Cultivation of Application-Oriented Talents in the Safety Discipline Integrated with “Air-Space-Ground" Information Coupling and "Prevention-Mitigation-Rescue" Whole-Industry-Chain Collaboration

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Abstract: In view of the current issue of disconnection between the current training of security disciplines and the needs of complex safety governance, this paper proposes to construct an application-oriented talent training system of security disciplines with integrated information coupling of Air-Space-Ground (ASG) and Prevention-Reduction-Rescue collaboration of the whole industry chain. Combined with the integration of scientific and technological innovation and industrial development, the transformation of safety discipline from the experience to the technology-data-intelligence driven is implemented, and a talent training curriculum system with professional characteristics is constructed. Through the integration of satellite remote sensing, unmanned aerial vehicle monitoring, ground sensing network and other technologies, the intelligent coupling of multi-source data is realized. At the same time, it breaks the traditional single-link training model of safety disciplines, and establishes a collaborative training mechanism for the whole industry chain covering risk prevention, disaster mitigation, and emergency rescue. It cultivates more high-quality and innovative safety talents for safety disciplines, and provides strong talent support for ensuring social security and stability and promoting sustainable economic and social development.

Keywords: Safety Disciplines, Talent Training, Data Coupling, Industrial Synergy; Innovative Applications

1. Introduction

With the intensification of global climate change and the acceleration of industrialization and urbanization processes, various safety risks exhibit the characteristics of multi-hazard coupling, cross-regional spread, and complicated impacts. Furthermore, the complexity of modern society has brought new threats and risks, while the increase in urbanization and dependence on infrastructure has further exacerbated these risks. Scholars at home and abroad have conducted extensive research on the cultivation of application-oriented talents in the safety discipline.

Tang et al. [1-2] integrated BIM and Digital Twin in the curriculum reform of fire safety engineering by combining virtual simulation and the Internet of Things (IoT). Yang et al. [3] proposed a "four-in-one" talent cultivation model of "Construction-Integration-Cultivation-Integration". By constructing a safety engineering curriculum system centered on digital and intelligent technologies and strengthening the integration of emerging technologies such as big data, artificial intelligence (AI), and the Internet of Things (IoT), this model effectively enhances students’ engineering practice capabilities and digital-intelligent thinking, thereby improving the quality of talent cultivation. Wang et al. [4] optimized the curriculum system based on industry needs, built interdisciplinary comprehensive courses to integrate students’ knowledge systems, utilized on-campus and off-campus teaching and practice platforms, and formed an interdisciplinary faculty team. These efforts promote the full implementation of the interdisciplinary education model and improve the quality of cultivating safety engineering and technology talents. Wang et al. [5] put forward an overall implementation plan for safety engineering talent cultivation under the background of "New Engineering" from aspects such as the optimized design of talent cultivation programs, the update of teaching concepts and methods, and the construction of a talent cultivation quality tracking, investigation, and feedback mechanism. Yao et al. [6] addressed issues such as the disconnection between theory and practice, the lag in updating teaching content, and the insufficient professionalism of faculty in the "New Engineering" context. They deepened the cultivation of application-oriented talents through measures including exploring industry-university-research integrated curriculum design, promoting the differentiated development of curriculum innovation, and addressing the shortcomings of professional faculty. Yao et al. [7], based on the interdisciplinary and comprehensive nature of the safety discipline and common problems in practical teaching (such as single internship forms, difficulties in securing practice sites, and unsatisfactory results), proposed an innovative model for undergraduate practical teaching in safety engineering using on-campus resources. Therefore, from the perspectives of the connotative development of higher education and the national strategy of building an education powerhouse, connecting with industries to construct an interdisciplinary talent cultivation model and effectively integrating advantageous disciplines with advantageous industries can promote the coordinated development of disciplines, majors, and courses, and provide talent and intellectual support for the formation of an industrial ecosystem [8-10].

In summary, the traditional talent cultivation models in the safety discipline mostly focus on a single field or link, lacking the integrated application of multi-dimensional monitoring technologies and systematic thinking for the whole-process collaboration of "Prevention-Mitigation-Rescue". Meanwhile, the rapid development of technologies such as satellite remote sensing, unmanned aerial vehicles (UAVs), and the IoT has provided technical support for Air-Space-Ground integrated monitoring. The development of emerging technologies such as "digital twin" and "artificial intelligence" has injected new momentum into the whole-industry-chain safety management of "disaster prevention, mitigation, and rescue". Against this background, constructing a safety discipline talent cultivation system that integrates multi-source technologies and whole-chain management has become an inevitable choice for cultivating interdisciplinary safety talents who meet the needs of the new era.

