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Modern normative and technical support of complex technical systems projects

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Abstract. *It is considered relevant to assess the potential of modern normative and technical support for programs/ life cycle projects of complex technical systems, which is based on system, process and project approaches, as well as on risk-oriented thinking, which is an integral condition for achieving (maintaining) competitiveness not only of products produced by the organization, but also the competitiveness of the organization itself.*

To develop the procedure for evaluation of expediency of normative and technical documentation use in the field of project management and system engineering as a basis for the development of enterprise standards for science-intensive products life cycle ensuring.

For the analysis of the existing array of information materials for this problem, such criteria were proposed and substantiated, which allowed to perform a criterion analysis, involving a comprehensive analysis of the information material content, identification of criteria significant for the organization, and subsequent expert evaluation of sources of scientific and technical information.

According to the results of the criterion analysis of the array of normative and technical documents that can be used by the domestic science-intensive sector of industry, the concepts of building of the programs/projects life cycle for the life cycle of complex technical systems were determined and recommended depending on the nature of the organizations' activities.

The approach proposed allows to choose the basic concepts of normative documents as possible analogues for their use based upon the peculiarities of the enterprise's activity and the specifics of the science-intensive product.

Keywords: *complex technical system; normative and technical documentation; life cycle; system approach; process approach; project approach.*

Introduction

Maintenance and evolution of competences in the development of complex technical systems (CTS) is an urgent problem for domestic science-intensive production. In order to maintain the competitiveness, the enterprises of science-intensive engineering should constantly solve two oppositely directed problems. On the one hand, enterprises (which are CTS themselves) should solve scientific and technical, as well as design and technological problems of the increasing complexity of their products (CTS) in order to ensure their market advantages - but this requires greater resources, particularly in time sense, in order to develop both the design and production technologies. On the other hand, in order to meet the same, constantly changing market needs, taking into account the pressure from competitors, it is necessary to solve the problems of maximally shortening the terms of bringing the developed products to the market in order not to lose the projected advantages of their products (CTS). In global practice, an important component of the task of highly effective CTS creation is the use of project management and system engineering methodology.

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Problem actuality

In recent decades, in order to ensure the competitiveness of the CTS, the world engineering community has developed and refined a significant amount of normative and technical documentation (NTD), which contains recommendations and regulations in the field of project manage-

ment and system engineering and which promote more efficient work of science-intensive products creators. In particular, such documentation may include the following:

1. General methodological guidelines:

– Guide to the Systems Engineering Body of Knowledge (SEBoK version 2.6., 2022).

– A Guide to the Project Management Body of Knowledge (PMBOK Guide). Sixth Edition.

2. International normative documentation, in particular ISO 21500 series standards, NATO standards (AAP-20 and AAP-48, and others), rules and standards of the aerospace industry AS9100, EASA, FAA, FAR, SAE ARP, and others, as well as ASTM, ANSI.

3. Domestic normative documents, first of all, DSTU standards (particularly DSTU V-P 15.004:2019, DSTU 15288:2016, DSTU 24748-1:2018, DSTU 24748-2:2015, DSTU 24774:2016, DSTU 16326:2015, DSTU V-P 15.213:2019 DSTU STANAG 4107:2018, DSTU STANAG 4107:2019, etc.).

For the organizations, that are systematically engaged in the CTS creation, the problem of determining the predominant areas of use of these and other normative and technical documents is relevant and important, and choosing those of them, that most correspond to the current situation, type and kind of the product, allow to use the available scientific technical basis and professional competences to achieve competitive advantages. Particularly, this concerns the definition of the structure and content of the characteristic periods of the life cycle of CTS programs/projects. On this base the appropriate corporate ("brand") standards and regulations are developed, adapted to the specific conditions of the organization's activities and the products created.

Analysis method

For the analysis of the existing array of information materials for the above-mentioned problem, a number of criteria were considered and substantiated (with a certain conditionality), which allowed to perform the appropriate criteria analysis, providing a comprehensive study of the information material content, identification of criteria significant for the organization and evaluation of the considered information on their base.

Of course, the products of the defense-industrial and civilian sectors of industry have slightly different models of presenting the life cycles of the CTS projects [1].

