

Big Centralization, Small Bets, and the Warfighting Implications of Middling Progress

Three Concerns about JADC2's Trajectory

April 2023 | Travis Sharp and Tyler Hacker

"It would be pleasant to predict that the multiplication of separate systems is about to be reversed; However, the probability is that in the near future there will not be a significant change in this massive trend."

Norman C. Dalkey, *Command and Control – A Glance at the Future*, RAND Corporation (1962)¹

Warfare has always been a contest of incomplete information and imperfect control, with each side straining to find the enemy in an unfavorable position and coordinate his destruction.² Although the technologies used to surveil, communicate, and attack have changed throughout history, the advantages gained from scouting and synchronizing more effectively than one's opponent have endured.³ Stripped of its jargon, the Joint All-Domain Command and Control (JADC2) vision of integrating sensors and shooters comprises merely the latest Pentagon effort to provide U.S. forces with the timeless military advantages of superior information and control. This basic thrust of JADC2 represents a vital objective worth pursuing – even if the idealized outcome, fully integrated C2, likely remains as unattainable today as when the epigram appeared 60 years ago.

Despite JADC2's worthy goal, its programs and governance present great difficulties. Commonly cited problems include ambiguous concepts, disjointed programs, and overemphasis on technology.⁴ To spur constructive dialogue, this policy brief raises three additional concerns that have received less attention.

1. Although the Pentagon has steadily added centralized controls to focus JADC2 efforts, further centralization risks curtailing the messiness essential to innovation and transforming stakeholders into opponents.
2. JADC2's annual funding, which we estimate at \$1.4 billion to \$3.5 billion in the fiscal year 2024 request, appears modest relative to its colossal ambitions, indicating a potentially risky reliance on small bets to produce large payoffs.
3. If JADC2 ultimately makes only middling progress, a realistic outcome regardless of how the Pentagon handles centralization and funding, policymakers should ensure that the U.S. military is not meaningfully worse off relative to potential adversaries than it would have been otherwise. Put differently, any changes introduced by JADC2, no matter how piecemeal, should adhere to a "first, do no harm" principle with respect to future warfighting. Modeling, simulation, and wargaming can help policymakers understand the potential consequences of varied levels of JADC2 realization.

1 N. C. Dalkey, *Command and Control – A Glance at the Future* (Santa Monica, CA: RAND Corporation, 1962), p. 5, <https://www.rand.org/pubs/papers/P2675.html>.

2 Wayne P. Hughes Jr. and Robert P. Girrier, *Fleet Tactics and Naval Operations*, Third Edition (Annapolis, MD: Naval Institute Press, 2018), pp. 184–191, 198–210.

3 Sun Tzu, *The Art of War*, translated by Lionel Giles (Salt Lake City, UT: Project Gutenberg eBook, last updated 2021), "Chapter XIII. The Use of Spies," <https://www.gutenberg.org/files/132/132-h/132-h.htm#chap21>.

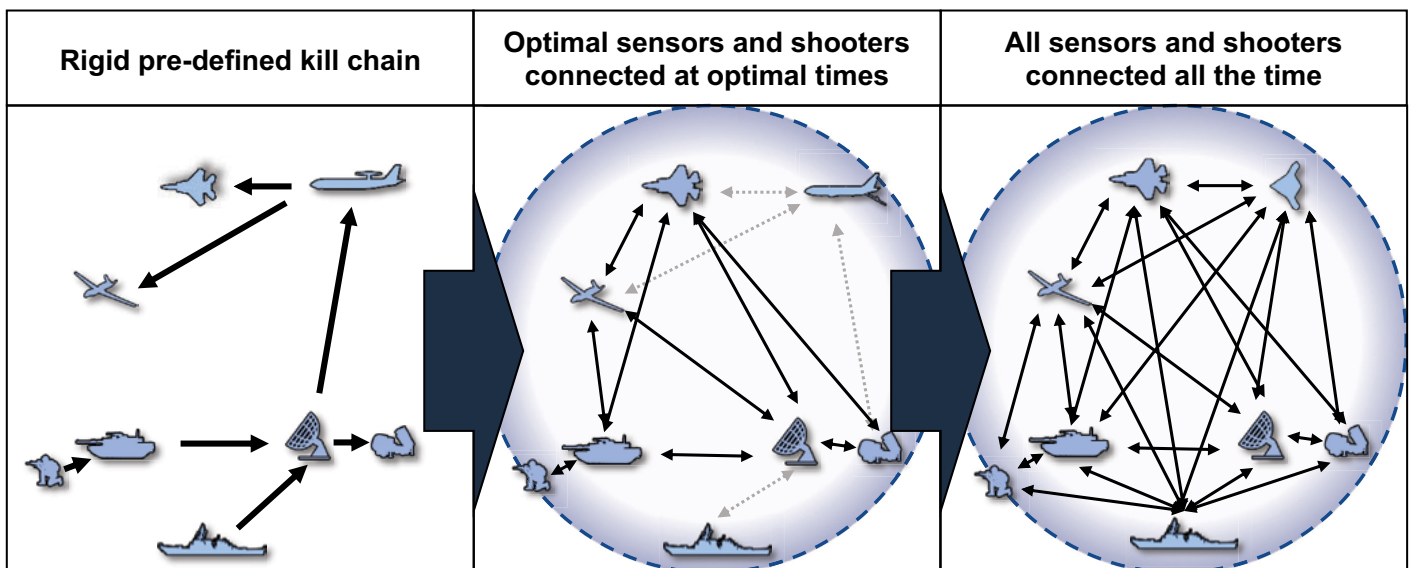
4 John R. Hoehn, *Joint All-Domain Command and Control: Background and Issues for Congress* (Washington, DC: Congressional Research Service [CRS], March 18, 2021), pp. 13–17, <https://crsreports.congress.gov/product/pdf/R/R46725/2>; and Andrew Metrick, "The Siren Song: Technology, JADC2, and the Future of War," *Breaking Defense*, January 19, 2023, <https://breakingdefense.com/2023/01/the-siren-song-technology-jadc2-and-the-future-of-war/>.

