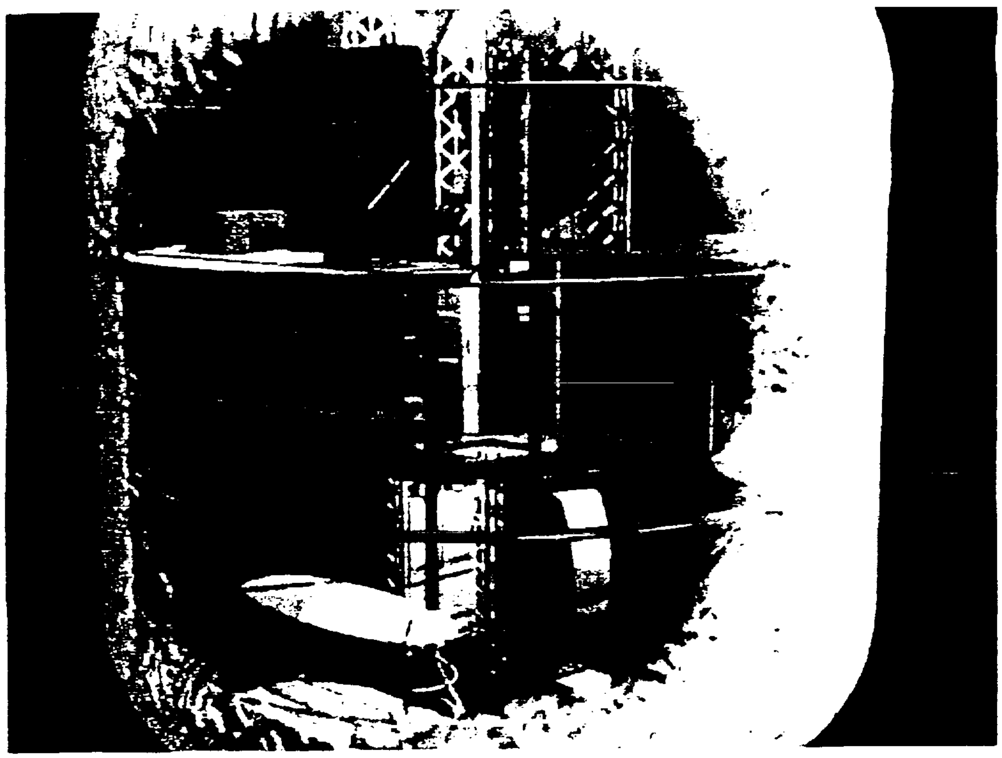
Final

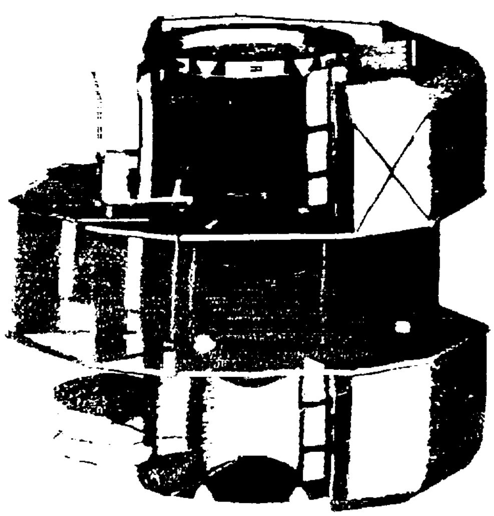
ITEM DESCRIPTION:

