EVENT TREE ANALYSIS

2nd Edition

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Sverdrup

EVENT TREE ANALYSIS IS…

- A bottom-up, deductive, system safety analytical technique
- Applicable to:
  - Physical systems, with or without human operators
  - Decision-making / management systems
- Complementary to other techniques, e.g.…
  - Fault Tree Analysis
  - Failure Modes and Effects Analysis

EVENT TREE ANALYSIS…

Explores system **RESPONSES**

to

Initiating **“CHALLENGES”**

and

Enables **PROBABILITY ASSESSMENT**

of

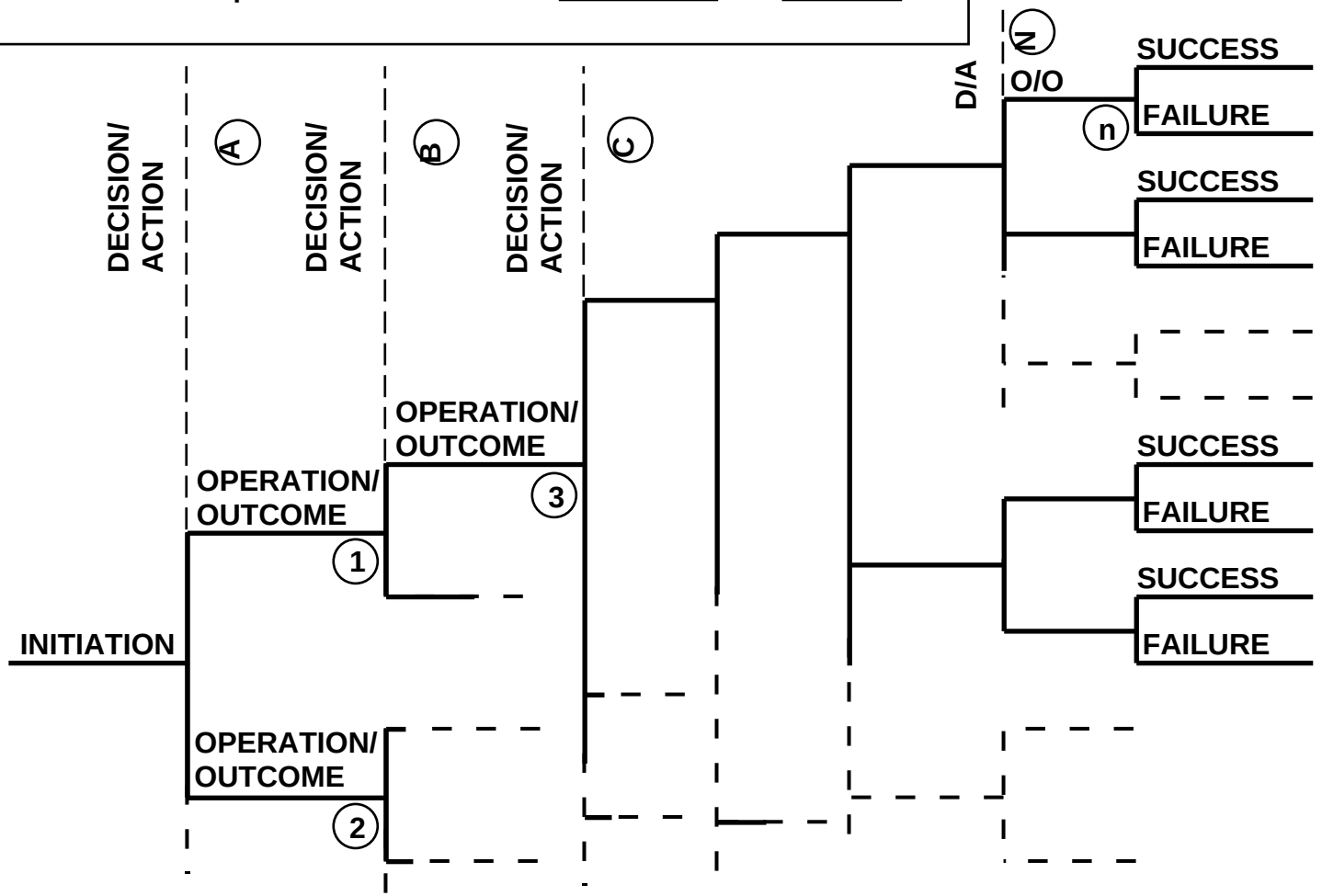
SUCCESS / FAILURE

EXAMPLE “CHALLENGES”…

- Pipe or Vessel Burst
- Ignition of Stored Combustibles
- Technology Need
- Utility System Failure
- Outbreak of Epidemic
- Heightened Business Competition
- Normal System Operating Command

EVENT TREE ANALYSIS (General Case)...

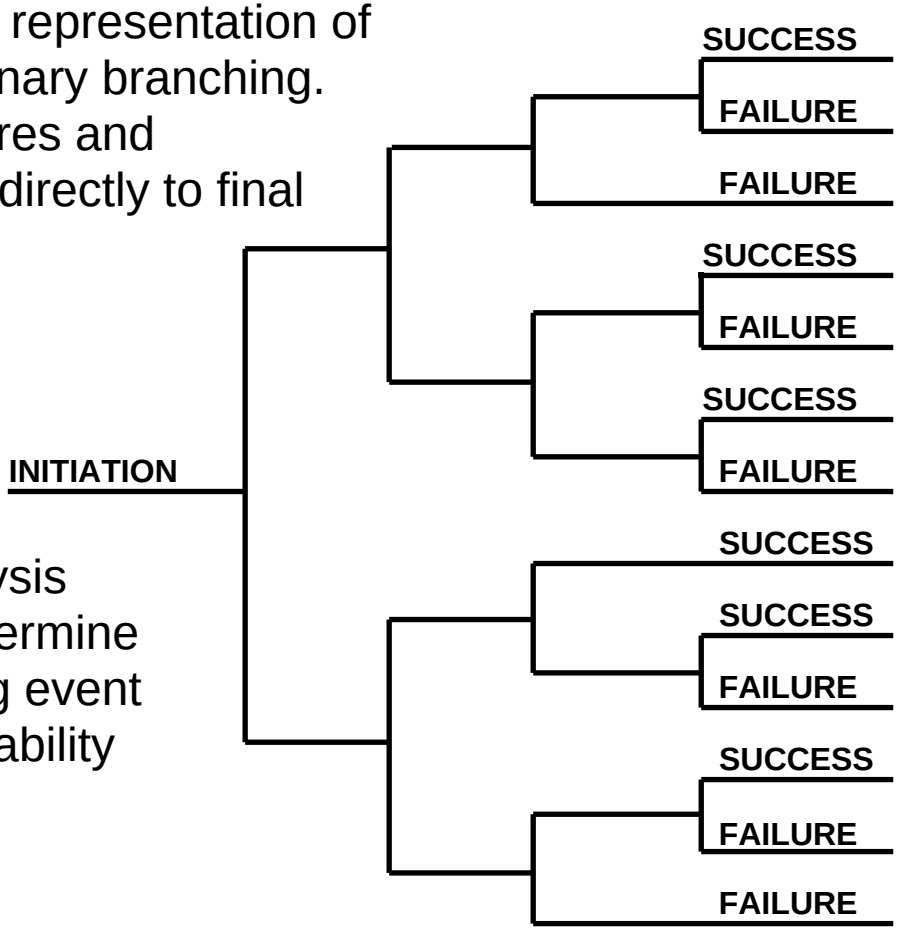
Portray all credible system operating permutations.
Trace each path to eventual success or failure.



