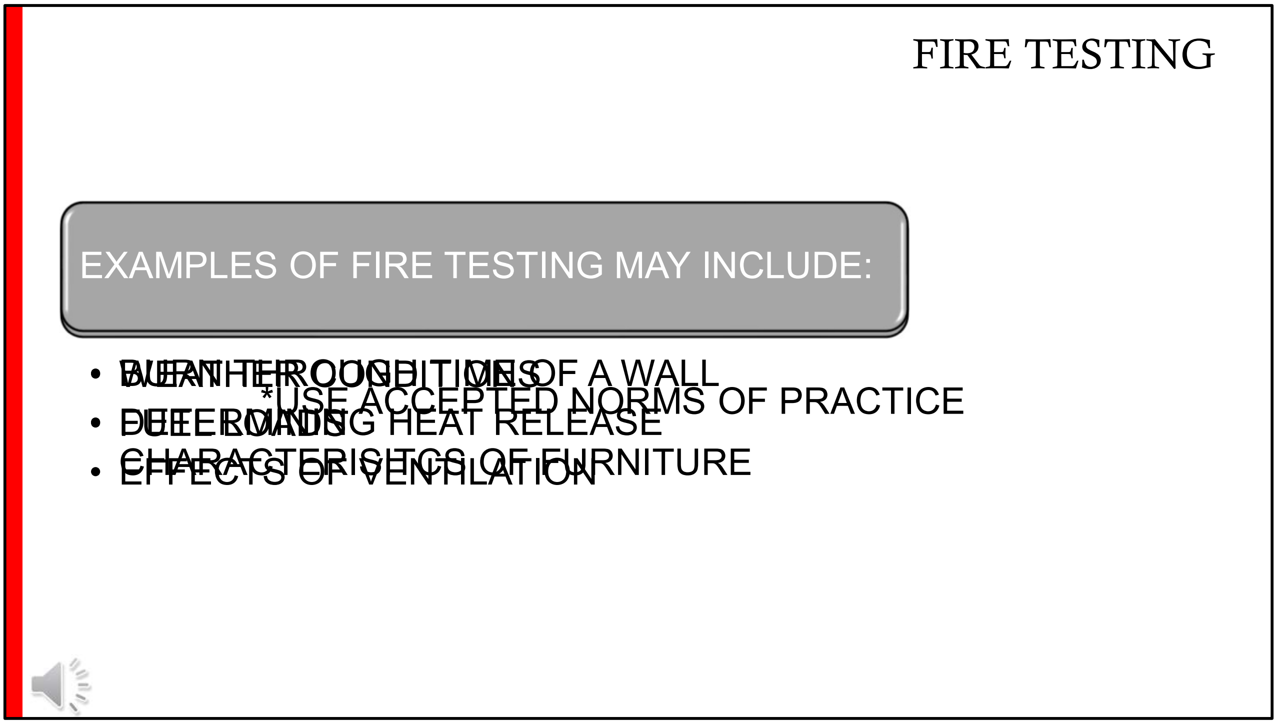
EFFECTS OF THE FIRE

* SHOULD NOT BE TAKEN AS FACT

Fire testing is a way to check the collected data and/or test hypotheses. It can be done in the field or in a lab, and be as simple as a bench test or as complicated as a full-size re-creation of the event.

Like all the models of analysis discussed in this chapter, fire testing helps to evaluate working hypotheses as well as pinpoint certain aspects of the fire such as origin and cause, fire growth and development combustion characteristics and the effects of the fire on the materials at hand.

However, it should not be taken as fact. The limits of fire testing are found in the uncertainties that arise due to the potentially different conditions that existed at the fire scene and the conditions existing during the re-creation or testing.



Among other things, the variables may include:

