

May 2021

Why GAO did this study

For decades, the satellite-based GPS has transmitted PNT data to receivers used by military platforms and personnel worldwide. PNT information is essential in many facets of DOD operations. Given the ubiquity of GPS, the failure, malfunction, or jamming of its signals or equipment could disrupt military activities involving aircraft, ships, munitions, land vehicles, and ground troops. This possibility has led DOD to explore alternatives to GPS.

GAO was asked to assess the alternative PNT technologies DOD is developing. This report discusses (1) how DOD plans to meet future PNT needs and the capabilities and limitations of alternative PNT technologies, (2) how alternative PNT technologies integrate with one another and with current PNT capabilities, and (3) policy options that may help address challenges with the development and integration of alternative PNT technologies.

To address these objectives, GAO reviewed technical studies, agency documents, and other key reports; interviewed government officials and researchers about alternative PNT technologies; and convened a 3-day meeting of experts from government, non-governmental organizations, academia, and industry. GAO is identifying policy options in this report.

View [GAO-21-320SP](#). For more information, contact Karen L. Howard at (202) 512-6888 or HowardK@gao.gov or Jon Ludwigson at (202) 512-4841 or LudwigsonJ@gao.gov.

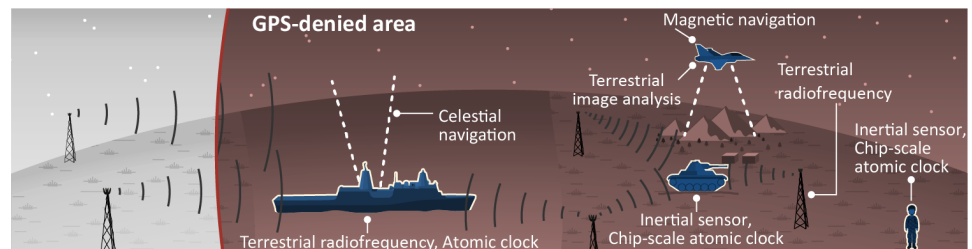
Defense Navigation Capabilities

DOD is Developing Positioning, Navigation, and Timing Technologies to Complement GPS

What GAO found

The Department of Defense (DOD) plans to keep the Global Positioning System (GPS) at the core of its positioning, navigation, and timing (PNT) solution, using other PNT technology to complement GPS or as an alternative for when GPS is degraded or unavailable. DOD's alternative PNT science and technology portfolio explores two approaches: improved sensors to provide relative PNT information, and external sources to provide absolute positioning and navigation. Relative PNT technologies include inertial sensors and clocks to allow a platform to track its position and keep track of time without an external signal like GPS. However, relative PNT technologies require another PNT technology to correct errors that can accumulate with such systems. Absolute PNT technologies allow a platform to use external sources of information to determine its position but rely on the availability of those external sources. Absolute PNT technologies include celestial and magnetic navigation as well as the use of very low radiofrequencies or low Earth orbit satellites to transmit information.

Technologies that could be used in GPS-denied environment



Source: GAO analysis of DOD information. | GAO-21-320SP

DOD may use multiple PNT technologies to provide sufficient PNT information to its various military platforms. DOD is pursuing approaches, such as creating common standards and interfaces, to aid in integrating and fielding new PNT technologies faster and at lower cost. DOD is developing its PNT modeling and simulation capabilities to evaluate the performance of new PNT technologies.

DOD faces challenges in developing and integrating alternative PNT technologies. Officials from across DOD and experts told GAO that alternative PNT solutions are not prioritized within DOD. For example, there is no central program office responsible for developing the variety of alternative PNT technologies across DOD. DOD's continued reliance on GPS, despite known GPS vulnerabilities to disruption, presents a challenge for obtaining sufficient support to develop viable alternatives. DOD officials and experts also said challenges in establishing clear PNT performance requirements hinder technology development.

GAO developed six policy options that may help address challenges with developing and integrating alternative PNT technologies. The policy options identify possible new actions by policymakers, who may include Congress, federal agencies, and industry groups. See below for details of the policy options and relevant opportunities and considerations.

