

# Frequency of Challenging Fires

by

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# Topics for Discussion

- ◆ “Frequency of Challenging Fires” task
  - Goals
  - Suggested improvements
  - Comparison with current approach
- ◆ Lessons learned from examination of challenging fire initial phase scenarios

# Goal of Frequency of Challenging Fires Task

- ◆ Develop a *practical, mechanistic*, improved methodology for defining, characterizing, and quantifying the frequency of nuclear plant fire scenarios

# Why Do We Want a New Method?

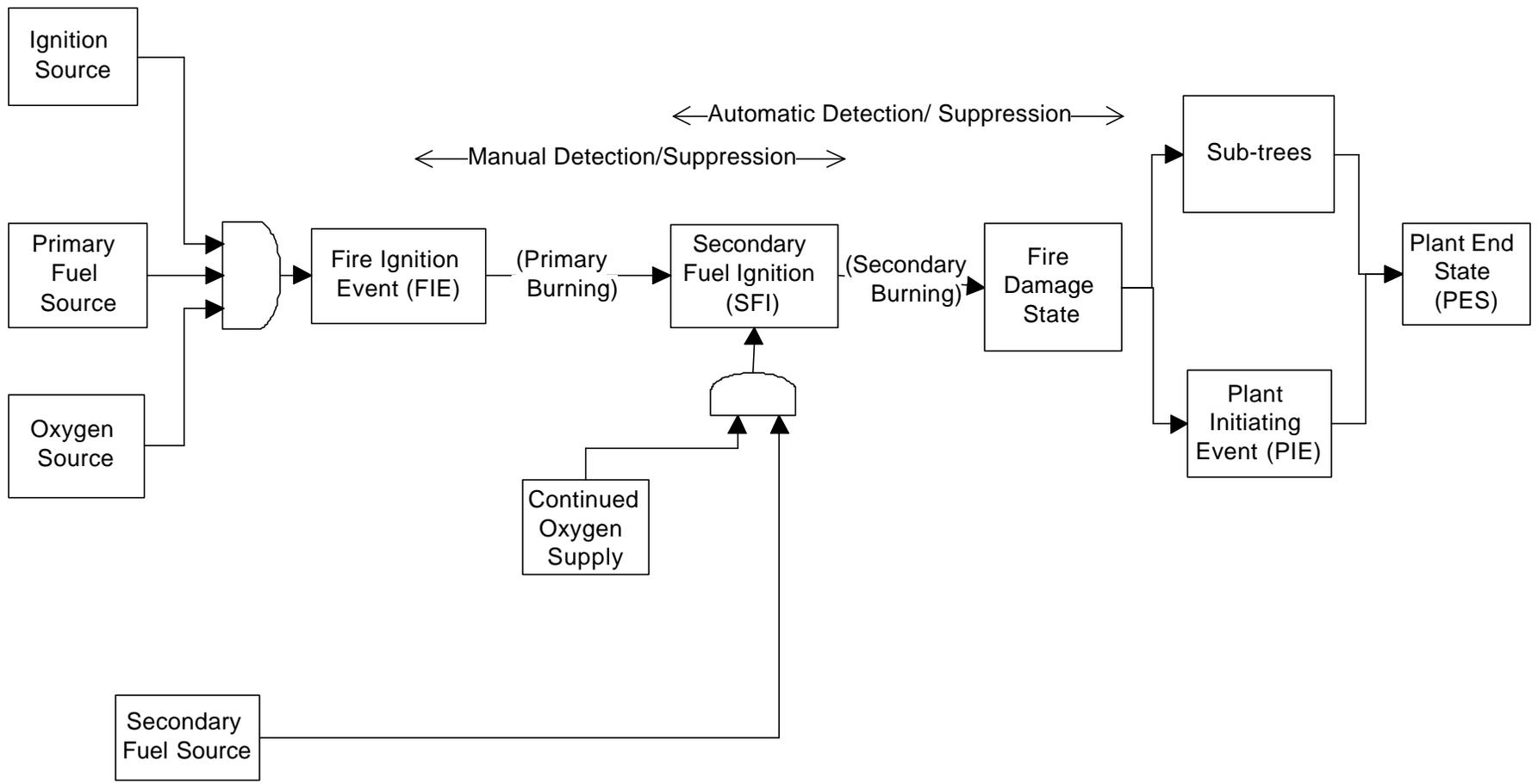
- ◆ To provide a mechanistic link between fire initiation and subsequent fire modeling
  - Current methods imbed this link in the “severity factor” and pilot fire assumptions
- ◆ The mechanistic approach is intended to eliminate or control optimistic and pessimistic assumptions, improve realism, and enhance clarity
  - Model how ignition occurs and progresses to burning a large source of fuel
  - Treatment of uncertainties is inherent in the approach (avoid “fallacy of the best estimate”)

