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FROM THE EDITOR

Dear Reader,

A drive to the Air University Press offices in the middle of Maxwell Air Force Base, Montgomery Alabama, is a trip down airpower memory lane. From a right turn onto Chennault Circle near the B-25 Mitchell bomber and Mitchell Street—home to Air University headquarters—to our building, adjacent to the Ira C. Eaker Center for Leadership Development, the pioneers of US airpower loom large. Although these men have been immortalized in institutional memory, concrete, iron, and stone, scholarship demands we are vigilant in ensuring history accurately records details about their service.

The stories and exploits of these men represent the dawn of the age of manned combat aircraft, an age some argue is waning in the face of unmanned aerial systems. These systems headline the airpower component of Russia's war in Ukraine, and as the airpower lessons from that and other recent conflicts emerge, the US Air Force must address, among other things, latency concerns in remotely piloted aircraft and repurposing crews and missions of first-generation systems.

Successful all-domain airpower and spacepower operations in the twenty-first century are rooted in technological dominance. This means our Department's scientists and engineers must have the career opportunities to pursue their educational foci, and the DoD labs they work for should be funded and structured to allow for not simply world-class but world-leading technological development organic to the US Department of Defense.

And finally, the United States must continue to lean on its critical security partners across the globe, in our hemisphere and beyond. The *Economist* recently observed "although the war [in Ukraine] caused America and Europe to unite after the ruptures . . . the danger is that a long conflict and economic tensions will gradually pull them apart again. [Russia's president Vladimir] Putin and China's president Xi Jinping, would love that."[1]

Canada, our NORAD partner, continues to be our stalwart Ally in continental security. Importantly, Canadian civilian and military air transportation coordination played a key role on 9/11 in a story not known by many Americans. And in early December 2022, we celebrated the friendship of France, one of our close Atlantic NATO Allies, with a visit by President Emmanuel Macron to the White House and to New Orleans (the first visit of a French president to the city in almost 50 years, and where, incidentally, a French-speaking resident chided him for selling Louisiana "for a loaf of bread").[2] As France develops hypersonics and related military capabilities, the Department of the Air Force will continue to build on its valuable partnership with the French Air and Space Force.

Our Winter 2022 authors explore these myriad threads. We hope you find it thought provoking. As always, we welcome informed reviews of our articles. If the review is selected for publication consideration, the author will be given the opportunity to reply to the review of the article, and the two will be published together in a future issue of the journal.

-The Editor

1. "Frozen Out," *Economist*, November 26 – December 2, 2022.

2. Roger Cohen, "As Macron Loses His Sheen at Home, Harmonious U.S. Visit Is 'Regenerative,'" *New York Times*, December 2, 2022, https://www.nytimes.com/.

Combat Drones in Ukraine

Adam Lowther
Mahbube K. Siddiki

Drones are playing an important role in the war in Ukraine. Without a large conventional air force, the Ukrainian military is employing a number of high- and low-end imported and domestically produced drones to devastating effect against Russian forces. This article examines how Ukrainian and Russian forces are employing these drones and their effects on the battlefield.

Ukrainian resistance to Russia's invasion surprised not only Russian president Vladimir Putin but also Western intelligence agencies and prominent analysts.[1] A wide range of drones are among the celebrated systems proving effective for Ukrainian forces, most notably the Baykar Bayraktar TB2. This combat drone now has a song and music video dedicated to its success against Russian troops.[2] Aside from this famous battle-tested drone, both sides have other drones now employed in combat. This article analyzes the drones being used by Ukraine and Russia, their effects on the battlefield, and implications for future combat.

Background

The Russian invasion of Ukraine, labeled a "special operation" by Putin, began on February 24, 2022. The planned days-long invasion soon turned into a war of attrition that, by its eight month, had triggered Europe's largest refugee crisis since World War II. As of October 2022, more than 4.6 million Ukrainians remain outside their own country, with millions more internally displaced.[3]

The Russian military under Putin has employed similar tactics to those used in the Second Chechen War. Putin further perfected these tactics—"siege, destroy, and take over"—with a heavy reliance on airpower and private military contractors in the Syrian

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Dr. Mahbube Siddiki serves as multidomain operations faculty at the Army Management Staff College.

1. Zack Beauchamp, "Why the First Few Days of War in Ukraine Went Badly for Russia," Vox, February 28, 2022, https://www.vox.com/.
2. _Skrrq_, "Bayraktar—Official Song (English)," March 2, 2022, YouTube video, https://www.youtube.com/.
3. Florian Zandt, "Chart: 6.8 Million Seeking Refuge from Russian Invasion," Statista, June 2, 2022, https://www.statista.com/.

Civil War.[4] Even though Western intelligence agencies estimated Russia would control Ukraine within four to five days, Russian forces, as of October 20, 2022, failed to control more than the areas directly bordering Russia, including the oblasts surrounding Luhansk, Donetsk, Mariupol, and Kherson.[5] Moreover, Russia failed to seize and hold Ukraine's capital, Kyiv, Putin's main target.

Although this article is largely focused on offering readers an understanding of the drones impacting the battlefield in Ukraine, it is worth noting the role of drones is unsettled within the security studies literature. Some analysts argue drones are, in fact, a revolutionary technology.[6] Others disagree and suggest they play a lesser role in reshaping conflict.[7] The truth, however, is likely somewhere in between. The war in Ukraine is certain to provide greater clarity in understanding the role drones play in conflict in general. But this analysis does not take a position on this critical topic at this early stage of their use.

The article employs the Department of Defense definition of unmanned aircraft systems (UAS): "That system whose components include the necessary equipment, network, and personnel to control an unmanned aircraft."[8] The term *drone* is the common vernacular used to describe UAS.

Ukraine's Drones

When Ukraine gained independence from the Soviet Union in 1991, the country inherited an antiquated defense infrastructure that included more than 750 factories and 140 research institutes, representing 30 percent of the Soviet Union's defense industry.[9] After Russia's seizure of Crimea in 2014, the country accelerated the development of

4. Jason Breslow, "What the Lessons from Putin's War in Syria Could Mean for Civilians in Ukraine," National Public Radio, March 1, 2022, https://www.npr.org/; and Krystel von Kumberg, "Russian Counterinsurgency Doctrine during the Second Chechen War 1999-2009," *Georgetown Security Studies Review* (website), March 6, 2020, https://georgetownsecuritystudiesreview.org.

5. Mason Clark, "Russian Offensive Campaign Assessment," Backgrounder (Washington, DC: Institute for the Study of War, October 23, 2022), https://www.understandingwar.org/.

6. James Rogers, "Future Threats: Military UAS, Terrorist Drones, and the Dangers of the Second Drone Age," in *A Comprehensive Approach to Countering Unmanned Aircraft Systems* (Kalkar, Germany: Joint Air Power Competence Center, 2021), https://www.japcc.org/; James Rogers, "The Dark Side of Our Drone Future," Bulletin of the Atomic Scientist, October 4, 2019, https://thebulletin.org/; and Kerry Chavez and Ori Swed, "The Proliferation of Drones to Violent Non-State Actors," *Defence Studies* 21, no. 1 (2021), https://www.tandfonline.com/.

7. Antonio Calcara et al., "Why Drones Have Not Revolutionized War: The Enduring Hider-Finder Competition in Air Warfare," *International Security* 46, no. 4 (2022), https://direct.mit.edu/.

8. Chairman of the Joint Chiefs of Staff (CJCS), *Joint Air Operations*, Joint Publication 3-30 (Washington, DC: CJCS, September 17, 2021), https://www.jcs.mil/.

9. Christian Mamo, "Revitalizing Ukraine's Defense Sector, and with It, Its Military," Emerging Europe, March 26, 2021, https://emerging-europe.com/.

defense technologies and began to modernize the military.[10] These efforts included cooperating with many Western nations to acquire state-of-the-art military hardware and software. In this regard, Ukraine's homegrown military drone technology was relatively young when Russia invaded in February 2022.[11] Many drones Ukraine has deployed against Russia were purchased from foreign nations, with Turkey leading the list of suppliers before the start of the war.

Baykar Bayraktar TB2

The Baykar Bayraktar TB2 is a medium-altitude, long-endurance unmanned combat aerial vehicle that, according to the manufacturer, is capable of remotely controlled or autonomous flight operations. This immensely popular drone is manufactured by the Turkish defense company Baykar Defense.[12] The manufacturer's primary objective is to build a less expensive alternative to Western drones, primarily for the Turkish Armed Forces. Although it is not comparable to state-of-the-art American drones like General Atomics' MQ-9 Reaper or Northrop Grumman's RQ-4 Global Hawk, its appeal lies in a brutally efficient cost-benefit calculation on the battlefield.

The TB2 can fly for almost 24 hours at a maximum altitude of 25,000 feet. It is 6.5 meters (approximately 21 feet) long with a wingspan of 12 meters (approximately 39 feet) and a maximum take-off weight of 650 kilograms (1,433 pounds).[13] Commonly called the Bayraktar, it can be equipped with four laser-guided bombs. Notably, these bombs are proving incredibly effective against Russian tanks and other armored vehicles.[14]

Before its appearance in Ukraine, this drone was used in Syria, Libya, and Azerbaijan.[15] In 2019, the Armed Forces of Ukraine began acquiring the Bayraktar TB2S, then upgraded to the TB2 as a part of its military modernization program. [16] Outmanned, outgunned, and primarily relying on unbreakable resolve, Ukrainian forces have found this drone to be very effective as a force multiplier.[17]

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10. Ted Galen Carpenter, "Whitewashing Ukraine's Corruption," Cato Institute (website), April 6, 2022, https://www.cato.org/; and Liam Collins, "In 2014, the 'Decrepit' Ukrainian Army Hit the Refresh Button. Eight Years Later, It's Paying Off," The Conversation, March 8, 2022, https://theconversation.com/.

11. John Wendle, "The Fighting Drones of Ukraine," *Air & Space Magazine*, February 2018, https://www.smithsonianmag.com/.

12. Baykar Technology, "Bayraktar TB2," Baykar Technology (website), accessed September 21, 2022, https://www.baykartech.com/.

13. Baykar Technology, "Bayraktar TB2."

14. Christiaan Hetzner, "The Cheap, Slow, and Bulky Drones Taking Down Russian Armored Tanks for Ukraine," *Fortune*, March 4, 2022, https://fortune.com/.

15. Scott Crino and Andy Dreby, "Turkey's Drone War in Syria—A Red Team View," Small Wars Journal, April 16, 2020, https://smallwarsjournal.com/.

16. "Ukrainian Navy Has Received First Unit of Turkish-Produced Bayraktar TB2 UCAV System," Defense Express, July 18, 2021, https://en.defence-ua.com/.

17. Aaron Stein, "The TB2: The Value of a Cheap and 'Good Enough' Drone," Airpower after Ukraine series, Atlantic Council (website), August 30, 2022, https://www.atlanticcouncil.org/.

Several dozen TB2s are now thought to be in Ukraine's arsenal. They are used to disable multiple launch rocket systems and take out columns of armored tanks and personnel transporters.[18] In June, Ukraine may have also hit two oil depots well inside Russian territory using these drones, bringing the war behind the front lines and embarrassing Russia's air defenses.[19] These drones have also been used for reconnaissance and surveillance.[20]

But the TB2 has its limitations and is certainly far from invincible.[21] The exact performance of the drone is difficult to assess effectively given the proliferation of Russian disinformation and misinformation.[22] According to Russian-linked sources, TB2s are regularly shot down. Given the relative simplicity of the technology used in the TB2, the losses to advanced Russian air defenses are not unexpected. The balance between relatively inexpensive and more advanced drones may prove to be the most interesting aspect of Ukraine's use of the TB2.

Punisher

In addition to the TB2, the Ukrainian Army is using a small and nimble locally made drone known as the Punisher, which has successfully completed numerous missions against Russian forces.[23] The drone is designed and manufactured by UA Dynamics, a company operated by veterans of the Crimea conflict. The company describes the drone as "reusable, fast, unexpected, precise, lethal."[24]

The Punisher has a 2-kilogram (4.5 pounds) combat payload, 45-kilometer (28 miles) range, and 43-knot cruising speed. It has a 2.3-meter (6.5 feet) wingspan and can fly at 400 meters (1200 feet) altitude for missions of up to 90 minutes.[25] Their small size and low altitude allow them to reach deep behind enemy lines with little risk of detection before or during strikes and then return for a quick five-to-seven-minute servicing. This combination of characteristics has reportedly allowed Punisher drones to hit supply lines

18. Hetzner, "Cheap, Slow, and Bulky."

19. Andrew Roth, "Drone Crashes into Russian Oil Refinery in Possible Attack," *Guardian*, June 22, 2022, https://www.theguardian.com/.

20. Stavros Atlamazoglou, "Why the Bayraktar TB2 Drone Was Such a Game Changer in Ukraine," *1945*, May 31, 2022, https://www.19fortyfive.com/.

21. Dylan Malyasov, "Russia Shoots Down 6 Ukrainian Bayraktar TB-2 Drones," Defence Blog, April 28, 2022, https://defence-blog.com/.

22. "Turkish TB2 Falling Like Flies, Another Ukrainian TB2 Drone Shot Down by Russia," Defense View, July 27, 2022, https://www.defenceview.in/.

23. Alia Shoaib, "Ukraine's Army Is Using a Nimble 'Game-Changing' Drone Called the Punisher That Has Completed Scores of Successful Missions against the Russians, Says Reports," *Business Insider*, March 5, 2022, https://www.businessinsider.com/.

24. Bruce Crumley, "Ukraine's Mid-Size Punisher Drone Is Living Up to Its Name against Russian Forces," Drone DJ, March 8, 2022, https://dronedj.com/.

25. "Reusable Airstrike Drone with the Cheapest Cost of Mission in the World," UA Dynamics, March 31, 2022) https://uadynamics.com.

supporting Russian troops and strike ground vehicles and trains transporting fuel and other resources to these troops.

Quadcopter Drones

The Ukrainian Territorial Defense Force is training volunteers in tactics employing drones, including making and deploying Molotov cocktails in the battle against Russian forces.[26] Ukraine's DJI-inspired (DJI is a Chinese manufacturer of small quadcopter drones) drone added another dimension to Ukraine's defense. The drone is a quadcopter that can stay aloft while carrying a Molotov cocktail horizontally and is reportedly triggered remotely to drop the explosive. The front-loaded camera appears to be angled straight downward, possibly to offer a clear view of intended targets directly below.[27] The use of consumer drones by Ukrainian forces for attacking Russian troops rather than for surveillance is another indication of the innovative employment of drones generated by the war in Ukraine.

Interestingly, recent reports suggest DJI is supporting both Ukraine and Russia.[28] If these reports are accurate, it exemplifies the role affordable commercial drones can play and that their ubiquity may make it the combatant that most wisely and creatively uses drones the one that succeeds in conflict.

Warmate 1

The Warmate 1 is a microloitering munition developed by the Polish company WB Electronics. Vaguely plane-shaped with a centrally mounted wing and a v-tail, the drone weighs around 5.3 kg (12 pounds) and has a top speed close to 150 kilometers (93 miles) per hour. It can remain aloft about 70 minutes and has an operating range of approximately 15 kilometers (9 miles), line-of-sight with a payload capacity of 1.4 kilograms (3 pounds).[29] The drone's control system allows a single operator to fly it to desired locations autonomously or manually control it. Ukraine uses this drone for surveillance and reconnaissance and for attacking Russian positions.[30]

26. Illia Ponomarenko, "Who Can and Can't Join Ukraine's Territorial Defense Force," *Kyiv Independent*, January 7, 2022, https://kyivindependent.com/.

27. Ben Kesslen, "Ukrainians Develop Drone That Drops Molotov Cocktails," *New York Post*, March 10, 2022, https://nypost.com/.

28. "Chinese Drone Maker DJI Is Equipping Both Ukraine and Russia," SOFREP, August 18, 2022, https://sofrep.com/.

29. "The Warmate," WB Group (website), accessed September 19, 2022, https://www.wbgroup.pl/.

30. Jonathan Baran, "Kamikaze Drones Are Showing Up in Bigger Numbers in Ukraine," *Washington Post*, March 24, 2022, https://www.washingtonpost.com/.

Switchblade

In March 2022, the Biden administration provided Ukraine with American-made Switchblade kamikaze drones as part of a military aid package, transferring about 100 drones.[31] The Switchblade has two variants—the 300 and 600. The 300 is designed for pinpoint strikes on personnel, and the larger 600 is meant to destroy tanks and other armored vehicles.[32] The Switchblade's effect on the battlefield is unknown.

Tupolev Tu-141 Strizh

The Ukrainian arsenal also includes the Soviet-era jet-powered Tupolev Tu-141 Strizh drone, a large, high-altitude UAS. Even though the Tu-141 was designed to conduct reconnaissance, it can also attack enemy positions, though with little success in past wars. Despite the limited success of these drones in the past, Ukraine upgraded the platform and fielded a useful Tu-141 fleet after the Russian invasion in 2014. This UAS looks more like a cruise missile than a traditional drone. It is rocket launched from its trailer and flies a predetermined course at transonic speed.[33]

While flying a predesignated path, the Tu-141 can collect various forms of intelligence. After its flight, the drone launches a parachute for recovery, allowing it to be reused. This drone created consternation among NATO members in March 2022, when an armed Tu-141 flew from western Ukraine, crossed Romanian and Hungarian airspace, and crashed in Zagreb, Croatia.[34] No official statement came from the Croatian or Ukrainian governments regarding who fired this drone. According to a source close to the Ministry of Defense of Croatia, the crashed drone belonged to Ukraine and was carrying a bomb to strike Russia's positions but veered off course, ran out of fuel, and crashed.[35] As this article was going to press, Russia reported that modified versions of the Tu-141 struck two Russian airbases hundreds of miles from the Ukraine border.[36.]

31. Paul McCleary and Alexander Ward, "U.S. Sending Switchblade Drones to Ukraine in $800 Million Package," *Politico*, March 16, 2022, https://www.politico.com/.

32. Ken Dilanian, Dan DeLuce, and Courtney Kube, "Biden Admin Will Provide Ukraine Killer Drones Called Switchblades," NBC News, March 15, 2022, https://www.nbcnews.com/.

33. "TU-141 VR-2, Strizh (SWIFT)," Global Security (website), n.d., accessed October 27, 2022, https://www.globalsecurity.org/.

34. Tyler Rogoway, "Tu-141 'Strizh' Missile-Like Drone from the War in Ukraine Looks to Have Crashed in Croatia (Updated)," The Drive, March 11, 2022, https://www.thedrive.com/.

35. Radio Free Europe (RFE)/Radio Liberty's Balkan Service, "Drone That Crashed Last Month in Zagreb Was Carrying Explosives, Investigators Say," RFE, April 13, 2022, https://www.rferl.org/.

36. Patrick Tucker, "Explosions at Russian Air Bases May Change Several Nations' Calculations," Defense One, December 6, 2022, https://www.defenseone.com/.

Russia's Drones

Despite being the world's second-largest arms exporter and producing advanced air and space systems, Russia's drones are not among the most advanced in the world.[37] Still, in recent years, the country has appeared to be highly concerned about the importance of drones in modern warfare, and Russian interest in drone development has increased dramatically.

Obviously, Russia lags behind the West in this sector, both in commercial and defense technology. But based on its proven ability to develop complex air and space systems, Russia is expected to master the competencies required for designing and manufacturing highly capable drones. Currently, Russia is employing domestically produced drones in Ukraine, which has prompted many Western companies to cease cooperating with Russian firms. Moreover, sanctions in place now will likely hamper Russian efforts to catch up with Western and Chinese drone manufacturers, particularly as critical technology transfers remain part of the technology sanctions.

Kalashnikov Kyb

The Kalashnikov Kyb drone, introduced in 2019 by Zala Aero, is a blended wing-body drone with uplifted wingtips. The aircraft is more than a meter wide and a meter long with a flight duration of 30 minutes. It typically cruises at 80 kilometers (50 miles) per hour but can fly up to 130 kilometers (78 miles) per hour for short distances. It has a payload capacity of three kilograms (6.6 pounds).[38] Russia's ground forces started using this drone to attack targets in Ukraine soon after the invasion commenced. Ukrainian forces have recovered at least two of the Kyb drones—evidence that Russia is using them in its invasion.[39]

Eleron-3SV

The Russian company ENICS developed the Eleron-3SV drone in 2013. The drone conducts round-the-clock reconnaissance using optical and electronic tools and has an operating range of 25 kilometers (15 miles). It can remain in the air for two hours.[40] Eleron-3SV drones have operated in the Donbas region since 2015 and were used in the Syrian theater. Russia has employed these drones in Ukraine, and the Ukrainian Army has reported capturing two.[41]

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37. Samuel Bendett, "Where Are Russia's Drones?" Defense One, March 1, 2022, https://www.defenseone.com/.

38. "Loitering Munition: KYB-UAV," Zala Aero (website), 2022, https://zala-aero.com/.

39. Stefano D'Urso, "Russia Is Now Using Loitering Munitions in Ukraine," Aviationist, March 17, 2022, https://theaviationist.com/.

40. ENICS Aero, "ELERON–3—ЭНИКС," *ЭНИКС,* 2019, http://enics.aero/.

41. "Russian Eleron-3SV Drones Destroyed in Donbas," Inform Napalm, July 6, 2019, https://informnapalm.org/.

Orlan-10

The Orlan-10 drone is a medium-range, multipurpose UAS developed by the St. Petersburg-based firm Special Technology Center. This drone entered the war early, and Russia used it to attack Ukrainian military assets and for aerial reconnaissance and electronic warfare. For surveillance and reconnaissance purposes, this drone is usually used in a group of two or three.

The first drone is used for reconnaissance at an altitude of 1–1.5 kilometers (4,000 to 6,000 feet) above a target; the second drone is used for electronic warfare; and the third transmits surveillance information to the control center.[42] The drone has a maximum speed of 150 kilometers (90 miles) per hour and a combat range of 140 kilometers (80 miles). It can remain in flight for a maximum of 16 hours and has a service ceiling of 5,000 meters (15,000 feet). Its capabilities are not yet fully known but it serves in many of the same capacities as the previous drones described.

Forpost R

The Forpost R is a Russian license-produced version of the Israeli IAI Searcher II drone.[43] Forpost R has a maximum speed of 200 kilometers (120 miles) per hour, a mission endurance window of about 18 hours, and a service ceiling of 20,000 feet. This drone conducted its maiden flight on August 23, 2019 and joined the Russian Armed Forces in 2020. The primary objective of the Forpost R is to conduct reconnaissance, and the 500-kilogram (1200 pounds) air vehicle is equipped with improved radar identification equipment among other reconnaissance devices. On March 11, 2022, a Russian Forpost R drone was destroyed by Ukrainian forces. Ukraine's military claimed the drone crossed into Polish airspace before reentering Ukrainian airspace, where it was shot down.

Orion E

The Orion-E combat drone is considered Russia's best strike drone. Russian forces first used the Orion-E in combat in Syria against forces opposing the Assad regime.[44] The Russian Ministry of Defense even claimed that the drone has "fighter-like" capabilities.[45]

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42. "Orlan 10 Unmanned Aerial Vehicle," Air Force Technology, March 15, 2021, https://www.airforce-technology.com/.

43. "Russia Uses Forpost-R Armed Drone with Guided Missile to Destroy Rocket Launcher of Ukrainian Army," Army Recognition, March 13, 2022, https://www.armyrecognition.com/.

44. Mansij Asthana, "Tested in Syria, Russia's Very Own Combat Drone 'Orion' Ready for Action: Watch Now," *Eurasian Times,* February 24, 2021, https://eurasiantimes.com/.

45. David Hambling, "Russia Reveals New Drone Capabilities, Hinting at What It Could Bring to Bear in Ukraine," *Forbes,* December 23, 2021, https://www.forbes.com/.

Developed by Kronshtadt, the drone has two variants: the export variant called Orion-E and the Inokhodets variant used by the Russian military.[46] It is a middle-altitude, long-flight drone with a maximum flight altitude of about 8,000 meters (25,000 feet) and can remain in the air for up to 24 hours. The drone's cruising speed is up to 200 kilometers (120 miles) per hour with a maximum payload of 250 kilograms (550 pounds). It features a turret under the nose with electro-optical and infrared cameras, and it possesses a laser-target designator to deliver guided weapons.

The Orion-E can carry up to four air-to-ground missiles, and its arsenal includes the KAB-20 and KAB-50 adjustable aerial bombs, the UPAB-50 guided gliding aerial bomb, and the X-50 guided missile.[47] The drone is expected to field electronic warfare systems soon. Russia has not disclosed how many Orion drones it operates in Ukraine, but it has claimed the drone has been used to attack Ukrainian positions successfully. Simultaneously, online photographic evidence shows the Ukrainians shot down at least one Orion-E.[48]

As the previous discussion of Russian drones in Ukraine suggests, Russia's claims that it fields state-of-the-art drones are certainly questionable.[49] To suggest Russia lacks dominance may be a generous description of the state of Russian capabilities. Simply stated, Russian drones are rarely in evidence in Ukraine. This failure is leading to speculation among analysts that follow the war in Ukraine that Russian drones are being held in reserve for a later escalation in the conflict.[50]

Others suggest logistical issues constrain drone use—as evidenced by the widespread reports of abandoned and broken Russian military vehicles.[51] This is prompting some to conclude Russia may not be able to support drone operations in Ukraine. According to other experts, one of the biggest reasons may be a lack of trust in domestic technology in its early stages.[52]

The offensive use of drones by Ukraine and Russia is roughly equivalent, even though the impact on the battlefield for each nation is not. This is, in part, because Ukraine enjoys an advantageous position when it comes to counter drone technology. Defensive drone technologies evolved from costlier systems (surface-to-air missile radars used to detect

46. Linda Kay, "Russian Orion-E Drone Makes Its First Kill in Ukraine," Defense World, March 8, 2022, https://www.defenseworld.net/.

47. Kay, "Orion-E Drone."

48. Linda Kay, "Ukraine Shoots Down Russia's Israel-Origin Surveillance UAV That Entered Polish Airspace," Defense World, March 16, 2022, https://www.defenseworld.net/; and Emily Atkinson, "Ukrainian Troops Celebrate as They Shoot Down Russian Drone and Flip the Bird as It Falls from the Sky," The Independent, April 11, 2022, https://www.independent.co.uk/.

49. Sebastien Roblin, "Russia Has Big Plans to Become a Drone Superpower (Like Stealth Drones)," 1945, July 13, 2021, https://www.19fortyfive.com/.

50. Bendett, "Russia's Drones?"

51. Brendan Walker-Munro, "Why Have Russia's Killer Drones Failed in Ukraine?" Asia Times, March 30, 2022, https://asiatimes.com/.

52. Brendan Walker-Munro, "Drones over Ukraine: Fears of Russian 'Killer Robots' Have Failed to Materialize," The Conversation, March 29, 2022, https://theconversation.com/.

and destroy drones) to cheaper systems (directed energy and electronic warfare). Ukraine holds the advantage here because of its work with Western militaries and defense firms after the invasion of Crimea in 2014.[53]

The Russian defense sector's progress in drone development was stymied in recent years by technology embargoes by Western nations and the lack of a sufficient domestic industrial base. Ukraine's greater-than-expected logistical and technological support from Western firms post-Crimea, including in the drone and counterdrone areas, showed in the early months of Russia's invasion, where Ukraine held a distinct advantage.[54] Whether this advantage remains as the war turns into a protracted engagement is yet to be determined. Western assistance may or may not outpace Russian efforts to close the gap.

