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Research on optimization ideas and paths of China's UAS standard system construction

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Abstract. As a leading industry of low-altitude economy and an emphasis area of consumer goods trade-in, in recent years, the Unmanned Aircraft System (UAS) industry has successively received the attention of the Standardization Administration of the P.R.C, the State Administration for Market Regulation and other departments, which have all emphasized the importance of giving full play to the leading role of standards. Up to now, the construction of China's UAS standard system has made great progress, and 126 key standards that are urgently needed by the market and support supervision have been formulated and revised in a timely manner, but the following problems still exist: the standard terminology is not yet unified, the way of prioritizing the formulation and revision is too simple, the content of the standard system is still imperfect, and there is a lack of a unified public service platform for standard information. In order to solve these problems, this paper combines the new international standardization construction experience of the European, the United States and other countries, and puts forward the corresponding optimization ideas for the construction of the UAS standard system, so as to promote the healthy and orderly development of the UAS industry.

Keywords: UAS, international experience, standards system, policy optimization, digitalization of standards

1. Introduction

In December 2023, Chinese President Xi Jinping regarded the low-altitude economy as a strategic emerging industry at the Central Economic Work Conference, while emphasizing the promotion of large-scale equipment renewal and consumer goods trade-in[1].In March 2024, to implement the deployment of the Central Economic Work Conference and the fourth meeting of the Central Financial and Economic Commission, the State Administration for Market Regulation and other seven departments issued the “Action Plan for Traction of Equipment Renewal and Consumer Goods by Standard Improvement” [2] to give full play to the leading role of standards in order to promote high-quality development in an orderly manner. The UAS industry, as one of the key areas of consumer goods replacement, has been put on the agenda for the formulation and revision of many relevant standards, such as the “Product Identification Requirements for Civil Unmanned Aircraft” and other standards that have been included in the “List of Priority National Standards Projects to be Formulated and Revised in 2024” or the “List of Priority National Standards Projects to be Formulated and Revised in 2025”. In addition, as the leading industry of low-altitude economy, the development of the UAS industry is in the explosive period of rapid growth, and new regulatory requirements have arisen from various sectors [3]. In order to improve the level of UAS regulation and promote the healthy, orderly, and sustainable development of UAS technology and industry, the Standardization Administration of the P.R.C and other departmental organizations formulated the “Guidelines for the Construction of the Standard System for Unmanned Aircraft System (2017-2018 Edition)” (hereinafter referred to as the Guidelines (2017-2018 Edition)) in 2017, and in 2021 it was updated (hereinafter referred to as the Guide (2021 Edition)).

After the establishment and development of any standard system for a certain period, systematic problems will arise due to changes in the development environment, mode and technical level [4]. According to the new development requirements and development trends, the systematic optimization of the standard system is an effective way to solve the “systematic degradation” of the standard system. At present, various industries are carrying out dynamic updating of the standard system in the corresponding areas of research. Li Min [5] et al. optimized the framework structure of soil environmental protection standard system based on the risk evaluation of soil environment. Fu Guanghui [6] et al. constructed a demand model of demand-standardized elements and provided ideas and methods for the optimization of industrialized building standard system. Niu Jingjuan [7] et al. proposed a new standard system in the field of nuclear power plant operation after researching the operational requirements of the U.S. Nuclear Power User Requirements Document and the European Nuclear Power User Requirements Document, as well as the business of

domestic nuclear power plants. Ji Cuiling [8] et al. optimized the original standard system framework based on the summary and analysis of meteorological standardization achievements and problems, in view of the situation of high-quality development it faces. Zhao Yan [9] et al. put forward the optimization idea of China's watch standard system by comprehensively considering factors such as national policies, industry development and the current status of international standards. Therefore, under the principle of dynamic updating in the construction of standard system, it is necessary to discover and solve the problems in the construction of UAS standard system based on the new policy environment and regulatory requirements.

This paper focuses on the ideas and methods of international standardization work in Europe, the United States and other international standardization work, combined with the current situation of China's UAS standardization construction and problems, puts forward a few optimization ideas for China's UAS standard system construction, and provides references for China's construction of scientific and perfect UAS standard system.

2. Drawing on international experience in the construction of the standard system

After years of practice and improvement, international standardization and UAS standard system construction has formed a relatively mature construction path, and China can learn from some of these ideas and methods to improve the quality and efficiency of China's UAS standard revision, meet the regulatory requirements of management departments in a timely manner, and promote the healthy development of the UAS industry.

