論文の内容の要旨

論文題目　　A Novel Method of Component-Placement and Structure Optimization for Easily-Serviceable Satellites

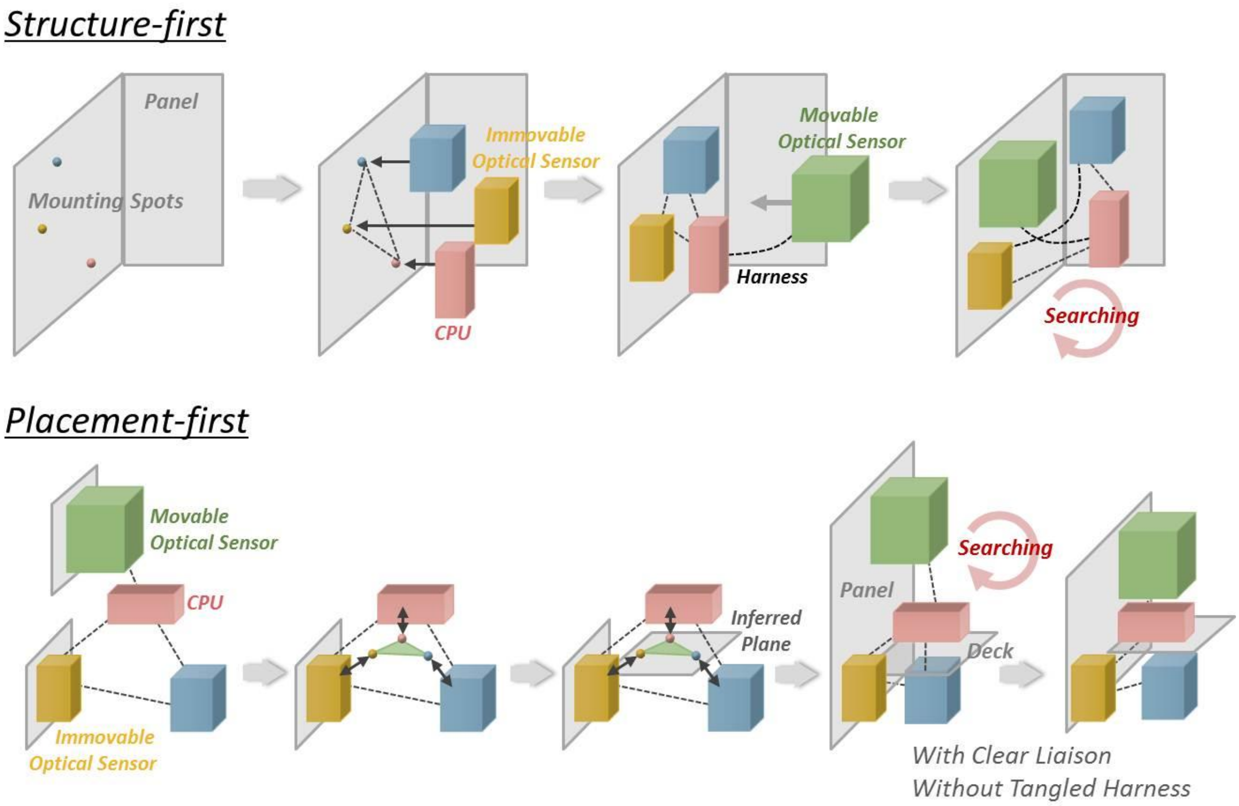
（サービスしやすい衛星のための新しい機器配置と構造の最適化手法）

氏　　名　　金　志娟

A satellite is a complex system consisting various subsystems and payloads but its structural shape has a high degree of freedom since it operates in a gravity-free environment - space. Except for some special mission-specific satellites, most satellite shapes have been less considered, leaving some room for optimizations. However, by the time mass production and on-orbit servicing start, can current shape and system cope with them effectively?

