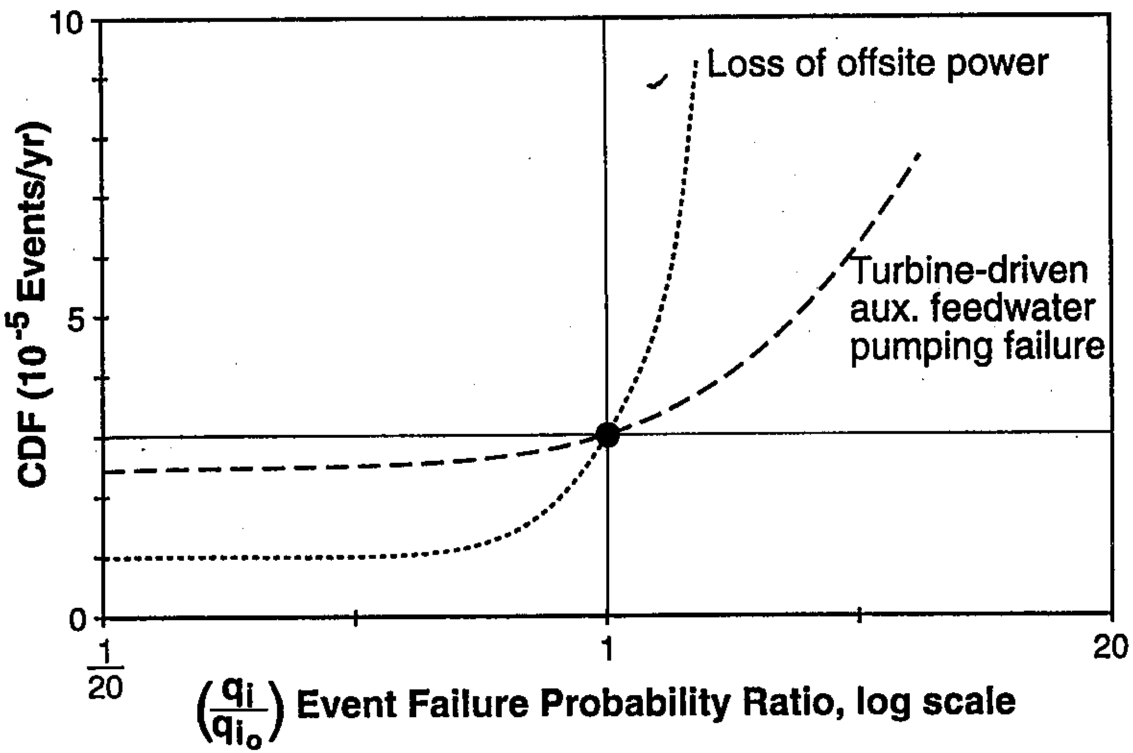
PRA IN MANAGING OPERATIONS USING A "RISK MONITOR"

CDF Evaluation of Future Plant Configurations

CDF Evaluation of Past Plant Configurations

CDF Sensitivity Evaluation of Future and Past Plant Configurations



Perform Analyses for Plant Operations Both Generating Power and Shutdown

Source: Vlahoplus, Christopher, Jr. "Safety regulation of advanced reactors : evolution of a nonprescriptive safety regulatory approach as applied to station blackout." MIT M.S. Thesis, 1986.

