Architecture Student Designs to Support Microhab Sortie Mission

Donna P. Duerk*
California Polytechnic State University, San Luis Obispo, CA, 93407

Second year architecture students were challenged to use the example of Moon Habitats as a resource for principles and concepts for sustainability to bring to their earthly designs. As part of their studies, they were treated to a visit to the Jet Propulsion Laboratory in Pasadena where they were privileged to see the ATHLETE rover as well as models of most of the other rovers and satellites that are under JPL's control. The highlight of their visit was a brief design charette in which the students were charged with the task of creating furniture from the packaging material that will used to contain supplies for the Microhabs, which JPL will study as a part of their analogue habitat scenarios. The students were thrilled to be able to design something that might possibly be useful to the program. This paper will describe the JPL Microhab project context, the supply packaging system, the Microhab sortie project, and the design challenge for the students. Student designs will be described and illustrated.

Nomenclature

ATHLETE = All-Terrain Hex-Legged Extra-Terrestrial Explorer, a Robot
Cal Poly = California Polytechnic State University, San Luis Obispo, CA
CTB = cargo transfer bag
ETDP = Exploration Technology Development Program
ISRU = in situ resource utilization
JPL = NASA's Jet Propulsion Laboratory, Pasadena, CA
JSC = Johnson Space Center
LSS = Lunar Surface Systems
Microhab = small habitats designed as mobile Moon habitat analogues

I. INTRODUCTION

Second year architecture students were not necessarily thrilled about designing habitats for the Moon when their research pointed out that the efficiencies of the surface to volume ratio of a sphere, torus, or a cylinder dominated the shapes of Moon habitats. They would much rather be Buck Rogers or Burt Rutan visionaries. Their field trip to the Jet Propulsion Laboratory (JPL) in Pasadena, CA, proved to be the highpoint of their Moon habitat design sequence when they were challenged to design furniture for the Microhabs. They discovered that design *inside* the volume was critical and was far more than just moving partitions around. Scott Howe acted as host, gave the class a tour of the JPL facilities, and set the design challenge. The photo shows a Microhab in the background with Scott in the foreground.

A. Background — Students

These second year Cal Poly architecture students were given the Moon habitat problem in order for them to discover first principles and concepts of sustainability that they could then transfer to a later project on Earth. The theory was that if they came to an understanding of a closed system in terms of its energy needs, its resource conservation and recycling needs, and its focus on small spaces and the multiuse of those spaces where feasible — then some of those design ideas could be translated into a multi-use building in San Luis Obispo, CA. Their research teams studied Class I structures — Pre-built, Class II structures — Deployed, and Class III structures — ISRU-based (in situ

* Professor Emerita, Architecture Department, 1 Grand Avenue, San Luis Obispo, CA, 93407, AIAA Sr. Member, Retired.

resource utilization). One of the major sustainability lessons learned from all three of these systems was the necessity for minimizing waste and for recycling all of the vital components: air, water, and nutrients. Thus the idea of recycling/redesigning the Cargo Transfer Bags (CTBs) into furniture was an exciting idea for the students.

B. Background — Microhabs

The Microhab program that the class visited at JPL is part of the NASA Exploration Technology Development Program (ETDP) under Constellation, which is NASA's program to go to the Moon, Mars, and beyond. JPL has a program called the Constellation Lunar Surface System (LSS) Habitation team that manages the Microhab and its simulations. Microhab's job is to simulate Moon habitats in mobility mode. These Microhabs are designed as a payload for the current version of the ATHLETE. ATHLETE is the name of a robot and stands for All-Terrain Hex-Limbed Extra-Terrestrial Explorer. This working model of ATHLETE is approximately half the size it is envisioned to be as a fully functional robotic member of a Moon team.

The first docking exercises for the Microhabs occurred in June 2008 in Moses Lake, Washington.

The Microhab project is one aspect of a multi-center effort to learn more about what the final Moon habitat will be like. There are currently several habitat analogues that are part of the LSS Hab team efforts:

- Microhabs at JPL
- Horizontal and torus habs at JSC (lumber and foam core mockups)
- Inflatable torus hab at JSC
- Instrumentation test bed habitat at JSC (some of this instrumentation is also being installed in the Microhabs)
- Inflatable vertical hab and airlock at Langley
- Mid-expandable habitat at Langley (9psi pressure-capable with steel end domes and inflatable center tube)
- NEEMO underwater habitat in Florida (used for crew training).

ATHLETE is in the foreground and two Microhabs are in the background as students examine them.