Countering Drones

Russia has deployed its advanced electronic warfare systems in Ukraine for comprehensive protection against air assets, including Ukrainian drones. Russian tactics have involved the simultaneous deployment of the Krasukha-2/4, R-330Zh Zhitel, and RB-301B Borisoglebsk-2 ground-based electronic warfare systems, which use a combination of jamming and spoofing.[55] Each system is designed to target a different element of the electromagnetic spectrum. Russia has also used these systems to conduct reconnaissance of Ukrainian radio communications, followed by interference once targets were identified.

The Ukrainian military has successfully hit some of Russia's electronic warfare systems. Moreover, they captured the command module of a Krasukha-4, considered the most advanced system developed by Russia.[56]

The Krasukha-2 system, also in the Russian arsenal, consists of three vehicles based on the Kamaz-6350 truck and can jam airborne warning and control systems at ranges of up to 250 kilometers (150 miles). It can also jam other airborne radars such as radar-guided missiles. The Krasukha-4 resembles the Krasukha-2 but can also effectively disrupt low-Earth orbit satellites and cause permanent damage to targeted radio-electronic devices.[57] The truck-based R-330Zh Zhitel system can interfere with satellite communications equipment, navigation systems, and mobile phones within a 30-kilometer (20 mile)

53. Josh Spires, "How Counter-Drone Systems Defeat and Destroy Rogue Drones," Drone DJ, December 20, 2020, https://dronedj.com/.

54. Vikram Mittal, "Puzzling Out the Drone War over Ukraine to Date, Russia Has Had Little to Show for a $9 Billion Investment in UAVs," Institute of Electrical and Electronics Engineers (IEEE) Spectrum, March 22, 2022, https://spectrum.ieee.org/.

55. "R-330 ZH Zhitel: Mobile Truck-Mounted Jamming Communication Station – Russia, Army Recognition, February 26, 2022, https://www.armyrecognition.com/.

56. Alia Shoaib, "Ukraine Captures Russian Hi-Tech Warfare System, Could Hold Military Secrets," *Business Insider,* March 26, 2022, https://www.businessinsider.com/.

57. Samuel Cranny Evans, "Russia Trials New EW Tactics," *Janes Defence Weekly,* June 14, 2019, https://www.janes.com/.

radius. Although these systems were not initially designed for counter-drone activities, they are useful if employed correctly.

Conclusion

Looking back on nine months of the war in Ukraine, it is evident the TB2 and other combat drones engaged in the conflict are making a useful contribution to the war. Yet, they are unlikely to be the deciding factor against a Russian army buoyed by greater manpower and long-range artillery.[58]

Still, as a result of the apparent success of its drone force, Ukraine is not only destroying critical targets but aiding in the degradation of morale among Russian forces. For Russian soldiers already struggling to rationalize their experience in Ukraine with the justification they were initially given for the war, adding the fear of attack from unseen drones only makes the anxiety of war more challenging. The fear of the unseen leads to a sense of helplessness, which diminishes hope. Thus, it should be no surprise that good order and discipline is often breaking down among Russian troops.[59]

The war in Ukraine clearly demonstrates drones are altering the dynamics of war. For Ukraine, airpower is largely taking the form of drones, a first for a large nation. Democratic and authoritarian regimes like Ukraine and Russia know that military drone technology is quickly becoming central to warfare. Given the relative cost-effectiveness of drones—compared to similar manned aircraft—they are challenging the existing assumptions about the use of airpower, allowing lesser adversaries to engage effectively in aerial warfare.

Turkey, the manufacturer of the most popular drone in Ukraine's arsenal, has a defense budget that is a fraction of that of the United States. Yet the country is still managing to develop and export highly capable and cost-effective drones. Turkey is accomplishing its success in the midst of a technological boycott by Western countries due to its role in Syria, Libya, and Azerbaijan.[60] If the first months of the war in Ukraine teach us anything about the present and future of drones in warfare, it is that they will appeal to countries that cannot afford costly manned fighters. The war between Armenia and Azerbaijan is already an example. These same states will rely on drones and develop new tactics, techniques, and procedures that employ them in unexpected ways.

58. Sean Hollister, "DJI Drones, Ukraine, and Russia—What We Know about Aeroscope," The Verge, March 23, 2022, https://www.theverge.com/.

59. Allison Quinn, "Russian Soldier Breaks Down: We Are Just Meat Here," Yahoo News, July 7, 2022, https://news.yahoo.com/.

60. "US Imposes Sanctions on Turkey over Russia Weapons," BBC News, December 14, 2020, https://www.bbc.com/.

Remotely Piloted Aircraft C2 Latency during Air-to-Air Combat

David L. Thirtyacre

Remotely piloted aircraft command-and-control latency could play a significant role during beyond-line-of-sight engagements in future conflicts. As the Air Force prepares to use these systems and artificial intelligence in within-visual-range combat, it must understand the effects of latency, or missing sensor data, during a dogfight. Research indicates technology-based latency influences the engagement outcome geometry similar to a slow decision-making cycle—foundational to the understanding of Boyd's Observe, Orient, Decide, Act (OODA) Loop. This study adds depth to the theory illustrating technology-induced latency has a similar effect as slow human decision making resulting in lower performance. Therefore, when combined with the human decision-making process, latency compounds the effect, resulting in significantly lower performance.

Military missions conducted by remotely piloted aircraft (RPA) continue to expand into all facets of operations, including air-to-air combat. While future within-visual-range (WVR) air-to-air combat will be piloted by artificial intelligence, RPAs will likely see combat first. Command-and-control latency could play a significant role during beyond-line-of-sight engagements. The study discussed in this article quantifies the effects of command-and-control latency on 1 v 1 WVR air-to-air combat success during high-speed and low-speed engagements.

The research, pursued in coordination with the Air Force Research Laboratory and the Air Force Warfare Center, employed a repeated-measures experimental design with variable latency to test the various hypotheses associated with beyond line-of-sight latency. Nellis AFB, Nevada, participants experienced in air-to-air operations were subjected to various latency inputs during 1 v 1 simulated combat using a virtual-reality simulator and were scored on the positional geometry of each engagement.

Background

Since the advent of the fighter plane in World War I, every Western-trained fighter pilot has learned the three axioms of air-to-air combat: (1) lose sight, lose fight, (2) maneuver in relation to the bandit, and (3) energy-versus-nose position. These three central themes permeate visual air-to-air combat tactics and describe the importance of analyzing the adversary's current position and state, executing offensive and defensive maneuvers based on the bandit's plane of motion, and making continuous decisions about conserving or exploiting energy.

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The common thread in these concepts is time. Losing sight of the adversary momentarily, maneuvering too early or late, or depleting energy at the wrong time all spell defeat in the dogfight. John Boyd codified these ideas in his Observe-Orient-Decide-Act (OODA) Loop theory—completing this faster than the adversary was the key to air-to-air combat success.[1]

Today, military aviation is increasingly expanding the use of remotely piloted aircraft into principal facets of military aviation. The MQ-1 Predator and MQ-9 Reaper have proven the utility of unmanned aircraft systems (UAS) in combat and have amassed millions of flight hours.[2] Since the 1995 introduction of the MQ-1 to the Bosnian theater of operation, the main mission of the medium-altitude, long-endurance RPAs has been intelligence collection and ground attack.[3] In the Department of Defense mission taxonomy, this includes intelligence, surveillance, and reconnaissance and close air support.

Despite not being designed or tasked for air-to-air combat, American RPAs have engaged in air-to-air combat, albeit on a limited scale.[4] The latency of command-and-control transmissions is an inherent drawback of these systems. While latency influences all teleoperations, the extent of the effect during within-visual-range air-to-air combat has not been explored. As the Air Force prepares to use RPA and artificial intelligence (AI) in WVR combat, it must understand the effects of latency, or missing sensor data, during a dogfight.

Requirements

Air-to-air combat typically requires a highly maneuverable fighter aircraft capable of transonic velocities that can sustain high acceleration loads.[5] These attributes are especially important during within-visual-range combat, where two aircraft are entangled in a rapidly changing, highly dynamic fight, each attempting to gain an advantage and employ ordnance. While there are reports of short skirmishes between American remotely piloted aircraft and manned enemy fighters, US RPAs were not well suited for such an engagement and were ultimately defeated.[6]

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1. Chuck Spinney and Chet Richards, eds., *John Boyd, Patterns of Conflict*, updated slide presentation, (Atlanta, GA: Project White Horse, February 27, 2005), http://www.projectwhitehorse.com/.

2. "MQ-1 Predator Unmanned Aerial Vehicle," Fact Sheet, Hurlburt Field (website), n.d., accessed October 24, 2022, https://www.hurlburt.af.mil/.

3. Robert B. Trsek, "The Last Manned Fighter: Replacing Manned Fighters with UCAVS" (master's thesis, Air Command and Staff College, 2007), https://apps.dtic.mil/.

4. John R. Hoehn, Kelley M. Sayler, and Michael E. DeVine, *Unmanned Aircraft Systems: Roles, Missions, and Future Concepts*, R47188 (Washington, DC: Congressional Research Service, July 18, 2022), https://www.everycrsreport.com/.

5. Michael Mayer, "The New Killer Drones: Understanding the Strategic Implications of Next-Generation Unmanned Combat Aerial Vehicles," *International Affairs* 91, no. 4 (2015), https://www.jstor.org/.

6. Hoehn, Sayler, and DeVine, *Unmanned Aircraft Systems*.

Medium-altitude long-endurance UAS such as the MQ-9 lack the attributes required to succeed in this dynamic air combat environment. Still, advances in unmanned aircraft system technology will inevitably yield an aircraft suited for WVR combat. As these fighter-unmanned combat aerial vehicles (F-UCAV) become operational, the opportunity for WVR engagements increases.

The first of these engagements will likely be between an F-UCAV and a traditionally occupied fighter aircraft in an area of responsibility far from the ground control station. Robert B. Trsek identified command-and-control delay as a major hurdle in F-UCAV air-to-air combat and concluded "it is presumptuous to assume that short-range engagements are a thing of the past."[7] But future "short-range engagements" will not look the same as they have in the past.

Future air-to-air engagements will include a mix of autonomous, remotely operated, small hypermaneuverable swarms and manned aircraft. This arsenal and the use of directed-energy and other advanced weapons should make the classic dogfight rare and only a last resort, especially in a conflict with a peer adversary. Still, the effects of latency in such a highly dynamic environment yield key insights into the decrease in human or AI performance with inaccurate or spoofed sensor data. The study isolated latency effects in a highly specific environment and should not be considered a prediction of the overall success of an air-to-air engagement.

Most combat missions employing medium-altitude, long-endurance UAS occur thousands of miles from the ground control station, using terrestrial and satellite communications architecture.[8] During these beyond-line-of-sight operations, the command-and -control signal from the ground control station must travel through terrestrial networks, be uplinked to a satellite constellation, and then downlinked to the UAS. Telemetry data and sensor information travel the same path in reverse before reaching the pilot in the ground control station.

This communication pathway injects latency between the adversary's true position and what is displayed to the pilot. This same latency occurs between the pilot's input and the aircraft receiving the command. Typically, in beyond-line-of-sight operations, the one-way latency can be as low as 0.25 seconds and as high as 1.0 seconds.[9] During completely autonomous AI operations, delayed, inaccurate, and jammed sensors will influence the fight, resembling command-and-control latency.

The latency can be applied to Boyd's OODA Loop as delays in observing, difficulty orienting, latent decisions, and delaying the act phase. The delay between the transmitted

7. Trsek, "Last Manned Fighter," 26.

8. Fubiao Zhang, Tim Fricke, and Florian Holzapfel, "Integrated Control and Display Augmentation for Manual Remote Flight Control in the Presence of Large Latency" (paper presented at the American Institute of Aeronautics and Astronautics Guidance, Navigation, and Control Conference, San Diego, CA: January 4–8, 2016), https://arc.aiaa.org/.

9. F. C. de Vries, *UAVs and Control Delays*, TNO report DV3 2005 A054 (Soesterberg, NL: TNO Defence, Security and Safety, September 2005), https://apps.dtic.mil/.

video/telemetry of the RPA and when the pilot receives this information corresponds to the observe phase. The delay between the RPA pilot making a flight control input and the aircraft receiving the command corresponds to the act phase (remote manipulation) in the OODA Loop. The sum of these two latencies is the total feedback loop latency induced by command-and-control transmission. But the effect of transmission latency while maneuvering against a changing target location adds another level of complexity, further increasing the error.

The review of relevant literature reveals a distinct gap: the effect of latency during highly dynamic maneuvering while both the vehicle and objective are rapidly changing parameters. This literature gap aligns with Boyd's OODA Loop theory, forms the theoretical construct of this study, and defines the independent variables.

The three research questions focus on the effects of latency while executing the phases of Boyd's OODA Loop theory and compare the results between high-speed and low-speed engagement entry conditions. The study focused on the control loop latency (input to feedback) in order to isolate the effects. The latency input through independent variable (IV) 1 can be seen as the delay from control manipulation to the aircraft movement plus the return delay.

Research question 1: To what extent do different levels of command-and-control latency affect combat success during 1 v 1, WVR, and air-to-air combat?

Research question 2: To what extent does initial engagement geometry/velocity affect combat success during 1 v 1, WVR, and air-to-air combat?

Research question 3: What is the possible interaction between command-and-control latency and initial engagement geometry/velocity during 1 v 1, WVR, and air-to-air combat?

Method

This quantitative research employed a repeated measures experimental design during air-to-air combat simulation. The design allowed multiple, randomized, single-blind treatments of each subject, including a no-treatment control measurement. Each subject experienced all six treatments for each type of engagement (high-speed and low-speed) assigned in the order specified through a balanced Latin square during a one-hour simulation session.

Population/Sample

All fighter pilots are trained in air-to-air combat, but the level of training and proficiency can vary depending on the aircraft and mission. To ensure tactical currency and maintain a homogenous population, participants were current fighter pilots who maintained flight currency in the past five years. All participants completed basic and advanced air-to-air training and achieved a qualification equivalent to four-ship flight lead (Air Force) or division lead (Navy and Marine Corps).

Only manned fighter pilots with air-to-air mission qualifications in aircraft such as the F-15C, F-15E, F-16C, F-18A-G, F-22, and F-35A-C were considered. Pilots who graduated from Navy Top Gun or the Air Force Weapons Instructor Course were preferred due to their advanced knowledge, training, and proficiency. The sampling strategy purposely selected participants from the sampling frame. The principal investigator-initiated selection ensured purposeful sampling was maintained (i.e., ensuring a mix of pilots from different fighter aircraft). (Information on participant prescreening, management, scheduling, and institutional review board authorization can be obtained from the author.)

Simulation

The experiment occurred in a purpose-built, unclassified simulator and induced a system delay. The Windows driver was delay-selectable, allowing an input range from 0.000 to 2.000 seconds in 0.001-second increments. The delay between the pilot controls and the simulation software allowed the investigator to manipulate IV 1.

The IVs, often referred to as the within-subjects factors, were the total round-trip latency (IV1) induced into the simulation system through the delay driver and the engagement type (IV2). The IV1 was operationalized by assigning the given latency to the delay driver. Independent variable 2 was the engagement entry geometry/velocity labeled high-speed or low-speed. The specific engagement type was operationalized by the engagement-starting parameters. The subjects experienced each engagement type six times, with the corresponding treatment of IV1 varying on each test run. Therefore, each subject completed 12 test runs during the simulation.

The dependent variable is the calculated combat score of the engagement. The score was derived from specific angles after the engagement.[10] While the computation of combat score does not directly measure combat success, it codifies the potentially offensive positional advantage. The combat score is, in effect, the normalization of a geometric relationship between the attacker and the target, where 1.0 equates to the optimal offensive position (i.e., the attacker directly behind and pointing at the target). A -1.0 combat score indicates the worst possible defensive position (i.e., the attacker directly in front of the target).

Data Collection Process

The experimental sequence consisted of 12 engagements with an approximate duration of 120 seconds each. Based on the field test results, the high-speed engagement concluded after 105 seconds, while the low-speed engagement concluded in 90 seconds. A 45- to 60-second rest period followed each engagement before the next run. For each engagement, one of the six preset latency categories was assigned through a balanced Latin square design until each subject on each engagement type experienced all latency levels.

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10. Heemin Shin et al., "An Autonomous Aerial Combat Framework for Two-on-Two Engagements Based on Basic Fighter Maneuvers," *Aerospace Science and Technology* 72 (January 2018), https://www.sciencedirect.com/.

The parameters of each engagement were closely controlled. The data runs for each fight category (i.e., high-speed and low-speed) began from the same starting point, altitude, and range saved in the primary test profile. But each engagement varied the adversary starting velocity vector, introducing slight differences in the engagement geometry; this input decreased predictability. The target and the attacking aircraft remained the same (airframe performance, visual depiction, and avionics) throughout all the test runs.

The high-speed simulation runs began with the attacker (subject) placed 3.5 nautical miles from the target aircraft with both aircraft pointing at each other at 450 knots true airspeed (KTAS), 20,000 feet above sea level. The low-speed engagements started from a 2000-foot line-abreast formation with both aircraft at 250 KTAS, heading in the same direction. These parameters resemble typical high-aspect WVR starting parameters. The adversary (target) flight artificial intelligence profile was set to expert, commanding the target aircraft to attempt to shoot the attacker with the gun throughout the engagement.

Each engagement concluded at a time specified by the field test. Since a combat score changes throughout the fight, angles and scores were assessed multiple times during the engagement. The assessment occurred near the end of the engagement and consisted of three measurements at start + 1:15, 1:30, and 1:45 for the high-speed engagements and start + 1:00, 1:15, and 1:30 for the low-speed engagements. The assessment times were determined during the field test. All engagements were recorded through the simulation system at a parametric update rate greater than 10Hz for post-test analysis and data collection. Researchers collected a sample of 29 participants, which included 348 separate and distinct engagements over the 12 IV combinations.

Results

The mean combat scores for each latency level are plotted in fig. 1.

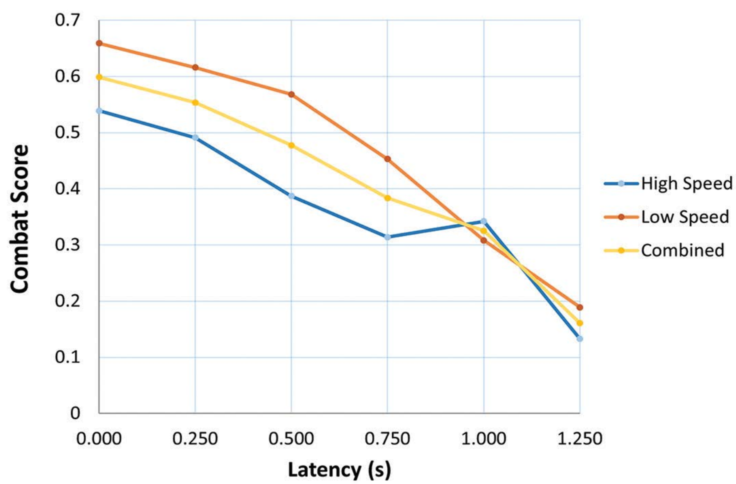

Figure 1. Mean combat scores by latency

The appropriate statistical assumption testing was completed for the two-way repeated measured design, including testing for outliers, sphericity, and normality. In some cases, statistical corrections were required in order to maintain the integrity of the statistical outcome. The two-way repeated measures analysis of variance (ANOVA) indicated a significant two-way interaction between the engagement speed and latency, indicating that the effect of latency on combat scores depends on the amount of latency and the starting velocity or geometry of the engagement. The experimental results were considered as individual functions of the independent variables (simple main effects) as well as combined (main effects).

Discussion

The results of this experiment clearly illustrate the effect of latency and engagement speed on combat success during a within-visual-range fight. But the experiment revealed several areas worthy of further examination, including the performance of the simulated aircraft and the theoretical and practical implications of the research. Before discussing the conclusions of this study, it is important to consider the performance of the simulated aircraft and adversary aircraft.

Performance

While the results of this study indicate pilots can still gain and maintain an offensive position even at the highest-tested latency, the simulated aircraft's superior performance must be considered. During the experimental runs, subjects often max-performed the aircraft, resulting in acceleration loads as high as 11.0 Gz, while the maximum observed adversary load was 7.3 Gz. This was especially true at higher latency levels when the pilots found themselves in poor tactical positions and used superior aircraft performance to outmaneuver the adversary.

A similar observation was present for the aircraft angle of attack. While the maximum observed angle of attack for the adversary was 25.2 degrees, the subjects routinely maneuvered the simulated aircraft to angles of attack greater than 35 degrees (indicated by a warning tone) and sometimes as high as 56 degrees.

Clearly, the simulated aircraft's superior performance influenced the combat outcome of the engagements. Still, this was an intentional aspect of the test plan designed to give pilots a maneuvering advantage resembling what an F-UCAV would provide. While the specific combat score was undoubtedly influenced by aircraft performance, it was apparent that the decrease in performance was present regardless of the F-UCAV's superior performance. Therefore, the conclusions of this study should be taken as combat effectiveness degradation (i.e., the difference between engagements without latency and those with latency) and not a specific value of combat success.

For example, if the combat engagement was between two evenly matched aircraft and pilots of similar skill, experience, and currency, the degradation due to latency would result in a negative combat score. The matched engagement would yield a combat score near zero when latency is not present. When a latency of 1.250 seconds is added to one of the aircraft, a decrease in the combat score of 0.406 should be expected during the high-speed engagement. *This degradation should not be taken lightly since this corresponds to a highly defensive position and would likely result in a combat loss.*

Effects of Latency

The data, observation, and engagement playback led to the conclusion there were several effects of latency with which the pilot must contend, including lift vector control, airspeed control, and general aircraft control. At lower latencies, the main obstacle was lift vector orientation and control. While the pilots may know where the optimal location of their lift vector should be, the latency caused them to either undershoot or overshoot the desired position (i.e., roll past the desired position).

As the latency increased, this issue was compounded, often leading to an orientation in the opposite direction than desired. Latencies of 0.750 seconds and above contributed to large variations in airspeed since the throttle and speed brakes were also delayed as part of the command-and-control link. These large-energy excursions led to a larger-than-desired turn radius or a lack of energy required to complete a maneuver. The airspeed control issues and poor lift vector control often resulted in difficulty controlling the aircraft.

The significant interaction effect indicates the effect of latency on combat scores depends on both latency and engagement speed. Further, it signifies latency does not similarly affect high-speed and low-speed engagements. Fig. 1 illustrates that during the low-speed engagements, the combat score decreased consistently with increased latency, while the high-speed engagements plateaued with latencies of 0.50, 0.75, and 1.00 seconds; there was no significant difference between combat scores at these latencies. The plateau is unique to this research and differs from ground vehicle teleoperations research.[11]

This result could be due to the geometry of the high-speed engagement that allows the pilot to maintain a turn with a constant plane-of-motion. During a turn with the lift vector orientation remaining constant, the latency is only perceptible while increasing or decreasing the turn rate of the aircraft (i.e., changing the acceleration load in Gz). This constant turn also occurred at a higher airspeed than during the low-speed fight, which allowed a higher sustained acceleration load. The higher loading (Gz) resulted in a higher sustained turn rate, allowing the pilot to remain in an offensive position while only adjusting the acceleration load. This conclusion was supported by observation during the engagements and the postflight review.

Overall, the reduction in the combat score was similar between the two engagement speeds. But the high-speed engagement experienced a total degradation of -.406, while the low-speed engagement decreased by -.470, as seen in fig. 1. This result indicates that latency had a larger effect on the low-speed engagement than on the high-speed engage-

11. David Gorsich et al., "Evaluating Mobility vs. Latency in Unmanned Ground Vehicles," *Journal of Terramechanics* 80 (2018), https://www.researchgate.net/.

ment. This is supported by the increased slope of the linear regression for the low-speed engagements as compared to the slope of the high-speed engagements. Additionally, while a significant difference existed between the engagement speeds at the lower latencies, the results showed no significant difference at latencies of 1.000 and 1.250 seconds.

Further examination reveals the advantages in combat scores of the low-speed engagements observed at low latencies did not carry over to high latencies. Observations during the simulation indicated early advantage in the low-speed engagements was centered around the superior simulated aircraft's angle-of-attack limit that allowed a higher-energy bleed rate at the start of the fight. This high-bleed rate slowed the simulated aircraft much faster than the adversary aircraft and resulted in a rapid offensive advantage.

This was evident during the engagement review, where pilots were consistently in an offensive position earlier during the low-speed engagements compared to the high-speed engagements. As the engagement continued, the early advantage of the low-speed engagement dissipated and was no longer statistically significant at the higher latencies.

Another point of discussion is the comparative decrease in combat scores between zero latency and 1.000 seconds. While the low-speed engagement score decreased by 0.351 in this region, the high-speed engagement only decreased by 0.197. The decrease in combat scores during the high-speed engagement was 44 percent less than the low-speed engagement. This result further indicates a significant advantage of engaging in a high-speed, two-circle fight when latency is present.

The research results clearly indicate a significant decrease in combat scores with increasing latency regardless of engagement speed. But several areas should be noted. First, there was not a significant difference between 0.000 and 0.250 seconds of latency for either engagement speed, indicating that delays up to 0.250 seconds did not affect the aircraft position after the engagement. This was true through an analysis of both the main effects and simple main effects. Observation also supported that the 0.250-second delay was acceptable and often unnoticed by the subjects. This result is similar to research that found no significant difference between zero latency and 0.2 seconds of latency for trained subjects.[12]

During the high-speed engagements, no significant difference existed between 0.000, 0.250, and 0.500 seconds of latency, although the mean combat score decreased. The standard deviations indicate a larger variance associated with the high-speed engagements than the low-speed engagements that influenced the p-value. The higher combat score deviations could be due to the subject's initial merge gameplan and geometry during the high-speed engagements that allowed more tactical options (variations) than the low-speed fight. Interestingly, the higher variation during the high-speed engagements occurred at lower latencies and resembled low-speed engagements at high latency.

12. Gorsich, "Mobility vs Latency," 11–19.

Conclusion

The theoretical foundation of this study was Boyd's OODA Loop. While the original construct of the OODA Loop theory was based on making tactical decisions faster than the adversary, this study indicates technology-based latency influences the engagement outcome geometry similar to a slow decision-making cycle. This is foundational to the understanding of the OODA Loop since, in its original form, it described the human decision-making process where the individual observes an action, orients based on knowledge and previous experience, decides on an action, and executes the action.

This study adds depth to the theory illustrating that technology-induced latency has a similar effect as slow human decision making, resulting in lower performance. Therefore, when combined with the human decision-making process, latency compounds the effect resulting in significantly lower performance.

The current understanding of the OODA Loop process was that command-and-control latency would only affect the observe and act phases of the OODA Loop. But this study indicates latency affects the entire OODA Loop and that the orientdecide-act process was particularly influenced. The pilots' ability to maintain congruency between orientation and action proved more difficult as latency increased. This caused the pilots to spend most of their time in the orient, decide, and act phases while occasionally returning to the observe phase. An analogy would be that the pilots were stuck in a dountil loop between orientation, decision, and action (fig. 2).

