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## *Origin of the Inter-Agency Space Debris Coordination Committee*

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The Inter-Agency Space Debris Coordination Committee (IADC) is recognized as the preeminent international technical organization for all issues associated with orbital debris. This august body now comprises 12 member agencies representing 11 nations and the regional European Space Agency (ESA). October 2012 marked the 25th anniversary of the first ESA-NASA orbital debris coordination meeting, which would evolve into the IADC, and the 20th anniversary of the proposal to establish a formal, multinational group of orbital debris experts.

Good things often arise from unfortunate events, and the IADC is a case in point. On November 26, 1986, an Ariane 1 second stage spontaneously exploded in low Earth orbit, creating the largest orbital debris cloud to that date. A total of 492 large pieces of debris were eventually cataloged from the fragmentation, although, fortunately, only 32 remain in orbit today. This significant space event led NASA's Orbital Debris Program Office to host an international conference on the breakup of launch vehicle upper stages the following May and led ESA to establish the Space Debris Working Group.

Following the successful conference, NASA and ESA decided to hold a bilateral orbital debris coordination meeting in Rolleboise, France, in October 1987, "to discuss the various aspects of space debris, exchange opinions, present study results and agree on contact points for policy, management, and technical experts." Due to the considerable number and breadth of topics of mutual interest, a decision was made to hold a second meeting the following year, which in turn led to additional meetings at roughly annual intervals.

In early 1989, a U.S. Government interagency report on orbital debris recommended that "the U.S. should inform other space-faring nations about the conclusions of this report and seek to evaluate the level of understanding and concern of other nations and relevant international organizations about orbital debris issues. Where appropriate, the U.S. should enter into discussions with other nations to coordinate debris minimization policies and practices." Consequently, by the end of 1989 NASA orbital debris experts had visited both the Soviet Union and Japan and established separate orbital debris working groups with the two nations.

Thus, in 1990 NASA was supporting three distinct, but very similar, bilateral orbital debris coordination meetings. This inefficient situation began to take a toll on NASA orbital debris experts in terms of time, travel, and expense. A consolidation of these efforts was the logical next step. At the sixth meeting of the ESA-NASA orbital debris coordination committee in April 1991, Japan was invited to be an active participant. Beginning with the next gathering in February 1992, the forum was officially renamed the ESA-Japan-NASA orbital debris coordination committee, but the original ESA-NASA numbering system was retained, making this the seventh official meeting. A few days after this meeting, which took place in the Netherlands, NASA orbital debris specialists extended

their journey to Moscow to meet with their Russian counterparts for the next meeting of the U.S.-USSR orbital debris coordination committee.

By the eighth meeting of the ESA-Japan-NASA committee, which was held at JSC in Houston, Texas, in October 1992, the need for a more formal and possibly more inclusive organization was apparent. A straw-man Terms of Reference for the new committee was circulated for review and comment. The scope of the proposed committee's activities was to "(1) review all ongoing cooperative debris research activities between member organizations, (2) identify, evaluate, and approve new opportunities for cooperation, and (3) serve as the primary means for exchanging information and plans concerning orbital debris research activities."

The ninth meeting of the committee, hosted by ESA at the European Space Operations Center (ESOC) at Darmstadt, Germany, in April 1993, was the first to include all four of the founding members of the IADC, although a new name for the committee had yet to be chosen. At this meeting, the concept of establishing a steering group and four working groups (measurements, environment and database, testing and shielding, and mitigation) was adopted. Each future meeting would be divided into opening and closing plenary sessions with concurrent splinter meetings of the steering group and the four working groups in between.

The name of the Inter-Agency Space Debris Coordination Committee was officially adopted in Moscow in October 1993. Here, the first formal IADC Terms of Reference was signed by the heads of the four delegations: K. Debatin for ESA, S. Toda for Japan, G. Levin for NASA, and A. Krasnov for the Russian Space Agency (RKA). Although much expanded, the current IADC Terms of Reference retains many elements of the original framework document.

