

A Quantitative Assessment of Organizational Factors Affecting Safety using a System Dynamics Model

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(System Dynamics)

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Abstract

The purpose of this study is to develop a system dynamics model for the assessment of organizational and human factors in the nuclear power plant safety. Previous studies are classified into two major approaches. One is the engineering approach such as ergonomics and Probabilistic Safety Assessment (PSA). The other is socio-psychology one. Both have contributed to find organizational and human factors and increased nuclear safety. However, since these approaches assume that the relationship among factors is independent they do not explain the interactions between factors or variables in NPP's. To overcome these restrictions, a system dynamics model, which can show causal relations between factors and quantify organizational and human factors, has been developed. Operating variables such as degree of leadership, adjustment of number of employee, and workload in each department, users can simulate various situations in nuclear power plants in the organization side. Through simulation, user can get an insight to improve safety in plants and to find managerial tools in the organization and human side.

(hardware)

가

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IAEA

OECD

(human error)

(safety culture)

가

가

(OECD, 1999a, 1999b, 1999c: IAEA, 1995).

,

(organizational and human factors)

가

(open system)

가

가

가

1.

가

가

PSA(Probabilistic Safety Assessment)

가

PSA

(event)

(tree)

(Apostolakis, 1992 ; Rasmussen, 1987 ;

Reason 1990).

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(

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가

(

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(Static)

가

,

(leadership),

(motivation),

(size),

가

(IAEA, 2000 ; Carter, Rudolf & Day, 1992 ; Perrow, 1984 ; Perrow, 1986 ; Weizel & Ellen, 1989).

(Checklist)

가

가

가

2.

Causal Loop Diagram

(numerical variables)

(Mental variables)

가 가

가

가

(Gharajedaghi, 1999),

(delay)

가

(individual performance)

가

(organizational performance)

가

가

가

Causal Loop Diagram

Stock and Flow Diagram

Causal Loop Diagram

Stock and Flow Diagram

1.

가

, PSA CDF(Core Damage Frequency)
 . PSA 가 (Event Tree)
 . PSA CDF
 가 (MCS : Minimum Cutsets)

, 가
 (normalized quality of work)
 (normalized total defects)

CDF
 (1).

$$CDF = f(BE_{HW}, BE_{HU}) \text{-----} (1)$$

BE_{HW} :

BE_{HU} :

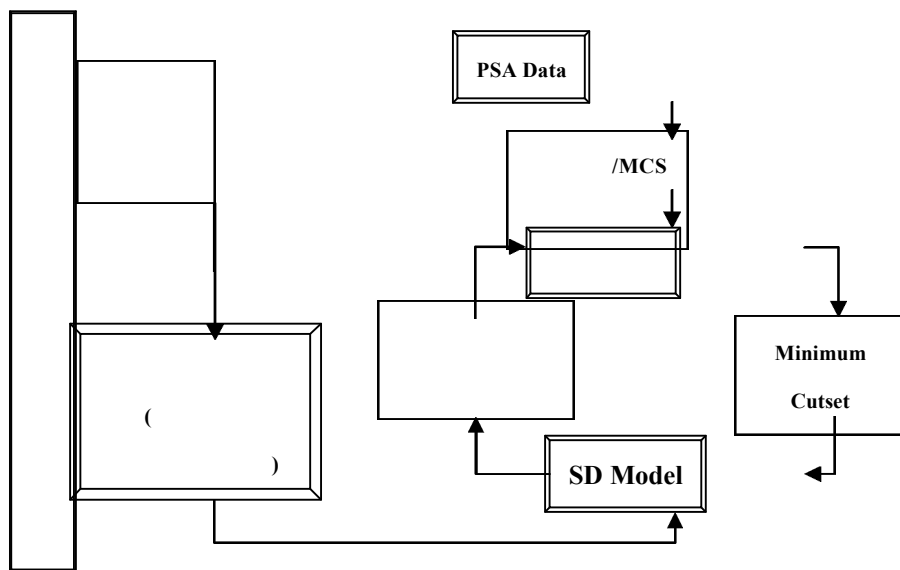
CDF
 CDF (2).

$$CDF_t = f(BE_{HW} * NTD_t, BE_{HU} * NQW_t) \text{-----} (2)$$

NTD_t : t (Normalized Total Defects)

NQW_t : t (Normalized Quality of Work))

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2. Causal Loop Diagram & Stock and Flow Diagram