JADC2 Vision: Integrating Sensors and Shooters

The Department of Defense (DoD) has described JADC2 as an approach to developing interconnected joint force C2 capabilities that sense, make sense, and act on information quickly.⁵ It builds upon long-running efforts to integrate military battle networks dating back to at least World War II.⁶ JADC2 aims to replace aging U.S. C2 capabilities with new technologies, connecting previously unintegrated tactical networks in the process. It envisions fielding C2 systems that can process voluminous data, identify targets, and automatically recommend target prosecution options across all domains. It intends to expedite kill chain completion by accelerating information sharing between sensors and shooters to near real-time.⁷

In our assessment, JADC2 envisages transforming the kill chain in two steps (**Figure 1**). First, it will link select systems into new networks, with optimal sensors and shooters connected at optimal times. Second, it will move from linking select systems in new networks to linking all systems in one network, with all sensors and shooters connected all the time.

FIGURE 1: HOW JADC2 INTENDS TO TRANSFORM U.S. MILITARY KILL CHAINS



Source: Graphic created by CSBA.

⁵ Department of Defense (DoD), *Summary of the Joint All-Domain Command & Control (JADC2) Strategy*, March 2022, p. 2, <https://media.defense.gov/2022/Mar/17/2002958406/-1/-1/1/SUMMARY-OF-THE-JOINT-ALL-DOMAIN-COMMAND-AND-CONTROL-STRATEGY.PDF>.

⁶ A battle network combines target acquisition sensors, target localization sensors, command and control (C2) elements, weapons, weapon platforms, and the electronic communications linking them together. John Stillion and Bryan Clark, *What It Takes to Win: Succeeding in 21st Century Battle Network Competitions* (Washington, DC: Center for Strategic and Budgetary Assessments [CSBA], 2015), p. 1, <https://csbaonline.org/research/publications/what-it-takes-to-win-succeeding-in-21st-century-battle-network-competitions/publication/1>; and Barry Watts, *Six Decades of Guided Munitions and Battle Networks: Progress and Prospects* (Washington, DC: CSBA, 2007), p. 17, <https://csbaonline.org/research/publications/six-decades-of-guided-munitions-and-battle-networks-progress-and-prospects>.

⁷ See General Mark Milley's comments in Colin Demarest and Courtney Albon, "Pentagon's JADC2 Strategy Focuses on 'Approach,'" *C4ISRNet*, March 18, 2022, <https://www.c4isrnet.com/battlefield-tech/it-networks/2022/03/18/pentagons-jadc2-strategy-focuses-on-approach/>.

Flagship JADC2 Initiatives by the Military Services

Advanced Battle Management System / Transport Layer: The Department of the Air Force's primary JADC2 effort is the Advanced Battle Management System (ABMS) data network.⁸ Originally intended to replace the E-3 Airborne Warning and Control System, ABMS has evolved into a broader C2 initiative led by a new program executive office.⁹ The Air Force wants ABMS capabilities to include secure processing, connectivity, data management, applications, sensor integration, and effects integration.¹⁰ ABMS will rely on the Space Force's transport layer, a planned constellation of hundreds of low earth orbit satellites transmitting C2 data worldwide.¹¹

Project Overmatch: The Department of the Navy's central JADC2 effort is Project Overmatch, a secretive program to develop data networks, infrastructure, and architecture, along with tools and analytics.¹² The Navy wants Overmatch to provide connectivity for dispersed naval maneuver against enemy forces, the approach enshrined in the concepts of Distributed Maritime Operations (Navy) and Expeditionary Advanced Base Operations (Marine Corps).¹³ According to media reporting, the Navy significantly increased its Overmatch spending request in 2023.¹⁴

Project Convergence: The Department of the Army's main JADC2 effort is Project Convergence, a campaign of learning aimed at developing technologies and techniques to integrate the Army with the joint force.¹⁵ Led by Army Futures Command, Convergence has emphasized five components: soldiers, information, terrain, weapons, and C2. The Army has tested advancements in these areas during annual Convergence exercises, to include using the new Integrated Battle Command System to C2 air and missile defense assets.¹⁶

