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# EVALUATION OF FIRST STAGE DEPLOYMENT OF MEMBRANE OF IKAROS BASED ON FLIGHT RESULTS AND SIMULATION

**Abstract**

Japan Exploration Agency (JAXA) launched a powered solar sail "Interplanetary Kite-craft Accelerated by Radiation Of the Sun (IKAROS)" on May 21, 2010. This spacecraft is on a mission to demonstrate technologies required at powered solar sail explore mission in the mid-2010s. One of the primal technologies demonstrated at IKAROS was the deployment of the sail whose diameter is 20m class. IKAROS is a spin type solar sail, and its membrane is deployed and maintained flat by the centrifugal force. This method is expected to be realized with simpler and lighter-weight mechanism than other ways, because it does not require rigid structural elements. This method also has a risk of instability of main central body's attitude. If the large sail is deployed dynamically, it should rewind around main body. To avoid the rewinding and to maintain a safety attitude of main body, the membrane is supposed to be deployed statically for this class of sail. The shape of the sail developed for IKAROS is a square which consists of four trapezoidal petals. The folding line of each petal is normal to the direction of centrifugal force. The deployment sequence is divided in two stages. In the first stage, rolling petals are extracted like a Yo-Yo despinner, and form a cross shape maintained by four rotating guides. In the second stage, these guides are released, and four extended petals form a square shape. If the first stage deployment is performed dynamically, each petal will be twisted around the main body just after the deployment. Therefore the membrane needs to be deployed quasi-statically at the first stage. In order to investigate the dynamics of membrane and to organize a detailed deployment sequence, several numerical simulations

were performed before the launch. To analyze the dynamics of membrane, multi-particle model was used. After the launch, IKAROS performed the deployment sequence and have confirmed that the membrane was successfully expanded. Through this sequence, many data which indicates the structural property of membrane was obtained. In this paper, these obtained data and observed motion via first stage deployment are reported. These are compared with the results of numerical simulation using multi-particle model, and the availability of this model is discussed. After the first stage deployment, it turned out that four petals form an asymmetric cross shape. This paper also presents the investigation of the cause of this asymmetric shape.