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**RISK-BASED
SPACECRAFT FIRE SAFETY EXPERIMENTS**

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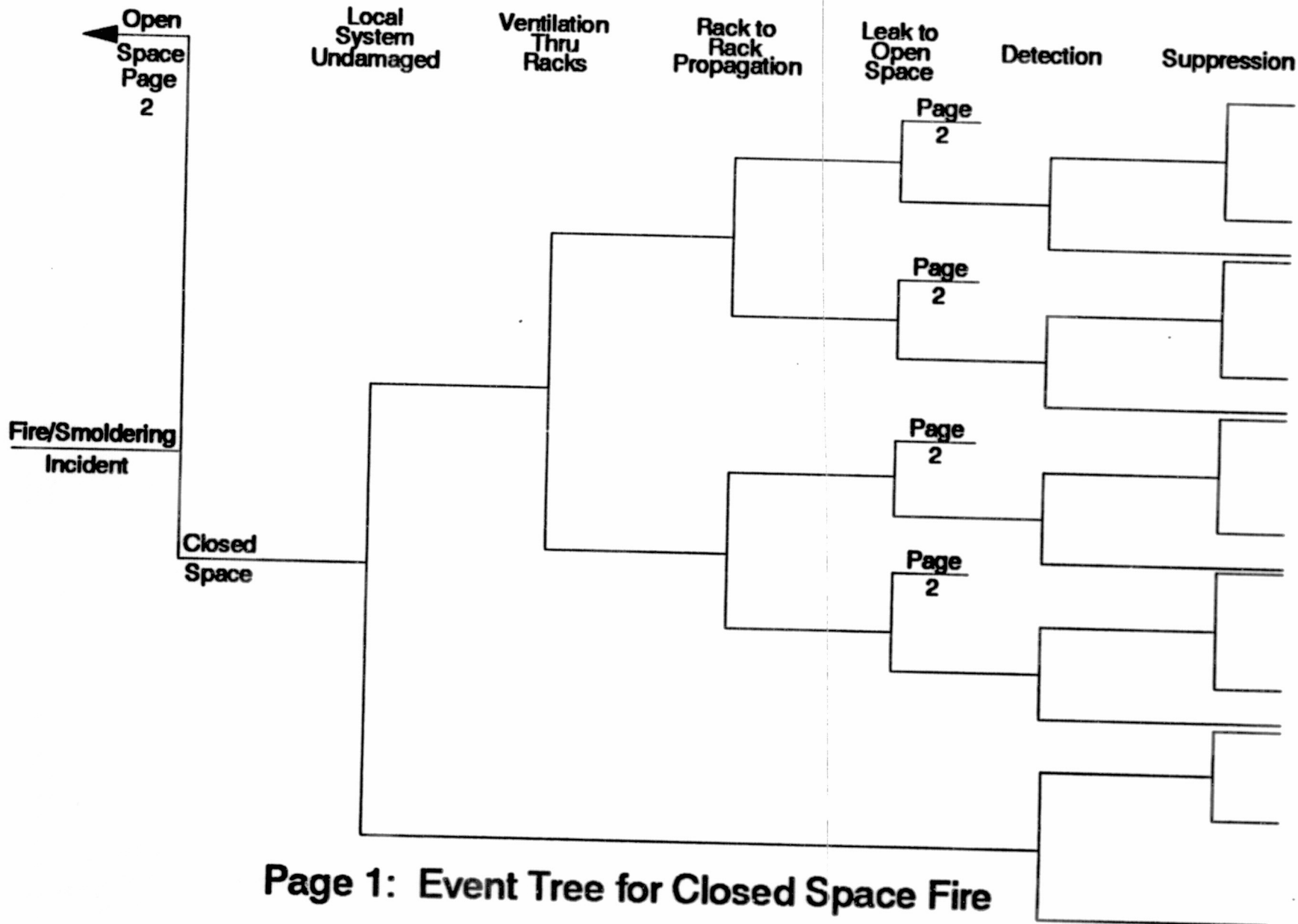
PROBABILISTIC RISK ASSESSMENT APPLIED TO FIRE SAFETY

