Aerospace Europe Conference 2023
Joint 10th EUCASS – 9th CEAS Conference

Abstract #XXX *(to be filled by the organizers)*
Preferred Topics: FDGNCAV /SPEXPLO/ STUDENT *(3 maximum from the list of topics)*
Corresponding author: Hongyi Xie
e-mail of corresponding author: hongyi.xie@polimi.it
Type: Oral
Status of corresponding author: Student member of AIDAA

Title

Fault-tolerant Orbit and attitude control of Solar sail with a rapid inspection and repair strategy of faulty RCDs

Authors

Fuqiang Duan[1], Hongyi Xie[2], Guoqiang Zeng[3], Franco Bernelli-Zazzera [4]*

** Corresponding author*

[1] National University of Defence Technology, Changsha 410073, People's Republic of China, duanfuqiang20@nudt.edu.cn
[2] Politecnico di Milano, 20156 MILAN, Italy, hongyi.xie@polimi.it
[3] Wuhan University, Wuhan 430079, People's Republic of China, gq.zeng@whu.edu.cn
[4] Politecnico di Milano, 20156, MILAN, Italy, franco.bernelli@polimi.it

Abstract

In recent years, the development of solar sails has been very rapid, with several artificial solar sails sent into orbit since 2010. As a large flexible space structure with RCDs (reflectivity control devices) or other mirror-like devices to generate propulsion from solar radiation pressure, the solar sail is very fragile with a high possibility of actuator malfunction. However, to the best knowledge of the authors, the fault-tolerant control of solar sails has not been seen in previous research, which may be due to the fact that the designs of solar sails are varied and there doesn't exist a unified criterion. Nevertheless, the most commonly seen solar sail is actuated by RCDs distributed on the surface of a 2D plane-like sail surface. As a result, the majority of a solar sail's fault-tolerant control problems can be reduced to the correct turn on and turn off of unnecessary RCDs after the malfunction occurs.

In this paper, a quick search strategy is designed to decide which RCDs should be closed and which should be kept on after a malfunction of an RCD happens. Before the quick searching strategy is triggered to run, a decision-making procedure called "employer" will calculate the quantity of calculations that need to be done and then decide whether to calculate the malfunction solving plan by using on-board computational resources or send the briefing of malfunction situations to the ground station and wait for corresponding orders calculated by ground computational resources. That's because the corresponding computation may take up a lot of computational resources, which may easily exceed the upper ability of on-board computers. The distance between the solar sail and the ground station has also been considered in the design of the "employer."

Considering that the thrust direction of the solar sail is determined by its own attitude, the quick searching strategy obeys the rule that closes all the extra RCDs that may destroy the distribution balance of RCDs. Following that, the solar sail's fault-tolerant control system will turn on some of the still-healthy RCDs in the unnecessary RCDs or turn off some of the still-working RCDs to stabilize the solar sail's attitude and restore normal states. Numerical simulation demonstrates that the proposed fault-tolerant decision and control system can successfully bring the solar sail back to its normal working state in different scenarios.