



BUSINESS PROCESS BASED REQUIREMENTS MODELING OF RADIOLOGICAL TRAUMA TRIAGE CAPACITY PLANNING FRAMEWORK

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ABSTRACT

Prior investigations indicated that Malaysian radiation and nuclear emergency plan stakeholders were not satisfied of having two-quarter of organizational issues in organizing and managing the indicated disaster scenario. Therefore, any organizational enhancement and improvement along the current radiation and nuclear emergency plan will give a positive and immediate impact on the public acceptance of the localized nuclear power program implementations. The policies and procedure issues must not be considered lightly because it may affect public adoption even though the nation has compromised on it for social and economic development. Moreover, any defect in the managerial and organizational structure might be a hindrance to the nuclear safety regulatory assurance. The structure of the respective emergency planning framework had to be tested and validated thoroughly in a structured manner to overcome this problem. This study proposed a hypothesis to build a current regulatory framework through empirical interpretive case study and computer simulation development. The hypothesis of the research framework was found to be useful and significantly accepted as it is interdependent and correlated with statistical measures and supported with the demonstrations of the agent based social simulation prototype. It has the potential to develop a structured and thorough emergency planning framework by interpreting and integrating mixed-method analyses and models through information systems theoretical lenses. Most probably, future works may imply them as strategized, condensed, concise, and comprehensive public disaster preparedness and response guidelines, and to be physically deemed as a useful and effective computer simulation.

Keywords: emergency, requirement, viewpoint, interpretive case study, planning framework, modeling, and simulation.

INTRODUCTION

Developing countries in ASEAN (Association of the South East Asia Nations) are demanding for efficient and effective energy policies by promoting renewable energy. An assessment of a nuclear power program (NPP) in Malaysia was suggested and developed during the proclamation of the Malaysian Budget in 2009. Therefore, the assurance of regulatory framework is critically acclaimed in order to obtain public acceptance towards the development of the NPP [1]. This critical factor is

supported and justified significantly from the prior research findings that indicated most of the stakeholders proposed a good, structured and thorough radiation and nuclear emergency planning framework (RANEPF) development so as to enhance public awareness about the dedicated power development program. However this causal factor (x) is significantly indicated that one-quarter (26%) of the organizational issues triggered due to the stakeholder's dissatisfaction in the respective emergency plan (y) as depicted in Figure-1.

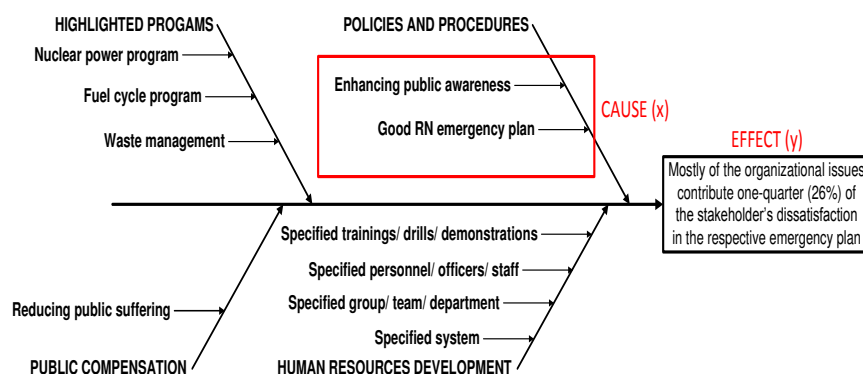


Figure-1. The key success in the event of Malaysian nuclear power program (NPP) [2, 3].