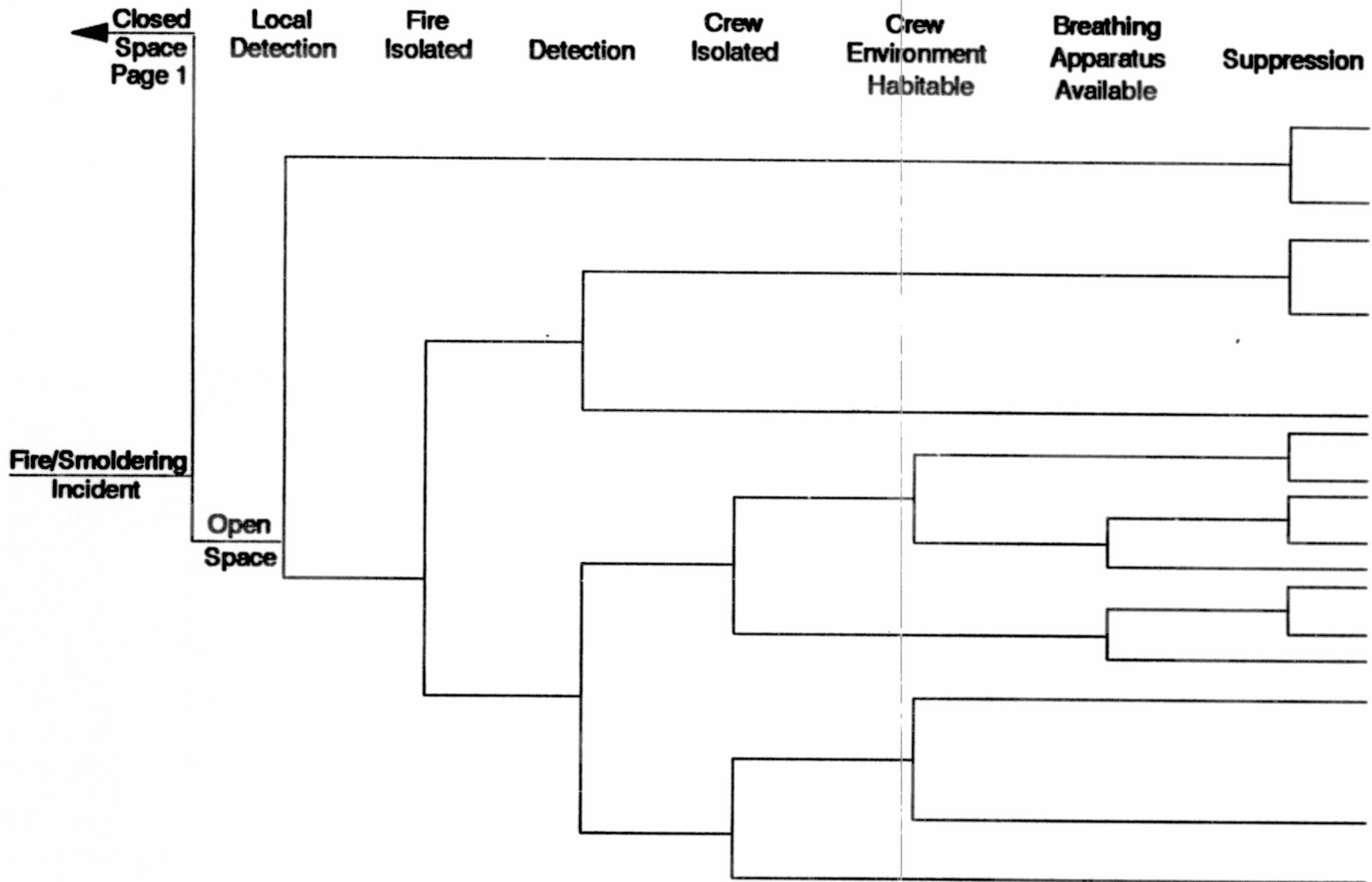
Spacecraft fire risk can never be reduced to a zero probability.

Probabilistic risk assessment is a tool to reduce risk to an acceptable level.

MAJOR STEPS:

1. Identification of "critical" locations and the assessment of the frequency of fires: overheating, spills, smoldering, ignition, etc.
2. Estimation of the fraction of fires that can lead to damage of specified components: fire growth time and the competing detection and suppression times
3. Estimation of the fraction of fires that can lead to mission damage