COMPONENT RISK IMPORTANCE

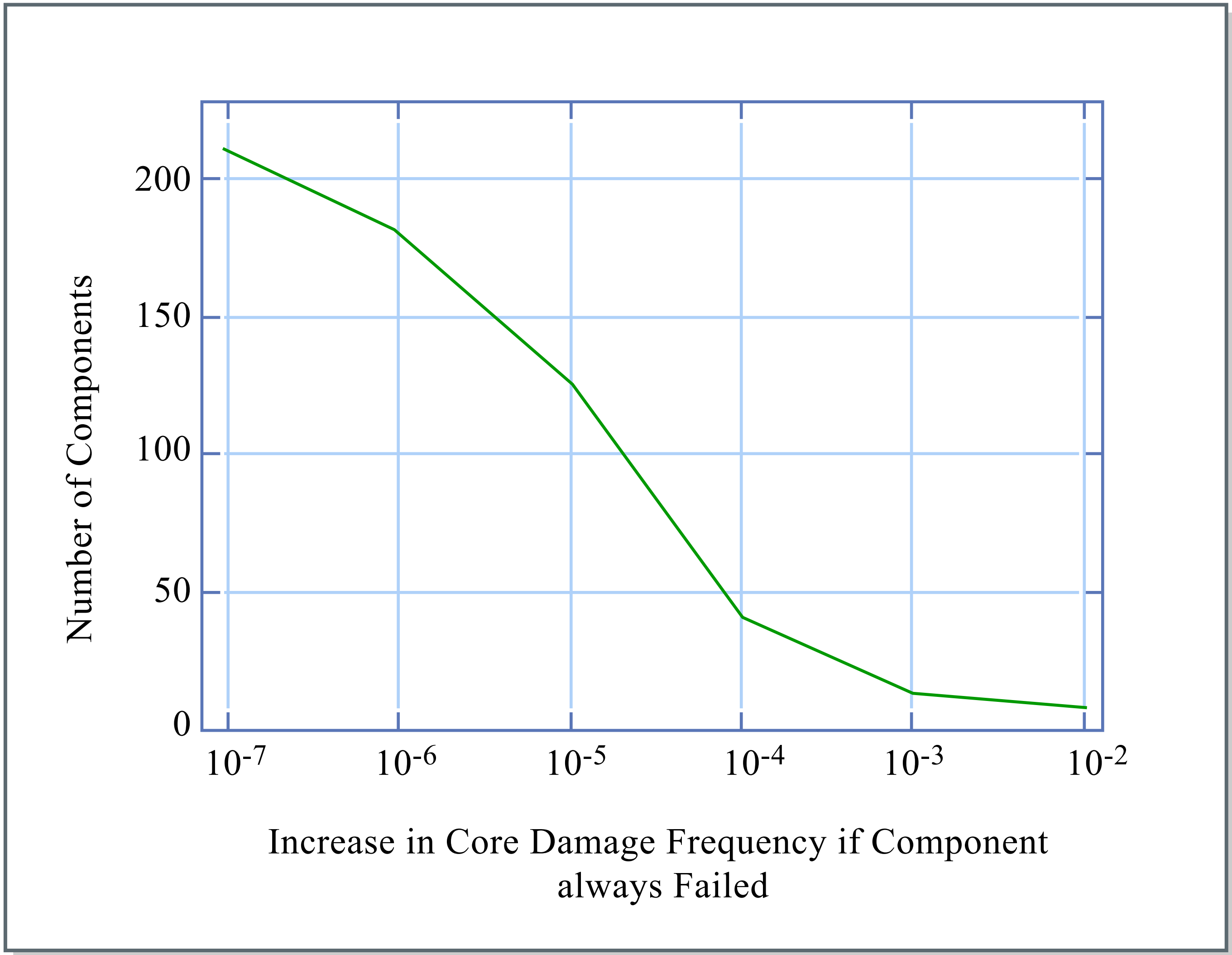