4

3

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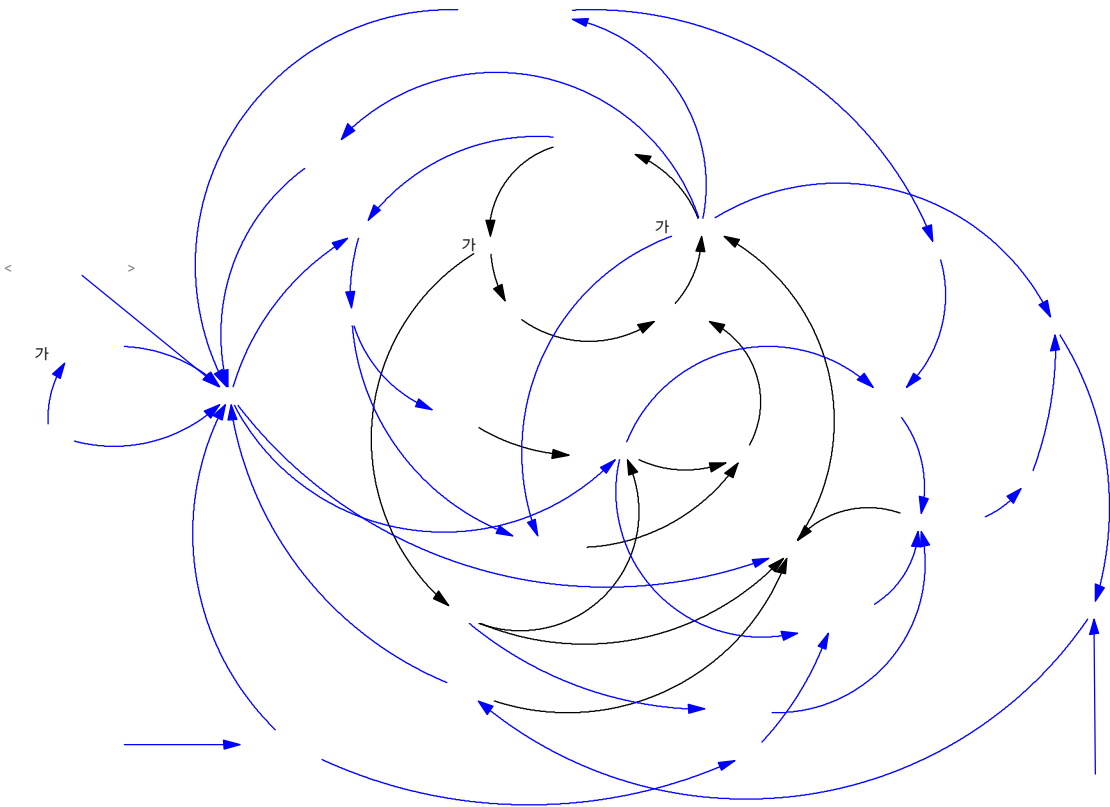
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High-Level Causal Loop Diagram < 2>

