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CLASSIFICATION OF AERODYNAMIC SYSTEMS FOR LOW EARTH ORBIT SPACE HARDWARE DEORBITING

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The aim of this paper is to develop a classifier of aerodynamic systems for low Earth orbit space hardware deorbiting. Aerodynamic deorbiting systems are classified. A coding scheme for systems of this type is proposed. The classification performed and the proposed coding scheme have made it possible to develop a classifier that can be used in the automation of the aerodynamic system design process. In the classifier, the features mainly relate to the shape, shaping, and various modifications of an aerodynamic element that directly interacts with the incident flow of the rarefied atmosphere.

Keywords: *space debris, classifier of aerodynamic deorbiting systems, classification principle, classification features.*

1. Monthly Number of Objects in Earth Orbit by Object Type. The Orbital Debris Quarterly News. NASA JSC Houston. 2016. Iss. 20, No 1, 2. Pp. 14.
2. IADC Space debris mitigation guidelines. IADC-2002-01. Revision 1. Prepared by the IADC Steering Group and WG4 members. 2003. September. 10 pp. URL: http://www.iadc-online.org/index.cgi?item=docs_pub. (last accessed on March 3, 2017).
3. *Kondakov N. I.* Handbook Dictionary on Logics (*in Russian*). Moscow, 1975. 720 pp.
4. US Patent for Invention No. 6830222, IPC B 64 G 1/62. Balloon device for lowering space object orbit, *K. T. Nock, A. D. McRonald, K. M. Aaron*. 10/394477; filed on March 21, 2003; published on December 14, 2004.
5. Russian Federation Patent for Invention No. 2199474, IPC B64G1/62. Device of an inflatable passive braking system for the last stage of a launch vehicle (*in Russian*). *Mayorov Yu. N., Dukin A. D.* 2000131539/28; filed on December 15, 2000; opublished on February 27, 2003.
6. US Patent for Invention No. 6550720, IPC B64G1/22. Fliter Aerobraking orbit transfer vehicle, *DeBra D.B., P. Gloyer, Z. Wahl, D. Goldshtein*. 09/925,207; filed on August 9, 2001, published on April 22, 2003.
7. *Gloyer P.* Aerobracking technology for Earth orbit transfers. 16th Annual/USU Conference on Small Satellites/SSC02-VII-2, August 12–15, 2002. URL: http://digitalcommons.usu.edu/cgi/
viewcontent.cgi?article=1932&context=smallsat (last accessed on March 10, 2015).
8. Russian Federation Patent for Invention No. 2435711, IPC B64G 1/24. Deployable aerodynamic surface for satellite aerobraking (*in Russian*). FR20060050661; filed on February 14, 2007; published on December 10, 2011.
9. *Dupuy C., Le Couls O.* Gossamer technology to deorbit LEO non-propulsion fitted satellite. 40th Aerospace mechanisms symposium, NASA Kennedy space center, may 12 – 14, 2010.
10. *Maesen D. S., Van Breukelen E. D., Zandbergen B. T. C., Bergsma O. K.* Development of a generic inflatable deorbit device for cubesats. 58th International astronautic congress, September 24 – 28, 2007, Hyderabad, Andhra Pradesh, India, IAC-07-A6.3.06.
11. *Roberts P. C. E., Bowling T. S., Hobbs S. E.* MUSTANG : A technology demonstrator for formation flying and distributed systems technologies in space. Proceedings of 5th conference Dynamics and control of systems and structures in space, Kings College, Cambridge, July 2002. URL: https://dspace.lib.cranfield.ac.uk/bitstream/1826/881/1/MUSTANG-formation%20flying%20in%20space-2002.pdf (jast accessed on May 1, 2014).
12. US Patent for Invention No. 4504031, IPC B64G 1/58. Aerodynamic braking and recovery method for a space vehicle. 353828; filed on March 2, 1982; published on March 12, 1985.
13. US Patent for Invention No. 4832288, IPC B64G 1/58. Recovery system. 76631; filed on July 23, 1987; published on May 23, 1989.
14. US Patent for Invention No. 6264144, IPC B64G 1/14. Material assembly for an inflatable aerodynamic braking device for spacecraft deceleration and the like. 09/520533; filed on March 8, 2000; published on January 24, 2001.
15. Application for a Patent for Invention No. WO2012092933, IPC 7 B64G1/62. Selfdeployable deorbiting space structure, *A. S. Kristensen, L. Damkilde*. PCT/DK2012/050009; filed on January 6, 2012; published on July 12, 2012.
16. *Stackpole E.* De-Orbit Mechanism for a Small Satellites. E. Stackpole. Presentation for Small spacecraft division of NASA Ames research center, Moffet Field, CA. URL: http://mstl.atl.calpoly.edu/~bklofas/
Presentations/DevelopersWorkshop2009/1_New_Tech_1/2_Stackpole-Deorbit.pdf (last accessed on July 1, 2015).
17. *Wolanski P.* PW-SAT first polish satellite. S&T Subcommittee of COPUOS 15 February 2012. URL: http://www.oosa.unvienna.org/pdf/pres/stsc2012/tech-44E.pdf (last accessed on January 10, 2014).

18. NASA – NanoSail-D Home Page. NASA – Home. URL: http://www.nasa.gov/mission_pages/smallsats/nanosaild.html (last accessed on January 14, 2014).
19. *Koshkin N. I., Korobeinikova E. A., Lopachenko V. V., Melikkiants S. M., Strakhova S. L., Shakun L. S.* On the motional behavior of a microsatellite with a sail in the atmosphere («NanoSail-D») *(in Russian*). Kosmichna Nauka i Tekhnologiia. 2012. V. 18. Pp. 31–38.
20. *Sinn T., Lücking C., Donaldson N. and other*. StrathSat-R: Deploying inflatable cubesat structures in micro gravity. Proceedings of 63rd International Astronautical Congress, Naples, Italy, 2012, IAC-12-E2.3.7.
21. PW-SAT2 Preliminary design review. Deployment team. URL: http://pw-sat.pl/en/documentation/ (last accessed on August 2, 2015).