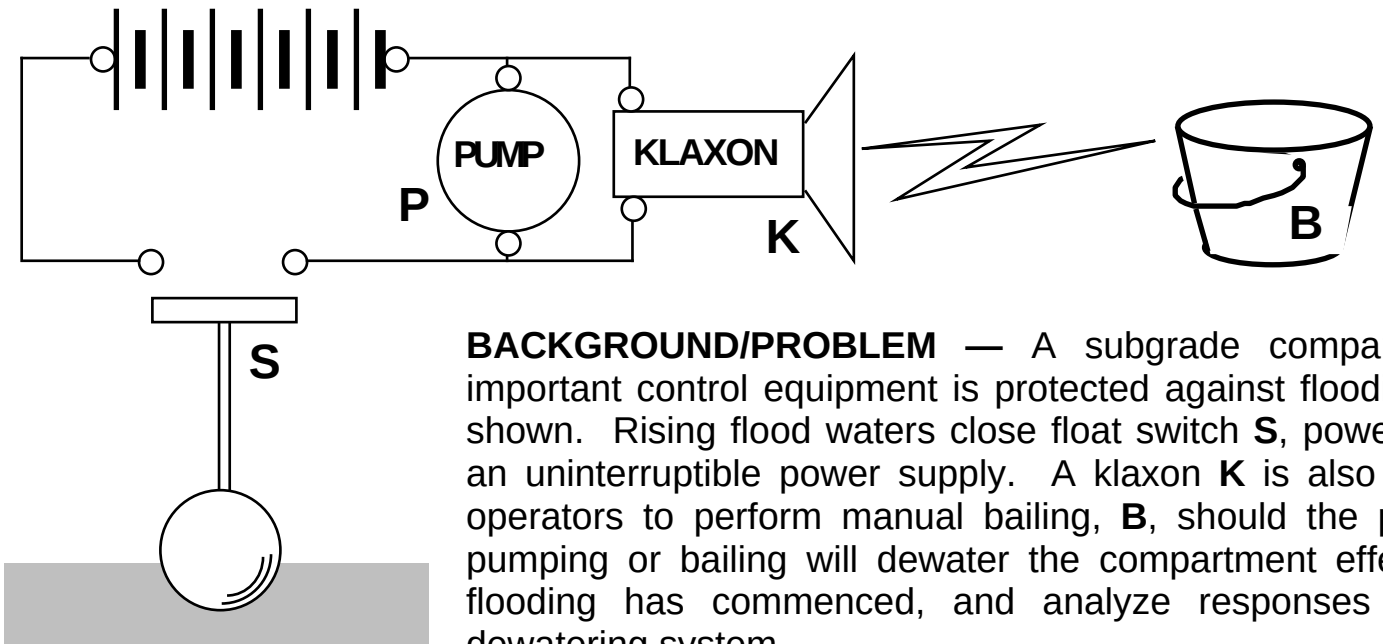
EVENT TREE ANALYSIS (Bernoulli Model)...

Reduce tree to simplified representation of system behavior. Use binary branching. Lead unrecoverable failures and undefeatable successes directly to final outcomes.

A fault tree or other analysis may be necessary to determine probability of the initiating event or condition. (Unity probability may be assumed.)