가 , 가
가 , (reinforcing
loop) 가 , 가
가 , 가



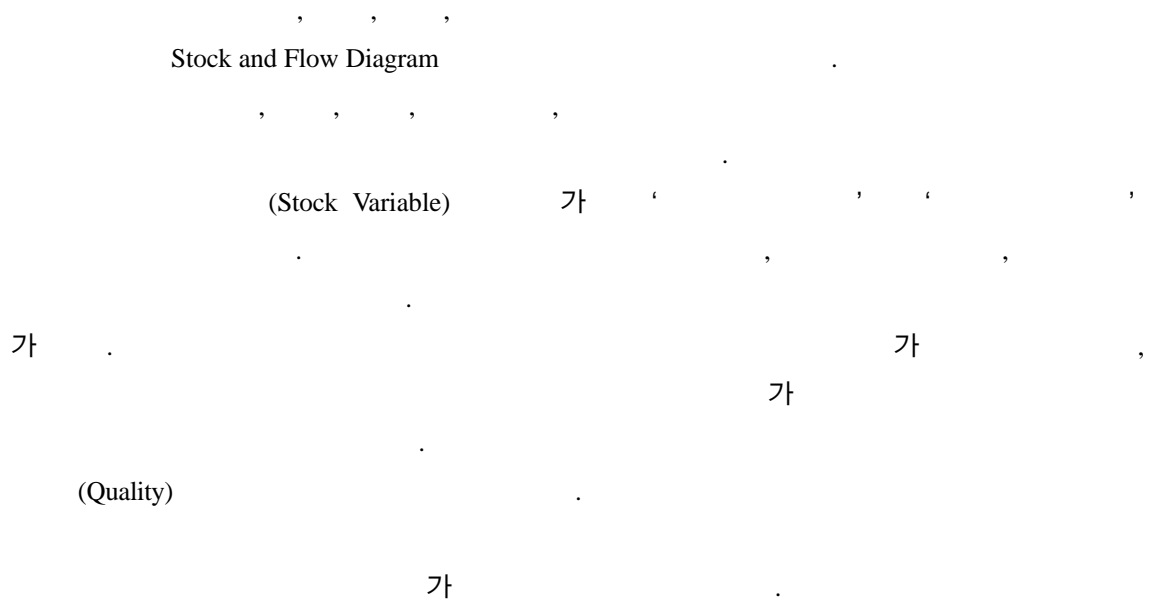
< 2> High - Level Causal Loop Diagram



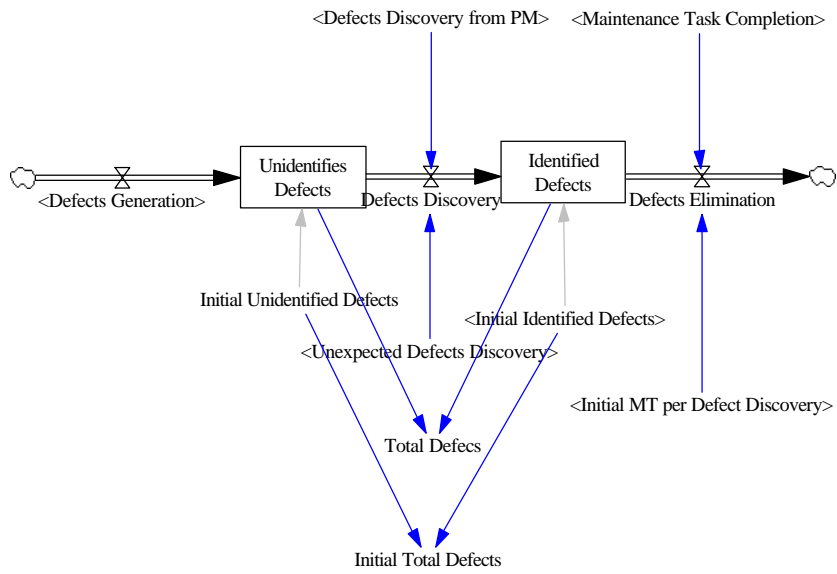
Causal Loop Diagram

Stock and Flow Diagram

3. Stock and Flow Diagram



Stock and Flow Diagram < 3> . < 3>



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Stock and Flow Diagram

1.

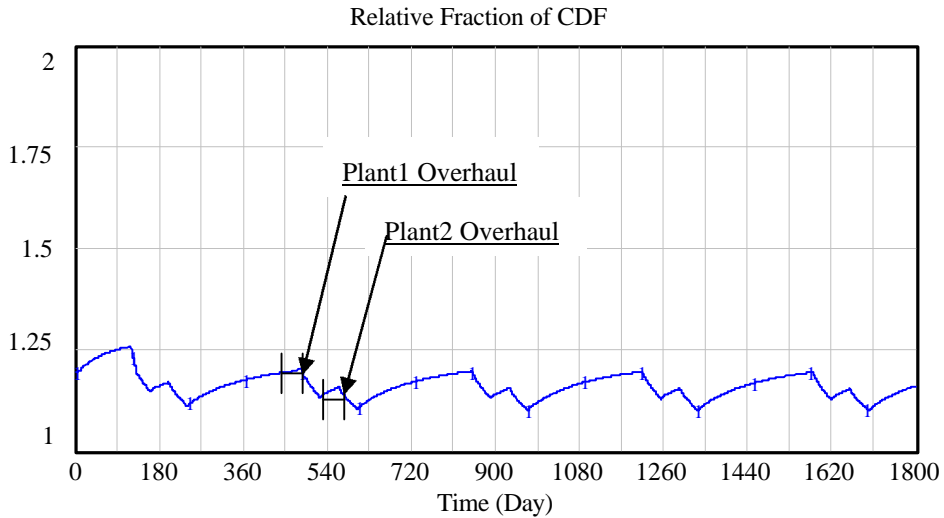
2 가

3>

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Case Study	Data set	
Case 1 :	Routine	Normal Status
	Good Edu	Normal Status 20% 가
	Bad Edu	Normal Status 20%
Case 2 :	Routine	Normal Status
	Pro20	: time 120 Normal Status 20%
	Layoff20	: time 120 Normal Status 20%
Time Unit	0 - 1800 Days (about 5 years)	
Time step	0.25 day	

(site) 가 .
 1 1 가 2 가 .
 가 가
 1 2
 가 ,
 ,
 CDF < 4> .



