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.

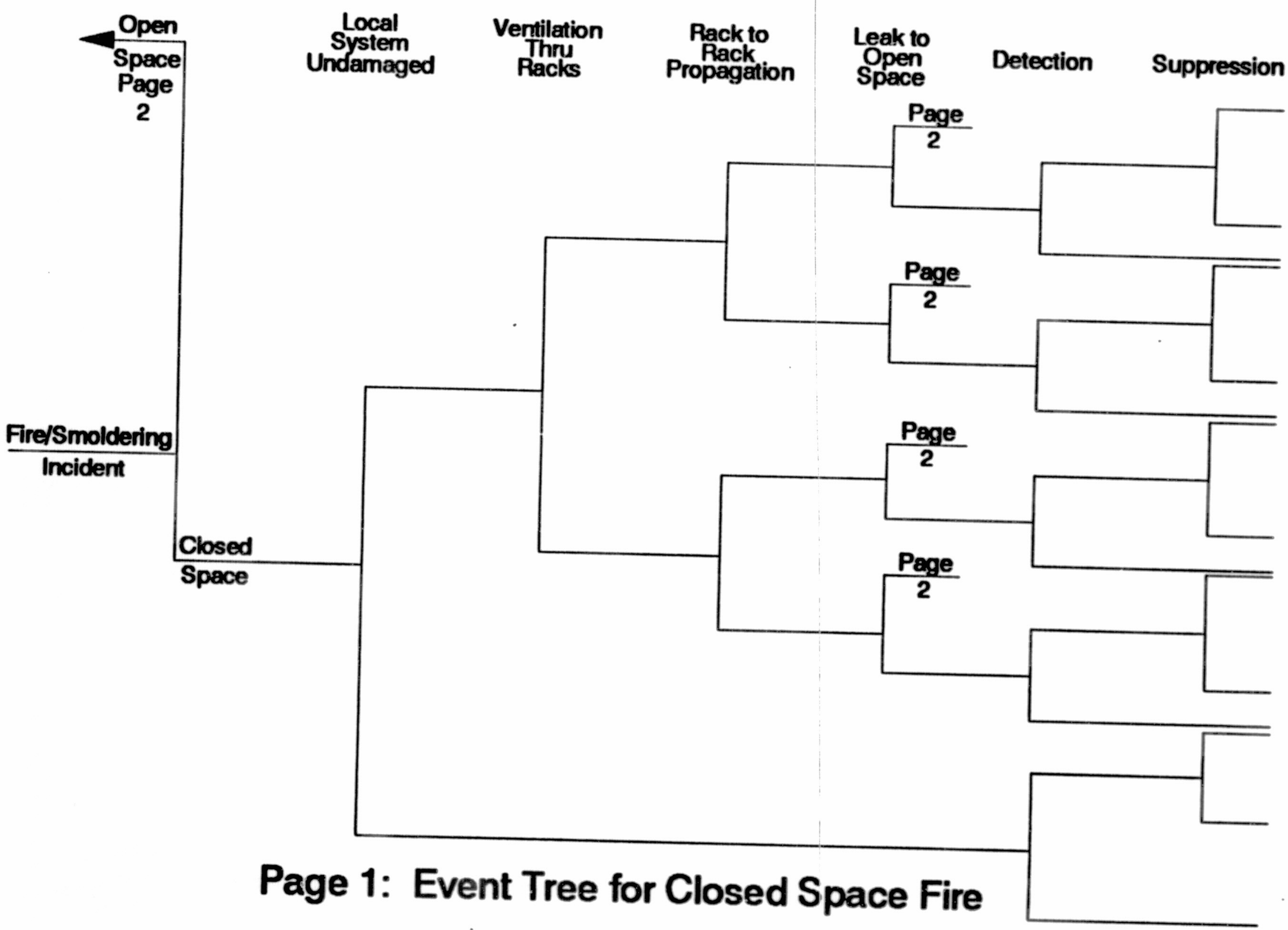
Probabilistic risk assessment is a tool to reduce risk to an acceptable level.