JADC2 Initiatives and Governance: Risks of Excessive Centralization

Over the past three years, JADC2 initiatives have grown in number, activity, and resourcing.¹⁷ The military services have advanced their flagship JADC2 initiatives and increased their share of estimated DoD-wide JADC2 funding (see next section). Relying on the services to drive JADC2 development has been necessary. Only they possess the statutory authority, organizational capacity, and warfighting expertise to equip themselves with JADC2 capabilities. Yet disjointedness has also appeared, predictably, with senior officials inside and outside the services warning about misaligned JADC2 efforts.¹⁸

- 8 Department of the Air Force, *Fiscal Year (FY) 2023 Budget Estimates, Research, Development, Test & Evaluation, Justification Book Volume 2*, April 2022, p. 97, https://www.saffm.hq.af.mil/Portals/84/documents/FY23/RDTE_/FY23%20Air%20Force%20Research%20Development%20Test%20and%20Evaluation%20Vol%20II.pdf?ver=LK67U_ThMsX7AwahfurKGw%3d%3d.
- 9 John R. Hoehn, *Advanced Battle Management System (ABMS)* (Washington, DC: CRS, February 15, 2022), p. 1, <https://sgp.fas.org/crs/weapons/IF11866.pdf>; and Government Accountability Office (GAO), *Battle Management: DOD and Air Force Continue to Define Joint Command and Control Efforts*, January 2023, pp. 6–7, <https://www.gao.gov/assets/gao-23-105495.pdf>.
- 10 GAO, *Battle Management*, p. 5.
- 11 Space Development Agency, "Transport," accessed January 25, 2023, <https://www.sda.mil/transport/>.
- 12 Chief of Naval Operations Memorandum to Rear Admiral Douglas W. Small, October 1, 2020, p. 1, https://insidedefense.com/sites/insidedefense.com/files/documents/2020/oct/10192020_overmatch.pdf.
- 13 Marine Corps Warfighting Lab, *Expeditionary Advanced Base Operations (EABO) Handbook*, June 1, 2018, <https://mca-marines.org/wp-content/uploads/Expeditionary-Advanced-Base-Operations-EABO-handbook-1.1.pdf>.
- 14 Nathan Strout, "Navy Dramatically Increases Funding for Secretive Project Overmatch," *C4ISRNet*, March 28, 2022, <https://www.c4isrnet.com/it-networks/2022/03/28/navy-dramatically-increases-funding-for-secretive-project-overmatch/>.
- 15 Army Futures Command, "Project Convergence," accessed January 25, 2023, <https://armyfuturescommand.com/convergence/>.
- 16 Andrew Eversden, "Army's IBCS Passed F-35 Sensor Data to Artillery System at Project Convergence 21," *Breaking Defense*, January 20, 2022, <https://breakingdefense.com/2022/01/armys-ibcs-passed-f-35-sensor-data-to-artillery-system-at-project-convergence-21/>.
- 17 This section and the next draw on material first published in Travis Sharp, "JADC2 Spending Is Sprawling. DoD Should Keep Watch, But Let It Go," *Breaking Defense*, October 20, 2022, <https://breakingdefense.com/2022/10/jadc2-spending-is-sprawling-dod-should-keep-watch-but-let-it-go>.
- 18 Brandi Vincent, "Hicks Wants More High-Level Oversight of Pentagon's JADC2 Efforts," *FedScoop*, August 23, 2022, <https://www.fedscoop.com/hicks-wants-more-high-level-oversight-of-pentagons-jadc2-efforts/>.

DoD has steadily added centralized controls to encourage unity of effort. In January 2020, the Joint Staff J6 deputy director started chairing a JADC2 cross-functional team tasked with coordinating day-to-day efforts and synchronizing common data standards.¹⁹ In May 2021, Defense Secretary Lloyd Austin signed a classified JADC2 strategy establishing lines of effort and guiding principles. In March 2022, DoD released an unclassified summary of the strategy while Deputy Defense Secretary Kathleen Hicks approved a classified implementation plan.²⁰ Finally, in October 2022, the Office of the Secretary Defense (OSD) created a new acquisition, integration, and interoperability office tasked with overseeing department wide JADC2 efforts.²¹

Although the centralized controls added to date seem appropriate, taking further steps toward centralization, such as creating a joint program executive office to manage all JADC2 initiatives, risks curtailing the messiness essential to innovation and transforming stakeholders into opponents.²²

Containing Messiness Risks Undermining Innovation

Successful research and development (R&D) often requires messiness and errors early to avoid them later. Overly centralizing JADC2 governance, whether in OSD or in the service leaderships, risks undermining this knowledge-creation process. As Thomas McNaugher concluded in his classic study of weapons acquisition, “The conundrum of R&D, it might be said, is that unless one is willing to waste money early, one is likely to waste much more money later [...] It is easier to stop and start projects in their early stages, but of course such choices are made on the basis of cost and performance information that is almost always wrong.”²³ If JADC2 “is really a software-centric enterprise problem,” as Hicks remarked, then software-style innovation — bottom-up and iterative — should outperform the top down and directive approach ingrained in DoD culture.²⁴

A critic might counter that JADC2 has little excuse for messiness because several initiatives are not early stage. Rather, they conglomerate long-running efforts that previously had different names. In this view, for example, ABMS is a rebranded continuation of older programs.²⁵ If these efforts should have been fielded in some form already, or been canceled due to infeasibility, then continuing to develop them under JADC2 is ill-advised.