Deliberately, in order to develop an effective emergency preparedness and response planning framework, two prioritized actions need to be accomplished. Firstly, greater determination on the considered information of core emergency processes and tasks must be clearly justified during the data collection and validation. Most likely, these information are remarkably implicit but still need to be taken as the "black box" [4]. In addition, communication is important to gain access of the data or expertise in order to piece together accurate and understandable circumstances during any emergencies or crisis [5]. Muhren (2008) highlighted that the design obstacles of a desirable and practical emergency planning framework would cause chaotic information systems (IS) representation due to exclusion of sensory information, feelings, intuitions and context. Regarding to these findings, disorganized situation might be felt during emergencies and crisis situation due to lack of information and messages that can be reliable and accurate enough to be referred among the people and organizations. A chaotic situation might occur among the society and organizations involved [6]. In the 21st century, any occurrence of disasters, emergencies, and crisis situation demand a sophisticated technological support such as IS representations (i.e. decision support system, geographic information system, social media, and others) to overcome the situation. Subsequently, problems will arise during the launching of the product, since the product does not meet user requirements [7]. Some literature highlighted that IS design mislead on how people make sense of their environment [4, 8, 9]. IS representations are chaotic due to the defect data and restricted processing capacity of the data manager. These two have caused interrelation with one another which comprised of incomplete data that consider whatever can be captured and processed through machines. This data excludes any sensory information, feelings, intuitions, and context, which is necessary but hard to be preserved by computerized machines and create incompatible information to the observer [4]. In this situation, inadequate information that lack objective and timely manner contributes to public health problem and socio-psychological stress among the authorities and public community [10].

Thus, this research is challenged as the previous research variables indicated in Figure-1 were significantly independent but interrelated and correlated. This prior finding failed to determine the dependent and independent research variables to be theoretically tested. This research also implemented purposive sampling which required a small number (more less than 50 people) of specified stakeholders to be the dedicated case studies [11, 12]. In conjunction of that, these research obstacles had brought to light by adapting theory building (generation) technique according to the prior hypothesis of the emergency planning framework development. Another way to achieve this research goal is by applying a desirable and practical IS design development of the emergency plan. The IS

design of the Malaysian RANEPF planning framework is targeted to perform and achieve technical and practical knowledge research approaches from the organizational perspectives. This action is important to obtain solutions to reduce the highlighted organizational issues using socio-technical approaches. However, there were no specified theories and research methodologies to be adapted in such a way. Additional worst case scenario of the research background came from the fuzzy components and composite networks of the radiological and nuclear disaster identifications, coordination and characterizations. Besides that, it is also difficult to identify the risk management failure of the phenomenon. Moreover, any conventional approaches of research experimentations are highly difficult and risky to be applied.

These literatures and research limitations bring to the objective of this paper to determine the coordination and characteristics of a disaster scenario in the suggested emergency planning framework. This framework is an extended conceptual studies that refer to the Iivari's Information Systems Development Approach (ISDA) framework and socio-technical related IS theories with the effect of business process based requirements modeling and simulation development process. In summary, this paper discusses the translation and transformation of Figure-1 into a more structured and practical conceptual framework as the process factors and responses diagram. This diagram is vital to justify and determine the coordination and characteristics of the simulation modeling and prototype development. By doing so, business process based requirements modeling and simulation (BPRMS) is suggested to develop and validate the RANEPF and radiological trauma triage capacity (RTTCPPF) planning frameworks. The final products were the improved emergency planning frameworks and RTTCPPF agent based social simulation system for Malaysian context. These development and validation are important so as to achieve regulatory assurance for obtaining public acceptance towards the development of the Malaysian NPP.

RESEARCH METHODOLOGY

The hypothesis (theory) building of the emergency planning frameworks referred to Figure-2. It is the indicator to determine and coordinate the characteristics of the disaster through embedded and concurrent triangulation of the theoretical and methodological research approaches. The research approaches are the interpretive case study and computer simulation development that validated and verified the data and knowledge (tacit and explicit) captured among the stakeholders as in Figures 3 and 4 [13-15]. Figure-2 determined coordination and characterization of disaster scenario within stakeholder's and system requirements of the planning frameworks. Figure-2 determined the coordination and characterization of the disaster scenario within the stakeholder's and system requirements of the planning frameworks.