MAJOR STEPS:

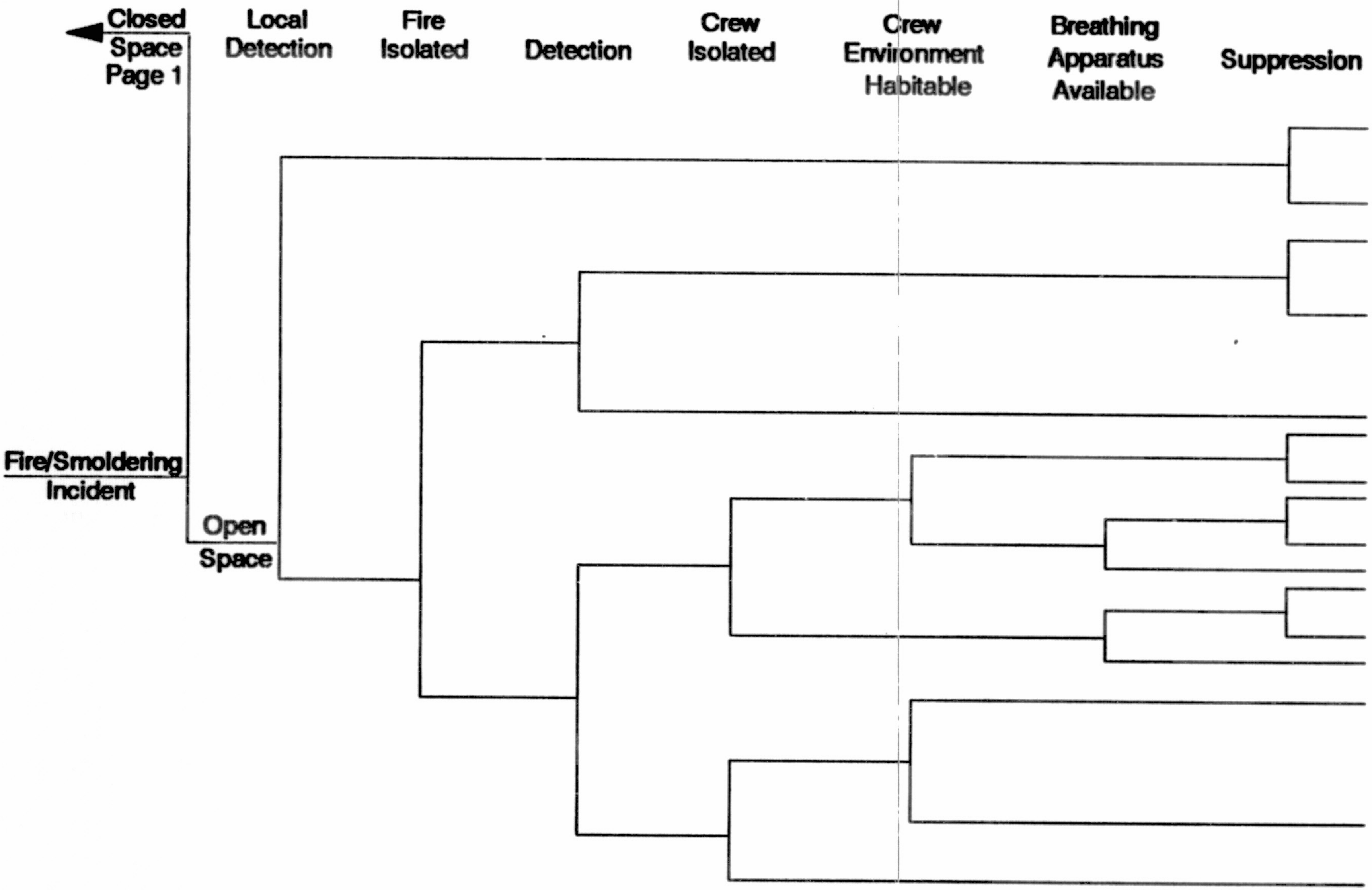
1. Identification of "critical" locations and the assessment of the frequency of fires: overheating, spills, smoldering, ignition, etc.

