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Telescoping Space Station Modules

Robert D. Witcofski

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Langley Research Center
Hampton, Virginia 23665

SUMMARY

A design concept for telescoping space station modules is described. The concept involves essentially a module within a module. After being carried to orbit within the payload bay of the Space Shuttle Orbiter, the outer module would be telescopically deployed to achieve nearly twice as much usable space station volume per Shuttle launch as would be achieved through the use of more conventional module concepts. By retracting the outer module over the inner module, significantly enhanced protection against space debris and radiation could be achieved. The telescoping nature of the modules lends the concept to variations in space station configuration, assembly, and disassembly. Adaptations of the telescoping concept could also provide flexibility in the methods in which the Shuttle Orbiter is docked or berthed with the space station and decrease the chances of damage because of accidental contact between the station and the orbiter during such maneuvers. The concept requires no new technologies.

INTRODUCTION

Current NASA plans regarding the construction of a permanently manned orbiting space station include the use of the Space Shuttle to deliver modules to orbit. These modules will provide living and working quarters for the space station crews and will house experimental and manufacturing equipment. In order to minimize the transportation costs, prudence must be exercised to assure the delivery of maximum space station capability per launch or per series of launches. Preliminary studies have indicated that if instrumented space station modules were packaged within the orbiter payload bay, payload volume constraints would be reached before payload mass constraints. A space station module design concept described herein seeks to take better advantage of the payload capabilities of the Shuttle Orbiter, while enhancing the capability of the space station.

The concept involves what might be described as telescoping modules (two modules in each assemblage). Two assemblages could easily fit within the Space Shuttle Oribter payload bay with additional volume and payload to spare. Upon deployment at the space station, each assemblage would provide essentially twice the usable volume of the more conventional module concepts. This concept appears to offer the following advantages over more conventional module concepts:

(1) Additional usable space station volume at a reduced delivery to orbit cost per volume.

(2) Enhanced protection against debris and radiation hazards.

(3) Amenability to variations in space station configuration.

(4) Enhanced flexibility regarding berthing and docking with the Shuttle Orbiter.

THE BASIC CONCEPT

The basic concept involves essentially a cylindrical can within a can (fig. 1). The outer can, which has one open end, encloses the inner can. The inner can has one tapered end with a hatch and one untapered end with a hatch. The outer can has one tapered end with a hatch. The overall length of the outer can is 25 feet, and its outer diameter is 14 feet. Two such assemblages could easily fit end to end in the Shuttle Orbiter payload bay, with room to spare. Assuming that the STS payload capability to the orbit for the space station is 65,000 pounds and that each twin can assemblage (uninstrumented) weighs 16,000 pounds, 33,000 pounds of payload are available (for instrumenting the cans). Only the inner can could be instrumented prior to launch.

PRESSURIZATION

There are two options regarding module pressure at launch. One is to vent the entire assemblage from ground to orbit and then pressurize on orbit. The other is to pressurize the inner can to 30 psia air prior to launch, and through expansion of the assemblage at the station and equalization of the compartment pressure, provide the standard 14.7 psia initial atmosphere.

DEPLOYMENT

Upon arrival at the station and removal of the assemblages from the Orbiter payload bay, the unpressurized and vented outer can is deployed from the inner can (fig. 2). Although this deployment could probably be accomplished by unventing the outer can and pressurizing it with air from the inner can, air losses would be quite high unless the inflatable seals (fig. 2 and detailed in fig. 3) were inflated. Deploying the outer can with the seals inflated could damage the seals. Therefore, mechanical deployers (fig. 4) might be advisable. Release of some air into the outer can may be necessary during deployment in order to prevent binding between the surfaces of the two cans. However, proper control and monitoring of the amperage on the electric drive motors should preclude such binding problems. Upon deployment of the outer can to obtain a total assemblage length of perhaps 48 feet, the three inflatable seals (fig. 3) are inflated, or an alternative seal system is engaged. All vents to the outer can are then closed, and the pressure between the inner and outer can be equalized to atmospheric pressure.