The do-until loop was continued until the action determined in the decide phase was satisfactorily completed. Other latency studies identified the move-and-wait strategy to compensate for delays in command and control; the effect seen in this study could be interpreted as a dynamic move-and-wait.[13]

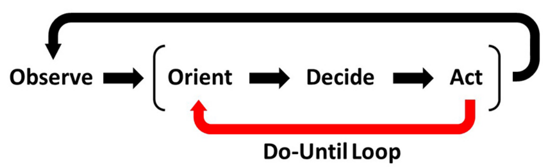

Figure 2. Do-until loop acting internal to OODA Loop process

The study revealed several practical outcomes that are of particular interest. Although the study showed a significant decrease in a combat score with increased latency, pilots could maintain an offensive advantage even at the highest tested latency. As mentioned above, this could be partially attributed to the superior performance of the simulated

13. Justin Storms, Kevin Chen, and Dawn Tilbury, "A Shared Control Method for Obstacle Avoidance with Mobile Robots and Its Interaction with Communication Delay," *International Journal of Robotics Research* 36 (2017), https://journals.sagepub.com/.

aircraft but also supports the conclusion that given enough performance advantage, an offensive position is possible even with a 1.250-second latency.

The field test results effectively bounded the upper limit of latency based on manual aircraft control. When latencies of 1.500 seconds and above were tested, severe aircraft control issues emerged, often resulting in ground impact during engagements. Conversely, the experimental results revealed that a latency of 0.250 seconds was not significantly different from the combat scores without latency. These results support the conclusion that command-and-control latencies of 0.250 seconds and below are acceptable and latencies above 1.250 seconds are unacceptable for a manually controlled aircraft. The results also support the conclusion that latencies greater than 0.250 seconds but less than 1.250 seconds may be at least partially offset by superior aircraft performance during high-speed, two-circle engagements and low-speed, one-circle engagements.

The experimental results showed no significant difference in combat scores between zero latency and 0.500 seconds of latency during the high-speed, two-circle fight. Also, the results displayed no significant difference between 0.500 and 1.000 seconds of latency for the high-speed fight. A possible conclusion from these results is that the two-circle fight is less susceptible to degradation due to latency. This conclusion is supported by observation during the experiment that orientation and maneuvering were easier during the two-circle fight versus the one-circle fight, where the lift vector orientation changes rapidly. The practical application of these results is that when latency above 0.250 seconds is present, the two-circle fight is desired over the one-circle fight.

Given that latency-induced control issues with lift vector orientation and airspeed were major obstacles, F-UCAV command-and-control design should consider automating these inputs. The airspeed could be controlled or limited onboard the aircraft by following an optimum maneuvering energy profile to eliminate extreme cases of airspeed mismanagement. The lift vector control issues could be reduced by implementing a predictive algorithm based on current aircraft performance, pilot control input, and measured latency. This would result in a predictive display, allowing the pilot more precise control when orienting the lift vector.

In a few cases, subjects achieved very high combat scores even at the highest tested latency. One subject achieved an average engagement score of .668 with a latency of 1.250 seconds. Results like this indicate that pilot technique may play a larger role than expected in countering the latency effects and should be explored in future studies.

The study's final and ancillary practical contribution demonstrated that a properly configured virtual reality simulator can produce an effective air-to-air training environment. While not the purpose of this experiment, the simulation provided an effective and efficient environment for practicing manual flight skills. Pilot comments, subject matter experts, and other simulation and aviation experts during the experiment support this conclusion. While this study intentionally excluded several variables such as sensors, weapons, weapon cueing, and weapon performance to isolate the pilot's ability to maneuver to and remain in the control zone, the research shows the first step in developing tactics to overcome latency is understanding how latency affects the basic fighter maneuvers.

Refocusing Reapers

Tangible Improvements Today That Prepare for the Future

Geoffrey T. Barnes

Numerous entities internal and external to the conventional remotely piloted aircraft community have enthusiastically promoted MQ-9 utility in a post-Global War on Terrorism world, however the platform has been aggressively targeted for retirement. A two-stage approach will refocus MQ-9 training and development efforts for the remainder of its life to wring additional value from the weapon system and accelerate changes to meet future challenges.

In the wake of the 9/11 terrorist attacks, the US Air Force found itself without aircrew, aircraft, or a methodology for embarking on the massive airborne man-hunting mission that became characteristic of the Global War on Terrorism (GWOT). Seemingly overnight, a General Atomics demonstration aircraft was mass produced as the RQ-1. This platform was paired with an assortment of pilots and intelligence analysts to create the world's first remote combat aviation force, charged with satisfying near-infinite demands for airborne intelligence, surveillance, and reconnaissance (ISR), and precision strike.[1]

For nearly two decades, a firehose of contingency funds quenched flaming capability gaps in the hardware and software of remotely piloted aircraft (RPA) weapon systems, and aircrew continuation training was eclipsed by operational requirements.[2] In parallel, the highly directive and dynamic nature of the typical GWOT customer eroded mission planning skills and mission ownership culture at the squadron level. The result was a force proficient only in a narrowly scoped mission, highly dependent on external acquisition, operational design, mission planning, and command and control, yet fluent in change adaptation.

The *2018 National Defense Strategy* received a warm welcome in the conventional RPA force, harkening a return to traditional designed operational capability missions such as air interdiction and strike coordination and reconnaissance.[3] Friction arose as the force struggled to train for doctrinal air-to-ground missions with scant training resources while still shouldering 24/7 support to special operations GWOT missions.

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1. Richard Whittle, *Predator: The Secret Origins of the Drone Revolution* (New York: Picador, 2015).
2. Bernard D. Rostker et al., *Building toward an Unmanned Aircraft System Training Strategy* (Santa Monica, CA: RAND Corporation, 2014), https://www.rand.org/.
3. James N. Mattis, *Summary of the 2018 National Defense Strategy: Sharpening the American Military's Competitive Edge* (Washington, DC: Department of Defense, February 2018), https://dod.defense.gov/.

As the Air Force slowly pivoted to support US competition with other powerful states, the conventional MQ-9 community tried to align by demonstrating its ability to perform doctrinal missions in training environments. Decisionmakers proposed 4th generation plus versions of the Reaper that would attempt to survive in moderately contested areas.[4] Several individuals external to the force published strong arguments for MQ-9 viability in state competition and emerging missions.[5]

Unfortunately, the community has largely encountered tepid enthusiasm from customers in the combatant commands, and the firehose of acquisition funds has slowed to an intravenous drip.[6] The Air Force's vision for unmanned aircraft systems appears bifurcated on small numbers of expensive multimission vehicles operated in the traditional 1:1 crew/platform ratio and artificial intelligence-enabled teaming at the formation level with 5th or 6th generation fighters.

Christian Brose describes the dangers of this vision but also advocates for divestment of legacy platforms, a family to which the MQ-9 belongs.[7] Thus the outlook for today's conventional RPA units is that they will be left without a chair when the GWOT music finally comes to an end, leaving a highly experienced remote combat workforce—the most valuable component of the weapon system—in limbo until the Air Force executes the planned 2035 retirement of the MQ-9. Is half-hearted training against doctrinal missions, waiting for "MQ-next," and hoping it is what combatant commands need, the best use of time and effort?

This article proposes a path to significantly improve MQ-9 value to combatant commands today, while simultaneously preparing its people and processes for the future by developing adaptable leader-aviators and leveraging the intrinsic strengths of the weapon system design.

Stage 1: Reimagine and Refocus

You can't just ask customers what they want and then try to give that to them. By the time you get it built, they'll want something new.

Steve Jobs

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4. John A. Tirpak, "Air Force to Upgrade MQ-9's Mission and Capabilities for Near-Peer Fight," *Air & Space Forces Magazine*, April 21, 2021, https://www.airforcemag.com/.

5. Thomas Mahnken, Travis Sharp, and Grace Kim, *Deterrence by Detection: A Key Role for Unmanned Aircraft Systems in Great Power Competition* (Washington, DC: Center for Strategic and Budgetary Assessments, April 14, 2020), https://csbaonline.org/; and Lawrence A. Stutzriem, "Reimagining the MQ-9 Reaper" Policy Paper, vol. 30 (Arlington, VA: The Mitchell Institute, November 18, 2021), https://mitchellaerospacepower.org/.

6. Brendan W. McGarry and Emily M. Morgenstern, *Overseas Contingency Operations Funding: Background and Status*, R44519 (Washington, DC: Congressional Research Service, September 6, 2019), https://sgp.fas.org/.

7. Christian Brose, *The Kill Chain: Defending America in the Future of High-Tech Warfare* (New York: Hachette Books, 2022).

The disparity between MQ-9 proponents and opponents is that the former sees capability and potential whereas the latter sees cost without benefit and vulnerability. For any mission, commanders can certainly accept higher risk with an unmanned aircraft, however the operator community appears to fall short in selling the benefits of doing so. Why task an MQ-9 to bring a few thousand pounds of ordinance to a target in contested space when a variety of air-, land-, and surface-launched fires can achieve effects faster and without a sensational shoot-down incident?

While an RPA training exercise may demonstrate fantastic doctrinal air interdiction mission execution in an operationally representative context, the value proposition to the customer is essentially a low-speed reusable cruise missile. MQ-9s can also perform strike coordination and reconnaissance, but the commonly advertised advantage—that a crew removed from the flight environment can organize, sort, and task targets more effectively than a manned aircraft—is undocumented and likely not accepted outside the RPA community.

Generally, the roots of weak MQ-9 customer demand in the peer competition market lie in failing to embrace its unique strengths and in some cases suppressing them. Rather than shackling to specific doctrinal mission sets, the MQ-9 should present for the remainder of its service life as a flexible long-range/endurance find-fix-track (F2T) system that provides a modest array of immediate kinetic response options. Furthermore, the potential strengths of the ground-based cockpit need to be explored instead of ignored to identify costs and benefits of beyond-line-of-sight (BLOS) connectivity in either manned or unmanned system contexts.

Train, Plan, and Lead

The F2T task spans mission boundaries, answering fundamental questions about the battlefield.[8] The RPA's demonstrated ability to conduct high-fidelity intelligence, surveillance, and reconnaissance across the electromagnetic spectrum thousands of miles from its base without personnel recovery needs is unique in the Air Force inventory. But MQ-9 crews are undertrained, and accountability for mission accomplishment is disaggregated across multiple organizations with competing agendas. Conventional MQ-9 continuation training programs are largely devoted to single-ship weapon employment, disregarding the bulk of knowledge and skills required to close a kill chain. MQ-9 crews need significantly more training on tasks only they can do, at a speed that keeps pace with a dynamic battlespace.

This training starts with airspace access, underpinned by aircrew proficient in planning and flying anywhere in the world, in military or civil airspace, with minimal notice. Self-imposed limits on operating areas, long lead times for new areas, and reliance on external planning support tells customers that remote aviation is inflexible, and it enables planning

8. LeMay Center for Doctrine Development and Education (LeMay Center) *Targeting*, Air Force Doctrine Publication 3-60 (Maxwell AFB, AL: LeMay Center, November 12, 2021), https://www.doctrine.af.mil/.

activities to be consolidated in a few personnel to the detriment of the larger force. The consequence is that the majority of the force cannot begin a new operation until the few experts have distilled and taught the procedures and shouldered self-imposed squadron-level reference material burdens.

Once in the tactical segment of the mission, MQ-9 units need additional training to organically plan, execute, and debrief ISR to their aircraft's maximum potential, skills which atrophied in GWOT where customers' ISR tactical coordinators (ITCs) performed those functions and fed direction to the crew.[9] Some have publicly questioned GWOT targeting practices that trace back to Special Operations Forces' Bosnian war criminal hunting in the late 1990s.[10]

Regardless of the efficacy of these practices, the conventional MQ-9 force has never rallied to take ownership and potentially improve GWOT targeting, despite their platform being the center of it. Mission ownership, not to be confused with formal supported/supporting unit relationships, has languished.

Under the typical GWOT operation, conventional MQ-9s supported task forces or strike cells charged with relatively narrow objectives, which frequently involved a kinetic strike and obvious indicators of mission results. The system was effective in removing terrorists from the battlefield, but it fostered an atmosphere where aircrew were prone to taking direction blindly from external intelligence or fires coordinators and thus abdicating their responsibility for mission failure or success. [11]

As these crews transition to executing predominantly ISR in the broader mission objectives of state competition, they find themselves members of a loose group, together with representatives from various sensor payloads, analysts, and operations center staff, where mission results and accountability for outcomes is nearly impossible to determine. While it may be tempting to reboot the ITC, adding another human to an already confusing structure of job titles and text chat windows will not improve effectiveness.

Instead, conventional RPA needs to reboot the ownership that the supported units exercised through ITCs, at the pilot-in-command level, and promote it at all levels of command.[12] A focus on the core strengths of aviation knowledge and skills, ISR expertise, and mission ownership will build airmanship that is timeless, platform independent, and crosses doctrinal mission boundaries. Critical details unique to specific missions will still need attention but given the high level of education across the ranks, digesting a Joint

9. Kenneth J. Hintz, *Sensor Management in ISR* (Norwood, MA: Artech House, 2020), chap. 7.

10. Joe Ritter, "Getting Drones Ready for Conventional War," War on the Rocks, June 20, 2022, https://warontherocks.com/; and Sean Naylor, *Relentless Strike: The Secret History of Joint Special Operations Command* (New York: St. Martin's Griffin, 2016).

11. Hearing before the Senate Committee on the Judiciary on 'Targeted Killing' and the Rule of Law: The Legal and Human Costs of 20 Years of US Drone Strikes, 117th Cong. (February 9, 2022) (statement of Nathan A. Sales, former ambassador-at-large and Coordinator for Counterterrorism), https://www.judiciary.senate.gov/.

12. Don J. Yates, "The ISR Traffic Jam: How to Improve ISR Operations in USINDOPACOM (master's thesis, US Naval War College, May 10, 2021), https://apps.dtic.mil/.

service tactics publication and platform-specific content should be feasible in the weeks leading up to a new tasking.

Consequently, the goal of aircrew development for the remaining MQ-9 service life should shift away from building experts in its designated operational capability mission sets of questionable utility to building adaptable, platform-agnostic remote combat aviators and leaders. For leadership, the challenge will be striking balance between traditional readiness metrics and a more subjective assessment of a unit's critical thinking, planning, and execution in response to unforeseen operational requirements. A force proficient only in kinetic portions of the mission will be hollow if the crews cannot efficiently get the aircraft to a new fight and independently close kill chains.

Ground-Based Cockpit

Remotely piloted aircraft offer the unique ability to bring unprecedented data, connectivity, and processing directly to the tactical edge via the command-and-control link. Although these links have been highlighted as a vulnerability baring RPA from major combat operations, growth in commercial space launch capacity and bandwidth availability challenge this claim even before intersatellite links and quantum cryptology are fielded.[13] Small numbers of flagship communication satellites in geosynchronous orbit have been joined by thousands of low-cost analogs in low Earth orbit, obfuscating jamming targets and blunting the threat of direct-ascent antisatellite missiles.

Meanwhile, the theoretically infinite network access and processing power that is possible in the RPA cockpit has been largely ignored and, in some cases, suppressed in future hardware design or operating principles in pursuit of a flying experience characteristic of a bygone era. The RPA cockpit today can funnel data from a wide variety of classified and open sources including signals intelligence, synthetic aperture radar, electro-optical imagery, and more, commonly referred to as national tactical integration.[14] This data is frequently available in graphical user interfaces with minimal training requirements, poising the RPA to become a desirable source of situational awareness over the battlefield vice a sink.

The RPA cockpit also enjoys reach-back to the entire Intelligence Community via web, voice, and text chat communication systems. MQ-9 aircrew and organic intelligence professionals should begin developing operating procedures immediately that integrate internet-derived data in all mission segments, from real-time weather to potential target locations, to friendly force disposition with an eye towards increasing Joint Force situational awareness regardless of mission set.

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13. Sandra Erwin, "Interoperability Demo Planned between DARPA's Blackjack and PredaSAR Satellites," Space News, December 16, 2021, https://spacenews.com/; and Denis Mandich, "Quantum Encryption: The Basics," *Infosecurity Magazine*, February 14, 2022, https://www.infosecurity-magazine.com/.

14. Lisa Crawford, Jeanette Rankin, and Ronald II Mims, "Air Force National Tactical Integration (AF NTI) FOCUS 2013 Planning Working Group (PWG) – Observation Handbook and Presentations" (SURVIAC, May 30, 2013).

Further, the MQ-9 community should strive to become an active participant in a real-time intelligence ecosystem, utilizing wide-area apertures to inform search areas, consequently improving target fidelity with onboard sensors and improving confidence through sensor fusion or complementary collection geometry. This also provides a forum for efficient tasking and cross-cueing while airborne. The community should also replace 4-way intersections and traffic cops with traffic circles.[15]

Lastly, the RPA force should significantly increase integration with practitioners of software-defined, wirelessly delivered effects to explore true "tactical cyber" applications in doctrinal mission sets and beyond.[16] Lessons learned pursuing these improvements with MQ-9s can be directly applied to the next generation of RPA or indirectly to future autonomous combat aircraft development.

The ground-based cockpit, and more generally, ability of an attack squadron to present forces remotely from a static CONUS location unlocks agile combat employment on a global scale. In theory, it allows MQ-9 capacity to reflow to alternate locations in only the time required for aircrew to digest local aviation and military directives, plan the flight, and reconfigure network settings.

In practice today, MQ-9s fully meet the core agile combat employment elements of posture, command and control, and movement and maneuver, and are actively improving protection and sustainment as defined by Air Force Doctrine Note 1-21.[17] MQ-9 agile combat employment can be further developed for contingency response by discretizing the flight and providing just-in-time training for essential tasks.

For example, if a regional crisis erupts in an unfamiliar operating area over which a squadron's RPAs are tasked to provide real-time ISR and immediate kinetic response options, the first wave of crew members would plan and execute enroute procedures to get sensors in the area as soon as possible. During the transit, a second wave of crews would plan the tactical ISR segment and swap in when the aircraft arrives on station. Over the course of only a few days, the cycle would continue with successive personnel shifts building upon the lessons learned from the previous.

Concurrently, a separate cadre would develop a concept of fires, rehearse in simulators, and remain on call for weapon employment for the duration of the operation or until enough crews were trained to provide coverage. The intent is not to turn every new operation into a pick-up game but replace an all-or-nothing training mentality with a tailored approach that is resilient to unforeseen mission requirements and leverage unique RPA strengths in agile combat employment. Developing squadron-level agile combat employment skills now will improve MQ-9 utility to combatant commands and establish a foundation for subsequent platforms.

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15. Yates, "ISR Traffic Jam."

16. Isaac R. Porche III et al., *Tactical Cyber: Building a Strategy for Cyber Support to Corps and Below* (Santa Monica, CA: RAND Corporation, 2017), https://www.rand.org/.

17. LeMay Center, *Agile Combat Employment*, Air Force Doctrine Note 1-21 (Maxwell AFB, AL: LeMay Center, August 23, 2022), https://www.doctrine.af.mil/.

Stage 2: Accelerate Change

If it feels comfortable, you're doing it wrong. We need to kill set-and-forget tendencies.

General Charles Q. Brown Jr., USAF

As the RPA community remains sandwiched between satisfying mission requirements today and meeting readiness requirements for tomorrow, the community should see value in regular exposure to combat theaters, embrace residual GWOT operations as a tactics sandbox, and capitalize on these as opportunities to pull advanced concepts and capabilities to the battlefield.

An Excellent Pickup Truck

Plank holders of the RPA enterprise remember the RQ-1 as a concept demonstrator that was directly fielded despite glaring human-machine interface issues and performance gaps.[18] While some tend to view that as an isolated uncomfortable event, where is the guarantee it won't happen again? What can the force do to hedge against a repeat?

The conventional Reaper force can provide a nurturing environment for high-readiness developmental efforts, regardless of the intended host aircraft. Numerous MQ-9 characteristics make it ideal for rapid modification: low speed and low acceleration (small performance envelope and test burden), nonlow-observable (no outer mold line to maintain, simple external carriage), large electrical generation capacity, long range and endurance, low cost per flight hour, and large number of domestic and international operating locations (opportunities for operational utility evaluations).

More importantly, after a decade of spiral development in pursuit of GWOT objectives featuring many niche or small-batch systems, MQ-9 aircrew are perhaps the most familiar in the Air Force with implementing new capabilities. In 2014, US Special Operations Command embarked on an agile acquisitions program anchored on operational flight program updates in six-month increments, delivering 50 new system-level capabilities in just the first three years.[19]

The adaptable aircrew/aircraft team coupled with a focused rapid development effort offers several advantages. This combination exposes today's aircrew to new systems and operating concepts, introduces emerging capabilities to current operational environments, and provides a surrogate to preserve signature or airframe time on classified platforms.

As a peripheral benefit, US Special Operation Command's MQ-9 program fostered collaboration between operators, acquisition professionals, and industry throughout the development process. Each operational flight program release improved the final deliverable, reduced training time for line aircrew, and reduced the number of discrepancy reports. Lastly, the current MQ-9 force laydown offers numerous opportunities to expose

18. Whittle, *Predator*.

19. Andrew Smith, "Agile Values in the MQ-9 Reaper's Software Development," *Defense Acquisition Magazine* (blog), September 1, 2018, https://www.dau.edu/.

new capabilities to operational environments. Even if an operating location is currently supporting counterviolent extremism organization missions and will not interact with an advanced adversary, core F2T functions cross mission boundaries such as mobile target tracking in complex terrain. A system's introduction in an unplanned use case may reveal unexpected value.

Humans and Hardware of the Future Force

Numerous combat experiences with silver bullets including air-to-air missiles, helicopters, and low-observable aircraft have shown that over-reliance on technological solutions can hinder flexibility and foster apathy.[20] US military culture in the last century has also shown that disruptive technologies can be resisted in the absence of a crisis or until significant time and effort generates overwhelming proof of utility.[21]

To preempt both unhealthy behaviors, the conventional MQ-9 force should regularly observe and advise developmental activities far upstream of operational fielding. The first goal is to improve end-item quality by incorporating line operator inputs early in the acquisition process when changes are far easier to make, exposing acquisition professionals and vendors to operational problems. This is not to say the program should be steered to solve today's problems but to ensure they are not duplicated by distilling tactical vignettes into fundamental tasks that are or are not being adequately addressed with today's systems.

The second goal is to season remote aviators with advanced technology early in their career to build deeper understanding and confidence, since they will be the ones leading its implementation later. In the case of the MQ-9, large portions of the force struggled to embrace automatic checklists and automatic takeoff and land capability. If the community cannot trust and utilize this relatively low level of automation, how can it be expected to trust and utilize any number of revolutionary autonomous unmanned airfcraft system concepts currently in development? Junior remote aviators should not only strive to master their trade as it exists today but be cognizant of how it could be made more efficient and/or lethal tomorrow.

Solve Joint Force Problems

Traditional Air Force large force exercises such as Red Flag certainly improve aircrew skills and unit-level planning expertise for designated operational capability missions. But the Reaper community has struggled to demonstrate value in these exercises, remaining firmly associated with the GWOT and aggressively targeted for divestment.[22] This

20. Pete Blaber, *The Mission, the Men, and Me: Lessons from a Former Delta Force Commander* (New York: Dutton Caliber, 2017).

21. Brose, *Kill Chain*.

22. Hearing before the Senate Appropriations Committee, Subcommittee on Defense on Weapons Systems Divestment, 117th Cong. (July 21, 2021) (statement of David S. Nahom), https://www.appropriations.senate.gov/.

contrasts sharply with the potential offered by an adaptable force flying adaptable aircraft, which was recently observed in US Naval Forces Europe's BALTOPS 22 exercise.

In the scenario, a fictional malign state seizes an Ally nation's coastal territory, driving a US-led amphibious assault with NATO support. US Air Force MQ-9s participated primarily in a close air support role but offered little unique value to the combined task group's organic AH-1, UH-1, AV-8B, and surface-based, land-attack capabilities. Meanwhile, the Ally fleet consisting of dozens of vessels and thousands of personnel was held at risk by an unknown number of camouflaged coastal defense cruise missiles similar to Russia's controversial Club-K launchers disguised in intermodal shipping containers.[23]

Closing an F2T2EA cycle on this "new" threat poses significant challenges: collecting signatures of targets in ubiquitous form factors, identifying patterns of life that separate them from surroundings, persistent surveillance, and immediate availability of fires when the target has been fixed—in other words, exactly the challenges the MQ-9 and its crews have been successfully overcoming for nearly two decades. Narrow focus on designated operational capability mission training turned BALTOPS 22 into a missed opportunity for crews to leverage decades of proven tactics against today's emerging battlefield problems.

Had the coastal defense cruise missile hunt required collection of a new signature, the MQ-9 would have offered several internal and external interface options for new sensor integration. Opponents will point out that mission success in this scenario is contingent upon permissive airspace. While true, this does not reduce relevant participation in that the MQ-9 creates an instantly useful capability if paired with suppression of enemy air defense and prepares crews and tactics that can be used on future survivable platforms for a similar mission. In either case, approaching current operations and large force exercises with a team-oriented, problem-solver mentality will reveal desperately needed, creative solutions given current fiscal, logistical, and technological constraints.

Conclusion

Numerous entities internal and external to the conventional RPA community have enthusiastically promoted MQ-9 utility in a post-GWOT world; however, the platform has been aggressively targeted for retirement. Without a clear vision for force development in the remaining years, thousands of highly experienced remote combat aviators will tread water with residual counterviolent extremist operations and training for improbable missions. This will continue until one of two events occur: an abrupt transition to "MQ-Next" subject to crew complement or reassignment after conventional RPA are abandoned in favor of low-quantity expensive, multimission unmanned aircraft systems and attritable "loyal wingmen."[24]

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23. Robert Clarke, "The Club-K Anti-Ship Missile System: A Case Study in Perfidy and Its Repression," *Human Rights Brief* 20, no. 1 (September 30, 2012), https://digitalcommons.wcl.american.edu/.

24. David A. Ochmanek, *Determining the Military Capabilities Most Needed to Counter China and Russia: A Strategy-Driven Approach* (Santa Monica, CA: RAND Corporation, 2022), https://www.rand.org/.

A two-stage approach will refocus MQ-9 training and development efforts for the remainder of its life to wring additional value from the weapon system and accelerate changes to meet future challenges. Stage 1 reimagines current MQ-9 operations anchored in intrinsic strengths, breaking from the notion that the community's identity is in the GWOT, when it actually rests in adapting to a mission when no one else can. A renewed training focus on airmanship, ISR, and mission ownership, executed with the cockpit as the heart of the weapon system, provides a means to significantly improve mission effectiveness, integrate with the intelligence ecosystem, and grow agile combat employment competency.

Stage 2 turns the MQ-9's twilight years into an incubator and information exchange that on-ramps advanced capabilities by exposing them to the operational environment and highly experienced RPA crews. This has the peripheral advantage of educating and preparing personnel today that will be needed to fully propagate advanced capabilities on future platforms. In short, the conventional Reaper force needs to refocus on playing to its strengths today while preparing people and processes for the future.

DoD Labs

Back to the Future?

