

# Digital Transformation of the Chinese Air Force: Initiatives Observed in the PLAAF's Introduction of a New Maintenance Management System\*

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## Abstract

The People's Liberation Army Air Force (PLAAF)<sup>1</sup> is significantly changing its aircraft maintenance and management procedures, raising the question of why it is doing so and what its significance is.

To answer these questions, this article examines authoritative Chinese sources concerning PLAAF logistics and support work that is otherwise hard to observe and reveals how similar the efforts observed in China are to the Digital Transformation (DX) of the U.S. Air Force (USAF).

In this paper, I posit the hypothesis that "the efforts observed in China are indicative of a PLAAF process of imitating the USAF's DX," and I develop my assessment from four perspectives.

The first perspective is the Chinese aviation experts' view of the USAF's DX, the second is the underlying factors facilitating the Chinese domestic industry's DX efforts, the third is the status of the Chinese aerospace industry's DX efforts, and the fourth is the impact of new systems and new inspection devices introduced to the PLAAF's maintenance management.

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## Introduction

Since Russia's invasion of Ukraine on February 24, 2022, it was assumed that the Russian Air Force, with its overwhelming numerical advantage in combat aircraft, would achieve air superiority. However, the predictions of most commentators were confounded, the infrequent and sporadic air operations of the Russian Air Force<sup>2</sup> have failed to have a decisive impact on the course of the war.<sup>3</sup> This shows how the "bean-counting" view of matters, in which superiority is determined by the number of fighters and bombers, has dominated many people's thinking.<sup>4</sup>

What is missing from the above discussion is the debate over military logistics, which must be added. To accurately assess the air power of a country which has become an object of concern in

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<sup>1</sup> In this paper, "maintenance management" is defined as the various management activities required to effectively and economically operate the resources used for undertaking the maintenance of aircraft.

<sup>2</sup> Phil Stewart et al., "What happened to Russia's Air Force? U.S. officials, experts stumped," *Reuters*, last updated March 2, 2022, <https://www.reuters.com/world/europe/what-happened-russias-air-force-us-officials-experts-stumped-2022-03-01/>.

<sup>3</sup> *It is also argued that the failure of Russia's air operations is due to issues in political or strategic judgments.*

<sup>4</sup> Justin Bronk et al., "The Russian Air War and Ukrainian Requirements for Air Defence," *The Royal United Services Institute for Defence and Security Studies*, last updated November 7, 2022, <https://rusi.org/explore-research/publications/special-resources/russian-air-war-and-ukrainian-requirements-air-defence>.

security terms, it is essential to reexamine the “basic physical fitness” aspect of its air force, such as “how many operational aircraft can be launched continuously per unit of time.”

In recent years, the rhetoric and actions of China, which has been increasing its military presence, have caused considerable alarm not only for surrounding countries but also for international society. The PLAAF has exhibited dramatic growth since its aim of becoming a “strategic air force” was officially recognized in 2015.<sup>5</sup> China has begun to deploy a variety of cutting-edge aircraft, including the J-20 stealth fighter aircraft and J-16 electronic warfare aircraft, and is gradually expanding its sphere of activities. There has been dramatic growth in the PLA aircraft’s intrusions into Taiwan’s Air Defense Identification Zone (ADIZ) since 2020, with over 2,637 Chinese aircraft making frequent sorties into Taiwan’s ADIZ as of the end of November 2022.<sup>6</sup>

Furthermore, with the introduction of Y-20 large transport aircraft into the PLAAF in 2016, the expansion of the PLAAF’s area of activity has become an alarming cause for concern for neighboring countries, as large numbers of transport aircraft have been flying over disputed areas in the South China Sea.<sup>7</sup> On the other hand, we need to return to the question of why the PLAAF has been able to become so vigorous in its aeronautical activities. We should be aware that the development of a logistics support infrastructure that is sufficient to keep launching PLA aircraft on a continuous basis is the reason why aircraft with complex systems can demonstrate their capabilities to the maximum extent possible.<sup>8</sup>

Generally, attention tends to focus only on the number of fighter and transport aircraft, but it goes without saying that logistical systems support these aircraft. Since air force organizations tend to rely more heavily on their base infrastructure than other service types to begin with, the PLAAF too has long faced the challenge of improving its logistics and support.

Indeed, Li Wénxiān, then Colonel of the PLAAF, argued in his book *Further Discussion on Modern Air Forces*, published on the 60th anniversary of the founding of the Air Force, that PLAAF is a huge system consisting of software and hardware systems. He argued that since an air force is a huge system consisting of soft and hard systems, improving logistics would have a “multiplier effect” that would increase air power many times over.<sup>9</sup> As he stated, the logistics and support that allows aircraft to be launched at will is a very important factor. It is also, in fact, an

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<sup>5</sup> Ma Xiaotian [马晓天], “On Building a Strong People’s Air Force that Integrates Aviation and Space Power, and Strike and Defense Capabilities [论建设空天一体、攻防兼备的强大人民空军],” *China Military Sciences* [中国军事科学], vol. 141, no. 3, 2015, pp. 1-5; “The Chinese Air Force Accelerating the Building of a “Strategic Military Branch [中国空军加快推进“战略性军种”建设],” *People’s Liberation Army Daily* [解放军报], September 1, 2015; “Strategic Transformation of the Chinese Air Force in 2016 in Numbers - Military Construction as a Focus while Enhancing Fighting Capability [一组数字诠释 2016 中国空军战略转型\_主建不能忘战],” *People’s Liberation Army Daily* [解放军报], December 23, 2016.

<sup>6</sup> Figures compiled by the author based on Republic of China (Taiwan) Ministry of National Defense website. <https://www.mnd.gov.tw/PublishTable.aspx?Types=%E5%8D%B3%E6%99%82%E8%BB%8D%E4%BA%8B%E5%8B%95%E6%85%8B&title=%E5%9C%8B%E9%98%B2%E6%B6%88%E6%81%AF>.

<sup>7</sup> Aita Moriki [相田守輝], “The True Meaning of the Chinese Air Force’s Flying Transport Aircraft Near Malaysia: Airborne Units in Power Projection [中国空军输送机的マレーシア接近事案に含まれる軍事行動の真意: パワープロジェクトのなかの空挺部隊],” *Hoyu* [鹏友], (July 2021) pp. 37-67.

<sup>8</sup> Li Yin [李因], “Crossing the Sky Harbor [天港的跨越],” *China Airforce* [中国空军], December 2020, pp. 49-50.

<sup>9</sup> Li Wenxian [董文先], *Further Discussion on Modern Air Forces* [再论现代空军], (Lan Tian Publishing, 2009) pp. 276-277. Li stresses that both combat and military logistics must be built comprehensively and collaboratively.

area that is “near-invisible”; thus, it is difficult to say to what extent the PLAAF has enhanced its logistics and support.

Amidst this context, reports deserving attention have appeared in the *People's Liberation Army Daily*, the official newspaper of the PLA. The newspaper reported on April 8, 2022, that a certain PLAAF aviation brigade had introduced a new style of system for managing the status of aircraft,<sup>10</sup> and on April 20 that a certain aviation division in the Northern Theater Command had introduced flight inspection equipment which would dramatically increase its maintenance efficiency for its aircraft.<sup>11</sup> What do these changes in maintenance management mean?

Although this will be discussed in more detail later, it is believed that these new systems will dramatically streamline maintenance work for aircraft and increase the operational readiness rate of aircraft. Furthermore, such systems seem to possess functions similar to the Autonomic Logistics Information System (ALIS),<sup>12</sup> which the USAF had attempted to introduce as an F-35 maintenance management system, and this could be interpreted as a sign that the PLAAF is engaging in initiatives similar to the USAF's DX.<sup>13</sup> Note, however, that due to defects in ALIS, the U.S. Department of Defense has developed the Operational Data Integrated Network (ODIN) and has started system migration; however, this paper will carry out its discussion by taking ALIS as the standard, for the sake of simplicity.