AN EXAMPLE PROBLEM…

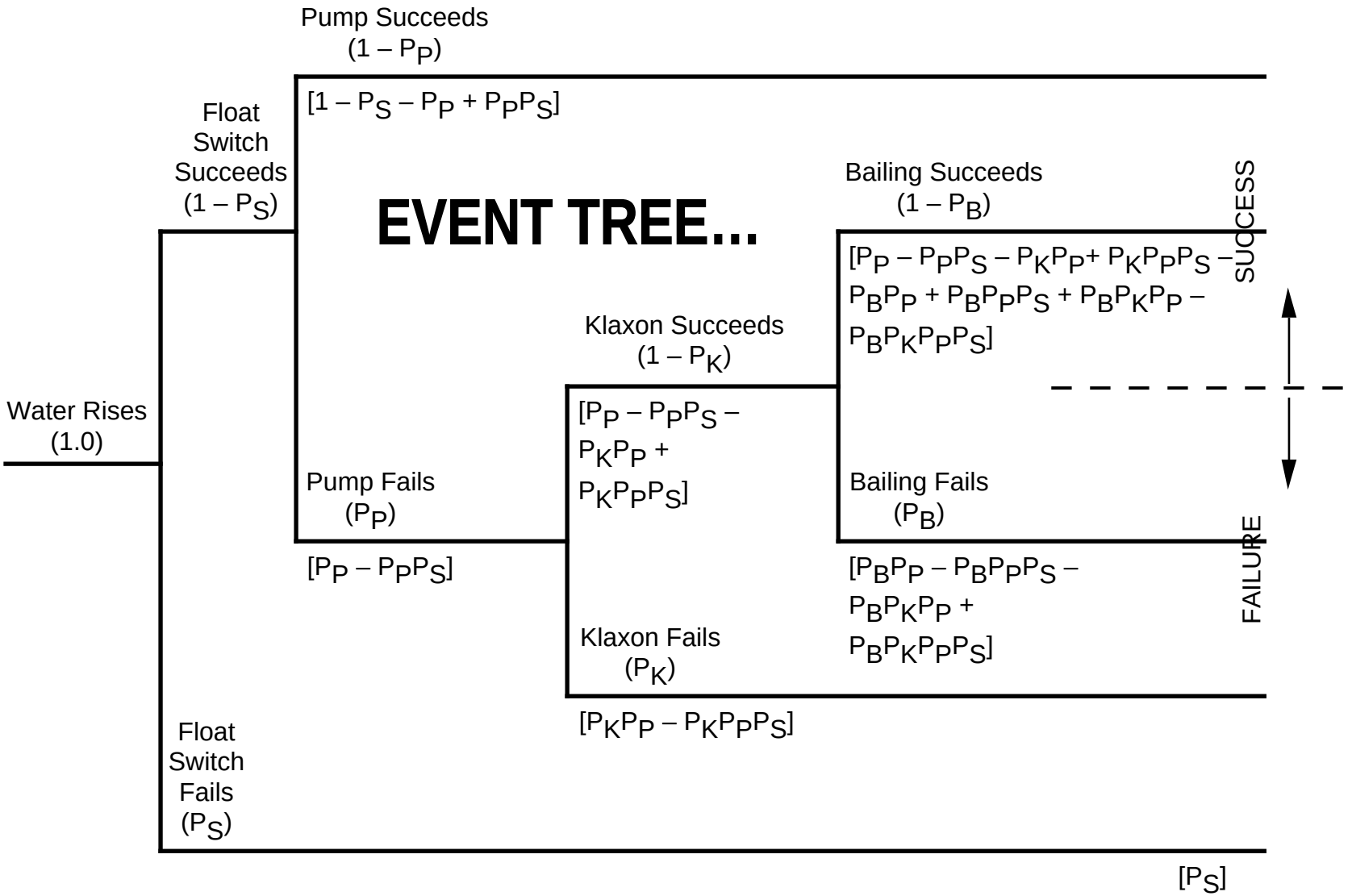


BACKGROUND/PROBLEM — A subgrade compartment containing important control equipment is protected against flooding by the system shown. Rising flood waters close float switch **S**, powering pump **P** from an uninterruptible power supply. A klaxon **K** is also sounded, alerting operators to perform manual bailing, **B**, should the pump fail. Either pumping or bailing will dewater the compartment effectively. Assume flooding has commenced, and analyze responses available to the dewatering system…

- Develop an event tree representing system responses.
- Develop a reliability block diagram for the system.
- Develop a fault tree for the TOP event *Failure to Dewater*.

SIMPLIFYING ASSUMPTIONS:

- Power is available full time.
- Treat only the 4 system components **S**, **P**, **K**, and **B**.
- Consider operator error as included within the bailing function, **B**.