2. Theoretical Basis and Core Logic of the Training System's Characteristics

The characteristic connotation of the safety discipline talent cultivation system, which integrates "Air-Space-Ground integrated information coupling" and "Prevention-Mitigation-Rescue whole-industry-chain collaboration", mainly includes two aspects: (1) Air-Space-Ground integrated information coupling; (2) Prevention-Mitigation-Rescue whole-industry-chain collaboration. The connotation of its logical framework is shown in Figure 1.

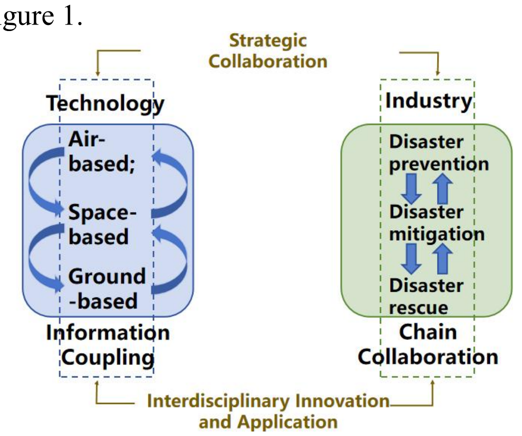

Figure 1. Framework Diagram of the Talent Cultivation System

2.1 Air-Space-Ground Information Coupling

Air-Space-Ground integrated information coupling refers to the integration of multi-dimensional monitoring technologies (air-based, space-based, and ground-based) to realize real-time collection, transmission, fusion, and intelligent application of information in the global space, forming a trinity information interaction network. This model breaks the limitations of single-dimensional monitoring and significantly improves the efficiency of risk identification, early warning, and decision-making in complex scenarios through data collaboration and intelligent processing. For example, in geological disaster monitoring, satellite InSAR technology can monitor millimeter-level surface deformation, UAV LiDAR can quickly acquire high-precision 3D topographic data, and ground-based GNSS sensors can track the displacement of local points in real time. The fusion of these three types of data can significantly improve the accuracy and timeliness of disaster early warning.

The technical characteristics of Air-Space-Ground integrated information coupling includes following aspects:

(1) High real-time performance. Through the collaborative work of satellite and ground systems, information can be acquired and transmitted in an extremely short time; for instance, when an earthquake occurs, satellite remote sensing can quickly image the earthquake-stricken area, and ground sensors can immediately collect earthquake-related data. This information can be transmitted to the command center within minutes, providing a timely basis for rescue decisions.

(2) Wide coverage. The overhead perspective of satellites enables them to cover any corner of the globe, including remote mountainous areas, vast oceans, and densely populated cities, overcoming geographical constraints. Additionally, it enables comprehensive information acquisition: air-space platforms and ground sensors collect information from different angles and scales, covering data in geography, meteorology, environment, population, and other aspects, providing rich materials for a comprehensive understanding of safety situations.

(3) High data accuracy. With the continuous advancement of technology, the resolution of remote sensing satellites has been continuously improved, and the accuracy of ground sensors has also been increasingly enhanced, providing precise data support for safety analysis.

2.2 Prevention-Mitigation-Rescue Industry Collaboration

2.2.1 Composition of the industry chain

The Prevention-Mitigation-Rescue whole industry chain covers the entire process of safety assurance. First, the prevention link includes safety risk assessment, safety planning formulation, and safety education and training. Through scientific assessment of various potential safety risks, reasonable safety plans are formulated (such as disaster prevention plans in urban construction and work safety plans in industrial enterprises). Extensive safety education and training are carried out to improve the safety awareness and prevention skills of the public and practitioners, thereby reducing the occurrence of safety accidents at the source. Second, the mitigation link mainly involves disaster monitoring and early warning, disaster prevention engineering construction, and emergency material reserves. Advanced monitoring technologies are used to monitor disasters in real time, and early warning information is released in a timely manner to allow sufficient time for people to take response measures. Disaster prevention engineering construction (such as reinforcing buildings and constructing flood control dikes) is strengthened to improve the disaster resistance of infrastructure. Emergency materials are reasonably reserved to ensure sufficient material support for rescue operations when disasters occur. Finally, the rescue link includes the activation of emergency response mechanisms, the deployment of rescue teams, the implementation of on-site rescue, and post-disaster recovery and reconstruction. After a disaster occurs, the emergency response mechanism is quickly activated, and professional teams (such as fire-fighting, medical, and rescue teams) are reasonably deployed. Scientific rescue methods are used to carry out on-site rescue, and after the rescue, recovery and reconstruction work is carried out in an orderly manner to help the disaster-stricken areas restore normal production and living order.

