RESEARCH SUMMARY

The Resilience Assessment Framework

Assessing Commercial Contributions to U.S. Space Force Mission Resilience

OSONDE A. OSOBA, GEORGE NACOUZI, JEFF HAGEN, JONATHAN TRAN, LI ANG ZHANG, MARISSA HERRON, CHRISTOPHER LYNCH, MEL EISMAN, CHARLES BARTON

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ISSUE

The U.S. government has stated its intent to leverage new commercial space capability, and the Department of the Air Force (DAF) has been assessing the use of some of these capabilities. However, there is a need to develop and apply a principled quantitative framework for evaluating the effects of proposed commercial contributions on the resilience of U.S. Space Force (USSF) missions.

APPROACH

We developed an assessment framework that combines physics-based modeling and statistical systems analyses to help assess the impact of select commercial services on USSF space-based mission performance. The framework considers the additional mission performance and mission resilience that a proposed commercial service could provide. It also includes a multilayered approach to grade information contributions from commercial services for trustworthiness.

The framework can be tailored to diverse missions by specifying the *relevant* mission assets or infrastructure, the commercial services available, and the mission performance measures. We used the framework to assess the commercial contributions for two specific example missions: tactical intelligence, surveillance, and reconnaissance (T-ISR) and data transmit and receive network (DTRN).

CONCLUSIONS

We applied the resilience assessment framework to the T-ISR and DTRN case studies.

- The results show that the framework is highly flexible and useful for providing insight into how the performance and resilience of whole mission systems respond to adaptations of their infrastructure, including infrastructure augmentation with commercial services, as we explored in this study.

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- The results depict such trends as the relative rates of performance decline for USSF-only versus the USSF + Commercial setups for both case-study missions. The results also provide estimates of how much degradation mission systems can withstand before their performance falls below prespecified limits. This allows analysts to compare degradation thresholds across USSF-only versus the USSF + Commercial mission systems. We also note that to effectively leverage commercial capabilities, the USSF will need to consider the entire concept of operations (CONOPS) associated with using these capabilities.[1]

RECOMMENDATIONS

The USSF should consider

- *extending the framework to simulate responses to adversarial targeted degradation*. Extending the shock simulation in the resilience assessment framework will enable the USSF to evaluate mission systems' response to more targeted *adversarial* system degradation. Adversarial targeted degradation contrasts with purely random degradation that our work assumed (i.e., we degraded the system by randomly excluding some satellites).
- *further developing and implementing the trust assessment subframework*. We identified a few viable approaches for "fingerprinting" commercially sourced information artifacts for security and chain-of-custody tracking. And we identified a promising approach for fusing together trust signals into a summary metric of trust. However, there is further work to do to implement the approach from end to end for a specific mission.
- *using improved representations of USSF mission systems in resilience analyses*. We make simplifying approximations of the missions for the purposes of this study; however, a higher fidelity representation should be used in future work.
- *operationalizing an appropriately tailored resilience assessment framework for USSF missions*. The resilience and trust requirements of USSF missions demand caution when considering integrating commercial services. The USSF (and the DAF more generally) needs a principled, quantitative framework for assessing the contributions of imminent or proposed commercial augmentations to space-based defense missions. Our resilience assessment framework serves this purpose and is designed to be modular and flexible.
- *exploring applications of the framework to other missions*. The motivating idea behind our resilience assessment framework is not limited in relevance to just missions in space. The application of the proposed framework to other missions should be considered.
- *assessing what modifications to the overall USSF CONOPS are required to effectively leverage commercial capabilities*. This should involve assessing the impact of integrating commercial capabilities with USSF mission systems on doctrine, organization, training, materiel, leadership, personnel, facilities, and policy.

1 We did not investigate the CONOPS modifications needed to leverage commercial capabilities. That should be the subject of future research.

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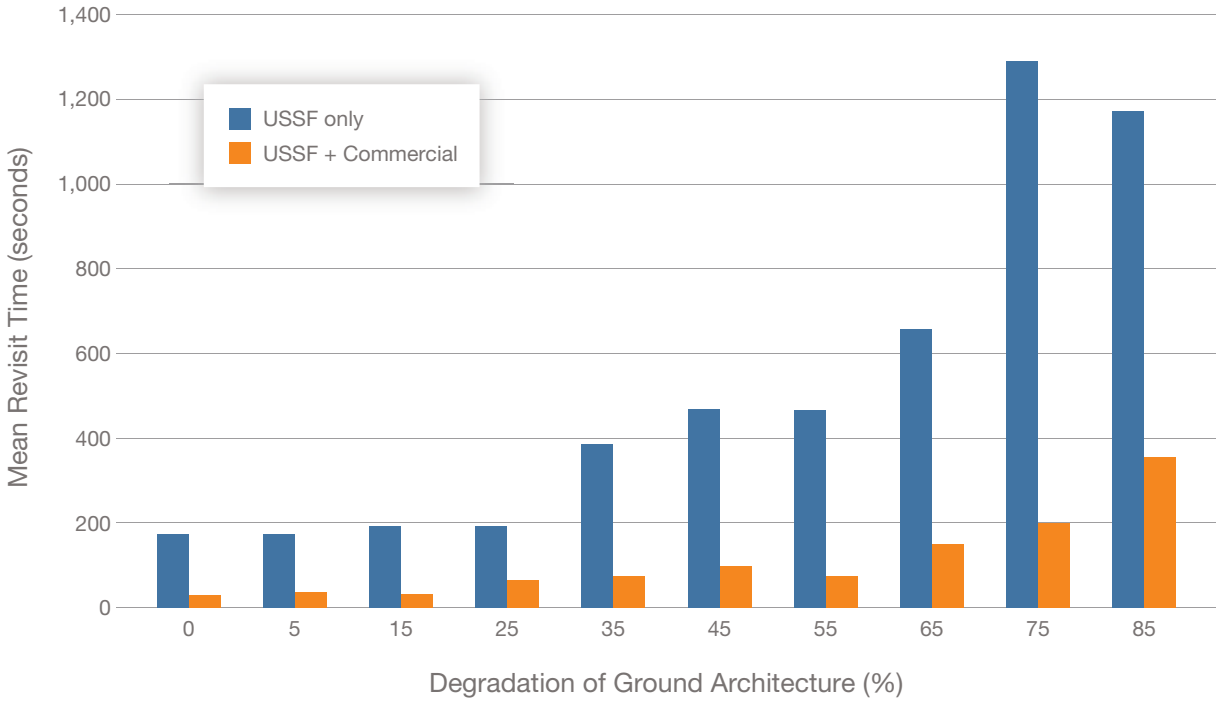
COMPARISON OF AVERAGE SATELLITE REVISIT TIME, BY MISSION SYSTEM

This figure shows a sample result from our assessment of the value of commercial services on the resilience of the DTRN mission.



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