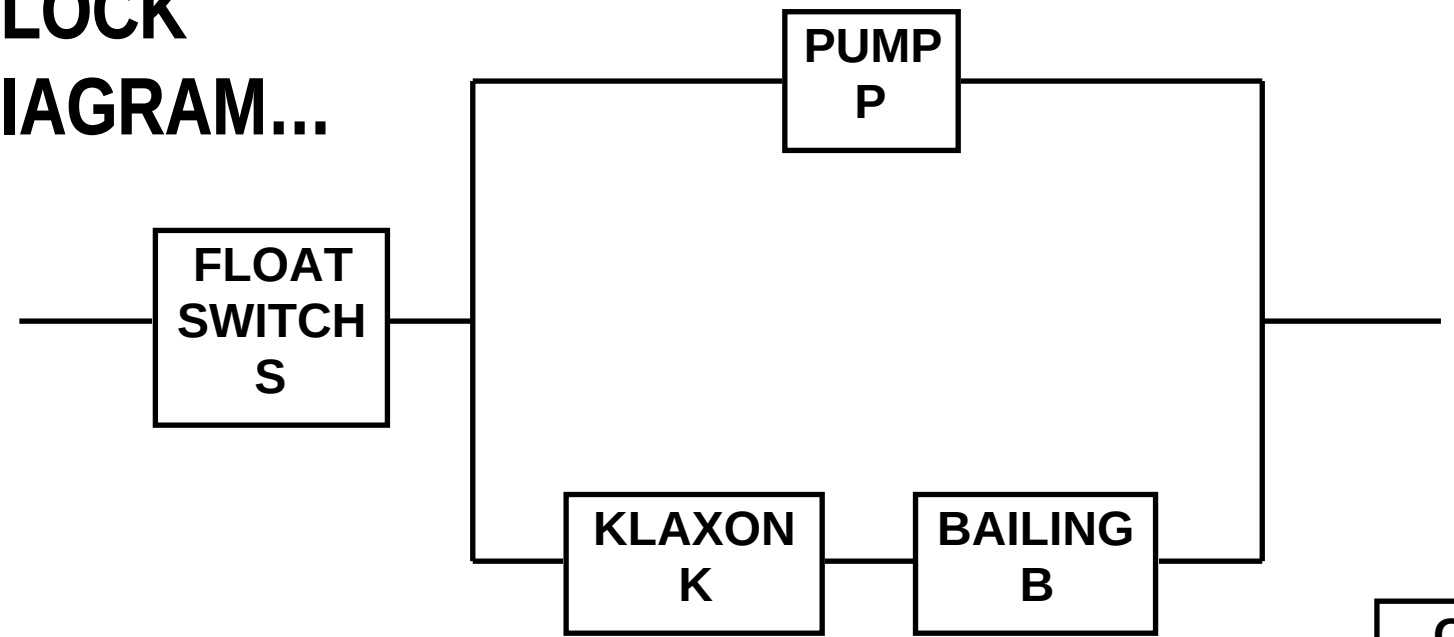


$$P_{SUCCESS} = 1 - P_S - P_K P_P + P_K P_P P_S - P_B P_P + P_B P_P P_S + P_B P_K P_P - P_B P_K P_P P_S$$

$$P_{FAILURE} = P_S + P_K P_P - P_K P_P P_S + P_B P_P - P_B P_P P_S - P_B P_K P_P + P_B P_K P_P P_S$$

$$P_{SUCCESS} + P_{FAILURE} = 1$$

RELIABILITY BLOCK DIAGRAM...



PATH SETS
S / P
S / K / B

CUT SETS
S
P / K
P / B

FAULT TREE...