In recent years the term “DX” has been discussed in a variety of domains, as a term implying “modernization” of information technology (IT) systems in a comprehensive sense in organizations.<sup>14</sup> Two parallel discussions are heard regarding the DX of military organizations: (1) Discussion about the equipping of weapon systems with new technology and operation of these; (2) Discussion about how organization operation can be made more efficient; the outcome of full-scale DX is expected to bring about changes in organizations, processes and culture, leading to their achieving competitive advantage.<sup>15</sup> In the sense that DX transforms the very nature of organizational operation itself, it differs greatly from the previous “shift to IT,” in which work that was previously carried out through analogue means was shifted to digitized means.<sup>16</sup> Therefore, if the PLAAF can undertake DX and adopt new technologies, this is expected to transform the PLAAF's organizations, processes, and cultures, resulting in their gaining a competitive advantage.

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<sup>10</sup> “Real-time Data Sharing - Intelligent Status Monitoring [数据实时共享\_状态智能监控],” *People's Liberation Army Daily* [解放军报], April 8, 2022.

<sup>11</sup> “Independent Innovation Boosting Warplane Performance [自主创新助力战鹰远航],” *People's Liberation Army Daily* [解放军报], April 20, 2022.

<sup>12</sup> ALIS is an information system supporting Autonomic Logistic Global Sustainment (ALGS) established as a global logistical support system for the F-35, developed by the U.S. firm Lockheed Martin. “The Current F-35 Situation: Towards the Introduction of ODIN to Replace ALIS [F-35は今ALISに代わるODINを導入へ],” *Air View* [航空情報], (January 2021), pp. 104-107.

<sup>13</sup> In terms of the DX of the USAF, a variety of equipment is in the process of being developed, incorporating the defense industry and military-industrial complex.

<sup>14</sup> Stelios Kavadias et al., “The Transformative Business Model,” in *HBR's 10 Must Reads on Leading Digital Transformation* (Boston: Harvard Business Review Press, 2021), pp. 15-27.

<sup>15</sup> U.S. Department of Defense, “Digital Transformation, AI Important in Keeping Battlefield Edge, Leaders Say,” *DOD News*, last updated June 9, <https://www.defense.gov/News/News-Stories/Article/Article/3058028/digital-transformation-ai-important-in-keeping-battlefield-edge-leaders-say/>; BAE SYSTEMS, “What is Digital Transformation?” <https://www.baesystems.com/en-us/definition/what-is-digital-transformation>.

<sup>16</sup> Thomas H. Davenport et al., “Digital Transformation Comes Down to Talent in Four Key Area,” in *HBR's 10 Must Reads on Leading Digital Transformation* (Boston: Harvard Business Review Press, 2021), pp. 181-185.

To ascertain the current reality and future outlook concerning these matters as swiftly as possible, it is essential to be able to scrutinize the content from limited Chinese sources, read these in conjunction with global trends, and make inferences while filling in missing parts using Western discussions. It can be assumed that this change in the PLAAF will boost the operational readiness rate of its aircraft through more efficient maintenance, thereby rapidly strengthening its capability.

## 1. Previous research and theoretical frameworks

### (1) Previous research and critical examination

Not many previous studies on Chinese aircraft maintenance and DX have been conducted to date. First, the arguments of Kenneth W. Allen of the USAF, who has studied the PLAAF for many years, can serve as research clarifying the actual situation of the Aircraft Maintenance Division of the PLAAF. According to Allen, there were 21 large-scale maintenance plants undertaking large-scale repairs of aircraft and overhauls of aircraft fuselage/engines in the Aircraft Maintenance Division of the PLAAF around the year 2000, as well as repair units, which carry out medium- and small-scale repairs in various air bases; in addition, maintenance groups (机务大队) affiliated with respective flight groups (飞行大队) are responsible for Combat Turnaround support and status management of aircraft.<sup>17</sup> Allen also carried out further research to investigate the reforms being carried out in maintenance at the PLAAF around 2010 in *70 Years of the PLA Air Force* co-authored with Cristina L. Garafola released in 2021. This publication noted that systems enabling management of aircraft had been introduced into certain aviation divisions in the (then-existing) PLAAF Beijing Military Region and that information networks connecting all maintenance divisions were in the process of being established.<sup>18</sup>

The discussions of Timothy R. Heath of the RAND Corporation of the U.S. serve as prior research on the relationships with the PLAAF's operational flights. Heath focuses on the concept of the new operational capability systems introduced by the PLAAF in 2005 "as a sort of brain and nervous system" characterized by "operations-support integration."<sup>19</sup> He notes that these initiatives, which aim at informatization, are a factor behind the rapid modernization of the PLA.<sup>20</sup> He also notes that, based on the results of the survey undertaken of the Aircraft Maintenance Division, changes have begun in the general maintenance management of cutting-edge aircraft, as a result of the application of *Standard Procedures in the Informatization Relating to Flight Support in PLAAF Air Bases*, which was published in 2014.<sup>21</sup>

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<sup>17</sup> Kenneth W. Allen, "PLA Air Force Logistics and Maintenance: What Has Changed?" in *The People's Liberation Army in the Information Age*, ed. James C. Mulvenon and Richard R. Yang (RAND Corporation, 1999), pp. 80–82.

<sup>18</sup> Kenneth W. Allen and Cristina L. Garafola, *70 Years of the PLA Air Force* (China Aerospace Studies Institute, 2021), p. 266.

<sup>19</sup> Timothy R. Heath, "New Type Support Developments in PLAAF Air Station Logistics and Maintenance," in *Assessing the Training and Operational Proficiency of China's Aerospace Forces*, eds. Edmund J. Burke, Astrid Stuth Cevallos, and Mark Cozad (RAND Corporation, 2016), pp. 70–86.

<sup>20</sup> "Direct the Modernization Building of the Air Force According to the Goal of Military Strengthening [以强军目标统领空军现代化建设]," *People's Daily* [人民日报], November 18, 2013.

<sup>21</sup> These innovations comprise four elements: (1) Customization of aircraft body maintenance plans; (2) Maintenance of aircraft fuselage in accordance with flight hours; (3) Coordination of different specializations; (4) Re-examination of quality management. "Four Transformations: Erecting a Generation of New Ladders to Success [四个转变: 架起一代\_新天梯]," *Air Force News* [空军报], May 12, 2010.

Hou Jian and Wang Liyuan of the Beijing Aeronautical Manufacturing Technology Research Institute argue in a paper on aircraft maintenance and DX titled “DX of Aviation Equipment Maintenance Support Method” that maintenance management in the PLAAF has been informatized in stages from the 1990s onwards. Their argument points out certain issues in the current situation, including the coexistence of multiple information systems and the fact that the latest systematic information functions are not fully utilized.<sup>22</sup>

These previous discussions, which have pointed out that “aircraft maintenance procedures are changing” while focusing on the “near-invisible” military logistics services amidst the dramatic development in the PLAAF, present a variety of viewpoints regarding the direction in which the Air Force is heading. However, most of these discussions concern the PLAAF in the 2010s, and therefore feel somewhat dated in terms of discussing the PLAAF's current DX efforts. Furthermore, despite the considerable changes taking place in Chinese society as a whole due to digitalization, there has been insufficient discussion about the ways in which the changes were taking place in the organization, processes and culture of the PLAAF with the ongoing lack of transparency of the military-civil relationship; therefore, these previous researches are limited in their ability to discuss DX efforts surrounding the PLAAF.

## (2) Theoretical framework

This paper will develop its arguments while making references to the DX underway in the USAF. In the global trends concerning the nature of future air forces, as an outcome centered on the USAF, streamlining is being pursued across the entire life cycle, from research and development to maintenance and management, with a focus on “centralized data management.”<sup>23</sup> In research and development (R&D) in particular, cases in which development of training aircraft has been completed in strikingly short periods of time due to improvements in simulations and manufacturing management, which makes use of data, have been widely reported.<sup>24</sup> Meanwhile, as the general meaning of streamlining the USAF using data has been expanded to include maintenance and management such as maintenance and repair works, it is essential to turn our attention to the innovative streamlining which is being pursued in domains like these, which are less obviously eye-catching.<sup>25</sup>

When sustaining and maintaining aircraft made up of tens of thousands of parts in terms of military capabilities, slight differences in maintenance management can sometimes make a huge difference in military strength. Thus, it is essential to gauge DX trends in military logistics domains.