The main difference is as follows. For the CTS, which are related to defense-technical and similar to it products, the period of "justification of the need" and evaluation of the "technical feasibility" of the future CTS is usually formed by the customer (as a rule, the department). In this case, the potential system developer can decide to start work on the creation of the CTS after the formal publication of a "request" by the structure that initiates such a "request", most often in the form of an RFP (Request for Proposal).

For civil products, the task of "justifying of the need" and assessing the "technical feasibility" of the future CTS falls on the shoulders of the initiator-sponsor, investor or actually the developer of the future CTS project. In this case, a set of research, analytical, and expert works is carried out, the result of which is, in particular, an assessment of the market volume for the future CTS and an assessment of the adequacy of possible costs required for the development of a new CTS (see Fig. 1).

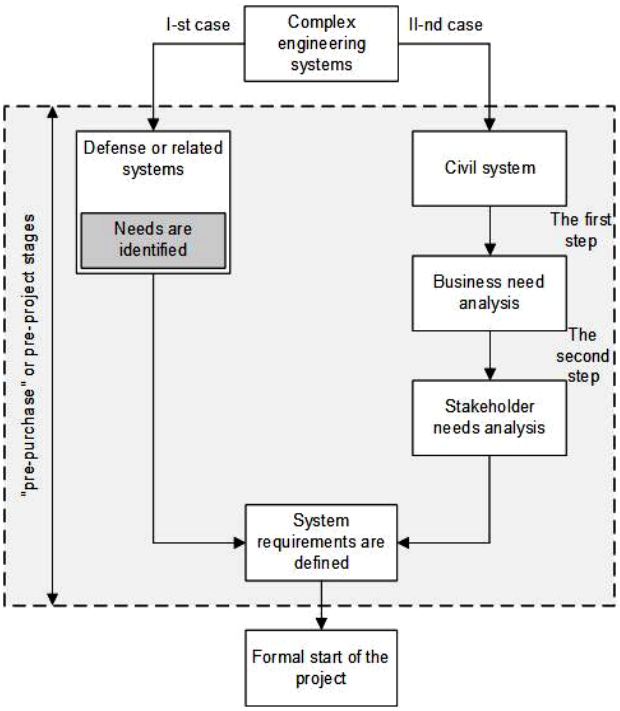


Fig. 1. Activation scenarios for the formal start of the project for the defense-industrial and civilian sectors of production

Thus, it is possible to formulate the first of the criteria for the analysis of the NTD array: whether the model of the CTS LC presentation belongs to the following:

– to defense-technical and related products;

– to civil products;

– can be used regardless of the type of product.

In different NTDs, the model of the CTS LC is often presented in different ways. Sometimes the attention is focusing on its various stages, phases and periods without covering the entire CTS LC. It is not always taken into account such an important period of the CTS LC, as the "dematerialization" of the system - disposal (an example of a graphical presentation of models of the life cycle of a product in different NTD is shown in the Fig. 2 and 3). In this connection, the second criterion for analysis of the information array is as follows:

– whether the model of the CTS LC provides consideration of its full LC;

– whether the model of CTS LC provides consideration of separate periods of LC (phases, stages).

