

Typical Operation Modes for Emergency Low-Altitude Logistics and In-Depth Industry-Education Integration Modes: A Two-Way Empowerment Perspective

Xudong Li^{1, #}, Qiang Li^{2, *, #}, Yao Yan^{3, #}, Hui Guo¹, Jiaqi Ye¹

¹Guangdong Communication Polytechnic, Qingyuan, Guangdong, China

²Institute of traffic science and Engineering, Civil Aviation University of China, Tianjin, China

³International Business School, Hainan University, Haikou, Hainan, China

*Corresponding Author

[#]These authors contributed equally to this article

Abstracts: Amid China's emergency management modernization, low-altitude logistics, with strong terrain adaptability and rapid response capability, stands as a critical pillar for last-mile emergency supply support. The upgrading of vocational college logistics programs and high-quality growth of the low-altitude logistics industry form a two-way empowerment symbiosis: industrial operational innovation equips education with real scenarios, competency standards and technical resources to boost talent training, while education's skilled talent supply and university-enterprise R&D drive industrial model optimization and risk control upgrades. Focused on practical emergency management needs, this paper outlines scenarios and bottlenecks of three typical emergency low-altitude logistics models, analyzes the inherent logic and practical gaps of two-way empowerment, builds a four-dimensional deep industry-education integration mode, and proposes three supporting pathways: collaborative governance, pooled resource investment, multi-party evaluation. Its findings offer practical references for optimizing the emergency low-altitude logistics system and advancing distinctive vocational logistics program development.

Keywords: Two-Way Empowerment; Emergency Low-Altitude Logistics; Operation Mode; Higher Vocational Education; Industry-Education Integration; Integration Mode

1. Introduction

Amid the accelerated expansion of the digital economy, the low-altitude economy — a strategic emerging industry — was formally

incorporated into China's 2024 Government Work Report, opening up new avenues for the utilization of urban airspace resources [1]. Low-altitude unmanned aerial vehicles (UAV) have been widely deployed in urban inspection, emergency rescue, and small-scale delivery scenarios, serving as a key vehicle to break through the bottleneck of air-ground coordination [2]. Low-altitude logistics, which mainly relies on multi-rotor UAV and unmanned helicopters, boasts flexible take-off and landing conditions, independence from ground road networks, and direct access to target locations. It has demonstrated irreplaceable application value in multiple emergency response operations in recent years, gradually evolving from a supplementary delivery method to an integral part of the emergency supply guarantee system. The in-depth integration of the low-altitude economy and the logistics industry will give rise to a series of high-value positions, raising requirements for the cultivation of high-skilled talents with both information technology and logistics expertise [3].

The large-scale and standardized application of emergency low-altitude logistics depends not only on mature and adaptive operation modes and a sound risk prevention and control system, but also on a sufficient pool of interdisciplinary skilled talents as fundamental support. At present, domestic academic research on low-altitude logistics mostly focuses on four dimensions: policy, standards, operations, and technology [4]. In contrast, systematic reviews and innovative studies on operation modes in emergency scenarios remain relatively scarce. Meanwhile, relevant research in the field of vocational education mostly follows the one-way logic of "education adapts to industrial

demands”, focusing on how talent training can keep pace with industrial development, while paying limited attention to the reverse empowerment effect of talent output and technical services from vocational colleges on the upgrading of industrial operation modes. As a core area for developing new quality productive forces, the low-altitude economy represents an important pathway to improve vocational education quality by promoting two-way empowerment between new quality productive forces and industry-education integration [5]. The emergency low-altitude logistics industry and logistics education in higher vocational colleges do not merely maintain a simple supply-demand relationship; instead, they form a symbiotic entity that supports and promotes each other bilaterally.

Against this backdrop, this paper adopts a two-way empowerment perspective to address two practical issues: the construction of the emergency low-altitude logistics operation system and the reform of talent training in higher vocational education. On the one hand, it

systematically sorts out the typical operation modes and existing shortcomings of emergency low-altitude logistics, and clarifies the carriers through which the industry empowers talent training. On the other hand, it analyzes the pathways through which vocational industry-education integration reversely empowers industrial development. Ultimately, the paper constructs an in-depth integration mode featuring two-way mutual promotion, so as to provide feasible ideas for achieving a win-win outcome of improved emergency management capacity and high-quality development of vocational education.