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<sup>22</sup> Hou Jian [侯建]and Wang Liyuan[王礼沅], “Digital Transformation of Aviation Equipment Maintenance Mode [航空装备维修保障模式数字化转型],” *Measurement and control technologies* [测控技术] (December 2020), pp. 16-21.

<sup>23</sup> “Air Force unveils ‘Digital Air Force’ initiative,” *Air Force Times*, last updated July 11, 2019, <https://www.airforcetimes.com/news/your-air-force/2019/07/10/air-force-unveils-digital-air-force-initiative/>.

<sup>24</sup> Daryl Mayer, “eT-7a earns digital designation,” *Air Force Life Cycle Management Center*, last updated February 26, 2021, <https://www.afllmc.af.mil/News/Article-Display/Article/2517676/et-7a-earns-digitaldesignation/>.

<sup>25</sup> John P. Biszko, “Understanding and Challenging ‘The Digital Air Force’ USAF White Paper,” *Wild Blue Yonder*, Air University, July 6, 2020, <https://www.airuniversity.af.edu/Wild-Blue-Yonder/Article-Display/Article/2255809/understanding-and-challenging-the-digital-air-force-usaf-white-paper/>.

For this reason, this paper aims to analyze the fragments of events in the near-invisible military logistics domains from Chinese official documents available and clarify how initiatives similar to the DX in the USAF are promoted in China. In doing this, this paper will adopt the view (hypothesis) that “Initiatives seen in China are processes which mimic the DX underway in the USAF” and shed light on the initiatives being undertaken in China.

Discussion will therefore be developed based on a theoretical framework comprising four perspectives.

The first perspective is the question of what kind of views are held towards DX by the relevant players in the Chinese aviation industry. Looking at DX in the USAF, how did China view DX and how did they plan to apply it? The second perspective concerns the background influencing Chinese domestic industry as it engages with DX. In considering this perspective, we will explore what role is played by the national strategy of military-civil fusion amid this process. The third perspective concerns the circumstances in which the Chinese aviation industry is working on DX. How much progress has DX made in the aviation industry, which supports the PLAAF? Finally, the fourth perspective concerns what kind of impact the new systems and flight inspection equipment introduced in the PLAAF have had on maintenance management.

Regarding to the changes in the maintenance procedures, which are beginning to be mentioned frequently in the *People's Liberation Army Daily*, how similar are these to the DX initiatives in the USAF? With such changes, how will the capabilities of the PLAAF change?

In terms of research methods, this paper's discussion will center on Chinese official documents, papers written by persons connected with DX in China and the PLA. At the same time, Western discussions will be incorporated into this investigation as well, given the limitations invariably found in Chinese documents.

## 2. Views towards DX of relevant players in the Chinese aviation industry

The first perspective is the question of what kind of views have been held towards DX by relevant players in the Chinese aviation industry.

### (1) A high level of interest in the maintenance support systems for the USAF's F-35 fighter aircraft

In 2017, there was growing interest in China in the research being undertaken in the United States into the air-station-level maintenance of the F-35 fighter aircraft, published in March of the same year by the RAND Corporation.<sup>26</sup> In particular, Chinese interest focused on data analysis methods for older generations of aircraft (传统机型数据分析方法), on data fusions with the data of new aircraft models, and on predictive maintenance (concerning the question of how to plan for maintenance work). Among these, a model that rationally differentiates the workload of maintenance departments in the USAF and the US defense industry respectively (模型重点是合理区分美国空军建制内维修与商业维修机构的工作量) has been evaluated as likely to become a new standard for maintenance management based on scientific evidence in the future, following which

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<sup>26</sup> *RAND Annual Report* (Santa Monica, CA: RAND Corporation, 2018), [https://www.rand.org/pubs/corporate\\_pubs/CP1-2017.html](https://www.rand.org/pubs/corporate_pubs/CP1-2017.html).

this idea has gradually started to permeate through the Chinese aviation industry.<sup>27</sup>

In their paper published in 2020, Hou and Wang, at the abovementioned Beijing Aeronautical Manufacturing Technology Research Institute, stressed that in order to thoroughly pursue the revolutionary value (革命性价值) of information interconnection while taking into account the DX trends in the United States, China will have to demolish the conventional way of thinking about informatization and promote DX (数字化转型) in Chinese aircraft maintenance.<sup>28</sup>

Statements that China should follow in the footsteps of the DX undertaken in the USAF have been observed frequently in the newspaper of the Chinese aviation industry. An article in the China Aviation News (中国航空新闻网) on November 17, 2020, presented the new T-7A training aircraft, the Ground Based Strategic Deterrent (GBSD) system (陆基战略威慑), the Next Generation Air Dominance (NGAD) system<sup>29</sup> (下一代空中主宰) and other areas as outcomes of DX in the USAF. At the same time, it also reported that a “digital triad (数字三位一体)” comprising (1) digital processes and digital management (2) agile development and (3) open system architecture could bring about a paradigm shift (颠覆传统) if fused deeply with next-generation ICT and military science and technology, as well as predicting that this could even result in a radical shift in the trends in military equipment acquisition seen in the two countries up until now.<sup>30</sup>

In addition, Xin Xin and Xie Chuan of the PLAAF Engineering University have presented a paper based on reports submitted by the U.S. Government Accountability Office (GAO) analyzing deficiencies in the F-35 ALIS and reasons for these. This paper notes, among other points, that ALIS's integration of the required data was incomplete as automation was limited, and stressed the need to improve organizational mechanisms for maintenance management including military logistics, recommending that China draw useful lessons from this experience for its own maintenance.<sup>31</sup>

## (2) Focus on the “digital thread” and “digital twin” concepts as critical elements for DX

There are numerous points of interest in the paper by Zhang Yuxin of Tsinghua University on research into the details of DX in the USAF, run in the international academic journal *Digital Transformation and Society*. In this paper, Zhang notes that the DX of the USAF is supported by subdivided two concepts, the “digital thread” and the “digital twin,” which exist in a virtual digital space.<sup>32</sup> Zhang, who has focused on discussions and trends in the USAF, sees these two digital

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<sup>27</sup> “RAND Corporation Providing a Data Model for F-35 Base-level Maintenance Decision-making, Aviation Maintenance & Engineering [兰德公司为F-35基地级维修决策提供数据模型],” *Aviation Maintenance and Processes* [航空维修与工程] (April 2017), pp. 26-29.

<sup>28</sup> Hou and Wang, pp. 19-20.

<sup>29</sup> Next Generation Air Dominance (NGAD) is rooted in the concept of “Air Dominance” which goes beyond “Air Superiority,” and refers to the sixth-generation fighter aircraft which the United States is developing as its next-generation fighter aircraft.

<sup>30</sup> “The U.S. Air Force's Deep Shift towards a New Paradigm of Digitalization: Beating Low Speed with High Speed and Digital Procurement [美空军深度转向数字化新范式: 以快制慢数字采办],” *China Aviation News* [中国航空报], November 17, 2020, <http://www.cannews.com.cn/2020/11/17/99315335.html>.

<sup>31</sup> Xin Xin [辛昕] and Xie Chuan [谢川], “Analysis of Defects of the F-35 Autonomous Aircraft Support System and Causes [F-35飞机自主式保障系统缺陷及原因分析],” *Aerodynamic Missile Journal* [飞航导弹] (August 2020), pp. 86-90.

<sup>32</sup> Zhang Yuxin, “The development of digital thread: the relations to digital twin and its industrial applications,” *Digital Transformation and Society*, vol. 1, no. 2, 2022, pp. 147-160, <https://www.emerald.com/insight/content/doi/10.1108/DTS-06-2022-0023/full/pdf>.

concepts as factors determining the success or failure of DX, and stresses that they should be applied to the development not only of aircraft but also of high-speed rail in China.