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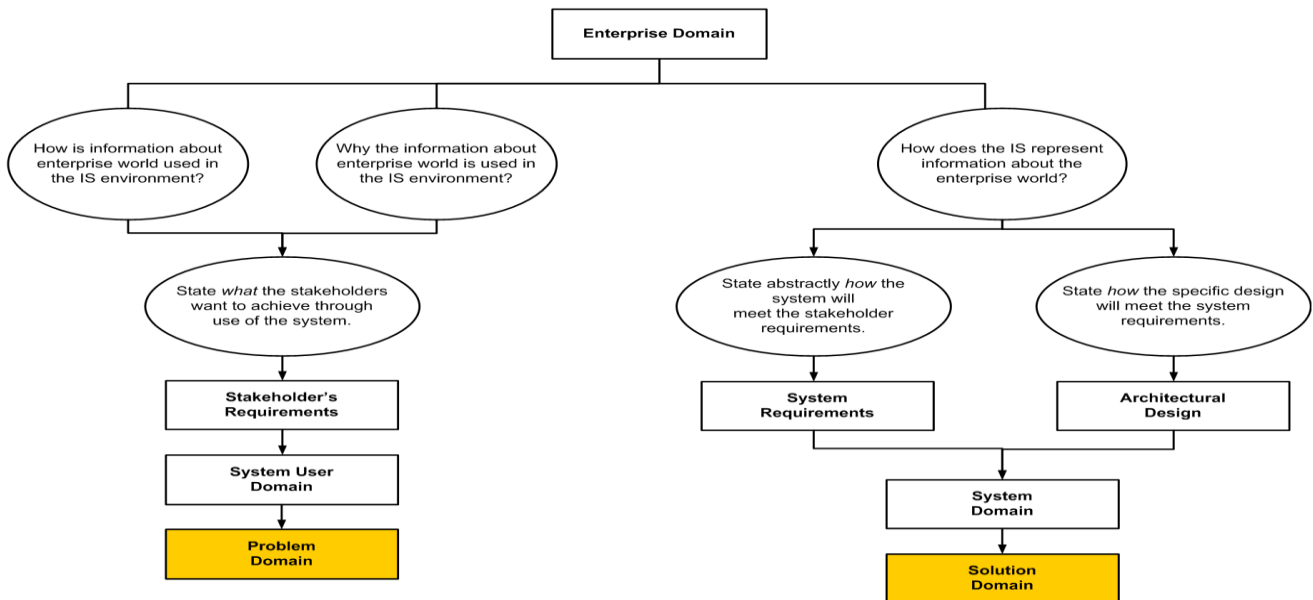


Figure-2. The categorization queries of requirements engineering for viewpoints and requirements.

Requirements engineering processing methods indicated that the problem domain justifications which involved the characterization of the business needs as the use cases to be acknowledged as the stakeholder's requirements. Meanwhile, the solution domain is based on the end product (simulator) justifications which refer to the system and technological requirements.

The hypothesis (theory) building of the emergency planning framework is justified and determine according to the external and organizational environment components in ISDA framework [16, 17]. These indicators are the main guidance in developing the information systems which are based on phenomenology such as interpretive case study. Firstly, the research philosophical and paradigmatic assumptions are recognized as the IS development process knowledge. Next, the organizational environment of the phenomena is suggested as the IS body of knowledge. The organizational environment involves research strategies and methodological assumptions of the phenomena. The organizational environment is divided into three environments consists of a user, IS operations, and IS development environments. Both user and IS operations environments represent the stakeholder's requirements in the problem domain. Meanwhile, IS development environment indicates the system requirements of the solution domain.