2. Typical Operation Modes and Development Bottlenecks of Emergency Low-Altitude Logistics

2.1 Application Scenarios and Characteristics of Three Typical Operation Modes

Three Emergency Low-Altitude Logistics Operation Modes is shown in table 1.

Table 1. Three Emergency Low-Altitude Logistics Operation Modes

Mode Type	Application Scenarios	Core Features
Pre-warehousing + Terminal UAV Delivery	Urban emergency, county mountain disasters, urban public health incidents	Pre-stored supplies, short-distance terminal UAV delivery, fast response, low cost, suitable for small-batch and high-frequency supply
Hierarchical Air-ground Collaborative Delivery	Severe disasters such as earthquakes and basin floods with massive ground traffic disruption	Three-level air-ground graded transportation, balancing load and coverage for large-scale and high-intensity material support
Grid Inspection & Delivery Integration	Urban waterlogging, forest fire, mountain geological hazard inspection and disposal	Grid-based on-duty operation, integrated inspection and delivery, greatly shortening emergency response time

(1) The pre-positioned warehousing combined with terminal UAV delivery mode. Primarily suitable for urban emergency response and disaster relief in mountainous county areas, this mode operates by deploying small pre-positioned emergency supply warehouses in advance around disaster-prone areas and densely populated communities, where materials such as medicines, daily necessities, and small rescue equipment are kept in stock. When an emergency occurs, supplies are first transported in bulk to the nearest pre-positioned warehouse via ground transportation, after which small multi-rotor

UAV complete point-to-point last-mile delivery. The prominent advantages of this mode include a short response chain and low operational cost per flight, making it ideal for small-batch, high-frequency supply replenishment needs.

During the static management period of the COVID-19 epidemic in Shanghai in the spring of 2022, several logistics and UAV enterprises leveraged pre-positioned warehouses around communities to deliver urgently needed medicines and epidemic prevention supplies to sealed-off buildings using small UAV. This practice effectively avoided the transmission risk caused by person-to-person contact, and verified the applicability of this mode in urban public health emergencies. The pre-positioned warehousing combined with terminal UAV delivery mode is shown in Figure 1.

(2) The hierarchical air-ground collaborative delivery mode. Mostly applied in major natural disasters such as earthquakes and basin-wide floods, this mode is designed to address scenarios where ground transportation is extensively disrupted and demand for bulk

supplies is concentrated. Its overall framework consists of three tiers: large transport helicopters undertake cross-regional trunk transportation, delivering bulk disaster relief materials to temporary transfer landing sites on the periphery of the disaster area; medium-sized fixed-wing or multi-rotor UAV are responsible for branch-line transfer, transporting supplies from transfer points to centralized resettlement sites at the township level; finally, small UAV complete terminal delivery from resettlement sites to scattered disaster-affected locations. The three-tier system is seamlessly connected,

balancing payload capacity and coverage, and can meet large-scale, high-intensity emergency supply demands. During the 2022 Luding earthquake in Sichuan Province, emergency management authorities, in collaboration with multiple enterprises, adopted the air-ground collaborative mode to successfully deliver tents, first-aid medicines, drinking water, and other supplies to remote villages where roads were completely cut off, buying valuable time for rescue operations. The hierarchical air-ground collaborative delivery mode is shown in Figure 2.