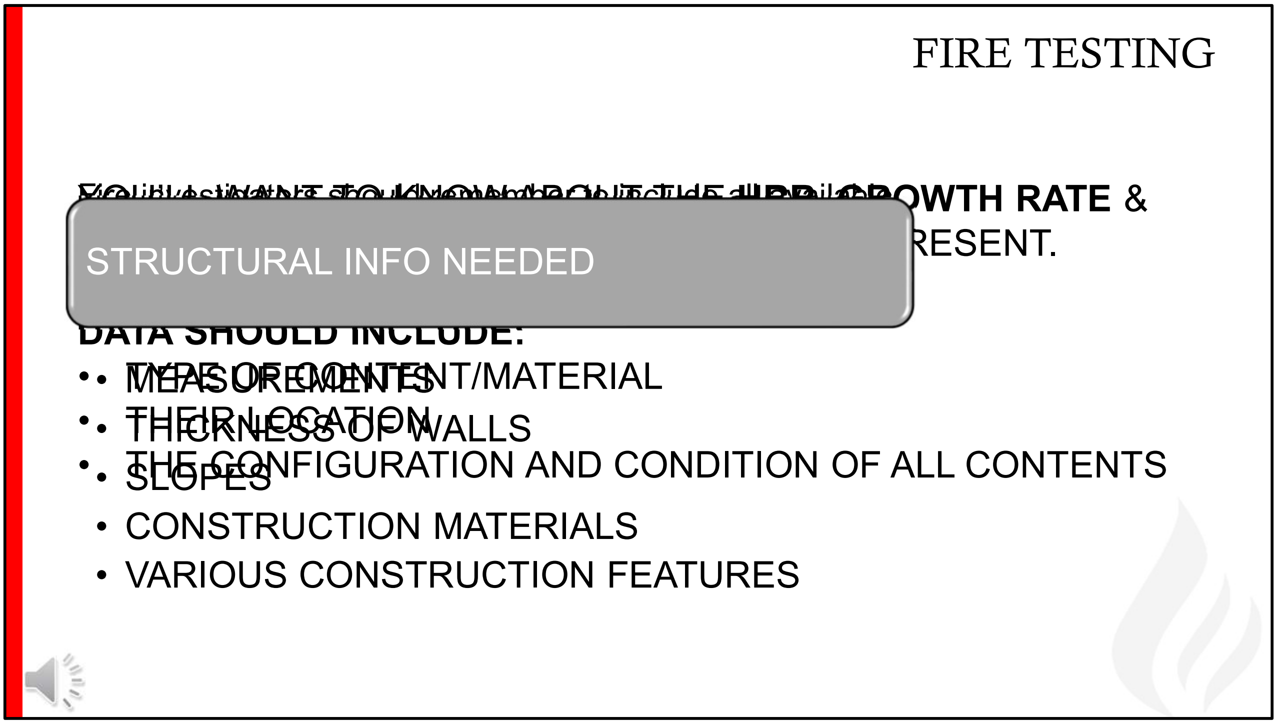
- Weather conditions,
- Fuel loads associated with contents and
- The effects of ventilation.

Because it is impossible to re-create exactly the conditions at a scene, there will inevitably be uncertainties in the results.

Having said this, using accepted norms of practice will go a long way in ensuring your testing has credible results.

Some examples of situations where fire testing would be applied include:

- Attempting to determine the burn-through time of a wall or
- Testing a piece of cushioned furniture in order to determine whether its heat release characteristics would make it a potential cause of fire growth.



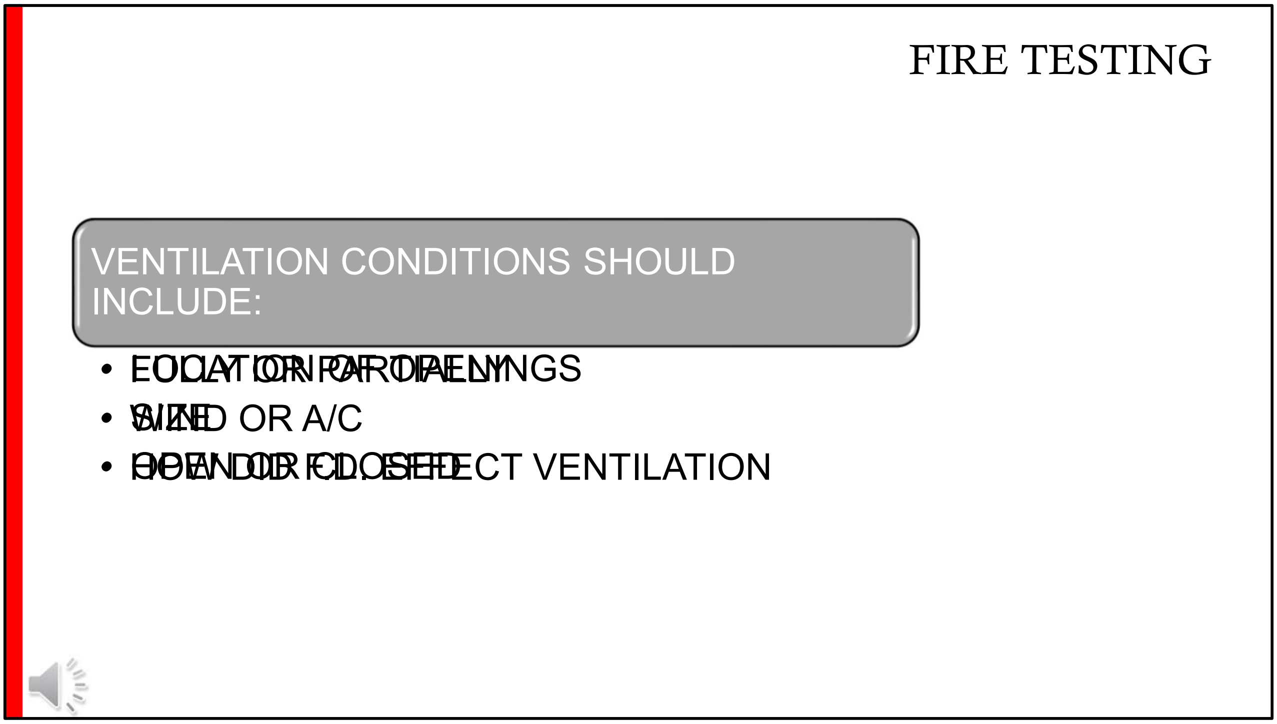
A post fire analysis is only as good as the accuracy of its input data.
Fire investigators should remember to include all available information on the building's structure, its materials and contents as well as its ventilation.

