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THE ON-ORBIT VALIDATION OF THE MAINTAINABILITY TECHNIQUES DURING THE  
MANNED FLIGHT MISSIONS

**Abstract**

Maintainability design and on-orbit servicing are effective methods for the long time operation of the manned spacecraft. The maintainability techniques should be validated on the ground and in the space. The manned-spacecraft maintainability design systems include maintainability design, maintainability verification, maintainability evaluation and maintainability management. The maintainability verification is an important part of the maintainability design systems. The verification of the maintainability techniques in space is very significant for the effectivity of the maintainability design.

The maintainability interfaces of the different devices include mechanical interface, electrical interface, pipe interface, seal interface and so on. The maintainability levels include organizational-level, intermediate-level and depot-level. All the operations of the maintainable devices should be validated on the ground. Only a few maintainable devices can be used for the verification of the maintainable techniques in the space when they are working well. The maintainability verification experiments on-orbit should be representative and can cover more maintainable interfaces.

Many on-orbit maintainable experiments have been implemented during the Shenzhou-Tiangong manned flight missions. The experiments include the installation of electrical devices, the replacement of the soft floor, operation of the seal ring and the plugging and removing of the pipe connectors. The operation levels include organizational-level, intermediate-level and depot-level. Each of the experiments on orbit has been conducted many times on the ground and the astronauts have been well trained. The training on the ground has been recorded.

During the three manned flight missions, from Shenzhou 9 to Shenzhou 11, the planned experiments are implemented successfully. Lessons learned through the experiments include the duration time of the repair operation, the fitness of the tools, and the skills of the astronauts. These experiences have been recorded, and can be used for future training of astronauts and the developing of the spacecraft.