2.1. Establishment of a "Prioritization Matrix" to refine the expected timing of the publication of standards

In order to coordinate and promote the standardization of UAS, the American National Standards Institute (ANSI) has established the Unmanned Aircraft Systems Standardization Collaborative (UASSC). The UASSC has developed a set of "UASSC Prioritization Matrix" (see Table 1) in the UAS Standardization Roadmap V2.0 to prioritize the development and revision of "standard gaps" [10].

Through this matrix, each gaps standard is assessed and ranked, and the prioritization of standards development and revision can be categorized into three levels with corresponding expected publication times, i.e., high-priority (0-2 years), medium-priority (2-5 years), or low-priority (more than 5 years). The high-priority criteria were further categorized into three tiers: tier 1 (most critical), tier 2 (critical), or tier 3 (least critical). After evaluation and ranking, the Standards Developing Organizations (SDOs) prioritize standardization talents, funds, time and other construction resources into the construction of the highest-priority "standard gaps" to meet regulatory requirements better and help improve the construction of the UAS standardization system construction.

Table 1. UASSC Prioritization Matrix

Criteria (Make the C-A-S-E for the Priority Level)		Scoring Values
Criticality (Safety/Quality Implications)	How important is the project? How urgently is a standard or guidance needed? What would be the consequences if the project were not completed or undertaken? A high score means the project is more critical.	3 - critical 2 - somewhat critical 1 - not critical
Achievability (Time to Complete)	Does it make sense to do this project now, especially when considered in relation to other projects? Is the project already underway or is it a new project? A high score means there's a good probability of completing the project soon.	3 - project near completion 2 - project underway 1 - new project
Scope (Investment of Resources)	Will the project require a significant investment of time/work/money? Can it be completed with the information/tools/ resources currently available? Is pre-standardization research required? A high score means the project can be completed without a significant additional investment of resources.	3 - low resource requirement 2 - medium resource requirement 1 - resource intensive
Effect (Return on Investment)	What impact will the completed project have on the industry? A high score means there are significant gains for the industry by completing the project.	3 - high return 2 - medium return 1 - low return
Score Rankings		
High Priority (a score of 10-12)	Medium Priority (a score of 7-9)	Low Priority (a score of 4-6)

2.2. Increase participation in civil society standards development and develop a digital standard writing process

In response to the issue of promoting the improvement of the standards system and filling in the gaps in standards, two perspectives for solving the problem have been put forward internationally: the incorporation of civil standards and the development of a digitized standard-writing process.

2.2.1. Incorporating civil standards and emphasizing the contribution of civil society in standardization work.

In the U.S. standardization system, although ANSI is in a leading position [11], but it is only as a coordinating platform to gather and "lead" stakeholders to assess and address specific areas of standardization needs, and the main force of the U.S. standardization work in fact, the U.S. civil industry groups [12]. The government and enterprises more use of civil standards, in promoting the development of civil standards, but also to ensure that the implementation of the advanced nature of the standard.

In Japan's standardization system, the Ministry of Economy, Trade and Industry (METI) put forward the "standardization government-civilian strategy", which constructed a government-civilian integration-type standardization mechanism with the private sector as the main body, in order to solve the problem of insufficient capacity and level of the private sector's participation in standardization work in the current stage of Japan. The proposed strategy has greatly improved the efficiency of Japanese standardization, and thus rapidly grasped the right to speak on international standards in the field of cutting-edge technologies [13].

2.2.2. Development of a digital authoring process to improve the efficiency of standards authoring

In the British standardization practice, the British Standards Institution (BSI) has developed a set of agile process BSI Flex for collaborative development of standards in the digital environment, which has the characteristics of new digital standards such as flexible formulation, rapid iteration, and rapid response to market demand [14]. The method adopts digital technology and information-based management, while combining the consultation process of a new version of a standard and the use of the previous version of the standard into the same process, which improves the speed of standard development and revision and shortens the standard development and revision cycle to only six months [15].

2.3. Publish a unified access to information on UAS standards to increase stakeholder engagement

UASSC describes in detail the types of standards involved in UAS standards and the related standards under that type in the UAS Standardization Roadmap V2.0 [10] with a list of UAS-related standards to help stakeholders understand the status of the U.S. UAS standards system construction.

