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RESEARCH AND ENGINEERING

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MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference – Defense Science Board Task Force on Position, Navigation, and Timing Control

The United States Global Positioning System (GPS) has led the world in the development and applications of global precision position, navigation, and timing (PNT). The U.S. Air Force (USAF) developed the system in the 1970s after a successful technology demonstration that the U.S. Naval Research Laboratory (NRL) originally developed in the late 1960s as an alternative to Transit, the first space-based navigation system developed by the then-Advanced Research Projects Agency and John Hopkins University Applied Physics Laboratory. Transit was successfully fielded in the 1960s in support of the U.S. Navy submarine Polaris Ballistic Missile System (SSBN). The Transit system provided accurate SSBN location for the launching of Polaris missiles from arbitrary ocean locations around the world. The system was based on a constellation of Low Earth Orbit (LEO) satellites broadcasting very high frequency and ultra high frequency signals and exploiting the physics of frequency difference of arrival (FDOA) for providing time and location. The NRL GPS technology was based on using time difference of arrival from four satellites in Medium Earth Orbit (MEO), each flying precision quantum clocks. It was chosen over the Transit FDOA approach due to superior dynamic PNT potential.

Today, the USAF GPS system is the world's premier PNT system, providing users with single meter positioning and 10s of nanosecond timing accuracy to support a myriad of defense and commercial applications. The system has undergone a sequence of development and production upgrades on both the space and ground segments (control system and terminals) leading to the current generation of GPS-3A satellites and the emerging Next Generation Operational Control System ground control segment with the associated M-code user segment enhancements. While performance and resilience continue to improve, the system has matured to the point that these changes have resulted in incremental improvement to overall system performance. Of greater benefit for consumers has been the integration of the many foreign GPS-like systems—i.e., European Union Galileo, Russian Global Navigation Satellite System, and the Chinese BeiDou systems—as can be seen in the modern iPhone and Galaxy cell phones using multiple Global Navigation Satellite Systems plus cellular network data augmentation to get responsive and accurate positioning information. The current system has less susceptibility to jamming and spoofing, but challenges remain, including the slow fielding of user M-code capability, cyber, and kinetic threats. System performance in clear line-of-sight situations is good, but degradation can occur in canyons, cities, and high-signal, multipath environments. The cost of the system and ongoing upgrades have undergone significant growth making it hard to increase the density of satellites to address the more challenging environments.

At the same time, the commercial world and new space communication providers are now beginning to populate the LEO and MEO regimes with proliferated constellations whose plans include hundreds to thousands of satellites in these orbital regimes with the promise of providing high bandwidth and high connectivity in the most restrictive terrain and city environments using radio frequency (RF) signals from 1 gigahertz (GHz) to 40 GHz. Opportunities abound with enabling technology of software defined receivers and RF waveform generators, active phased array antennas in both the space and the user segments for multi-mission systems that can provide communications, PNT broadcast, and electronic warfare functions. In addition, with the large-scale production required, it offers the promise of low cost by taking advantage of production learning curves and economies of scale. A future multi-mission constellation that can transmit and receive RF signal across a broad spectrum will allow both the ability provide and deny communications and PNT globally and will provide support to all essential warfighting missions.

Given these opportunities, I am establishing a Task Force under the Defense Science Board (DSB) that will study the issue and send its advice and recommendation to the DSB for it, through discussion and deliberation in a properly noticed and open meeting. This study will identify and recommend specific architectures and operational approaches to enhance current PNT and support communications missions as well as provide ability to deny and confound other space based PNT systems over the next 10 years. Also, the Task Force will consider what synergy and dual use opportunities are possible for both PNT and communication missions across military, government infrastructure, and commercial applications. Key questions to be address include:

- What are the performance and resilience limits of the current GPS systems, and how is this expected to change over the next decade?

- What are the benefits and risks associated with employing military PNT systems that rely upon new commercial space communication systems to provide terrestrial and space PNT?

- What are the benefits and risks associated with utilizing architectures that rely upon RF array technology to provide PNT, along with advanced communication abilities? Consider the impact of RF frequency and waveform diversity on navigation, time distribution, and communication.

- What are the performance and resilience benefits of incorporating alternative means to acquire and update PNT information to accomplish military missions? These can include portable atomic clocks, imaged-based navigation, quantum sensors, or terrestrial-based navigation and timing distribution.

I will sponsor the study. I am recommending to the Chief Management Officer that Dr. William LaPlante and Mr. James Shields serve as the co-Chairmen of this study. Col Brent Grimes will serve as the Executive Secretary. Mr. Kevin Doxey will serve as the DSB Secretariat and Designated Federal Officer.

The Task Force members are granted access to those Department of Defense (DoD) officials and data necessary for the appropriate conduct of their study. I, as the Under Secretary of Defense for Research and Engineering, will serve as the DoD decision-maker for the matter under consideration and will coordinate decision-making as appropriate with other stakeholders identified by the study's findings and recommendations. The nominal start date of the study period will be within 3 months of signing this Terms of Reference, and the study period will be between 9–12 months. The final report will be completed within 6 months from the end of the study period. Extensions for unforeseen circumstances will be handled accordingly.

The Task Force will operate in accordance with the provisions of the Federal Advisory Committee Act (Title 5 United States Code (U.S.C), Appendix), the Government in the Sunshine Act (Title 5 U.S.C., Section 552b), and Title 41 Code of Federal Regulations, Sections 102-3.140 and 102-3.150, DoD Instruction 5105.04, and the Deputy Secretary of Defense memo "DoD Federal Advisory Committee Management Program," dated 6 August 2007. The Task Force does not have the authority to make decisions or recommendations on behalf of the DSB nor may it report directly to any Federal representative. DSB discussion and deliberation will be properly noticed and open, subject to the Government in the Sunshine Act. It is not anticipated that this study will need to go into any "particular matters" within the meaning of title 18, U.S.C., section 208, nor will it cause any members to be placed in the position of action as a procurement official.

Michael D. Griffin