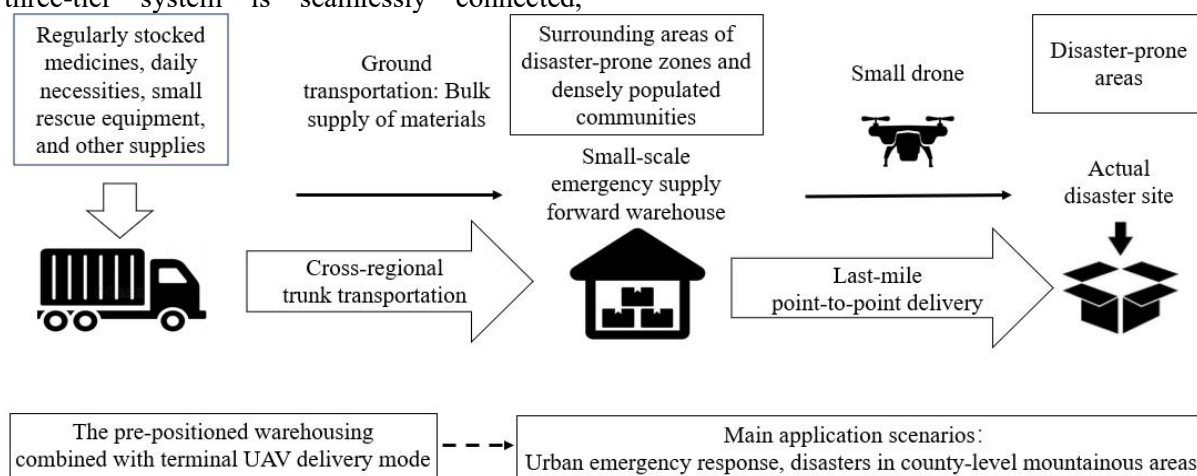


Figure 1. The Pre-Positioned Warehousing Combined with Terminal UAV Delivery Mode

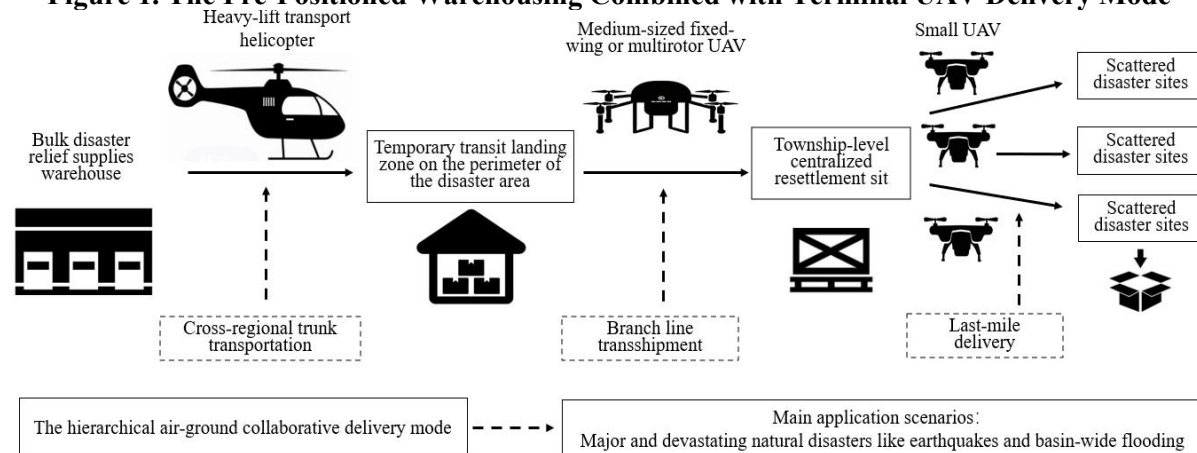


Figure 2. The Hierarchical Air-Ground Collaborative Delivery Mode

(3) The grid-based integrated inspection and delivery mode. Commonly seen in scenarios such as urban waterlogging, forest fires, and hidden danger investigation of mountainous geological disasters, its core feature is the integrated operation of disaster reconnaissance and material delivery. Specifically, the emergency responsibility area is divided into several grid units, each equipped with a fixed UAV operation team and standby supplies. During daily patrols and disaster investigation, once UAV detect trapped personnel, hidden

danger points, or supply demands, they can immediately report to the command center via the on-board system, and carry out nearby delivery of small emergency supplies using their on-board payload. This mode combines the functions of information collection and material guarantee into one, greatly shortening the emergency response chain. It has been widely adopted in flood control and fire prevention emergency drills across many regions of China in recent years. The grid-based integrated inspection delivery mode is shown in Figure 3.