Figure-3 is the research framework in implementing the development of the respective emergency planning frameworks and simulation

development through IS theoretical and methodological triangulation of research approaches. This research framework is divided into three main studies of analyses, namely; the feasibility study and requirements elicitations, requirements specifications and validations. The first study is implemented to interpret the stakeholder's statement of needs in other word; collective viewpoints in the phenomenon. Most probably, these viewpoints were analyzed according to the theoretical acceptance strategy. Consequently these viewpoints were justified into recommended stakeholders and system requirements through system test strategy. The system test strategy applied prior process modeling and the baseline simulation user interface development. Above all, the final study indicated the development of the system architectural design as to validate the suggested framework process models into justified baseline simulation and improved case-based simulation experimentations. The simulation prototype was tested eventually by implementing the framework evaluation and prototype usability test.

Figure-4 depicted the detailed research process as the high level development process of the simulation prototype. The research process were divided into five development phases of the process framing, the "as-is" process understanding and definition, the "to-be" process design development, and finally the development and validation of the system architectural design. The development phases consisted to the similarly equal research phases indicated in Figure-3.

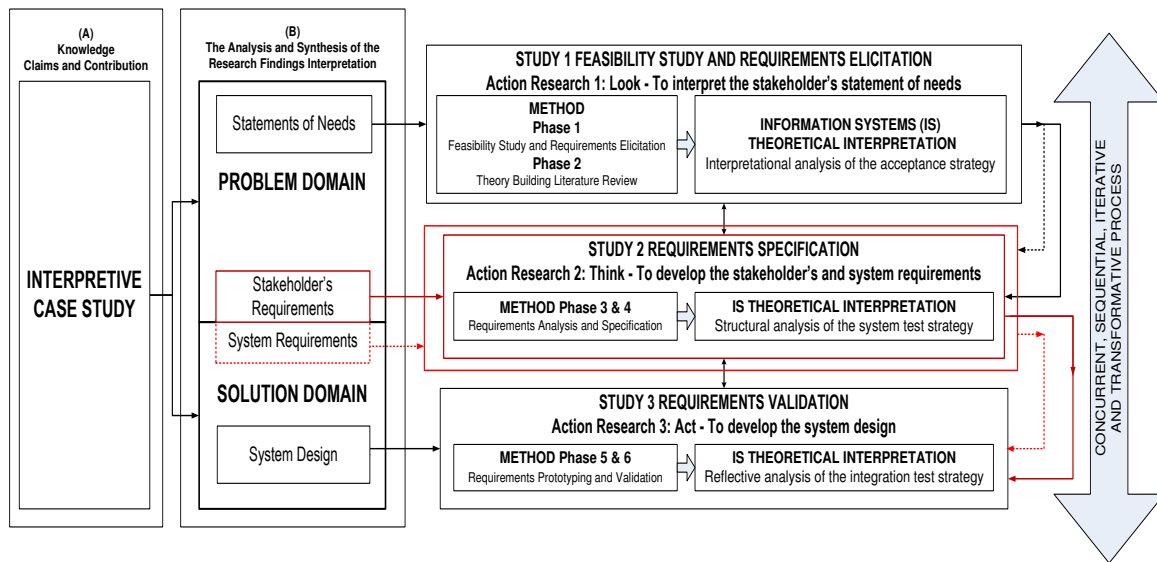


Figure-3. Research framework.