II. Design Challenge

The Microhabs are to be deployed in the field at full human scale to simulate Lunar Outpost buildup. The dimensions are roughly 2.2 meters in diameter by 3.5 meters long. The JPL LSS Habitation team has developed a "Logistics to Living" concept that has the following features:

- Scenario: two Microhabs arrive on ATHLETEs, which are operated remotely and docked together to simulate outpost buildup.
- One Microhab is the core habitat module for two crew members, the second is the logistics module containing most of the expendable supplies.
- The core habitat module initially has no furniture or partitions.
- The logistics module is packed with Cargo Transfer Bags (CTBs).
- When the Microhabs are docked together in the field, the crew will "eat their way" through the materiel in Logistics module.
- The empty CTBs can be converted to furniture.
- The first "Logistics to Living" simulation will occur in Sept 2009 in Arizona.

The students were challenged to take the afternoon at JPL to design a piece of furniture from the CTBs — given the Microhab interior and the webbing structure that holds the CTBs in place for launch.

The CTBs fold out to 72” long and 30” wide and are of a thickly padded plastic material with grommets in the edges. The photograph shows the racking system of webbing based on roughly 10” squares. If a CTB were to be unfolded, it would cover the webbing top to bottom and side to side. In the photo there is an unfolded CTB hung vertically just beyond the webbing and a folded one behind and to the left of the webbing.

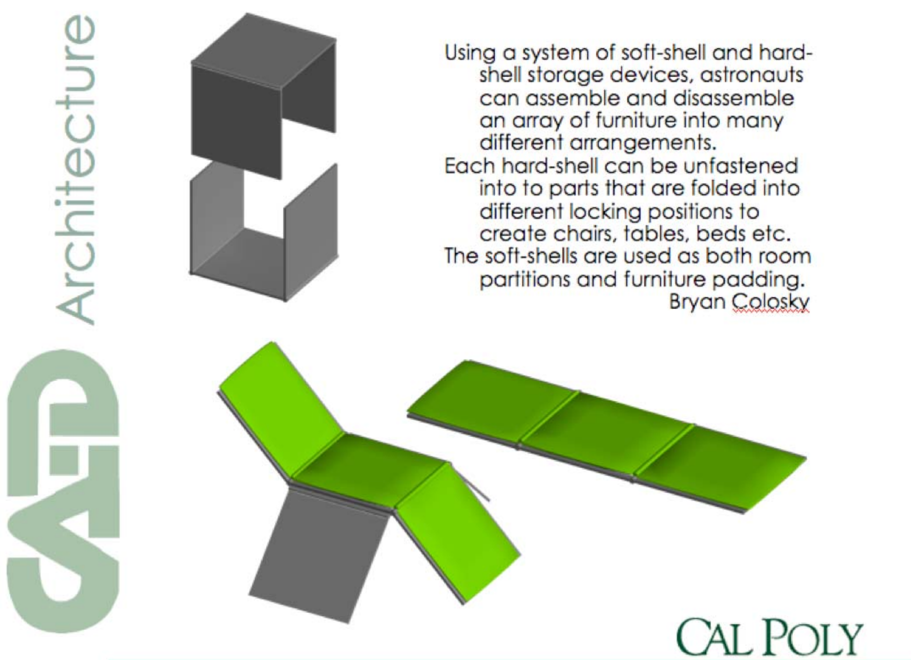
Students were given the freedom of adding stiffeners, grommets, hangers, or other supporting pieces that might enhance their furniture designs.

In order to make their designs presentable, students were given several days back at Cal Poly to refine their ideas and to put them into presentable formats. The class put together a PowerPoint presentation for JPL with all of their designs. Only a sample of the best ones will be presented here.

