

# A Scrutinized Analysis Method of the Human Error Potential due to the Introduction of New Digital Devices to Nuclear Power Plants

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**Abstract.** This paper describes a new method proposed for human error analysis (HEA) in case of the introduction of new digital devices to nuclear power plants (NPPs). Preventing human errors has been a main issue especially for the safety of NPPs. The hi-touch human interface must be proved to be safe before being introduced to NPPs. Although many good HEA methods are available, a scrutinized one is inevitable against to the new types of errors, for utilizing new digital devices and their human interfaces in NPPs. All possible interactions between the device and the user through the designed interfaces are investigated by the term of Interaction Segment (IS), and Error Segment (ES) is assessed by human factors criteria and their consequences to predict the human error potential (HEP). Results such as a list of ISs and ESs and their combinatorial sequences are provided to the human interface designers for qualifying the digital devices to NPPs.

**Keywords:** human error, human interface, digital device, nuclear power plant.

## 1 An Approach to Human Errors in Digital Human Interface

Human error has been notorious as a universal enemy which has potential to break down all barriers and protective features for system safety. Many researchers have investigated the task performance of human and its influence to overall level of functional reliability. They have performed the studies to predict and prevent the human error through probability and usability; however, inadequate decisions and/or unwanted behaviors are inevitable to human itself. It has been complicated to know the details mechanism of human errors previously as the high technology digital instruments have been developed and introduced. Thus, it was needed to predict the detailed error potential, and to prevent previously in design of, especially NPPs. ES and IS were defined according to exterior physical units and operation options of the digital devices. It could be possible to review all interactions through ES and IS for using digital devices.

This paper describes a new method proposed for human error analysis (HEA) in case of the introduction of new digital devices to nuclear power plants (NPPs).

Recently, the human interface has been drastically revolved by virtue of the hi-touch technology as well as the digital and computer technology. It is still strongly doubtful to find such an up-to-date interface in NPPs in near future. Every new design and new technologies must be proved to be safe before introducing to NPPs, and free from defects including all kinds of human errors.

The human error potential within the digital devices should be thoroughly investigated from the early phase of design to the integration and operational phase. Although many good HEA methods are available, a scrutinized one is inevitable against to the new types of errors, for utilizing new digital devices and their human interfaces in NPPs.

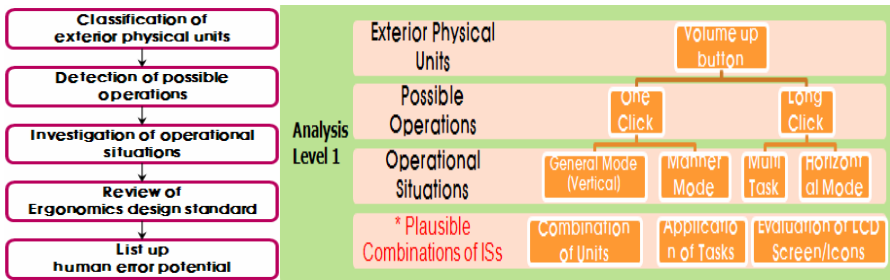


Fig. 1. Steps for HEA proposed

## 2 Interaction Segments (IS) and Error Segments (ES)

A digital device has various design factors of interface itself that might give very different impact to the user by not only the shape and color but also the operation methods, control states, and so on. Lee, et al. (2003) defined *Error Segment* as “the basic unit has the potential causing negative affect for use”[1]. In this study to find out the human error potential (HEP), two new terms such as *Interaction Segment (IS)* and *Error Segment (ES)* are introduced. All possible interactions between the device and the user through the designed interfaces are described in term of *Interaction Segments*. And *Error Segments* are assessed among the various combinations of ISs. They are enumerated into the combinatorial structures of all applicable tasks, nevertheless their frequencies might be extremely low.

The human error potentials of each *IS/ES* are respectively examined by human factors engineering criteria, and the plausible sequences of various combination of all ISs are assessed by their evolutionary paths to the ultimate consequences. Results such as a list of *Error Segments (ESs)* and their combinatorial sequences are provided to the human interface designers for qualifying the digital devices to NPPs.

## 3 Example Application and the Results

Three kinds of smart phones were analyzed and they are named type A, B, C. It has been using with the limited function in NPPs currently [2]. ES and IS were defined from instrument (device character, H/W and S/W design problem, and component

breakdown), user (operation method, knowledge level, and user character), operation situation and so on. ES was classified by exterior physical units of the smart phone and IS was listed from user and operation situation. (LCD buttons are excluded just they are reviewed as an integrated icon in the applications.) They will be considered to a further research. Followings are results of example application of the proposed method to three different types of smart-phones for design review before NPP field applications. Table 1 shows a part of IS lists coded at capital alphabet. Figure 1 shows a comparative result about the total numbers of ISs. It is quite clear that type C smart phone has less exterior physical units and less ISs than the others.