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 1: Event Tree for Closed Space Fire



Page 2: Event Tree for Open Space Fire

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

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
$Q_{loss\ d/j,k}$	fraction of class j fires leading to damage of the k^{th} system that cause the loss of the spacecraft

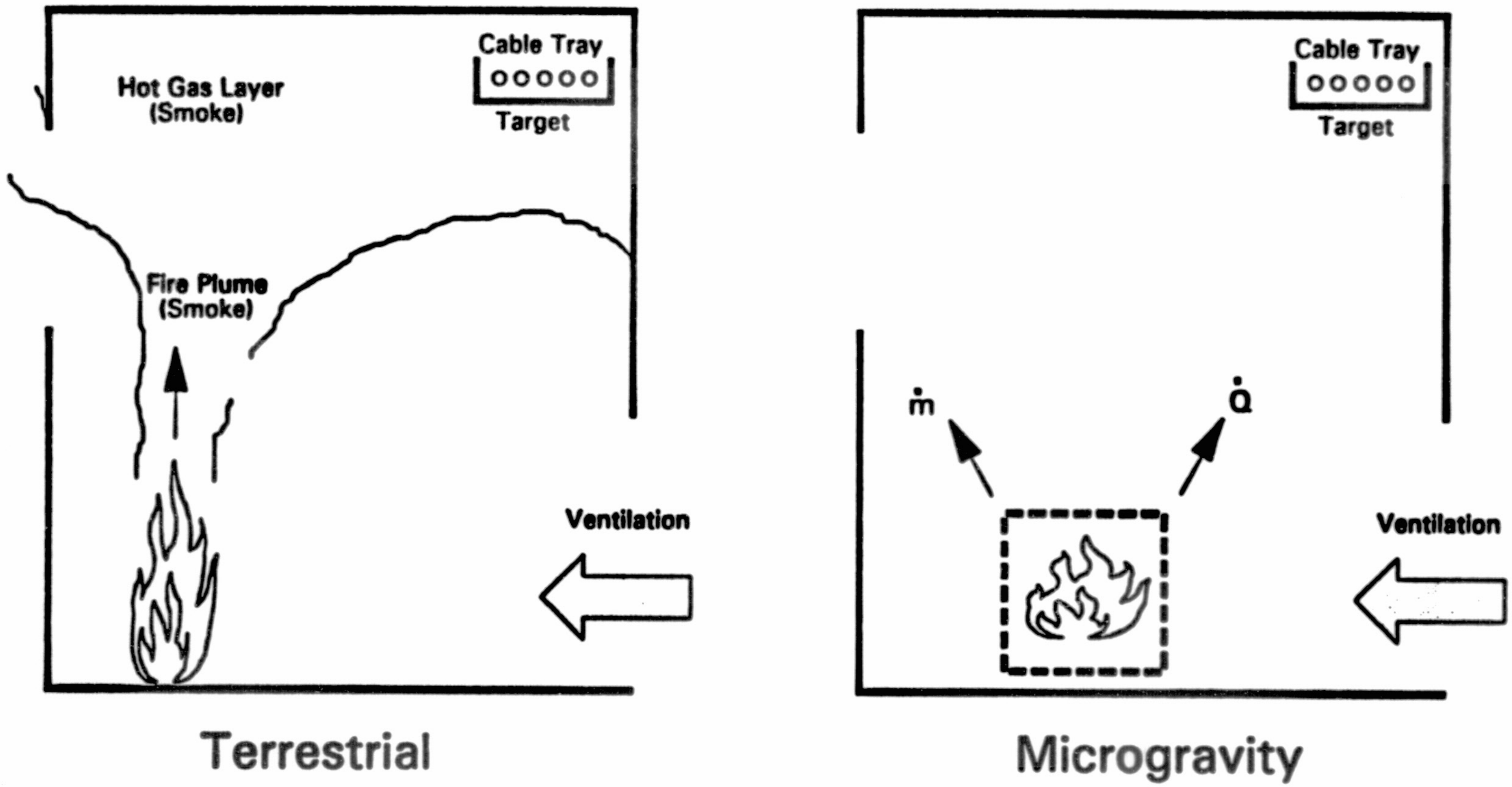
$$Q_{d/j} = Fr\,[T_G < T_H \,/\, fire]$$

