

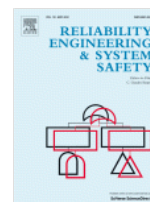
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## Investigating the effect of communication characteristics on crew performance under the simulated emergency condition of nuclear power plants

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### Abstract

It is well known that the safety of large process control systems could be significantly affected by the communication characteristics of crews that have a responsibility for their operations. Accordingly, many researchers have spent huge amount of effort to grasp the relationship between the characteristics of crew communications and the associated crew performance. Unfortunately, in the case of nuclear power plants (NPPs), it seems that most of existing studies have tried to identify the relationship between the characteristics of crew communications and the associated crew performance using empirical observations without a firm technical underpinning. For these reasons, Park suggested a novel framework that is able to represent the characteristics of crew communications based on social network analysis (SNA) metrics. In order to confirm the appropriateness of the suggested framework, in this study, the characteristics of crew communications that are gathered from the simulated emergency condition of NPPs are additionally compared with the associated crew performance data. As a consequence, it is observed that there are significant relationships between communication characteristics and the associated crew performance. Therefore, it is reasonable to expect that the characteristics of crew communications can be properly grasped using the suggested framework.

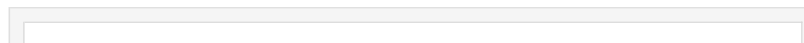
### Highlights

- Communication data of MCR operating crews are collected from a simulated emergency condition.
- Communication characteristics are represented by the associated SNA metrics.
- Identified communication characteristics are compared with the results of existing studies.
- SNA metrics are meaningful for explaining the characteristics of crew communications.

### Keywords

Crew communication; Crew performance; Social network analysis; Cognitively demanding situation; Nuclear power plant

Figures and tables from this article:



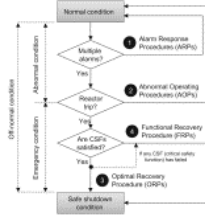


Fig. 1. Simplified strategy to cope with the off-normal conditions of NPPs.

Figure options

Communication Content	Crew member				Sum	Average
	OP <sub>1</sub>	OP <sub>2</sub>	OP <sub>3</sub>	OP <sub>4</sub>		
A	34	9	3	6	52	13.0
B	6	25	10	8	49	12.3
C	21	6	3	5	35	8.8
D	4	9	6	5	24	6.0
E	6	4	6	4	20	5.0
F	4	4	2	2	12	3.0
Sum	75	57	30	30		
Average	12.5	9.5	5.0	5.0		

Fig. 2. An example of raw data related to arbitrary crew communications.

Figure options

	OP <sub>1</sub>	OP <sub>2</sub>	OP <sub>3</sub>	OP <sub>4</sub>
A	1	0	0	1
B	0	1	1	1
C	1	0	0	1
D	0	0	1	1
E	0	0	1	0
F	0	0	0	0

$M_1 =$

Fig. 3. A matrix representing relations between communication contents and crew members.

Figure options

		Communication content					
		A	B	C	D	E	F
Communication content	A	2	1	2	1	0	0
	B	1	3	1	2	1	0
	C	2	1	2	1	0	0
	D	1	2	1	2	1	0
	E	0	1	0	1	1	0
	F	0	0	0	0	0	0

Fig. 4. Content-Content matrix derived from  $M_1$ .

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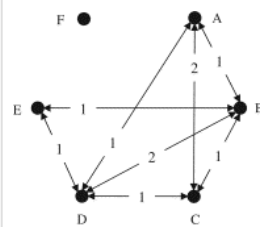


Fig. 5. The social network of an adjacent matrix depicted in Fig. 4.

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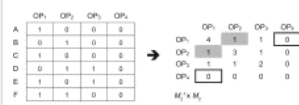


Fig. 6. Constructing a social network pertaining to the structure of crew communications.

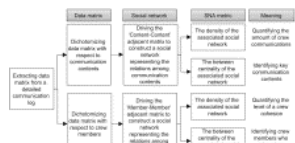


Fig. 7. The overall scheme of a novel framework to grasp the characteristics of crew communications.

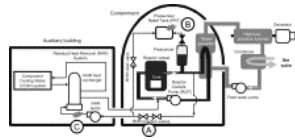


Fig. 8. Simplified diagram of ISLOCA 1 scenario.

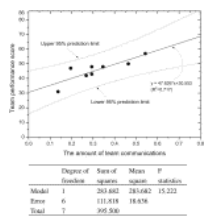


Fig. 9. Result of comparisons: the amount of crew communication and crew performance.

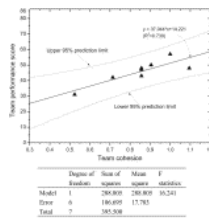


Fig. 10. Result of comparisons: crew cohesion and crew performance.

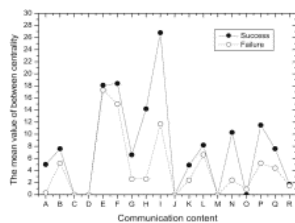


Fig. 11. Comparing the mean value of between centrality with respect to each communication content.

a					b				
	OP1	OP2	OP3	OP4		OP1	OP2	OP3	OP4
A	0	40	0	0	A	10	10	10	10
B	0	0	0	40	B	10	10	10	10
C	40	0	0	0	C	10	10	10	10
D	0	0	40	0	D	10	10	10	10
E	40	0	0	0	E	10	10	10	10
F	0	40	0	0	F	10	10	10	10

Fig. 12. Raw data representing the extreme cases of crew communications. (a) Crew A and (b) crew B.

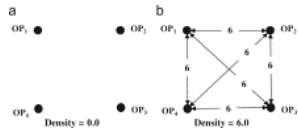


Fig. 13. Density values of two extreme crews.

Figure options

Table 1. Communication characteristics and the associated crew performance.



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Table 2. Existing studies pertaining to crew communications in NPPs.



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Table 3. An example of coding scheme to analyze the contents of crew communications in NPPs.



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Table 4. A part of the required actions to cope with the ISLOCA 1 scenario.



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Table 5. Two kinds of communication characteristics and the associated crew performance scores collected under ISLOCA 1 scenario.



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Table 6. The values of between centrality—successful MCR operating crews.



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Table 7. The values of between centrality—failed MCR operating crews.



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