Design and Realization of Emergency Desktop Drill System for Open Sea Exploration Accidents

Haodong Chen[1, a], Yi Huang[1, b], Yingying Zhu[2, c*], Jianchun Fan[2, d], Yajie Wang[2, e]
*Corresponding author: 2924573716@qq.com[c]
547199285@qq.com[a], 591349895@qq.com[b], 804420372@qq.com[d], 648809025@qq.com[e]

[1]CNOOC Hainan Energy Co., Ltd, Hainan, China

[2]China University of Petroleum (Beijing) College of Safety and Ocean Engineering, Beijing, China

Abstract: China's open-sea areas are far from the mainland, and the open-sea environment is complex and changeable. Therefore, the open-sea exploration accident emergency drill is difficult and expensive. In order to solve this problem, an emergency desktop drilling system is developed, which integrates the functions of emergency training and emergency drilling and is suitable for open-sea exploration. According to the emergency experience of typical cases at home and abroad, the accident emergency drill scene is designed. Based on the 3ds Max, three-dimensional model of open-sea exploration accident is established. The simulation of fire, explosion and other effects is realized. The development of emergency training and emergency drill function module is completed by using visual studio and SQL server and the visual display of the drill scene and the human-computer interaction function are also realized. The results show that the system can not only achieve the purpose of daily emergency training and accident emergency drill for operators, but also help to improve the emergency disposal ability of operators in open-sea exploration area.

Keywords: Open-sea exploration accident; Emergency drill; Emergency training; Desktop drill system; 3D simulative scene

1 Introduction

In recent years, with the continuous development of oil and gas exploration and development technology, China's oil and gas exploration began to focus on open-sea areas. The open-sea area is rich in oil and gas reserves and has a low degree of development[1], but it is far from the mainland and has complex sea conditions, which is vulnerable to the impact of water depth, typhoon and other marine natural environment. At present, China's open-sea exploration is still in its infancy, and the exploration technology is not mature enough. Open-sea exploration and development will face great security risks[2]. Once an emergency occurs, it is very easy to cause disastrous consequences, such as the "Deepwater Horizon" accident in 2010. Therefore, it is an important guarantee for the safety of open-sea exploration operations to strengthen the daily training and emergency drill for open-sea exploration operators and improve the overall emergency disposal capacity and emergency level of the platform.

Emergency drill can be divided into actual drill and desktop drill according to the drill method[3]. Actual drill is to simulate the real accident scene, which takes a long time and manpower. Desktop drill is an emergency drill scenario that uses words, pictures and videos to describe

ICICA 2022, December 02-04, Chongqing, People's Republic of China

DOI 10.4108/eai.2-12-2022.2328043

accidents. It has short preparation time and few resources. However, China's open-sea areas are far away from the mainland of China, and the open-sea marine environment is complex and changeable. It is difficult and expensive to simulate the real accident emergency scene. Therefore, for open-sea areas, desktop exercise is the most cost-effective exercise method.

Desktop exercise was first used in the military field. In foreign countries, the United States, the European Union and other countries, desktop exercise was earlier used as an important form in emergency exercise activities, and achieved more results in emergency simulation. For example, shendarker[4] used virtual reality to simulate crowd dispersion, Wojtowicz J[5] and other desktop simulation on traffic Araz[6] and others' emergency simulation on influenza transmission. In China, desktop drill was first applied to emergency response of earthquake disasters in 2004, and then extended to other industries[7]. Song Huihui et al.[8] put forward the overall framework of chemical accident emergency rescue simulation system; Li Qun[9] designed the overall structure of emergency deduction platform and emergency plan platform; Chen Guohua et al.[10] developed a GIS based dangerous chemical leakage simulation system; Wan Suping et al.[11] analyzed the basic operating procedures and methods of emergency desktop deduction.

To sum up, although the research on desktop drill system is relatively mature in the field of chemical engineering, the open-sea platforms are far away from the mainland and need to be equipped with floating docks to ensure the daily and emergency supplies supply of the platforms. The current desktop drill system cannot meet the emergency drill requirements of the open-sea platforms and floating docks. Therefore, according to the characteristics of the far sea exploration, this paper designs the table-top drill system for the accident emergency in the far sea exploration.