Edie Williams
John Fischer

US Department of Defense labs are faced with significant challenges including an aging workforce and infrastructure, the inability to compete successfully for new scientists and engineers, and the loss of research prominence. This comes at a time when China is challenging the technological standing of the United States across the globe. This article proposes governance models that retain the best of the DoD lab workforce and infrastructure while leveraging the larger US research and development ecosystem to reset and retool the DoD labs for the twenty-first century. This article engages an historical account of the DoD Lab enterprise and offers recommendations for moving forward to regain our strengths through rethinking the way we do business.

In an acclaimed May 1915 *New York Times* interview, American icon Thomas Edison called on the US government to "maintain a great research laboratory. . . .[To develop] . . . all the technique of military and naval progression, without any vast expense."[1] Edison's advocacy was rooted in concerns about US military advantage in World War I, and funding was appropriated in the next year. But due to disagreements within the oversight board charged with establishing it, the Naval Research Laboratory was not launched until 1923. In the decades that followed, the Army and Air Force also established labs further contributing to America's military technological dominance. US Department of Defense labs have a rich innovation, invention, and problem-solving history. Since the Cold War, however, DoD labs have faced several challenges with shifting priorities, workforce constraints, and infrastructure challenges.

This article examines the "glory days" of the DoD labs, the shift of research and development dominance from the Department of Defense to the US commercial sector, and challenges with attracting and retaining a scientist and engineer workforce. These concerns, in the midst of technological threats from state and nonstate adversaries, call for a serious reconsideration of the role of DoD labs. Leaders in the Air Force and other Defense Department services that provide oversight over the lab structure should consider alternative governance models that retain the best of the DoD lab workforce and infrastructure while leveraging the larger research and development ecosystem in the United States. In short, the department must reset and retool its labs for the twenty-first century.

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Dr. John Fischer served as the director of the DoD Laboratories Office from 2009 to 2015.

1. Edward Marshall, "Edison's Plan for Preparedness," *New York Times*, May 30, 1915, https://timesmachine.nytimes.com/timesmachine/1915/05/30/issue.html.

The Glory Days

Suffice it to say, the fact the Department of Defense still has more than 60 laboratories, warfare centers, and combat development centers in the Defense laboratory enterprise speaks to their importance in the DoD research, development, test, and evaluation ecosystem.[2] Each DoD laboratory was created for specific purposes within the military technology base. At the time of establishment, each lab focused on specific needs expressed by its service or the military in general.

The Naval Surface Warfare Center Dahlgren was founded in 1918 as a proving ground for naval guns. In the 1920s and 1930s, scientists and engineers at Dahlgren invented the Norden bombsight that the Army Air Forces used in World War II, greatly increasing the success of aircraft bombing runs.[3]

The Army Research Lab (formerly the Ballistic Research Laboratory) was also founded in 1918 with the mission to work on land-based gun (cannon) ballistics. The Ballistic Research Laboratory is best known for developing the Electronic Numerical Integrator and Computer—the first programmable, electronic, general-purpose digital computer—in 1945 to calculate ballistics for the Army and the Defense Department.[4]

The Naval Research Lab, Thomas Edison's laboratory, was originally conceived to develop technology to counter the submarine threats posed by Germany in World War I. With a rich history of technology firsts, the Naval Research Lab invented, developed, and in 1938, installed the first operational US radar. The lab also built and deployed early versions of satellites and engaged in basic and applied research that provided the foundations for the global positioning system.[5]

Naval Air Weapons Station China Lake was established during World War II in cooperation with the California Institute of Technology to develop and test air-launched weapons. This organization developed weapons including the Sidewinder air-to-air missile in the 1950s and the Tomahawk, still in use today.[6]

Redstone Arsenal was originally established in 1941 in Huntsville, Alabama as a chemical weapons production facility. Since the latter part of World War II, Redstone and its tenant activities have become the premier center for Army aviation and airborne

2. "Research, Technology & Laboratories: Defense Laboratories and Centers," Department of Defense (DoD) Research and Engineering Enterprise (website), June 7, 2019, https://rt.cto.mil/.

3. Timothy Moy, *War Machines: Transforming Technologies in the U.S. Military, 1920–1940* (College Station: Texas A&M University Press, 2001).

4. William T. Moye, "ENIAC: The Army-Sponsored Revolution," Army Research Laboratory (website), January 1996, https://ftp.arl.army.mil/.

5. "NRL History: About Us," US Naval Research Laboratory (website), n.d., accessed October 25, 2022, https://www.nrl.navy.mil/.

6. Tom Hildreth, "The Sidewinder Missile," *Air-Britain Digest* 40, no. 2 (March–April 1988): 39–40; and "Weapons," China Lake Museum Foundation (website), n.d., accessed October 25, 2022, https://chinalakemuseum.org/.

ordnance, including the first laser-guided bombs. Redstone Arsenal now leads hypersonic weapons development for the Army.[7]

The Air Force Research Laboratory (AFRL) was founded as the Air Force Cambridge Research Laboratories/Center in 1945. After World War II, the center developed the first telephone modem communications for a digital radar relay in 1949.[8]

Throughout the Cold War and until 1986, DoD labs were responsible for technology development and owned the technical data packages for each weapon system. The technical data packages developed by the in-house workforce served as the foundation for most contracts issued to private industry. The DoD labs either created new technologies in-house or managed technical programs for new product development.

The labs developed technology products with strong linkages to acquisition programs that drove the deployment of war-fighting technologies for decades.[9] In-house laboratory technologies were translated into technical data packages and issued to industry as requirements demanded. Industry served the role of advancing technology development through prototyping and transitioning to a contract for manufacturing, often under the guidance and approval of laboratory scientists and engineers.

These roles and responsibilities began to change during the mid-to-late 1980s. In his history of the Sidewinder missile development, Ron Westrum noted industry had lobbied to lead technology development, prototyping, and manufacturing instead of the government.[10] The defense industrial base convinced Pentagon decisionmakers they could innovate faster and at less cost than the Defense Department's laboratory system. Congress agreed and responded in favor of industry.

Shift to the Private Sector

Further details and foundations for this sea change can be found in the Packard Commission Report of 1986.[11] The findings of the Packard Report generated many reforms that were codified in Title 10 via the Goldwater-Nichols Act: the DoD labs arguably lost their role as technology developers and became mostly acquisition support as program managers of industry.[12] This shift was codified in the Defense Acquisition Reform Act

7. "A History of Redstone Arsenal Airfield," US Army Aviation and Missile Life Cycle Management Command (website), n.d., accessed October 25, 2022, https://history.redstone.army.mil/.

8. Paul N. Edwards, *The Closed World: Computers and the Politics of Discourse in Cold War America* (Cambridge, MA: MIT Press, 1996), 19, chap. 3.

9. J. Ronald Fox, *Defense Acquisition Reform 1960–2009: An Elusive Goal* (Washington, DC: US Army Center of Military History, 2011), https://history.army.mil/.

10. Ron Westrum, *Sidewinder: Creative Missile Development at China Lake* (Annapolis, MD: Naval Institute Press, 1999).

11. David Packard, *A Quest for Excellence – A Final Report to the President by the Blue Ribbon Commission on Defense Management* (Washington, DC: The White House, June 1986), https://www.documentcloud.org/.

12. Goldwater-Nichols Department of Defense Reauthorization Act of 1986, 10 U.S.C. § 105 (1986).

(DAIWA) as part of the National Defense Authorization Act of 1991.[13] One of the most significant negative results of DAIWA was the loss of career laboratory systems engineers in the 1990s, as the government shifted the responsibilities for systems engineering to the largest defense contractors.[14] Supporting acquisition programs was not as attractive to the nation's best and brightest technical talent as actually working in a lab to develop cutting-edge technology products and creating fundamental scientific knowledge for next-generation systems.

Program failures such as Future Combat Systems and the Navy's A-12 program soon followed.[15] A close Defense Science Board examination of the many high-profile program failures in 2002 revealed a preponderance of systematic cost overruns, schedule slippages, and capability shortfalls in addition to "hollowing out of organic systems engineering capability within DoD."[16]

It is very difficult for a DoD lab-developed technology to be deployed as industry is the identified source for all new technologies delivered to acquisition programs of record. For example, Lockheed-Martin has a Total Systems Program Responsibility contract for the F-35 Joint Strike Fighter. The practical implication of this arrangement is that Lockheed-Martin has an overwhelming say about what technologies will be delivered for the F-35, provided the program's requirements are met by the deliverables provided. Because of their profit incentives, Lockheed-Martin is not motivated to integrate emerging technological advances resulting in the commonly heard statement that DoD weapons systems take too long to develop, and their technology is out of date by the time they are deployed.

While industry has assumed the dominant role in technology development, the government still assumes product liability for all weapon systems today. That is, as industry delivers its contractually obligated hardware and software to top-level performance specifications, if any problems occur, the Defense Department must find a remedy, including financial penalties. It cannot be overstated that shifting technology risk to the major prime defense contractors results in less capable weapons systems being deployed. If the risk of technology insertion was shifted back to the government through the labs, upgrades could be made more seamlessly.

Since the advent of the War on Terror in the early 2000s and subsequent operations in Iraq and Afghanistan, innovation and invention at DoD labs have been limited to and

13. National Defense Authorization Act for Fiscal Year 1991, Pub. L. No. 101-510, 104 Stat. 1485 (1990).

14. Michael Gibbs, "Returns to Skills and Personnel Management: U.S. DoD Scientists and Engineers," Discussion Paper 1539 (Bonn, Germany: Institute for the Study of Labor (IZA), March 2005), https://papers.ssrn.com/.

15. Sebastian Sprenger, "30 Years: Future Combat Systems—Acquisition Gone Wrong," Defense News, October 25, 2016, https://www.defensenews.com/; and David Montgomery, "How the A-12 Went Down," *Air & Space Forces Magazine*, April 1, 1991, https://www.airforcemag.com/.

16. Kathlyn Hopkins Loudin, *Lead Systems Integrators: A Post-Acquisition Reform Retrospective* (Fort Belvoir, VA: Defense Acquisition University Press, January 2010), https://www.dau.edu/.

focused on highly specific technologies to meet the new and unexpected threats experienced in the unconventional warfare practiced in a particular area of operation. Two examples of these technologies are "bunker-busting" bombs and improvised explosive device-detection devices.

While these technologies were successful in their application and impact on specific situations as niche tools and saving lives—improvised explosion device-detection detection technologies, for example—they were not on the same scale as the major weapons systems still under development by DoD prime contractors. A 2016 Air Force Studies Board report recommended the Air Force should embrace failure in the Edisonian sense (learning from small failures) and change the culture, including experimentation, to make way for disruptive innovation on a larger scale.[17]

The National Academies of Sciences, Defense Science Board, and other DoD-affiliated research institutions like the RAND Corporation have looked at national and international trends in science and technology and research and development shifts from government to the commercial or private sector. An often-cited 2007 National Academy of Sciences report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, expresses significant concern "that the scientific and technical building blocks of our economic leadership are eroding at a time when many other nations are gathering strength."[18]

Almost 15 years later, the Congressional Research Service noted that "from 1960 to 2019, the U.S. share of global R&D fell (from 69%) to 30%, and the federal government's share of total U.S. R&D fell from 65% to 21%, while business' share more than doubled from 33% to 71%."[19] The CRS report recommended that because of this shift, the Department of Defense must explore new ways to acquire new technology and maintain US military technical superiority in three ways: (1) developing and modifying organizations and business models to access this technology; (2) adapting the DoD business culture to seek and embrace technologies developed outside of the department, the United States, and its traditional contractor base; and (3) finding ways to adapt and leverage commercial technologies for defense applications.[20]

One consideration is that these and similar recommendations over the years fail to account for the compounding statutory restrictions put in place because of the 1986 Packard Commission. But changing the governance structure of some of or all the labs

17. National Academies of Sciences, Engineering, and Medicine, *The Role of Experimentation Campaigns in the Air Force Innovation Life Cycle* (Washington, DC: National Academies Press, 2016), https://doi.org/.

18. National Academy of Sciences, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (Washington, DC: National Academies Press, March 2007), https://nap.nationalacademies.org/.

19. John F. Sargent Jr. and Marcy E. Gallo, *The Global Research and Development Landscape and Implications for the Department of Defense*, R45403 (Washington, DC: Congressional Research Service, June 28, 2021), Summary, https://sgp.fas.org/.

20. Sargent and Gallo, *Development Landscape*.

would present an opportunity to leverage the shift in research and development investments to the commercial sector, adapt their business processes to take advantage of this commercial investment, and change the culture by focusing scientists and engineers on science and technology that is unique or must be done in DoD labs due to its sensitivity.

Loss of Scientific and Engineering Expertise

The "corporate labs" of the Department of Defense include the Naval Research Lab, Army Research Lab, and Air Force Research Lab. A majority of the workforce at the corporate labs are scientists and engineers. The rest of the DoD labs, especially the engineering centers, have a larger concentration of engineers and focus almost exclusively on acquisition support with emphasis on testing and evaluating contractor-developed products. While testing and evaluation is a critical product of the labs in direct support of acquisition programs of record, resources could be used for more prototyping and experimentation if the military services pursued those efforts more aggressively.

Because of the high visibility of military acquisition programs, many scientists and engineers in the three main service labs have also been redirected to acquisition. From the 1970s to the early 1990s, both civilian and military scientists and engineers used their technical skills in laboratory and engineering environments and were valued for the skills they brought to the development of technology.[21] After the Cold War, several trends in acquisition reform dominated the decision making in the Department of Defense and shifted the responsibility for developing technology to contractors, primarily a few major DoD contractors. Total System Performance Responsibility and the rise of lead systems integrators were used to justify the downsizing of the "in-house" laboratory and engineering center workforce.[22]

The DoD labs were also reduced in number and scope of influence through the Base Realignment and Closure processes of 1995 and 2005. As Brian Fry noted, from 1994 to 2020, "Air Force active-duty-officer end strength . . . decreased 21 percent, scientists decreased 26 percent, engineers decreased 22 percent, while acquisition managers increased 42 percent."[23] In the last two decades, the scientist and engineer workforce has continued to experience retention problems. As a result, a bathtub effect has been created as the aging senior workforce begins to retire in larger numbers and the mid-career workforce recruited in the late 1990s and early 2000s shrinks because of reduced opportunities and more robust non-DoD work opportunities.

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21. Brian J. Fry, "Taking the Brakes Off Uniformed Scientists and Engineers," *Air & Space Operations Review* 35, no. 1 (Spring 2022), https://www.airuniversity.af.edu/.

22. National Research Council, *Owning the Technical Baseline for Acquisition Programs in the U.S. Air Force: A Workshop Report* (Washington, DC: National Academies Press, 2015), 6, https://nap.nationalacademies.org/.

23. Fry, "Scientists and Engineers," 20.

Fry explained that uniformed scientists and engineers were relegated to program management and not given enough opportunity to engage in science and engineering that benefits Air Force war fighting. He recommended military scientists and engineers be given operational assignments via AFWERX Spark Cells and other programs to use their technical knowledge while enhancing their experience and usefulness to the Air Force. He used the example of how Air Force scientists and engineers were deployed to work with vehicle-mounted jamming equipment deployed by the Army in the Global War on Terrorism. They could understand the equipment and articulate applications and modifications that helped make its use more effective.[24]

Fry's observations about Air Force uniformed scientists and engineers are focused on better coupling their talents and warfighter training to innovate and adapt on a small scale. Still, the underlying theme of focusing on innovation to motivate the workforce can also be applied to the thousands of civilian scientists and engineers across the DoD laboratory enterprise who work on larger and more complex weapons systems.

A Call for Reform

In 2012, RAND reported on an expert panel that looked at the future of Army laboratories, discussing many of the same issues. The research questions for the expert panel and discussed in the report included: (1) What do broad trends in basic research and research and development, both federal and in the private sector, mean for the future of Army research? (2) What are the characteristics of top-quality research laboratories? And (3) How can the Army get the best long-term value from its investments in basic research?[25]

Five years later in 2017, a defense task force addressed four themes: (1) how well the defense laboratories anticipated and responded to the needs of the department; (2) the mechanisms that existed to refurbish and recapitalize DoD labs and how the state of the infrastructure (both physical and research) compared with other government, academic, international, and industrial counterparts; (3) how well the DoD laboratories and centers attracted, recruited, retained, and trained their workforce to remain technically current and flexible to respond to emerging national requirements; and (4) whether the appropriate balance existed between service control and laboratory-director discretion to maximize laboratory mission effectiveness.[26]

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24. Fry, "Scientists and Engineers," 28.

25. Gilbert Decker et al., *Improving Army Basic Research: Report of an Expert Panel on the Future of Army Laboratories* (Santa Monica, CA: RAND Corporation, 2012), https://www.rand.org/.

26. DoD Defense Science Board (DSB) Task Force, *Defense Research Enterprise Assessment* (Washington, DC: DoD DSB, January 2017), 21, https://dsb.cto.mil/.

Most recently, in January 2022, Heidi Shyu, Undersecretary of Defense for Research and Engineering, was tasked by Kathleen H. Hicks, Deputy Secretary of Defense, to assess the health of the Department's and individual services' laboratory and test infrastructure."[27]

This article could go on at length, summarizing all the studies and reports that explore the efficiency and effectiveness of the DoD labs. But the studies cited and summarized in table 1 highlight important issues that are driving an ongoing discussion about the ability of the current DoD lab enterprise to meet the new demands of the twenty-first century.

Table 1. Summary of recommendations from studies cited

	Structure/Process	Culture	Risk
2012 RAND Report	Resources are lacking to execute strategy and responsibilities	Workforce is not keeping up with emerging technologies	Army basic research program is risk-averse
2016 AF Studies Board	Fence-off organizations working on innovation	Create innovation catalysts	Embrace Edison failure
2017 DSB Report	Use innovative recapitalization mechanisms like minor MILCON (mainly Section 219 funds) and Enhanced Use Lease	Implement authorities that have already been granted – local control for local matters	Embrace open innovation – leverage Open Campus model to collaborate more easily with academia and industry
2021 CRS Study	Modify organization and business models	Adapt the DoD business culture to seek and embrace technologies developed outside of DoD	Leverage commercial technologies for defense applications

The answer for the future lies in an analysis of the historic strengths of the DoD lab system. The Department must regain those strengths by altering the governance structure to take advantage of the shift of research and development dominance of the Department of Defense after World War II to the current dominance of private sector R&D in twenty-first-century science and technology.

Consideration of New Governance Models

A few DoD lab realities must be considered. The first is aging infrastructure—the Department has failed to make sufficient investments to enable the labs to develop and test twenty-first-century technology. DoD labs will never be a military construction budget priority as operational infrastructure always takes priority. Lab directors have statutory authority for the creation and expenditure of discretionary budgets (e.g., 10 U.S. Code § 2805–unspecified minor construction) that could be used for laboratory enhancements

27. John A. Tirpak, "DOD's Research and Engineering Priorities Focus on Contested Areas," *Air and Space Forces Magazine*, January 20, 2022, https://www.airforcemag.com/.

including minor MILCON projects. But often they cannot exercise this authority as they must receive approval from service leadership which often refuses permission. This was not Congress's intent but still an operational reality.

The second reality is that competition for the scientist and engineer workforce is fierce, and the DoD lab workforce is aging fast.[28] Congress has given the DoD lab directors many legislative authorities for recruiting, hiring, and retention via Science and Technology Reinvention Lab statutes.[29] Implementing these flexible authorities has been challenging, though, because each service requires approval from senior nonlab leadership, which hesitates to support them for various reasons.

Given these realities, the Department of Defense should consider alternative governance models to revitalize the DoD labs. The 2016 task force mentioned above reviewed different operating models across the DoD labs and compared them with those of federally funded research and development centers (FFRDCs), university-affiliated research centers, government-owned, contractor-operated facilities, and overseas and private partner labs.[30]

The task force found the DoD labs operate under a more restrictive environment than the others that were reviewed. While the *Defense Research Enterprise Assessment* stopped short of suggesting a shift to alternative governance models, the challenges and restrictions outlined earlier in this article were the same.

One example of a lab that transitioned its governance model to adapt to resource challenges is HRL Laboratories. Formerly Hughes Research Laboratories, established in 1948, it transitioned to a limited liability company (LLC) in 1997 to perform research and development for the Boeing Company and General Motors (LLC members). This lab has millions of dollars of government and commercial contracts (as a prime and a subcontractor). It is a DoD-trusted foundry with 250,000 square feet of lab space and a 10,000-square-foot Class 10 clean room located on 72 acres in Malibu, California.

The HRL mission is to "enhance the mission of our government and commercial customers through the development and application of world-class science, technology and engineering."[31] It specializes in four core areas: (1) information and systems sciences, (2) materials and microsystems, (3) microfabrication technology, and (4) sensors and electronics.

HRL is considered a globally recognized premier lab that performs cutting-edge research and development for the government and commercial sectors and limits its specialization areas. The lab invests in talent development from the time students enter college

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28. Courtney Buble, "The Aging Federal Workforce Needs 'New Blood,' Experts Say," Government Executive, August 30, 2019, https://www.govexec.com/.

29. "Science and Technology Reinvention Laboratory," Research, Technology, and Laboratories, DoD Research and Engineering Enterprise (website), n.d., accessed November 15, 2022, https://rt.cto.mil/.

30. DoD DSB Task Force, *Defense Research Enterprise Assessment*, 21.

31. "HRL Laboratories," accessed October 25, 2022, https://www.hrl.com.

through grants and engagement with faculty and continues its engagement by offering opportunities for scholarships, internships, and fellowships.

Similarly, the Department of Energy's (DOE) National Nuclear Defense Administration's primary weapons laboratories, including Sandia, Los Alamos, and Lawrence Livermore, are government-owned, contractor-operated, and FFRDCs. These laboratories and other DOE labs are considered among the world's most innovative and productive technical organizations. Indeed, these facilities not only support the nation's nuclear mission but also play significant roles in developing new conventional military technologies. Their facilities and, most importantly, the technical workforce exemplify how these business models can sustain the nation's security by creating new and innovative technology products.

Summary and Recommendations

One hundred years have passed since the founding of the first DoD lab. The present lab system developed in response to global threats during two world wars, one Cold War, two additional wars in the Far East, and multiple protracted engagements in the Middle East. Scientists and engineers at these labs played vital roles in building and maintaining US military dominance in the twentieth century, but the landscape has changed.

In the twenty-first century, the threats are more technology-centric, and technology itself is more ubiquitous. More broadly, the US government, and more specifically the Department of Defense, no longer dominate spending in the research and development sector. What has not changed is the creativity and ingenuity of our scientists and engineers. They need to continue to excel in their field by focusing on doing what only they can do and leveraging what the commercial sector has to offer. They must also be supported by policies and infrastructure that allow them to be the best.

In 2014, the DoD Laboratories Office sponsored a study by the RAND Corporation to examine innovation within the in-house laboratory system using patents as the gauge of performance.[32] Were patents emerging from the labs' new and innovative technologies, or were they variations on existing themes? This approach is widely used by industry to measure the potential market value of new products and the performance of an organization's technical base, including scientists, engineers, laboratories, and contract performers.

Utilizing this approach, the in-house labs could be measured against the DOE's national labs (science labs and the National Nuclear Security Administration weapons labs), FFRDCs (e.g., the MIT Lincoln Laboratory), university-affiliated research centers, (e.g., the Johns Hopkins University Applied Research Lab), industry laboratories (e.g., HRL), and nonprofit labs (e.g., the Southwest Research Institute). (Note: National Nuclear Security Administration labs are also FFRDCs and government-owned, contractor-operated facilities.)

32. Christopher A. Eusebi and Richard Silberglitt, *Identification and Analysis of Technology Emergence Using Patent Classification*, RR-629-OSD (Santa Monica, CA: RAND Corporation, 2014), https://www.rand.org/.

This comparison may yield valuable information on the best-performing business models that could be applied to the in-house DoD laboratory system.

Recommendations—DoD

1. As an internal assessment, in Base Realignment and Closure-like fashion, the Under Secretary of Defense (Research & Engineering) should engage the three service lab management organizations (Office of Naval Research, Army Research Laboratory, and AFRL) to prioritize lab assets and workforce strengths to determine priority foci and consider alternatives for the utilization of other lab assets.
2. Using the same metrics-based approach, the Department should commission a follow-on to the *Defense Research Enterprise Assessment* by the Defense Science Board to determine the current state of physical infrastructure, scientist and engineer workforce trends, and technology prominence of the DoD Labs. This assessment should solicit recommendations about which resources should be retained and improved, which resources should be shared or contracted out within the defense industrial base, and which resources should be divested.
3. The office of the undersecretary should engage major defense contractors in the defense industrial base in a discussion about options for repurposing existing DoD in-house laboratory resources under alternative governance models like government-owned, contractor-operated facilities, university-affiliated research centers, and FFRDCs.
4. As an external arbiter of laboratory prominence and the needs of the national security ecosystem, the Department of Defense should commission the National Academies to provide the results of the internal assessments and make recommendations for changes to strengthen the DoD lab system.

Recommendations—US Air Force

1. The Air Force should permit the Air Force Research Laboratory executive director to implement all authorities granted to the position by science and technology laboratory statutes and not require any additional permissions or restrictions from senior Air Force leadership. The service should hold the executive director responsible for laboratory performance based on those decisions.
2. The Air Force should clearly identify AFRL's role. In other words, is the lab a center for innovative technologies or is its primary role the support of acquisition programs of record? If the lab is responsible for innovative technologies, the Air Force should consider implementing a governance structure resembling the Army Futures Command, where the science and technology and acquisition communities share responsibilities for executing Budget Activities 1-7 and the transition of new products into acquisition. Within this structure, there must be a working relationship

between the lab and Air Force prime contractors. If the role of AFRL is acquisition support, the Air Force must hold the lab accountable for contract performance regarding cost, schedule, and deployment of new products. If the Air Force decides upon a hybrid approach, the service must clearly identify which laboratory elements are responsible for specific deliverables. It is improper to hold any laboratory responsible for products it is not authorized or staffed to accomplish.

3. The Air Force should establish performance metrics independent of which course of action is selected. If research, development, technology, and engineering is the path, publications in referred journals and scientific accomplishments are appropriate. If acquisition support is needed, prime contractor performance is necessary if the technical staff has decision authority.
4. The Air Force should measure AFRL performance compared to other service corporate labs (Naval Research Lab, Army Research Lab) and the DOE National Nuclear Security Administration National Labs. The service should consider a technology S-curve analysis on patents. This type of study was performed in 2013–14 by the office of the Undersecretary of Defense for Research & Development Laboratory, but results were not released. The service should implement Fry's recommendations to enhance career opportunities for uniformed scientists and engineers that will benefit their growth and the effectiveness of Air Force systems.
5. Based on the results of the analysis above, if performance is not sufficient when compared to other labs, the Air Force should consider alternative governance models such as the Working Capital Fund, reimbursable funding, FFRDCs, and university-affiliated research centers.

While this type of change is disruptive and disconcerting to many, all indications are that the DoD laboratory system will not be a competitive force in the twenty-first century without this change. One approach to forestall concerns about how to transition to a new model of operations is to maintain the existing system while moving to a new operational system over time. That is, offer the existing workforce the opportunity to move to a new organizational construct—primarily the early- and mid-career workforce—while allowing senior technical staff to remain government employees to eliminate risks and concerns with retirement planning. Although a potentially complex approach, this would eliminate political resistance because no one's financial well-being would be jeopardized.