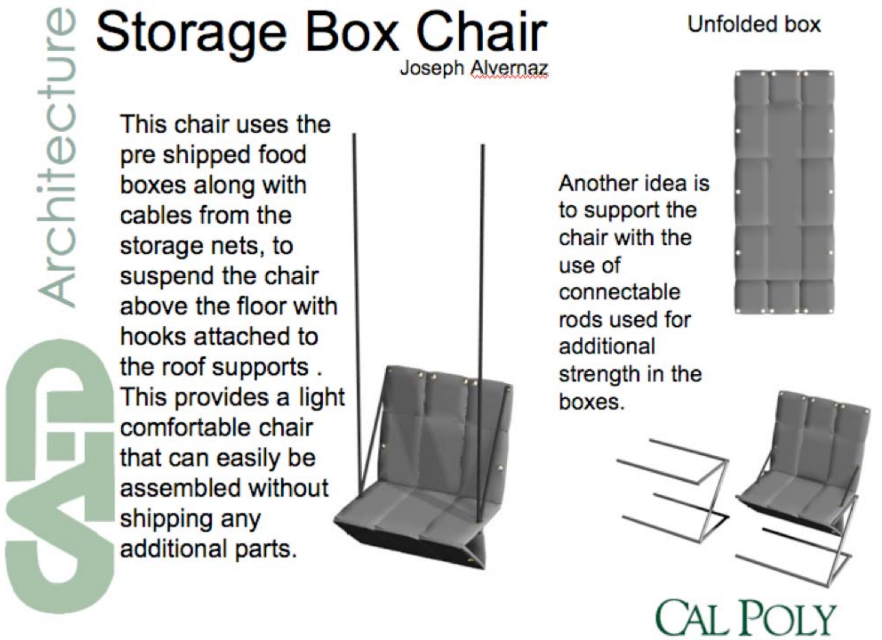
III. Student Furniture Designs

The students took a wide variety of different approaches and designed a variety of different types of furniture. They ranged from the simplest “U” shaped table to the complex panel insert-supported structures. Given the very short period of time that the students had to complete their designs, they are very interesting in what they completed, and in what they left to the imagination.

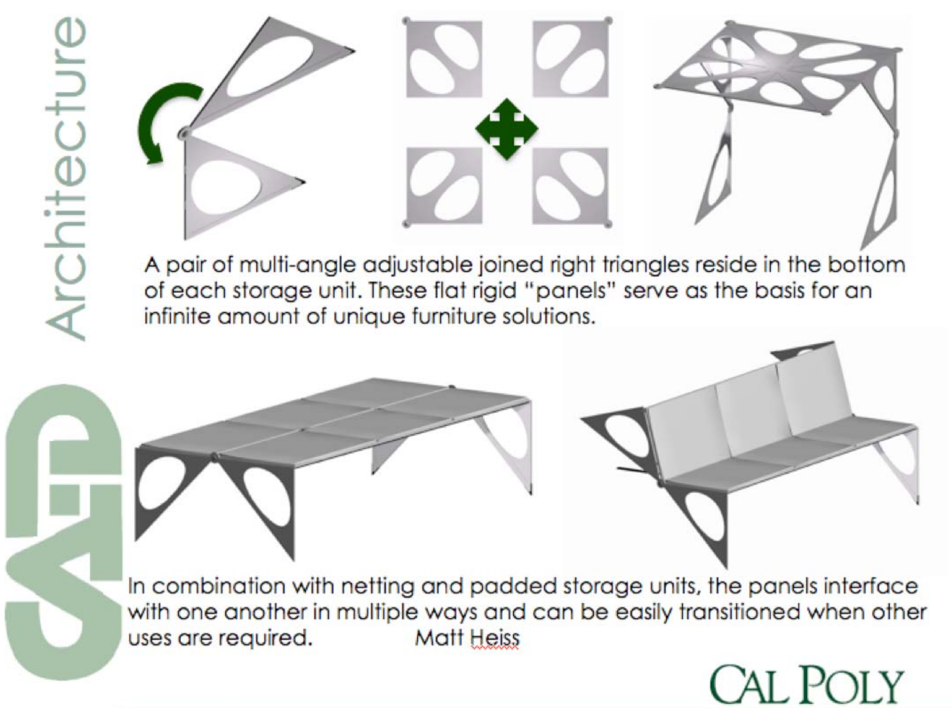
The first presentation took the liberty of ignoring the existing grommets and fold points and adding new ones. Also added is a hard-shell system with a yet-to-be-engineered hinge system that locks in place at a minimum of three different angles. One can assume that some grommets will be used to fasten the soft-shell to the hard-shell with some yet-to-be-determined fastener.



A second idea uses a minimalist approach. It assumes that the webbing can be turned into cables in order to suspend a chair. A second idea includes a frame that assumes very rigid joints to support a person’s weight — even in the Moon’s 1/6th gravity. One might also assume that these frames would be stored in between the CTBs as they are shipped in the logistic modules.

