INTER-AGENCY SPACE DEBRIS COORDINATION COMMITTEE (IADC)

SPACE DEBRIS MITIGATION

Presented to:

35th Session of the
SCIENTIFIC AND TECHNICAL SUBCOMMITTEE
COMMITTEE ON PEACEFUL USES OF OUTER SPACE
UNITED NATIONS

On behalf of the IADC

INTER-AGENCY SPACE DEBRIS COORDINATION COMMITTEE

- ESTABLISHED IN 1993:

  - TO EXCHANGE INFORMATION ON SPACE DEBRIS RESEARCH ACTIVITIES BETWEEN MEMBER SPACE AGENCIES,

  - TO FACILITATE OPPORTUNITIES FOR COOPERATION IN SPACE DEBRIS RESEARCH,

  - TO REVIEW PROGRESS OF ONGOING COOPERATIVE ACTIVITIES, AND

  - <u>TO IDENTIFIY DEBRIS MITIGATION OPTIONS</u>

- OF THE FOUR IADC WORKING GROUPS, TWO ARE DEDICATED TO EXPLORING NEW AND MORE EFFECTIVE MITIGATION TECHNIQUES.

IADC MEMBERSHIP

- THE PRESENT IADC MEMBERS ARE AS FOLLOWS:

  - BRITISH NATIONAL SPACE CENTRE (BNSC)
  - CENTRE NATIONAL d'ETUDES SPATIALES (CNES)
  - CHINA NATIONAL SPACE ADMINISTRATION (CNSA)
  - EUROPEAN SPACE AGENCY (ESA)
  - GERMAN AEROSPACE CENTER (DLR)
  - INDIAN SPACE RESEARCH ORGANIZATION (ISRO)
  - NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)
  - JAPAN
  - RUSSIAN SPACE AGENCY (RKA)

- THE MOST RECENT IADC MEETING (15TH) OCCURRED IN DECEMBER 1997 WITH MORE THAN 100 PARTICIPANTS.

SPACE DEBRIS MITIGATION

MITIGATION COMPRISES THREE MAIN ASPECTS

- PREVENTION OF SPACE DEBRIS
- PROTECTION OF SPACE SYSTEMS AGAINST DEBRIS
- REMOVAL OF SPACE DEBRIS

- THE CURRENT SPACE DEBRIS ENVIRONMENT POSES NO UNACCEPTABLE RISKS TO SPACE MISSIONS.
- WITHOUT MITIGATION, FUTURE SPACE OPERATIONS WILL FACE AN INCREASINGLY HOSTILE ENVIRONMENT.
- THE PRINCIPAL OBJECTIVE OF SPACE DEBRIS MITIGATION MEASURES IS TO STEM THE GROWTH OF THE SPACE DEBRIS POPULATION FOR THE BENEFIT AND THE SAFETY OF MANNED AND ROBOTIC EARTH ORBITAL MISSIONS.

SPACE OBJECT PASSIVATION

- **COMPLETE PASSIVATION OF SPACECRAFT AND LAUNCH VEHICLE UPPER STAGES REQUIRES THE ELIMINATION OF ALL FORMS OF STORED ENERGY, INCLUDING**

  - **RESIDUAL PROPELLANTS, INCLUDING BOTH MAIN PROPULSION SYSTEM AND ATTITUDE CONTROL SYSTEM (BY VENTING OR DEPLETION BURNS)**

  - **RESIDUAL PRESSURANTS (BY VENTING)**

  - **ELECTRICAL ENERGY (BY DISCHARGE AND DISCONNECTION OF BATTERIES OR OTHER STORAGE DEVICES)**

  - **KINETIC ENERGY (BY UNLOADING OR DE-SPINNING MOMENTUM WHEELS AND GYRODYNES)**

- **RANGE SAFETY EXPLOSIVES SHOULD ALSO BE DISABLED.**

SPACE DEBRIS PREVENTION

- **THE MOST SIGNIFICANT SOURCES OF SPACE DEBRIS WHICH POSE THREATS TO OPERATIONAL SPACECRAFT ARE SPACECRAFT AND ROCKET STAGE FRAGMENTATIONS.**

  PREVENTION: (1) PASSIVATION OF SPACECRAFT AND ROCKET STAGES AT END OF MISSION;
  (2) AVOIDANCE OF INTENTIONAL BREAKUP DEBRIS IN LONG-LIVED ORBITS.