Policy options that may help address challenges with developing and integrating alternative PNT technologies

	Opportunities	Considerations
<p>Increase Collaboration</p> <p> Policymakers could consider mechanisms to coordinate across DOD to clarify responsibilities and authorities in prioritizing the need for alternative PNT technologies.</p>	<ul style="list-style-type: none"> • Increased coordination could allow the military services to leverage one another’s research and development activities. • Prioritization of alternative PNT could increase the technology’s visibility, allowing more programs and platforms within DOD to better understand available technologies. 	<ul style="list-style-type: none"> • PNT solutions for a particular mission or platform may still need significant customization, possibly offsetting the benefits from centralized coordination. • Current mechanisms, such as the PNT Oversight Council, may not have the capacity to take on alternative PNT coordination.
<p>Focus on Resiliency</p> <p> Policymakers could consider selecting the most resilient technologies as the cornerstone of the PNT suite for military missions, rather than defaulting to GPS.</p>	<ul style="list-style-type: none"> • By focusing on resiliency, technologies that add to resilient PNT could receive higher priority for development, even if they are not full replacements for GPS. 	<ul style="list-style-type: none"> • A PNT solution will likely need multiple technologies to meet full PNT requirements, because no single alternative PNT technology is currently able to provide all of the required information. • DOD will need to continue maintaining GPS, as it will remain a part of the PNT solution.
<p>Clarify Requirements</p> <p> Policymakers could consider opportunities for DOD to clarify what level of PNT performance is actually needed for missions, rather than defaulting to requirements that match GPS performance.</p>	<ul style="list-style-type: none"> • With performance requirements that better reflect mission needs, DOD could make more informed decisions (such as savings in cost or integration time) in developing viable alternative technologies that will meet the actual mission needs, but not necessarily have GPS-level performance. 	<ul style="list-style-type: none"> • GAO previously reported that creating requirements involves appropriately skilled personnel. • Programs may still want GPS-level performance because more precise PNT information is always desired, even when it goes beyond what is needed to complete a specific mission.
<p>Coordinate with Industry</p> <p> Policymakers could consider ensuring that DOD and commercial industry coordinate so industry is prepared to meet DOD’s needs, and DOD can leverage industry advances.</p>	<ul style="list-style-type: none"> • DOD clearly communicating its needs to industry could allow industry to be better positioned to meet those needs. • Industry may have alternative PNT technologies that could be applied to defense. 	<ul style="list-style-type: none"> • Commercial industry may not be incentivized to develop and manufacture alternative PNT technologies if the market is too small. • A lack of transparency into proprietary commercial technology may mask vulnerabilities of different PNT technologies.
<p>Institutionalize Open Architecture</p> <p> Policymakers could consider making the open architecture initiative more permanent, including providing funding.</p>	<ul style="list-style-type: none"> • With appropriate resources, DOD’s open architecture initiative has the potential to greatly reduce integration costs and time for all PNT technologies. • Open architecture could keep DOD ahead of evolving threats to PNT, as it would be easier to field new alternative PNT technologies. 	<ul style="list-style-type: none"> • The open architecture initiative will need buy-in across the military services, as well as with commercial industry partners, which may be difficult to achieve. • Once implemented, the open architecture initiative could need continued resources and governance, as the architecture will likely evolve.
<p>Analyze Vulnerabilities</p> <p> Policymakers could consider having DOD conduct ongoing analysis of vulnerabilities of different PNT systems.</p>	<ul style="list-style-type: none"> • Given that a future solution will likely require a PNT system comprised of a combination of different technologies, users could be better informed about each combination’s overall vulnerabilities. • Users could better match PNT solutions to the mission and threat. 	<ul style="list-style-type: none"> • The complexity of having a unique PNT system for each mission and platform could make this analysis difficult. • If DOD relies more on alternative PNT, the threats will evolve in response to that strategy, which may mean the vulnerability analysis needs to be updated regularly.

Source: GAO. | GAO-21-320SP