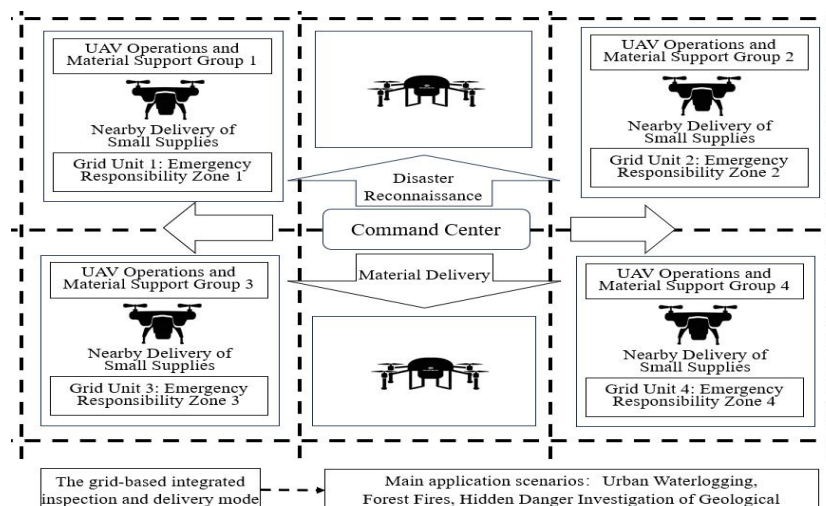


Figure 3. The Grid-Based Integrated Inspection and Delivery Mode

2.2 Core Development Bottlenecks Facing Current Operation Modes

Although the three modes have played a remarkable role in practice, there are still three prominent shortcomings that restrict the full release of their effectiveness, when measured against the high standards of emergency management and the requirements of large-scale industrial development.

(1) The limited scenario adaptability and a lack of emergency-specific design. Most current emergency low-altitude logistics solutions are derived from commercial UAV delivery systems, directly adopting route planning, scheduling logic, and operation specifications from commercial scenarios. They have not undergone systematic optimization tailored to the uncertainty, harsh environmental conditions, and sudden nature of tasks in emergency scenarios. Commercial delivery features fixed take-off and landing points, stable routes, and predictable delivery demands, whereas emergency scenarios often require temporary airspace opening, responses to complex meteorological and topographical changes, and handling of sudden task adjustments. As a result, existing modes show obvious deficiencies in dynamic scheduling and flexible response capabilities.

(2) The risk management and control system is absent, leading to prominent safety hazards throughout the entire process, with frequent issues regarding accident risks and liability definition in low-altitude flight activities [6]. Low-altitude operations in emergency scenarios face multiple risks such as sudden meteorological changes, electromagnetic signal interference, complex terrain obstacles, and

difficulties in airspace coordination. Nevertheless, most operation modes still take delivery efficiency as their core orientation, and have not established a full-chain risk prevention and control mechanism covering pre-event prediction, in-event management, and post-event review. There is a lack of standardized management methods for risk points such as flight safety, material integrity, and data confidentiality in the operation process, which to some extent restricts the large-scale promotion of emergency low-altitude logistics.

(3) The problem of talent shortage and difficulty in adapting to new trends and changes remains prominent [7]. Specifically, front-line operational capabilities have obvious deficiencies. Emergency low-altitude logistics operations require practitioners to possess interdisciplinary capabilities including UAV operation, emergency material management, on-site risk identification, and basic emergency response. However, most current industry practitioners have a single-skill background: some are UAV pilots who only master flight operations but lack professional knowledge of emergency logistics, while others are traditional logistics practitioners who do not have low-altitude operation skills. The supply-demand gap for interdisciplinary talents directly makes it difficult for advanced operation modes to be effectively implemented at the front line, and also restricts the continuous iterative optimization of such modes.

3. Inherent Logic and Practical Deviations of Two-Way Empowerment

3.1 Empowerment Pathways of Industrial

Operation Mode Upgrading for Talent Training in Higher Vocational Colleges

The development of the emergency low-altitude logistics industry and innovations in its operation modes provide core empowerment for talent training in higher vocational colleges from three dimensions.

(1) Scenario-based empowerment. Diverse emergency operation modes and real enterprise operation projects provide irreplaceable practical training carriers for logistics majors in higher vocational colleges. Logistics management major in universities is currently caught in a double bind: structural flaws in their curricula and a lag in digital integration. On top of that, courses still operate in silos, failing to weave knowledge together around real-world scenarios [8]. Traditional logistics training mostly relies on simulation software and static equipment, making it difficult for students to develop an understanding of real operation environments. In contrast, various operation scenarios and real task cases of emergency low-altitude logistics allow students to immerse themselves in front-line operation processes, and hone their practical abilities in near-real combat environments, thus addressing the pain point of disconnection between training and industry practice.

(2) Standard-based empowerment. The gradual improvement of the post system for emergency low-altitude logistics clarifies the competency benchmark for talent training in higher vocational colleges. With the standardized development of operation modes, the industry

has gradually formed clear post competency standards and operation specifications. These front-line industrial standards can be directly transformed into course teaching content and talent training objectives, ensuring that program development always keeps pace with industrial development and avoiding the disconnection between talent training and industry demands.