UASSC also defines "Gaps" as the "absence of published standards, specifications, etc. that cover a particular issue" and publishes a real-time updated "Gaps Progress Report" [16]. The report unifies the revision priority, development status, and list of standards that need to be updated for the Gaps. UASSC members can understand and monitor the development status of the missing standards through the Report, and at the same time, they can comment and update the Report by e-mail. This has opened the channels for members to understand the progress of standards development and increased their participation.

3. Status and problems of China's UAS standard system construction

In the "Deepening Standardization Work Reform Program" issued in 2015, the State Council of China explicitly proposed the establishment of a new type of standard system consisting of standards developed by the government-led development of standards and standards developed by the market on its own. Among them, national standards, industry standards, and local standards are formulated by the government-led development, focusing on the preservation of the basic; group standards are formulated by the market independently, focusing on the improvement of competitiveness [17]. Since group standard construction is a market behavior, this paper takes the government-led standard as the main research object to explore the problems existing in the construction of China's UAS standard system.

The Guide (2021 Edition) constructs a standard system structure consisting of four categories of standards: basic standards, management standards, technical standards and industry application standards (as shown in Fig. 1), and breaks down the standard system structure into a number of substandard systems to establish the UAS standard system framework. The "UAS Standard System Table" (hereinafter referred to as the "Standard System Table") is also given in the Annex to accompany the UAS Standard System Framework, with a view to guiding the construction of the UAS Standard System and the related standardization work. The "Standard System Table" includes the name of the standard and the position of the standard in the structure and branches of the standard system, and provides the names of a total of 336 government-led standards, of which 94 are standards that have already been published and projected (with standard and program numbers recorded), and 242 are standards that have potential demand but have not yet been projected (with the name of the standard provided only).

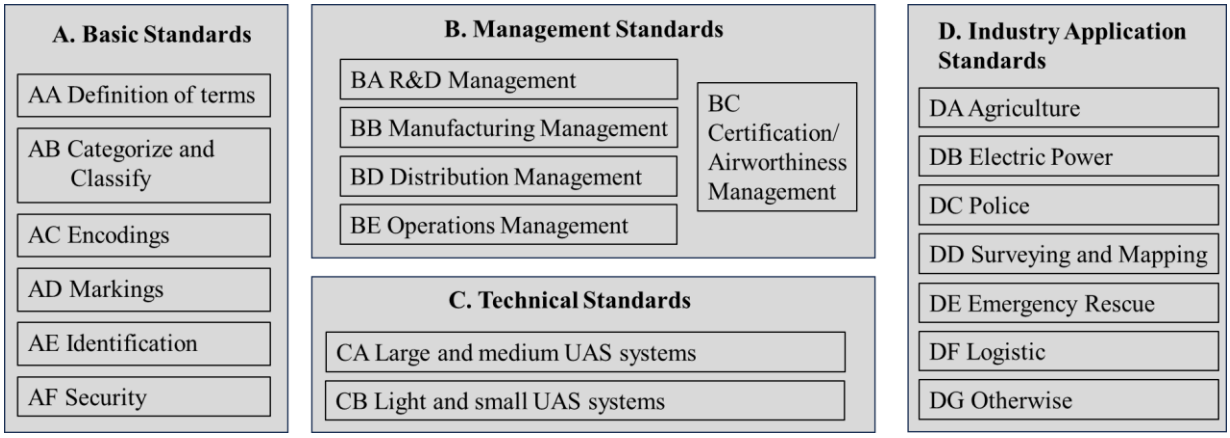

Figure 1. UAS Standard Architecture

To understand the current status of China's UAS standards system, this paper includes 475 current and upcoming UAS standards (based on the "China Standard Service Network", data as of March 2, 2024), and by comparing the current status with the "Guidelines (2021 Edition)", the following issues are identified.

3.1. Overly simplistic way of prioritizing standards development and revision

To reasonably allocate resources for standardization, the two editions of the Guide use different approaches to prioritize the preparation and revision of a large number of standard gaps to better meet market demand and regulatory requirements.

The Guide (2017-2018 Edition) distinguishes the priority of standard development and revision by annotating the planning standards with two different degrees of "urgently need to be developed" and "to be developed"; the Construction Guide (2021 Edition) prioritizes standard development and revision by describing the "construction focus" of a certain type of standard under the standard architecture, for example, "in the marking standards, the focus is on the development of UAS product classification icons, marking styles, marking locations, marking information requirements and other standards; and the standard development and revision of product quality information and risk warnings, and so forth".