In terms of structural information, make sure to have available:

- The length, width, and height of the rooms and buildings,
- The thickness of the walls,
- The slopes of floors and/or ceilings,
- The construction materials and
- The various construction features.

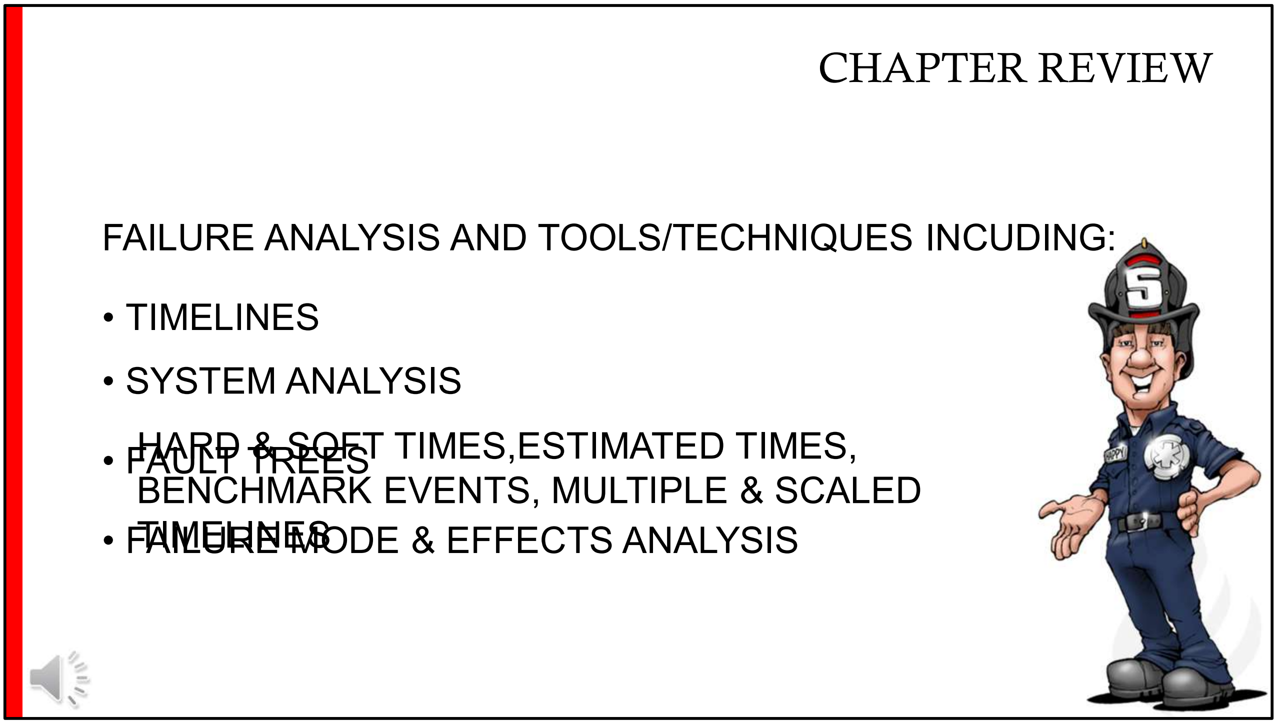
When considering materials and contents, investigators want to know about the heat release rate, the fire growth rate and the total heat released of all materials present.
Therefore any data regarding materials and contents should include:

- The type of content or material,
- Their location as well as
- The configuration and condition of all contents.