ISS TRANSHAB RESTRAINT SAMPLE AND PHOTO DOCUMENTATION

December 8, 1999

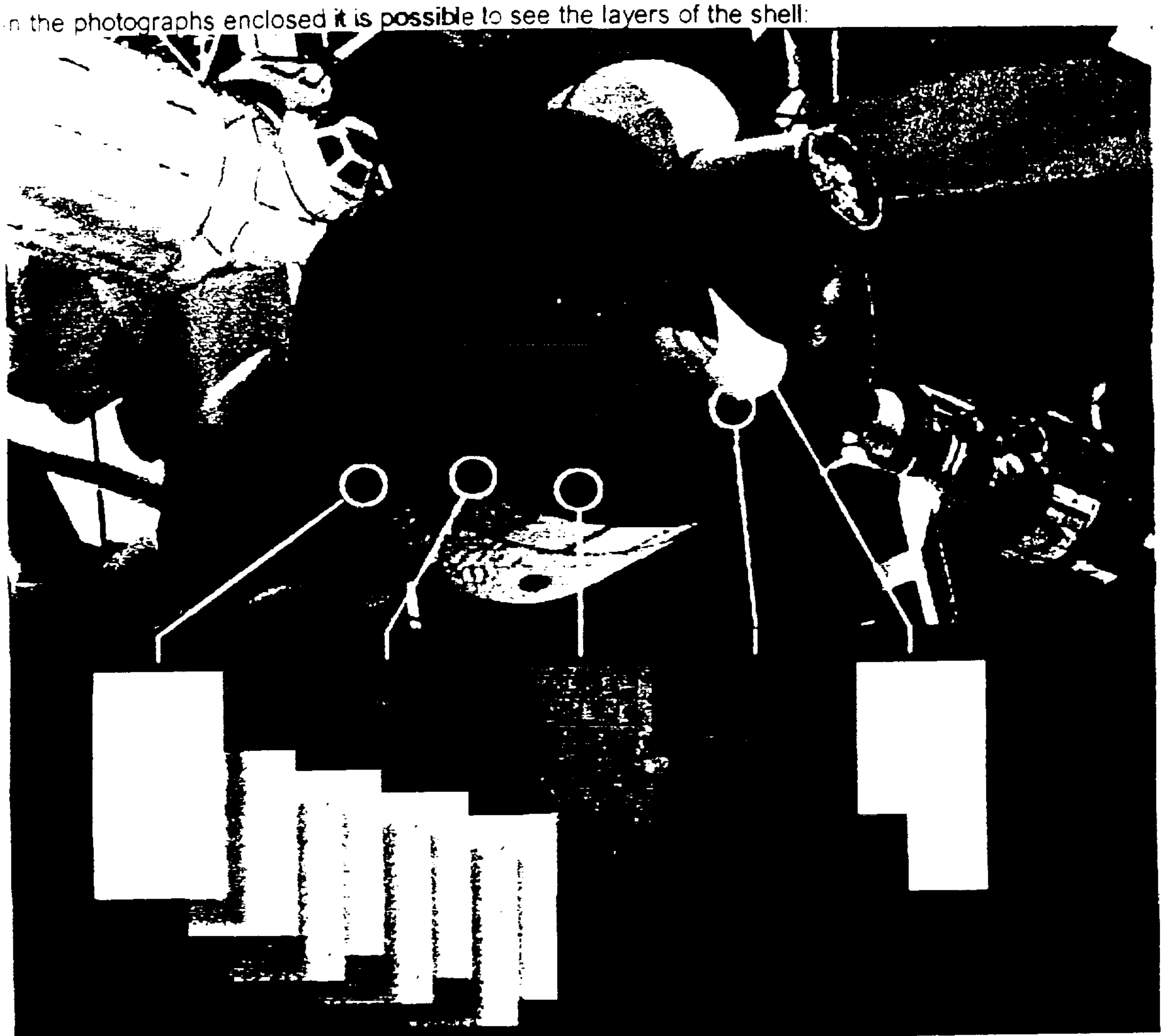
The yellow strap you see in this display is a piece of the main restraint layer of a test article for the ISS-TransHab spacecraft. First conceived as a technology which is capable of supporting a [human] crew of six on an extended space journey such as the six-month trip to Mars, TransHab (short for "Transit Habitat") is the first space inflatable module ever designed. As this text is written it is being considered as a replacement for the Habitation module on the International Space Station (ISS). It constitutes a major breakthrough both in technology and in tectonics: capable of tight packaging at light weight for efficient launch, the vehicle can then be inflated to its full size on orbit via its own inflation tanks. This is made possible by the separation of its main structural elements from its pressure-shell. In other words, all spacecraft flown to date have been of an **exoskeletal** type—i.e., its hard outer shell acts both as a pressure container and as its main channel for structural loading. This includes the ISS, which is currently under construction in Low Earth Orbit [275 miles above the Earth].