EXACT SOLUTION

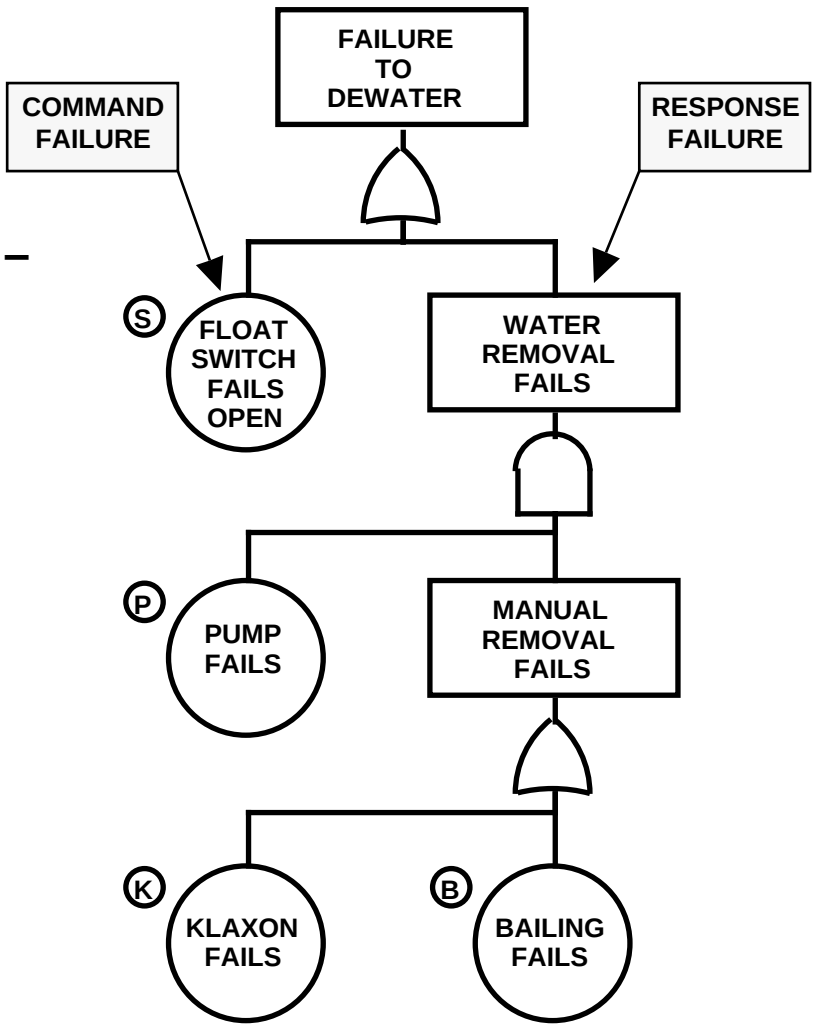
$$P_{TOP} = P_S + P_P P_K - P_P P_K P_S + P_B P_P - P_B P_P P_S - P_B P_K P_P + P_B P_K P_P P_S$$