Although this technological maturity critique merits continued attention, it is worth noting that senior DoD officials, including those who have left government, have not criticized JADC2 as unnecessary even though they have incentives to stop wastefulness.²⁶ Instead, they have lamented its ambiguity. As Hicks said, “If you ask any two people what they think JADC2 is, you’ll probably get different answers.”²⁷ Observers could interpret this comment in different ways, but it seems more indicative of the early problem-defining stage when messiness is a virtue, not a vice.

19 GAO, *Battle Management*, pp. 16–22.

20 Colin Demarest, “Pentagon’s Secret JADC2 Plan ‘Evolving,’ Official Says, as Lawmakers Seek Audit,” *Defense News*, July 11, 2022, <https://www.defensenews.com/battlefield-tech/it-networks/2022/07/11/pentagons-secret-jadc2-plan-evolving-official-says-as-lawmakers-seek-audit/>.

21 Jaspreet Gill, “Pentagon Seeks More ‘Jointness’ for JADC2 as OSD Stands Up New Office,” *Breaking Defense*, October 27, 2022, <https://breakingdefense.com/2022/10/pentagon-seeks-more-jointness-for-jadc2-as-osd-stands-up-new-office/>.

22 Nicolas M. Chaillan, “Let’s Catch-Up with China within 6 Months,” *LinkedIn*, November 24, 2021, <https://www.linkedin.com/pulse/lets-catch-up-china-within-6-months-nicolas-m-chaillan/>; and Cynthia R. Cook et al., *Pathways to Implementing Comprehensive and Collaborative JADC2* (Washington, DC: Center for Strategic and International Studies [CSIS], September 2022), pp. 4–6, https://csis-website-prod.s3.amazonaws.com/s3fs-public/publication/220927_Cook_Pathways_ImplementingJADC2_o.pdf?VersionId=UZ5C9IjGtHoRMITUkowJBuToEei92zGJ.

23 Thomas L. McNaugher, *New Weapons Old Politics* (Washington, DC: Brookings Institution Press, 1989), pp. 5, 123.

24 Vincent, “Hicks Wants More High-Level Oversight”; Eric S. Raymond, “The Cathedral and the Bazaar,” *First Monday* 3, no. 3 (March 1998), <https://firstmonday.org/ojs/index.php/fm/article/view/578>; and Defense Innovation Board, “Software is Never Done: Refactoring the Acquisition Code for Competitive Advantage,” May 3, 2019, <https://media.defense.gov/2019/May/01/2002126691/-1/-1/o/SWAP%20FLYER.PDF>.

25 Robert K. Ackerman, “Air Force Flies into Network-Centric Airspace,” *Signal*, February 1, 2005, <https://www.afcea.org/signal-media/air-force-flies-network-centric-airspace>.

26 Chaillan, “Let’s Catch-Up with China.”

27 Vincent, “Hicks Wants More High-Level Oversight.”

Dictating Outcomes Risks Turning Stakeholders into Opponents

Overly centralizing JADC2 risks alienating stakeholders and wrecking the advocacy network that supports JADC2 in principle but views its ambition and nebulosity skeptically.²⁸ Numerous JADC2 initiatives are conducting experimentation. The services' flagship initiatives have held demonstrations regularly. In the coming years, experimentation will intensify due to new congressional requirements included in the 2023 National Defense Authorization Act.²⁹

History shows that if senior officials appear to be picking winners and losers before experimentation has produced results, key stakeholders may revolt against the entire undertaking.³⁰ No leader wants to lend their credibility to a sham process. In 2002, Lieutenant General (Ret.) Paul Van Riper's public accusations of scriptedness in the Millennium Challenge exercise weakened support for the new concepts being developed.³¹

In light of this risk, DoD should avoid permitting any centralized authority to dictate JADC2 outcomes until initial experimentation has progressed further. Determining how much experimentation is enough represents a judgment call, but successful efforts historically have taken at least a few years.³²

JADC2 Funding: Small Bets for Large Payoffs

DoD has never publicly released a full list of programs falling under JADC2, although it reportedly tracks this information internally.³³ Given the absence of such a list, generating a detailed estimate of JADC2 funding requires summing the costs of individual initiatives that, in one's judgment, directly support JADC2. This aggregation technique has shortcomings, including potential imprecision and irreproducibility. Still, it remains a widely used and reasonable method for estimating total funding when DoD has not released program-by-program cost figures for the concept of interest to an analyst.³⁴

We searched DoD budget requests for keywords such as ABMS, Overmatch, and Convergence, identifying a sample of 23 to 25 initiatives whose descriptions conveyed, in our judgment, that they directly supported JADC2 (see appendix).³⁵ The range expresses uncertainty about the extent to which two Space Force initiatives, Space Technology Development and Prototyping and Defensive Cyberspace Operations-Space, directly or only partially support JADC2. Future research can refine our work.

28 Dan Gouré, "Are the Wheels Coming Off the JADC2 Bus?" *RealClear Defense*, September 6, 2022, https://www.realcleardefense.com/articles/2022/09/06/are_the_wheels_coming_off_the_jadc2_bus_851924.html.

29 117th Congress, *James M. Inhofe National Defense Authorization Act for Fiscal Year 2023*, H.R. 7776, Section 915, pp. 358–361, <https://www.congress.gov/117/bills/hr/7776/BILLS-117hr7776enr.pdf>.