These recommendations for the Department of Defense and for the Air Force will help retain the best of the DoD lab workforce and infrastructure while leveraging the larger research and development ecosystem in the United States. These actions will reinvigorate DoD labs, making them once again a critical DoD and service asset for the twenty-first century as they were in the years of lab research and development excellence following World War II.

Stars on Tombstones

Honorary Promotions of Air Corps and Air Force Leaders

Dwight S. Mears

The legality of honorary promotions accomplished outside of legislation is questionable. An examination of proposed promotions for US Army officer William Mitchell and US Air Force officers Claire Chennault, James Doolittle, and Ira Eaker reveal the process through which these became standardized, the questionable motives and methods behind some, and the persistent failure over time of many service media entities to verify historical claims related to these promotions. Claims about honorary promotions should be corrected to enhance public trust and counter misinformation.

Honorary promotions have existed in different forms throughout US military history.[1] In the twentieth and early twenty-first centuries, honorary promotions for officers were normally authorized via joint resolutions or bills from Congress. But not all such honorary promotions were accomplished via legislation, and perhaps not all were lawful as a result. Several case studies of proposed promotions for William Mitchell, Claire Chennault, James Doolittle, and Ira Eaker illustrate the process by which these promotions became standardized, the questionable motives and methods behind some of them, and the widespread failure of many Air Force functionaries to verify associated historical claims. The ahistorical claims about honorary promotions should be corrected to enhance public trust and counter misinformation.

History of Honorary Promotions

Starting in 1776, the Continental Congress authorized the Continental Army to confer brevets on officers—brevets were a form of honorary rank that could be used in courts martial or detached duty but lacked formal recognition in an officer's own regiment or for pay or retirement purposes.[2] The practice of conferring brevets continued through the Civil War, but this recognition was gradually replaced by military awards.[3] Brevets also

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1. I would like to thank Dr. Dick Kohn, Elliott Converse, Col, USAF (Ret.), William J. Ott, Col, USAF (Ret.), Fred Borch, COL, USA (Ret.), Erik WinbornCol, USAF (Ret.), Michael Davidson, LTC, USA (Ret.), L. Neal Ellis, COL, USA (Ret.), Gary Solis, Lt. Col. USMC (Ret), and the archivists and reviewers who helped shape this article.

2. Art. 24, Articles of War, Sep. 20, 1776, in *Journals of the American Congress, From 1774 to 1778,* vol. 1 (Washington, DC: Way & Gideon, 1823), 489.

3. A Resolution to Provide for the Presentation of "Medals of Honor" to the Enlisted Men of the Army and Volunteer Forces Who Have Distinguished, or May Distinguish, Themselves in Battle during the Present Rebellion, Pub. Res. 43, 37th Cong. (1862) 12 Stat. 623, 624.

atrophied during conflicts with Native American tribes in the mid to late 1800s because of the statutory requirement that brevets "shall only be conferred in time of war."[4] This was due to the Senate's view that these conflicts were merely forms of domestic insurrection.[5]

Another form of special promotion, known as "tombstone promotion," appeared at the turn of the twentieth century.[6] This type of promotion was not strictly honorary at its inception, and it allowed officers to retire with the rank and partial or full pay of a grade higher than they actually held. Since beneficiaries either never held the rank in active service or held it only briefly, the higher rank predominately appeared on their tombstone and other retirement records—hence the name "tombstone." In the words of one congressman, the motive for such promotion was to "provide an incentive for voluntary retirement," in order to reduce a backlog of officers in a given rank and thus facilitate the promotion of those below them.[7]

The Navy was authorized tombstone promotions by statute in 1889.[8] In contrast, the Army had no such authority at that time, and simply retired many officers as generals with only nominal service in a given grade. For example, in 1900 one congressman observed that several recently retired brigadier generals had served in that grade for only one day.[9] This was possible because while the number of Army generals in active service was capped, there was no such restriction on general officers in retirement, and also no time-in-service requirement to retire at a grade.[10]

In 1904, Congress finally sanctioned the practice of tombstone promotions for the Army with legislation permitting the procedure for certain officers who served in the Civil War.[11] Congress also closed the loophole allowing Army general officers to retire with little or no service at their grade; a statute enacted in 1906 specified that such officers "shall have served at least one year in such rank."[12]

In the 1930s, several statutes authorizing tombstone promotions for veterans of World War I made the advancements strictly honorary for select groups of retirees; they included provisos such as "no increase in active or retired pay or allowances shall result from

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4. An Act to Amend the Act of April Tenth, Eighteen Hundred and Six, for Establishing Rules and Articles for the Government of the Armies of the United States, 40th Cong. (1869) 15 Stat. 281.

5. Committee on Military Affairs, Conferring Brevet Rank on Officer of the Army for Gallant Services in Indian Campaigns, Report to Accompany Bill H.R. 478, H.R. Rep. No. 79, at 3, 51st Cong. (1890).

6. See, e.g., An Act to Reorganize and Increase the Efficiency of the Personnel of the Navy and Marine Corps of the United States, 56th Cong. (1899) 30 Stat. 1004, 1006.

7. 32 Cong. Rec. 708 (daily ed., Jan. 17, 1899) (statement of Mr. Foss).

8. 30 Stat. 1004, 1006.

9. 33 Cong. Rec. 3320–21 (daily ed., Mar. 26, 1900) (statement of Mr. Jett).

10. 33 Cong. Rec. 3319–21.

11. An Act Making Appropriation for the Support of the Army for the Fiscal Year Ending June Thirtieth, Nineteen Hundred and Five, and for Other Purposes, Pub. L. 58-149, 58th Cong. (1904) 33 Stat. 259, 264.

12. An Act Making Appropriation for the Support of the Army for the Fiscal Year Ending June Thirtieth, Nineteen Hundred and Seven, Pub. L. 59-224, 59th Cong. (1906) 34 Stat. 240, 245.

the passage of this Act."[13] Subsequent litigation over one of these provisions ruled that such advancements were merely "a gloss, put over a lower, still permanent rank," and were "an honorarium only."[14]

Blanket tombstone promotion authorizations continued through the 1950s, but in later years evolved to apply only to select retirement specialties such as service academy department heads, senior military acquisition advisors, and assistant judge advocates general of the Navy.[15] For other deserving retirees, Congress pioneered the practice of passing personalized legislation via joint resolution, which has the same force as a law after signature by the president.[16]

This method also conferred only honorary rank, meaning the promotions were solely an elevation on paper and incurred no pay or benefit increases.[17] This was accomplished by adding similar provisos to those used with blanket tombstone promotions in the 1930s.[18] Since these honorary promotions normally targeted individuals rather than entire ranks in a given service, this also meant the motive behind such promotions had shifted from incentivizing retirement to recognizing individual service or achievement.

Congress eventually codified the prerequisites for honorary promotion in 2000, establishing a formal process through which a member of Congress could solicit a review of a proposed honorary promotion by a military secretary.[19] The results of such a review were reported back to the House and Senate Committees on Armed Services. If favorable, the committee would authorize the promotion as part of the national defense authorization act, and the president would have the option of promoting the individual.[20]

But the Office of the Secretary of Defense objected to the report requirement on the grounds that it required "coordinat[ing] the efforts of personnel in five separate offices" and thus was "overly burdensome."[21] In 2021, Congress delegated authority to the Department of Defense to make its own honorary promotions up through the grade of

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13. An Act to Give War-Time Rank to Retired Officers and Former Officers of the Army, Navy, Marine Corps, and/or Coast Guard of the United States, Pub. L. 71-406, 71st Cong. (1930) 46 Stat. 793; and An Act to Give War-Time Commissioned Rank to Retired Warrant Officers and Enlisted Men, Pub. L. 72-123, 72nd Cong. (1932) 47 Stat. 150.

14. Denny v. United States, 162 Ct. Cl. 640, 645 (1963).

15. 10 USC. § 7342; 10 U.S.C. § 9342; 10 U.S.C. § 1725; and 10 U.S.C. § 8080(b).

16. US Senate, "Types of Legislation," US Senate (website), n.d., accessed November 28, 2022, https://www.senate.gov/.

17. An Act to Promote the Efficiency of National Defense, Pub. L. 74-225, 74th Cong. (1935) 49 Stat. 505, 507; and An Act to Provide for the Promotion of Promotion-List Officers of the Army After Specified Years of Service in Grade, and for Other Purposes, Pub. L. No. 76-612, 76th Cong. (1940) 54 Stat. 379, 381.

18. See Committee on Military Affairs, William Mitchell, S. Rep. No. 933, at 2 (1942).

19. National Defense Authorization Act for Fiscal Year 2001, Pub. L. 106-398, 106th Cong. (2000) 114 Stat. 1654, 1654A- 115.

20. 114 Stat. 1654A- 115.

21. Office of the Secretary of Defense, "Repeal and Modification of Reporting Requirements FY14 NDAA Submission," Washington Headquarters Services (website) n.d., accessed December 2, 2022, https://www.esd.whs.mil/.

major general so long as the department provided 60 days notice along with a "detailed rationale supporting the determination."[22] This streamlined the process to involve committee action only in the event of disagreement.

William L. Mitchell

Colonel William "Billy" Mitchell, US Army, is an outsized figure among airpower theorists. According to one Air Force historian, "he was the most prominent American to advocate a vision of strategic airpower that would ultimately come to dominate future warfare," and "the US Air Force is Billy Mitchell's physical legacy."[23]

Yet, simultaneously Mitchell was also "the single most . . . controversial figure in the history of American airpower" as a result of his repeated insubordination.[24] In 1925, Mitchell was ultimately tried and convicted by courts-martial for making statements to the press that recent aviation accidents were "the result of the incompetency, the criminal negligence, and the most treasonable negligence of our national defense by the Navy and War Departments."[25] He was sentenced to five years suspension with half pay, but instead chose to resign rather than accept this punishment.[26]

Mitchell had formerly held the temporary rank of brigadier general as assistant chief of the Air Service, but reverted to his permanent rank of colonel in 1925 after his appointment lapsed.[27] As a result, public perception was that he was demoted, although this was not a sentence flowing from his court-martial. Later, in 1930, Congress enacted legislation authorizing a blanket tombstone promotion to former World War I officers, authorizing their advancement to the highest temporary rank held during the war.[28] The act did not advance Mitchell on account of his resignation without retirement, as it required beneficiaries to already be "retired according to law."[29] It did allow him to use the title of his highest wartime grade, meaning that Mitchell can be referred to as a brigadier general despite being a former colonel on official records.

Efforts to restore Mitchell's rank or retirement began just prior to his death in 1936, when the House Military Affairs Committee considered restoring him to the Army's retired list.[30] But the proposal ultimately failed over the committee's inability to honor

22. National Defense Authorization Act for Fiscal Year 2021, Pub. L. 116-283, 116th Cong. (2021) 134 Stat. 3388, 3598; and 10 U.S.C. § 1563.

23. Roger Miller, *Billy Mitchell: "Stormy Petrel of the Air"* (Washington, DC: Office of Air Force History, 2004), 45.

24. Miller, *Billy Mitchell*, 45.

25. Miller, 42.

26. Miller, 43.

27. Miller, 53.

28. 46 Stat. 793.

29. 46 Stat. 793.

30. Miller, *Billy Mitchell*, 45; To Authorize the Payment of Retired Pay to William Mitchell, H.R. 7412, 74th Cong. (1935); and To Authorize the Payment of Retired Pay to William Mitchell, S. 2804, 74th Cong. (1935).

Mitchell's strategic vision without simultaneously condoning his insubordination.[31] This same problem repeatedly scuttled proposed legislation for the next seven decades.

Perhaps the strongest push to restore Mitchell's rank came in the 1940s. The Army and the president received multiple letters urging them to make Mitchell's legacy whole. One angry citizen wrote to President Franklin D. Roosevelt suggesting he promote Mitchell in order that "all the moss backs who were so blind and hide bound by tradition then should be forced to pay tribute [to him]."[32] The adjutant general replied there was "no existing law under which such title or rank could be conferred posthumously," since Mitchell met none of the public law criteria.[33] This reply was unsurprising, for the practice of honorary promotion of individuals was relatively unprecedented at that time. In fact, it is very likely that modern honorary promotions were shaped by the many unsuccessful attempts to promote Mitchell.

Many bills were introduced in the 1940s to restore Mitchell's rank or to promote him posthumously to major general, a rank he had never held.[34] Two bills introduced in 1940 and 1941 simply sought to make Mitchell whole; they specified that "his rank in War Department records should appear as that of Brigadier General," or alternatively that Army records would be amended "so as to show the said William Mitchell was a brigadier general . . . at the time of his death."[35] Other bills added the proviso that "no pay, allowances, or other financial benefit" would flow from the promotion, a way of making the legislation less controversial by imposing no costs on the government.[36] Nevertheless, none of these bills passed both chambers.

The Army struggled to respond to the bills of relief seeking to promote Mitchell, as well as to the constituents who motivated them. One Texan wrote to his congressman asking him to "clear the record of Gen. Billy Mitchell . . . even school boys knew [Mitchell] was right, and that he was crucified on the altar of prejudice and ignorance."[37] The

31. Miller, *Billy Mitchell*, 45.

32. Donald Elrod to Franklin Roosevelt, May 26, 1940, Official Military Personnel File for William L. Mitchell, Official Military Personnel Files, 1947-1998, Record Group 342, National Archives at College Park, MD.

33. MG R. S. Adams to Donald Elrod, Jun. 20, 1940, Mitchell OMPF, NARA.

34. Relating to the Military Record of William Lendrum Mitchell, S. 4286, 76th Cong. (1940); To Restore the Rank of Brigadier General to the Late William Mitchell, S.J. Res. 109, 77th Cong. (1941); Relating to the Military Record of William Lendrum Mitchell, S. 1706, 77th Cong. (1941); To Restore the Rank of Brigadier General to William Mitchell, Deceased, H.R. 2756, 77th Cong. (1941); Relating to the Military Record of William Mitchell, S. 1543, 77th Cong. (1941); To Restore the Rank of Brigadier General to the Late William L. Mitchell, H.J. Res. 240, 77th Cong. (1941); Authorizing the President to Issue Posthumously to the Late Col. William Mitchell a Commission as a Major General, United States Army, and for Other Purposes, S.J. Res 34, 79th Cong. (1945); and Authorizing the President to Issue Posthumously to the Late Col. William Mitchell a Commission as a Major General, United States Army, and for Other Purposes, S.J. Res. 70, 80th Cong. (1947).

35. H.R. 2756, 77th Cong.; and S. 1543, 77th Cong.

36. S.J. Res. 109, 77th Cong.

37. F. E. Morriss to W. R. Poage, undated, Mitchell OMPF, NARA.

congressman wrote to the secretary of the Army, asking for "any suggestions . . . as to how I should reply to this letter."[38]

Acting Secretary of the Army Robert Patterson replied that "General Mitchell's convictions [on the importance of aviation] were not involved in his trial," which only concerned "insubordination and disloyalty to his superiors" under the 96th Article of War.[39] He further reminded the congressman that Mitchell's court martial had found him "guilty of highly censurable conduct," namely "expressions which can not be construed otherwise than as breathing defiance toward his military superiors."[40] Thus, the War Department did not support having Mitchell "exonerated of all the charges" against him.[41]

The efforts to promote Mitchell continued into the 1950s but were not enacted into law.[42] Nevertheless, the director of the Air Force Records Center misunderstood this, for in the late 1950s, he added a summary of military service to Mitchell's personnel file claiming that "on 18 July 1947, a special bill was passed by Congress promoting General Mitchell to the rank of Major General."[43] The summary claimed it was drawn from the "Press Branch, Office of Public Information, Department of Defense," suggesting the Air Force Records Center misunderstood a media report about the promotion legislation. In fact, the joint resolution in question only passed the Senate on July 16, 1947—it would have had to also pass the House to achieve its aim of authorizing Mitchell's promotion.[44]

Mitchell's promotion was finally authorized in the twenty-first century. In 2004, Representative Perkins Bass (R-New Hampshire), a relative of Mitchell's, successfully inserted a provision into the FY2005 National Defense Authorization Act which authorized his promotion to major general.[45] Still, the promotion reportedly did not occur, which perfectly illustrates the separation of powers issues behind such a promotion; authorization by Congress merely permitted the action and could not require the executive to carry it

38. W. R. Poage to Henry Stimson, Mar. 15, 1943, Mitchell OMPF, NARA.

39. Robert P. Patterson to W. R. Poage, Mar. 22, 1943, Mitchell OMPF, NARA.

40. Patterson to Poage.

41. Patterson to Poage.

42. Authorizing the President to Issue Posthumously to the Late Colonel William Mitchell a Commission as a Major General, United States Army, and for Other Purposes, S.J. Res. 121, 84th Cong. (1956); Authorizing the President to Issue Posthumously to the Late Colonel William Mitchell a Commission as a Major General, United States Army, and for Other Purposes, H.J. Res. 333, 85th Cong. (1957); Authorizing the President to Issue Posthumously to the Late Colonel William Mitchell a Commission as a Major General, United States Army, and for Other Purposes, S.J. Res. 124, 85th Cong. (1957); and Authorizing the President to Issue Posthumously to the Late Colonel William Mitchell a Commission as a Major General, United States Army, and for Other Purposes, H.J. Res. 414, 85th Cong. (1957).

43. A. J. Petroski, "Statement of Military Service of William C. Mitchell," undated, Mitchell OMPF, NARA; *Official Register of the United States*, *1958* (Washington, D.C.: Government Printing Office, 1958), 217; and *Official Register of the United States, 1959* (Washington, D.C.: Government Printing Office, 1959), 220.

44. 93 Cong. Rec. 9031 (daily ed., Jul. 16, 1947).

45. Sec. 564, National Defense Authorization Act for Fiscal Year 2005, Pub. L. 108-375, 108th Cong. (2004) 118 Stat. 1918; and William J. Ott, "Maj. Gen. William 'Billy' Mitchell: A Pyrrhic Promotion," *Air & Space Power Journal* 20, no. 4 (Winter 2006): 27.

out.[46] One Air Force officer opined that a posthumous promotion would only be "a pyrrhic victory," since it would not "erase the questionable actions that proceeded from [Mitchell's] passionate advocacy of airpower's independence."[47]

There is no dispute Mitchell was never posthumously promoted. Yet, as of the time of this writing, the mistaken promotion claim from Mitchell's personnel file still appears on an Air Force website for Medal of Honor recipients.[48] The website claims that in 1947, "a special bill of Congress promoted him to major general," despite the fact that this bill did not pass Congress and would not have resulted in automatic promotion.[49]

Perhaps unsurprisingly, the claim that Mitchell is a Medal of Honor recipient is also ahistorical—a fact which is acknowledged by the Office of Air Force History.[50] While Congress did recognize Mitchell with a medal in 1946, it was a Congressional Gold Medal, not a Medal of Honor.[51] The bill's sponsor did not understand the difference, leading to language that originally authorized a Medal of Honor. The House Committee on Military Affairs recognized the error and amended the bill to remove all substantive references to the Medal of Honor, and clarified that "the legislation under consideration does not authorize an award of the Congressional Medal of Honor."[52] Nevertheless, the title of the bill mistakenly remained uncorrected, which understandably misled many readers.

The Air Force may have advanced mistaken claims about Colonel Mitchell in good faith. But the service has many historical and legislative resources at their disposal, so it is difficult to explain both why these errors were made in the first place, and why they remain uncorrected.

Claire L. Chennault

The first Air Force general to be advanced in retirement was Major General Claire Chennault, who famously trained the Chinese Air Force during the Sino-Japanese War and then commanded the Flying Tigers in China during World War II.[53] Chennault retired in 1945 but received a retirement promotion to lieutenant general authorized by

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46. John T. Correll, "The Billy Mitchell Court-Martial," *Air & Space Forces Magazine*, Aug. 1, 2012; and Ott, "Pyrrhic Promotion," 27.

47. Ott, "Pyrrhic Promotion," 32.

48. Department of the Air Force (DAF), "Mitchell, William," US Air Force (website), n.d., accessed December 2, 2022, https://www.af.mil/Medal-of-Honor/Mitchell/.

49. DAF, "Mitchell, William."

50. Miller, *Billy Mitchell*, 55.

51. Authorizing the President of the United States to Award Posthumously in the Name of Congress a Medal of Honor to William Mitchell, S. 881, 79th Cong. (1945); and An Act Authorizing the President of the United States to Award Posthumously in the Name of Congress a Medal of Honor to William Mitchell, Priv. L. 79-884, 79th Cong. (1946) 60 Stat. 1319.

52. Committee on Military Affairs, Authorizing the Award of a Medal to William Mitchell, H.R. Rep. No. 2625 at 2 (1946).

53. DAF, "Major General Claire Lee Chennault," US Air Force (website), n.d., accessed December 2, 2022, https://www.af.mil/.

private law in 1958.[54] The fact that Chennault received this tribute despite a rocky relationship with his Air Corps colleagues can perhaps be attributed to his association with the influential anticommunist "China Lobby" of that period.[55] Chennault was also immortalized in popular media—one historian called him "one of America's more famous airmen."[56] His biographer was more candid, calling him "a great man and a flawed one."[57]

Chennault's promotion authorization was only discernible from Mitchell's in that it was advanced by bill rather than resolution, and was not posthumous. After Chennault was hospitalized with terminal lung cancer, Congress was incentivized to pass the promotion bill "without objection or debate," and officials "sped it to the White House" for immediate signature only hours later.[58] Unlike the Mitchell legislation, Chennault's bill was also passed separately rather than part of an omnibus package, but this was likely due to the desire to recognize Chennault before his imminent death. It is also notable that Chennault's promotion was far less controversial than Mitchell's, which undoubtedly helped to forge a legislative consensus. According to one report, the promotion represented "a heartfelt vote of respect to the man."[59]

Chennault's legislation was also likely influenced by nearly contemporaneous attempts to promote Mitchell in the 1950s, as it included a similar proviso stipulating that "no increase in retired pay or benefits shall accrue as a result of the enactment of the Act," which meant it was a promotion in name only.[60] The proviso was added by the House Committee on Armed Services, which insisted that there be "no cost to the Government involved in the proposed legislation."[61] According to the committee, "the fact that no funds are involved" obviated the need for reports from the Department of Defense or Bureau of the Budget and thus expedited the bill's passage.[62]

Finally, unlike Mitchell's promotion, Chennault's was actually carried out.[63] This made it perhaps the first individual promotion of a retired officer that was strictly honorary, although the process of honorary promotions was not yet codified in law.

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54. An Act to Provide for the Advancement of Major General Claire L. Chennault, United States Air Force, Retired, to the Grade of Lieutenant General on the Retired List, Priv. L. 85-493, 85th Cong. (1958), 72 Stat. A67.

55. Catherine Forslund, *Anna Chennault: Informal Diplomacy and Asian Relations* (Wilmington, DE: SR Books, 2002), 27.

56. Phillip Meilinger, "US Air Force Leaders: A Biographical Tour," *Journal of Military History* (October 1998): 843–44.

57. Daniel Ford, *Flying Tigers: Claire Chennault and the American Volunteer Group* (Washington, DC: Smithsonian, 1991), 9.

58. "President Acts Quickly to Promote Chennault," *New York Times*, July 19, 1958, 8.

59. "Promote Chennault."

60. 72 Stat. A67 (1958).

61. Committee on Armed Services, Advancement of Maj. Gen. Claire L. Chennault, United States Air Force, Retired, To the Grade of Lieutenant General on the Retired List, H.R. Rep. No. 2158, at 2 (1958).

62. H.R. Rept. No. 2158, at 2 (1958).

63. Special Order No. C-360, Chennault Promotion to Lieutenant General, Jul. 18, 1958, Official Military Personnel File for Claire L. Chennault, Official Military Personnel Files, 1947-1998, Record Group 342, NARA.

James H. Doolittle and Ira C. Eaker

Starting in the early 1980s, various individuals began to petition President Ronald Reagan to advance Lieutenant General James "Jimmy" Doolittle in retirement to the grade of four-star general, a successful effort that eventually was packaged with another retirement promotion for Lieutenant General Ira Eaker. By this time the pathway for authorizing honorary promotions had long since atrophied, which perhaps influenced the administration's choices. This case study depicts an administration and a senator seeking to circumvent congressional oversight.

In April 1981, actor and retired Air Force Reserve Brigadier General James "Jimmy" Stewart wrote to his friend President Reagan as part of a coordinated lobbying campaign to promote Doolittle to the rank of four-star general.[64] Stewart was only providing access for other interested parties, as he offered no justification other than Doolittle being "a fine American."[65]

Doolittle had many impressive qualifications, which led one Air Force historian to call him "the United State Air Force's true Renaissance man."[66] During World War II, he headed the so-called "Doolittle Raiders" to bomb Tokyo, and he commanded the Fourth Bombardment Wing, the Northwest African Strategic Air Forces, the Fifteenth Air Force, and the Eighth Air Force.[67] Doolittle had attempted to retire in 1946, but was convinced to revert to inactive reserve status until 1959, when his retirement was finally accepted.[68]

The promotion request was referred to the Air Force, and the service's reaction was decidedly tepid. Air Force Secretary Verne Orr opined that Doolittle had already received a Medal of Honor, which was recognition enough.[69] Orr also claimed Doolittle did not necessarily deserve promotion compared to his contemporaries, particularly Eaker, whom he noted "had greater responsibilities during World War II."[70]

Special Assistant to the Secretary of Defense John Rixse also researched the proposed promotion and discovered the prior honorary promotion of General Chennault in 1958, which he considered "one precedent for this type of initiative."[71] But the Department's reluctance led to the drafting of a letter that pushed back on the suggestion; Reagan ultimately informed Stewart that promoting Doolittle "might create disappointment and

64. US Air Force Staff Summary Sheet, "Promotion of Lt. General Doolittle," n.d., Official Military Personnel File for James H. Doolittle, Official Military Personnel Files, 1947-1998, Record Group 342, NARA.

65. Telegram, James Stewart to Ronald Reagan, No. 03991, April 28, 1981, Doolittle OMPF, NARA.

66. George M. Watson Jr., *General James H. Doolittle: The Air Force's Warrior-Scholar* (Washington, DC: Air Force History & Museums Program, 2008), 1.

67. Watson, *Doolittle*, 7–15.

68. James Doolittle and Carroll Glines, *I Could Never Be So Lucky Again* (New York: Bantam, 1991), 470.

69. Verne Orr, "Lieutenant General James H. Doolittle, USAF Retired," memo for Special Assistant to the Secretary of Defense, May 4, 1981, Doolittle OMPF, NARA.