Each of the two deployed assemblages consists of an empty can and one which is probably already instrumented. Either end can be attached to an existing set of space station modules or utilized to formulate the initial space station. The empty end may remain unattached in order to simplify transfer of equipment from the Orbiter. The useful space station volume delivered to orbit by a Shuttle mission can be essentially doubled by utilizing this concept. Use of this volume is discussed later.

SAFE HAVEN

If a situation evolves where the station is in danger of being struck by space debris, and evasive maneuvers by the space station are impractical, a potential option offered by this concept is to make one of the assemblages a safe haven. With volume a prime concern onboard the station, the uninstrumented end of the safe haven assemblage could provide an excellent location for storage, cleaning, and repair of extravehicular activity (EVA) suits. Provided sufficient warning was available, the EVA suits and associated equipment could be removed from the uninstrumented can, the hatch between the two cans closed, the outer can vented, seals depressurized, and the outer can translated over the inner can. Both of the cans could consist of a double wall structure, the inner wall being the pressure vessel and the outer wall being a meteoroid/debris "bumper." With the outer can covering the inner can, all but one end of the inner can is afforded four layers of protection against space debris. Should such a technique be utilized, four layers of protection could be built into the end of the inner can which is not protected by the outer can. Because of the nature in which meteoroid "bumpers" function, actual double protection might not be achieved, but substantial enhancement of protection would be assured.

Similar actions could be taken in the event of a potential exposure to abnormally high radiation levels. A high-altitude nuclear explosion could cause such a situation. There also exists the possibility of a solar flare producing abnormally high radiation levels at the altitude and inclination of the space station. (Plasma from the solar flare may alter the structure of the Earth's magnetosphere and thus the distribution and levels of radiation.) Although doubling the mass of a radiation shield does not double its shielding capabilities, substantial shielding enhancement is achieved. In addition, proper selection of pressure vessel and "bumper" materials may greatly enhance the ability of the multiwall protection system described herein to reduce the formation of Bremsstrahlung or "secondary radiation" (formed by space radiation penetrating the station structural material) and enhance the ability of the system to attenuate that which is formed.

Provided there is sufficient free volume in the safe haven (instrumented inner can), enhanced safe haven capabilities could be obtained by placing the EVA suits in the inner can safe haven prior to enclosing the safe haven in the outer can. By doing so, the suits would be available for EVA inspection of the exterior of the station following a hazardous situation. This could be particularly important in that it would preclude entering a potentially dangerous volume of the station in order to don the suits. Also, if on the outside chance that a tumbling uncontrolled station resulted from some mishap, direct EVA egress would permit rescue by the Shuttle Orbiter without attempting a hazardous berthing or docking of the Orbiter with the tumbling station.

STATION CONFIGURATION VARIATIONS

Closed loop or "race track" space station configurations (fig. 5) have an advantage over other configurations in that dual egress is provided from any hazardous area within the station. Only one safe haven is required for such configurations because it can be reached by anyone onboard. Having a single safe haven has the advantage of holding down the cost of consumables, monitoring systems, and controls required for multiple safe havens. "Race track" concepts have been difficult to configure, particularly for an initial station. The modules currently being considered for space station are too short and not sufficient in number to lend themselves to such a configuration. The present concept would essentially double the length of the modules, making a "race track" configuration more viable.

A potential problem with "race track" configurations is that they can present difficulties when replacing a module, particularly if the station configuration is rectangular in nature. Care must be taken not to induce undue moments in the connecting joints of the remaining modules. This can mean dealing with very close clearance between very large structures. The telescoping concept would nullify such problems. Modules could be partially or fully collapsed to permit module change out without fear of overloading joints.