A-Phone : 22			B-Phone : 21			C-Phone : 12				
category	code	Ext. Segment Unit Physical Unit	category	code	Ext. Segment Unit Physical Unit	category	code	Ext. Segment Unit Physical Unit		
Exterior Button	P	Power button	Exterior Button	P	Power button	Exterior Button	P	Power button		
	V+	Volume button(up)		V+	Volume button(up)		V+	Volume button(up)		
	V-	Volume button(down)		V-	Volume button(down)		V-	Volume button(down)		
Touch-Button	H	Home button	Touch-Button	T	Track-ball	LCD	I	Icons		
	B	Go Back button		B	Go Back button		D/C	Data/Charging Port		
LCD	M	Menu button	LCD	L	List button	Etc.	EH	Ear-phone hole		
	I	Icons		H	Home button		UR	USIM-card remove		
Etc.	D/C	Data/Charging Port	Etc.	S	Search button	Etc.	SE	Speaker(Ext.)		
	EH	Ear-phone hole		LCD	I		Icons	Etc.	SI	Speaker(Int.)
	BC	Battery Cap			D/C		Data/Charging Port		MH	Mic-hole
	BR	Battery Remove		Etc.	SE		Speaker(Ext.)	Etc.	CL	Camera Lens
	UR	USIM-card remove			EH		Ear-phone hole		CF	flash
	SR	SD-card remove		BC	Battery Cap					
	SE	Speaker(Ext.)		BR	Battery Remove					
	SI	Speaker(Int.)		UR	USIM-card remove					
	MH	Mic-hole		SR	SD-card hole					
	CL(F)	Front Camera		SE	Speaker(Ext.)					
	CL(R)	Rear Camera		SI	Speaker(Int.)					
	DA	DMB Annt.		MH	Mic-hole					
	AS	Sensor-recep.		RC	Recharging					
IS	Sensor- flash	CL	Camera Lens							
CF	flash	CF	flash							

Fig. 2. The example of IS and ES for A and B type smart phone

Table 1. List of IS and ES (a part for smart phone)

IS Code.	Operation method	Test for ES by Operation situation				
		No option(Vertical)	Manner mode	Horizontal mode	Multi task	Lock
P	One Click	Screen on/off				
	Long Click	Pup-up window for option				
V +	One Click	Vol. up by stages	Manner mode cancel and vol. up by stages	Vol. up by stages (space compatibility) Oper. intended: down		None
	Long Click	Vol. up rapidly	Manner mode cancel and vol. up rapidly			None
V -	One Click	Vol. down by stages → manner mode	Vibration	Vol. down by stages (space compatibility) Oper. intended: up		None
	Long Click	Vol. down rapidly → manner mode	Vibration			None
T	Rotation	Move	Move	Move	Move	None
	Click	Selection	Selection	Selection	Selection	None

For an example, in case of HEP at ‘V+’ in ES and ‘Horizontal mode’ in IS, operators have different intention about Volume up button (V+) between no option and horizontal mode in IS. However they showed the same response. When V+ is in horizontal mode, it has performed to turn down the volume (V-). It caused confusion to operators by violating the space compatibility. If V+ is in horizontal mode, volume would be decreased by stage or rapidly. Because V+ is in the left of the device at horizontal mode, usually operators are likely to push the left button for decreasing the volume. The application includes a review by design criteria from the human factors

engineering/ergonomics design standards such as functional availability, suitability of design, consistency, compatibility, effectiveness for use, and so on.(see Figure 2).

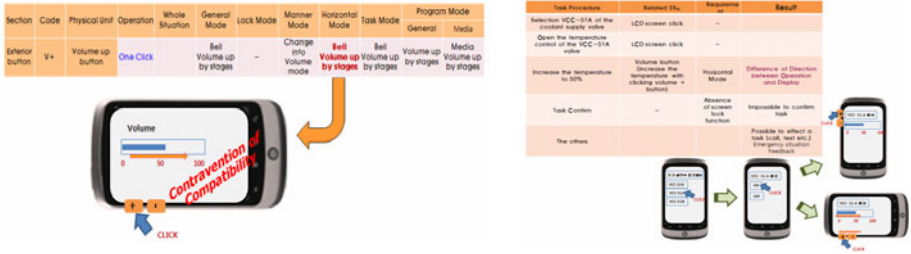


Fig. 3. Review on the interface by the human factors criteria

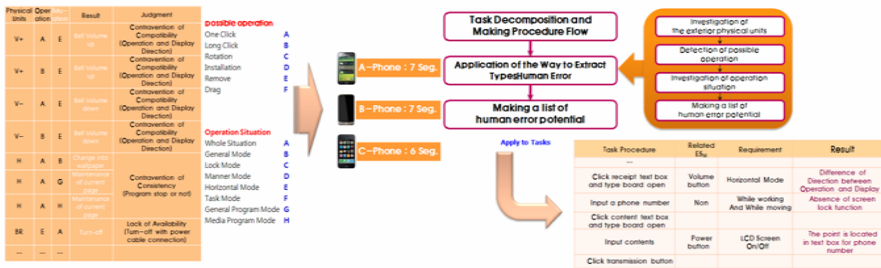


Fig. 4. Steps and results according to the applications to smart-phones

### 4 Conclusions and Discussions

A new HEA method summarized in figure3 can facilitate to specify HEP of a digital device based on the *Error Segment (ES)* and *Interaction Segment (IS)*. All possible interactions can be described in term of IS/ES, and HEP can be thoroughly investigated from the early phase of design by providing a list of IS/ESs to the human interface designers for qualifying the digital devices to NPPs. The results are to be verified through the experimental observation [3].

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