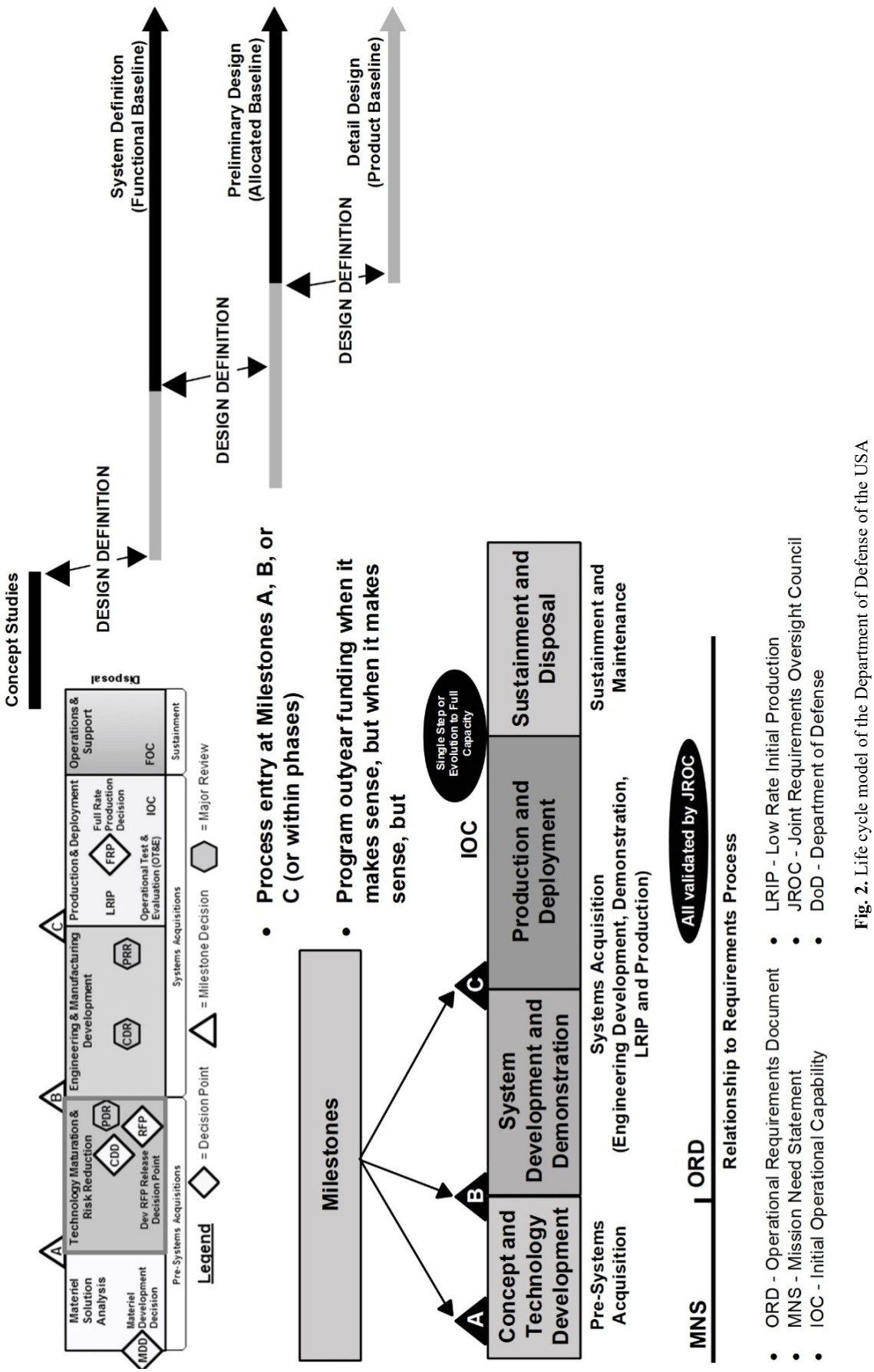


Fig. 2. Life cycle model of the Department of Defense of the USA

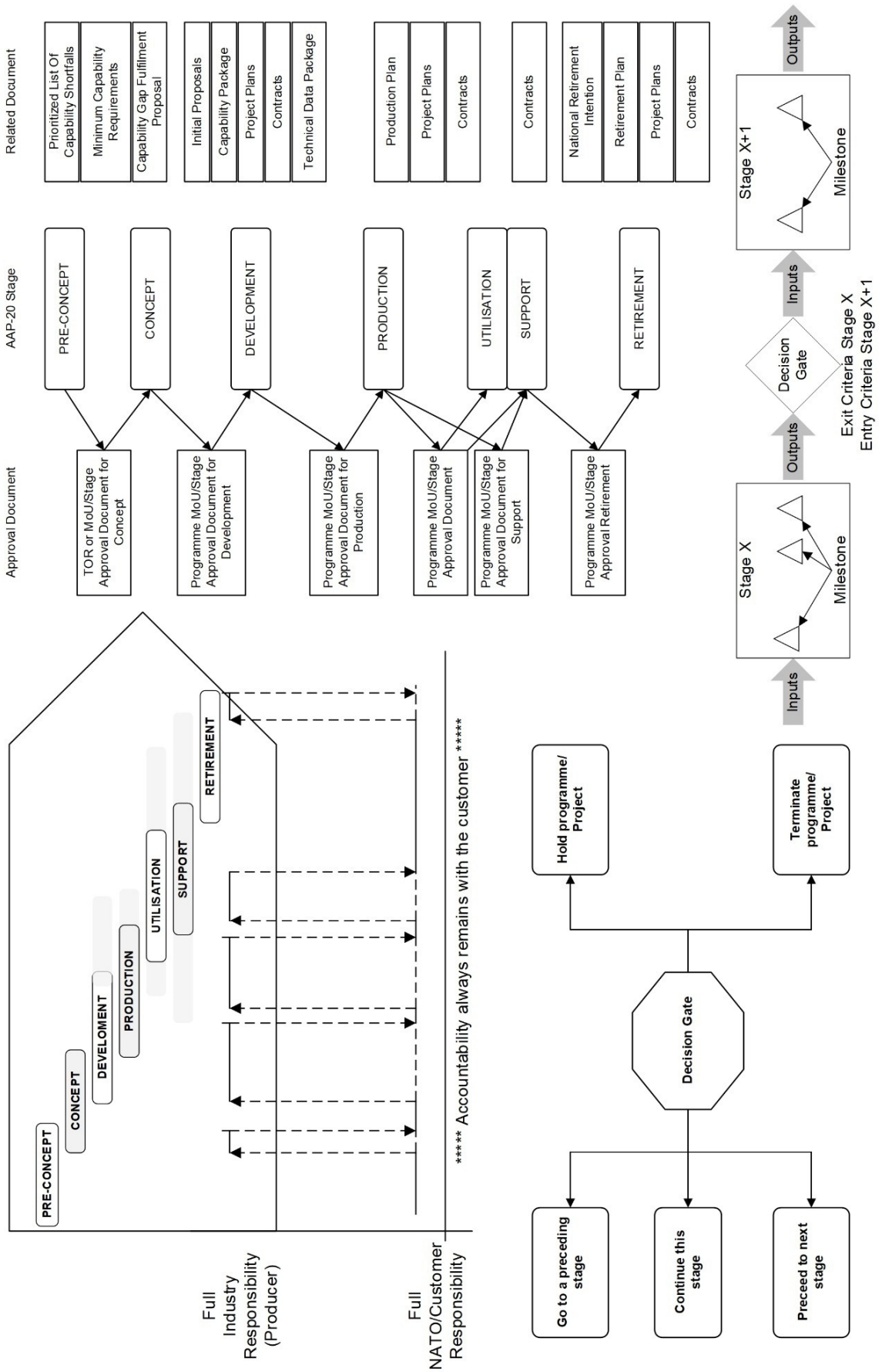


Fig. 3. AAP-20-2015 NATO life cycle model

It is well known, that the greatest risks to the project are found in its early periods. Thus, the third criterion can be presented as an assessment of the level of information detailing in the CTS LC model:

– high level of detailing;
– average level of detailing;
– small level of detailing.

Also, the following criteria can be attributed to the criteria of analysis of information materials on the topic "Management of CTS projects":

– availability for use;
– compliance with modern international practices;
– compliance with corporate practices;
– ability to develop, actualize and evolve.

A full set of proposed criteria for the analysis of information materials is given in Table 1.

Table 1. Simplified presentation of criteria for the analysis of information materials on the topic "Management of CTS projects"

Criterion category	Essence of the criteria	Criterion designation
1	Attribution of the CTS LC model to the appropriate field of activity	1.1. General-civilian sphere of activity 1.2. Defense-technical sphere of activity 1.3. General-civilian and defense-technical sphere
2	Completeness of the period coverage in the CTS LC	2.1 Full coverage of all the CTS LC period 2.2 Incomplete coverage of the CTS LC period 2.3 Fragmentary coverage of the CTS LC period
3	The level of information presentation detailing in the CTS LC model	3.1. High 3.2. Average 3.3. Low
4	Availability for use	4.1. Available (yes) 4.2. Not available (no)
5	Compliance with modern international practices	5.1. There is (specify the specific standards and directives) 5.2. Absent
6	Compliance with corporate practices	6.1. There is (yes) 6.2. Absent (no)
7	Level of ability to development and actualization	7.1. Outdated 7.2. In force

