

Table of contents of the IAA Space Debris Situation Report – 2016

Recalled for discussions within the Committee to prepare the table of contents of the 2019 update

Table of Contents

Preamble and executive summary	5
1. Introduction	9
2. Current status of the space debris environment	13
2.1. Current situation	13
2.2. Consequences of collisions	14
2.3. Distribution of debris per orbital regime	15
2.4. Contributors to orbital debris environment	19
2.5. Debris collision risk assessments	23
3. Measurements	27
3.1. High level requirements	27
3.2. Existing technologies and technical means for space debris observation	28
3.3. Existing and currently developed techniques for space debris observations	30
3.4. Existing practices for international cooperation in the field of space debris measurements	38
3.5. Existing gaps and multidisciplinary issues	39
4. Space situational awareness systems	43
4.1. Introduction	43
4.2. USA	45
4.3. Russia	48
4.4. France	53
4.5. Germany	54
4.6. ESA	55
4.7. Japan	56
4.8. Commercial Space Operations Center (ComSpOC®)	58
4.9. Other sources of orbit data and conjunction services	59
5. Collision avoidance	61
5.1. In-orbit collision avoidance	61
5.2. Satellite owner/operator collaborative collision avoidance	63
5.3. Collision risk mitigation in mission design and disposal	65
5.4. Collision avoidance at launch	65
5.5. International standards and best practices	66
6. Hypervelocity impact effects and protection	69
6.1. Introduction	69
6.2. Hypervelocity impact effects on spacecraft	69
6.3. Experimental studies to investigate the effects of impacts on satellite components	70
6.4. Light-gas gun accelerators: workhorses for experimental impact testing	75
6.5. Shielding investigations for spacecraft	76
6.6. Risk assessment methodology for spacecraft	78
6.7. On-orbit impacts and analysis of returned spacecraft surfaces	81
6.8. Concluding remarks	83

7. Reentering space objects	85
7.1. Background	85
7.2. Reentry location/time determination	86
7.3. Hazardous objects.....	93
7.4. Statistics on reentries	95
7.5. Reentry survivability analyses	97
7.6. Policy issues.....	99
7.7. Solutions	99
8. Future environment	103
8.1. Historical orbital debris environment	103
8.2. Future orbital debris environment.....	106
9. Space debris mitigation.....	115
9.1. General objective of space debris mitigation guidelines.....	116
9.2. Protected regions	116
9.3. Mitigation measures	118
9.4. Post mission disposal measures	119
9.5. Prevention of on-orbit collision	120
9.6. Global implementation of mitigation measures.....	121
10. Debris remediation.....	125
10.1. Introduction.....	125
10.2. Methods for Lethal NonTrackable (LNT) debris and Catalogued Fragments (CF)	126
10.3. Intact Derelict Objects (IDO)	127
11. Legal aspects of space debris	139
11.1. Introduction.....	139
11.2. The UN space treaties and space debris	139
11.3. The relevance of non-legally binding instruments	143
11.4. The future: debris remediation.....	145
11.5. National legislation	145
11.6. Conclusion.....	145
12. International aspects	149
12.1. Towards an international recognition of the space debris issue	149
12.2. Major events that raised public awareness on debris	150
12.3. Addressing the debris issue	150
13. Synthesis and further References.....	157
13.1. Synthesis.....	157
13.2. Overall logic of works	157
13.3. To know more.....	162
Appendices	165
1. List of contributors to the Study Group 5.14/ "IAA Space Debris Situation Report – 2016"	165
2. List of acronyms.....	166
3. IAA – A brief description	16

7. Reentering space objects	85
7.1. Background	85
7.2. Reentry location/time determination	86
7.3. Hazardous objects.....	93
7.4. Statistics on reentries	95
7.5. Reentry survivability analyses	97
7.6. Policy issues.....	99
7.7. Solutions	99
8. Future environment	103
8.1. Historical orbital debris environment	103
8.2. Future orbital debris environment.....	106
9. Space debris mitigation.....	115
9.1. General objective of space debris mitigation guidelines.....	116
9.2. Protected regions	116
9.3. Mitigation measures	118
9.4. Post mission disposal measures	119
9.5. Prevention of on-orbit collision	120
9.6. Global implementation of mitigation measures.....	121
10. Debris remediation.....	125
10.1. Introduction.....	125
10.2. Methods for Lethal NonTrackable (LNT) debris and Catalogued Fragments (CF)	126
10.3. Intact Derelict Objects (IDO)	127
11. Legal aspects of space debris	139
11.1. Introduction.....	139
11.2. The UN space treaties and space debris	139
11.3. The relevance of non-legally binding instruments	143
11.4. The future: debris remediation.....	145
11.5. National legislation	145
11.6. Conclusion.....	145
12. International aspects	149
12.1. Towards an international recognition of the space debris issue	149
12.2. Major events that raised public awareness on debris	150
12.3. Addressing the debris issue	150
13. Synthesis and further References.....	157
13.1. Synthesis.....	157
13.2. Overall logic of works	157
13.3. To know more.....	162
Appendices	165
1. List of contributors to the Study Group 5.14/ "IAA Space Debris Situation Report – 2016"	165
2. List of acronyms.....	166
3. IAA – A brief description	16

List of contributors to the Study Group 5.14/ IAA Space Debris Situation Report

Vladimir Agapov	KIAM	(Russia)
Fernand Alby	CNES	(France)
Christophe Bonnal (co-editor)	CNES	(France)
Christian Cazaux	CNES	(France)
Eric Christiansen	NASA	(USA)
Juan-Carlos Dolado-Perez	CNES	(France)
Dave Finkleman	Sky Sentry	(USA)
Seishiro Kibe	JAXA	(Japan)
Heiner Klinkrad	ESA	(Germany)
Holger Krag	ESA	(Germany)
Paula Krisko	NASA	(USA)
Jer-Chyi Liou	NASA	(USA)
Darren McKnight (co-editor)	Integrity Applications	(USA)
Tanja Masson-Zwaan	University of Leiden	(The Netherlands)
Charlotte Mathieu	ESA	(France)
Manuel Metz	DLR	(Germany)
Dan Oltrogge	AGI	(USA)
Frank Schäfer	EMI	(Germany)
Thomas Schildknecht	AIUB	(Switzerland)
Marlon Sorge	The Aerospace	(USA)
		7 USA inc. 3 NASA
		11 Europe
		1 French ESA
		4 French CNES
		2 German ESA
		1 German DLR
		1 other German
		1 Dutch
		1 Swiss

The authors wish to acknowledge the reviewing work of:

Luciano Anselmo	1 Russia
Richard Crowther	1 Japan
Tim Flohrer	Need for:
Moriba Jah	Italy
Akira Kato	China
T. S. Kelso	Ukraine
Carmen Pardini	India
David Spencer	South-Korea
Hedley Stokes	Australia...

members of the IAA Space Debris Committee⁴⁷