DOCKING AND BERTHING

The telescoping module concept or modifications thereof might provide flexibility in docking/berthing of the Orbiter with the station. A concern has been the avoidance of accidental contact with and damage to portions of the station or Orbiter during such maneuvers. The use of a telescoping module, perhaps one comprising more than two cans (fig. 6), could greatly decrease the chance of the Orbiter contacting other parts of the station during docking or berthing by moving out to meet the Orbiter.

USE OF ADDITIONAL VOLUME

Studies (unpublished) of the human factors aspect of living and working on a space station have indicated the importance of free volume to occupants of the station. The additional volume made available through the use of telescoping modules could likely be put to good use in providing privacy areas, exercise areas, and a place for all the crew to meet. Unallotted volume tends to fill up as a space program progresses. As activity on the station grows, new pieces of scientific equipment will be arriving. This equipment could be either temporarily or permanently placed within the volumes available in the outer cans.

SEALS

Initial studies of seal concepts (fig. 3) indicate several possibilities. Inflatable seals of the type used for many years in the large butterfly valves in vacuum systems at NASA Langley Research Center are one option. The outer surface of the inner can would be grooved to prevent the seals from translating. Included in the figure is a process by which the outer seal could be replaced. The outer seal is the only one which would require replacement by EVA. Additional safety features not discussed herein could easily be incorporated into this seal system. Two concepts involving compression seals or a combination of compression and inflatable seals are also shown.

MECHANICAL DEPLOYERS

Two potential translation mechanisms are shown (fig. 4). They consist merely of electric motors and either worm gears or gear tracks embedded in the inner wall of the outer vessel. These would be located every 90° around the assemblage.

CONCLUSIONS

A design concept has been described wherein telescoping space station modules would be utilized to take better advantage of the payload capabilities of the Shuttle Orbiter, while enhancing the capability of the space station. The concept requires no new technologies, and appears to offer the following advantages over more conventional space station module concepts:

(1) Nearly twice the usable space station volume at no additional launch cost.

(2) Enhanced protection against space debris and radiation.

(3) Amenability to variations in space station configuration, assembly, and disassembly.

(4) Enhanced flexibility and safety regarding docking or berthing with the Shuttle Orbiter.

