#### COE CST Fifth Annual Technical Meeting

Task 244: Autonomous Rendezvous & Docking for Space Debris Mitigation

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October 27-28, 2015 Arlington, VA



# Agenda

- Team Members
- Task Description
- Schedule
- Goals
- Results
- Conclusions and Future Work



# **Team Members**

- Principal Investigator
  - Norman Fitz-Coy
- Students
  - Bungo Shiotani (PhD student)
  - Kathryn Cason (accepted job with MEI)
  - Takashi Hiramatsu (PhD in 2012 Keio Univ.)
- Organizations
  - Collaborator: NASA ODPO
  - Matching provided by: Space Florida



# Task Description (Original)

- Active debris removal is required
  - Interests in small satellites (e.g., CubeSats) especially by new space entrant leads to:
    - More spacecraft  $\rightarrow$  more failure (debris)
    - Debris likely to be non-cooperative
- Objective
  - Develop strategies to minimize interactions during removal of non-cooperative debris
  - Develop strategies for safe proximity operations / collision avoidance during removal



# **Task Description (Modified)**

- Objectives
  - Identify/quantify the global growth trends of CubeSat-class satellite; assess the interests of US and international communities for CubeSat applications and investigate emerging CubeSat products (e.g., Planet Labs constellation of CubeSats).
  - Survey the assembly integration and testing practices of these CubeSat developers and utilize that information to investigate the mortality rates of CubeSats
  - Assess the space debris mitigation strategies utilized / implemented by these developers

Replace CubeSats with "Containerized" Satellites



#### Schedule

- Start date: September 2014
- Develop survey strategy: October 2014
- Pilot test questionnaire: December 2014
  - Reviewed by NASA ODPO
- Disseminated questionnaire: January 2015
- Survey closed: May 2015
- Analyze survey results: June-Aug. 2015
- Finalize/publish results: September 2015



#### Goals

- Outcomes
  - Utilize the growth trends, mortality information, and mitigation strategies to access the impact of "containerized" satellites to LEO debris
  - Sensitize containerized satellite community of their potential impact on space debris
  - Work with NASA ODPO and IADC to develop protocols to reduce debris growth trend (e.g. modify 25-year rule)
- Relevance to FAA
  - Debris in LEO will re-enter the airspace and could interact with sub-orbital flights and/or air traffic
  - Collision with 5 mm sized debris could be consequential



#### **Task Motivation**





### **Task Motivation**

- Debris growing due to increases launch rate of containerized satellites
- Large constellations (hundreds of satellites) are being "developed"



Constellation of traditional satellites (e.g., Iridium)



Constellation of containerized satellites (e.g., OneWeb, SpaceX, PlanetLabs)



#### **Containerized Satellite Survey**



• Survey disseminated to small satellite community through mailing lists (e.g., CubeSat, AMSAT, and working groups of INCOSE and IAA) and personal contacts worldwide.



• 200 survey links opened





Participant affiliation



Academia (37)Government (14)

Industry (10)

- Joint Government and Industry (2)
- Private (8)
- Other (2)



#### Past and future launch masses

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#### Past and future sizes





#### Systems Engineering Activities





- 91 respondents familiar with the "25-Year-Rule"
  - 56% of these respondents have procedures in place to satisfy the "25-Year-Rule"



• Further details to be published in Journal of Small Satellites



## **Conclusions and Future Work**

- Survey results show a healthy continuous growth of containerized satellites
- Small satellite community acknowledge the debris issue and either have procedures in place or are developing procedures to be in compliance with the "25-Year-Rule"
- Statuses vary depending on mission assurance (i.e., systems engineering) activities and affiliation
- The small satellite community is capable of becoming/being responsible users of space



# **Conclusions and Future Work**

- Observations from the study
  - Lack of survey responses leads to inconclusive assessments (e.g., mortality rates)
  - Some participants thought the survey asked proprietary information and refused to answer
- Future work
  - Disseminate results (paper to be submitted)
  - Work with NASA Orbital Debris Program Office to develop protocols and continue assessment of debris
  - Work with INCOSE SSWG to develop a CubeSat reference model utilizing MBSE
  - Further assess mission assurance (i.e., systems engineering) activities



## Acknowledgement

- We would like to express sincere gratitude to:
  - All participants that responded to the survey
  - NASA ODPO for their guidance

- Contact information
  - Bungo Shiotani
  - Norman Fitz-Coy

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