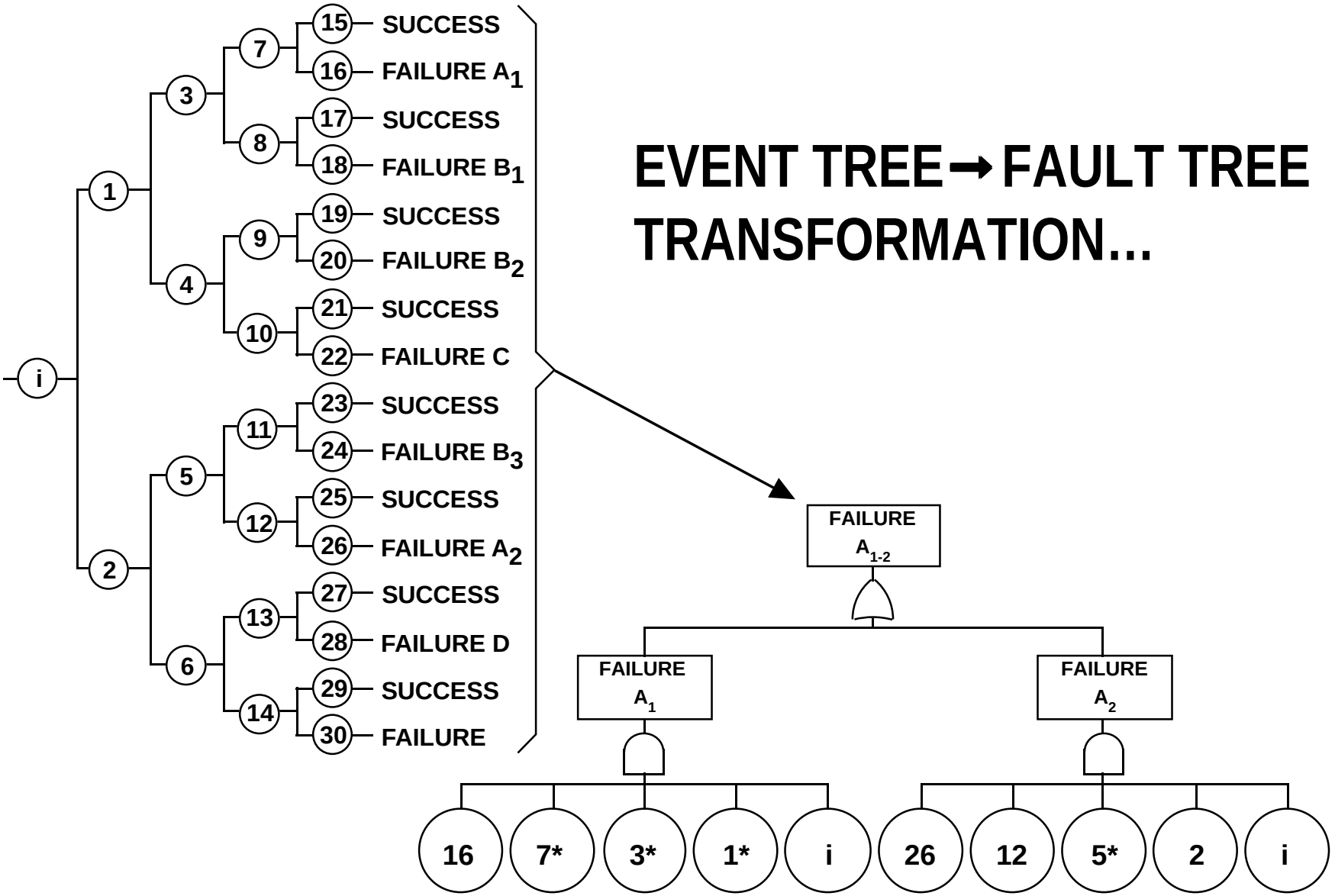
RARE EVENT APPROXIMATION

$$P_{TOP} = P_S + P_P P_K + P_P P_B$$

PATH SETS
S / P
S / K / B

CUT SETS
S
P / K
P / B





EVENT TREE → FAULT TREE TRANSFORMATION…

*Note that not all events represented here are failures.

ASSESS RISK AND JUDGE TOLERABILITY…

Failure statements express SEVERITY

Event Tree Analysis explores OUTCOMES / assesses PROBABILITY

PROBABILITY and SEVERITY establish RISK

IS THE RISK ACCEPTABLE?

If not, develop intervenors!

Select intervenor(s) on the basis of:

EFFECTIVENESS

COST

FEASIBILITY (incl. schedule)

EVENT TREE SHORTCOMINGS & ADVANTAGES...

- SHORTCOMINGS:
  - Operating pathways must be anticipated.
  - Partial successes/failures are not distinguishable.
  - Initiating events are treated singly. (Multiple trees are required for multiple events; co-existing initiating events are not considered.)
  - Sequence-dependent scenarios are not modeled well.
- ADVANTAGES:
  - End events need not be foreseen.
  - Multiple failures can be analyzed.
  - Potential Single-Point Failures can be identified.
  - System weaknesses can be identified.
  - Zero-payoff system elements/options can be discarded.

BIBLIOGRAPHY —
Selected references for further study…

- Center for Process Safety; “Guidelines for Hazard Evaluation Procedures; 2nd Edition with Worked Examples” 1992 (461 pp); American Institute of Chemical Engineers
- Lees, Frank P.; “Loss Prevention in the Process Industries”; 1980 (1316 pp — two volumes)
- Henley, Ernest J. & Hiromitsu Kumamoto; “Reliability Engineering and Risk Assessment”; 1981 (568 pp)