REMARKS ON SUSTAINABILITY OF SPACE ACTIVITIES

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ABSTRACT

Technical and legal difficulties may make the de-orbiting of space objects of large mass impractical in the near future. Traffic Separation may help in minimizing collisions while the space debris population is increasing.

1 DE-ORBITING

The most important risk to sustainability of space activities is posed by space debris of large mass which will eventually enter into collisions and generate very large number of small fragments. Consequently, the risk of damage to active spacecraft would become so high that it would not be possible to maintain the present extent of space activities. De-orbiting of a significant fraction of massive space debris seems to be a necessary condition for sustaining present space activities.

Any project of de-orbiting space objects, however, would be costly, ambitious, technically difficult, and possibly illegal under present space law. It would have to decrease the total mass of objects in orbit – which is between 6000 and 7000 metric tons – in order to significantly diminish the risk of collision of debris with active spacecraft. The mean value of **6500** metric tons will be used here. According to the DISCOS system, there are, as of November 2012, the following numbers of inactive (95%) as well as active (5%) objects in orbit:

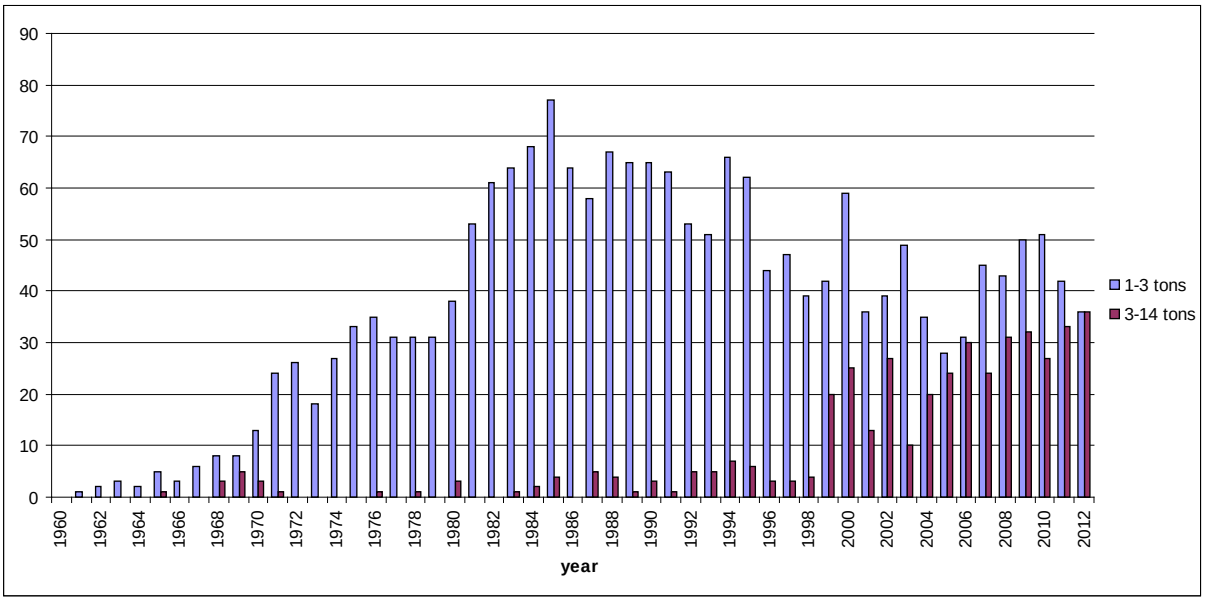

Fig. 1. Numbers of objects of large mass in years of launch.

Close to **2000** objects with masses between **1** and **3** metric tons, total mass **3500** tons, or **54%** of the total mass. Almost 900 objects have apogees above altitude of 30000 km and 34 have apogees between 200 and 400 km.

Close to **400** objects with masses between **3** and **14** tons, total mass **2000** tons, or **30%** of the total mass. Almost 300 objects have apogees above 30000 km and only 12 have apogees between 200 and 400 km.

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Objects below **1** metric ton, down to the limit of detection at size 10 cm contribute to the total mass by **500** to **1500** tons, or about **16%.**

All objects of large mass have a COSPAR identifier and their launching country or present owner has been listed in some of the current encyclopedias.

Fig.1 shows that the group of 1-3 tons was very numerous in the 1970's. It declined since then while the group 3-14 tons slowly increased and both groups were equally frequent in 2012 (first ten months). A trend to more massive objects is apparent but only future years will confirm the fact.