The importance of the concepts of the “digital thread” and “digital twin” in the virtual digital space for digital transformation is also supported in discussions in Europe and the United States. According to Robin Schmücker and Hendrik Meyer of the German Aerospace Center (DLR), the aviation industry is currently approaching a time of revolutionary change, and emerging technologies such as the internet of things (IoT), cloud computing, AI and 3D printers are making DX possible in industries throughout the world. Meanwhile, many processes in aircraft maintenance continue to be performed manually and practices of paper-based record-keeping still remain, so even when individual processes are digitalized using new technologies, this does not necessarily result in processes as a whole becoming more efficient. They suggest that only the full and complete implementation of digital technology can, for the first time, bring about interactions between objects in the real world and objects in the virtual world (the “digital twin” concept) through the construction of networks. Schmücker therefore stresses the need for total digital transformation of all processes.<sup>33</sup>

Looking at the April 2021 issue of *Defense News*, it is reported that Raytheon Missiles & Defense is developing the new cruise missiles intended to replace the USAF’s legacy cruise missiles using DX. The engineers involved in the development test new weapon components day and night in a virtual digital space and use feedback from simulations to continually evolve their designs. The important information obtained from the repetition of this testing cycle has been identified as an “authoritative source of truth” for design and would be managed going forward as a crucial element of the “digital thread” in the virtual space. It is suggested that it will be possible to easily amend weapon systems designed through digital means by using the “digital twin” in virtual space, with design amendments then leading to actual mass production later.<sup>34</sup>

As a result of all this, the remarks made by Tsinghua University’s Zhang on the importance of the two concepts of the “digital thread” and “digital twin” remind us of the considerable interest in DX in China.

Summarizing, having focused on the USAF’s F-35 maintenance support system, relevant players in the Chinese aviation industry gradually came to assess the US-led approach to DX as being extremely important for the development of aircraft and the management of aircraft maintenance, accepted this way of thinking, and gradually spread discourses which urge the importance of following in the footsteps of the United States. As will be discussed later in this paper, it may be believed that these movements are convenient for the PLA, which is also keeping intelligentized warfare in mind at the same time.

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<sup>33</sup> Robin Schmücker et al., “Digitalization and Data Management in Aircraft Maintenance based on the Example of the Composite Repair Process,” (*Deutsche Gesellschaft für Luft- und Raumfahrt*, 2021), [https://elib.dlr.de/143748/1/DLRK2021\\_550066\\_Schmuecker\\_Robin\\_Hendrik\\_Meyer\\_DLR\\_final.pdf](https://elib.dlr.de/143748/1/DLRK2021_550066_Schmuecker_Robin_Hendrik_Meyer_DLR_final.pdf).

<sup>34</sup> “Weaving a digital thread for the US Air Force,” *Defense News*, last updated September 2, 2021, <https://www.defensenews.com/native/raytheon-missiles-defense/2021/09/02/weaving-a-digital-thread-for-the-us-air-force/>.



### 3. The military-civil fusion which has influenced Chinese domestic industry which is working on DX

The second perspective concerns the background influencing Chinese domestic industry, which is working on DX.

#### (1) The digital social infrastructure created out of the military-civil fusion

The China of today could be described as a one-party authoritarian Communist state which makes extensive use of digital IT technology. In particular, China could also be described as the world's largest and most striking example of a digital surveillance state, with surveillance cameras having been progressively installed over the whole of China's territory since Chinese Communist Party (CCP) General Secretary Xi Jinping came to office, resulting in a situation where individuals can be identified at any time.<sup>35</sup> It was reported in *The New York Times* (May 22, 2019) that the Chinese state-owned company Hikvision is providing surveillance systems equipped with facial recognition functions to Chinese security agencies.<sup>36</sup>

The background to the formation of social infrastructure that makes such extensive use of digital technology is deeply related to the policy set out by Xi Jinping, termed "military-civil fusion." The military-civil fusion advocated by Xi began as a political slogan aimed at promoting an extensive connection between the "military" and "civilian" domains.<sup>37</sup> At the third session of the 12th National People's Congress (NPC) (during the plenary meeting of the PLA delegation) in March 2015, Xi announced that the military-civil fusion would be elevated to the status of a national strategy.<sup>38</sup> Following this, an announcement was made at the Central Military Committee (CMC) in November of the same year that the military-civil fusion policy would be strongly promoted<sup>39</sup> to ensure victory in the war of information<sup>40</sup>; based on this policy, the Central Military-Civil Fusion Development Committee (CMCFDC) was established in January 2017.<sup>41</sup> Then, at the 19th National Congress of the CCP in October of the same year, the promotion of military-civil fusion was mentioned as a key policy while also being connected with the "China

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<sup>35</sup> Aita Moriki [相田守輝], "Xi Jinping's Military-Civilian Fusion: An Investigation from the Perspective of the Garrison State Theory [習近平の軍民融合: 兵營国家論からの理論的検証]," *Journal of International Public Policy* [国際公共政策論集], vol.43 (February 2021), p. 11.

<sup>36</sup> This surveillance system is able to identify 6 million individuals in 24 hours. *The New York Times* (May 22, 2019), <https://www.nytimes.com/2019/05/22/world/asia/china-surveillance-xinjiang.html>.

<sup>37</sup> Aita [相田], "Xi Jinping's Military-Civilian Fusion [習近平の軍民融合]," p. 2.

<sup>38</sup> "The elevation of the military-civil fusion to the status of a national strategy was authorized by the Politburo of the CCP in 2016," *China National Defense News*, June 2, 2016.

<sup>39</sup> In this paper, the "war of information" refers to all-out combat (undertaken primarily between states) in which IT technology serves as an intermediary. As such warfare places an emphasis on the destruction of the enemy nation's decision-making systems and infrastructure through attacks via outer space, cyber space and electromagnetic domains, thus eliminating the enemy nation's willingness to continue fighting, victory/defeat can ensue before direct combat between military forces even begins.

<sup>40</sup> Xi Jinping[习近平], *The Governance of China* [习近平谈治国理政] vol. 2 (Foreign Languages Press, 2018), pp. 406-411.

<sup>41</sup> Looking at the background to the CMCFDC established in January 2017, it appears that the PLA designed this primarily as a military-civil fusion. Brian Lafferty, "Civil-Military Integration and PLA Reform," in *Chairman Xi Remakes the PLA*, ed. Joel Wuthnow and Phillip C. Saunders (National Defense University Press, 2019), p. 649.

Dream” promulgated by Xi.<sup>42</sup>

(2) The research framework within the military-civil fusion promoted in order to turn technical inferiority into superiority

China, which is aware that its science and technology lag behind those of the United States, is establishing a research system to contribute to the military-civil fusion while mobilizing a variety of social resources in order to independently transform its position of inferiority into one of superiority.<sup>43</sup> As part of this strategy, the Military-Civil Fusion Intelligent Equipment Research Institute was established in November 2016 to allow research outcomes at universities to contribute to the PLA. For example, joint research is now underway between North China University of Technology and the Zhongbo Longhui Information Technology Co., Ltd. (中博龙辉信息技术有限公司).<sup>44</sup>

In addition, a number of think tanks have held “innovation development conferences” on a joint basis in various locations, and are beginning to carry out joint research with private-sector companies on challenges and solutions for dealing with the digital integration of weapons and systems.<sup>45</sup> Meanwhile, the PLA has invited around 300 relevant persons not only from the CMC but also from the PLA Academy of Military Sciences (PLA AMS), state-owned companies, private-sector companies, universities and think tanks, and has begun holding “fora” to look at how to acquire emerging technologies such as 3D printers.<sup>46 47</sup>

These initiatives are supported by the Military-Civil Fusion Research Center within the PLA Academy of Military Science (which formulates future plans for military-civil fusion); PLA Academy of Military Science Vice-President He Lei has presented his views that because the success or failure of the scientific innovation supporting the development of the military-civil fusion is directly linked to future strategy formulation and war, it is essential to pursue new combat powers by fusing together military and civilians through networking and unmanned technology, while making use of digital technologies.<sup>48</sup>

By 2021, China’s military-civil fusion policies were bringing new business opportunities to companies planning to work on DX. Private-sector companies starting to engage in DX often found it hard to get beyond the level of partial digital design in the initial stages and tended to start

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<sup>42</sup> (On the occasion of receipt of the political mandate at the 19th National Congress of the CCP) “CCP General Secretary Xi Jinping proclaims a new journey aimed at securing a decisive victory in fully establishing a moderately prosperous society and embarking on a new path towards the comprehensive building of a modern socialist nation,” *Xinhua* [新华网], October 18, 2017, [http://jp.xinhuanet.com/2017-10/18/c\\_136688582.htm](http://jp.xinhuanet.com/2017-10/18/c_136688582.htm).