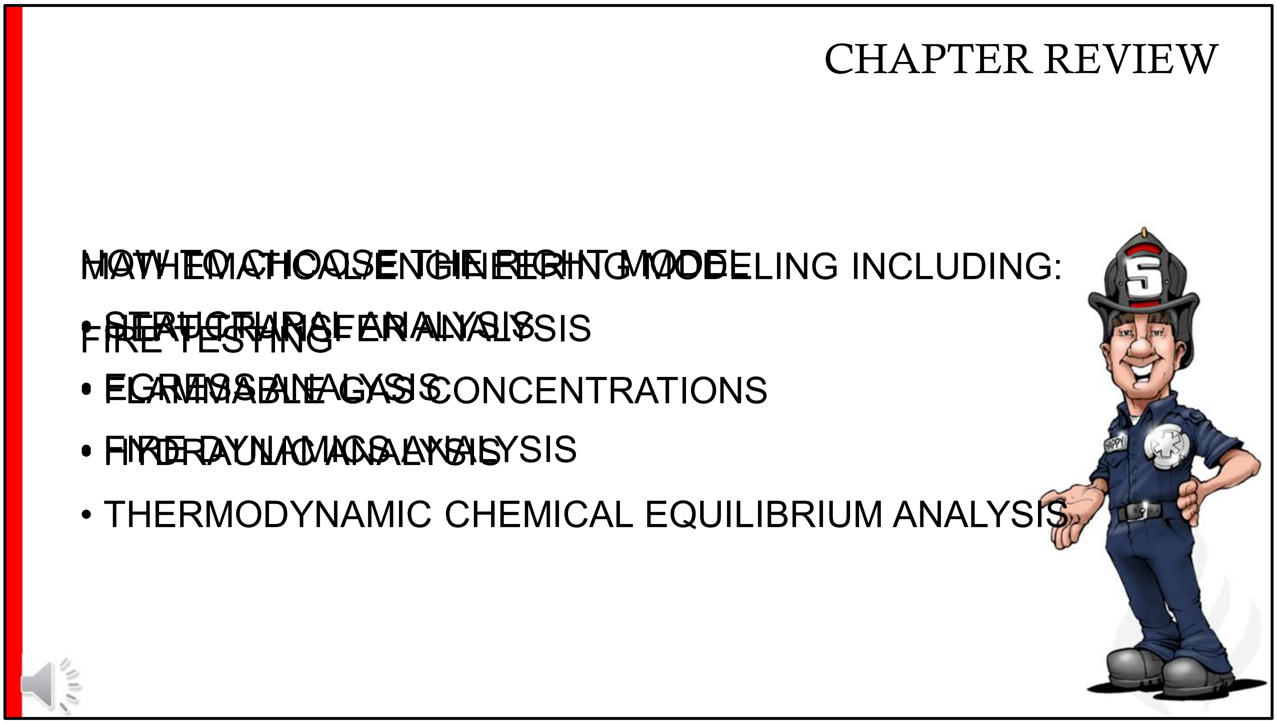


Remember to list any and all information about the ventilation conditions including:

- The location of openings,
- Their size,
- Whether they were open or closed and then
- Whether they were fully open, partially open or closed,
- Was there a wind that day or was the air conditioning on and finally,
- How did the fire department operations affect the ventilation conditions?



- The definition of failure analysis and some of the tools and techniques used in it including:
  - Timelines and what is meant by hard and soft times, estimated times, benchmark events, multiple and scaled timelines,
  - Systems analysis,
  - Fault trees,
  - Failure mode and effects analysis



- Mathematical/engineering modeling including:
  - Heat transfer analysis
  - Flammable gas concentrations
  - Hydraulic analysis
  - Thermodynamic chemical equilibrium analysis
  - Structural analysis
  - Egress analysis
  - Fire dynamics analysis
- How to choose the right model, and finally
- Fire testing.

END OF CHAPTER 15 PART 1

PLEASE MOVE ON TO PART 2

That's the end of **Part 1 of Chapter 15, Analyzing the incident**. You're ready to move on to **Part 2 of Chapter 15 which deals with Incendiary Fires**, but please complete the unit quiz first. If you have any questions now is a good time to contact your teacher.