**SPACE DEBRIS: COLLABORATION, COOPERATION, AND IMPLEMENTATION**

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**I thank Dr. Klinkrad for the invitation to address this meeting of the most competent members of the space debris community. I am not new to this endeavor, having conceived the first United States military directives for space debris mitigation and management, but I am a relatively new to the civil, commercial, and international stakeholders. CSSI is devoted to dealing with the existing debris environment and mitigating its growth in the future. We accomplish this with open source orbit data exchange, trusted conjunction assessment, and conjunction consequence estimates. My goal tonight is to encourage the collaboration and cooperation required to implement debris mitigation world-wide.**

**Collaboration is difficult. Process and data diversity are the greatest inhibition. We emerged from a common source, SPUTNIK and the international geophysical year 1957. National priorities and a tense Cold War political environment encouraged disparate paths. The space environment was untouched, just as the pioneers in my country enjoyed expansion without limit. Now space is a crowded, common environment in which each player has a responsibility not to encroach on others.**

**Professional rivalry often impairs collaboration. We are an academic community. Most who enjoy the benefits of space could not understand the underlying concepts and principles. Our knowledge is valuable, and unique knowledge is a treasure to be guarded. Sharing critical concepts and data could diminish our stature and our competitive advantages. But the same is true of driving in the city. We must share the road even though that act delays individual progress. There are ways to overcome this conflict. Many are addressed in this conference.**

**There are also illogical rivalries, such as not building confidence by not exposing information essential to the growth of the space enterprise. This is most evident in astrodynamics techniques. Unless we share these concepts freely, those whom we wish to use our products can never be confident of favorable outcomes. In that regard, I state the Law of Large Numbers: “There is always someone smarter than you!” Rapid progress is possible only in a collaborative environment.**

**Occasionally implementing important standards is impaired by one or a few items that lack consensus. Despite the preponderance of provisions enjoying wide consensus, those who feel strongly about one item can hold the rest hostage either by abstaining or casting negative votes. Not to deny deep commitment and to allow deep analysis, we propose to move such items from those for which there is consensus, exposing the controversial items to individual scrutiny and eventual separate consensus.**

**Our task is beyond the capabilities of any single country or industry. None have either the geography or the resources to characterize the space environment sufficiently. ISON, presented well in this conference, illustrates the advantages of a collaborative, distributed near Earth space surveillance capability. All sources of observations that are the bed rock of all missions in space suffer from calibration, measurement, and computational limitations. More well characterized data is now essential. “Well characterized” is an important term. Good data from systems whose uncertainties are suppressed is worse than bad data with well characterized uncertainty. We can provide information sufficient for users to understand and employ our techniques and data through common standards and practices. Standards do not force members of the community to work together, but they are the essential environment for collaboration. For our own benefit, we must make common standards and practices are uniform as possible. Competitive and insular standards defeat their own purpose. We must avoid multiple xenophobic national, international, or industrial standards. We see the complication of non-standard standards in electrical wall outlets. It is not good.**

**Finally, there are unquestionable and well justified national security matters, such as the United States International Trade in Arms Regulations. These are not overpowering constraints. In ISO we overcome this by guiding what should be done, not how to do it. Even in arcane mechanical standards, such as thread patterns in fasteners, the thread patterns are standardized but not the implementation of devices to produce those patterns. We can exchange orbit data and metadata that users trust and can employ without revealing the numerical and computational foundations. Our political and diplomatic colleagues must be involved in and understand our work if we are to avoid dogmatic political judgements of profound scientific work.**

**Untoward conservatism is the consequence of the lack of collaboration and sharing. Lacking confident and well characterized orbit data, we bound critical satellites in overly large keep out volumes. This causes very high false alarm rates and inappropriate, unnecessary, and wasteful maneuvers. Lack of knowledge of the presence of other satellites complicates station keeping and maneuver. This great unknown worries insurers. They have no basis for estimating risk and establishing reasonable rate structures. Collaboration in itself can mitigate this pressure, since insurers and regulators would recognize that even being aware of each other diminishes risk.**

**Debris is a serious environmental concern. It is the ash from Krakatau enveloping the Earth and creating perpetual winter. We should not exacerbate the problem through intentional debris causing events (FY1C) or less than diligent constellation management. I contend that these are a more important source of debris problems than the natural proliferation of debris through mutual interaction of existing debris or debris associated with launch and normal operations.**

**How can we enjoy the benefits of collaboration despite the inhibitions I have described? Conferences such as this are a good start. But there may already be too many for us to participate in productively. Some of us meet so frequently in venues such as this that one wonders how anyone really accomplishes anything. In my opinion, joint sponsorship of fewer gatherings would be welcome. More concretely, we must create the environment for fruitful collaboration through standards at an appropriate level, multi-lateral data sharing agreements, and bi-national interface control documents. We must make current practices less proprietary and more transparent. Interfaces should not be impermeable boundaries. We are dealing with large systems of interacting elements. Unless we can see behind the interface, we cannot deal with entropy of mixing and impedance mismatches. We must revolutionize orbit data acquisition and orbit determination through modern communication and networking and common formats. The commercial communications satellite – CSSI data center has already uncovered and overcome unanticipated procedural and functional issues such as diverse coordinate systems and reference frames, different ways of representing orbits, and the synchronization of operator provided orbit data. We have learned that a scheme imposed dogmatically and created by bureaucrats with no operational experience will not work.**

**I thank you for this opportunity. I expect that in the future I will be able to speak of our mutual, collaborative advances rather than the reasons for not having done so.**