The IADC grew rapidly with the addition of the space agencies of China (CNSA) in 1995; France (CNES), India (ISRO), and the United Kingdom (then BNSC, now UKSA) in 1996; Germany (then DARA, now DLR) in 1997; Italy (ASI) in 1998; the Ukraine (then NSAU, now SSAU) in 2000; and Canada (CSA) in 2010. The 12-member committee now holds its annual 4-day meeting each spring with more than 100 orbital debris specialists attending. The Steering Group, composed primarily of the heads of each member agency delegation, also meets for 1 day each fall on the sidelines of the International Astronautical Congress.

The many achievements of the IADC include the publication of the first international set of space debris mitigation guidelines, the establishment of a data exchange network for the uncontrolled reentry of satellites posing elevated risks to people and property on Earth, organized campaigns for observation of untracked debris in both low- and high-altitude orbits, and a manual on the design and effectiveness of shielding to protect spacecraft from space debris. Although it is not part of the United Nations (UN), since 1997 the IADC has normally provided a special technical presentation before the annual meeting of the Scientific and Technical Subcommittee of the UN Committee on the Peaceful Uses of Outer Space (COPUOS). The IADC space debris mitigation guidelines were used as the foundation for the development of the UN COPUOS space debris mitigation guidelines.

Additional information about the IADC and its activities can be found at [www.iadc-online.org](http://www.iadc-online.org).

## *Effectiveness of Satellite Postmission Disposal To Limit Orbital Debris Population Growth in Low Earth Orbit*

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Orbital debris mitigation measures have been developed to reduce the growth of the debris population. A major component in debris mitigation is postmission disposal (PMD). The key PMD element for low Earth orbit (LEO – the region below 2000-km altitude) satellites is the 25-year rule. It is intended to limit the long-term presence of rocket bodies (R/Bs) and spacecraft (S/C) as well as mission-related debris in the environment. The effectiveness of PMD has been demonstrated and documented since mitigation measures were developed in the 1990s. This article provides an update, based on the current environment, using the NASA orbital debris evolutionary model – LEGEND (Low Earth orbit-to-Geosynchronous orbit ENvironment Debris model). This model was developed by the NASA Orbital Debris Program Office at JSC, and the PMD study was completed in 2012.

The study focused on the  $\geq 10$  cm population in LEO. The historical simulation spanned the years 1957 through 2011 and followed the recorded launches and known breakup events. The simulation was projected 200 years into the future, with launch traffic from a span of 8 years, 2004–2011, repeated during the projection period. An 8-year mission lifetime was assumed for future S/C. No station-keeping or collision-avoidance maneuvers were implemented, and only objects 10 cm and larger were included in collision consideration. Additionally, no explosions were allowed for R/Bs and S/C launched after 2011. The 25-year PMD rule compliance rates were set at 0 percent, 10 percent, 50 percent, 75 percent, and 95 percent, respectively, for the five study scenarios.

Figure 1 shows the effective numbers of objects in LEO, including both the historical and the five future projections. Each projection curve is the average of 100 Monte Carlo (MC) LEGEND runs. As expected, the 0-percent PMD projection follows a rapid and nonlinear increase in the next 200 years. With 50-percent compliance with the 25-year rule, the population growth is reduced by approximately half. However, even with 95-percent compliance with the 25-year rule, the LEO debris population will increase by an average of more than 50 percent in 200 years.

The projected collision activities are shown in figure 2 and summarized in figure 3. A catastrophic collision occurs when the ratio of impact energy to target mass exceeds 40 J/g. The outcome of a catastrophic collision is the total fragmentation of the target, whereas a noncatastrophic collision results only in damage to the target and the generation of a small amount of debris. Even with 95 percent compliance with the 25-year rule, on average, 26 catastrophic and 19 noncatastrophic collisions are expected in the next 200 years.