30 Ryan C. Kendall, "Playing War: U.S. Military Experimentation and Innovation During Peacetime," Ph.D. dissertation, University of Texas at Austin, May 2022, <https://repositories.lib.utexas.edu/bitstream/handle/2152/114777/KENDALL-DISSERTATION-2022.pdf>.

31 *Ibid.*, pp. 258–259; and Sean D. Naylor, "Rigged War Game? Millennium Challenge Fixed, Opposing Forces Commander Says," *Army Times*, August 26, 2002.

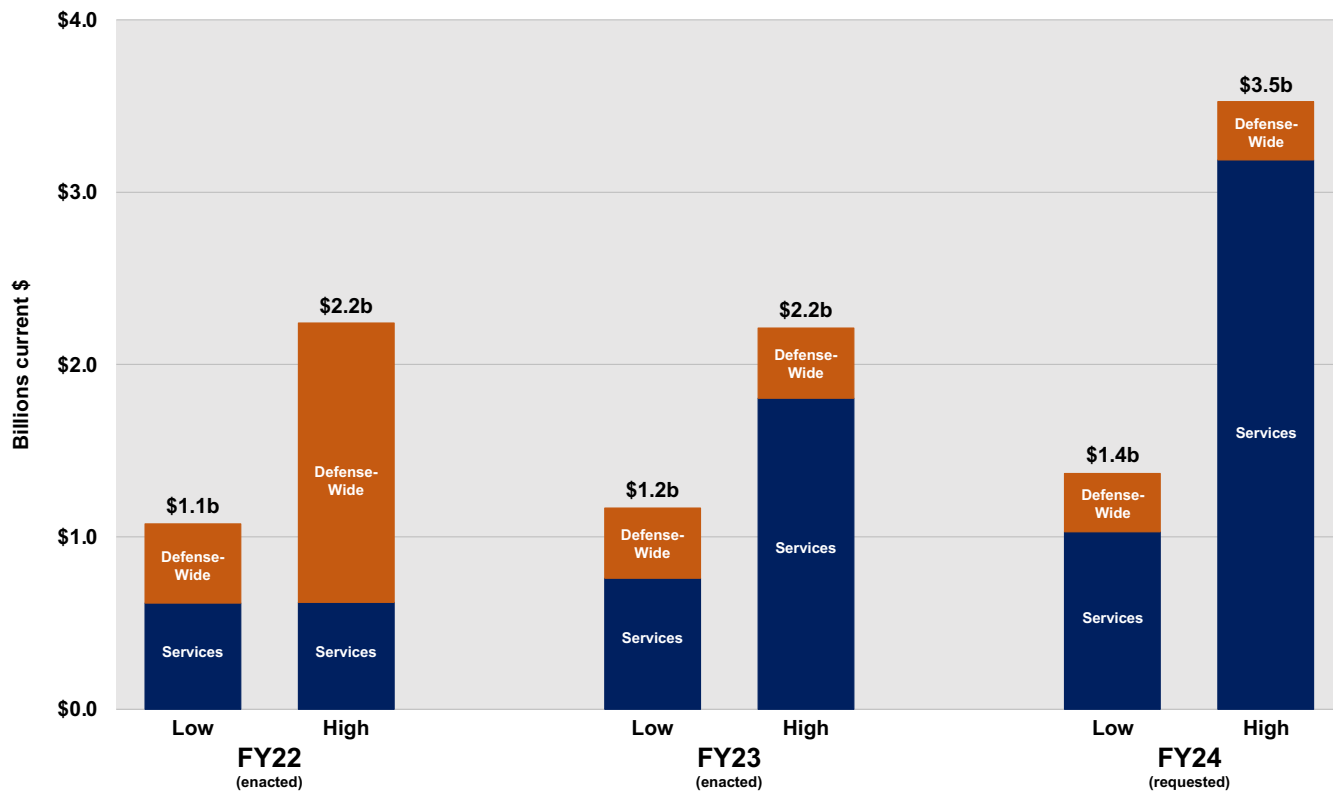
32 Robert G. Angevine, "Innovation and Experimentation in the U.S. Navy: The UPTIDE Antisubmarine Warfare Experiments, 1969–72," *Journal of Strategic Studies* 28, no. 1 (February 2005), pp. 77–105.

33 GAO, *Battle Management*, p. 23.

34 Path-breaking examples of the aggregation technique appear in Stephen I. Schwartz, ed., *Atomic Audit: The Costs and Consequences of U.S. Nuclear Weapons Since 1940* (Washington, DC: Brookings Institution Press, 1998).

35 We searched for the following keywords, including spelled out acronyms: JADC2, ABMS, MDC2, Project Convergence, Project Overmatch, Mosaic, FNC3, 5G Info Comms Tech, and UDL. The keywords came from Hoehn, *Joint All-Domain Command and Control*, p. 2 of PDF. Using keywords from an independent third-party source guarded against sampling bias. We added an initiative to the sample if the budget justification material conveyed, in our assessment, that the initiative likely would not exist in its present form if JADC2 did not exist.

FIGURE 2: ESTIMATED RANGE OF RDT&E FUNDING FOR JADC2, FY22 TO FY24



Source: FY24 DoD budget request documents. See appendix for data and sourcing.