- **APPROXIMATELY 12% OF CATALOGED SPACE DEBRIS ARE MISSION-RELATED OBJECTS (USUALLY SPACECRAFT AND ROCKET STAGE HARDWARE RELEASED WITHIN 24 HOURS OF LAUNCH).**

  PREVENTION: (1) USE OF TETHERS OR OTHER DEVICES TO RETAIN CLAMP BANDS, SENSOR COVERS, EXPLOSIVE BOLTS, ETC.;
  (2) IMPROVED DESIGN OF SPACECRAFT AND ROCKET STAGE SEPARATION AND STABILIZATION DEVICES.

SPACE DEBRIS PREVENTION (continued)

- **DERELICT SPACECRAFT AND ROCKET STAGES POSE COLLISION AND DEBRIS GENERATION HAZARDS IF LEFT IN DENSELY POPULATED REGIONS OF SPACE.**

  PREVENTION: (1) DEORBIT OR TRANSFER TO LOW ALTITUDE, SHORT-LIVED ORBITS AT THE END OF MISSION.

  (2) TRANSFER TO SPARSELY POPULATED DISPOSAL ORBITS AS A NEAR-TERM MITIGATION MEASURE. THE LONG-TERM IMPLICATIONS OF THE USE OF DISPOSAL ORBITS IS THE SUBJECT OF ONGOING INVESTIGATION.

- **ALTHOUGH UNLIKELY, COLLISIONS MAY OCCUR BETWEEN NEWLY LAUNCHED OBJECTS AND RESIDENT SPACE OBJECTS.**

  PREVENTION: PERFORM COLLISION AVOIDANCE ASSESSMENT BEFORE LAUNCH AND ADJUST LAUNCH TIME AS NECESSARY.

PROTECTION FROM SPACE DEBRIS

- **SMALL SPACE DEBRIS PARTICLES (< 1 mm in diameter) POSE A RISK TO SPACECRAFT SENSORS, ELECTRICAL CABLES, AND FLUID LINES.**

  PROTECTION: **(1) IF POSSIBLE, LOCATE SENSORS AWAY FROM DIRECTION OF HIGHEST SPACE DEBRIS FLUX AND PLACE SHIELDS AROUND THEM;**
  (2) RUN ELECTRICAL CABLES AND FLUID LINES INSIDE SPACECRAFT WALLS OR PLACE IN CONDUITS ON EXTERIOR OF SPACECRAFT.

- **MODERATELY SIZED SPACE DEBRIS PARTICLES (1 mm - 1 cm in diameter) MAY PENETRATE SPACECRAFT WALLS AND CAUSE SEVERE DAMAGE.**

  PROTECTION: **NEW APPLICATIONS OF MATERIALS AND DESIGN TECHNIQUES PERMIT SHIELDING AGAINST PARTICLES AS LARGE AS 1 cm; THE INTERNATIONAL SPACE STATION RELIES HEAVILY ON SUCH SHIELDS.**

PROTECTION FROM SPACE DEBRIS (continued)

- **COLLISIONS WITH LARGE SPACE OBJECTS (> 1 cm in diameter) WILL NORMALLY CAUSE SEVERE SPACECRAFT DAMAGE OR DESTRUCTION. CURRENTLY, ONLY OBJECTS 10 CM AND LARGER IN LEO CAN BE RELIABLY TRACKED BY TERRESTRIAL SENSORS. THE TRACKING OF OBJECTS IN THE 1-10 CM RANGE IN LEO IS A FUTURE GOAL. IN GEO ONLY OBJECTS GREATER THAN 1 M IN DIAMETER ARE NORMALLY TRACKED.**

  PROTECTION: COLLISION AVOIDANCE MANEUVERS ARE POSSIBLE FOR SOME SPACECRAFT IF CONJUNCTION ASSESSMENTS ARE PERFORMED IN A TIMELY MANNER.

- **DENSELY POPULATED REGIONS OF SPACE POSE GREATER RISKS OF COLLISIONS FROM SPACE DEBRIS OF ALL SIZES.**

  PROTECTION: SELECTION OF LESS DENSELY POPULATED ORBITAL REGIONS FOR NEW SPACE SYSTEMS WILL LOWER THE COLLISION RISK AND PROVIDE ADDITIONAL PROTECTION TO THE SPACECRAFT.