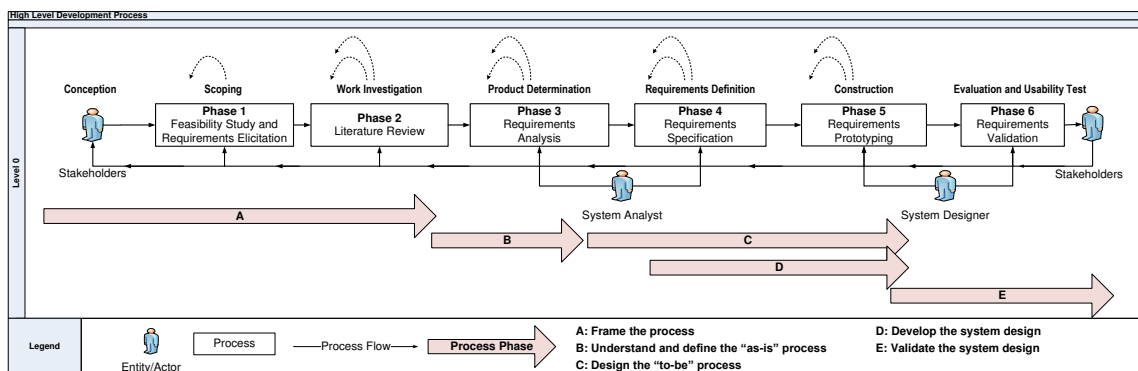


Figure-4. Research process.

RESULTS AND DISCUSSIONS

This study was the integration between empirical and non-empirical studies that combined several research design elements as a mixed method strategies namely purposive sampling, case study and action research protocol, instruments that based on operational, managerial and clinical data, qualitative and quantitative data analysis, and conceptual and process modeling. Most significantly, these components were validated and justified according to the proposed IS theoretical interpretations captured earlier. The non-empirical studies were a combination of theory building literature review and computer simulation which triangulate with those mixed methods research design (acknowledged empirical studies) [15, 16, 18-20]. The data collection of this study was conducted three times in order to achieve theoretical saturation among the radiation and nuclear emergency planning stakeholders, international and national expertise as well as academia. They were divided into three case studies which were conducted in 2011 as the pilot case study (56 respondents), 2013 as the interpretive case study (20 respondents) and 2015 as the framework evaluation and prototype usability test case study (20 respondents as well). While theoretical sampling is common in this study,

therefore minimum cases of four cases with a maximum of 15 seem to be favored (Cooper & Schindler, 2007). Distribution of each focus groups (2011 results indicated $\chi^2 = 1.26$; $p = 0.532$; 2013 explained $\chi^2 = 4.00$; $p = 0.406$ and 2015 is $\chi^2 = 1.90$; $p = 0.592$) according to gender distribution was not significantly different. This result reflected homogeneity in gender distribution among the research participants. Thus, any differences to gender were not accepted.

The integration of empirical and non-empirical studies is to perform a desirable and practical IS design development according to socio-technical approaches. Empirical studies refer to how people act in an organizational context, non-empirical studies refer to the theoretical focus on the relationship understandings between people actions take and organizational structures, and philosophical focus is the IS theoretical perspectives on the roles of practices in producing organizational reality [21]. The principles of this integration involved consequential and situated actions in the social life, dualisms are rejected in the theorizing and, recognized these inherent relationships as mutually constitutive [21]. Basically, this mixed methods triangulation demonstrated the practical implications of developing IS design



consisted of technical and practical knowledge interest as explained in Table 1. An information system is defined separately between a technical system and the integration of technical and social system. Technical knowledge interest is the human “work” related to the structured physical work. Meanwhile practical knowledge interest involved human intervention to interpret, understand and shared the meanings of related communication and language used (Zining & Sheffield, 2006). IS should imposed of practical implications of system development and understandings of organizational and social system. It should be fitted according to the organizational requirements. Ultimate purpose of an IS development is to produce organizational changes by enhancing organizational effectiveness. The fit is achievable by integrating the technical, organizational and social system (in a socio-technical perspective). The outlook is to produce richer view of organizational and social consequences by extending desirable and practical IS design (Iivari, 1991).