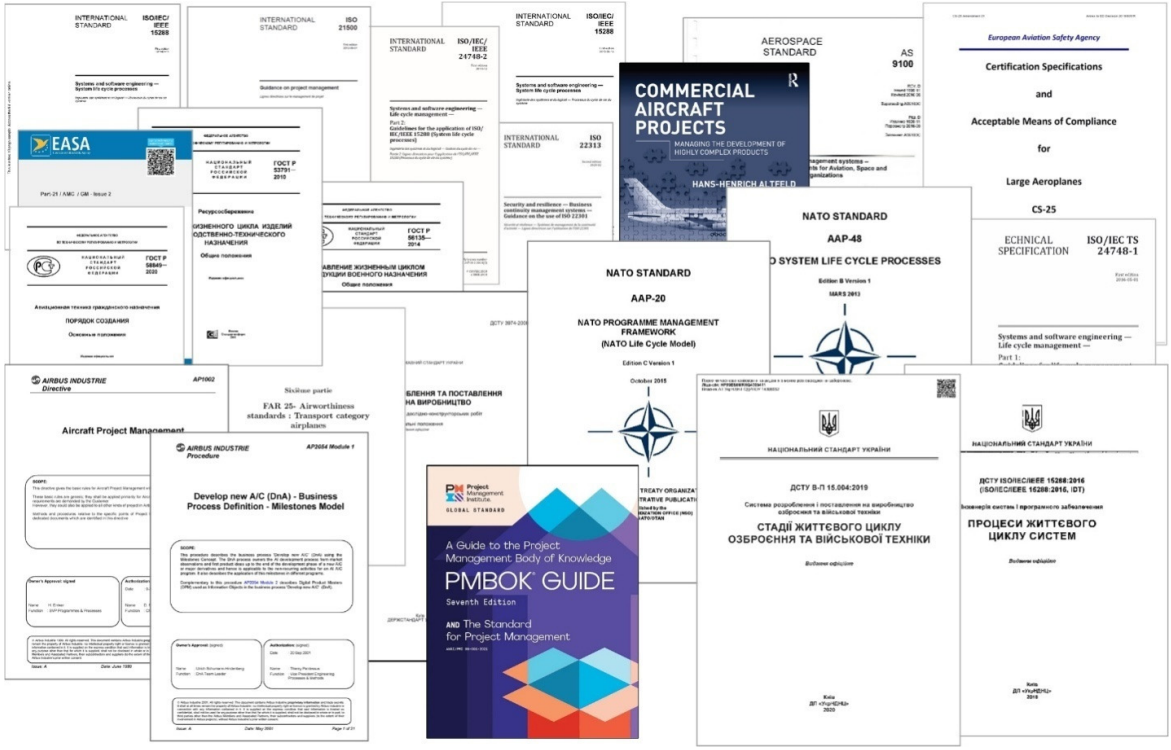


Fig. 4. List of scientific and technical documentation sources

On the basis of the proposed criteria, a qualitative expert assessment analysis of about 80 STD sources was conducted (see Fig. 4).

For the purpose of quantitative analysis of NTD, the "expert assessment" method was used, which included the following measures:

– formulation of the examination task – assessment of expediency of the NTD using by organization specialized in the development of aviation equipment (AE) for civil and military transport purposes, it plans to cover full period of AE LC and consider in detail the presentation of the processes of AE development;

– formation of an expert group of specialists with specialized qualifications;

– organization and conducting of expert surveys;

– analysis and processing of expert (score) evaluations received from experts;

– submission of evaluation results in the form of consolidated criterion analysis of scientific and technical documentation.

Analysis results

As a result of the analysis fulfilled, the expediency of documentation using as a base during the enterprise standards development regarding the formation of structure and content of the life cycle of science-intensive products was assessed (see Fig. 5). The results of the analysis are shown in Table 2.

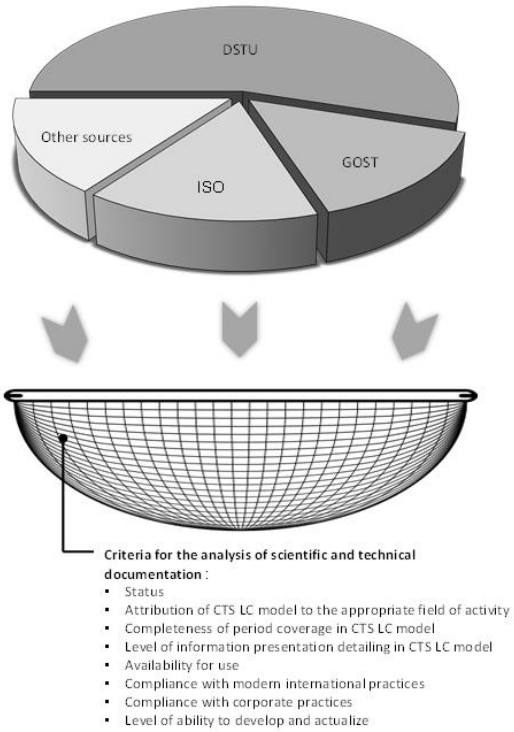
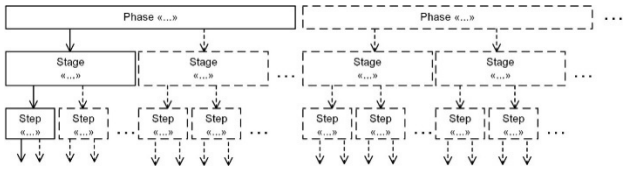