2 The General Design System

2.1 System development environment

The far sea exploration accident emergency desktop drill system uses Visual Studio as the main development tool, C# as the development language, and SQL Sever database for storing relevant data. 3ds Max was used to develop 3d simulation scenes, and the scene library was established. Its particle system and Phoenix FD were used to realize the simulation of accident, fire, explosion and other special effects.

2.2 Designing the system function

The system mainly includes five functional modules, including system maintenance, basic information base, emergency training, emergency drill and drill evaluation, as shown in Figure 1.

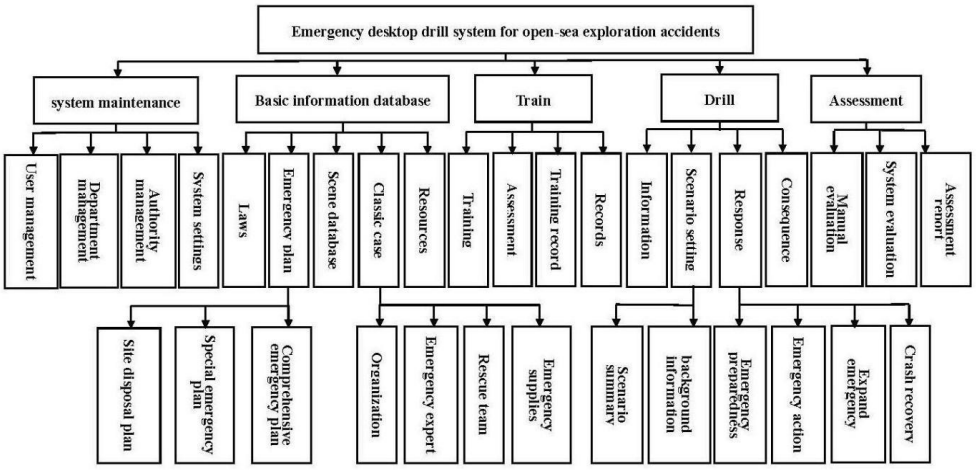

Figure 1 Functional of the system design

2.2.1 System maintenance

System maintenance includes user management, department management, rights management, and system Settings. Administrators can periodically maintain accounts.

2.2.2 Basic information base

The basic information base consists of five parts: laws and regulations, emergency plans, scenario base, typical cases, and emergency resource base. Users can query, add, modify, and delete related information as required.

a) Laws and regulations: The database provides four categories: laws, regulations, department regulations and regional Marine laws and regulations, including countries and regional laws and regulations concerning Marine exploration and development, accident emergency and environmental protection, as well as rules and regulations of various departments of enterprises.

b) Emergency plan: The database includes comprehensive emergency plan, special emergency plan and accident emergency response plan for open-sea exploration and development of enterprises.

c) Typical cases: The database includes the world Marine Accident database WOAD (1970-2015) and the accident name, accident time, accident location, accident type, accident cause and emergency handling process of the typical accident cases of offshore platforms at home and abroad in the past 30 years.

d) Scene library: 3ds Max is used to build three-dimensional scene models, such as the scene when an accident occurs on an offshore platform, a platform fire or a blowout, etc., so that the accident scene can be visually presented in a three-dimensional visualization, and emergency drill personnel can truly feel the accident scene.

e) Emergency resources: The emergency resource database mainly includes four categories: the location and contact information of emergency organizations, the characteristics and contact

information of various emergency experts, rescue teams and relevant emergency materials. Drill personnel can timely dispatch emergency resources according to the development of accidents.

2.2.3 Emergency training

The emergency training module includes two parts: emergency training and training assessment. Managers can conduct irregular training and assessment for operators. At the same time, they can query the previous training records and assessment results of operators and analyze their mastery of relevant basic knowledge, which is conducive to making targeted training and drill plans for operators.

2.2.4 Emergency drill

Based on the scenario construction theory, the initial scenario, emergency response and emergency consequences of the drill scenario are designed according to the four stages of emergency preparation, emergency action, expanded emergency and emergency recovery, and stored in the database according to the principle of minimizing the emergency scenario unit. The drill personnel feedback the corresponding emergency operation according to the scenario display to complete the emergency drill.