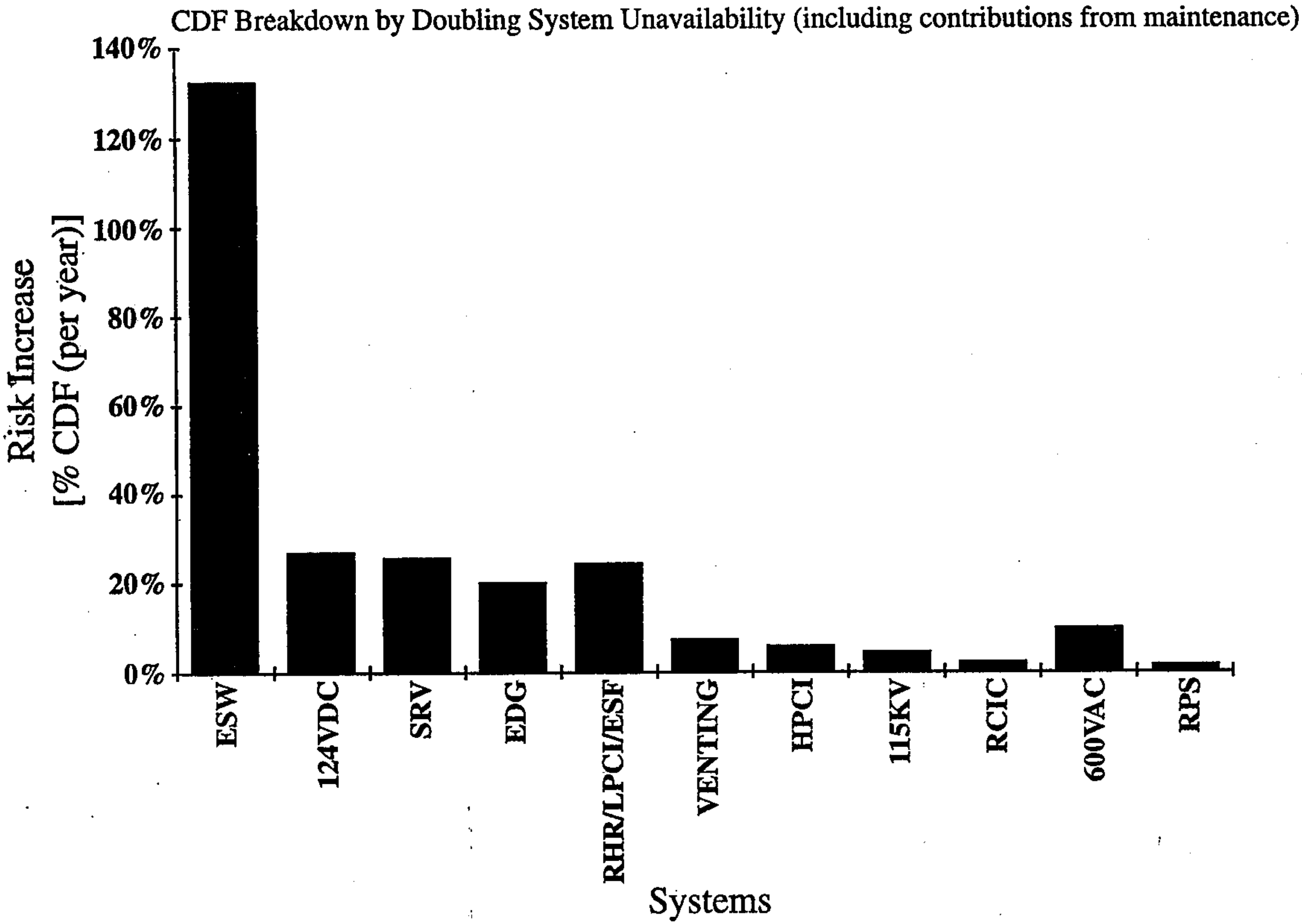