70. Orr, "Doolittle."

71. John H. Rixse, "Lieutenant General James H. Doolittle, USAF Retired," memo for Deputy Assistant to the President, May 4, 1981, Doolittle OMPF, NARA.

resentment that would outweigh the pleasure and favorable publicity of selecting one national hero for unusual promotion."[72]

Around the same time Senator Barry Goldwater also lobbied the president for Doolittle's promotion, writing that "no one man living in America has done more for the science of flying than [Doolittle]."[73] Obviously aware of the administration's position, he argued "Jimmy Doolittle should take precedence" over the promotion of other retired generals.[74] Goldwater's involvement was significant because as a prominent senator he had an outsized influence on any congressional action authorizing such a promotion. Goldwater was also a retired Air Force Reserve major general himself, having served contemporaneously as a general officer and a senator for ten years.[75]

The repeated interest in Doolittle's promotion drew another rebuttal from Orr, who wrote to the White House expressing several concerns. In particular, he noted promotion should be solely "based on the individual's potential to serve in a higher grade."[76] Orr claimed "in the past, all of the military services have guarded against using flag or general officer promotions as a reward for performance," and "we have not made any posthumous or honorary general officer promotions in any of the services."[77] Evidently Orr's staff had not discovered the Chennault precedent.

A frustrated Goldwater wrote to Air Force Chief of Staff General Charles Gabriel in 1984, asking about potential blowback from the Doolittle promotion. Specifically, Goldwater wanted to know if the service could "come up with some way of regulation that can be made solid and permanent, placing an absolute limit on two stars as the ultimate rank of a Reservist or a National Guardsman."[78] Goldwater was worried the four-star promotion—unprecedented for a reservist like Doolittle—would potentially "open the lid to [other] three star National Guard officers and three star Reserve officers" to also seek promotion.[79]

Lieutenant General Duane Cassidy, the deputy chief of staff for Air Force Manpower and Personnel, took a hard look at the legality of the proposed promotion. He wrote to the chief of staff expressing it was not merely policy that prevented promotion of reservists above major general. Rather, he believed "Chapter 837 of Title 10, in its failure to address promotions above major general, places a de facto cap on non-active duty officers at two-stars."[80] Further, Cassidy noted that 10 USC. § 601 made retired officers ineligible for

72. Ronald Reagan to James Stewart, May 13, 1981, Doolittle OMPF, NARA.

73. Barry Goldwater to Ronald Reagan, No. 025873, May 15, 1981, Doolittle OMPF, NARA.

74. Goldwater to Reagan.

75. Barry Goldwater, "Personal and Political Papers of Senator Barry M. Goldwater 1880s–2008," "Biographical Note," n.d., accessed December 2, 2022, Arizona Archives Online (website), http://www.azarchivesonline.org/.

76. Verne Orr to Edward V. Hickey, Jr., September 11, 1981, Doolittle OMPF, NARA.

77. Orr to Hickey.

78. Barry Goldwater to Charles Gabriel, August 22, 1984, Doolittle OMPF, NARA.

79. Goldwater to Gabriel.

80. Memo, Duane Cassidy to Charles Gabriel, "4-Star Promotion for LGs Doolittle and Eaker," September 12, 1984, Doolittle OMPF, NARA.

promotion, since the law "requires that officers be serving on active duty."[81] Thus, promoting retirees would require either "a change in the law" or a bill of relief from Congress, based on the precedent of promoting Chennault in 1958.[82]

By this time Doolittle's proposed promotion had grown to include Eaker—a shift in strategy apparently suggested to avoid embarrassing him.[83] Eaker had a long list of accomplishments during World War II, including commanding the Eighth Bomber Command, the Eighth Air Force, the Mediterranean Allied Air Forces, and serving as the deputy commander, Army Air Forces and chief of the Air Staff.[84] He had likely been denied a fourth star because of his transfer out of the European Theater during World War II, which was perceived as a rebuke from the US Army Air Forces commanding general, Henry H. Arnold.[85] Ironically, Doolittle was Eaker's replacement—Doolittle's autobiography recorded that he was "pleased" that he had proved himself to the leadership, but also "sensitive about Ira's feelings."[86]

Gabriel wrote to Goldwater expressing that he had convinced the secretary of the Air Force to endorse the proposal, and that he agreed with Cassidy's conclusion that "special legislation will be required to get Ira and Jimmy their fourth stars," since the law "states specifically that officers must be on active duty to be eligible for three- and four-star promotions."[87] He referenced the Chennault promotion, remarking "I'm convinced that's the right way to go."[88] Gabriel even had his chief of legislative liaison draw up a draft bill.[89]

In October 1984, Goldwater informed Gabriel that the proposed resolution was doomed in that legislative session—he speculated that "at this late date, someone would for whatever reasons, object to it and we would get into a long harangue about whether or not it should be done."[90] The resolution was thus delayed until January 1985.[91] It was substantively equivalent to the earlier act that promoted Chennault and contained a proviso stating that "advancement . . . shall not increase or change the compensation or benefits from the United States to which any person is now or may in the future be

81. Cassidy to Gabriel.

82. Cassidy to Gabriel.

83. Clifford Rees Jr. to Gerald Smith, August 13, 1984, Doolittle OMPF, NARA.

84. "Promotion Ceremony: General Ira C. Eaker," April 26, 1985, Box II:125, Ira Eaker Papers, Library of Congress (LOC).

85. James Parton, *Air Force Spoken Here: General Ira Eaker and the Command of the Air* (Maxwell AFB: Air University Press, 2000), 336–39, 434; and Meilinger, "US Air Force Leaders," 848.

86. Doolittle and Glines, *So Lucky*, 372.

87. Charles Gabriel to Barry Goldwater, October 3, 1984, Doolittle OMPF, NARA.

88. Gabriel to Goldwater.

89. Gabriel to Goldwater.

90. Barry Goldwater to Charles Gabriel, Oct. 15, 1984, Doolittle OMPF, NARA.

91. Copy of S.J. Res. 14, January 3, 1985, Doolittle OMPF, NARA.

entitled."[92] Goldwater sent the resolution to Secretary of Defense Caspar Weinberger for comment, even though the draft originally came from the Air Force.[93]

The Doolittle and Eaker resolution passed the Senate on February 21.[94] But Air Force officials recorded that it "[met] resistance in the House," which led them to search for other options.[95] Lieutenant Colonel Andrew Pelak in the Air Force office of the deputy chief of staff for Manpower and Personnel advocated one alternative. According to Pelak, "the White House asked if some more expeditious method existed" to accomplish the promotions.[96] He claimed both the Defense and Air Force General Counsel's Offices believed Doolittle and Eaker "could be advanced in their retired grade pursuant to the appointment power of the President contained in Article II, Section 2, Clause 2 of the US Constitution," (known as the "Appointments Clause") although there were no legal opinions attached to evidence this claim.[97] An added bonus, he believed, was that this pathway would authorize "increases in retired pay under Title 10," since the absence of legislation meant there was no pay or benefit proviso.[98]

Pelak's suggestion quickly ascended into orbit, presumably because it was backchannelled to Goldwater without significant staffing. Goldwater boasted to friends that he brought the proposal directly to Reagan, telling him that "even though the reserve rules prevent the additional third or fourth star," he could ignore the statute and "promote anybody he wanted."[99] According to Goldwater, the nominations dropped and were confirmed by the Senate the very next day.[100]

The strategy of seeking Senate confirmation was clearly uncoordinated, for it was not communicated to the Senate Committee on Armed Services. Weeks later, the committee incorporated Goldwater's promotion resolution into a draft of the FY1986 defense bill.[101] According to the report, the promotions were justified by Doolittle and Eaker's "unique contributions . . . to the development of air power and to the defense of this nation."[102]

92. Copy of S.J. Res. 14, February 21, 1985, Box 223, White House Office of Speechwriting (WHOS), Ronald Reagan Presidential Library.

93. Barry Goldwater to Caspar Weinberger, January 10, 1985, 99 S.J. Res. 14 docket, Center for Legislative Archives, NARA, Washington DC.

94. Advancement of Ira C. Eaker and James H. Doolittle to the Grade of General on the Retired List, 131 Cong. Rec. 3056 (Senate, Feb. 21, 1985); and National Defense Authorization Act for Fiscal Year 1986, Sen. Rep. 99-41, 99th Cong. § 534 (1985).

95. Andrew J. Pelak, Staff Summary, "Retired General Officer Nomination Action," April 3, 1985, Doolittle OMPF, NARA.

96. Pelak, "Officer Nomination Action."

97. Pelak, "Officer Nomination Action."

98. Pelak, "Officer Nomination Action."

99. Barry Goldwater to Richard Knobloch, November 7, 1985, Box 29, C.V. Glines Papers, University of Texas at Dallas; and Barry Goldwater to John O'Connor, April 17, 1985, Barry Goldwater Papers, Box 492, Arizona State University.

100. 131 Cong. Rec. 7673 (daily ed. April 4, 1985).

101. 131 Cong. Rec. 7673 (daily ed. April 4, 1985); and S. Rep. No. 99-41, at 201 (1985).

102. S. Rep. No. 99-41, at 201 (1985).

The committee expressed that while such promotions were rare, "there have been a number of cases in the past 20 years in which similar authority has been enacted into law."[103] Yet, the provision had already been preempted by its own sponsor and was removed from later drafts of the defense bill.

On April 26, 1985, Eaker was promoted at the Pentagon by Gabriel.[104] A written transcript of prepared remarks shows that Eaker thanked "the members of Congress" among other Air Force officials, perhaps suggesting that he misunderstood who was responsible.[105] His biography, written by a former member of his staff in cooperation with the Air Force Historical Foundation, also incorrectly recorded that Congress "passed special legislation" authorizing the promotion.[106]

Doolittle was promoted by Reagan and Goldwater at the White House on June 13, 1985.[107] Reagan thanked Goldwater "for his part in making this ceremony possible today."[108] An earlier draft of the speech also thanked Representative Ike Skelton (D-Missouri), who along with Goldwater was credited in the speech's border as being an "[initiator] of legislation."[109] Skelton's name was removed after speechwriters ordered a legislative trace of the resolution, which uncovered that the House had no involvement.[110] Newspaper reports credited Goldwater as the "sponsor of the legislation promoting the 89-year-old Doolittle," suggesting the administration did not make the authorization clear.[111]

The authority behind the promotions was also distorted in multiple releases. An Air Force public affairs spokesman told the media this was "the first time [such promotions have] ever happened."[112] The Air Force biography of Eaker claims that "Congress passed special legislation awarding four-star status to General Eaker, prompted by Senator Barry Goldwater and endorsed by President Ronald Reagan."[113] Doolittle's Air Force biography claims "the US Congress advanced him to full general on the Air Force retired list."[114] As the record clearly shows, Congress did not pass any legislation, and the full Congress was intentionally bypassed.

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103. S. Rep. No. 99-41, at 201 (1985).

104. "Promotion Ceremony: General Ira C. Eaker," April 26, 1985, Box II:125, Eaker Papers, LOC.

105. "Gen. Eaker's Response," Box II:125, Eaker Papers, LOC.

106. Parton, *Spoken Here*, 492.

107. Associated Press (AP),, "Jimmy Doolittle Given Fourth Star by Reagan," *LA Times*, June 14, 1985, https://www.latimes.com/.

108. "Presidential Remarks: Dropby Meeting of USAF Senior Statesmen in Honor of General James H. Doolittle," June 13, 1985, Box 223, WHOS, Reagan Library.

109. Douglas/BE, "Presidential Remarks: Dropby Meeting of USAF Senior Statesmen in Honor of General James H. Doolittle," draft, June 11, 1985, Box 223, WHOS, Reagan Library.

110. Legi-Slate Report for 99th Congress, Sen. J.Res. 14, June 11, 1985, Box 223, WHOS, Reagan Library.

111. AP, "Jimmy Doolittle."

112. Chuck Conconi, "Doolittle Gets His Fourth Star," *Washington Post*, April 10, 1985.

113. DAF, "General Ira C. Eaker," US Air Force (website), n.d., accessed December 2, 2022, https://www.af.mil/.

114. DAF, "General James Harold Doolittle," US Air Force (website), n.d., accessed December 2, 2022, https://www.af.mil/.

As chairman of the Senate Committee on Armed Services and a retired major general, Goldwater certainly knew the promotions raised separation of powers issues, but it appears that any such concerns were subordinate to his own interest in securing Doolittle's recognition. Goldwater originally informed Doolittle that "all we need to do is get the [promotion] bill through the House of Representatives," but then told him "I went to the President . . . because of some complication that arose with my bill in the House."[115] He later explained Senate confirmation was "a way around these scoundrels [in the House]" who wanted to "trade these promotions" for his vote on their "boondoggling projects."[116] Yet Goldwater himself had introduced a joint resolution, which suggests he believed House approval was a prerequisite.

By way of authorization, Doolittle and Eaker's promotion orders listed only the Constitution and Senate confirmation.[117] While the attorney general had previously ruled the president could appoint officers in violation of statutory provisions "in exceptional cases," he also ruled "Congress may point out the general class of individuals from which an appointment may be made, and may impose other reasonable restrictions."[118] In this case, the primary statutory restriction was to be presently serving in the military and thus capable of actually occupying the office in question. This seems like a reasonable restriction that would not encroach on the president's constitutional appointment authority. The Air Force leadership apparently reached the same conclusion, since they believed statutory provisions barred promotions of this type.

The authority behind the promotions became even murkier the next year. In November 1986, the comptroller general accepted the Air Force Accounting and Finance Center's request to review the promotions.[119] The comptroller general ruled "when retired service members are advanced in grade on the retirement lists, their retired pay may not be recalculated . . . in the absence of statutory authority."[120]

He opined, "there does not appear to be an Act of Congress authorizing a recalculation of the officers' retired pay," and "we are unaware of any provision of statute which would provide for a recomputation of their retired pay predicated on the action that was taken to advance them on the retired list."[121] While this ruling concerned only pay implications, it plainly contradicted the claims of Pelak, who argued Doolittle and Eaker would receive higher pay in retirement.

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115. Barry Goldwater to James Doolittle, February 22 and April 9, 1985, Box 66, James Doolittle Papers, University of Texas at Dallas.

116. Doolittle and Glines, *So Lucky*, xiv.

117. Special Order AA-775, April 4, 1985, Doolittle OMPF, NARA.

118. 41 Op. Att'y Gen. 293–94; and 29 Op. Att'y Gen. 256.

119. Comptroller General, B-224142, "General Ira C. Eaker, USAF (Retired) and General James H. Doolittle, USAF (Retired), Nov. 28, 1986.

120. Comptroller General, B-224142, 1.

121. Comptroller General, B-224142, 1.

While the process for honorary promotions of retired members was not yet codified in 1985, a precedent already existed for legislative authorization, and there were many such promotions authorized later which passed both chambers of Congress.[122] No caselaw exists on this precise issue, for a claimant must be denied promotion to have the standing and motive to litigate. Even if standing were satisfied, separation of powers concerns are often nonjusticiable political questions.[123] It is likely the Appointments Clause permits some promotions to override statutory restrictions, but these particular promotions lack the exigency and other circumstances to make a compelling case.

Conclusion

These case studies offer a window into the evolution of honorary promotions into present-day statutory provisions, as well as the questionable methods behind some individual promotion efforts. Some were driven by personal motives, which at times may have been conflicts of interest. There are also questions about the validity of some promotions, such as those for Generals Doolittle and Eaker. Both men certainly deserved this recognition, and yet the ends do not justify the means.

As mentioned earlier, Congress recently delegated the authority for honorary promotions up through major general, meaning that many defective honorary promotions of the past could be easily remedied without legislation. Unfortunately, this remedy would not apply to Doolittle and Eaker because of their ranks. As a result, reauthorizing those promotions would require Congress to waive public law, much like the aim of Goldwater's unsuccessful resolution in 1985. Mitchell is another matter, as his advancement remains bound-up in his own impropriety. While that promotion has already been authorized by Congress, the effort appears to have been abandoned, and is probably best left alone.

This article also documents that various Air Force officials repeatedly made ahistorical claims which remain uncorrected. The service's website continues to claim, incorrectly, that Colonel Mitchell was promoted to major general and earned the Medal of Honor. Official biographies also incorrectly state that Generals Doolittle and Eaker were promoted under legislative authorization. Perhaps these mistakes were made in good faith, but even if true, this means that many officials are not soliciting information from government historians or attorneys, and are not critical consumers of information themselves. This is potentially a strategic problem in today's information environment, which is why these inaccurate claims deserve correction. With public trust in the federal government at record lows, the Air Force cannot afford to contribute to misinformation.[124]

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122. See authorizations for Ellison Onizuka (1986); Benjamin O. Davis Jr. (1998); Husband Kimmel (2001); Walter Short (2001); Charles Yeager (2004); George Day (2016); Charles McGee (2020); and Richard Cole (2020).

123. Baker v. Carr, 369 U.S. 186, 217 (1962).

124. Ronald Reagan Institute, Reagan National Defense Survey (Simi Valley, CA: Ronald Reagan Institute, November 2022), https://www.reaganfoundation.org; and Brian Kennedy, Alec Tyson, and Carey Funk, "America's Trust in Scientists, Other Groups Declines," Pew Research Center (website), February 15, 2022, https://www.pewresearch.org/.

Canada's "Open Door" on 9/11

Adapting NORAD

Anessa L. Kimball

Despite criticisms of NORAD's effectiveness on 9/11, a retrospective analysis from an original sample of 27 Canadian stakeholders in national defense, foreign affairs, and the Royal Canadian Air Force reveals Canadians deployed political capital to adapt and secure the institution's future in an uncertain environment after 9/11. Canada managed a mobility crisis, opening doors to more than 30,000 travelers flying to the United States. In the aftermath, stakeholders negotiated NORAD modifications using existing provisions to reduce insecurities and uncertainties. These findings yield two operationally relevant implications. First, NORAD's flexible structure, amendment provision, and review process facilitated modification. Second, its future requires continued partner engagement through identified processes to adapt, react, and respond to continued uncertainties in continental and global environments.

The September 11, 2001, terrorist attacks motivated an extensive examination by American stakeholders of the concept of North America and the institutions underlying the Canada-US security and defense relationship. The binational North American Aerospace Command (NORAD) link required Canada to engage in similar high-level reflections. The institution's "role is transferring information to national governments regarding aerospace and maritime threats. In performing its warning mandate[s] . . . NORAD reduces uncertainty by providing information."[1] This article examines Canadian stakeholders' memories from the day of the attack and Canada's punctual management of the mobility crisis—a product of the US decision to close its airspace.

Despite NORAD's faults, its role in shepherding 33,000 travelers through Canada to other destinations is underappreciated. Mobilizing bargaining and rational institutionalist notions, this article analyzes the uncertainty, information transmission, and management of Canadian airspace during crisis in collaboration with NORAD.[2] The article

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1. Anessa Kimball, "Future Uncertainty, Strategic Defense, and North American Defense Cooperation: Rational Institutionalist Arguments Pragmatically Suggest NORAD's Adaptation over Replacement" in *North American Strategic Defense in the 21st Century*, ed. Christian Leuprecht, Joel J. Sokolsky, and Thomas Hughes Cham, Switzerland: (Springer-Verlag International, 2018), 124, https://link.springer.com/.

2. Kenneth W. Abbott and Duncan Snidal, "Hard and Soft Law in International Governance," *International Organization* 54, no. 3 (2000), https://www.jstor.org/; Barbara Koremenos, "When, What, and Why Do States Choose to Delegate," *Law & Contemporary Problems* 71, no. 1 (2008), https://scholarship.law.duke.edu/; and "Timeline: 9/11 and Canada," Canadian Public Access Channel, accessed December 20, 2020, https://www.cpac.ca/.

considers 27 interviews with Canadian actors, including the transport minister, the NORAD deputy commander, and NORAD's director of operations on 9/11 and offers an original set of reflections.[3]

About one-third of those interviewed were connected to the Canadian Air Force, reflecting the key position of the service in NORAD for years until mandated enlargement to the maritime domain. Finally, this article mobilizes distinct approaches to explain how political capital and goodwill permitted essential modifications to NORAD, ensuring its survival in the years following the 9/11 attack and resulting mobility crisis.

The interviews completed over several months in 2014 offer a retrospective on the events and are compared to stakeholder interviews, testimony, and comments offered in the years following 2001. This article demonstrates a continuum in stakeholder narratives from the months and years immediately following 9/11 to 2014, but the timeframe the article covers is 9/11 to the 2006 NORAD renewal.

Turning Crisis Management into Political Capital

Canada co-led the mobility crisis with NORAD because assets and synergies existed. Canada's willingness to lead in managing the crisis was an often-overlooked but essential security contribution. This leadership, through participation in the Permanent Joint Board on Defense, a long-standing body, and the Binational Planning Cell/Group (2002–06), deepened the Canada-US bilateral relationship.[4] Canada's resulting political capital facilitated bargaining adaptations to NORAD that clarified delegation—expanding NORAD's mandate and eternalizing it using mechanisms identified by rational institutionalists to manage strategic problems.[5]

Canada sought to ensure bilateral defense coordination while maintaining national defense policy autonomy given the fixed link provided by geography through the development of institutions. Continental security (including strategic defense command and control) remains fragile given that demands to centralize collective efforts rise with increasing uncertainty about the future state of the world and actor behavior. [6] Properly

3. Université Laval, "Ethics Committee Approval," CEUL # 2012-245/07-12-2012.

4. *The Permanent Joint Board on Defence (PJBD): How Permanent and Joint? Celebrating 80 Years of Cooperation* (Manitoba, Canada: Centre for Defence and Security Studies, University of Manitoba, February 25, 2020); and Andrea Charron and James Fergusson, "From NORAD to NOR[A]D: The Future Evolution of North American Defence Co-operation," Canadian Global Affairs Institute (CGAI) Policy Paper (Manitoba, Canada: CGAI, May 2018), https://d3n8a8pro7vhmx.cloudfront.net/.

5. Kimball, "Future Uncertainty"; Koremenos, "Why Do States Choose"; and Kimball, "Examining Informal Defence and Security Arrangements' Legalization: Canada–US Agreements, 1955–2005," *International Journal* 72, no. 3 (2017), https://journals.sagepub.com/.

6. Kimball, "Future Uncertainty," 123.

designed institutions include mechanisms that manage unintended consequences from the environment and crises.[7]

When reflecting on why NORAD floundered, Richard Williams, Western Hemisphere policy director at National Defence, pondered, "(it was) a wake-up call for an agreement born [in] the cold war. . . . People looked at [NORAD] and said, 'why do we need it?' It came back to the top of the agenda. . . . It was good. . . . 9/11 put it back on the table. . . . We are serious about protecting North America(n) air, land, sea and from space."[8] In his position, Williams was a key stakeholder coordinating the process within National Defence across the various departments. Moreover, his office was to collaborate with Foreign Affairs in responding to anything the Americans wanted to discuss concerning continental defense and security.

The strategic and operational uncertainties of the crises on 9/11 made a noisy information environment and a multistakeholder command-and-control structure even more complex. The NORAD director of operations reports to the NORAD chief of staff and is the advisor for warning and assessment of strategic maritime, missile, space and air attacks on North America. The operations director coordinates with the directorate to ensure an effective North American air defense against strategic attack and for peacetime air sovereignty.

Lieutenant General Rick Findley, Royal Canadian Air Force (RCAF), operations director on 9/11 at Cheyenne Mountain Air Force Station, Colorado, confirmed: "We routinely exercised commercial aircraft, arriving from overseas, that had something on the airplane we did not want any further than where it [landed]. So, there were some procedures and different things, levels of authority . . . to be gone through to deal with it. It was not a number one priority on any exercise. . . . Specific authorities in each nation had to be consulted for a (civilian) aircraft crisis exercise."[9] There were kinks in the chain of command on those exercises such as adding actors, which complicated planning.

The command-and-control issues encountered on 9/11 were unpredictable. A future American congressional inquiry intimated fault lay with NORAD. Findley defended the institution's readiness in an interview in 2014. "There was no way of knowing, 'If we think in the next week or two there is going to be this type of activity'–how they are going to execute it [then] there is how we are going to deal with it, and we need the authority to engage with it and take down that aircraft."[10]

In 2001, NORAD mandates covered military aircraft; civilian aircraft, as offensive weapons, were not a top threat for the institution with its outward-facing threat

7. Barbara Koremenos, Charles Lipson, and Duncan Snidal, "The Rational Design of International Institutions," *International Organization* 55, no. 4 (2001), https://www.jstor.org/.

8. Richard Williams, director general of Western Hemisphere Policy, Department of National Defence (DND), 2006 and 2006 NORAD renewels, interview with author, April 3, 2014.

9. Eric A. Findley, RCAF, retired, NORAD deputy commander during the 2006 NORAD renewal, interview with author, February 14, 2014.

10. Findley, interview.

perceptions. NORAD's posture was northward and Atlantic facing as threats were expected to arise from either of those geographic vectors with greater likelihood than others. (The pivot to Asia for the United States would occur some years later under the Obama administration.)

Weeks later, on October 30, 2001, Vice Chief of the Canadian Defence Staff Lieutenant General George E. C. Macdonald, testified before Canada's Standing Committee on National Defence and Veterans Affairs, drawing on years at the Permanent Joint Board on Defence and NORAD Headquarters. "Leaders and planners within the military had identified the potential challenges and threats posed by terrorism long before the events of 11 September this year. This is not to say anyone anticipated the specific events, but rather that efforts were ongoing to address the many issues associated with a potential terrorist attack."[11]

Macdonald's recollection aligns with others'—there was a terrorist threat, but it was too ambiguous and uncertain concerning immediate attributability of any attack. Strategically, NORAD was backpedaling on the day of the crisis, yet it saved tens of thousands of civilians' lives with Canada stepping up to manage the crisis.

On 9/11: An Uncertain Environment Plus a Mobility Crisis

At 9:45 a.m., reeling from the attack, the US Federal Aviation Administration national operations manager closed US airspace to civilian aircraft from abroad, a US national security decision with consequences for Canada, a continental partner. This action required the redirection and return of civilian aircraft inside no-return points for fuel capacity, an outcome Canada managed with the UK. Hundreds of planes with thousands of travelers over the Atlantic and Pacific oceans, enroute to the United States, were stranded—a midair crisis. In 2014, Findley noted that "situational awareness was quite limited at that time," echoing comments made in a 2003 CBC interview and 2011 documentary.[12]

Canada cancelled internal flights opening doors to travelers. The centralization of command-and-control power in an elected official in the Ministry of Transport facilitated management. The Canadian Ministry of Transport, led by a civilian, could retask civilian airports in a security crisis without needing concurrence by another authority, civil or military. The United States had left travelers stranded, creating an externality for its neighbor and transatlantic partners.

Through effective and efficient collaboration with NORAD and civil aviation authorities, NAVCANADA, the Canadian equivalent of the Federal Aviation Administration,

11. George E. C. Macdonald, "Evidence 28 on 31 Oct 2001" (Ottawa, Canada: House of Commons of Canada, Standing Committee on National Defence and Veterans Affairs, 2001), October 30, 2001, https://www.ourcommons.ca/.

12. Canadian Broadcasting Corporation (CBC), "NORAD and September 11," accessed March 11, 2021, https://www.cbc.ca/archives/; and Priscilla Jones, *The First 109 Minutes of 9/11 and the US Air Force* (Washington, DC: Air Force History and Museums Program, 2011), 82.

identified 239 flights destined for the United States to reroute and land on Canadian soil. Lieutenant General Ken Pennie, RCAF, NORAD deputy commander on 9/11 explained, "once the FAA decided they were not going to accept the airplanes a lot of these planes had no place to go. Some of them could go back to Europe and they did, others did not have enough gas. . . . There [was] no other option."[13]

David Collenette, the minister of Transport in Canada on 9/11, confirmed flight landing authorization was autonomously under the control of Transport–the civilian agency.