Table 1 and Figure-5 displayed the process factor and response diagram as the hypothesis building diagram of the inquiry. The hypothesis is built, theoretically based on the case, and affect arguments in the earlier part. The

causes were divided into controllable and uncontrollable input factors, responses, and output measures. The main contribution of the study was the determination of coordination and the characteristics of the respective emergency planning framework. This indication is assumed according to the design of experiment (DOE) by which a structured and organized method is used to determine the relationship between the input factors (X1, X2) affecting the process and the output of the process (Y1, Y2) [22]. Process box displayed how the coordination level and setting of the phenomena will be captured, determined, and validated through business process based requirements modeling of the planning frameworks. Meanwhile the controllable output measures box showed the development of the respective simulator. Y1 responds to the deliverance of X1 indicator through business process based requirements modeling in order to reduce or avoid 26% of organizational issues which consisted of two-quarter (66%) of the stakeholder’s organizational incapability and incompetence [2]. By doing so, we can enhance and improve the public awareness and acceptance on NPP by assuring the suggested regulatory framework in this study.

Table-1. Feature map and descriptions of the research input, process and output factors as depicted in Figure-5.

Indicators/ Items		Descriptions	
		Problems	Solutions
Input Factors	Controllable input factors X1	<ul style="list-style-type: none"> • Causal conditions of the research. • The causal factor (x) is one-quarter (26%) of the organizational issues were triggered due to the stakeholder’s dissatisfaction in the respective emergency plan (y). 	<ul style="list-style-type: none"> • A good, desirable and practical IS design of an emergency planning framework consisted of structured and thorough components referring to the sense making of the human factors in the DERMIS design model.
	Uncontrollable input factors X2	<ul style="list-style-type: none"> • Regulatory framework assurance is critically acclaimed in order to obtain public acceptance towards the development of the NPP. 	<ul style="list-style-type: none"> • Enhancing and improving public awareness and acceptance towards the development of the NPP. • Assuring the radiological and nuclear safety regulatory framework assurance is achievable in parallel.
Process	Coordination of the disaster scenario level and setting	<ul style="list-style-type: none"> • Difficult to determine the disaster coordination and characteristics of the radiological and nuclear disaster scenario. • Difficult to integrate the applied IS conceptual studies in the phenomenon. • Difficult to translate and transform the conceptual studies into a physical form of external and organisational environment of system design. 	<ul style="list-style-type: none"> • Suggested business process based requirements modelling and simulation development (BPRMS). • The research process outcomes are the improved RANEPF and RTTCPF emergency planning frameworks.
Output Factors	Controllable responses and output Y1	<ul style="list-style-type: none"> • The intervening conditions created two-quarter (66%) of the stakeholder’s organisational incapability and incompetence in organising and managing the disaster circumstances (Y1). 	<ul style="list-style-type: none"> • The determination of the development and implementation of the RTTCPF agent based social simulation system and prototype.
	Uncontrollable responses and output Y2		<ul style="list-style-type: none"> • Consequently, will avoid and reduce two-quarter (66%) of the stakeholder’s organisational problem by achieving better understanding and classifications of the disaster phases (i.e. improved regulatory framework and anatomy of the RTT triage system).



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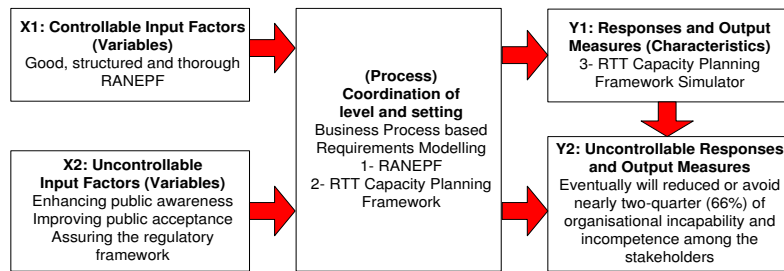


Figure-5. Process factor and response diagram.