2.2.5 Drill evaluation

The drill evaluation module includes two parts: system evaluation and manual evaluation. After the emergency drill, the system and evaluation experts give the evaluation results and evaluation reports according to the emergency feedback of the drill personnel and the matching of various accident operation points, and feedback relevant suggestions.

2.3 Designing the system architecture

The overall architecture of open-sea exploration accident emergency desktop drill system is divided into three parts: user layer, application layer and data layer, as shown in Figure 2.

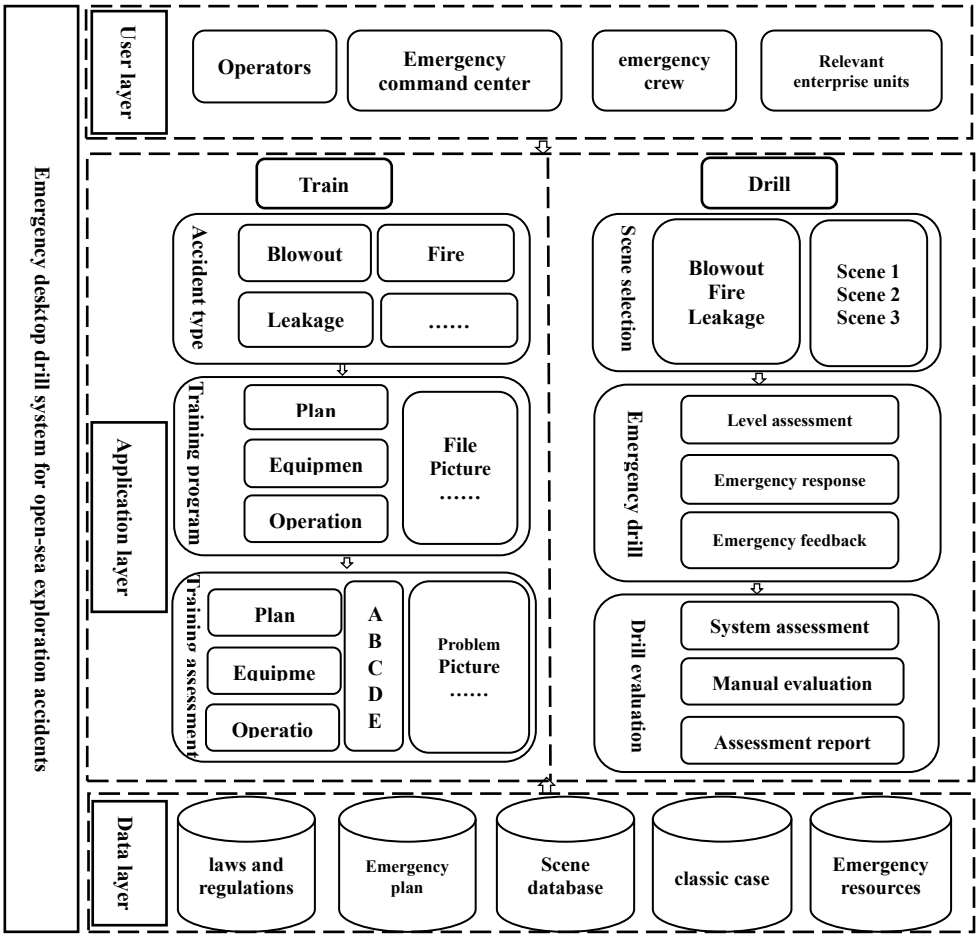

Figure 2 Architecture of the system design

2.3.1 User layer

The user layer is mainly used to manage accounts. Managers can add, delete and modify accounts regularly.

2.3.2 Application layer

The application layer is used to realize the functions of the system, including emergency training and emergency drill. Users can enter the corresponding modules according to their needs. In the emergency training module, the user can select the corresponding accident type for training or assessment as required. After the assessment, the system will automatically give the corresponding score and grade. In the emergency drill module, the users can select a scene of the accident for emergency drill, and the drill personnel can make corresponding emergency operations according to the three-dimensional display of the scene.

2.3.3 Data layer

The data layer provides data support for the user layer and application layer, and can be used to store emergency training records and emergency drill records.