Notes: Figures represent total obligational authority expressed in billions of current (i.e. non-inflation adjusted) dollars. Joint Warfighting Cloud Capability excluded from sample because DoD has not yet released a year-to-year spending plan or obligated any funds to the four contractors (Google, Oracle, Amazon, Microsoft).³⁶

For fiscal year 2024, the JADC2 initiatives in our sample together requested between \$1.4 billion and \$3.5 billion (Figure 2), with the range driven by whether one includes \$2.1 billion requested for Space Technology Development and Prototyping.³⁷ The services requested 75 percent of the funds in 2024 under the low estimate, up from 57 percent in 2022. In non-inflation-adjusted terms, the services’ JADC2 funding grew by over \$400 million from 2022 to 2024 under the low estimate, while defense-wide funding shrank by about \$120 million over the same period.

Our sample of JADC2 programs likely does not match perfectly with DoD’s own internal tracking, particularly since we cannot see into classified programs. Still, our estimate aligns with new information released by the Pentagon in March 2023. In the fiscal year 2024 budget request, DoD revealed that it was seeking \$1.4 billion in research and development funds for JADC2.³⁸ To the authors’ knowledge, this represents the first time that DoD has disclosed a figure for total annual JADC2 spending. The congruence between DoD’s \$1.4 billion figure and our low estimate for 2024 validates our analytical approach, especially since

36 DoD, “Contracts for Dec. 7, 2022,” <https://www.defense.gov/News/Contracts/Contract/Article/3239197/>.

37 The appendix includes the raw data used in this paragraph’s calculations.

38 DoD, “FY 2024 Budget Briefing,” updated March 15, 2023, p. 15, https://comptroller.defense.gov/Portals/45/Documents/defbudget/FY2024/FY2024_Budget_Request.pdf.

we disseminated previous versions of our estimate prior to March 2023 – meaning our analytical approach existed prior to DoD releasing an official figure.³⁹

Zooming out from the details, our estimate indicates a striking mismatch between JADC2's modest funding and its immodest vision. Spending a few billion per year on JADC2 represents a surprisingly small investment given JADC2's colossal ambitions of transforming joint force C2 capabilities.⁴⁰ Even if JADC2 spending increased by a factor of 10, reaching \$14 billion, that amount would still equal less than \$0.02 of every dollar DoD spends in 2023, a tiny commitment to a big priority.⁴¹ To be fair, small budgetary bets have sometimes produced large operational payoffs in the C2 domain. The German army's investment in low-cost radios contributed to its successful tank operations in 1939–40.⁴² However, the cutting-edge technology and force-wide transformation envisioned by JADC2 strongly suggest that it will not succeed on the cheap.

Warfighting Implications of Middling Progress

Realistically, we should expect JADC2 to make uneven progress across the military services regardless of DoD's decisions about centralization and funding. The mixed success of past JADC2-like initiatives suggests that middling progress is the most likely outcome.⁴³ Different JADC2 initiatives will surely encounter different technical obstacles during their development and implementation, meaning some initiatives and organizations will progress faster and further than others.⁴⁴ Additionally, differences in scale among the services will naturally lead to imbalanced progress. Equipping all the Air Force's active combat-coded fighters with new JADC2 systems would involve upgrading over 940 aircraft.⁴⁵ In contrast, equipping just one of the Army's eleven armored brigades with new systems would involve upgrading over 1,200 vehicles.⁴⁶

The high likelihood of middling progress carries potentially detrimental consequences for U.S. military effectiveness. If JADC2 fields unevenly or lacks backward compatibility with key legacy systems, then the resulting disjointedness in C2 could undermine U.S. military effectiveness. Incompatible C2 systems have contributed to tragic events before, including fatal friendly fire incidents in the skies over northern Iraq in 1994 and between air and ground forces in Afghanistan in 2014.⁴⁷ Establishing standardized C2 between front and rear echelons or between warfighting functions presents a constant challenge. These hazards appeared during the 2003 invasion of Iraq when forward maneuver units operated with little of the situational awareness possessed by rear command centers.⁴⁸ Heterogeneous C2 systems can cause a commander to prefer certain capabilities over others, even if they are suboptimal for the mission at hand. Such preferences appeared during Operation Inherent Resolve when combat forces

39 Sharp, "JADC2 Spending Is Sprawling. DoD Should Keep Watch, But Let It Go"; and Andrew Eversden, "What the Budget Reveals – and Leaves Unclear – about the Cost of JADC2," *C4ISRNet*, June 15, 2021, <https://www.c4isrnet.com/c2-comms/2021/06/15/part-1-what-the-budget-reveals-and-leaves-unclear-about-the-cost-of-jadc2/>.

40 We thank our former CSBA colleague Chris Bassler for highlighting this interpretation of the spending analysis.

41 The omnibus provided DoD with \$816 billion in FY 2023 discretionary base budget authority, such that $\$12b/\$816b = \sim 0.015$.

42 Michael O'Hanlon, *How to Be a Cheap Hawk: The 1999 and 2000 Defense Budgets* (Washington, DC: Brookings Institution Press, 1998), p. 108; and Robert Citino, "Beyond Fire and Movement: Command, Control and Information in the German Blitzkrieg," *Journal of Strategic Studies* 27, no. 2 (June 2004), pp. 324–344.