2.2.2 Collaboration model

Whole-industry-chain collaboration emphasizes close coordination and information sharing between various links. In the prevention stage, through the analysis of historical safety accident data and the integration of real-time monitoring data, risk prediction information is provided for the mitigation and rescue links to facilitate preparedness in advance. During the mitigation process, monitoring and early warning information is promptly transmitted to rescue departments, enabling them to deploy rescue forces in advance; meanwhile, the status of disaster prevention engineering construction and emergency material reserves is closely related to the rescue link, providing hardware support for rescue operations. In the rescue stage, information obtained by rescue teams on-site (such as the actual disaster situation and casualties) is promptly fed back to the prevention and mitigation departments, providing a basis for subsequent recovery and reconstruction and the improvement of disaster prevention and mitigation measures.

It can be seen that in the process of chain collaboration, the various links of the Prevention-Mitigation-Rescue industry are not isolated but interdependent and dynamically connected. Therefore, this collaborative logic requires safety talents to possess cross-link coordination and dynamic decision-making capabilities.

2.2.3 In-depth integration of science & technology and industry

Science & technology and industry are interdependent and mutually driving, forming a symbiotic relationship. They are closely interlocked like gears, jointly promoting the progress of economy and society. The integration of "air-based, space-based, and ground-based" technologies with the "disaster prevention, mitigation, and rescue" industry essentially promotes the transformation of the safety discipline from "experience-driven" to "technology-data-intelligence"-driven. The use of digital twin technology to build urban safety models, with real-time operation of the models driven by Air-Space-Ground data, enables whole-process digital management of "risk prediction (prevention) - plan simulation (mitigation) - rescue deduction (rescue)". Therefore, this places higher requirements on talents' capabilities in data processing, system modeling, and decision optimization.

3 Architectural Design of the Training System

3.1 Training Objectives

Based on the professional characteristic framework integrating "air-based, space-based, and ground-based" technologies with the "disaster prevention, mitigation, and rescue" industry, the cultivation of interdisciplinary safety talents includes the following capabilities:

(1) Technology Integration Capability: Proficiency in Air-Space-Ground data collection, processing, and analysis technologies, and the ability to realize intelligent coupling of multi-source information;

(2) Whole-Chain Thinking Capability: Understanding the logical connections between the various links of "Prevention-Mitigation-Rescue" and possessing the ability to design cross-link collaboration plans;

(3) Innovative Application Capability: The ability to use digital tools (e.g., digital twin platforms, AI algorithms) to solve complex safety problems.

3.2 Construction of the Curriculum System

Based on the training objectives mentioned in the previous section, in accordance with the OBE (Outcome-Based Education) talent cultivation model, and combining the integration points of technological innovation and the connection points of industrial development, the curriculum system is constructed to implement the transformation of the safety discipline from "experience-driven" to "technology-data-intelligence"-driven. The specific curriculum system is shown in Table 1.

Table 1. Curriculum System

	Core Course Group	Air-Space-Ground Technology Integration Points	Prevention-Mitigation-Rescue Whole-Chain Connection Points
Technical Foundation	Principles and Applications of Remote Sensing, UAV Technology, Sensor Networks	Satellite image interpretation, UAV payload data collection, ground sensor network deployment, etc.	Prevention stage: Air-Space-Ground data used for risk map mapping
Safety Theory	Safety Systems Engineering, Risk Assessment, Emergency Management	Multi-source data fusion algorithms (e.g., satellite InSAR + UAV LiDAR fusion for deformation monitoring), etc.	Mitigation and rescue stages: Air-Space-Ground data-driven rescue path optimization
Interdisciplinary Innovation	Digital Twin Technology, AI Safety Applications, Whole-Chain Collaborative Management	Digital twin model platforms based on Air-Space-Ground data, application of GIS+BIM spatial emergency response platforms, etc.	Whole-chain links: Digital twin deduction of the whole process of "prevention - rescue - reconstruction"

Moreover, the relation of curriculum system itself can be illustrated in Figure 2. It is revealing that this curriculum system includes three parts, namely Technical Foundation (TF), Safety Theory (ST), and Interdisciplinary Innovation (II).

This figure illustrates the concept of interdisciplinary innovation in the safety discipline through a Venn diagram, highlighting the synergy between two core components:

(1) Technical Foundation (left circle). This represents knowledge and skills from technical fields, such as Air-Space-Ground information technologies (remote sensing, UAVs, sensor networks), digital twin, artificial intelligence, etc.

(2) Safety Theory (right circle). This part represents fundamental knowledge in the safety discipline, including risk assessment, emergency management, safety systems engineering, etc.