Figure by MIT OCW. Adapted from: F. Gillespe, average of NUREG-1150, Surry, and Sequoyah results.

CORE DAMAGE FREQUENCY PERCENT INCREASE PER SYSTEM[1]



1 For Fitzpatrick Nuclear Power Station

Source: Ouyeng, Meng. "The impact of maintenance program changes on common cause failure rates." MIT M. S. Thesis, 1992.

RISK IMPORTANCE MEASURES

$$\text{Risk} = R(q_1, q_2, \ldots, q_n),$$

where

r_i = reliability of the i^{th} plant component, action, or cut set

q_i = unreliability of the i^{th} component = $1 - r_i$

$I_{\text{Fussell-Vesely}i}$ = the fraction of total risk involving failure of element, i

$$I_{\text{Fussell-Vesely}i} = \frac{R(q_i)}{R_{Nom}} = \frac{R(mcs_{i_1} + mcs_{i_2} + \ldots + mcs_{i_m})}{R(mcs_1 + \ldots + mcs_n)}$$

where

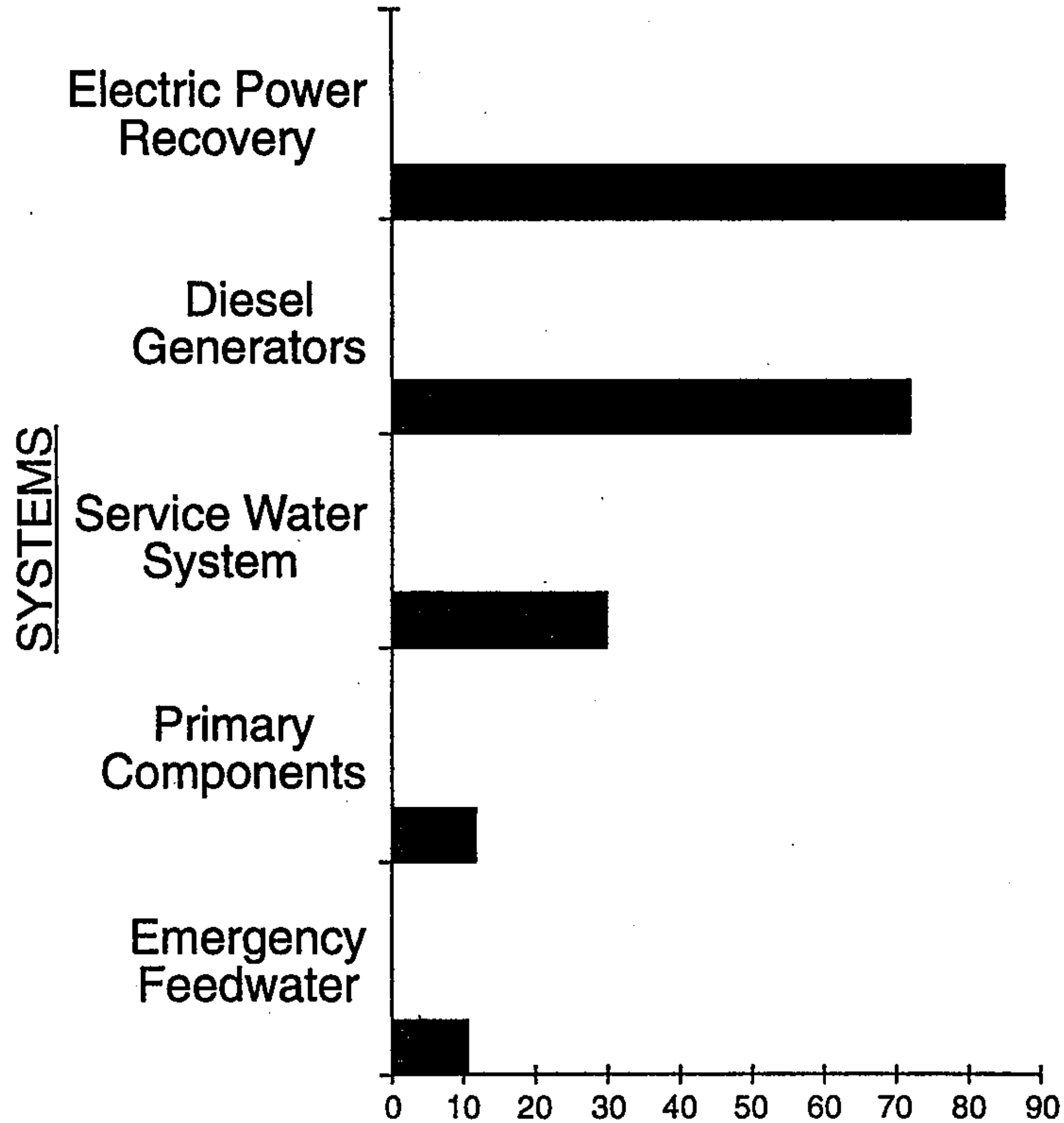
$R(q_i)$ = risk arising from event sequences involving failure of component, action, or cut set, i

R_{Nom} = nominal plant risk

m = number of minimal cut sets invovling element (basic event) i

n = total number of minimal cut sets.

EVOLUTIONARY PWR LOOP CDF SYSTEM FUSSELL-VESELY IMPORTANCE RANKING



Source: Ouyeng, Meng. "The impact of maintenance program changes on common cause failure rates." MIT M. S. Thesis, 1992.