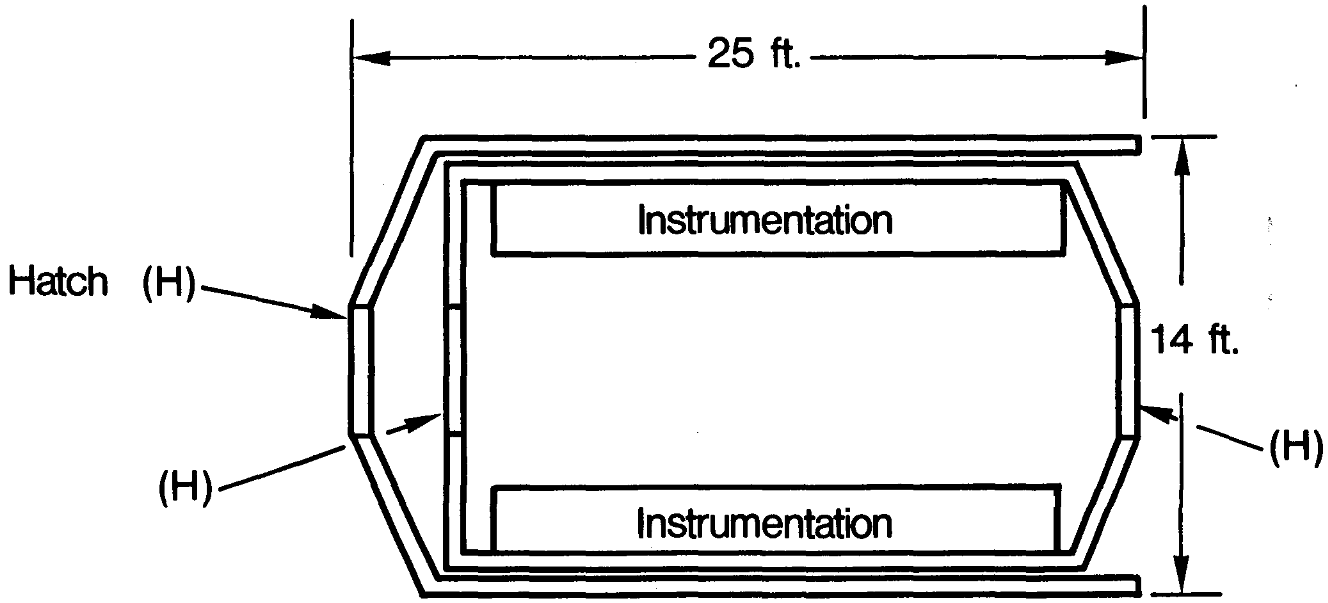


Fig. 1. Telescoping module assembly (undeployed).

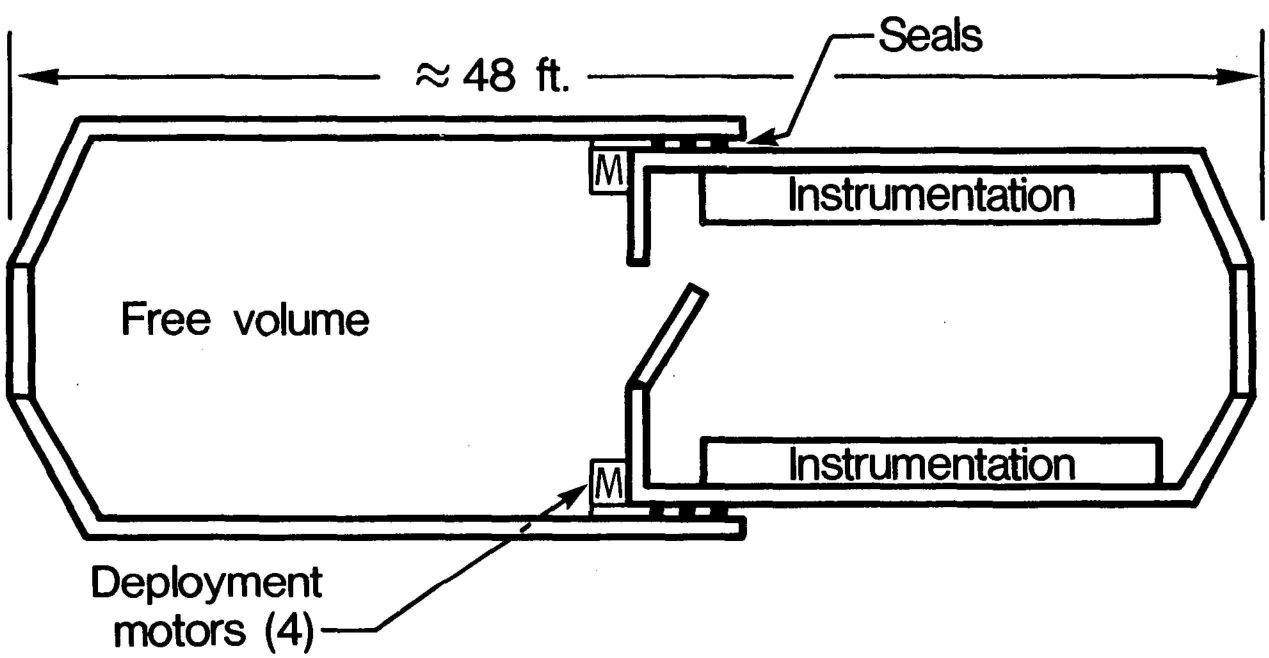
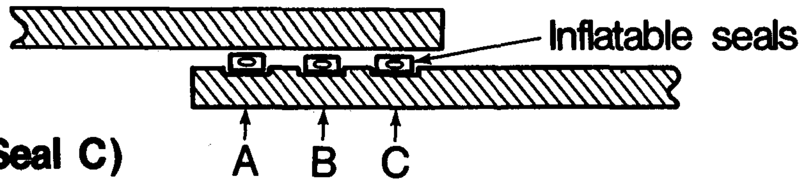


Fig. 2. Deployed module concept.