Relative Fraction of CDF : Routine — Index

< 4> Routine (CDF)

< 5>

(line 2 : Good Edu).

가 (line 3 : Bad Edu).

가 가

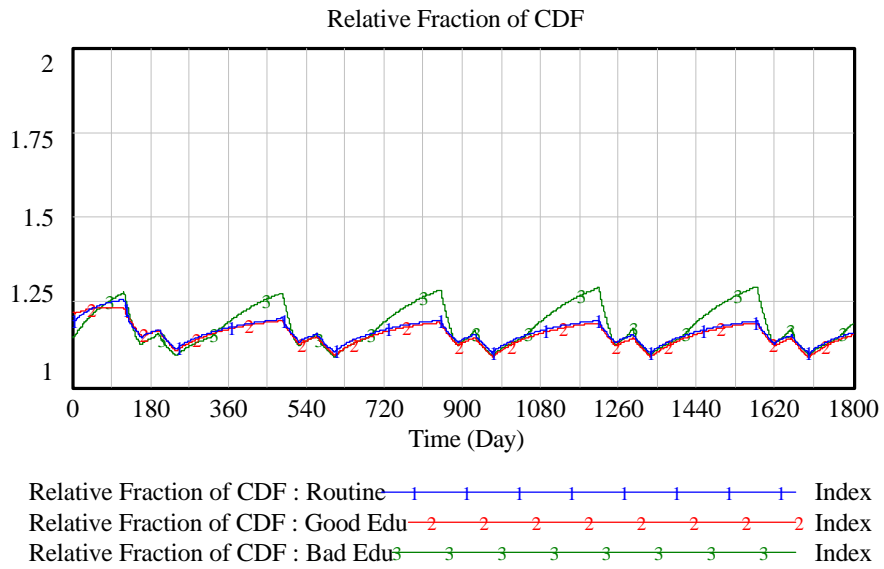
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(line 2 : pro20).

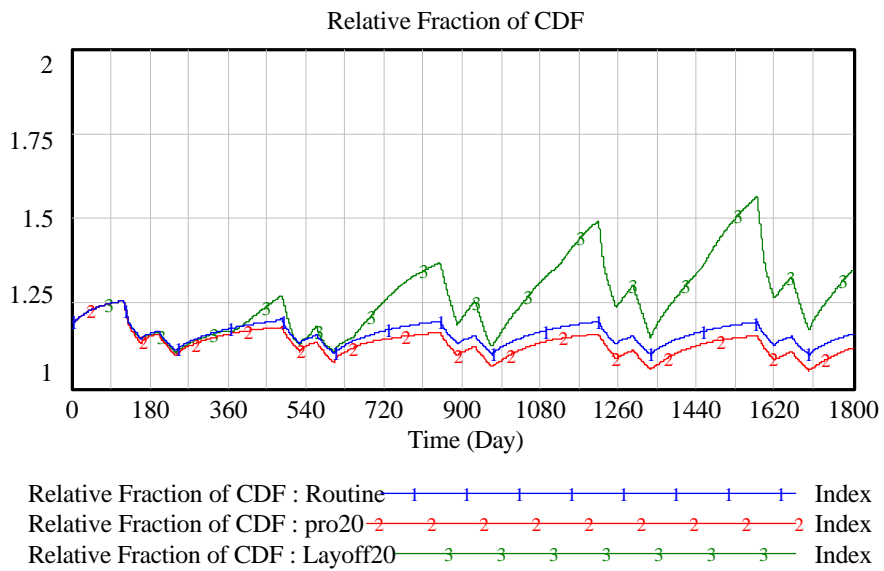
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가 ,

가



< 5 >



< 6 > 가

2.

가

가

PSA 가

가

(system thinking)

PSA

가

(Anderson, 1997 : Kim,

1993 : Senge, 1990 : Sterman , 2000, Schein, 1996, Sastry, 1997).

가(PSR : Periodic Safety Review)

(19)

가

가

가

가

(numerical data)

가

가

가

(mental data)

가

가

가

가

PSA

가가

가 가 ,

가 . 가 가 .

가 ,

가

* 가 "

가 "

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