<sup>43</sup> Aita [相田], “Xi Jinping’s Military-Civilian Fusion [習近平の軍民融合],” pp. 18-19.

<sup>44</sup> “Military-Civilian Integration Intelligent Equipment Research Institute established [军民融合智能装备研究院成立], *Military-Civilian Integration Strategy and Practice* [军民融合战略与实践] (CCP Central Committee Central Party School Publishing, 2018), pp. 304-305.

<sup>45</sup> “Technological Innovation Promoting Deep Development of Military-Civilian Integration [科技创新助推军民融合深度发展],” *People’s Liberation Army Daily* [解放军报], May 3, 2018.

<sup>46</sup> This is also referred to as “additive manufacturing.”

<sup>47</sup> “Medium for “Military-to-Civilian Conversion” and “Civilian Participation in the Military Field [“军转民” “民参军”的摆渡者],” *People’s Liberation Army Daily* [解放军报], February 19, 2019.

<sup>48</sup> “Technological Innovation Promoting Deep Development of Military-Civilian Integration [科技创新助推军民融合深度发展],” *People’s Liberation Army Daily* [解放军报], May 3, 2018.

projects without having established integrated design concepts, resulting in many cases becoming derailed part-way through. However, it is believed that the provision of a commonly shared design to all companies participating in this military-civil fusion framework has enabled the optimization of individual businesses within the whole, resulting in substantial streamlining of the automation of tasks and internal management.<sup>49</sup>

Based on the discussion so far, China's military-civil fusion policy appears to serve as an effective support platform for companies engaging in DX. This suggests that the momentum in China that is continuing to bring about structures which will enable constant collaboration between military and civilian players, aiming to dramatically boost China's military strength, has helped to establish a social infrastructure that will enable Chinese domestic industry to push forward DX on an ongoing basis.

#### 4. The state of progress of DX in the Chinese aviation industry

This section examines the third perspective concerning the status of the initiatives towards DX underway in the Chinese aviation industry.

##### (1) DX endeavors underway at commercial airlines

DX initiatives have begun in advance in the maintenance divisions of commercial airlines in China. China Southern Airlines, a civil aviation company based in Guangzhou, has started an initiative which aims to transform the company's focus from "IT support and maintenance work (IT 支撑和服务于维修)" to "DX and predictive maintenance (数字化驱动和引领维修)", based on the need to keep business needs in mind when maintaining passenger aircraft.<sup>50</sup>

In addition, at China Eastern Airlines based in Shanghai, efforts are being made to find ways to apply emerging technologies such as virtual reality (VR), augmented reality (AR) and artificial intelligence (AI) to aircraft maintenance. In specific terms, attempts are being made to save labor by using AR goggles to align maintenance-related information (manuals, work instructions, presentation of dangerous areas, guidance on sequences of work procedures etc.) with actual on-site maintenance conditions in real time.<sup>51</sup>

##### (2) How the national defense industry aims to drive forward DX across all industries

With the military-civil fusion being promoted in China, the defense industry is taking a leading role in DX initiatives. At Chengdu Aircraft Industrial Group (CAIG), which is handling the J-20 cutting-edge stealth fighter aircraft, R&D into fully-digitalized aircraft is already underway.<sup>52</sup> Aircraft design has already been made completely paperless (飞机设计完全无纸化), and efforts are

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<sup>49</sup> "A Military-Civilian Integration Enterprise Stepping up the Building of an Intelligent Industrial Data Platform to Improve Integrated Production and Operation Capabilities [某军民融合公司发力工业数据智能平台建设, 提高一体化生产经营能力]," *Electronic Engineering Times* [电子工程专刊], May 24, 2022, <https://www.eet-china.com/mp/a134002.html>.

<sup>50</sup> Wang Jinzhong [王锦中], "Thinking on Digital Transformation in Aircraft Maintenance Management of Major Airline Companies [大型航空公司飞机维修管理数字化转型思考]," *Aviation Maintenance and Engineering* [航空维修与工程], vol. 356 (No. 1, 2021), pp. 14-17.

<sup>51</sup> Yue Xia [岳霞], "Thinking on Smart Aircraft Maintenance [飞机智慧维修的思考]," *Aviation Maintenance and Engineering* [航空维修与工程], vol. 363 (No. 9, 2021), pp. 16-19.

<sup>52</sup> Chengdu Aircraft Industrial (Group) Co. Ltd., <https://cac.avic.com/>

underway to enable R&D modelling for fighter aircraft, and to dramatically shorten the production cycle for prototype aircraft while enabling processes to be fundamentally reviewed during the production process.<sup>53</sup>

The initiatives implemented by CAIG involve simulation-based design, which makes extensive use of the (previously mentioned) “digital thread” and “digital twin” concepts<sup>54</sup> and resembles the case of the USAF’s T-7A training aircraft, which was developed in an extremely short space of time.<sup>55</sup> Similarly, the engine divisions of the Chinese aviation industry are also working on DX and efforts are starting to be made in R&D and the efficient production of relevant components, by establishing big data management systems and are starting to make efforts to realize efficient production of R&D and related parts.<sup>56</sup>

As part of this, the aircraft industry centering on the defense industry has begun attempts to establish a “digital intelligence capabilities system (数智能力体系)” since 2021. This endeavor by the aircraft industry has prompted the industry to re-examine itself as a model for driving forward DX in Chinese manufacturing as a whole and created a wave of momentum aimed at boosting the whole of China’s domestic industry by energetically pushing forward DX across the entire period of China’s 14th Five-Year Plan. It may be assumed that the complexity of aircraft systems lies in the background behind the fact that the aircraft industry now represents the cutting-edge in digitalization. Indeed, with the numbers of components required for increasingly complex cutting-edge aircraft now running into the millions, it has been argued that introducing digitalized design/manufacturing tools across a wide scale is essential in order to design and manufacture systems of such complexity.<sup>57</sup> Even though grappling with this task is putting the aircraft industry to the test, the industry itself appears to take pride in its position as the player responsible for leading DX in other Chinese domestic industries.

In September 2021, the aviation industry centering on the Aviation Industry Corporation of China (AVIC) hosted a “DX innovation”<sup>58</sup> forum aimed at establishing “digital aviation (数字航空)” based on the “strong aviation state (航空强国)” strategy. This forum invited digital transformation experts not only from aircraft manufacturers such as CAIG but also from IT companies including

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<sup>53</sup> “Aircraft Industrial Boosting the Takeoff of the Chinese Air Force in a Bid to Fulfill its Mission [航空工业成飞与使命同行, 助推中国空军奋力腾飞],” *People’s Liberation Army Daily* [解放军报], April 15, 2022.

<sup>54</sup> The “digital thread” concept expresses the idea of times series storage of information and data across the lifecycle of a single product, or from a number of physical objects. This concept can produce a single, accurate information source which enables perfect traceability of data of all kinds throughout the whole lifecycle. Hendrik Meyer et al., “Development of a digital twin for aviation research,” DGLR, Hamburg, 2020.

<sup>55</sup> Mayer, “eT-7a earns digital designation.”