RISK IMPORTANCE MEASURES

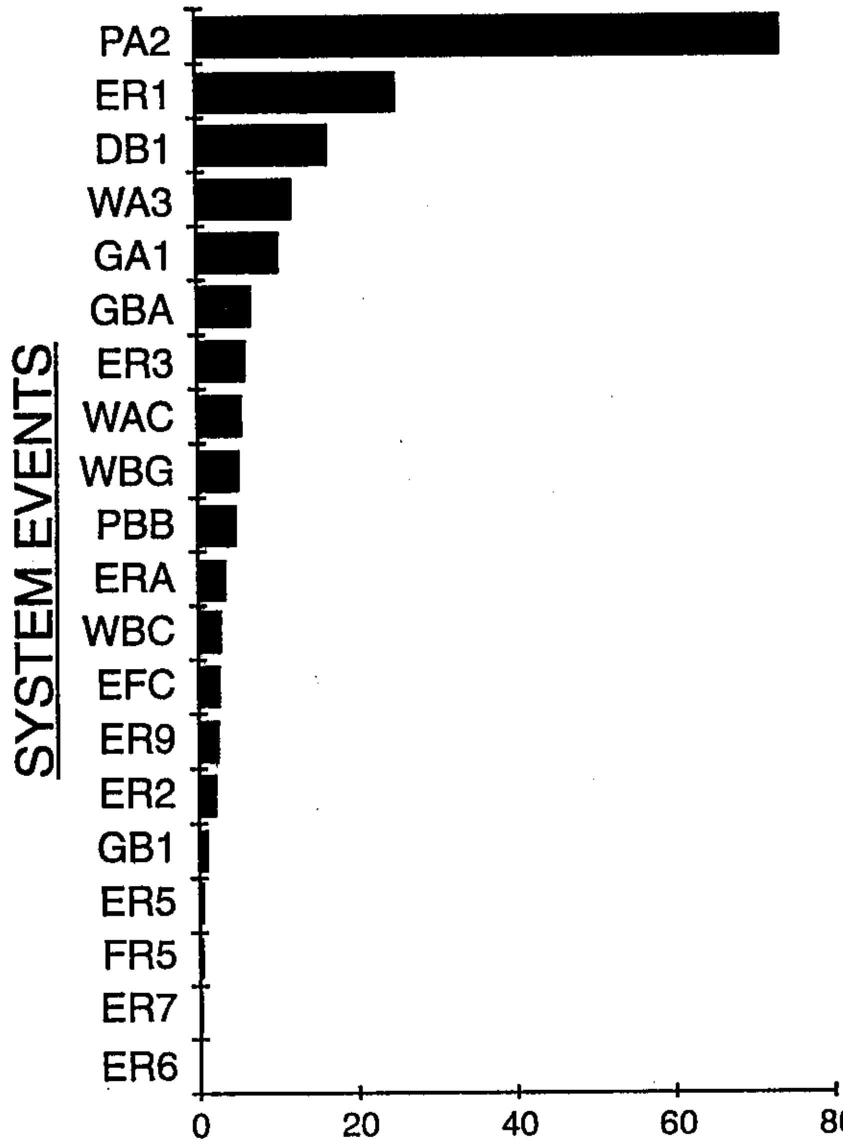
Risk Achievement Worth (RAW_i) = (i.e., Risk Increase Importance, RII_i) = Maximum possible relative increase in total risk due to failure of element, i; the element is assumed to fail every time.

$$RAW_i = RII_i = \frac{R\,(q_i = 1)}{R_{Nom}}$$

where

RAW_i = the risk achievement worth of the i^{th} component, action or cutset

EVOLUTIONARY PWR LOOP CDF SYSTEM RISK ACHIEVEMENT WORTH IMPORTANCE RANKING



Source: Ouyeng, Meng. "The impact of maintenance program changes on common cause failure rates." MIT M. S. Thesis, 1992.