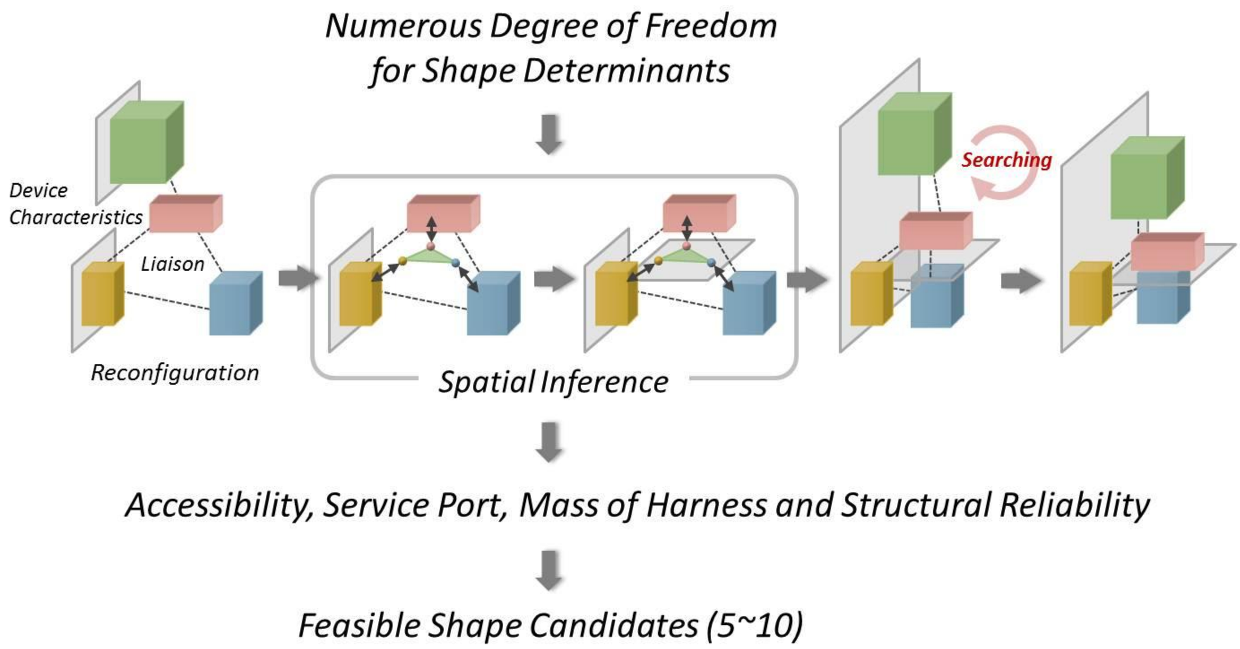
Unlike ground-based repairs, space-based repairs have few opportunities for human labor. Repairing malfunctioning components would be performed only by robotic manipulation. So, if components configuration is not optimized for repair services, many robotic arms have to repeat disassemble and reassemble process of the obstacle components, and then disassembled components would float in space during repair. To prevent these problems, the designs of the satellites serviced on orbit should consider not only their manufacturability but also their serviceability - the ease of maintenance - in the design phase. The serviceability in on-orbit servicing is related to accessibility, which is determined by how effectively the accessible routes can be secured so that the servicer's manipulator can approach the targets in the system. If there is a high-failure or a frequent need to repair component located in the hard-to-access zone of a satellite, on-orbit servicing may be impossible or become more expensive than launching a new satellite. However, it is hard to secure enough degree of accessibility for on-orbit servicing just by simply reconfiguring the system. Also, while there have been many studies about on-orbit servicing so far, those studies were focused on servicers' infrastructures and the market potential but not on the system of the target/client for servicing. Therefore, this research would suggest a new satellite shape focused on the on-orbit servicing clients for the serviceability.