(3) Technology-based empowerment. The iteration of risk control technology, scheduling technology, and collaboration technology driven by operation mode innovation forces the continuous updating of the curriculum system in higher vocational colleges. UAV technology, risk management methods, and air-ground collaborative scheduling concepts involved in emergency low-altitude logistics are all absent from traditional logistics professional courses. Technological upgrading on the industrial side prompts colleges to continuously optimize their curriculum setup, integrating new technologies, processes, and specifications into teaching, so as to ensure talent training advances with the times.

3.2 Reverse Empowerment Pathways of Higher Vocational Talent Training for Industrial Operation Modes

The systematic talent output and industry-education integration practices of higher vocational education also reversely support the development of the emergency low-altitude logistics industry from three dimensions. Reverse Empowerment Paths of Higher Vocational Talent Cultivation on Industrial Operation Modes is shown in table 2.

Table 2. Reverse Empowerment Paths of Higher Vocational Talent Cultivation on Industrial Operation Modes

Empowerment Dimension	Core Content	Empowerment Value
Talent Supply Empowerment	Batch output of skilled talents matching frontline job requirements	Reduce corporate training costs and ensure stable operation of modes
Collaborative Innovation Empowerment	Teachers and students participate in process optimization, risk screening and scheme design	Provide grassroots intellectual support and drive continuous mode iteration
Emergency Reserve Empowerment	Faculty, students and training equipment serve as supplementary social emergency forces	Expand personnel reserve and enhance overall emergency response capacity

(1) Talent supply empowerment. High-quality skilled talents cultivated by higher vocational colleges can fill the gaps in front-line positions in the industry and support the normal operation of various operation modes. Positions such as front-line operation, grass-roots scheduling, and basic risk control in emergency low-altitude logistics emphasize practical ability rather than in-depth theoretical knowledge in terms of academic requirements, which exactly matches

the training orientation of higher vocational education. Large-scale and standardized supply of skilled talents can reduce enterprises' pre-job training costs, ensure the stable implementation of operation modes, and address the bottleneck of industry talent shortage to better respond to and meet the urgent demand of new quality productive forces for high-caliber technical and skilled personnel [9].

(2) Collaborative innovation empowerment. In

the process of in-depth university-enterprise cooperation, college teachers and student teams can participate in enterprise operation process optimization, risk point investigation, scheme design, and other work, providing grass-roots intellectual support for operation mode innovation. At the same time, hands-on training needs to be seamlessly tied to real-world industry operations. By engaging in actual production and delivering community services, these practical processes can generate real economic value [10]. Teachers in higher vocational colleges have systematic professional theoretical foundations, while student teams have strong hands-on ability and innovative vitality. They can identify process redundancies and risk blind spots in enterprise front-line operations from a third-party perspective, assist enterprises in optimizing operation schemes, and promote the continuous iteration of modes.

(3) Emergency reserve empowerment. The faculty, student teams, and training equipment of higher vocational colleges can serve as a supplementary reserve of social emergency forces, assisting enterprises in completing auxiliary operations during sudden emergency events. Through regular industry-education integration training and emergency drills, universities and enterprises can jointly build an emergency standby team, which is used for teaching and training in normal times and can be quickly transformed into an operation force in emergency states. This expands the personnel reserve of emergency low-altitude logistics and improves the overall social emergency response capability.

3.3 Practical Deviations in Current Two-Way Empowerment

According to field research on relevant enterprises and higher vocational colleges in the Pearl River Delta region conducted in the first half of 2024, the current two-way empowerment between the two sectors is still at a superficial stage, with three obvious deviations.

(1) Cognitive deviation, with one-way thinking

dominating. Most enterprises regard vocational education merely as a talent supply channel, failing to recognize the multiple values brought by university-enterprise cooperation, such as mode optimization and cost reduction. Meanwhile, most colleges simply equate industry-education integration with meeting employment demands, passively adjusting training programs to follow industrial needs, and lack the awareness of actively serving industrial development and reversely empowering industrial upgrading.

(2) Content deviation, with insufficient integration depth. University-enterprise cooperation mostly stays at superficial forms such as equipment donation, base listing, and enterprise lectures. Real operation scenarios, core operation data, and key risk control standards of enterprises have not been fully opened to colleges. Similarly, the talent training programs and curriculum systems of colleges have not fully absorbed the post demands of enterprises, meaning two-way resource sharing and value exchange have not been truly realized.