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



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Fire Safety Assessment

Damage Time

Detection & Suppression Time

Target Identification

Crew
Station System

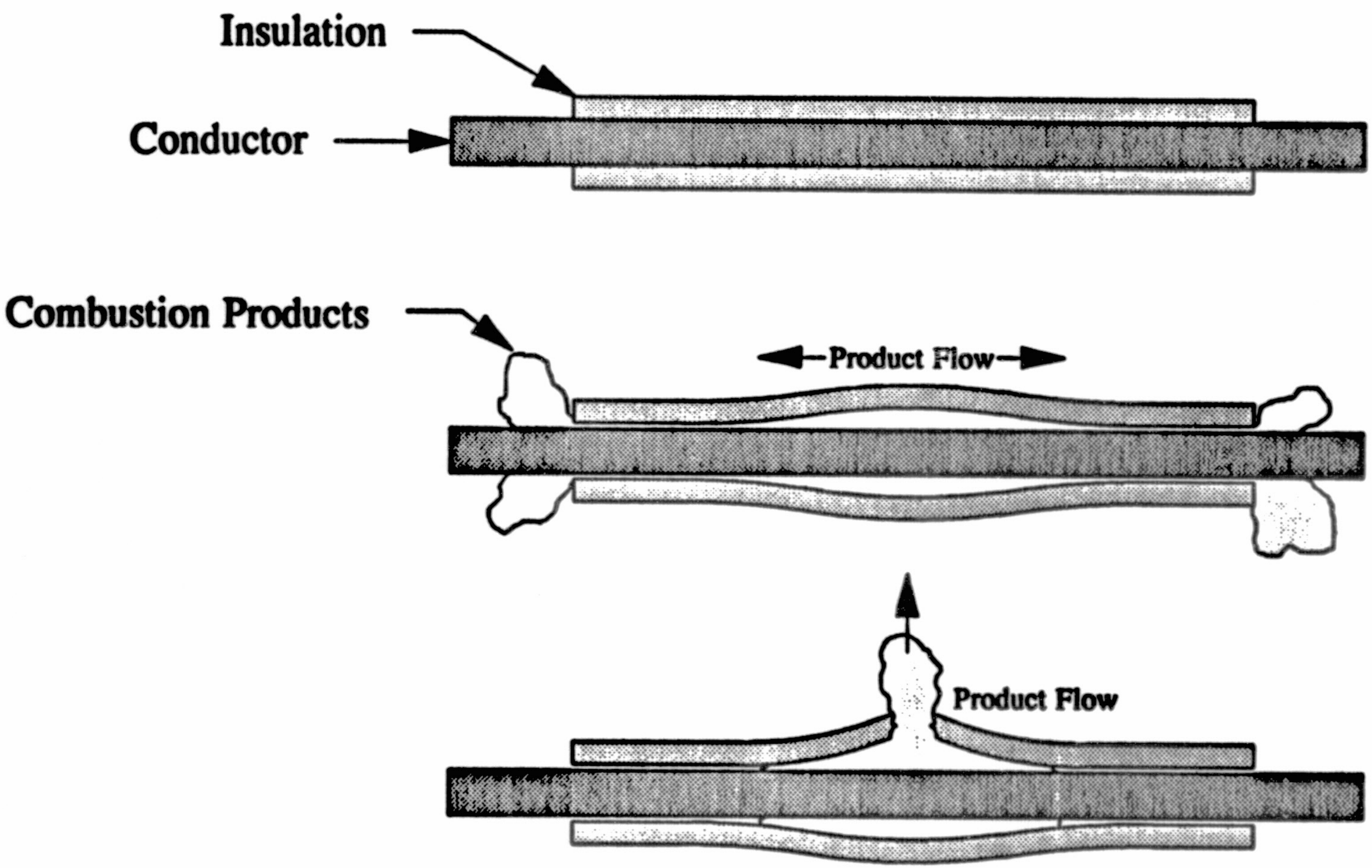
Modes Identification

Heat
Smoke
Toxins

Event Description

Source
Transport
Deposition

Wire Overload Phenomena



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	Damage Modes	Tests	Models
Source	Heat Release	temperature measurements	f(T)
	Smoke Release	obscuration, TEM grids	f(T)
	Toxin Release	IR/Mass spec.(White Sands), sampling	f(T)
Transport	Heat Transport	temperature measurements	fluid flow, temp., etc
	Smoke Transport	TEM grids/visualization	fluid flow, temp., etc
	Toxin Transport		fluid flow, temp., etc
Deposition	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

UCLA μg

Sample Materials

PTFE - Teflon $[-CF_2-CF_2-]$	Interior wiring	Smoke Production Toxic Production Acidic Production Combustible Production
ETFE - Tefzel $[-CF_2-CH_2-]$	Exterior wiring	
Bundles	Interior/Exterior	+ Adjacent Wire Damage
Twisted Pairs	Interior/Exterior	

PTFE

Polytetrafluorethylene
Thermal Degradation Products