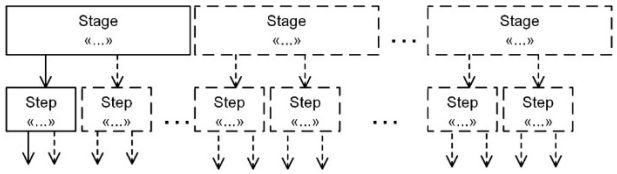
Fig 5. Visualization of procedure of the consolidated criterion analysis of scientific and technical documentation

According to the results obtained after the consolidated criterion analysis of the concepts of CTS models, investigated in the considered information materials, in particular, three alternative concepts of the models were determined:

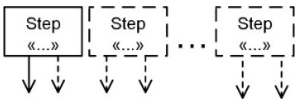
– the concept of a three-level model of CTS LC:



– the concept of a two-level model of CTS LC:



– the concept of sequential model of CTS LC:



Each of identified alternative models is appropriate for application in programs/projects of enterprises depending on their specialization and globalization of activities. In particular, the three-level model of CTS LC can be recommended to global corporations that have to provide the entire life cycle, and not only the "Production" stage, but also the subsequent stages, up to the "Withdrawal" stage. That is, the system approach in the three-level model of LC creates the possibility of consumer confidence in the guaranteed ownership of long-term use products, which may require not only "operational support", but also, for example, "modernization". The two-level model of the CTS LC can be recommended to such enterprises that are associated or are directly part of global organizations, but their activities are limited, for example, only to the products production or to the modernization of outdated (morally, physically) products. Finally, the single-level model of CTS is recommended for enterprises that have a certain specialization, i.e., either develop knowledge-intensive products, or manufacture products developed by an external organization, or engage in the restoration of knowledge-intensive products, service, etc.

According to the same results of the criterion analysis of CTS models conceptions, it was determined, that common for organization of science-intensive areas of activity is the need to regularize the CTS according to generally recognized rules and approaches: systemic, process and project, as well as on the basis of risk-oriented thinking. It is just on this basis of compliance with such approaches, a number of standards were determined as not actual.

Table 2. Consolidated criterion analysis of scientific and technical documentation

Document	Status	Attribution of CTS LC model to the appropriate field of activity	Completeness of period coverage in CTS LC model	Level of information presentation detailing in CTS LC model	Availability for use	Compliance with modern international practices	Compliance with corporate practices	Level ability to develop and actualize	Expert assessment of feasibility, points
GOST 2.103	Interstate standard	General-civilian and defense-technical spheres of activity	Fragmentary coverage	Low	yes	absent	yes	out of date	5
GOST 15.001	Interstate standard	General-civilian sphere of activity	Incomplete coverage	Low	yes	absent	yes	out of date	5
DSTU 3278	National standard	General-civilian and defense-technical spheres of activity	Fragmentary coverage	Low	yes	absent	yes	out of date	5
DSTU V-P 15.004	National standard	Defense-technical sphere of activity	Full coverage	High	yes	ISO 15288	no	new, valid	100
GOST R 15.2001	RF standard	General-civilian and defense-technical spheres of activity	Incomplete coverage	Aver-age	no	ISO 24748-1	yes	out of date	10
GOST R 53791	RF standard	General-civilian and defense-technical spheres of activity	Full coverage	Aver-age	no	AAP 20	yes	valid	20
DSTU 15288, DSTU 24774, DSTU 24748-1, DSTU 24748-2, DSTU 16326	National standard	General-civilian and defense-technical spheres of activity	Full coverage	High	yes	total, fundamental	no	new, valid	100
GOST R 58849	RF standard	General-civilian sphere of activity	Full coverage	High	no	absent	avia-tion	new, valid	85
ISO 21500, ISO 21502	Interna-tional standard	General-civilian and defense-technical	Full coverage	Low	yes	absent	yes	new, valid	60
ISO 21503 ISO 21504, ISO 21505		spheres of activity							