Page 2: Event Tree for Open Space Fire

$$\lambda_{\text{loss}} = \sum \lambda_j Q_{d/j,k} Q_{\text{loss } d/j,k}$$

λ_{loss}	frequency lost
λ_j	frequency of class j fires
$Q_{d/j,k}$	fraction of class j fires that lead to damage of the k th critical system
$Q_{\text{loss } d/j,k}$	fraction of class j fires leading to damage of the k th system that cause the loss of the spacecraft

$$Q_{d/j} = \text{Fr} [T_G < T_H / \text{fire}]$$

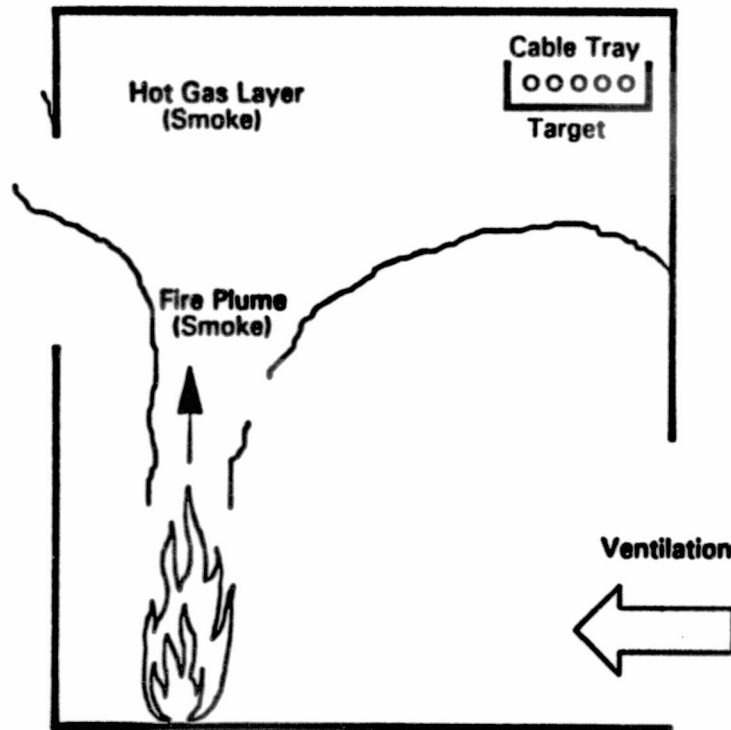
T_G	growth time
T_H	hazard time

$$T_H = T_f + T_d + T_s$$

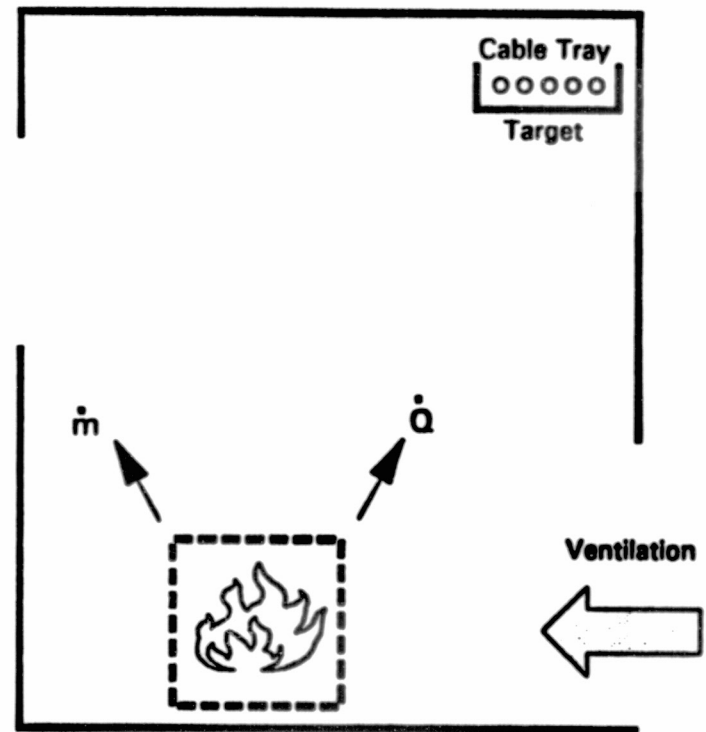
T_f	time to detection
T_d	detector response time
T_s	suppression time



