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Statement of
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before the

Subcommittee on Tactical Air and Land Forces
Committee on Armed Services
United States House of Representatives

Chairman Turner, Ranking Member Tsongas and Members of the Subcommittee, thank you for this opportunity to discuss the NASA Engineering and Safety Center's (NESC) independent assessment of the Navy's efforts to understand and mitigate the F/A-18 Fleet Physiological Episodes. I am honored to be serving as the Lead for this NESC team. The NESC performs independent testing, analysis, and assessments to help address some of NASA's tougher challenges. We can draw upon technical experts from all ten NASA centers, industry, academia, and other government agencies. This allows us to bring the country's best experts to bear on the problems and challenges of NASA programs.

In February 2017, the US Navy's Naval Air Systems Command requested NASA's assistance in assessing the Navy's efforts to understand the causes of physiological episodes affecting aircrew on their F/A-18 fleet. NASA was requested to conduct an independent review of:

- the Navy's efforts to understand the causes of the F/A-18 Physiological Episodes
- the aircraft mishaps potentially related to such physiological episodes
- factors that may reduce the physiological episode rate and
- the performance of the relevant F/A-18 subsystems.

In March 2017, the NESC assembled a multi-disciplinary team with a broad range of expertise that included flight

surgeons, Life Support System experts, Engineers, and several subject matter experts.

In the course of this investigation, the team reviewed data from a variety of sources, visited multiple manufacturing sites and Navy Commands, and held numerous discussions with knowledgeable personnel. The NESC team's findings, and recommendations are based on this data and not an exhaustive review of all F/A-18 documentation.

To address the complex causes of physiological episodes, the NESC team used a multi-systems trends analysis approach and formed the resulting findings.

First and foremost, physiological episodes are a human phenomenon. Although the Navy has put significant effort into investigating the physiologic episodes, the bulk of their efforts to date have been directed to the aircraft rather than human physiology. Centering our investigation on the human element revealed new information about the character of physiological episodes.

Second, hypoxia—determined to be the most prevalent cause of physiological episodes —is not a condition of insufficient oxygen in breathing gas; it is insufficient delivery of oxygen to tissues in the body, importantly, the brain.

Third, a key to reliable Onboard Oxygen Generating System (or OBOGS) performance is uniform operating

conditions, which the F/A-18 design and dynamic operating environment rarely provides.

Fourth, the F/A-18 program has a large amount of aircraft performance data but a shortage of evidence related to human health and performance in an F/A-18 environment.

Fifth, the F/A-18 systems that support human health are complex, dynamic, and interactive; this requires a well-coordinated, "systems approach" to design requirements, interfaces and operations.

The team found that the technical aspects of physiological episodes that cause the greatest concern relate to the variability of complex system interactions. Finally, an unacceptable number of physiological episodes will persist in the F/A-18 program if there continues to be a piecemeal approach to human systems integration.

The NESC team made the following observations regarding the Navy processes.

Until recently, the absence of a single leader to coordinate and prioritize the Navy's physiological episodes efforts resulted in organizational stove-piping and the exclusion of key stakeholders.

Investigations have been structured as if physiological episodes were isolated events rather than a series of related events. Furthermore, troubleshooting efforts used a top down approach that emphasized component level behaviors

instead of evaluating the performance of the system as a whole. In this case, the system means the aircraft, the pilot and the environment.

The NESC team asserts that a dedicated, coordinated, cross-organizational, and cross-discipline program – under the direction of a single leader with clearly defined authority – would improve US Navy effectiveness in finding and fixing the causes of physiological episodes.

The NESC team has identified a number of near-and long-term recommendations. Near-term tasks are focused on gathering key evidence about human health and performance and understanding hypoxia in the F/A-18 flight environment. Long-term tasks which may provide substantial benefit include utilizing a data-driven causal analysis effort, updating the F/A-18 to conform to MIL-STD-3050, and developing a systems level understanding of bleed air management systems.

In conclusion, and although key data is lacking, the NESC believes that the majority of F/A-18 physiological episodes are a result of hypoxia. This hypoxia, it is believed, is caused by a combination of issues affecting the various stages of the oxygen delivery process, including those stages within the human. We applaud the Navy's efforts to gather the necessary data to resolve these issues. The NESC report has provided a conceptual framework to view the issue of physiological episodes in a new light and offers

recommendations that may guide future processes and technology improvements.

I thank you for the opportunity to testify before this Subcommittee and look forward to any questions you may have.