RISK IMPORTANCE MEASURES

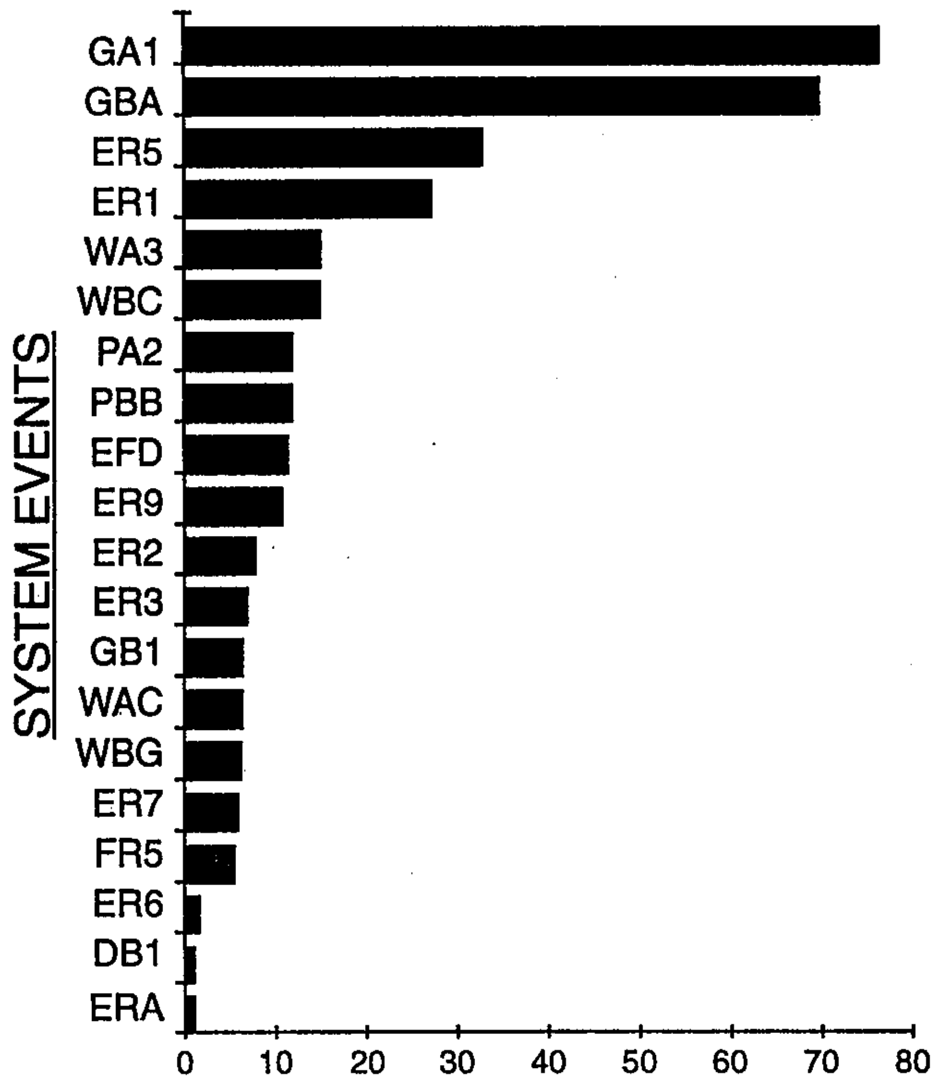
Risk Reduction Worth (RRW_i) = Maximum possible relative reduction in risk due to perfection of element, i; the component is assumed to succeed every time.

$$RRW_i = \frac{R_{Nom}}{R\,(q_i = 0)}$$

where

RRW_i = the risk decrease importance of the i^{th} component, action or cutset

EVOLUTIONARY PWR LOOP CDF SYSTEM RISK REDUCTION WORTH IMPORTANCE RANKING



Source: Ouyeng, Meng. "The impact of maintenance program changes on common cause failure rates." MIT M. S. Thesis, 1992.