In a conventional satellite design, satellite designers try to imagine a suitable shape by their intuition and knowledge with its mission requirements and predefined list of components. But in practice, it is not easy to conceptualize a creative model that they never have imagined. Moreover, the design factors which determine the shape are numerous and their degree of freedom cannot be fully controlled by only the spatial relationships. Also, it is hard to quantify and generalize the complex interrelations among these factors. Thus, this research proposes a new concept of 'Easily Serviceable Satellite Shape' adopting the criteria 'serviceability' to reduce the degree of freedom of Shape Determinants. Then introduce Component Placement and Structure optimization Method for automatically creating 'Easily Serviceable Satellite Shape' based on features of satellite equipment. The overview of Component Placement and Structure optimization Method shows in figures below.



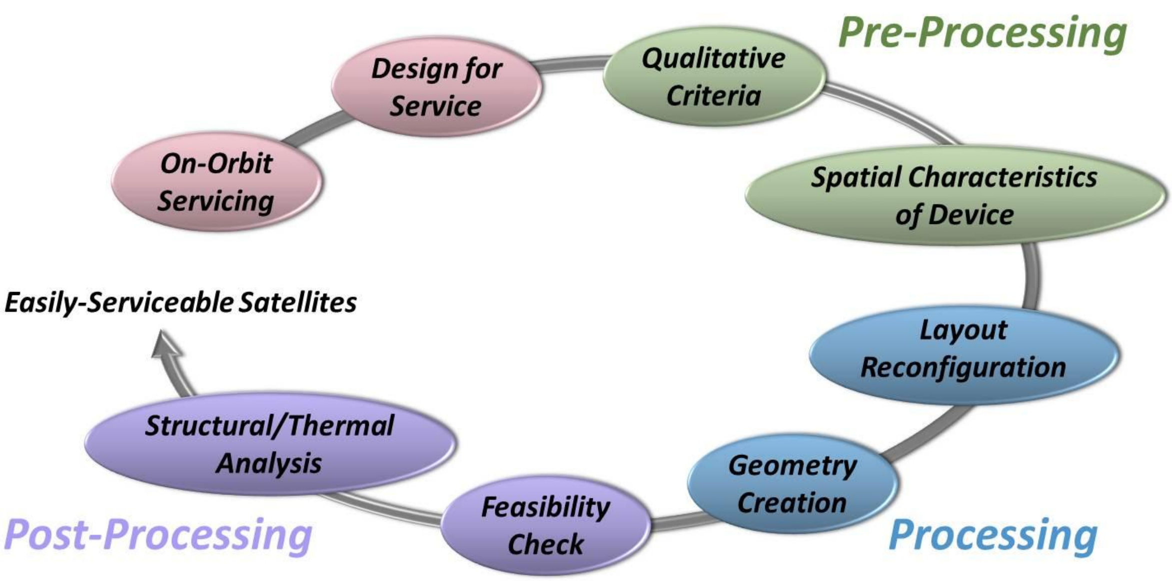
In practice, creating mating features is an extensive work because the model deals with a high degree of freedom and uncertain and incomplete geometry factors. Therefore, shape determinants control is required to adjust the key geometry factors in order to simplify the model and keep the simulation load to an appropriate level.

However, it is not easy to control shape determinant. If there are too many user-defined rules, only shapes that human can imagine would be generated. Otherwise, in case of too much depending on spatial inference, physically unfeasible shapes or too many feasible shapes can be created.



Therefore, in this thesis, shape determinants have controlled by defining accessibility, service port, mass of harness and structural reliability.

A process of this research is described in figure below. Whole process is divided into three categories; pre-processing, processing, and post-processing, and each category has several steps as follows:



The special advantage of this technique is that geometry can be created automatically using a qualitative spatial inference technique. The second key advantage is that it can also be applied to satellites having different objectives or criteria.

Consequently, this research will propose feasible but creative shapes for the Easily Serviceable Satellite and improve the performance of the future on-orbit servicing. In addition, we expect this methodology can be a new approach to designing other mechanical systems besides satellites.