(3) Institutional deviation, with a lack of long-term guarantee. Most university-enterprise cooperation relies on personal connections or short-term projects for promotion, and no stable collaborative governance mechanism or benefit-sharing mechanism has been established. It is difficult for enterprises to obtain reasonable returns on their investment in talent training, and colleges lack smooth channels to connect with industrial demands. As a result, two-way empowerment lacks sustained momentum, and cooperation tends to become a mere formality.

4. Construction of an In-Depth Industry-Education Integration Mode for Higher Vocational Colleges from the Two-Way Empowerment Perspective

The in-depth industry-education integration mode for higher vocational colleges from the two-way empowerment perspective is shown in table 3.

Table 3. In-depth Industry-education Integration Mode in Higher Vocational Colleges

Integration Dimension	Core Measures	Integration Value
Two-way Connection between Posts and Courses	Schools and enterprises co-build modular courses, transform industrial standards and integrate post-course-competition-certificate system	Match job requirements and equip students with vocational competency
Two-way Sharing of Scenarios	Build real-scenario training bases for teaching and emergency standby with dual usage for peacetime and emergency	Make up training deficiencies and expand emergency reserve capacity

Two-way Mobility of Personnel	Teachers take temporary posts in enterprises; enterprise experts serve as part-time teachers to build dual-teacher teams	Connect teaching with industry and realize shared teacher resources
Two-way Project Output	Adopt real enterprise projects for teaching; teachers and students participate in technical and process optimization	Improve talent training quality and achieve win-win for school-enterprise cooperation

4.1 Two-Way Alignment between Positions and Courses: Co-Building a Modular Curriculum System Adapted to Post Competencies

The curriculum system is the core carrier of talent training and also a key connection point for two-way empowerment. Universities and enterprises should be promoted to jointly formulate talent training programs, and build a modular curriculum system based on the core post competencies of emergency low-altitude logistics, so as to realize two-way alignment between post standards and course content.

On the one hand, enterprises should systematically sort out the competency lists of three core positions: low-altitude logistics operation and maintenance, emergency scheduling management, and risk control and compliance. Industrial standards such as operation specifications, risk control standards, and operation procedures should be transformed into teaching content to ensure that course content keeps pace with industry practice. On the other hand, colleges should combine the teaching laws of vocational education with students' cognitive characteristics, and decompose post competencies into corresponding course modules to avoid simply copying enterprise training content. Content such as fundamentals of emergency management and low-altitude flight regulations should be added to the public basic module to consolidate students' awareness of compliance and safety. Featured courses such as Practice of Emergency Low-Altitude Logistics Operation, UAV Delivery Operation and Maintenance, and Risk Identification and Control of Emergency Logistics should be added to the professional core module to systematically cover the core skills of the industry. Progressive links such as basic flight training, emergency scenario simulation, and enterprise on-the-job internship should be set up in the practical training module to realize the step-by-step improvement of abilities.

Meanwhile, the concept of "post-course-competition-certificate integration"

should be deeply integrated. The vocational skill level certificate for UAV pilots and relevant vocational standards for emergency logistics should be incorporated into the assessment system to realize the interconnection between course assessment and vocational certification, enabling students to be competent for posts immediately upon graduation.

4.2 Two-Way Sharing of Scenarios: Joint Construction of Practical Training and Emergency Standby Bases by Universities and Enterprises

Training scenarios serve as the physical carrier of two-way empowerment. The barriers between campus training and enterprise operations should be broken, and universities and enterprises should jointly build practical bases integrating teaching training, social services, and emergency standby functions, so as to realize two-way sharing of scenario resources.

Colleges provide venues, infrastructure, and daily management, while enterprises invest in UAV equipment, scheduling systems, and technical guidance to jointly build a training environment that simulates multiple emergency scenarios. Simulated scenarios such as urban waterlogging, mountainous disasters, and community lockdown can be set up in the base, equipped with various types of delivery UAV, emergency material storage facilities, and visual scheduling systems to meet daily teaching and training needs. Students complete training projects such as route planning, material delivery, and risk disposal in a near-real environment, effectively improving their scenario adaptability and practical operation level.

At the same time, the base also functions as an emergency standby point for enterprises and is incorporated into the local emergency supply guarantee system. It is used for teaching and training in normal times, and can be quickly converted into an emergency operation node in the event of a sudden emergency. The auxiliary team composed of college teachers and students can cooperate with enterprises to complete auxiliary work such as material handling, basic scheduling, and information statistics. Through

the dual-purpose use of the site and the combination of peacetime and emergency functions, the problem of unrealistic training scenarios in colleges is solved, and the emergency reserve force for enterprises is expanded, realizing the maximization of two-way value of scenario resources.