43 Todd Harrison, *Battle Networks and the Future Force Part 2: Operational Challenges and Acquisition Opportunities* (Washington, DC: CSIS, November 2021), pp. 6–7, https://csis-website-prod.s3.amazonaws.com/s3fs-public/publication/211103_Harrison_Battle_Networks_Part2_o.pdf?vsuBpGNyDDOwNE_hMzckmGEfb8fq13dx.

44 For instance, the Air Force has attributed ABMS delays to problems developing F-35 data links. GAO, *Battle Management*, pp. 11–12.

45 John Venable, "U.S. Air Force," in Dakota L. Wood, ed., *2023 Index of U.S. Military Strength* (Washington, DC: Heritage Foundation, October 2022), p. 410, https://www.heritage.org/sites/default/files/2022-10/2023_IndexOfUSMilitaryStrength.pdf.

46 Sydney J. Freedberg, Jr., "ABMS Can't Be 'Sole Solution' For Joint C2, Army Tells Air Force – Exclusive," *Breaking Defense*, January 22, 2020, <https://breakingdefense.com/2020/01/abms-cant-be-sole-joint-c2-solution-army-tells-air-force-exclusive/>; and Steven J. Adams, "Maneuvering the Armored Brigade Combat Team in Restrictive Terrain," *Armor*, Winter-Spring 2018, <https://www.benning.army.mil/armor/eArmor/content/issues/2018/Winter-Spring/2Adams18.pdf>.

47 In 1994, Air Force F-15s operating more advanced radios shot down two Army helicopters equipped with older incompatible radios. In 2014, the infrared beacons used as friendly identifiers by U.S. special forces personnel were not visible through the advanced targeting pod of a B-1 bomber. N.G. Leveson, Polly Allen, and Margaret-Anne Storey, "The Analysis of Friendly Fire Accident using a Systems Model of Accidents," working paper, Massachusetts Institute of Technology, 2002, p. 4, <http://sunnyday.mit.edu/accidents/issc-bl-2.pdf>; and *CBS News*, "The Afghan War's Deadliest Friendly Fire Incident for U.S. Soldiers," November 9, 2017, <https://www.cbsnews.com/news/the-afghan-wars-deadliest-friendly-fire-incident-involving-u-s-soldiers/>.

48 David Talbot, "How Technology Failed in Iraq," *MIT Technology Review*, November 1, 2004, <https://www.technologyreview.com/2004/11/01/232152/how-technology-failed-in-iraq/>.

overtasked MQ-1 and MQ-9 unmanned aircraft systems because of their responsiveness and flexibility, generating inefficiency and tension between air and ground components.⁴⁹

The dangers of middling progress extend to U.S. interactions with allies and partners, an area where legacy C2 systems have long struggled. As DoD implements JADC2, it will confront new challenges related to information and technology sharing.⁵⁰ Even in NATO, with its relatively high levels of trust and interoperability, multi-national kill chains today face obstacles that the U.S. joint forces overcame decades ago.⁵¹ Implementing JADC2 risks orphaning U.S. allies who do not belong to certain information-sharing agreements or do not use certain C2 technologies. Even if U.S. allies and partners successfully adopt compatible C2 systems, they may also need to adopt the broader decision-centric concepts embedded in JADC2. DoD must ensure that JADC2's implementation does not inadvertently reduce hard-earned interoperability with allies.

The likelihood of piecemeal progress on JADC2 across the military services and U.S. allies highlights the need to use modeling, simulation, and wargaming to explore the consequences of varied levels of JADC2 realization. Ultimately, modeling pessimistic scenarios in which some or all of JADC2 fails is just as important as modeling optimistic scenarios in which it succeeds. Despite the enduring appeal of harnessing new technology to aid warfighting, history is replete with examples of technology failing to withstand the friction of combat. The U.S. military must be prepared to fight and win regardless of how JADC2 turns out.

49 Becca Wasser et al., *The Air War Against the Islamic State: The Role of Airpower in Operation Inherent Resolve* (Santa Monica, CA: RAND Corporation, 2021), pp. 303–304, https://www.rand.org/pubs/research_reports/RRA388-1.html.

50 Todd Harrison, *Battle Networks and the Future Force Part 3: The Role of Allies and Partners* (Washington, DC: CSIS, March 2022), https://csis-website-prod.s3.amazonaws.com/s3fs-public/publication/220304_Harrison_Battle_Networks_3.pdf?VersionId=gIu7IDrCNMqMObYzHoIOIfCeWErbzv7J.

51 James Shoop, “Baltic Fire Support,” United States Field Artillery Association, June 28, 2020, <https://www.fieldartillery.org/news/3-16FAR-AtlanticResolve-Part4>.