<sup>56</sup> “Reshaping Business Value and Enhancing Core Competencies, Aero Engine Corporation of China [中国航发: 重塑业务价值\_提升核心竞争力],” *State-owned Assets Supervision and Administration Commission of the State Council* [国务院国有资产监督管理委员会], May 2021, <http://www.sasac.gov.cn/n4470048/n13461446/n15927611/n15927638/n16135038/c16416302/content.html>.

<sup>57</sup> Li Zhiqiang, “Member of the National Committee of the Chinese People’s Political Consultative Conference: Accelerating the Application of Wireless Short-range Communication Technology in the Military Industry and Promoting the Construction of Digital Intelligence Capabilities in the Aviation Industry [全国政协委员李志强: 加快军工行业无线短距离通信技术应用推进航空工业数智化能力建设],” *The Aviation Industry Corporation of China, Ltd. (AVIC)* [中国航空工业集团有限公司], March 5, 2021, <https://www.avic.com/c/2021-03-05/509141.shtml>.

<sup>58</sup> “2021 Digital Transformation and Innovation Forum Organized by AVIC INTL [中航国际举办2021年数字化转型与创新论坛],” *China Aviation News* [中国航空新闻网], September 13, 2021, <https://www.cannews.com.cn/2021/0913/332260.shtml>.

Huawei and Midea Group from whom participants learned about the understanding, practice, and outlook concerning DX, while they also exchanged opinions on future vision for topics such as the establishment of “digital intelligent cloud networks (数智云网)” and “human intelligence + industry big data + aviation manufacturing (人工智能+工业大数据+航空制造)”. The result of this forum was the sharing of a common consciousness of the need for the Chinese aviation industry, a domain in which continual change is essential, to push forward DX in all situations, in a world that is progressing from IT to informatization and further to digitalization.<sup>59</sup>

With DX-related projects being enthusiastically undertaken not just in commercial airlines in China but also in the defense industry, strategies for pushing DX forward are beginning to take concrete and visible form. Given this situation, it is hard to imagine that the PLA is not engaging in DX. This suggests that the view (hypothesis) that “initiatives seen in China are processes which mimic the DX processes underway in the USAF” has already been confirmed as valid to a certain extent.

## 5. Signs of DX apparent in aircraft maintenance in the PLAAF

In this section, we will adopt the fourth perspective to examine what kind of impact the new systems and flight inspection equipment introduced in the PLAAF have had on maintenance management.

### (1) Maintenance situation for increasingly complex aircraft

The PLAAF boasts one of the largest-scale air forces in the world. The stations of the PLAAF are located across the whole of China, with a dedicated maintenance squadron established along with a flying squadron at each air base as a basic rule. Looking at the maintenance divisions for aircraft maintenance alone, the PLAAF has 21 large-scale maintenance plants responsible for large-scale repairs of aircraft and overhauls of aircraft fuselage and engines, as well as a maintenance squadron at each air station responsible for turnaround (relaunching) of aircraft on flight lines,<sup>60</sup> in addition to numerous maintenance support departments providing military logistics services of various kinds such as repairs, inspections and replenishment.<sup>61</sup> Maintenance work is carried out both day and night at these air station platforms that support aircraft maintenance, in order to deliver aircraft for the next mission without delay after their last flight.<sup>62</sup>

Generally, modern aircraft maintenance continually requires higher levels of efficiency. For example, due to the extreme and growing complexity of systems in fourth-generation aircraft such as the F-15 and cutting-edge fifth-generation aircraft,<sup>63</sup> extraordinary numbers of factor analysis

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<sup>59</sup> Allen, “PLA Air Force Logistics and Maintenance: What Has Changed,” pp. 80-81.

<sup>60</sup> Allen, pp. 81-82.

<sup>61</sup> James C. Mulvenon, *The People's Liberation Army as Organization*, ed. Andrew N. D. Yang (RAND Corporation, 2002, Santa Monica), pp. 272-299.

<sup>62</sup> An Aerial Arm Regiment of the Air Force: Performing Every Small Task Properly to Boost Warplane Performance [空军航空兵某团:把每一件小事做美、助力战鹰高飞远航], *People's Liberation Army Daily* [解放军报], March 28, 2022.

<sup>63</sup> The definition of “generations” in Chinese aircraft differs from that used in the United States, meaning that an aircraft defined as “fifth generation” in the United States is defined as “fourth generation.”

processes are generated when carrying out trouble-shooting as part of maintenance work.<sup>64</sup> In weapon systems, which incorporate a large number of complex systems, numerous renovations are carried out, including function improvement measures, countermeasures against component deterioration and safety measures, from the development stage through operation to the point when the system is taken out of use. As a result, it is not uncommon for the maintenance procedures to differ slightly for each aircraft, depending on the progress of such renovations.

Previously, the departments responsible for maintenance control (M/C) in the management of third-generation aircraft like the F-4 have undertaken an analog style of management using whiteboards and magnets. However, in the case of the fifth-generation aircraft mentioned earlier, the excessive complexity of weapon systems means that the analog style of management has approached its limits. As a result, maintenance for cutting-edge aircraft is now at a point where maintenance tasks must be streamlined as much as possible.

## (2) Maintenance management where change is evident: The introduction of the Fighter Aircraft Status Management System

An article titled “Real time data sharing: Status monitoring using intelligent systems” was reported in the *People’s Liberation Army Daily* of April 8, 2022. The article reported that as a result of the Fighter Aircraft Status Management System (战机状态管理系统) introduced for the first time into certain aviation brigades of the PLAAF, workload per maintenance personnel member had been reduced by 30% and maintenance processes streamlined, resulting in a substantial increase in readiness capabilities for all stations.<sup>65</sup> The processes in the systems used previously were cumbersome due to the need to check manuals and maintenance logs while carrying out maintenance, and problems were caused when users accidentally overlooked items; utilization of the new system, however, connected commanding officers, staff members and a whole range of maintenance personnel together, which allowed them to share information on the status of aircraft in real time and sift out the ideal aircraft for a particular purpose, enabling faster delivery to the pilot side. This new system, which, for example, allows a user in charge of a particular aircraft to see at a single glance not just the amount of oil but also detailed inspections and oil sample analysis results simply by clicking on the aircraft in question, has enabled users to accurately gauge the status of all aircraft and manage their quality.<sup>66</sup>

How should this kind of Fighter Aircraft Status Management System be viewed? Firstly, because this system reduces the amount of work for maintenance personnel<sup>67</sup> and makes it possible to gauge the status of each individual aircraft, this new system can be seen as a maintenance management tool that enables effective and economically efficient operation. An unusual aspect

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<sup>64</sup> In the case of fifth-generation aircraft, the evolution of self-diagnosis functions and computer diagnosis functions has reduced the amount of human labor required from maintenance personnel for factor analysis. However, maintenance processes are still becoming increasingly complex.

<sup>65</sup> “Real-time Data Sharing and Intelligent Status Monitoring [数据实时共享\_状态智能监控],” *People’s Liberation Army Daily* [解放军报], April 8, 2022.

<sup>66</sup> *Ibid.* As an example, it was reported that a maintenance department which received a report of a mechanical failure from a fighter aircraft in which a pre-takeoff inspection had discovered such a failure was able to immediately sift out from the system a spare aircraft able to fly in the place of the plane with the problem, and to promptly carry out the necessary preparations including refueling, enabling the spare aircraft to be launched in time for the pre-arranged takeoff time.

<sup>67</sup> *Ibid.*

long seen in Chinese military aircraft is the fact that improvements in military aircraft tend to be carried out during each of the manufacturing processes, which has resulted in the formation of aircraft varying depending on the model.<sup>68</sup> Given this fact, there is little doubt that this new system will dramatically improve the operational readiness rate of aircraft if it enables users to identify the aircraft most suited to a particular mission from among a number of aircraft in a variety of situations at an air station, and send it out to the flight operation side. Furthermore, if the new system possesses such capabilities, this suggests the possibility that, as in the USAF, use is being made of the “digital twin” concept, which fuses data, probabilistic analysis tools and the like together, and provides the practical information required to coordinate maintenance contents for each model.<sup>69</sup>

One point deserving attention is the sharing of aircraft maintenance management information in real-time among commanding officers, staff officers and various maintenance personnel.<sup>70</sup> If the PLAAF is already capable of this, then it means that the PLAAF can monitor the status of each aircraft on the system, regardless of the model, and even manage the workload of each maintenance worker. If this is the case, it suggests that the PLAAF may possess functions exceeding those of ALIS, the maintenance management system for F-35s in the USAF (previously described). In addition, if the system also “enables immediate dispatch of maintenance personnel,”<sup>71</sup> there is a possibility that this new system alone already has the function of “M/C” as well.