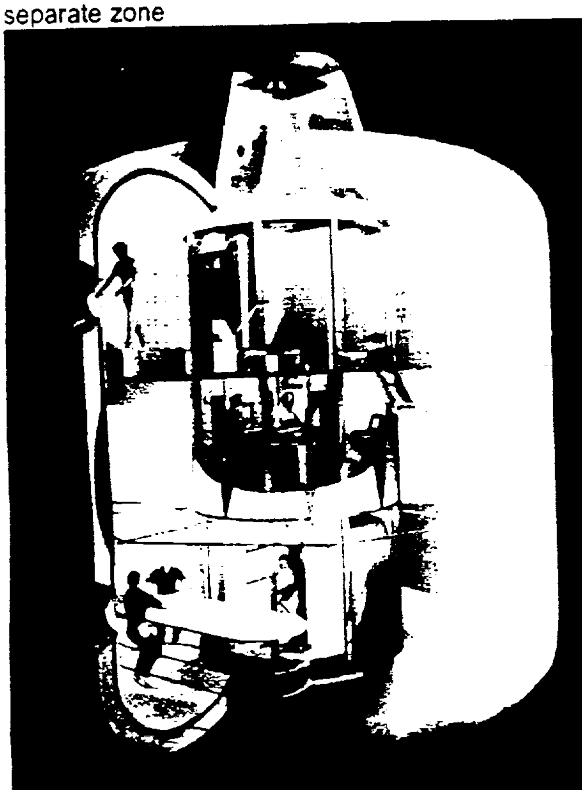
By contrast, TransHab is the first **endoskeletal** space habitat, consisting of a dual system: a light, reconfigurable central structure of graphite composite and a multilayered, deployable pressure shell.

n the photographs enclosed it is possible to see the layers of the shell:



Principal among these is the yellow webbing of the restraint layer, which uses the ancient technology of basket-weaving to distribute tremendous loads evenly and efficiently around its torus. Each strap—like the one you have before you—is made of woven Kevlar, a glass-fiber material which has a very high strength ratio and great impact resistance, and is often used today in the making of bullet-proof vests or similar body armor. Woven together into the vehicle's main shell, these straps are indexed to one another at 26,000 points and when inflated form a system which is capable of withstanding up to 4 atmospheres (54 bars) of pressure differential between interior and exterior. Three redundant bladders are mounted inside this layer to hold the air outside it, a multilayered shield of five layers of Nextel (a ceramic fabric which is also used to resist impact) separated by five centimeters of open-pore foam is mounted to defend the TransHab against micrometeoroic particles traveling at orbital velocities up to seven kilometers per second. The outermost layer of the shell is made of beta cloth, a glassy substance which to date is the only known material to resist long-term abrasion by atomic oxygen and other charged particles in the Earth's ionosphere.

History: TransHab was first conceived in 1997 by a team of engineers and two architects headed up by engineers Donna Fender and Horacio De la Fuente at the Johnson Space Center in Houston, Texas. In June of that year, a small group from the Exploration office put forward the idea of developing an inflatable space habitation module that was capable of supporting the needs of a crew on a long transit journey. In October the Space Human Factors group was asked to perform a habitability evaluation of the vehicle as proposed (layout by architect Kriss Kennedy) and to recommend a dimension for the pressure-shell based on this. Their evaluation, performed by architect Constance Adams, based its findings on extensive study of the technology being proposed and on lessons learned from earlier missions on social, performance and anthropometric issues associated with human spaceflight. This study recommended a new, three-level internal configuration and a shell radius of 7 feet [2.15m] greater than the core, with crew quarters isolated at the center, mechanical systems grouped together in a separate zone

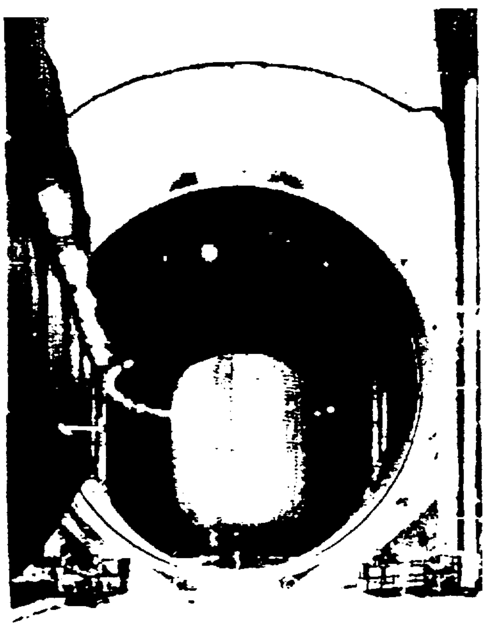


and exercise and hygiene situated on a different level from the public functions of galley, wardroom and conferencing. By January of 1998 the TransHab Project Team had adopted this configuration and requested fulltime Human Factors support in developing the vehicle outfitting and integration.