> Me, absolutely. I was giving a speech in Montréal (and) was passed a note saying there had been a tragedy. I had no idea it would be a huge airliner. . . . I said to my ADM, we are going back to Ottawa. I had to make all the decisions based on advice, the lawyers [on the phones], I did not even inform the Prime Minister. There was no hesitation. Chrétien, in his book, acknowledged I made the decisions, luckily, I got it right. I didn't even talk to him until . . . 1:30 p.m. I said, 'are you going to have a Cabinet meeting?' He said, 'I can't there are not enough ministers in Ottawa (he was mad. . .) but why should we have a Cabinet meeting, you've made the decisions so go ahead.'[14]

Canada faced important decisions: where to land planes (coming at a rate of several per minute at one point) and the operational task of processing thousands of international citizens in several days. There was some amount of uncertainty concerning the possibility of terrorists on incoming planes despite the hijacked flights originating in the United States.[15] The collaborative effort across civil aviation, local emergency, and security services accomplished the task with efficient communication and transparency.

The first planes landed at Canadian Forces Base, Goose Bay in Eastern Canada, lacking fuel to land elsewhere. Before the end of the day, Goose Bay accepted seven planes. Gander, Newfoundland, rose to the crisis due to its location; this town of about 10,000 Canadians added 6,600 travelers from 38 flights—15 percent of all incoming flights with *only two active runways*.[16] Airports at Gander and Goose Bay combined with St. Johns and Halifax (21 and 47 flights respectively) managed 47 percent of incoming flights to North America. Even with more flights from the East than West, Vancouver, Calgary and Edmonton took 18 percent.

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13. Lieutenant General Kenneth Pennie, RCAF, retired, director general Strategic Planning, DND-Ottawa, during the 2000 NORAD renewal, interview with author, February 5, 2014.

14. David Collenette, Canadian minister of Transport on 9/11, interview with author, Feburary 4, 2014; Jean Chrétien, *My Stories, My Times* (Canada: Knopf, 2018); and CBC, "Untold Stories of 9-11," CBC, 2003, https://www.cbc.ca/.

15. David Lyon, "Airport Screening, Surveillance, and Social Sorting: Canadian Responses to 9/11 in Context," *Canadian Journal of Criminology and Criminal Justice* 48, no. 3 (2006), https://utpjournals.press/.

16. Jim DeFede, *The Day the World Came to Town: 9/11 in Gander*, *Newfoundland* (Canada: Harper Collins, 2003).

> The United States closed its air space but did not think about the 500 planes in the air. So, one at a time NAVCANADA analyzed every flight with the British. We ordered half back to Europe not past the point of no return. So, we had another 239 to land; the decision (was) to land them on the east coast . . . ('listing locations'). The point is those places were the stages for the Second World War; . . . 10,000-foot runways, huge air capability infrastructure (existing) to take the biggest jets.[17]

In 2003, Williams testified before the Canadian Senate:

> NORAD with Canada accomplished the mission ensuring that what was happening with the landing of the airplanes followed the pattern agreed to between the various civil agencies. The structure in place reacted to the circumstances and, in an orderly manner, dealt with the situation, which was horrific. It was handled in such a way that there was no further loss of life and that public confidence in the state of peace, order and good government was re-established.[18]

Ensuring peace and order while landing the flights, including no fatalities in the process, contributed to public confidence that the traveler crisis was being resolved by competent authorities, given the collective shock from the death tolls in the United States that day. Those involved understood the capabilities existed and the decision was facilitated by the structure in Canada. Collenette explained, "the US military was much more involved. We have no military air traffic control capability, so it was exclusively us (at Transport)."[19]

Again in 2003, Williams further testified, "there was close coordination between NORAD, NAVCANADA and the FAA; the decision of where to put airplanes (was) more of a civil thing." [20] NORAD's supporting 400 fighter planes ensured the civilian flights landed where directed—a critical distinction. The defense diplomatic mission, internally named, "Operation Yellow Ribbon" normatively signaled a credible public endorsement of Canada's leadership and a successful international collaboration in a complex crisis environment demonstrating the indivisible bilateral operational utility of NORAD.[21]

Aftermath: Adapting NORAD to Manage Uncertainty

In the aftermath of 9/11, the consensus in Ottawa was that although NORAD had provided essential support, it was underprepared and therefore did not escape scrutiny. The Binational Planning Group ordered a comprehensive review to identify gaps in

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17. Collenette, interview.
18. Richard Williams, "Evidence 12," (Ottawa: Senate of Canada, Standing Committee on Defence & National Security (SCDNS), March 17, 2003), https://sencanada.ca/.
19. Collenette, interview.
20. Williams, "Evidence 12."
21. "Four Days in September," Transport Canada (website), January 7, 2014, https://tc.canada.ca/.

continental defense and the command-and-control chain. This group included NORAD stakeholders seeking to conserve the relationship.[22] Its mandate included cataloging and examining all US-Canadian arrangements to determine gaps in surveillance, warning, command-and-control, as well as the defense of land, air, and maritime approaches to the continent.

Two reports by the group, published in 2004 and 2006, addressed crisis command-and-control delegation and decision making. Key strategic problems had arisen in the continental and NORAD relationship, particularly, uncertainty about future actor behavior and uncertainty about the future state of the world, alongside concerns about ensuring Canada's credible commitment to continental defense given its wavering about NORAD's role in strategic defense.[23] Cracks had materialized within the Canadian government, and stakeholders were divided, but the external position to the United States was to signal unified support. Williams recounted:

> (Starting) the (BPG) preparations, we discovered full support wasn't shared in other parts of the government . . . a shock. The FA folks felt NORAD, as an arrangement, was too cozy. It did not give them the control they were looking for in terms of a binational arrangement. . . . Military decisions were being dealt through the military chain but not through a POLMIL chain. And they started a series of blocking maneuvers to try to regain control . . . over where we were going to move, with respect to the NORAD mandate. For a period of a year, there was a sort of interdepartmental engagement, serious interoffice politics . . . keep(ing) it close within government to not necessarily indicate to the US there was friction.[24]

Canada completed a comprehensive defense review in months, astonishingly fast. Williams recalled that "it forced us to put on the table, not only the gaps and the objectives but also the intentions we had to fill them. And the US, being serious, expected Canada to step up to the plate and contribute."[25] Findley argued in an interview that NORAD's survival was at risk.

> During the emergence of new institutions dealing with homeland defense and security there were differing perspectives. In the end its relevance was proven, and the consensus was NORAD is a fine institution. The prevailing attitude became one of formalizing it; not tinkering with it too much; not taking it out of the box and examining it too hard, too often.[26]

22. Findley, interview; and Pennie, interview.
23. Kimball, "Informal Defence Agreements"; Kimball, "Strategic Uncertainty"; and Barbara Koremenos, "Continent of International Law," *Journal of Conflict Resolution* 57, no. 4 (2013), https://www.jstor.org/.
24. Williams, interview.
25. Williams.
26. Findley, interview.

Macdonald testified, "a cruise missile attack could be another, where a country develops a capability to launch from a ship, for example, a cruise missile that may carry a high explosive or a weapon of mass destruction. Those are clearly within the mandate of NORAD Command."[27] He argued investments in communications satellites were required to continue collaboration. Canada needed defense goods that reduced uncertainty about the future state of the world and increased continental situational awareness. Still, internal Canadian divisions complicated bilateral relations over strategic defense.

Perceptions of US pressures depended on one's perspective; Canadian Armed Forces and National Defence respondents agreed on pressure to fully participate in continental strategic defense. Those at NORAD and the National Defence policy group received messages from US counterparts indicating it was proceeding on strategic defense (with or without our participation).[28] Foreign Affairs peers remained unconvinced.

Defense stakeholders in Canada in the Armed Forces and National Defence wanted to get as close as necessary to protect the Canada-US relationship and preserve Canada's privileged (senior foreign policy and defense) position, whereas within Foreign Affairs there was a division between those wanting closeness to the Americans and those weary of being too close to "the elephant." Charles Bouchard, NORAD Regional Commander-Canada on 9/11 commented in 2014, "It's the old Trudeau with the mouse in bed with the elephant that no matter how benevolent the elephant is . . . when it rolls over it will crush you."[29] This aligns with Williams' perspective as well, stated above.

One study of several NORAD renewals (1996, 2000, 2006) identified agreement provisions shaping institutional flexibility and modifications associated with information management.[30] That analysis concluded amendment, review and renewal, and withdrawal provisions reduce uncertainty about partner behavior, whereas enlarging mandates, limiting the number of stakeholders, and privileging executive prerogative over information transmission associated with NORAD negotiations reduced chances of politicization domestically.

Specifically in the period following 2001, an amendment to the NORAD agreement concerning strategic defense was added in 2004, and three notable modifications were implemented at the 2006 renewal. First, the scope of the agreement was widened to maritime warning. Second, the intervals between reviews were reduced to four years from five. Finally, it was renewed 'in perpetuity'; indicating the institution remains valid without a scheduled date to reopen its foundational concept. The agreement's mechanisms served to ensure its endurance and adaptation to changing strategic contexts (e.g., end of the Cold War, post-9/11).[31]

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27. Macdonald, "Evidence 28."
28. Based on author analysis of interview responses.
29. Charles Bouchard, NORAD regional commander during the 2006 NORAD renewal, interview with the author, March 5, 2014.
30. Kimball, "Future Uncertainty."
31. Kimball, "Future Uncertainty."

Alongside the Binational Planning Group's study and reporting, in 2002 a reorganization of the US command structure resulted in the USNORTHCOM commander being double-hatted as the NORAD commander, signaling US intent for NORAD. Charron and colleagues noted, "Canada established Canada Command, the functional equivalent of NORTHCOM . . . [which was] then replaced by the Combined Joint Operations Command (CJOC);" Canada retained a legal distinction between the two commands at the national level.[32] Consequently, NORAD slid beneath NORTHCOM, and thus generated the image of NORAD being subordinate to NORTHCOM, rather than independent per se. This was not replicated in Canada, as NORAD remained firmly outside of Canada Command/CJOC.

The structural distinction concerning NORAD's location in each partner's national command hierarchy evidences pragmatic institutional discretion, ensuring NORAD does not gain too much binational character for the United States while signaling respect for Canadian defense and security decision making sovereignty in a continental context.

This structural shift by the United States raised flags for those in Ottawa worried about the political externalities of Canada's implicit participation in continental strategic defense. Beyond command-and-control concerns, Canada needed to consent to a NORAD strategic defense role or risk the impending renewal in 2006 that was based on Canadian beliefs drawn from US signals—a belief shared by most National Defence interviewees. Despite uncertainties (the technology, costs, and geostrategic effects), Canada needed assurances to limit entrapment. The United States was uninterested in a separate system. Pennie, chief of the Canadian Air Staff in 2004, responded,

> (It) was a red line . . . they did not want to build another system for warning. . . The [August 2004] elicited amendment took away a lot of US angst because it meant they did not have to build another warning system . . . or dismantle a core part of NORAD, and probably saved NORAD from irrelevance. There was still political support for NORAD from both sides, but it would have essentially killed it as a viable military instrument. It would have become air defense against the Russian bear [bomber aircraft] only, it would have had no other role to play. So, we dodged the bullet.[33]

Despite the amendment increasing Canada's and NORAD's relevance to the Americans, Robert Fowler, a career civil servant, deputy minister of policy at National Defence, was unconvinced. "This was the maintenance of as much of the essence of NORAD without getting our feet wet. It was somewhat shameful."[34] The amendment permitted Canada to keep its foot in the door ensuring NORAD was protected.

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32. Andrea Charron and James Fergusson, *NORAD in Perpetuity? Challenges and Opportunities for Canada* (Winnipeg, Manitoba: Centre for Defence and Security Studies, 2014), 26, https://umanitoba.ca/.

33. Pennie, interview.

34. Robert Fowler, DM Policy, DND during the 1996 NORAD renewal, interview with the author, March 6, 2014.

Amendment negotiations were led by Foreign Affairs, under Michael Kergin, the Canadian ambassador to the United States, who would sign for Canada. The formal consultation mechanism was meant to control American strategic defense aspirations for NORAD by ensuring Canada was consulted. Paul Meyer, from his perspective as director general of International Security at Foreign Affairs, argued,

> Given the flux of American thinking, particularly on this (BMD) program . . . we had concerns and reservations. There was a concern in the loop. There was some formal acknowledgement by the American side. Insofar as they were going to take decisions [that had] implications for NORAD, there was a requirement for prior consultation with Canada. And designating that channel was a way you might say of enshrining that hope into the formal agreement. And it also allowed the Canadian government to say to critics or its own population simply, "Nothing was going to happen, insofar as NORAD is concerned, without explicit Canadian consent." That is important![35]

The amendment ensures a commitment by the United States to consult Canada on strategic defense decisions within NORAD ensuring access to information and 'reducing uncertainty about future partner behavior.' The institution was modified during the 2006 quinquennial revision process adding two survival adaptations. The institution enlarged its mandate and anchored its legacy during a regular revision in a bargaining coup de grace.[36]

The 2004 Binational Planning Group report suggested NORAD consider extending to maritime awareness, that is, warning and command and control.[37] The final mandate extended to only warning, since control increased the number of players (coast guards, navies). NORAD's reduced stakeholders saved it from political agendas. Findley, NORAD deputy commander at the time, concluded, "why do we need to do this bilaterally, this is a national vulnerability?"[38]

Despite the logic of centralization, William Graham, Minister of National Defence during negotiations, identified infighting for limiting a maritime mandate. "There is a good reason to have that under control of NORAD but . . . there was a kind of turf war between the Navy and Coast Guard."[39] Still, Williams, seeing the interdependences from his position as director of Western Hemisphere Policy, National Defence, at the time, offered a different reason why there was an unwillingness to go beyond warning, explain-

35. Paul Meyer, director general, International Security, Foreign Affairs in 2006, interview with the author, February 25, 2014.

36. Barbara Koremenos and Allison Nau, "Exit, No Exit," *Duke Journal of Comparative & International Law* 21, no. 1 (2010), https://scholarship.law.duke.edu/.

37. Binational Planning Group, *Interim Report on Enhanced Canada-US Cooperation* (Colorado Springs: Peterson AFB, CO, 2004), 55.

38. Findley, interview.

39. William Graham, Minister of Defense during the 2000 NORAD renewal, interview with the author, January 29, 2014.

ing it "was the fight within the Canadian government as to how close we wanted to get with the US on some of the big issues."[40]

Findley argued in an interview that "it (w)as an evolution. When NORAD started, it was strictly designed to provide air warning and fight bombers. As new threats emerged, for example, missiles, then missile warning became more important. As space became a reality, as an entity, then space warning became part of the mission. Then, we started doing theatre ballistic missile warning—it was . . . an evolution."[41]

NORAD's flexibility permitted adaptation; Macdonald connected the planning group to mandate change. "(It) looked at ways in which NORAD-Canada-US could cooperate beyond the traditional NORAD mission, and maritime was easiest."[42] NORAD retained relevance with the added mandate and adaptation. Canada faces challenges fully participating in strategic defense through NORAD because

> the addition of strategic defense to its mandate requires Canadian consent per the terms of the 1996 provision but, there rests room to maneuver. Canada could set distinct terms for its participation in strategic defense within NORAD in the context of the amending agreement. But Canada faces the policy and information challenge of demonstrating strategic defense is not inconsistent with its stated policy against weapons in space to a public already skeptical of the need for it.[43]

Renegotiation and renewal provisions manage uncertainty.[44] No one identified who suggested perpetuity. Williams asserted in an interview with the author that the idea eliminated politics, "it was difficult to bring the US to the table because they were preoccupied. If we put any barriers like a time that would run out, we risked making this a big issue and forcing something neither wanted. . . . Perpetuity spoke to us being connected at the hip in North America and that is always going to be the case. We just acknowledged it."[45]

Major General Pierre Daigle's comments are consistent with Williams' 2003 statements, and they testified side-by-side during Binational Planning Group development.[46] The 2003 Evidence outlined the evolution of thinking on how NORAD (and Canada) could respond to increasing coordination. It detailed command-and-control operational collaboration, and the required "vertical versus horizontal" relations. This speaks directly

40. Williams, interview.

41. Findley, interview.

42. George Macdonald, NORAD deputy commander during the 2000 renewal, interview with author, January 16, 2014.

43. Kimball, "Future Uncertainty," 134.

44. Koremenos, "States Choose"; and Koremenos, "Continent of International Law."

45. Williams, interview.

46. Evidence 12.

to "uncertainty about the future behavior of actors" and "concerns about the future state of the world;" both are strategic problems resolved by ending renewals.[47]

In 1996, some participants suggested lengthening the renewal interval to ten years in order to reduce commitment concerns, but that did not occur.[48] The 2006 NORAD renewal replaced the five-year review and renewal clause with reviews every four years or as requested.

The 1999 Russam Affair increased high-level political attention to cross-border defense and security. Mohamed Russam, intent on destroying the Los Angeles International Airport, was caught at the British Columbia-US border days after Christmas in a truck with explosives. Several officials interviewed for this analysis referenced that particular event as a credible binational threat and indicated the risk was considered but how the threat might reveal itself functionally was not discussed. There was uncertainty about how a terrorist threat to the binational institution would manifest itself.

A renewal without modifications was signed in 2000 instead of the scheduled 2001. The early renewal prevented politicization in the 2000 US elections; advancing the calendar was pragmatic and strategic. Moreover, Canadians took the initiative to open talks.[49]

The exogenous shock of 9/11 permitted the political, defense, and security conditions that compelled actors to resolve future uncertainty associated with renewals by enshrining the binational institution in international relations history, an institution created through a 1957 Exchange of Diplomatic Letters. One lasting effect of the 2006 renewal on North American defense was the resolution of commitment problems and the closure of several defense and security gaps.

Summary of Modifications

After 9/11, NORAD adopted three modifications: a strategic defense consultation amendment (2004); a renewal in perpetuity with quadrennial review process or by request (2006); and a broadened mandate to maritime warning and surveillance (2006). Canada requested the first two modifications and the Binational Planning Group proposed the third.

In these modifications Canada mobilized its recently generated political capital—the 1996 modification request had been unsuccessful—and a modified, arguably better, bargaining outcome was delivered (i.e., the absence of future renewal negotiations; limiting modifications to quadrennial review cycles and amendments). The 2004 amendment prevented entrapment in strategic defense beyond limits and offered a formally jointly

47. Kimball, "Understanding Uncertainty."

48. Ron Guidinger, Director General of Continental Policy, National Defence during the 1996 NORAD renewal process, interview with author, January 17, 2014; and James King, Royal Canadian Navy, Associate Deputy Minister for Policy during the 1996 NORAD renewal process, interview with author, January 14, 2014.

49. Melvin Cappe, Clerk of the Privy Council during the 2000 NORAD renewal, interview with author, March 6, 2014; and Macdonald, interview.

approved addition to the institutional structure without reopening the founding documents of the institution.

NORAD modifications were designed to ease insecurities. Actors reduced sources of uncertainty while increasing commitment credibility. In tying the continental partners together by increasing the institution's mandate and clarifying its relationship to missile defense, Canada deployed the soft power of defense diplomacy to shift the institution's contours and reduce future uncertainty without major political scrutiny in either partner's capital.

Bargained adaptations notwithstanding, concerns remain due to the evolution of partners' command structures. The need for modernizing "a supported and supporting command" emphasize structural issues, and national caveats shape effectiveness.[50] These issues include the command-and-control arrangements about the tricommand relationship of NORAD, USNORTHCOM (as a double hat), and the Canadian Joint Operations Command with respect to expanding delegations of authority, and the challenges of adopting a maritime control mission.[51]

Pierre St-Amand testified in 2017, "it's very difficult to isolate a threat to the US from a threat to Canada and vice versa. . . . The maritime domain now is becoming a domain of interest challenging [thinking] . . . in terms of continental defense, as opposed to only from a perspective of the US or Canada."[52] The binational command collaborates alongside national ones focused in multiple domains with independent command-and-control structures.[53] Divisions remain over maritime control and cyberdefense roles in conjunction with modernization equipment negotiations underway after the Canadian government's summer 2022 investment announcement.[54]

North America and NORAD in Threat Management

Reconsidering North America's (NORAD's) role in managing threats reveals how partners bargained to mitigate strategic uncertainties with existing tools. First, NORAD, a binational institution, binds partners perpetually to monitoring threats in multiple domains. It diffuses information and is a forum for maintaining the operational collaboration required to ensure continental defense.

Experts observed, "if there is any North American perspective, it is only found through NORAD as a function of its binational nature and roles and missions," and further argued, "to maintain the high level of defense cooperation between the United States and

50. Charron and Fergusson, *NORAD in Perpetuity*, 18.

51. Andrea Charron and James Fergusson, Beyond NORAD and Modernization to North American Defence Evolution (Calgary, Manitoba: Canadian Global Affairs Institute, 2017), https://www.cgai.ca/.

52. Stephen Fuhr, *Canada and the Defence of North America: NORAD and Aerial Readiness*, Second Report to the Standing Committee on National Defence (Ottawa, Ontario: Parliament of Canada, 2017), 18, 25, https://www.ourcommons.ca/.

53. Fuhr, *North America*, 34.

54. Government of Canada, "Fact Sheet: Funding for Continental Defence and NORAD Modernization," (Ottowa, ON: Government of Canada, June 22, 2022, https://www.canada.ca/.

Canada, each must avoid relative gains perceptions of continental security and focus on maintaining the functional and operational aspects of its indivisibility."[55]

Second, NORAD's essential continental public goods such as aerospace warning, aerospace control, and maritime warning (articulated around missions in Article I clause 1 of the 2006 agreement) provide a defense capability Canada could not provide alone, while Canada offers space and defense assets.[56] Yet, a third strategic concern remains—the possibility of a midcourse ballistic missile intercept over Canadian territory before its trajectory could distinguish targeting between Ottawa and Washington, DC, originating from Iran, North Korea, or China.

The geostrategic realities of Canada's situation were identified in the 1970s; scholars argued Canada's risks were structured by the United States, Russian, and Chinese strategic defense futures.[57] Canadian stakeholders mobilized NORAD's mechanisms to manage uncertainty about future behavior, credible commitment, and information quality. The 2004 amendment secured consultations on a NORAD strategic defense response. NORAD's role as a transmitter of information was reinforced with maritime awareness. Finally, granting NORAD permanence retained minimal stakeholders and protected it from national politics.

Conclusions and Operational Relevance

Jointly acknowledging the indivisibility of North American sovereignty via the permanent institutionalization of a binational command covering multiple domains of awareness is consistent with critical security arguments on state deterritorialization.[58] The practical and legal management of sovereignty concerns by US asymmetric partners motivates scholars to examine how existing institutions maintain that balance. NORAD, as an institutional actor, overcomes defense issues practically, but for philosophical reasons some stakeholders keep it off the political radar.

Treating institutions such as NORAD as delegatory independent actors has consequences for how stakeholders perceive their value. Evidence confirms leaders at Foreign Affairs and National Defence were divided over how close to get to the United States and at what political and economic costs. NORAD, as an institution, was considered too close for Foreign Affairs, leading to an internal cleavage emerging when discussing decision autonomy and strategic defense within the context of the institution.

55. Charron and Fergusson, *NORAD in Perpetuity*, 18; and Kimball, "Future Uncertainty," 126.

56. Kimball, "Future Uncertainty," 126–28; and Fuhr, *North America*, 31.

57. George R. Lindsey "The Realities of Strategic Deterrence and Its Implications for Canada," (Kingston, Ontario: CAF Staff College, May 1980); and Lindsey "General Strategic Considerations Affecting BMD," in *The Selected Works of George R. Lindsey: Operational Research, Strategic Studies, and Canadian Defence in the Cold War (The Canadian Experience of War)*, ed. Michael Wiseman (Toronto, Ontario: University of Toronto Press, 2019).

58. Stephen D. Krasner, "Compromising Westphalia," *International Security* 20, no. 3 (Winter 1995–96), https://www.jstor.org/.

Canada's successful management of the 9/11 mobility crisis generated political capital and trust. The country then mobilized to reduce uncertainty, manage information transmission, and execute operational delegation through negotiating NORAD modifications and an amendment during the next five years. Canada ensured its consultation in strategic defense decisions through the 2004 amendment, and at NORAD's renewal two years later, the binational command was made permanent, retaining flexible review and enlarged to maritime warning.

An informal agreement evolved and adapted into a permanent institution with a defined region supporting bargaining notions. NORAD exemplifies three needs for Canada. It provides self-help for Canada's security and defense; it ensures Canada's voice in its own defense; and it represents a "treaty-based institution, with predictable understandings and a structure for addressing changed circumstances . . . [that continues] to serve the national interest."[59]

NORAD progressively and legally secured its space in the tapestry of institutions and actors constituting North America. NORAD's flexible structure, review process, and extended mandate ensures its operational relevance into the next decades. Notwithstanding this, the institution faces uncertainties around the extent of Canada's participation in continental strategic defense (an internal information transmission issue); identifying and securing the institution's role in cyberdefense as it relates to the missions, threats and risks; and ensuring coverage in the gaps and seams of various national, territorial, and NATO commands.

Canada must convince citizens continental strategic defense participation through NORAD does not contravene national preferences concerning the "weaponization of space" supported by former Canadian Prime Minister Pierre E. Trudeau. These preferences are, partially, found in the United Nations Outer Space Treaty of 1967 and restated in a 2009 Canadian position response to the Conference on Disarmament treaty proposals for transparency and confidence-building measures concerning space security.[60]

Joint financial commitment to NORAD modernization permits an opportunity to negotiate aspects of the system to advance continental strategic defense aspirations in the context of Canada's domestic constraints. The provisions of the agreement can let Canada determine how far it will collaborate with the institution without fundamentally changing the structures in place.

This remains highly relevant to the Canadian Air Force, defense, and civilian national security decisionmakers as stakeholders determine what equipment is required for

59. Michael Dawson, "NORAD: Remaining Relevant," University of Calgary, School of Public Policy Research Papers, 12, no. 39 (2019), https://papers.ssrn.com/.

60. UN General Assembly, Resolution 2222 (XXI), Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, A/6431 (December 19, 1966), https://www.unoosa.org/; and Canada, "On the Merits of Certain Draft Transparency and Confidence-Building Measures and Treaty Proposals for Space Security," CD1865, working paper, UN Conference on Disarmament, June 5, 2009, https://www.reachingcriticalwill.org/.

NORAD modernization and sufficient for collective continental defense as threat sources have multiplied, diversified, and broadened geographically. As a bilateral institution, NORAD's future requires continued engagement by partners through identified bargaining processes to review, adapt, and respond to future uncertainties presented by the global strategic environment.

Hypersonics

Between Rhetoric and Reality

David Pappalardo*

While it may be an exaggeration to assert the uncontrollable proliferation of hypersonic weapons, many countries are expressing interest in developing these capabilities. Still, the growing interest in hypersonics cannot be a distraction from the development of other more accessible missile technologies, which are at a higher risk of proliferation. And while the label hypersonic must not be used to lure and exhaust the opponent into the arena of strategic competition, France must continue to explore such technology to avoid being caught strategically off-guard. The changes that the deployment of these weapons could introduce into the French national defense strategy must continue to be assessed in both their offensive and defensive dimensions, nuclear as well as conventional, and within all armed services.