From these arguments, we can infer at the PLAAF an approach of attempting to streamline maintenance through the introduction of new systems, while making substantial changes in maintenance management. In particular, if the new systems are able to connect with previously introduced systems and data, enabling already-present data to be utilized as well, this is also likely to result in successful DX.

### (3) Streamlining of maintenance work where changes are evident: Introduction of the Audio Call System Based Outdoor Flight Inspection Equipment

An article titled “Autonomous innovation supporting combat aircraft” was run by the *People's Liberation Army Daily* on April 20, 2022.<sup>72</sup> It is reported that the new Audio Call System Based Outdoor Flight Inspection Equipment (语音通信系统外场检查仪) introduced by certain air divisions (航空兵某师) in the Northern Theater Command was substantially boosting maintenance capabilities for aircraft.<sup>73</sup> With the old flight inspection equipment, users had to inspect all systems

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<sup>68</sup> Solen Derek, “Third Combat Brigade of PLA Air Force Likely Receives Stealth Fighters,” *China Airspace Studies Institute*, last updated January 31, 2022, <https://www.airuniversity.af.edu/Portals/10/CASI/documents/Research/CASI%20Articles/2022-01-31%20Third%20Combat%20Brigade%20of%20PLA%20Air%20Force%20Likely%20Receives%20Stealth%20Fighters.pdf>.

<sup>69</sup> The ultimate objective is to modernize the lifecycle management of aircraft. Pam Kobryn and Brench Boden, “Digital Thread Implementation in the Air Force: AFRL's Role,” *NIST MBE Summit*, AFRL\_USAF, last updated April 19, 2017, [https://www.nist.gov/system/files/documents/2017/04/19/boden\\_kobryn\\_usaf\\_nist\\_mbe\\_2016\\_dist\\_a.pdf](https://www.nist.gov/system/files/documents/2017/04/19/boden_kobryn_usaf_nist_mbe_2016_dist_a.pdf).

<sup>70</sup> “Real-time Data Sharing and Intelligent Status Monitoring [数据实时共享\_状态智能监控],” *People's Liberation Army Daily* [解放军报], April 8, 2022.

<sup>71</sup> Ibid.

<sup>72</sup> “Independent Innovation Boosting Warplane Performance [自主革新助力战鹰远航],” *People's Liberation Army Daily* [解放军报], April 20, 2022.

<sup>73</sup> Ibid.

with equipment connected to the main power supply from outside. With this method, carrying out the various types of inspection required considerable time and labor, a further problem being that individual parameters could not be measured accurately. However, the introduction of this new inspection equipment has enabled rapid trouble-shooting and substantially reduces inspection time, as it enables information processing at a single click (“一键式”信息处理), while also allowing detailed categorization of data and data conversion. Because the new system allows parameters to be inspected on the spot, it has succeeded in improving quality to the point of eliminating undetectable mechanical failures.<sup>74</sup>

How should we view this Audio Call System Based Outdoor Flight Inspection Equipment? There is little doubt that this is apparatus which makes it easy to inspect the components making up aircraft and detect the locations of mechanical failures.

The generally accepted pattern is that when maintenance personnel discover a mechanical failure in an aircraft, they will remove the constituent component suspected of causing the failure at the flight line, bring it into the maintenance dock, and carry out repairs. If it is not a repairable failure, the repair work will be consigned to a supply depot or manufacturer. In other words, repair work up until now has been carried out as a three-level process, namely (1) The flight line → (2) The maintenance dock → (3) The supply depot (or manufacturer). However, as the increasing complexity of systems has made them harder for maintenance units to handle in all cases, maintenance guidance has been streamlined from the traditional three-level approach to a two-level approach. For example, if a mechanical failure is discovered in a component within an aircraft system (example: the Line-Replaceable Unit<sup>75</sup>) on-site at the flight line, the component is replaced with a sound one of the same type on-site, and with the continuity inspection passed without problems, “repair completed” status is considered to have been achieved at this point. Meanwhile, the component with the mechanical fault will be shipped to the manufacturer designated as “(3).” In this manner, the sequence is gradually shifting towards a more streamlined two-level process: (1) The flight line → (3) The supply depot (or manufacturer).<sup>76</sup>

Let us look back on the *People’s Liberation Army Daily* article once again, taking the above differences into account. Given that the new flight inspection equipment is said to have speeded up maintenance in comparison with the old flight inspection equipment, it seems reasonable to assume that this new flight inspection equipment is being used conveniently on-site on the flight line (designated as “(1)”). In other words, this suggests that it is highly likely that two-level maintenance has now begun. This, in turn, is suggestive that the PLAAF has begun operation of aircraft complex enough that it has become essential to streamline maintenance processes.

Moreover, the fact that the Audio Call System Based Outdoor Flight Inspection Equipment enables information processing at a single click, detailed categorization of data, and data conversion<sup>77</sup> brings to mind the equipment introduced by the USAF for the maintenance of the

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<sup>74</sup> Ibid.

<sup>75</sup> Line-replaceable units (LRUs) are products produced by US firm Lockheed Martin, as an example of a component.

<sup>76</sup> For the most part, this kind of two-level process has been adopted for aircraft from the fourth generation onwards, such as the F-15.

<sup>77</sup> “Independent Innovation Boosting Warplane Performance [自主革新助力战鹰远航],” *People’s Liberation Army Daily* [解放军报], April 20, 2022.



F-35. At the Hill Air Force Base (Utah, United States), portable flight inspection equipment has been distributed to maintenance personnel on the flight line where the F-35 is handled,<sup>78</sup> and efforts are being made to streamline the work through confirming work instructions and relevant information shared over the cloud.<sup>79</sup>

These arguments suggest that the PLAAF is working to streamline aircraft maintenance in the manner of the USAF where DX initiatives are underway.

(4) What impacts will the new system have on the PLAAF?

The two analyses previously described suggest the possibility that the newly introduced Fighter Aircraft Status Management System possesses M/C functions and note the possibility that this is also being used on flight lines along with the Audio Call System Based Outdoor Flight Inspection Equipment.

Let us re-examine these issues using the preceding research by Allen and Garafola, in which they mention the maintenance reforms undertaken in the PLAAF around the year 2010. This study points out that some kind of system enabling the management of aircraft status had been introduced into certain air divisions in the then-existing PLAAF Beijing Theater Command, and that information networks connecting all maintenance divisions were in the process of being established.<sup>80</sup> In other words, their comments imply that a maintenance management system already existed at the 2011 point, meaning that the Fighter Aircraft Status Management System introduced in 2022 could be seen as an updated version of the old system. Even more important are the comments of these researchers that this old system was already in operation on flight lines from 2011. In the maintenance reforms undertaken in the PLAAF in 2011, maintenance work was reported to be divided fully into two—minor maintenance work to be carried out on flight lines and more time-consuming maintenance work to be carried out in maintenance docks—and a change had been made so that the maintenance support flight line command center on the flight line would exercise the control over most maintenance work.<sup>81</sup>

Namely, it is believed that since 2011 the flight line has exercised on-site control over all maintenance departments regarding work. It is therefore natural to assume that the Fighter Aircraft Status Management System that is newly introduced is also controlled in terms of its work by the flight line, and that this new system could even be described as possessing the functions of M/C. If the PLAAF is to establish an information system along the lines of ALIS, it is assumed that the networking of servers in each aviation brigade will migrate to cloud computing.