This study has contributed an integration of paradigmatic and methodological assumptions by implementing mixed methods design. Table-1 displayed the embedded and concurrent triangulation of socio-technical research approaches using interpretive case studies and simulation development in order to achieve technical and practical knowledge interests. This research design involved mainly in qualitative data collection, but concentrated on both quantitative and qualitative analysis of data (perceptions (tacit), explicit knowledge, operational, managerial, and clinical data) in a single case study. Those data are collected concurrently and sequentially with a given priority, and involved the data integration in multiple stages of the research process [23]. The research process involved iterative data transformation to be translated into information and knowledge, as well as business process based requirements modeling and simulation [18]. This study produced and contributed to the implicit and explicit

research outcomes [23]. The implicit criteria of this study were implied in the theory building through the empirical interpretive case study research. By doing so, the collected and investigated stakeholder's perception in terms of tacit and explicit knowledge were interpreted and infused, combined with other operational, managerial, and clinical data. By integrating these data with unstructured and fractured perception of the stakeholder, an additional explicit outcome of this study was established. The explicit outcome produced design characteristics of the business process based requirements modeling and simulation. In short, the other novelty of this approach is quantifying (analyze and model) qualitative data into functional process models and interpreting supporting quantitative data to be value added to the phenomena. This finding is as such in order to support and fulfill separate technical and practical research interests (Table-1). The finalized deliverables are displayed in Table-2.

Table-2. Summary of the research process deliverables.

Criterion	User Environment	IS Development Environment	IS Operations Environment
Organisational Environment	Development of Radiological Trauma Triage (RTT) Capacity Planning Framework Simulator in the Radiation and Nuclear Emergency Planning Framework (RANEPF).		
Human	Radiation and Nuclear Emergency Planning Stakeholders or other disasters/ emergencies (decision maker, emergency planner and organiser as well): <ul style="list-style-type: none"> Disaster Coordinator. Main Rescue Agency and Regulator. Technical Support Team. Healthcare Support Team in the Accident and Emergency Department. 		
Technology	<ul style="list-style-type: none"> Theory building (generation) conceptual studies. Conceptual strategic management. RANEPF Regulatory Framework. Anatomy of the RTT Triage System. 	<ul style="list-style-type: none"> Business Process based Requirements Modelling and Simulation Development (BPRMS). 	<ul style="list-style-type: none"> RTTCPP Agent based Social Simulation Model Prototype/ Simulator.
IS Development Methods	No Need	<ul style="list-style-type: none"> Embedded and concurrent triangulation of theoretical and methodological research approaches. Theory Building through Empirical Interpretive Case Study. Goal and Viewpoint based Requirements Engineering Methods. 	No Need

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CONCLUSIONS

As the concluding remarks, this paper indicated that application of the proposed RANEPF and RTT capacity planning frameworks and simulator assumed to avoid and reduce one-quarter (26%) of the organizational issues consisted of two-quarter (66%) of the stakeholder's

organizational incapability and incompetence by chance. The consolidation of empirical and non-empirical studies was claimed to be successfully deployed in the dispersed mixed methods elements strategies suggested. These research findings concluded that this approach can bridge the gaps identified in the organizational environment in the Iivari's ISDA framework. Furthermore, this study incorporated the stakeholder's tacit and explicit knowledge as the main contribution of the emergency planning frameworks and simulator development.



This paper demonstrated the conceptual and practical entanglement between people (human), technology, and organizational and managerial (operations) environments. The proposed research framework displayed the effectiveness and usefulness of IS theoretical (in technical and practical research interest) in the information systems (IS) development approach. This paper demonstrated that integrated validation and verification of analyses and models can be achieved through IS theoretical interpretations. The main contribution of this study was bridging the gap in ISDA which refers to the study of phenomenology using unstructured and fractured data in an empirical interpretive case study. Integrated interpretations of qualitative and quantitative analyses and modeling of the stakeholder's and system requirements were proven to be accurate, agreed, and correlated with statistical measures. Useful transformation of those data included soft and hard coded research outputs in terms of policy making guidelines rather than system development solely. This proposed research framework and process successfully coordinates and characterizes the setting of the recommended emergency planning framework in a dynamic and complex crisis situation of a specified emergency scenario. Additionally, it is also useful to translate and transform those unstructured data into the application of emergency planning framework and simulator.

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