REMOVAL OF SPACE DEBRIS

- **THE REMOVAL OF SPACE DEBRIS REDUCES THE GROWTH OF THE SPACE DEBRIS POPULATION.**

REMOVAL:

(1) DEORBIT SPACECRAFT AND ROCKET STAGES AT END OF MISSION BY PROPULSION SYSTEMS OR OTHER MEANS;

(2) ORBITAL LIFETIME REDUCTION BY TRANSFER TO LOWER ORBIT, BY USE OF NATURAL PERTURBATIONS (SUN AND MOON), OR BY DRAG AUGMENTATION DEVICE;

(3) ACTIVE REMOVAL BY SPACE VEHICLES;

(4) ACCELERATE ORBITAL DECAY FOR SMALL AS WELL AS LARGE SPACE DEBRIS USING ADVANCED TECHNOLOGIES.

SATELLITE CONSTELLATIONS

- **THE USE OF LEO BY NEW SYSTEMS OF LARGE NUMBERS OF SPACECRAFT UNDERSCORES THE BENEFITS OF ADOPTING THE AFOREMENTIONED MITIGATION MEASURES.**

- **MANY OF THESE OPERATORS ARE REDUCING THE AMOUNT OF MISSION-RELATED DEBRIS CREATED AND THE ORBITAL LIFETIMES OF THEIR SPACECRAFT AND UPPER STAGES AND ARE PASSIVATING VEHICLES AT THE END OF MISSION.**

- **SPECIAL ISSUES OF INTRA- AND INTER-CONSTELLATION INTERACTIONS ARE ALSO BEING ADDRESSED.**

MITIGATING UNCONTROLLED REENTRIES

- **LARGE SPACE DEBRIS (> 1 m^2 cross-section) NATURALLY REENTER THE ATMOSPHERE AT AN AVERAGE RATE OF 1-2 PER WEEK BUT REPRESENT LITTLE RISK TO PEOPLE AND PROPERTY ON THE EARTH.**

  - IN GENERAL, THOSE WHICH SURVIVE REENTRY IN WHOLE OR PART HAVE A PROBABILITY OF 70% TO FALL INTO THE OCEAN.

- **RISK OBJECTS (THOSE WITH MASS > 5 METRIC TONS OR CONTAINING RADIOACTIVE MATERIALS) REENTER INFREQUENTLY BUT MAY POSE GREATER THREATS. EXAMPLE HISTORICAL RISK OBJECTS:**

  - SKYLAB - SALYUT 7 / KOSMOS 1686 - KOSMOS 954

- **SINCE EARLY 1996 IADC HAS BEEN DISCUSSING THE POTENTIAL BENEFITS OF CONDUCTING INTERNATIONAL RISK OBJECT REENTRY ASSESSMENTS.**

EFFICIENCY OF ORBITAL DEBRIS MEASURES

- SPACECRAFT AND ROCKET STAGE PASSIVATION WILL HAVE THE GREATEST IMPACT ON THE NEAR-TERM SPACE DEBRIS ENVIRONMENT.

- THE REMOVAL OF MASS FROM EARTH ORBIT (NON-FUNCTIONAL SPACECRAFT AND ROCKET STAGES) WILL HAVE THE GREATEST IMPACT ON THE FAR-TERM SPACE DEBRIS ENVIRONMENT BY REDUCING THE NUMBER OF ACCIDENTAL COLLISIONS.

- SHIELDING CAN PROVIDE SIGNIFICANT PROTECTION AND SAFEGUARDING FROM MOST OF THE SPACE DEBRIS THREATS, PARTICULARLY DEBRIS < 1 cm IN DIAMETER.

- CONCEPTS FOR CLEANSING THE PRESENT SPACE DEBRIS ENVIRONMENT LACK SUFFICIENT TECHNOLOGICAL MATURITY AND ECONOMIC FEASABILITY.

SUMMARY

- MITIGATION OF THE EARTH SPACE DEBRIS POPULATION IS ESSENTIAL TO KEEP THE HAZARDS FOR SPACE OPERATIONS WITHIN TOLERABLE LIMITS.
- SPACE DEBRIS MITIGATION GUIDELINES HAVE BEEN OR ARE BEING DEVELOPED BY THE UNITED STATES, JAPAN, ESA, FRANCE, AND RUSSIA.
- AT PRESENT, VOLUNTARY ADOPTION OF SPACE DEBRIS MITIGATION MEASURES HAS PROVEN EFFECTIVE IN BOTH LEO AND GEO.
- IN THE FUTURE, HOWEVER, WIDER COMPLIANCE WITH THE FULL RANGE OF MITIGATION MEASURES WILL BE NEEDED IN ORDER TO AVOID AN UNCONTROLLED GROWTH OF THE DEBRIS POPULATION.
- THE IADC PROMOTES CONTINUED RESEARCH INTO SPACE DEBRIS MITIGATION OPTIONS.