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<sup>78</sup> On the laptop terminals previously used by the USAF, the maintenance personnel member had to move away from the flight line to log in to the network; however, because the new equipment can be used on-site on the flight line, it has been much praised for dramatically streamlining maintenance processes. 388th Fighter Wing Public Affairs, “New tech to ease F-35A flight line maintenance,” *Air Force Material Command*, last updated October 5, 2018, <https://www.afmc.af.mil/News/Article-Display/Article/1655885/new-tech-to-ease-f-35a-flight-line-maintenance/>.

<sup>79</sup> To speculate a little further, the Audio Call System Based Outdoor Flight Inspection Equipment is probably a device possessing similar functions to the “Voice over IP” (VoIP) that the USAF ordered for the first time in relation to DX from US private-sector firm Tyto Athene, LLC in April 2021. “Tyto Athene Gets USD 11.6M for USAF Global Sustainment Task Orders,” *Telecomworldwire*, latest updated April 13, 2021, <https://gotyto.com/award-usaf-global-sustainment-tms-cts-e911/>.

<sup>80</sup> Allen, *70 Years of the PLA Air Force*, p. 266

<sup>81</sup> Allen, pp. 266-267.

In this way, the more complex aircraft systems become, the greater the tendency for requiring maintenance management that is centered on “centralized data management,” and similar trends are seen in the USAF where work on DX is currently underway. The fact that “maintenance personnel’s work efficiency is managed”<sup>82</sup> by the new system in the PLAAF resembles the initiatives underway in the USAF, which aim to bring about innovations in the maintenance work taking place on the flight line. At Tyndall Air Force Base, interview surveys are carried out among flight line maintenance personnel with the cooperation of the Rapid Sustainment Teams of the Air Force Life Cycle Management Center as an initiative to optimize daily tasks.<sup>83</sup>

The fact that “the availability status of each aircraft information can be gauged, and the information can be shared in real time between commanding officers, staff officers and maintenance personnel”<sup>84</sup> as a result of the introduction of the new system in the PLAAF also resembles the DX initiatives underway in the USAF. That is to say, the USAF’s Air Force Materiel Command (AFMC) has been working to establish the Repair Network Integration (RNI) and enjoys improved aircraft maintenance as a result of the introduction of this integrated program, which makes it possible to gauge “who is doing what, where and when.”<sup>85</sup>

Why is the USAF taking its work on DX to the level of such detailed maintenance work? The USAF is already making use of a private-sector AI application software company (C3-AI), and is sharing maintenance information for 22 models (including the B1-B, KC-135, F-15, C-130, F-16, C-17, B-2A, B-52, HH60, A-10 and F-22) with the overall command of the USAF deployed worldwide, and has begun predictive maintenance using AI.<sup>86</sup> In other words, the USAF is working to boost its capabilities in the terms of “basic physical fitness” to maintain military capabilities, even if a large budget is required, and is actively incorporating DX in this area as well. The ultimate objective, as stressed by the AFMC, is “to gain a competitive advantage in air power against hostile forces in the future.”<sup>87</sup>

Based on this, it would appear that the PLAAF aims to be able to turnaround aircraft at a faster battle rhythm than hostile air powers while maintaining a high operational readiness rate, thereby gaining a competitive advantage in future air operations against hostile air powers.

It is natural to deduce that any improvement in the logistic support capabilities, which are one aspect of “basic physical fitness” for an air force in this manner is likely to relate to activities spanning the range of different models. The PLAAF is working to transform into a logistics/replenishment model in line with actual combat (实战要求推动保障模式转型升级) in order to

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<sup>82</sup> “Independent Innovation Boosting Warplane Performance [自主革新助力战鹰远航],” *People’s Liberation Army Daily* [解放军报], April 20, 2022.

<sup>83</sup> Kortinae Lozano, “Revolutionizing the flightline of the future,” *Air Force Materiel Command Public Affairs*, last updated February 5, 2021, <https://www.afmc.af.mil/News/Article-Display/Article/2496650/revolutionizing-the-flightline-of-the-future/>.

<sup>84</sup> “Independent Innovation Boosting Warplane Performance [自主革新助力战鹰远航],” *People’s Liberation Army Daily* [解放军报], April 20, 2022.

<sup>85</sup> Monica D. Morales, “AFMC Repair Network Integration program delivers service-wide benefits of aircraft readiness, improved supply,” *Air Force Materiel Command Public Affairs*, last updated March 1, 2017, <https://www.afmc.af.mil/News/Article-Display/Article/1097827/afmc-repair-network-integration-program-delivers-service-wide-benefits-of-aircr/>.

<sup>86</sup> “U.S. Air Force Wins the 2021 SuperNova Award for AI Excellence,” *C3 AI Public Relations*, last updated November 8, 2021, <https://c3.ai/u-s-air-force-wins-the-2021-supernova-award-for-ai-excellence/>.

<sup>87</sup> “U.S. Air Force Wins the 2021 SuperNova Award for AI Excellence,” *C3 AI Public Relations*.

boost its military logistics capabilities in a cross-domain circumstance, while bringing in a variety of units.<sup>88</sup> In this sense, if the PLAAF can develop a competitive advantage by reforming its organizations, processes and culture in the future, it can be assumed that logistic support by the PLA Joint Logistics Support Force will be fully involved in this transformation.

## Conclusion

This paper has clarified how initiatives similar to the USAF's initiatives on DX have been pushed forward in China. This question has been examined from four perspectives.

The first perspective was the question of what kind of views were held towards DX by the relevant players in the Chinese aviation industry. Relevant players in the Chinese aviation industry, who had been focused on the USAF's F-35 maintenance support system, gradually came to assess the US-led approach to DX as being extremely important for the development of aircraft and the management of aircraft maintenance, resulting in spread of discourses which urge the acceptance of such an idea and the importance of following in the footsteps of the United States.

The second perspective concerns the background influencing Chinese domestic industry as it engages in DX. The results of the examination of this paper suggest that the military-civil fusion promoted as a national strategy of China serves as a valuable support platform for companies which are starting to engage with DX for the first time. The military-civil fusion can be said to provide a wide-ranging social infrastructure to enable Chinese domestic industry to promote DX on an ongoing basis, in order to dramatically boost the military capabilities of China.

The third perspective examines the status of initiatives towards DX underway in the Chinese aviation industry. With DX-related projects being enthusiastically undertaken not just in commercial airlines in China but also across the national defense industry, strategies for pushing DX forward are beginning to take clear and concrete form. This suggests that the view (hypothesis) that "initiatives seen in China are processes which mimic the DX processes underway in the USAF" has already been confirmed as valid to a certain extent.

Finally, the fourth perspective concerns how the new systems and inspection equipment introduced in the PLAAF have been influencing maintenance management. A new system, which is envisaged as possessing functions for conducting M/C on-site on flight lines suggests that efforts are underway to streamline maintenance while making substantial changes to maintenance management in the PLAAF. If the previous information system is connected to the new system and existing data can be used as before, this is likely to result in successful DX. In summary, the PLAAF aims to be able to turnaround aircraft at a faster battle rhythm than hostile air powers while maintaining a high operational readiness rate, thereby gaining a competitive advantage in future air operations against hostile air powers.<sup>89</sup>

The position of this paper, which rests on the central tenet that "Initiatives seen in China are processes which mimic DX underway in the USAF," is supported by empiric generalizations of

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<sup>88</sup> Ma Jialong [马嘉龙], Li Yang [李杨], "A Comprehensive Warehouse of the Air Force Carries out a Direct Supply Drill, with Supplies Delivered to the Battlefield Smoothly across a Long Distance [空军某总库开展直供一线保障演练物资跨千里畅达战场]," *People's Liberation Army Daily* [解放军报], January 21, 2022.

<sup>89</sup> From a perspective of principles such as maintaining the ability to continue fighting, it is assumed that the PLAAF is attempting to gain competitive advantage against hostile air powers.

what is evident from these four perspectives on DX relating to the PLAAF and the initiatives being undertaken by relevant players.

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