3 Realizing System Functions

3.1 Realizing 3D simulation scene

The system uses 3ds Max to develop the emergency simulation scene. According to the pictures and drawings of the offshore platform, the overall model of the of offshore platform, Floating Wharf and guard ship is established by using the method of polygon modeling. Simulate the sky and natural light by adding spheres, maps, and lights to the scene. Add a noise modifier and adjust parameters such as phase to simulate the marine environment. Particle system and Phoenix FD are used to simulate special effects such as fire, as shown in Figure 3.

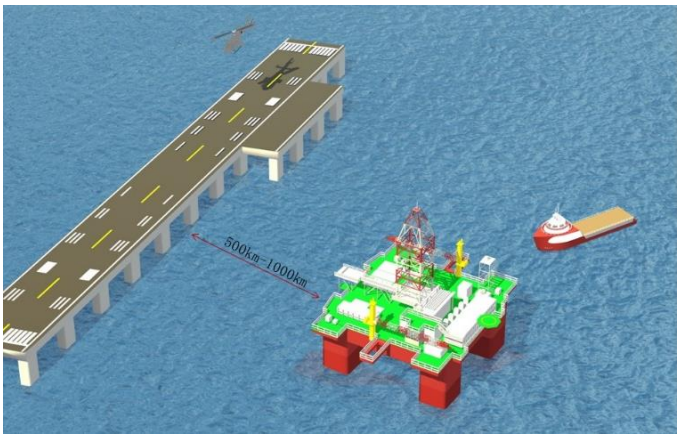

Figure 3 Simulation model of open-sea platform and Floating Wharf

3.2 Realizing emergency training function

The emergency training function is divided into two parts: emergency training and training assessment. Emergency training mainly focuses on the basic knowledge of emergency plan, emergency equipment and emergency operation; Training appraisal is mainly for the training content, with a total score of 100. You can select the corresponding button to switch topics and select options. After the appraisal, the system will automatically calculate the appraisal score, as shown in Figure 4.

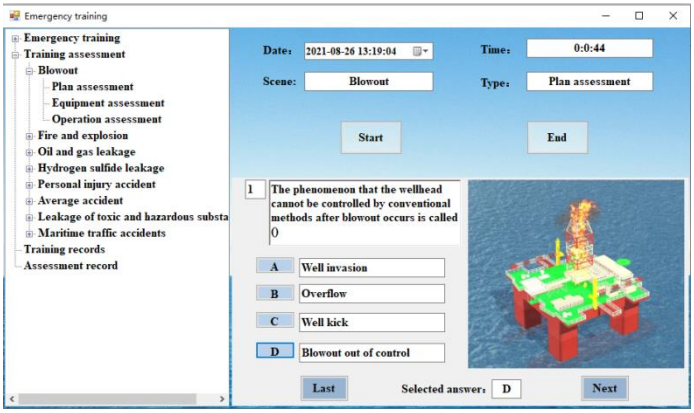

Figure 4 Training assessment interface

3.3 Realizing emergency drill function

The open-sea exploration platform is far away from the mainland. Therefore, this system is mainly aimed at the on-site staff of the platform.

Taking the platform blowout fire accident as an example, the emergency simulation drill is carried out according to the four stages of emergency preparation, emergency action, expanded emergency and emergency recovery. According to the different stages of accident development in the simulation scene animation of the scene display panel, the drill personnel feedback the emergency operation through the emergency action operation panel of the emergency drill interface according to the response flow chart in Figure 5, and the real-time information window can display the current drill process.