In 1998-9 TransHab broke all space program records by building three full-scale mockups and successfully completing three tests on the major shell, along with numerous ballistic, vacuum and radiation tests on samples of the proposed layup. In part this was made possible by the separation of major systems, which allows the pressure-shell to be developed and tested independently of the major core structures.

Space Human Factors: The ISS-TransHab has been designed based on lessons learned from both American and Russian experience in long-duration spaceflight. Input was used from the Skylab mission (US: 1972-4), the Salyut missions (USSR, 1973-8), and Space Station Mir (USSR/Russia: 1986-99), including debriefs with Astronauts and Cosmonauts, and with space medical and human factors experts from both programs. In the dawning of long-duration spaceflight, human performance issues are recognized as increasingly significant in guaranteeing the success of any extended mission. TransHab's generous volume—over 342 cubic meters—and its layered internal tectonics allow this vehicle for the first time to provide discrete areas for public, semiprivate and private activities and to offer the crew dedicated areas for exercise, dining, conferencing, and medical operations without the need to stow and deploy equipment associated with these activities. In other words, TransHab's corridor is separate from its rooms, and its internal layout is programmed for continuous, low-friction use by a diverse crew. This volume is provided once the core package, with its folded shell,

is launched, inflated and activated; at that time, floor struts unfold out of the core to form three separate levels and elements which serve structural functions during launch are reconfigured to serve as walls, partitions and furnishings in the lower loading conditions of orbit.



Engineering: Engineering assessments have been provided by many experts in the US Space Program including Dr. Chris Kraft, George Jeffs and Charlie Jencks three of the principal designers of the Mercury, Gemini, Apollo and Space Shuttle vehicles. It is a wonder of applied engineering: cutting-edge materials technologies have been borrowed from various terrestrial applications and combined to create the first viable space inflatable structure. Space inflatables have long been considered a valuable idea because of their high volume-to-mass ratio; at this time, due to the propellants and technologies used to insert payloads into orbit, it costs nearly US$100,000 to launch 500 grams of mass to LOE. However, an inflatable alone does not have the tectonic stability to function well in a vacuum. The pioneering cosmonaut Aleksei Leonov attempted to use an inflatable airlock from a Soyuz module in the late 1960s with unsatisfactory results. One reason for this was the lack of appropriate materials; the other, the lack of any sort of rigid structure to stabilize the shell. TransHab has broken both of these barriers, and proven in four subsequent tests in 1998 and 1999 that this combined type of vehicle is viable for spaceflight.

It is believed at this time that TransHab or a variation will be launched for permanent attachment to the International Space Station by the end of 2004. This vehicle, which combines ancient methods with the most advanced technologies of our time, profits in its conceptualization and design from the combined experience of three decades of American and Russian spaceflight—in short, it is a fusion of innovative engineering with the entire history of human travel in space. TransHab represents a major benchmark in typology, design method and technology which will enable humans to take the next step in scientific exploration of our Solar System, travelling to Mars and, some day, beyond.

Constance M. Adams, RA, AIAA*
Architect RA / Space Architect
TransHab "Tiger Team" Participant: Vehicle Architecture, Integration and Outfitting

TransHab Project Team (1997-9) includes: *(bolded name is system lead)*
Donna Fender, *Project Manager*
Horacio De la Fuente, *Chief Engineer*
George Parma, *Deputy PM*
Kriss Kennedy, RA / Damon Wilson / Tim Lawrence / Geoff Degraff, *Systems Integration*
David Fitts / Constance Adams, RA / **Janis** Connolly / Kurt Bush / Webb Byford, *Architecture, Integration and Crew Accommodations*

Gregg Edeen / Jasen Raboin / Gerry Valle / Shalini Gupta / **Gary Spexarth**, *Structures*
Elizabeth Kluksdahl / Jose Christian, *Power*
Bill Dwyer / Bob Davis, *Avionics (Command and Data Handling)*
John Cornwell / Karen Myers / Jay Almlie / Tom Paul / Fred Smith, *Environmental Control and Life Support Systems*
Randy Rust, *Safety*
Mike Pedley / Rajib Dasgupta, *Materials*
Steve Rickman / Raoul Blanco / Gautam Badhwar, *Environments and Radiation*
Bill Studak, *Inflation*
James Dunn, *ISS Interface*

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