Continuation **table 2**

1	2	3	4	5	6	7	8	9	10
ECSS–M–30A	European Space Agency	General-civilian sphere of activity	Full coverage	Average	yes	total, fundamental	no	valid	50
DoD 5000, MIL-STD-881E	Standard of the Department of Defense of the USA	Defense-technical sphere of activity	Full coverage	High	no	considerable	no	valid	70
AAP-20, AAP-48	NATO standard	Defense-technical sphere of activity	Full coverage	High	yes	total, fundamental	no	new, basic	95
Series AP, series AM	Airbus standard	General-civilian sphere of activity	Incomplete coverage	High	yes	considerable	aviation	actually	90
Boeing management	Boeing management	General-civilian sphere of activity	Full coverage	Average	no	considerable	aviation	actually	70
NASA Systems Engineering Handbook	NASA handbook	General-civilian sphere of activity	Full coverage	Average	no	considerable	space	actually	75
PMBOK® management	management	General-civilian and defense-technical spheres of activity	Fragmentary coverage	Low	yes	considerable	no	actually	60
The PRINCE2® Practitioner Training Manual	management	General-civilian and defense-technical spheres of activity	Full coverage	Low	yes	limited	no	actually	25

Conclusions

The proposed approach for evaluation the expediency of existing normative and technical documentation use in the field of project management and system engineering in the development of enterprise standards for ensuring the life cycle of science-intensive products.

Criterion analysis of scientific and technical information according to proposed and substantiated criteria and subsequent expert assessment of sources of scientific and technical information was performed.

Alternative models of the life cycle of complex technical systems were proposed, appropriate for use in programs/projects of enterprises depending on their specialization and globalization of activities.

List of abbreviations

AE – aircraft equipment,
LC – life cycle,
NTD – normative and technical documentation,
CTS – complex technical systems,
NATO – North Atlantic Treaty Organization,
Airbus – aircraft building company (https://www.airbus.com),
Boeing – aerospace corporation (https://www.boeing.com),
ECSS – European Cooperation for Space Standardization - joint efforts of the European Space Agency, National Space Agencies and European Industry Associations to develop and maintain common standards ,
NASA – National Aeronautics and Space Administ ration,
RFP – Request for Proposal.

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Сучасне нормативно-технічне забезпечення проєктів складних технічних систем

С.Г. Кривова, О.Є. Зубаньов, К.О. Зворикін, С.І. Трубачев

Анотація. *Актуальним вважається оцінка потенціалу сучасного нормативно-технічного забезпечення для програм/проєктів життєвого циклу складних технічних систем, який заснований на системному, процесному і проєктному підходах, а також ризик-орієнтованому мисленні, що є невід'ємною умовою досягнення (збереження) конкурентоспроможності не лише продукції, що випускається організацією, але й конкурентоспроможності самої організації.*
Розробити методику оцінки доцільності використання нормативно-технічної документації в області проєктного управління і системної інженерії в якості базової при розробці стандартів підприємства з забезпечення життєвого циклу наукоємної продукції.
Для аналізу наявного масиву інформаційних матеріалів за даною проблемою запропоновані та обґрунтовані критерії, які дозволили виконати критеріальний аналіз, який передбачував всебічний аналіз змісту інформаційного матеріалу, виявлення значущих для організації критеріїв та наступної експертної оцінки джерел науково-технічної інформації.
За результатами критеріального аналізу масиву нормативно-технічних документів, які можуть бути використані вітчизняним наукоємним сектором промисловості, були визначені концепції побудови життєвого циклу програм/проєктів життєвого циклу складних технічних систем та рекомендовані в залежності від характеру діяльності організацій.
Запропонований підхід дозволяє обирати базові концепції нормативних документів, як можливі аналоги для використання їх виходячи з особливостей діяльності підприємства та специфіки наукоємного продукту.

Ключові слова: *складна технічна система; нормативно-технічна документація; життєвий цикл; системний підхід; процесний підхід; проєктний підхід.*