APPENDIX. JADC2 INITIATIVES INCLUDED IN FUNDING ESTIMATE

Sample id #	JADC2 direct support	JADC2 initiative	Department	Title	Program element	Program name	FY22	FY23	FY24	Source	Source PDF page
1	Yes	Mosaic	DW / DARPA	RDT&E	0603760E	Resilient Networked Distributed Mosaic Communications (RNDMC)	22.2	18.8	17.3	Link	222
2	Yes	Mosaic	DW / DARPA	RDT&E	0603766E	Air Combat Evolution (ACE)	22.7	21.7	14.6	Link	234
3	Yes	GCCS-J	DW / DISA	RDT&E	0303150K	CC01 / Global Command / Development and Strategic Planning	32.8	35.0	33.2	Link	173
4	Yes	JADC2 CFT	DW / JCS	RDT&E	0604826J	Joint C5 Capability Development, Integration, and Interoperability Assessments	17.4	28.2	28.5	Link	27
5	Yes	SA / TDL	DW / OSD	RDT&E	0604771D8Z	Joint Tactical Information Distribution System (JTIDS)	20.6	9.0	9.8	Link	791
6	Yes	FNC3	DW / OSD	RDT&E	0605142D8Z	Systems Engineering / Mission Engineering / Mission Integration	12.4	12.6	13.1	Link	954
7	Yes	5G ICT	DW / OSD	RDT&E	0604011D8Z	Next Generation Information Communications Technology (5G)	327.7	248.5	179.3	Link	539
8	Yes	SA / TDL	DW / SOCOM	RDT&E	1160431BB	Mission Command System/Common Operational Picture (MCS/COP)	4.4	32.4	43.3	Link	235
9	Yes	Convergence	USA	RDT&E	0602181A	All Domain Convergence Applied Research	25.0	27.4	14.3	Link	429
10	Yes	Convergence	USA	RDT&E	0603041A	All Domain Convergence Advanced Technology	20.1	45.4	33.3	Link	103
11	Yes	Convergence	USA	RDT&E	0604035A	LEO BMC2 and Ground Infrastructure / Project BX7	18.9	35.5	38.9	Link	407
12	Yes	SA / TDL	USA	RDT&E	0604541A	Unified Network Transport	33.9	37.0	40.9	Link	349
13	Yes	Overmatch	USN	RDT&E	0604027N	Digital Warfare	45.0	165.8	181.0	Link	1079
14	Yes	Overmatch	USN	RDT&E	0603597N	Automated Test & Re-Test (ATRT)	36.5	60.1	10.8	Link	681
15	Yes	Overmatch	USN	RDT&E	0603382N	Advanced Combat Systems Technology / Adv Combat System Technology	1.5	2.5	2.2	Link	239
16	Yes	Overmatch	USN	RDT&E	0307577N	Intelligence Mission Data (IMD)	0.9	0.9	0.8	Link	1495
17	Yes	Overmatch	USN	RDT&E	0308601N	Modeling & Simulation Support	9.5	9.4	11.0	Link	1503
18	Yes	ABMS	USAF	RDT&E	0604003F	Advanced Battle Management System (ABMS)	262.5	237.3	500.6	Link	167
19	Yes	MDC2	USAF	RDT&E	0602788F	C4I Dominance Technology / Multi-Domain Command & Control (MDC2)	21.9	17.9	19.4	Link	256
20	Yes	HMT	USAF	RDT&E	0602202F	Sensory Evaluation and Decision Science / Collaborative Interfaces and Teaming	6.3	10.8	12.0	Link	163
21*	Yes	ABMS	USAF	RDT&E	0207412F	Control and Reporting Center (CRC)	9.6	6.6	19.5	Link	915
22	Yes	ADCP	USAF	RDT&E	0303248F	All Domain Common Platform (ADCP)	60.9	46.5	71.3	Link	395
23	Yes	UDL	USSF	RDT&E	1203940SF	Space Situation Awareness Operations / Space Data Fusion / Project 673940	62.8	58.0	73.7	Link	773
24**	Partial	SA / TDL	USSF	RDT&E	1206410SF	Space Technology Development and Prototyping	1160.2	1015.8	2081.3	Link	163
25	Partial	SA / TDL	USSF	RDT&E	1203040SF	Defensive Cyberspace Operations (DCO)-Space	6.2	28.1	76.0	Link	635

* FY24 figure for Control and Reporting Center (CRC) includes \$2.005m listed as new start under same program element in USAF R&D Vol 1 ([Link](#), PDF pg 417).

** FY22 figure for Space Technology Development and Prototyping fell under DW/SDA, not USSF ([Link](#), PDF pg 23). Figure 2 categorizes the associated funds accordingly.

JADC2 INITIATIVE ACRONYMS

5G ICT	5G Information Communications Technology
ABMS	Advanced Battle Management System
ADCP	All Domain Common Platform
FNC3	Fully Networked Command, Control, and Communications
GCCS-J	Global Command and Control System – Joint
HMT	human-machine teaming
JADC2 CFT	JADC2 Cross-Functional Team
MDC2	Multi-Domain Command & Control
SA / TDL	situational awareness / tactical data layer
UDL	Unified Data Library

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LIST OF ACRONYMS USED IN MAIN TEXT AND FOOTNOTES

ABMS	Advanced Battle Management System
C2	command and control
CSBA	Center for Strategic and Budgetary Assessments
CSIS	Center for Strategic and International Studies
DoD	Department of Defense
EABO	Expeditionary Advanced Base Operations
FY	fiscal year
GAO	Government Accountability Office
JADC2	Joint All-Domain Command and Control
OSD	Office of the Secretary of Defense
R&D	research & development