Source - Transport - Deposition



Terrestrial



Microgravity



Fire Safety Assessment

Target Identification

Crew
Station System

Damage Time

Modes Identification

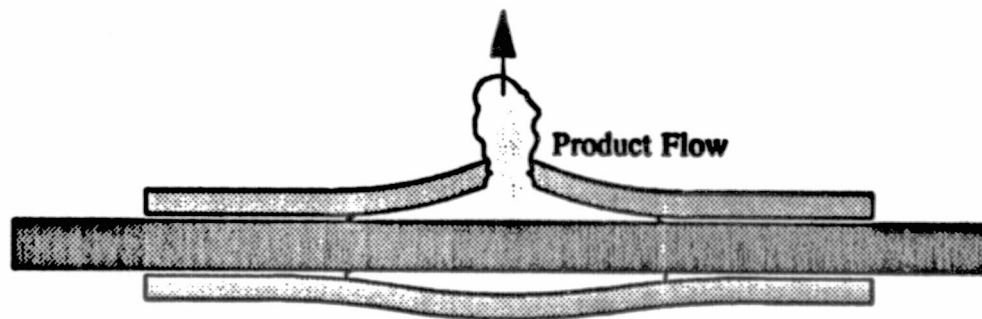
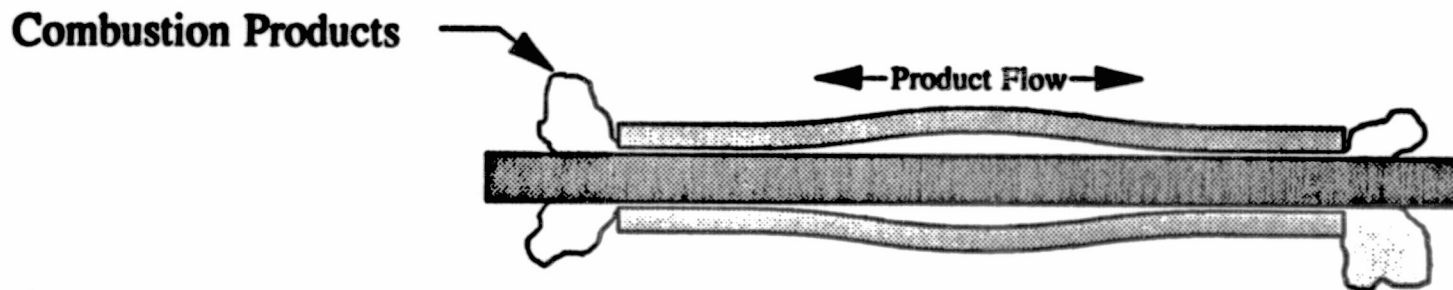
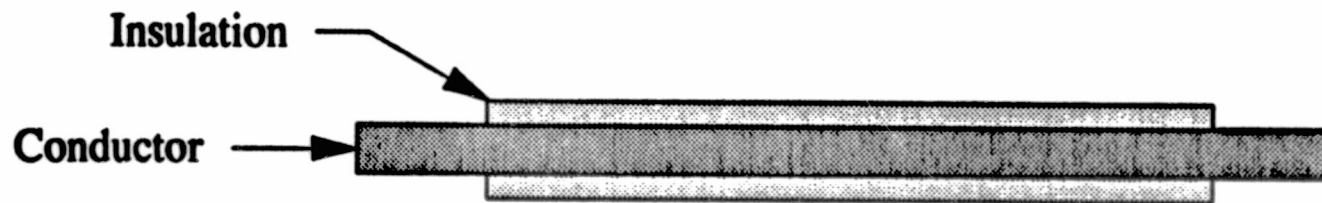
Heat
Smoke
Toxins

Detection &
Suppression Time

Event Description

Source
Transport
Deposition

Wire Overload Phenomena





Source



Transport



Deposition

Damage Modes

Tests

Models

Heat Release	temperature measurements	f(T)
Smoke Release	obscuration, TEM grids	f(T)
Toxin Release	IR/Mass spec. (White Sands), sampling	f(T)
Heat Transport	temperature measurements	fluid flow, temp., etc
Smoke Transport	TEM grids/visualization	fluid flow, temp., etc
Toxin Transport		fluid flow, temp., etc
Adjacent Wire Damage	pairs, bundles	heat release, qualitative
Particulate Deposition	TEM grids	TBD
Corrosivity	thin copper target plate	qualitative



NASA Lewis 2.2 sec Drop Tower

Sample Materials

PTFE - Teflon
[-CF₂-CF₂-]

Interior wiring

Smoke Production

Toxic Production

Acidic Production

Combustible Production

ETFE - Tefzel
[-CF₂-CH₂-]

Exterior wiring

Bundles

Interior/Exterior

Twisted Pairs

Interior/Exterior

+ Adjacent Wire Damage

PTFE

Polytetrafluorethylene

Thermal Degradation Products

