Robust Space Situational Awareness via Hard/Soft Information Fusion in the Presence of Uncertainty

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Abstract: For most of space situational awareness, there is no rigorous approach to integrating observations originating from both physics-based sensors (hard inputs) and humans (soft inputs). An opportunity exists to develop a framework for gathering, curating, fusing, and exploiting multi-source information to achieve meaningful space situational awareness to be underwrite US National Security Space. The reason that this has not been achieved to date (which this proposed work seeks to remedy) is because (a) we lack science on space environment effects and impacts on satellites and their operations, (b) no one has been able to model soft sciences computationally to apply to this problem. In other words, there is a critical need to apply cultural context and competency to this problem and nobody has made any real attempt at that (c) most people interested in this have not had the extant computational and transdisciplinary skills and facilities to apply to the problem (d) nobody has truly applied rigorous uncertainty quantification (UQ) principles to the space domain to appropriately distinguish and model uncertainty driven by randomness (aleatory) and ignorance (epistemic) along with the decisions derived from there.

The research will focus on three basic tasks: (a) High/multi-fidelity physics modelling of the space environment interactions with artificial satellites (b) Computational representation of behavioural scientists, social scientists, anthropologists, and (geo)political scientists (c) hard/soft information fusion and data science/analytics. The goal is to significantly improve the ability to quantify and assess the behaviour of operational satellites and to be able to predict these for any given scenario in space with reliable uncertainty, regardless of the nature or nationality of the satellite owner/operator. This underscores the ability to make decisions regarding space activities and the challenge is linked to meaningful Battlespace Management, Command and Control (BMC2 for Space).

The result of this work will provide the US government with a verifiable framework and methodology to maximize the unhindered use and access to the space domain as well as better predict, deter, avoid, operate through, recover from, or attribute cause to the loss, disruption, or degradation of space services, capabilities, or activities. This underscores the foundation of National Security Space. It also is directly aligned with National Space Policy Direct #3.