Seal Replacement (Seal C)

1) Deflate "C".
2) EVA to pull out seal "C".
3) Deflate seal "B".
4) Pull seal "B" to "C" slot and reinflate.
5) (IVA) deflate seal "A" and push it to slot "B" and reinflate seal.
6) Put new seal in slot "A" and inflate seal.

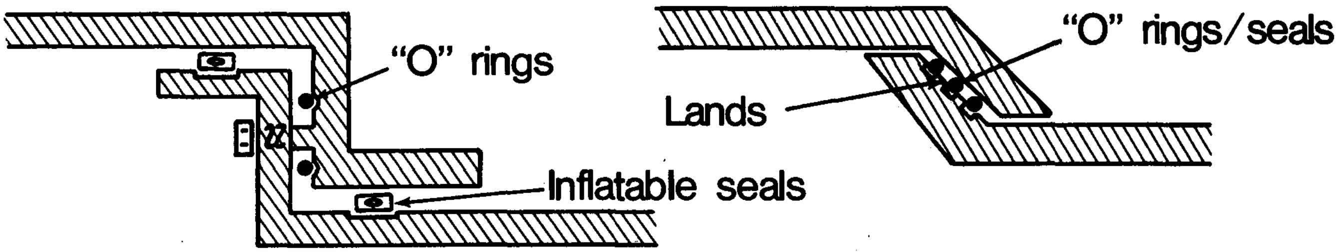


Fig. 3. Module seal concepts.

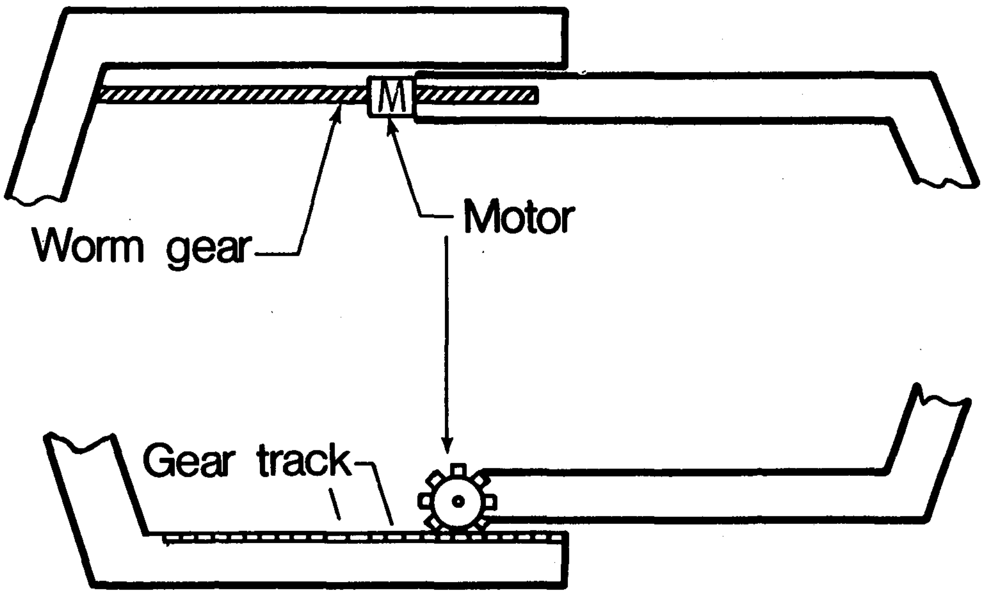


Fig. 4. Mechanical deployment concepts.