If the intention is to reduce the total mass of space objects, evidently the first group, 1 to 3 tons, has to be selected. The range of masses is narrow enough to make the de-orbiting possible with one kind of "debris de-orbiter". Many objects are in and above the geostationary altitude, quite a few are around the 12-hour orbit. Still there are some objects below 400 km. Even a relatively small number of missions would make a dent in the total mass in orbit. Let us assume that the first "de-orbiter" would be of a size comparable with the Space Shuttle. The mass of debris considered is less than the mass of the supposed "debris de-orbiter" thus making the supposed tether maneuvers efficient.

In this hypothetic – and limited - case, the operation would be unprecedented, the number of missions large. The de-orbiting by tethers would require more theoretical studies and experiments.

Moreover, the legal situation poses a serious obstacle. According to the Outer Space Treaty, space objects remain under control of launching states and are their property. Only their launching countries or subsequent owners have the right to de-orbit their space objects. Opening that Treaty for a new discussion, or starting in the UN a discussion on ownership of space debris is theoretically possible, but it might take a very long time to reach a solution. Another possibility to solve the legal problem in the form of declaration of owners of debris permitting the disposal of debris by third parties has not yet appeared. Another important factor is that the technology of de-orbiting is similar to technology of anti-satellite weapons. Preventing such misuse might be difficult once the relevant technology becomes known. The UN COPUOS would probably hesitate to open the legal door for undesirable activities.

The above avenues will have to be discussed, more efficient methods of de-orbiting massive debris will have to be investigated and the problems finally solved. Designing and testing a new kind of spacecraft, the "debris de-orbiter", and finally the de-orbiting of a significant number of objects of large mass, may take a time which is difficult - if not impossible - to estimate.

2 TRAFFIC SEPARATION

In the meantime, that is in the foreseeable future, we shall have to learn how to live with a larger number of debris than we have today. Steps will have to be taken to mitigate the problem of space debris. In the first place attention has to be paid to elaborate more detailed guidelines. The process has already started in the United Nations in the Committee on Peaceful Uses of Outer Space (COPUOS) and its Scientific and Technical Subcommittee. It might lead to an upgrading of the guidelines to a higher status. In particular, policy guidelines should be listed separately from technical guidelines because they are addressed to different authorities in launching countries.

In the second place it should be noted that some activities, broadly called "Separation of Traffic" have already been implemented. Separation of traffic has solved traffic problems on the ground in railroad and highway traffic. It is used also in space, in particular in the geostationary orbit. Satellites which terminated their activities are re-orbited into disposal orbits sufficiently high above the geostationary orbit. However, in LEO and MEO no convenient altitudes for disposal orbits have as yet been found practical. Separation of traffic has to have a different form in those altitudes. It would be rather a separation in the space-time continuum than in the 3D space. Actually, separation is being used in the form of evasive maneuvers, when an active satellite slightly changes its orbit to let pass an object which cannot maneuver. Efficiency of maneuvers would be increased if orbital elements of debris were known with higher precision. The accuracy of the Two-Line Elements (TLE) should be increased and data from the International Scientific Optical Network (ISON) and possibly from other sources should be made accessible and compatible with the TLE. That point was discussed and adopted in general terms at the meeting of Expert Group B on Space Debris at the recent session of the Scientific and Technical Subcommittee.

In this context it should be noted that the most accurate method for measuring distances and deriving orbital elements of objects in space is by Satellite Laser Ranging (SLR). The attainable accuracy is in centimeters, much less than the dimension of a massive object in orbit. There are approximately 40 observatories engaged in SLR for geodesy and other programs. Some of the existing observatories might include observations of massive objects in their activities. Moreover, new observatories could be built at affordable cost, if necessary. The only condition is to have retro-reflectors mounted on space objects. There is no problem in mounting retro-reflectors on objects which will be launched in the future. That would be of particular importance for objects of masses above 3 tons which might be difficult to be disposed of by tethers. Their numbers are increasing, as shown in Figure 1. If the trend continues for the next 5 years we might face the presence of some hundreds additional objects of large mass. If a recommendation to mount retro-reflectors on massive objects is adopted today, precise orbits of many massive objects would be available in a near future.

The advantage of precise knowledge of orbits would be substantially enhanced if retro-reflectors could be mounted on objects already in space. Of importance In this respect are new developments of technology of repairing and refueling of orbiting objects, as was announced recently by NASA and other space agencies. Fixing retro-reflectors on an orbiting object need not be much different from repairing it.

For the moment, i.e. for the June session of COPUOS, it would be sufficient if some support is shown for the recommendation to equip large objects to be launched with retro-reflectors or other means for increasing the accuracy of orbital elements.

If the proposal is made by one delegation only, it will hardly be adopted.