Issues in Integrated Model of I&C Systems and Human Operators

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Reliability issues and some countermeasures for hardware and software of I&C systems in large-scale systems are discussed in Chapters 1–6. Reliability issues and some countermeasures for human operators in large-scale systems are discussed in Chapters 7–9. Reliability issues and countermeasures when the I&C systems and human operators in large-scale systems are considered as a combined entity are in Chapters 10–12.

The conventional way of considering I&C systems and human operators as parts of large-scale systems is introduced in Section 10.1. Reliability issues in an integrated model of I&C systems and human operators in large-scale systems are summarized based on some insights from the accidents in large-scale systems in Sections 10.2 and 10.3. Concluding remarks are provided in Section 10.4.

10.1 Conventional Way of Considering I&C Systems and Human Operators

PRA is widely used for reliability and/or risk analysis of large-scale systems. PRA usually consists of the development of event trees and fault trees for describing possible scenarios after the occurrence of an initiating event and determining branch probabilities for event trees, respectively.

An example of how I&C systems and human operators are considered in conventional event-tree-and-fault-tree-based PRA models is shown in Figure 10.1 [1]: an event tree, including a low-pressure safety injection system (LPSIS) in an NPP, and a part of a fault tree for calculation of branch failure probability of safety
injection by LPSIS. I&C systems are considered in the basic event for evaluated failure of safety injection actuation signal (SIAS) generating devices. Human operators are considered in the basic event for the failure of operator manually generating SIAS as part of the fault tree (Figure 10.1). I&C systems and human operators are not described in detail in conventional PRA models because PRA mainly focuses on hardware failures. I&C systems and human operators are considered to be independent in conventional PRA models (Figure 10.1).

10.2 Interdependency of I&C Systems and Human Operators

I&C systems and human operators are independently modeled in the conventional PRA (Section 10.1). Researchers in the field of quantitative safety assessment of large industrial systems consider the interdependency of I&C systems and human operators.

![LPSIS Injection](image)

**Figure 10.1.** An example of how I&C systems and human operators are considered in conventional PRA models