(2) Interdisciplinary Innovation (overlapping area). The purple overlap, marked by a downward arrow, denotes the innovative outcomes generated by integrating technical foundations with safety theory. This intersection is where technologies are applied to solve complex safety problems, enabling advancements like intelligent risk early warning, whole-chain collaborative management, and data-driven safety decision-making.

In essence, the diagram conveys that true innovation in the safety discipline emerges not from isolated technical or theoretical knowledge, but from the cross-fertilization of these two domains—combining technical tools and methods with safety principles to address modern, multifaceted safety challenges.

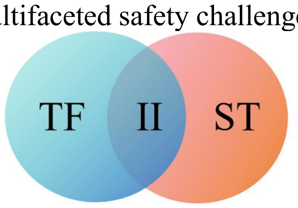

Figure 2. The Combination of Curriculum System

3.3 Practical Teaching System

By establishing a practical platform featuring "combination of virtual and real, whole-chain connection", technology and industry are integrated to carry out corresponding practical teaching. The main contents include the following two aspects:

(1) Air-Space-Ground technology training. Constructing a satellite data reception laboratory, a UAV training base, and a ground-based intelligent sensing platform to carry out training on multi-source data collection and processing.

(2) Whole-chain practical drills. Using digital twin platforms to simulate disaster scenarios (e.g., earthquake-fire coupling incidents), where students are required to complete the whole-process operations of "risk early warning - evacuation planning - rescue deployment - post-disaster assessment".

(3) Industry-university cooperation projects. Cooperating with the government and enterprises to participate in actual safety monitoring projects.

4. Innovation Points of the Training System

4.1 Enhancing the Comprehensiveness of the Knowledge System

Integrating Air-Space-Ground integrated information coupling technology into the teaching of the safety discipline enables students to learn knowledge covering multiple fields such as satellite remote sensing, geographic information systems (GIS), and communication technologies, broadening their knowledge horizons. In addition, in the teaching of Prevention-Mitigation-Rescue whole-industry-chain collaboration, students in-depth study knowledge of all links in safety assurance—from risk identification and assessment in the prevention stage, to the application of engineering technologies and the principles of early warning systems in the mitigation stage, and then to emergency response procedures and rescue technologies in the rescue stage—thus constructing a comprehensive and systematic knowledge system of the safety discipline.

4.2 Strengthening the Cultivation of Practical Capabilities

Schools cooperate with enterprises and scientific research institutions to establish a practical teaching platform based on Air-Space-Ground integrated information coupling technology. Students participate in actual projects on the platform, such as using satellite remote sensing to monitor urban environmental safety hazards and applying ground sensor networks to conduct safety monitoring of industrial parks, thereby improving their ability to use technologies to solve practical safety problems. In terms of Prevention-Mitigation-Rescue whole-industry-chain collaborative practice, students are organized to participate in emergency drills, simulating the entire process of disaster occurrence. Students conduct practical operations in different links such as prevention, mitigation, and rescue, training their collaborative work capabilities in all links of the whole industry chain.

4.3 Cultivating Innovative Thinking and

Teamwork Spirit

The continuous development of Air-Space-Ground integrated information coupling technology and the innovation of the Prevention-Mitigation-Rescue whole-industry-chain collaboration model provide students with a broad space for innovation. In the process of learning and practice, students can propose innovative solutions to address the shortcomings of existing technologies and collaboration models. Meanwhile, both technology application and whole-industry-chain collaborative practice require students to work in teams. In the team, students are responsible for different fields of work: some focus on satellite data processing, some are in charge of ground sensor operation, and others are responsible for formulating emergency rescue plans. Through teamwork to complete tasks, students' teamwork spirit and communication skills are cultivated.

5. Conclusion

Air-Space-Ground integrated information coupling and Prevention-Mitigation-Rescue whole-industry-chain collaboration bring distinct characteristics and significant advantages to the talent cultivation of the safety discipline. By enhancing the comprehensiveness of students' knowledge systems, strengthening their practical capabilities, and cultivating their innovative thinking and teamwork spirit, interdisciplinary talents who adapt to modern safety needs are cultivated. In the future, further efforts should be made to strengthen the interdisciplinary integration between the safety discipline and related technical fields, continuously update teaching content to keep up with the cutting-edge of technological development, and strengthen multi-party cooperation to improve the whole-industry-chain collaboration mechanism. These efforts will create a better environment for the talent cultivation of the safety discipline, cultivate more high-quality and innovative safety discipline talents, and provide strong talent support for ensuring social safety and stability and promoting the sustainable development of the economy and society.

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