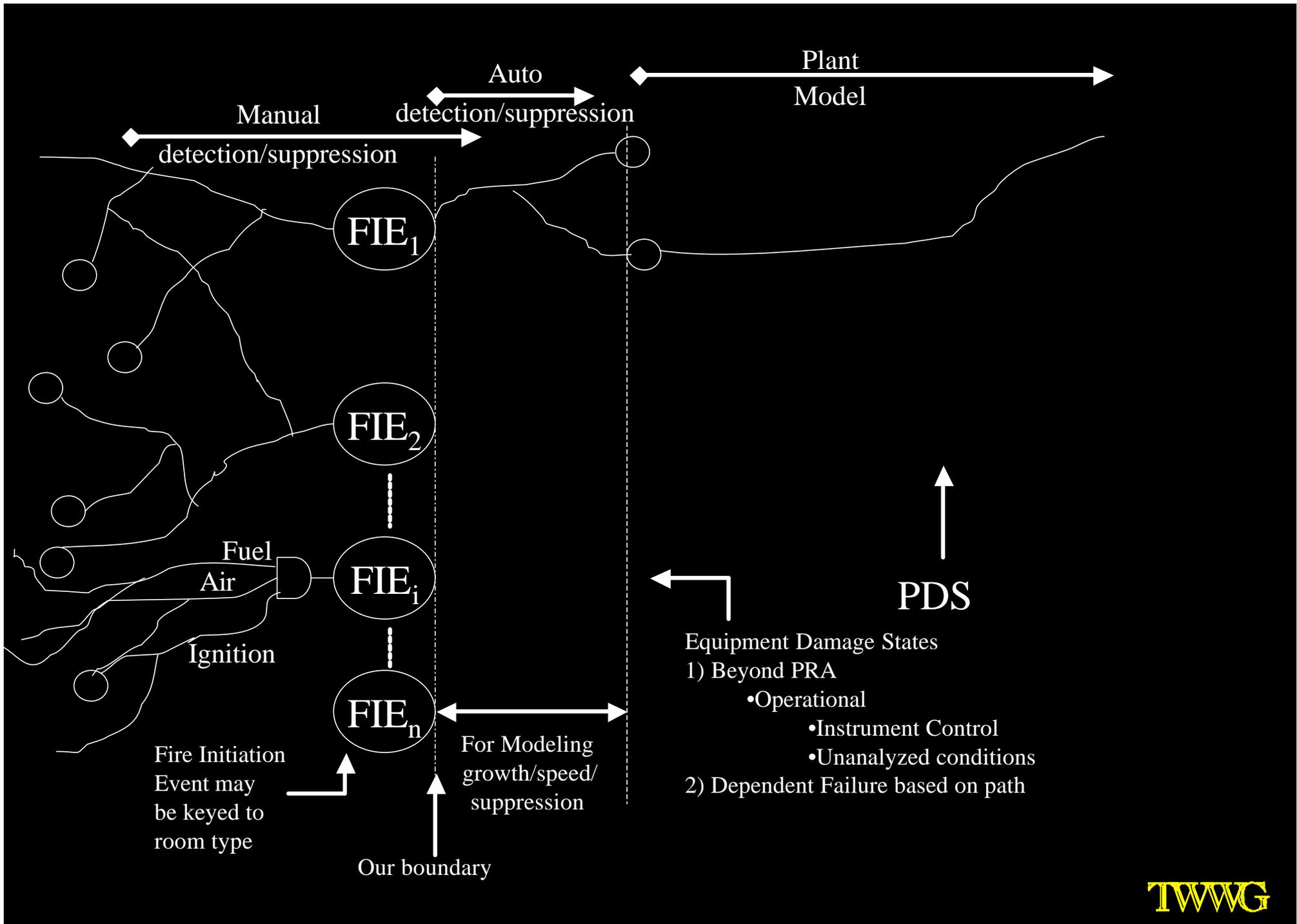
# Process for Modeling Fire Initiation

- ◆ Define fire initial phase scenarios (FIPS) applicable to a given location in a plant, with well-defined characteristics specified in terms (probability distributions) that will support subsequent fire modeling
- ◆ Define an approach for adapting current data to the new model using expert judgment. Define a path to improved data collection to better support the new models.