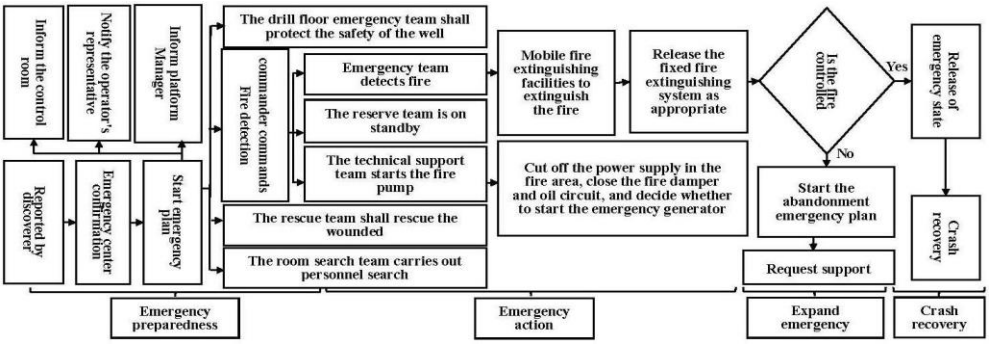

Figure 5 Emergency drill process of the platform fire

In the emergency preparation stage, the discoverer found a blowout fire and reported it to the platform emergency command center. The platform emergency commander started the fire site disposal plan. All personnel entered the fire emergency state, and the guard ship approached the platform under the command of the commander in chief to assist in the emergency. In the emergency action stage, all personnel shall evaluate the current accident level, estimate the accident evolution trend and feedback the corresponding emergency operation according to the

emergency deployment table and the development of the accident. In the expanded emergency stage, if the fire is out of control, the platform emergency commander in chief shall report to the emergency command center for support and start the abandonment emergency plan. The emergency command center shall send a helicopter from the Floating Wharf to the platform to assist personnel evacuation. In the emergency recovery stage, the emergency state is relieved, and the first emergency team and the second emergency team clean up the site. Some emergency drill simulation scenarios are shown in Figure 6-7.