Although both methods prioritize the standard gaps, the large number of standards covered under "urgent development/construction priorities" are not further prioritized, making it difficult to give full play to the guiding role of planning for the standardization of UAS construction in a general way. Moreover, the prioritization is not linked to time, and since there is no time limit, the urgency of the "urgent formulation/construction priority" standards is not reflected.

3.2. The content of the current UAS standards system is still not perfect

Under the guidance of the Guidelines (2021 Edition), various UAS-related parties have newly formulated and revised 126 national, local and industry standards that cover the entire standard architecture, which are urgently needed by the market and support regulation, such as "Safety Requirements for Civil Unmanned Aircraft System", "Specifications for the Construction and Acceptance of Low, Slow and Small UAS Detection and Countermeasures Systems", and "Specifications for the Civilian UAS Real-Name Registration Data Exchange Interface" etc. The number of new industry application standards has reached 99, and if group standards are considered, the number of such standards can reach 234. This change shows that the application of UAS in various industries is gradually deepening, its standardization demand is rising, and the enthusiasm of relevant groups and institutions to participate in UAS standardization work is increasing.

However, if we compare the number of existing standards with the number of standards planned in the Guide (as shown in Table 2), we can find that there are still a lot of standard gaps in the construction of China's current standard system ("number of existing standards" - "number of standards planned in the Guide"), and the content is still not perfect. There is a small gap in the number of basic standards, a large gap in management and technical standards, and only industry application standards exceeded expectations, which narrowed the gap in the total number of existing and planned standards. In addition, among the industry standards being drafted, there are still 16 that have not been completed and released in the expected time, including eight basic public welfare standards, such as the "Horizontal Measurement Methods for Small and Medium-sized Fixed-wing UAS" and the "Requirements for Autonomous Control Levels of Civilian UAS", as well as one key standard, the "Requirements for Ground Control Units of Civilian Light-weight and Small-sized Multi-rotor UAS Software".

Table 2. Comparison of the number of existing standards and the number of planning standards in the Guide

Standardized Architecture Typology	Basic Standards	Management Standards	Technical Standards	Industry Application Standards	Total
Published standards in the Guide	11	6	35	18	70
Criteria established in the Guide but not completed	1	0	16	7	24
Criteria not established in the Guide	19	47	133	43	242
Existing standards in force or about to enter into force	10	11	49	149	219
"Number of existing standards" - "Number of planning standards in the Guide"	-10	-36	-100	99	-47

3.3. Lack of a sound and unified public service platform for UAS standard information

Standard information service platform "integrated construction" and provide "one-stop service" has become a significant feature of the "Internet +" era, most enterprises and users need an official standard information service platform to improve the efficiency of standard work and realize the sharing of resources [18]. At present, China has "China Standard Service Network", "National Public Service Platform for Standards Information", "Industry and Information Technology Standard Information Service Platform" and "Standard System Table", which are several standard inquiry channels in the field of UAS, but there is a lack of an official, sound and unified information public service platform to provide UAS stakeholders with electronic standard documents and information, including basic information such as standard name, standard number, standard effective status, and standard summary, as well as information on the development status of the standard and the process of making and revising the standard.

The "China Standards Service Network" can provide a relatively comprehensive list of standards in a "one-stop service", but the list of standards contains only basic information on the standards and lacks information on the process of making and revising the standards. In addition, some of the old versions of group standards included on the website have not been eliminated, and some of the industry standards in the process of drafting have not been included.

At the same time, the current channels for searching information on the process of standardization and revision are scattered and imperfect. Information on the process of making and revising national standards for UAS can be queried by using the function of "National Standards Program Query" in the "National Public Service Platform for Standards Information", but the disadvantage is that the platform is unable to query information on the process of formulating and revising industry standards, local standards and group standards. Information on the revision process of some industry standards can be queried on the "Industry and Information Technology Standard Information Service Platform", with the disadvantage that the platform cannot query relevant standards in industries such as agriculture, which means that it is difficult to understand information on the revision process of all the standards for the application of the UAS industry.