USES OF RISK IMPORTANCE MEASURES

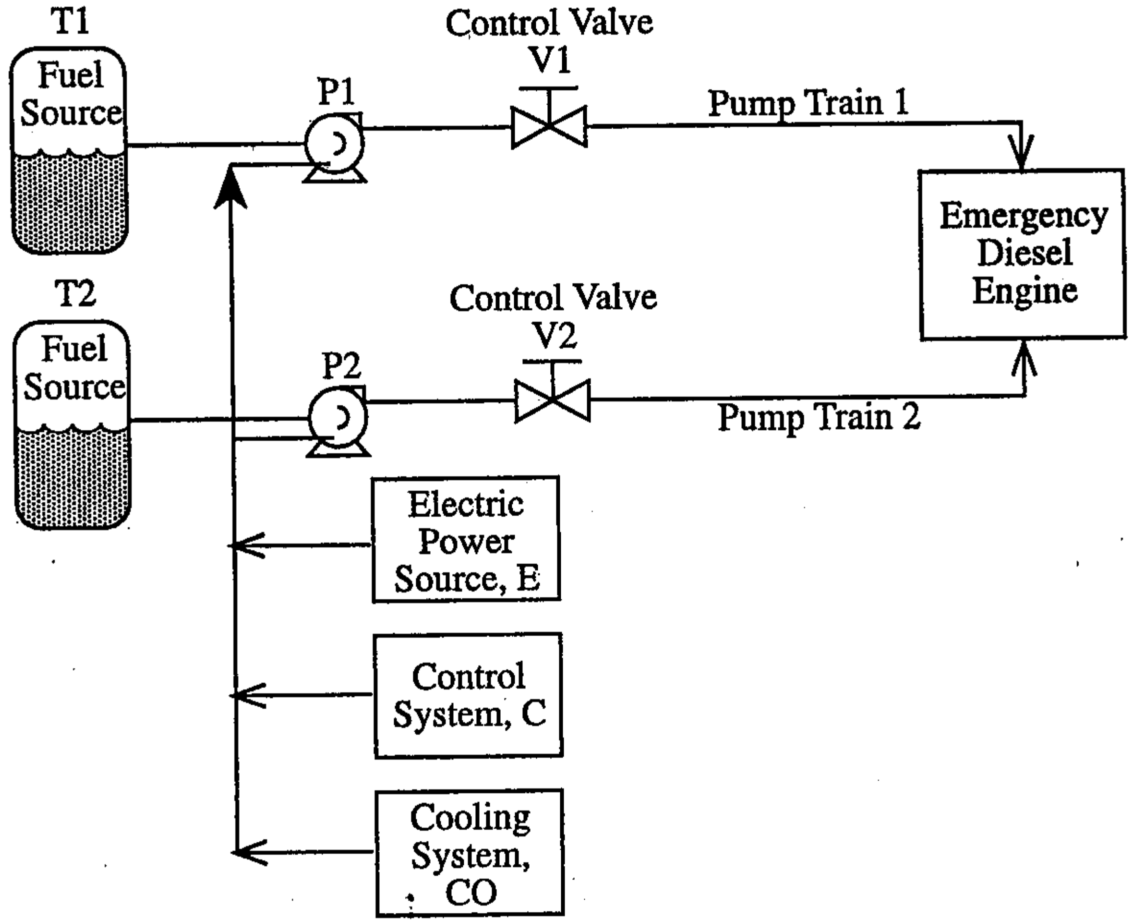
- Fussell-Vesely
  - Measures a Component's or System's Participation in Risks
  - Can Be Used to Identify Which Components or Systems Contribute to Current Risks

- Rish Achievement Worth
  - Identifies Which Components or Systems Must Be Kept Reliable

- Risk Reduction Worth
  - Identifies Which Components or Systems Are Most Valuable for Improvement
  - Note

$$I_{\text{Fussell-Vesely}_i} = 1 - \frac{1}{RRW_i}.$$

AN EXAMPLE OF A FUEL PUMPING SYSTEM



The System Succeeds if Fuel is Provided by Either Train 1 or 2.

Source: Ouyeng, Meng. "The impact of maintenance program changes on common cause failure rates." MIT M. S. Thesis, 1992.

SYSTEM COMPONENT RELIABILITY DATA
(Typical of One Year in Standby Status)

Component	Component Failure Probability
Tank, T-1 or T-2	3.00E-5
Valve, V-1 or V-2	1.20E-4
Pump, P-1 or P-2	9.00E-5
Electric Power, E	1.50E-4
Control System, C	3.00E-4
Cooling System, CO	1.00E-4

SUMMARY OF IMPORTANCE RANKINGS

Importance Measures \ Component / or System	Control System, C	Electric Power System, E	Valve, V-1
Fussell-Vesely	0.54	0.27	$5x10^{-5}$
Risk Reduction Worth	2.18	1.37	1.00005
Risk Achievement Worth	1819	1819	1.44