From "new lethal weapons" and "spectacular and revolutionary" to "Sputnik moment," there is no shortage of hyperboles to describe current developments in hypersonic technology. It is so much so that on January 4, 2022, an investigation by the French newspaper, *Les Echos*, headlined that this new arms race was likely to "reshuffle the cards of global security."[1] Indeed, 2021 was filled with various new cases. In August, the United States accused China of testing a new disruptive weapon that was capable of circling the earth at low orbit before striking its target. Although Beijing denied this, arguing that it was a test for a reusable space vehicle, US Chairman of the Joint Chiefs of Staff General Mark Milley compared the test to the 1957 launch of the Soviet's Sputnik satellite, which had overtaken the United States in its space conquest by surprise.

In addition, on October 11, 2021, North Korea unveiled a range of weapons at the Defence Development Exhibition, Self-Defence-2021, including a hypersonic glider and a maneuverable reentry vehicle (MaRV) coupled with a new booster named Hwasong-8.[2] Although the glider, flight-tested a few days earlier, generated much doubts about the speed achieved and the actual success of the test, Pyongyang's statements focused solely on the hypersonic feature, thereby generating a viral buzz.

They used this same declaratory strategy during the two tests for a maneuvering reentry warhead on January 6 and January 11. Yet, this was not only similar to what the United States had developed in the 1980s with the Pershing-II missile, but it had also heavily

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1. Anne Bauer, "La course aux armes hypersoniques rebat les cartes de la sécurité mondiale," *Les Echos*, January 4, 2022, https://www.lesechos.fr/.

2. Colin Zwirko, "*New Missiles and Kim Jong Un Idolatry Dominate 'Self-Defense-2021' Expo*," NKPRO, October 12, 2021, https://www.nknews.org/.

referenced China's DF-21D and DF-26 missiles. According to the Korean Central News Agency, during its first test, the warhead accurately hit a target at a distance of 700 km while demonstrating a capacity to move laterally over 120 km once in position.

Finally, Russia claimed on March 19, 2022 that it had used its Kh-47M2 Kinzhal air-launched ballistic missile fired from a modernized MiG-31 to destroy an underground ammunition storage in Ukraine. (This weapon was unveiled in 2018. It has been in operational experimentation on the MiG-31 K since 2020.) While it was a first in combat operations, the strategic messaging mainly focused on the hypersonic nature of this weapon to intimidate NATO. However, the Kinzhal is neither a disruptive weapon nor does it offer Russia a significant operational advantage in the war in Ukraine. Rather, Kinzhal is a modified ground-launched Iskander-M short-range ballistic missile, the latter having been used many times since the beginning of the conflict to create similar military effects.

To focus blindly on the word hypersonic is to forget that a large proportion of ordinary ballistic missiles are already hypersonic, insofar as, depending on their range, they often reach speeds well over five times the speed of sound. In contrast, current technological developments demonstrate the search for maneuverability at very high speeds and under very high aerodynamic constraints in either the upper layers of the atmosphere (gliders, cruise missiles) or during the reentry of a warhead into the atmosphere (MaRVs).

Such efforts must be deciphered in light of the classic dialectic between attack and defense. In such cases, it must aim to increase penetration capabilities in the face of ever more elaborate and integrated missile defenses. Hypersonics thus serve four strategic ambitions. The first is to ensure the credibility of nuclear deterrence for nuclear states. Secondly, hypersonics aim to increase conventional deep precision strike capabilities, which can either support an anti-access posture (Russia and China) or, on the contrary, seek to bypass them through a combination of energy maneuverability (United States).

Finally, they are vectors of strategic signaling that can serve as an intimidation posture (Russia, China, and North Korea). These four strategic ambitions are already supported by more classical missile technologies. In this regard, hypersonics are therefore less of a revolution than an incremental progress in established functions.

Nonetheless, the strategic signaling of various competitors intertwines rhetoric with reality. Hence, the effects on strategic stability should not be overestimated in comparison with other missile technologies already in use. On the one hand, the proliferation of these technologies remains relative to date, given their high level of sophistication; on the other hand, hypersonic weapons do not significantly alter the logic of nuclear deterrence, insofar as the current arsenals already guarantee (and will continue to guarantee for the foreseeable future) the mutual vulnerability of nuclear states.

In this sense, claiming that the United States and its Allies are facing a "Sputnik moment" is exaggerated. Yet, even if these hypersonic weapons do not create new problems, they can certainly amplify existing ones in terms of escalation management, expansion of battlefield space, and the reduction of reaction times, especially when they are serving opaque and ambiguous doctrines. (The expansion of the battlefield is more significantly related to the increased range of precision weaponry, hypersonic or otherwise.)

A Redefinition of the Dialectic between Attack and Defence

High Speeds for the Energy-Maneuver Ratio

Weapons capable of reaching speeds above Mach 5 already exist as ballistic missiles, whose maximum speed increases with range (up to more than 20 times the speed of sound for ICBMs with a range of over 5,500 km). But their trajectory is predictable: as soon as they are detected, it is relatively easy to determine the point of origin (and therefore to assign responsibility for the attack) and to estimate the ballistic missile's impact point. This is also the case for any space-orbiting vehicle moving at hypersonic speeds along a predictable trajectory. In fact, in order to penetrate elaborate defenses, current developments of weapons capable of speeds above Mach 5 focus instead on using energy to maneuver at very high speeds within the upper atmosphere.

There are two main types of hypersonic weapons. The first is the hypersonic glide vehicle (HGV), which is combined with a ground- or air-launched ballistic missile. Once separated from its booster, it can fly at speeds of around 3 to 5 km/s and at altitudes between 50 and 70 km. These weapons rebound off the atmosphere to increase range and convert their speed into energy for maneuvering. The absence of propulsion, on the other hand, creates a range-penetration dilemma: should the range obtained from the first rebound allow it to maintain a sufficient speed, subsequent maneuvers would then slow it down, exposing the vehicle to the risk of interception at the terminal flight phase.

The second major category is the hypersonic cruise missile (HCM), which is usually powered by a scramjet throughout the flight (supersonic combustion ramjet). These missiles are slower than gliders (around 2 to 2.5 km/s) with generally shorter ranges. Yet, because they fly at lower altitudes (between 30 and 40 km), their detection is even more complicated. They can also maneuver very effectively, especially during their final phase, and can be air-, sea- or ground-launched. On the down side, the development of scramjet technology is not a walk in the park: operating them is akin to "keeping a match lit in the middle of a hurricane," leading certain competitors to initially favor gliders instead in their development of hypersonic weapons.

However, significant progress has been made since then. Today, scramjets have become a key priority for the US Air Force in achieving their large-scale hypersonic strike capability. At the end of 2021, Russia also actively engaged in a testing campaign for their 3M22 Tsirkon hypersonic cruise missile, launched from the *Admiral Gorshkov* frigate and the Severodvinsk submarine. Moscow is thus on the verge of fielding the first scramjet missile, capable of reaching speeds of around Mach 8, several months ahead of its initially scheduled deadline.[3] Finally, France aims to bring its future ASN-4G missile into service by 2035 for its nuclear deterrent.

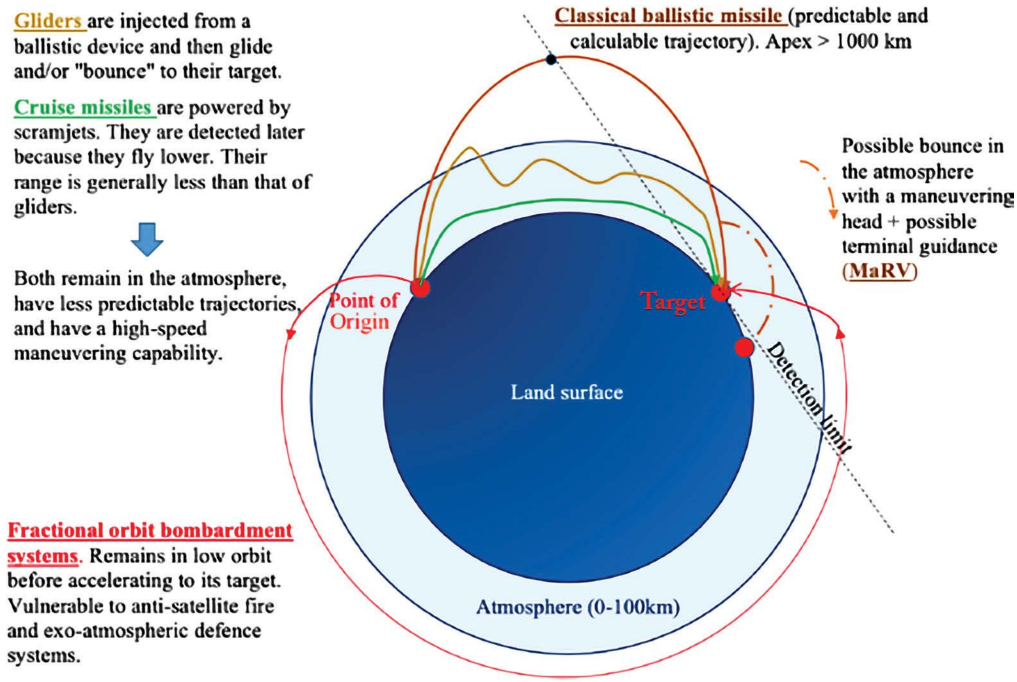

Figure 1: This figure summarizes the different flight profiles and the main characteristics of the hypersonic weapons under consideration (ballistic missiles, maneuvering warheads, HGV, HCM, and FOBS).

Beyond HGV and HCM, two other hybrid categories can be identified. The first are ballistic missiles attached to MaRVs, which can increase the accuracy of terminal guidance and possibly hit slow-moving targets. Iran, China, and North Korea are developing this technology, which is a serious point of concern, particularly in the context of antiship warfare. The second is the Fractional Orbital Bombardment System (FOBS), which has returned to the spotlight with China's testing in the summer of 2021 (although the exact nature of these tests remains unconfirmed).

Unlike gliders that "fly" in the atmosphere, FOBSs circulate in low orbit before performing a reentry maneuver and heading towards their target. The Soviets introduced the first FOBS in 1968 before abandoning them in the 1980s. While they did not contravene the letter of the Outer Space Treaty per se, they evidently contradicted its intended purpose. The 1967 Outer Space Treaty explicitly prohibits the placing weapons of mass

3. "3M22 Zircon," Missile Defense Advocacy Alliance (website), n.d., accessed July 20, 2022, https://missiledefenseadvocacy.org/.

destruction in orbit. Just like ballistic missiles that only pass through space, FOBSs are not legally considered space objects as they do not complete a full orbit around the earth. As such, they do not fall within the scope of space law.

Moreover, FOBSs have limited operational value. Admittedly, they can navigate via the South Pole to evade the northbound-oriented US missile defenses. Yet, the extension of an ICBM's range can also achieve the same capabilities, like Russia's new SARMAT, due to enter into service by 2025. FOBSs also suffer from payload limitations, with reentry into the atmosphere being more difficult to manage. Finally, the use of a low orbit makes their trajectory more predictable than that of gliders or hypersonic cruise missiles.[4] However, coupling a FOBS to a maneuvering reentry body would increase the uncertainty on the final trajectory, as well as on the point of impact.

Increasing Penetration Capacity as an Operational Objective

Beyond the different technologies used, the operational objective remains the same: guaranteeing and increasing the penetration capabilities of offensive systems by thwarting adversary defenses (bypassing) and/or destroying them (suppression). The principles remain the same: converting speed into maneuverability; adopting a flight profile in the higher layers of the atmosphere that are ill-suited to current detection and interception systems; crippling the adversary to the point of paralysis (undermining decision loops); and increasing the unpredictability of trajectories (thus posing an interpretive dilemma).

Four Main Strategic Purposes

Ultimately, the development of hypersonic weapons supports four main purposes, epitomized by the choices of the main hypersonic players today.

1 – Guaranteeing the Credibility of Nuclear Deterrence

The first purpose is ensuring the credibility of exercising nuclear deterrence in the face of an increase in adversary missile defenses. For example, Russia particularly insisted on this rationale as it presented its Avangard system as a response to both US and NATO missile defenses, despite the latter being neither directed at Russia nor designed to counter a large-scale ballistic attack. As an HGV previously known as Project 4202, the Avangard is equipped with a nuclear warhead and can reach speeds of around Mach 20 for maneuvering, thus granting its high penetration capacities. The Avangard is currently carried by the SS-19 Stiletto, pending the entry into service of Russia's new RS-28 Sarmat ICBM by the end of 2025.

The United States believes that China is also using these technologies in a more obscure way as part of an overall modernization effort—both quantitative and qualitative—

4. Emmanuelle Maitre, "Système de bombardement orbital fractionné (FOBS): une nouvelle capacité chinoise?," Observatoire de la Dissuasion, *Bulletin* no. 91 (2021): 6-9, https://www.frstrategie.org/.

for its nuclear deterrent. For example, the test conducted in the summer of 2021 may well have been a glider deployed from an ICBM. Albeit unconfirmed, this hypothesis is more credible today than that of the FOBS due to its few operational advantages, as mentioned above.

France is also moving towards hypersonics, developing a fourth generation air-to-ground nuclear missile (ASN-4G) to be put into service in 2035. In parallel, the V-MAX experimental project aimed at developing a hypersonic glider was granted to the Ariane Group by the French Directorate General of Armaments in 2019. This innovative project aims to develop technological building blocks related to the hypersonic glider, whose future use has yet to be decided (conventional or nuclear).This new maneuvering HCM will guarantee the credibility of the French deterrent's airborne component beyond 2040, while respecting the principle of strict sufficiency.

The United States, on the contrary, seems to not be using hypersonic technology to modernize their nuclear triad, for which Washington has already provisioned more than 27 billion USD by 2022 (Columbia-class nuclear-powered ballistic missile submarine; ground-based strategic deterrent program; B-21 bombers; and AGM-181 long-range stand-off weapon). In particular, it is worth noting that the United States has maintained its focus on stealth and numbers rather than hypervelocity in regard to its nuclear deterrent's airborne component.

2 – Increasing Conventional Deep Precision Strike Capabilities

The second strategic objective consists in improving conventional deep precision strike capabilities (DPS) as coercive tools. This logic was inherited from the US Conventional Prompt Global Strike program, envisioned in 2003 but never realized.[5] The initial objective of this program was to precisely strike any position on the globe in less than an hour with conventionally armed, submarine-launched intercontinental ballistic missiles. This program was put to a halt for two reasons: not only was the cost-effectiveness ratio too detrimental, but the misinterpretation risk for an adversary on the warhead's nature (conventional or nuclear) was also too high, potentially leading to an uncontrollable nuclear escalation.

With the end of the Treaty on Intermediate-Range Nuclear Forces (INF) and the hardening of Russia and China's anti-access/area-denial postures, the United States is now revisiting this concept in light of hypersonic developments in all three services. The US Army is developing the long-range hypersonic weapon (LRHW) "Dark Eagle", which is set to enter into service by 2023. With a range of over 2,000 km, the LRHW uses a ground-launched glider codeveloped with the US Navy, the common-hypersonic glide body (C-HGB). The latter has initiated the Intermediate-Range Conventional Prompt Strike (IRCPS) program, which will integrate the same hypersonic system on

5. Amy F. Woolf, *Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues*, R41464 (Washington, DC: Congressional Research Service (CRS), July 16, 2021) https://sgp.fas.org/.

Zumwalt-class destroyers from 2023, and on future Virginia-class nuclear attack submarines from 2028.

The US Air Force is still exploring two complementary avenues. The first concerns the development of the AGM-183A air-launched rapid response weapon (ARRW, dubbed "Arrow"). Due to be deployed this year on the B-52, the program is currently experiencing many technical difficulties: the United States suffered a third consecutive failure during the propulsion system's testing on December 15, 2021 from a B-52. This is a further setback for an already backlogged program, and one for which the Air Force had set aside $161 million to buy twelve units in FY22.[6]

While the AGM-183A was planned to be the first operational hypersonic weapon to enter service in the United States, the fiscal 2023 budget has clouded the horizon of the program, canceling procurement in 2023 and reinvesting funds in research and development.[7] Concomitantly, the Air Force has accelerated its scramjet-powered, hypersonic cruise missile program, following the successful flight tests of its hypersonic air-breathing weapon concept (HAWC) demonstrator on September 27, 2021 and in March 2022. The objective is to finalize the design for its future missile, the hypersonic attack cruise missile (HACM), by 2023.

The hypersonic attack cruise missile is set to constitute the Air Force's main airborne hypersonic system by the end of the decade. The contract for the first missile design of the hypersonic air-breathing weapon concept program was awarded in June 2021 to Lockheed and Raytheon (for a period of 15 months). In addition, there is a strong linkage with Australia's Southern Cross Integrated Flight Research Experiment (SCIFIRE) program.

In short, at this stage, the United States is considering a purely conventional application of hypersonic weapons, for which they are not currently considering reaching intercontinental ranges (to avoid ambiguity with their nuclear deterrent). Nevertheless, hypersonics embody the current strategic competition with Russia and China. Washington is thus investing massively to catch up with Moscow and Beijing, as shown by the budget allocated for the 2022 fiscal year in the National Defense Authorization Act ($2.7 billion provisioned, accounting for a 750 percent increase in investments between 2015 and 2020).[8]

For the United States, hypersonic systems have become essential pillars of operational superiority in response to Russia's anti-access/area-denial posture in Europe and China's in Asia. Hypersonics can help reestablish access by neutralizing enemy defenses and, more specifically, the key elements of these postures (detection and command centers, surface-to-air systems, launch sites for the main offensive systems, etc.). This does entail

6. Valerie Insinna, "Air Force Hypersonic Weapon Runs into Trouble after a Third Failed Test," Breaking Defense, December 20, 2021, https://breakingdefense.com/.

7. Valerie Insinna, "Air Force Ditches Plans to Buy First Hypersonic ARRW Missile in FY23," Breaking Defense, March 29, 2022, https://breakingdefense.com/.

8. Kelley M. Sayler, *Hypersonic Weapons: Background and Issues for Congress*, R45811 (Washington, DC: CRS, May 5, 2022), https://sgp.fas.org/.

a risk of escalation, given the entanglement of conventional and nuclear elements in the command, control and intelligence architectures.

3 – Toughen Up Anti-Access Postures

In contrast, the third strategic ambition of hypersonic weapons relates to the strengthening of anti-access postures, as evidenced by Russia and China. Seeking to stun the adversary and strike targets in depth at short notice, the hypersonic systems developed by Moscow and Beijing not only threaten key Allied infrastructures but are also likely to prohibit maneuvering and/or reduce freedom of action.

Anti-access aims to counter the adversary's ability to project power from all domains. By targeting airpower-enabling infrastructures, hypersonic systems can challenge air superiority. They can also contribute to anti-access/area-denial in the maritime domain to keep carrier strike groups' air components—symbolic of US naval supremacy—at bay.

Russia's Tsirkon missile is presented primarily as being antiship with characteristics that could reach its target despite a fleet's layered defense architecture. China's case is even more striking for maritime anti-access. Taking advantage of geography, Beijing has sought to extend its maritime interdiction zone up to the second island chain, including Bonin Island and the Marshall Islands. China has specifically developed MaRV-equipped ballistic missiles: the 1,400 km-range DF-21D and the 4,000 km-range DF-26, known as the "Carrier killer" and the "Guam killer,"respectively.

In addition, in 2019 Beijing officially commissioned the 2500 km-range DF-17 ballistic missile, equipped with a hypersonic glider capable of reaching Mach 10, suggesting an antiship function.[9] In parallel, China is developing a two-stage, antiship, air-launched ballistic missile on its H6-N bomber. Known as the CH-AS-X-13, it is believed to have been developed from the DF-21D surface-to-surface missile, thereby posing an additional threat to opposing naval forces.

Finally, regional powers like North Korea and Iran are also seeking to develop similar capabilities, although they are mainly focused on maneuvering warheads.

4 – A Vector for Strategic Signaling

Beyond posture strengthening, hypersonic weapons are also undoubtedly a tool for strategic signaling. They not only serve as a broader intimidation posture in the context of renewed great power competition, but may also embolden regional powers (Iran and North Korea in particular). Beyond the operational purposes mentioned above, hypersonic weapons also contribute to the prestige of a nation. The current escalation of verbal volleys must also be interpreted from this angle in order to untangle the skein where rhetoric and reality intertwine. This is all the more necessary since a hypersonic strike capability, especially on a moving target, does not only depend on an effector and a

9. CSIS Missile Defense Project, "DF-17," Center for Strategic and International Studies, August 2, 2021.

technological building block. It also requires a highly integrated intelligence, targeting, and command architecture, in which space assets are of paramount importance.

Between Rhetoric and Reality: What Are the Effects on Strategic Stability?

Either a source of concern or hope, the tensions caused by hypersonic vectors in regard to strategic stability are widely discussed in the light of the four previous strategic purposes. They must be analyzed even more carefully because the frenzy over hypersonic technology can be used to endorse both aggressive rhetoric and bureaucratic rationales to secure budgets.

Today, strategic stability can be defined as a situation in which actors are not structurally inclined to choose escalation over restraint. The question is therefore to understand to what extent hypersonic weapons are likely to undermine strategic stability according to its three commonly defined pillars: nuclear stability, crisis stability, and arms race stability.[10]

Perhaps Overestimating the Threat to Nuclear Stability

Following the US disclosure of China's FOBS-like tests carried out in the summer of 2021, US Air Force General John Hyten (then vice chairman of the Joint Chiefs of Staff) accused China of seeking a disarming first strike capability to prevent the United States from retaliating.[11] Tempered a few days later by Secretary of Defense Lloyd Austin, this single statement shows how rhetoric can exaggerate the reality when it comes to hypersonics.

Contrary to Hyten's assertions, the threat of hypersonics to nuclear stability should not be blown out of proportion. The principle of mutual vulnerability, which lies at the heart of deterrence, is already assured by existing means. Indeed, there is already no defense against a complex intercontinental ballistic missile attack, and this situation is unlikely to change.

With only 44 exo-atmospheric interceptors located in Alaska and California, the US homeland missile defense is not suited to counter a saturated attack. In fact, such a composition is only geared towards regional powers, such as North Korea or Iran, with whom the US refuses to concede mutual vulnerability. The same applies to NATO's missile defense as it is only capable of intercepting medium-range ballistic missiles (embodied by four Aegis ships and two Aegis Ashore sites, the first of which has been operational in Romania since 2016 and the second of which is due to be in service in 2023). Furthermore, the second-strike capability of nuclear-powered ballistic-missile submarines is not directly threatened by such developments. In other words, there is most likely not a "Sputnik moment" in today's nuclear stability.

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10. Benjamin. Hautecouverture, Emmanuelle Maitre, and Bruno Tertrais, *The Future of Strategic Stability*, Recherches & Documents, no. 7 (Paris, France: Fondation pour la Recherche Stratégique, 2021), https://www.frstrategie.org/.

11. David Martin, "Exclusive: No. 2 in U.S. Military Reveals New Details about China's Hypersonic Weapons Test," CBS News, November 16, 2021, https://www.cbsnews.com/.

Conversely, one could argue that advances in hypersonic technology are, in fact, beneficial to nuclear stability since they increase the effectiveness of penetrating defenses (qualitative improvements) without oversaturating attacks (quantitative moderation). This is, for example, the path taken by France with its ASN-4G programme, which concurs, as mentioned above, with the strict sufficiency principle.

A Risk to Crisis Stability and Escalation Management

Hypersonic systems, by their intrinsic nature, alter the relationship between time and space by reducing the former (shortened reaction time) and expanding the latter with less trajectory predictability (destination uncertainty), and could therefore complicate escalation management during a crisis. In addition to ambiguous doctrines, hypersonics further exacerbate preexisting risks, forcing the adversary to blindly decide in a two-tiered security dilemma.[12] The first level is an interpretive dilemma due to a double ambiguity. For one, the attack destination remains unclear as it is impossible to determine with certainty the intended target. In the case of two nuclear powers, this ambiguity only raises the adversary's suspicions that a conventional decapitation strike may be meant for its nuclear forces. On the other hand, ambiguity also lies in the warhead's nature, which can be either conventional or nuclear.[13]

Even once this dilemma has been resolved, it gives way to another in which the decision-maker has to tailor his response in an extremely short timeframe. The use of hypersonic weapons can aggravate the response dilemma by aggressively escalating the situation. In order to not lose the strategic advantage conferred by their own offensive systems, the defending belligerent might resort to hypersonics before knowing the outcome of the enemy's strike (the use-it-or-lose-it scenario).

In this context, there is a high risk of misinterpreting the adversary's intentions, which sets the path towards uncontrollable escalation. This is especially the issue if the defender relies on a high alert posture (launch upon warning) and/or grants strong transfers of authority for utilization (including preventive strikes). On the contrary, one may argue that these risks could also incentivize states into maintaining strong political control over the deployment and use of these capabilities in order to prevent undesired escalations.

In sum, the ambiguity at the source of instability lies in doctrine rather than in technologies. For example, China and Russia remain nebulous about the nature of their warheads (hypersonic or otherwise) deployed from their delivery systems, as well as strong obscurity on nuclear or non-nuclear forces. Moreover, the entanglement of conventional and nuclear use in command, control, and intelligence structures already increases the risk of unintended escalation in the event of a conventional strike against one of these

12. Charles-Philippe David et Olivier Schmitt, *La guerre et la paix. Approches et enjeux de la sécurité et de la stratégie* (Paris: Presses de Sciences Po, 2020): 564.

13. Heather Williams, "Asymmetric Arms Control and Strategic Stability: Scenarios for Limiting Hypersonic Glide Vehicles," *Journal of Strategic Studies* 42, no. 6 (2019), https://www.tandfonline.com/.

dual-use components.[14] Therefore, even if hypersonics do not create new problems in escalation management, the use of these weapons could significantly amplify them should there be a tense strategic competition.

Speeding Towards a Hypersonic Arms Race?

Undoubtedly at the onset of a hypersonic arms race, it is still too early to say with certainty that the cards to global security will be significantly reshuffled to the point of disrupting strategic stability. To speak of uncontrollable proliferation seems excessive when the technology needed to operationally field gliders and even more scramjets remains only within the realm of major powers for the time being. Yet, it is true that a growing number of countries' interests have been piqued, independently or in cooperation, as evidenced by the acquisition of MaRVs by regional powers, such as Iran and North Korea.

Moreover, the commotion surrounding hypersonics cannot be a distraction from the development of other more accessible missile technologies. The latter are, in fact, at a higher risk of proliferation, for which there still remains little or no tangible operational response (loitering munitions, drones, conventional cruise missiles, etc.). The label hypersonic must not become the bullfighter's muleta used to lure and exhaust the opponent into the arena of strategic competition. Nevertheless, France must continue to explore such technology to avoid being caught strategically off-guard. The changes that the deployment of these weapons could introduce into the French national defense strategy must continue to be assessed in both their offensive and defensive dimensions, nuclear as well as conventional, and within all armed services.

14. James M. Acton, "Escalation through Entanglement: How the Vulnerability of Command-and-Control Systems Raises the Risks of an Inadvertent Nuclear War," *International Security* 43, no.1 (2018), https://direct.mit.edu/.

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