The most recent document that provides uniform information on the status of entry into force of existing standards is the "Standards System Table" in the Guide (2021 Edition). The table only gives the program number or standard number of some standards to indicate the status of standard production and revision at the time of the release of the Guide (2021 Edition). Since then, there has been no public document that uniformly updates the status of China's UAS standard construction.

As mentioned above, inconsistent access to information on standards at different levels and incomplete information on the development and revision process make it more difficult for stakeholders to follow up and monitor the development status of the required standards in real time, as well as the coordination of the multi-departmental development and revision process.

4. Optimization ideas for China's UAS standard system

4.1. Establishment of a standard-setting prioritization assessment methodology and refinement of standard-setting priority levels

In the process of promoting the construction of standards revision, a set of standard-setting prioritization assessment methodology can be identified first, with specific standard gaps as the object, existing and potential standard gaps are assessed and ranked, and categorized into different time-related priority levels, and based on the assessment results, funds, time and other resources for standard construction are reasonably allocated to promote the standardization work in an orderly manner to meet the regulatory requirements and market demands in a timely manner.

Combined with the research of Chinese scholars on standard revision timing planning methods [19-22], multi-attribute decision-making methods can be considered to be applied in the field of UAS standard revision ranking, such as the Vlsekriterijumska Optimizacija I Kompromisno Resenie (VIKOR). Referring to the evaluation elements and priority ranking of

the “UASSC Prioritization Matrix”, we summarize the characteristics of China's UAS standard requirements, improve the VIKOR method, and establish a decision-making model suitable for the revision of China's UAS standards, to evaluate and rank the priority of the standard-setting.

4.2. Actively improve the standard system, promote the adoption of group standards, and develop a digital standard writing process

To comply with the rapid development trend of UAS technology and accelerate the improvement of the UAS standard system, comprehensive consideration should be given to market demand and regulatory requirements, existing and potential standard gaps should be systematically analyzed, and key standards that are urgently needed by the market and supportive of regulation at this stage should be actively formulated and revised. Specifically, this can be done from the perspectives of promoting the adoption of group standards and developing a digitized standard-writing process.

4.2.1. Promote the adoption of group standards and improve the efficiency of the content improvement of the UAS standard system

In view of the great importance that countries attach to civil standards, the important influence of group standards on the construction of standard systems, and the high enthusiasm of relevant groups and institutions in China to participate in the standardization of UAS, consideration can be given to adopting some of the outstanding group standards to help improve the standard system. In August 2023, China issued and implemented the “Interim Provisions on the Adoption of Group Standards for Recommended National Standards” [23], and opened the “Recommended National Standards Adoption Group Standards Project Declaration System”. Relevant departments can use this system to adopt the excellent group standards as national standards, and promote the more rapid improvement of national standards. Industry standards, local standards should be formulated as soon as possible similar “Adoption Declaration System”, to absorb the excellent group standards in a timely manner.

4.2.2. Development of a digitized standards writing process to improve the efficiency of UAS standards writing

It is recommended that reference be made to the British BSI Flex standard process to promote the digital transformation of the UAS standard preparation process and shorten the standard preparation and revision cycle, to ensure that the UAS standard responds to market demand in a timely manner with the iteration of technology.

4.3. Aggregate and expand access to standard information on UAS and harmonize access to UOM

On August 22, 2022, CAAC released “Civil UAS Development Roadmap V1.0” [24], which proposes to build Integrated Management Platform of Civil Unmanned Aerial Vehicle (UOM). Under UOM, there is a public service platform, which can provide querying of policies and regulations, flight information, airspace, meteorology and other information; query personnel qualification application, organization and other information of public service functions.

Consideration can be given to combining with the existing UOM platform to complete the construction of the UAS standards database and on-line network, and to realize the function of nationwide network search. Specifically, reference can be made to the UASSC “Standardization Roadmap For Unmanned Aircraft Systems, Version 2.0” and the “Gaps Progress Report”, summarize the existing UAS-related standards management platforms, expand the channels for obtaining information on UAS standards, cover multiple levels of national standards, industry standards, local standards and group standards, and dynamically track the standard information. In addition, these channels can be unified into the public service platform of UOM to provide users with “one-stop” standard information services. Further, the functions of opinion solicitation and feedback maintenance can be added to smooth the supervision and feedback channels of the public and other stakeholders on the standardization construction of UAS, so as to promote the implementation and improvement of the standards on the ground.

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