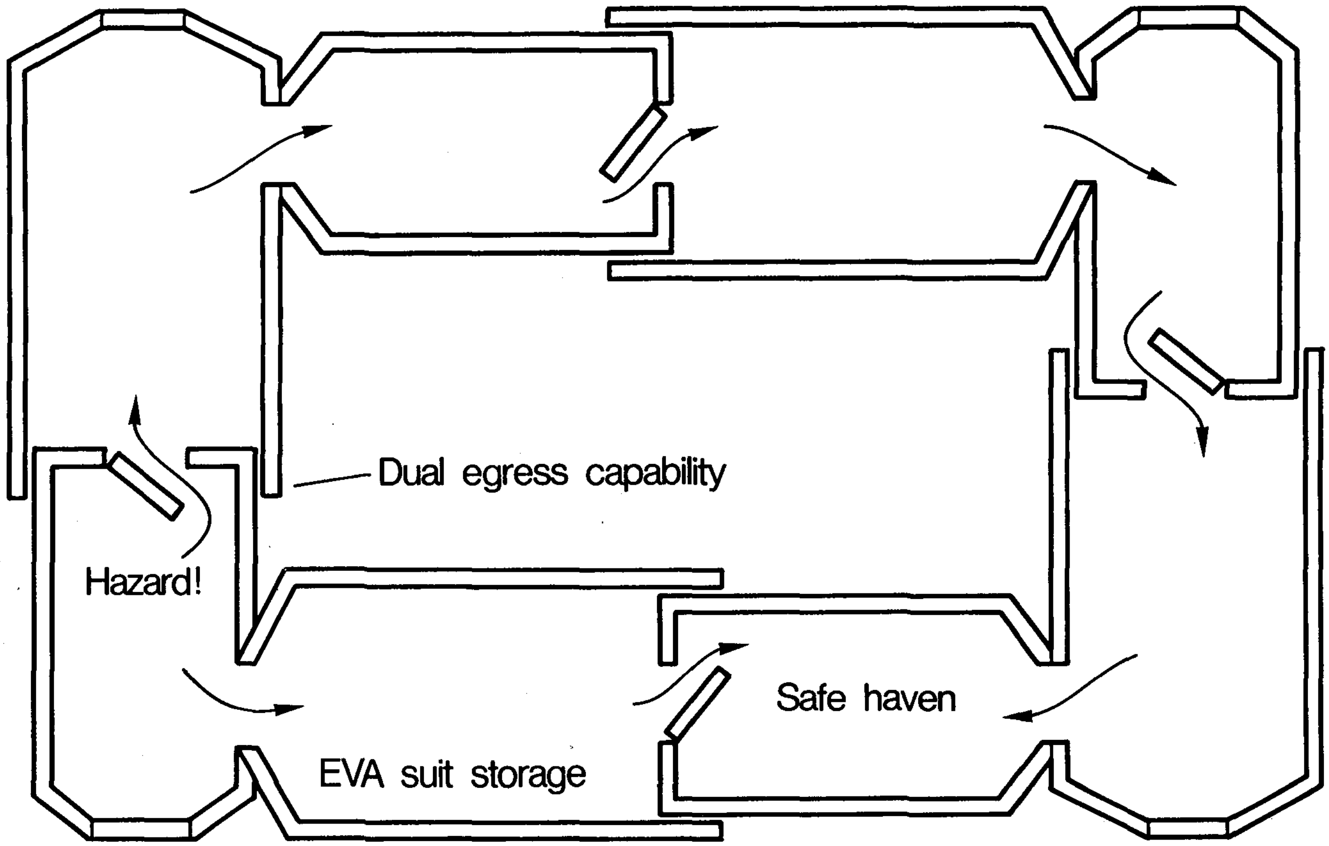


Fig. 5. Four-assemblage "race track" configuration.