# Comparison with existing approach

- ◆ Overall FRA model
- ◆ What is changing:
  - $\phi_{IE} \times$  (Severity Factor) versus  $\phi_{FIPS}$ 
    - ❖  $\phi_{IE} \times$  SF focus is on stylized “best estimate” pool fire
    - ❖  $\phi_{FIPS}$  focus is on uncertainty in 3-D HRR for particular FIPS
- ◆ Uses of data
  - Identify FIPS
  - Quantify FIPS
  - Compare challenging fires versus all fires





# Classes of FIPS

Class 1	ignition source → primary fuel → secondary fuel	large fire:  flames heat smoke toxic gases
Class 2	high energy ignition source → large fuel source	
Class 3	dispersed air/fuel mixture → ignition source → deflagration (→ secondary fuel)	
Class 4	dispersed air/fuel mixture → ignition source → detonation (→ secondary fuel)	

# Development of FIPS

- ◆ Catalog of generic FIPS
- ◆ Method for developing new FIPS
- ◆ Plant-specific analyses
  - Adapt generic FIPS
  - Develop new FIPS
- ◆ Plan – collect results of new FRAs to expand catalog of generic FIPS

# Data Categories for Fires

- ◆ Data collected by “large component groups” within room types
- ◆ Implicit assumptions
  - All members of LCG within RT are equally likely to burn
    - ❖ within RTs across plants
    - ❖ with sub-room within RT
  - Equivalent to
    - ❖ all members of LCG in RT are equivalent
    - ❖ within RT, frequency is independent of location
- ◆ Implication: subdivide RTs and LCGs as far as necessary to make assumption true

# Quantification

- ◆ Evidence for frequency
  - Industry data for prior,  $\phi_{\text{Prior}}$ 
    - ❖ Can use as is for now
      - Routine cases – adjust data among categories judgmentally\*
      - Big fires – perform expert elicitation to interpret available data\*
    - ❖ Can develop as wanted in future data\*
  - Plant-specific data for Bayesian updating
  
- ◆ Evidence for heat release rate (HRR)
  - EPRI/Sandia experiments/data
  - Elicitation\*
  - Experiments

\* NRC/EPRI may cooperate for these cases

# Lessons Learned from Examination of Challenging Fire FIPS

- ◆ Electrically induced multiple (often simultaneous) fires are much **more heavily represented in challenging fires than in the general fire database**
- ◆ Self-ignited cable fires all involved power cables
  - Low cable rating
  - mechanical damage
  - excessive current due to other electrical faults
- ◆ Few transient fuel challenging fires, but staging for outages may be increasing exposure

# Lessons Learned (continued)

- ◆ Room-to-room fire propagation observed
  - FSU plants – doors left open or cable penetrations not sealed
  - US plants – fire barriers failed in vertical cable trays
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  - FSU plants – doors left open or cable penetrations not sealed
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- ◆ Most large NPP fires occur in turbine building
- ◆ Three fires where suppression system was defeated by sheer magnitude of fire
  - Turbine building, large oil-filled transformers, areas where large quantities of flammable liquid stored
- ◆ A number of fires affected multiple safety trains

# Lessons Learned (continued)

- ◆ Effects of fire and smoke on plant operators not well documented or analyzed
  - Operators have ensured available cooling path, when significant degradation in performance occurred
  - Damage to non-safety related control systems may create cognitively challenging situations for operators
  - Smoke can seriously affect operators and fire fighters
  - Ex-control room actions and control room evacuation procedures can be challenging
  - Confusion in “proving” a fire exists and methods for suppression have delayed suppression and caused confusion
  - Response implementation can be complicated by fires

# Lessons Learned (continued)

## ◆ Shipboard fires

- Rapid spread of fire through dust in ventilation ductwork
- Invisible spread of fire along temporary cables run through ductwork
- Direct heating of propulsion systems digital control system from fire in ventilation duct caused permanent control system failure; dead in water
- Spray of oil onto hot equipment caused major fire (maintenance/temporary fix failed)

# Lessons Learned (continued)

## ◆ Observations from the fire database

- There are very few automatic suppression cases in the database; almost all were detected by humans
- Fires detected by sensors are almost all manually suppressed
- Three cable spreading room fires in database; two are among the few automatically suppressed
- Switchgear fires all small except two medium
- Eight control room fires in database; all extinguished by humans
- A number of fires in the database are indicated as explosions
- Many welding initiated fires, including a few at power; all extinguished by attending personnel

# Conclusion

- ◆ Certain factors not generally modeled in FRA need to be considered
- ◆ Inclusion can be either explicit or implicit in the quantification of uncertainty
- ◆ Full-scale applications are needed