4.3 Two-Way Mobility of Personnel: Building an Interdisciplinary Dual-Qualification Teacher Team with University-Enterprise Interconnection

The teaching team serves as the human link for two-way empowerment. A long-term mechanism for two-way mobility, mutual employment, and shared use of university and enterprise personnel should be established, so as to build an interdisciplinary teaching team that masters both educational laws and industrial practice.

On the one hand, a regular system for professional teachers to take temporary posts in enterprises should be established. Every year, professional teachers are selected to take temporary exercise positions in cooperative enterprises, fully participating in emergency project operation, on-site scheduling management, and risk control work of enterprises. This helps them accumulate front-line practical experience and update their professional knowledge system, avoiding the disconnection between teaching content and industrial reality. During their temporary posts, teachers can combine teaching needs to collect real enterprise cases and extract typical work tasks, which are reversely supplemented into course teaching to improve the practicality of teaching.

On the other hand, a mechanism for enterprise technical and skilled talents to teach in colleges should be established. Senior UAV pilots, scheduling supervisors, and risk control experts from enterprises are hired as part-time teachers to participate in curriculum development, practical training teaching, graduation project guidance, and other work, bringing the latest industry technologies, front-line operation experience, and real project cases into the classroom. Enterprise part-time teachers can not only make up for the shortage of practical teachers in colleges, but also transmit enterprise talent demand standards to the teaching side, promoting the precise matching between talent training and post demands. Through two-way mobility, the sharing and co-cultivation of

human resources between universities and enterprises are realized.

4.4 Two-Way Output from Projects: Driving Talent Training and Mode Optimization with Real Projects

Real projects serve as the core starting point for two-way empowerment. Enterprises' actual operation projects and technical improvement projects should be fully introduced into the talent training process, and project-based teaching should be implemented to realize two-way output of talent training and industrial optimization.

In daily teaching, typical emergency delivery cases from enterprises are selected as teaching projects, allowing students to complete tasks such as operation scheme design, risk assessment, and route planning in groups, and master professional skills in the process of solving practical problems. While guiding the projects, teachers can review and optimize the original enterprise schemes, form optimization suggestions and feed them back to enterprises, helping enterprises improve their operation processes.

In the internship and graduation project stage, students are arranged to join enterprise project teams and participate in daily standby, emergency drills, and auxiliary work of actual emergency tasks, so as to hone their post abilities in real projects. Meanwhile, students are encouraged to carry out small-scale technological innovation and process optimization topics jointly with enterprise technicians, such as improving terminal delivery accuracy and investigating risk points in emergency scenarios. The research results are directly applied to enterprise front-line operations. Through project-based cooperation, colleges have improved the quality of talent training, and enterprises have obtained actual benefits from process optimization and technical improvement, forming a win-win pattern of value co-creation.

5. Guarantee Pathways for the Implementation of the Two-Way Empowerment Integration Mode

5.1 Establish a Collaborative Governance Mechanism as Institutional Support

A regular university-enterprise collaborative governance framework should be established,

and a joint committee for program construction composed of college program directors, enterprise technical supervisors, and industry experts should be set up as the decision-making and deliberative body for two-way empowerment. The committee holds regular joint meetings to jointly study and judge industry development trends, changes in post demands, and adjustment directions of talent training, and reviews major issues such as talent training programs, curriculum system updates, and training base construction, so as to ensure that cooperation always meets the actual needs of both parties.

Meanwhile, in-depth cooperation agreements with clear rights and responsibilities should be signed to clarify the rights, obligations, and benefit distribution methods of both parties in curriculum development, base construction, personnel mutual employment, project cooperation, and other aspects. A long-term cooperation mechanism featuring benefit sharing and risk sharing should be established. For example, it should be clarified that enterprises participating in talent training can obtain priority recruitment rights and technical service support, while colleges can obtain practical resources and teaching cases by connecting with enterprise projects. Through a clear value distribution mechanism, the enthusiasm of both parties for in-depth participation can be fully mobilized, preventing cooperation from becoming a mere formality.