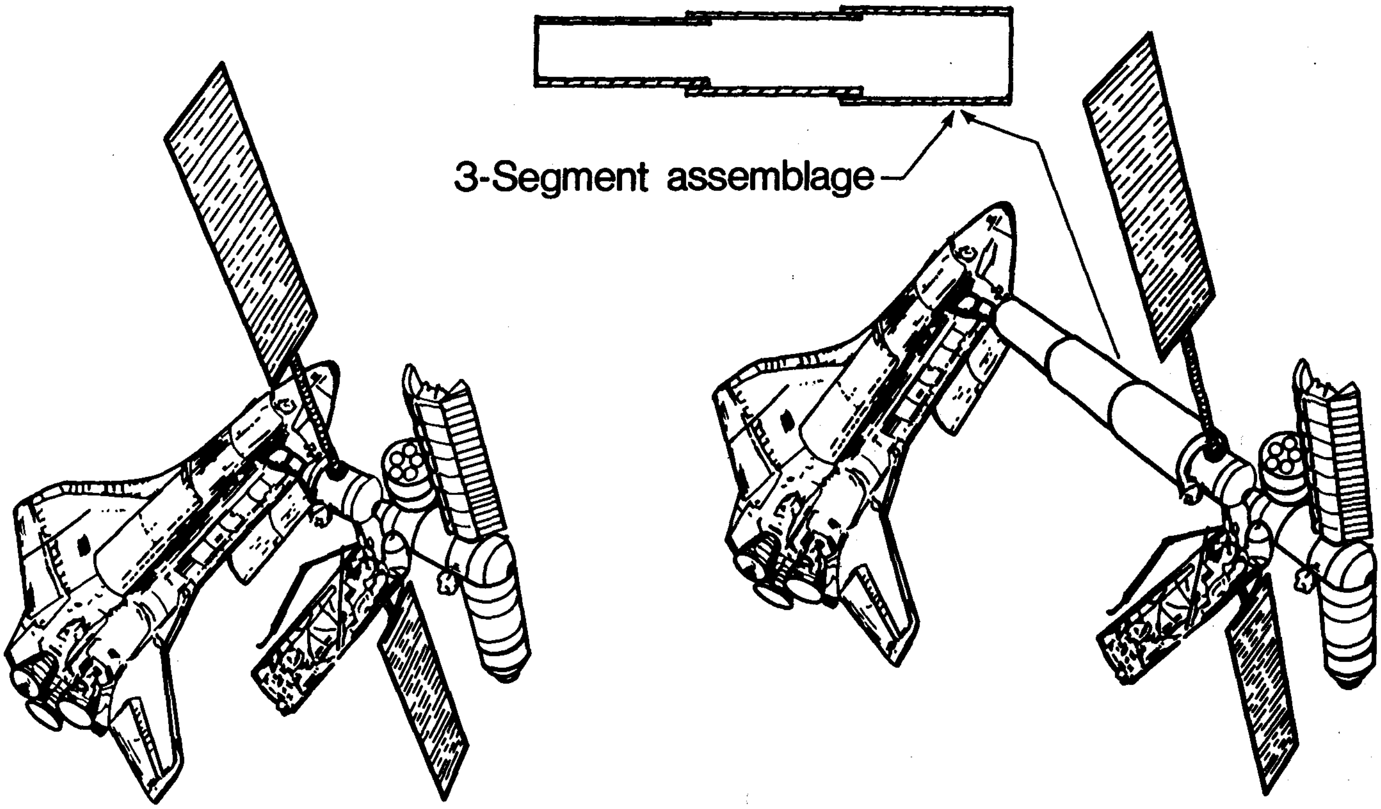


Fig. 6. Collision avoidance during docking/berthing.

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15. Supplementary Notes

16. Abstract

A design concept is described wherein telescoping space station modules would be utilized to nearly double the useful volume onboard a station. Methods for utilizing the concept to obtain enhanced protection from space debris and radiation are described. The amenability of the concept to variation in station configuration, assembly, and disassembly is discussed. A modification of the concpet which could provide flexibility in the manner in which the Shuttle Orbiter is docked with the station and enhance collision avoidance during such maneuvers is described.

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