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ISS FORCED TO CONDUCT BACK TO BACK DEBRIS AVOIDANCE MANOEUVRES

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The International Space Station (ISS) in the past few days was threatened and was subjected to potential impact from space debris on two occasions within a fortnight. On both the occasions, ESA's Automated Transfer Vehicle (ATV) initiated the corrective manoeuvres by firing its thrusters to push the orbital outpost and its six occupants out of harm's way.[1] The first instance of Predetermined Debris Avoidance Manoeuvre (PDAM) was carried out on October 27, 2014 using ATV-5 **Georges Lemaitre** to avoid the remains of the Russia's Cosmos-2251 satellite that broke up after colliding with United States commercial satellite Iridium-33 in 2009.[2] The second instance of urgent PDAM was carried out on November 12, 2014 again by ATV-5 to prevent a potential impact from a lens cover or cap believed to be remnant of Chinese spy satellite 'Yaogan-12'.[3] This satellite was launched in November 2011 and the lens accessory is assumed to be discarded in the process of commissioning the satellite.[4] While both the pieces of debris were small, they were big enough to cause appalling damage to ISS. The warnings of potential collision incidences were issued by NASA to the ATV Control Centre in Toulouse, France, which initiated the PDAM to increase the speed of ISS by 0.5 m/sec in both the cases.

The ISS is a huge structure spanning a size of a football ground and weighing approximately 450, 000 kg. Launched in the year 1998, the ISS is stationed in the low earth orbit maintaining an altitude between 330 km to 435 km and travels at an average speed of

27, 724 km per hour.[5] The ISS as photographed on May 23, 2010 by a crew member on board the Space Shuttle *Atlantis* is shown below.[6]

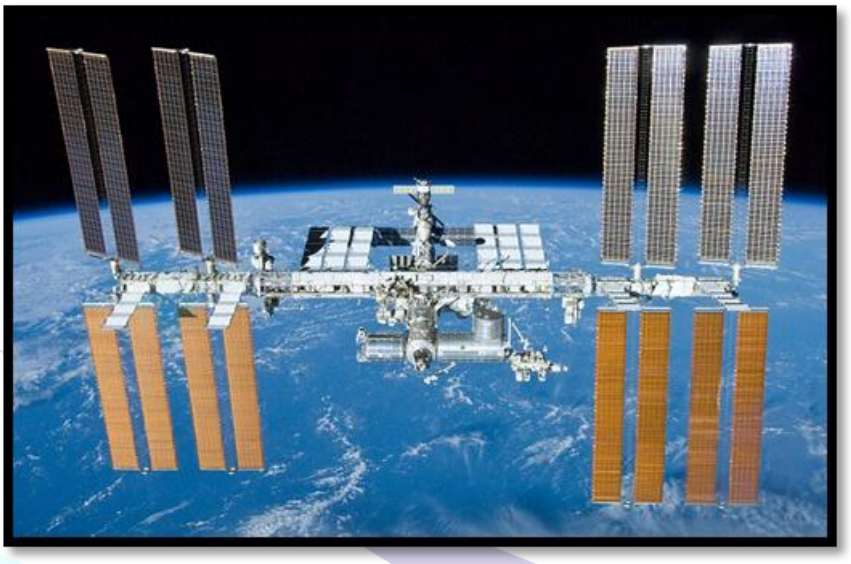

Figure 1: ISS photographed from Space Shuttle Atlantis[7]

NASA and associate organisations traditionally suggest a debris avoidance manoeuvre when space debris is expected to move in close quarters in a cubical area extending over 25 km in the vicinity of International Space Station and over a vertical separation of approximately one kilometre above and below the orbiting laboratory. The debris avoidance manoeuvre is not uncommon and has been carried out on more than 15 occasions since year 1998. The probable debris collision threats called as conjunctions, in past have forced the ISS crew to evacuate and take shelter in the docked spacecraft for emergency evacuation. NASA issues a 'yellow warning' when the probability of debris collision is one in 100,000 and the preparations for PDAM are initiated. As the probability of collision increases to one in 10,000, a 'red warning' is issued making PDAM imperative.[8] PDAM is resorted to change the speed/ trajectory of spacecraft by firing of main engine thrusters of the mother station or that of docked cargo spacecraft to increase the speed of ISS so as to maintain a relatively safe distance from the passing debris. [9] The docked cargo spacecraft like ATV's, Soyuz and NASA's space shuttles can dock with the mother station on the respective docking ports to carry out maintenance, upgrade and any repairs needed. They also cater for propellant, water, air and carry additional payloads for research activities.

More than 5, 00,000 pieces of space debris encompassing both natural (meteoroids) and manmade debris (defunct satellites, their parts and debris resulting from deliberate or accidental collisions) are presently tracked as they orbit around the earth at the average speed of 7.8 km/s. Of these, approximately 20,000 pieces of debris are in excess of 10 cm in size. In addition there are millions of pieces of debris that are very small sized and cannot be tracked. While the larger pieces of debris can be tracked and evasive action can be initiated, the smaller pieces of debris have now become major cause of concern as even a fleck of paint can potentially damage a space asset. The satellites and spacecraft can obviate catastrophic damages to some extent by incorporating protective shielding. The damage that a collision with debris can cause to a spacecraft depends on the kinetic energy released in the collision, the design of the spacecraft, and the geometry of the collision.[10] The extent of damage to a thick aluminium metal sheet carried out in laboratory conditions by a 7 gram projectile fired from a light gas gun and travelling at speed of 7 km/s is depicted in figure 2. Taking into consideration the enormous station size of ISS, one can well visualise the fallout of debris collision threats.

Figure 2: A 7 gram object (shown in centre) shot at 7 km/s (23,000 ft/sec) (the orbital velocity of the ISS) made this 15 cm (5 7/8 in) crater in a solid block of aluminium.[11]

One of the major causes of concern is the creation of debris cloud due to the collision of defunct satellites and ASAT tests. The Chinese ASAT test of 2007 created a debris cloud of 3000 pieces and in February 2009, a defunct Russian satellite collided with an operational Iridium satellite of the United States resulting in excess of 2000 fragments. The rising population of fast orbiting small pieces of debris pose a serious challenge to all satellites, spacecrafts, space shuttles and in particular to the International Space Station (owing to its size) with humans aboard. Reduction of space debris is now gaining prominence amongst the space faring nations and efforts are underway to adopt mitigation techniques. The mitigation guidelines would include a series of measures that would help containing creation of space debris. The other way of reducing space debris would involve active removal of debris by manmade systems. While both these methods if implemented effectively would help in arresting the exponential growth in debris population, the space junk is bound to grow and may even become unmanageable in centuries to come.

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[1]"ESA Space Ferry moves space station to avoid debris", accessed at http://www.esa.int/Our_Activities/Human_Spaceflight/ATV/ESA_space_ferry_moves_Space_Station_to_avoid_debris November 05, 2014

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[8] Jonathan O'Callaghan, "Did a Chinese LENS CAP almost destroy the ISS? Station dodges space debris from spy satellite to avoid disaster", *MailOnline*, accessed at http://www.dailymail.co.uk/sciencetech/article-2834434/Did-Chinese-LENS-CAP-destroy-ISS-Station-dodges-space-debris-spy-satellite-avoid-disaster.html on November, 17, 2014

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