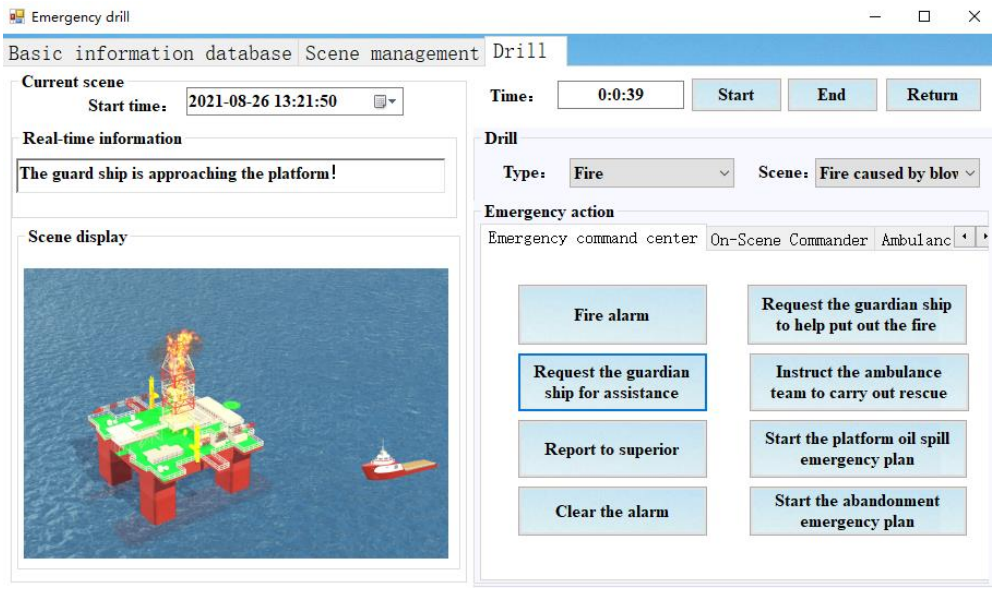

Figure 6 The standby ship approaches the platform

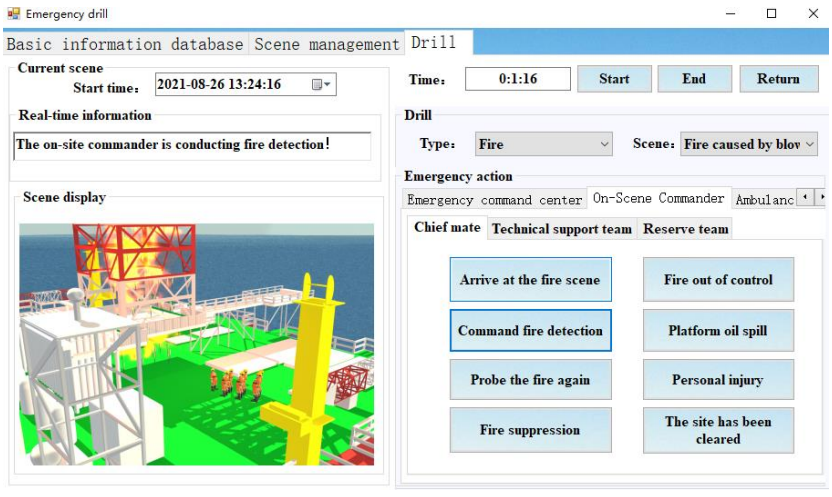

Figure 7 Local commander commands fire detection

After the drill, the system and evaluation experts shall evaluate according to the matching of accident response time and operation points of the drill personnel, and the evaluation experts shall feedback relevant suggestions. The total score of system score and expert score is 100. The overall score of drill personnel is the weighted sum of the scores of the system and expert, that is:

$\omega=0.5x_1+0.5x_2$

among:

ω: The overall score of drill personnel;

x_1: System score;

x_2: Expert score.

Through the system history query function, managers can query the records of previous emergency drills. According to the scores of previous drills, the emergency response ability of operators can be analyzed. Operators with poor performance in previous drills need secondary training to improve their emergency response ability. Analyze the current emergency capacity of the platform from the historical emergency response time of various accidents and the matching of emergency operation points, and put forward targeted suggestions for managers to specify the platform emergency drill plan, so as to improve the platform's emergency preparedness ability and emergency level.

4 Conclusion

At present, China's offshore exploration and development is still in its infancy, and operators face great safety risks in the exploration process. Therefore, it is necessary to strengthen emergency training and emergency drill for operators in the process of offshore exploration and development.

The system integrates the functions of emergency training and emergency drill, and can realize human-computer interaction and visual display of emergency drill scenes. It not only makes up for the deficiency that the current desktop drill system is not suitable for offshore exploration, but also meets the needs of daily emergency training and drill of platform operators, and helps to improve the emergency disposal ability of operators in offshore exploration area.

References

[1] Wang L X, Pan J P, Yang L L. (2020) The present situation and prospect of deep water oil and gas exploration and development in the world. Petroleum Science and Technology Forum, 39(02):31-37.

[2] Li Z. (2021) Progress and development prospect of CNOOC deepwater drilling technology. China Offshore Oil and Gas, 33(03):114-120.

[3] Qi C, Wang H W. (2015) Design of emergency drill simulation platform for high level commanders. Theory and practice of system engineering, 35(07):1871-1877.

[4] Shendarkar A, Vasudevan K, Lee S, et al. (2008) Crowd simulation for emergency response

using BDI agents based on immersive virtual reality. Simulation Modelling Practice and Theory, 16(9): 1415-1429.
[5] Wojtowicz J, Wallace W A. Traffic management for planned special events using traffic microsimulation modeling and tabletop exercises[J]. Journal of Transportation Safety & Security, 2010, 2(2): 102-121.
[6] Araz O M, Jehn M, Lant T, et al. (2012) A new method of exercising pandemic preparedness through an interactive simulation and visualization. Journal of Medical Systems, 36(3): 1475-1483.
[7] Zheng T Y, Chen T, Dong M. (2015) Application Research of earthquake emergency desktop exercise based on 3D software platform. Disaster science, 30(03):176-182.
[8] Song H H, Zhang L J, Xing P Y, et al. (2009) Discussion on the implementation of chemical accident emergency rescue simulation drill system. Journal of Safety Science and Technology, 5(01):99-102.
[9] Li Q. (2017) Design and implementation of emergency preparedness and emergency plan system platform. Journal of Safety Science and Technology, 13(02):33-39.
[10] Chen G H, Huang T F, Chen W J, et al. (2013) Dynamic simulation system of hazardous chemical gas leakage and diffusion based on true 3D GIS. Journal of Safety Science and Technology, 9(01):113-118.
[11] Wan S P, Qian H W. (2020) Basic operation procedures and methods of emergency desktop deduction. China Emergency Rescue, (04):34-40.