5.2 Strengthen Resource Guarantee with Multi-Party Joint Investment

In-depth integration of two-way empowerment requires sufficient resource input, and a resource guarantee system with joint investment from colleges, enterprises, and governments should be constructed. At the college level, funding investment in the characteristic direction of emergency logistics should be increased, focusing on supporting training base construction, teacher training, and curriculum development. Industry-education integration should be incorporated into the core plan of program construction, with preferential support in terms of venues, personnel, and policies. At the enterprise level, enterprises should fulfill their social responsibilities for vocational education, regard talent training as an important part of enterprise human resource reserve and brand building, take the initiative to open up

project resources, technical resources, and post resources, and invest necessary equipment and teaching staff to participate in university-enterprise cooperation.

Meanwhile, efforts should be made to actively connect with local emergency management departments, education departments, and industry associations to strive for policy support and special funds. Emergency low-altitude logistics talent training should be incorporated into local emergency system construction plans and key vocational education construction projects, so as to strive for resource support from the government level and provide broader policy space for two-way empowerment.

5.3 Construct a Multi-Dimensional Evaluation System for Two-Way Effectiveness

The traditional single evaluation method centered on examination scores should be broken, and a multi-dimensional evaluation system oriented to two-way effectiveness should be constructed to comprehensively measure the value of industry-education integration. The evaluation of talent training quality should involve three parties: colleges, enterprises, and the industry. Students' practical ability, project completion quality, enterprise internship performance, and vocational certificate acquisition should be included in the assessment indicators, with enterprise evaluation accounting for no less than 40%, so as to truly measure the effectiveness of talent training with post competency as the core.

Meanwhile, evaluation dimensions for industrial empowerment effectiveness should be added, such as the improvement of enterprise operation efficiency brought by talent supply, the process optimization effect brought by university-enterprise collaborative projects to enterprises, and the social service capability of the emergency standby team, so as to comprehensively evaluate the reverse empowerment value of the education side to the industrial side. On this basis, a graduate tracking feedback and cooperation effectiveness review mechanism should be established to regularly collect enterprise feedback and cooperation data, and reversely optimize talent training programs and cooperation modes, forming a closed loop of "empowerment-evaluation-optimization" and promoting the continuous deepening of two-way empowerment. The guarantee paths for the

implementation of the two-way empowerment integration mode are shown in Table 4.

Table 4. The Guarantee Paths for the Implementation of the Two-Way Empowerment Integration Mode

Guarantee Dimension	Core Measures	Guarantee Value
Collaborative Governance Mechanism	Establish school-enterprise joint committees and long-term cooperation mechanism with shared interests and risks	Standardize cooperation operation, mobilize enthusiasm and avoid formal cooperation
Multi-resource Investment Guarantee	School and enterprise invest special resources and strive for government and industry policy and fund support	Integrate multi-party resources to consolidate foundation for industry-education integration
Two-way Diversified Evaluation	Build a tripartite evaluation system covering talent cultivation and industrial empowerment with closed-loop optimization	Accurately assess cooperation effects and optimize talent training and cooperation modes

6. Conclusion

Emergency low-altitude logistics is an important starting point for improving China's emergency supply guarantee system and enhancing emergency management capabilities. Its high-quality development depends not only on continuous innovation in operation modes, but also on solid talent support provided by vocational education. Different from the traditional one-way talent supply-demand docking, there is a significant two-way empowerment relationship between the emergency low-altitude logistics industry and logistics education in higher vocational colleges: scenarios, standards, and technologies from the industrial side empower the education side to improve quality and upgrade, while talents, intellectual support, and reserves from the education side empower the industrial side to optimize implementation. The deep coupling of the two can achieve a win-win outcome.

From the two-way empowerment perspective, this paper sorts out three typical operation modes and development bottlenecks of emergency low-altitude logistics, analyzes the inherent logic and practical deviations of two-way empowerment, constructs an in-depth industry-education integration mode with four-dimensional linkage of position-course alignment, scenario sharing, personnel mobility, and project output, and proposes corresponding guarantee pathways. Limited by the research scope, this paper insufficiently discusses the adaptability differences across different regions and types of colleges. Future research can combine local industrial characteristics and college running characteristics to further refine the implementation pathways and specific schemes of two-way empowerment. Overall, promoting the two-way empowerment and

in-depth integration of the emergency low-altitude logistics industry and higher vocational education is not only a practical demand for the modernization of the emergency management system, but also an important direction for the transformation and upgrading of logistics programs in higher vocational colleges and the improvement of social service capabilities, which has important practical value and social significance.

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