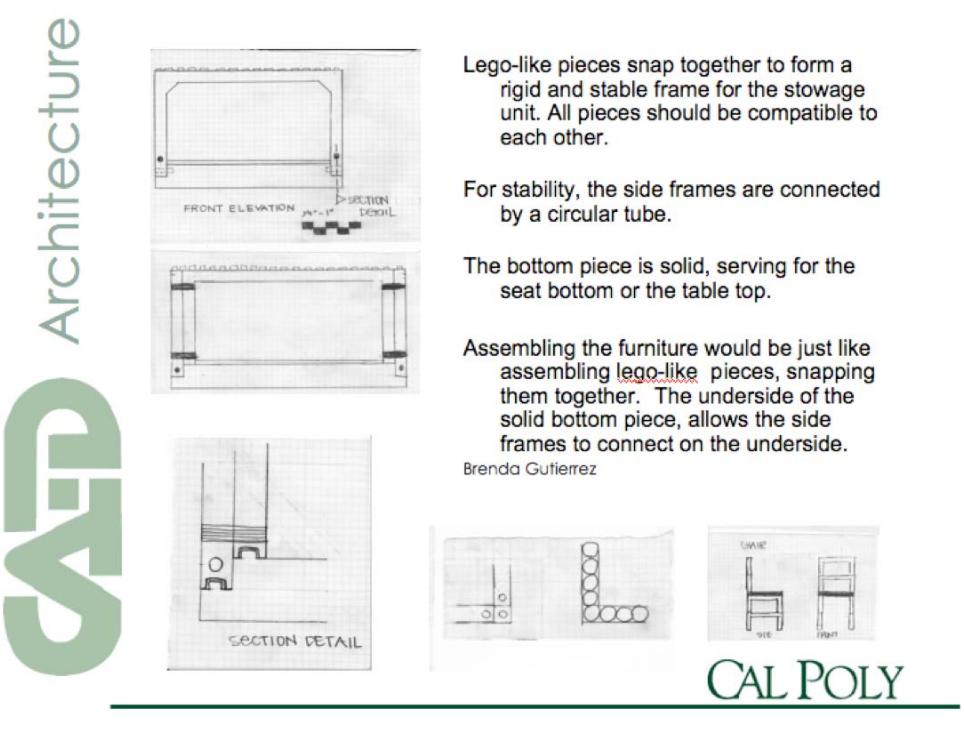


A third student took the panel insert approach. Again the hinges are yet to be engineered and the rigidity of the joints is an interesting question to be resolved. The connection to the interior of the Microhab is assumed rather than illustrated. The geometry was the focus of the design. These panels slip inside the CTBs to reinforce them.

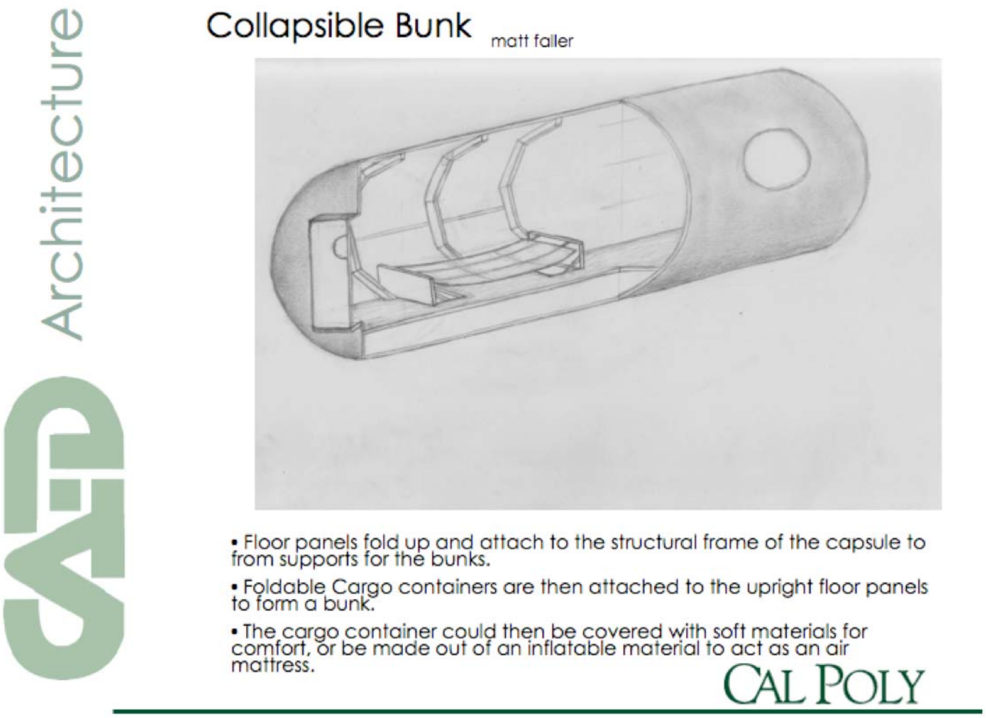


Another minimalist approach reuses the existing materials with the addition of a frame that hooks into the existing structural framework of the Microhab. The CTBs become a mattress while the cargo net is disassembled to become the supporting structure attached to the new frame.

Then there were a couple of students who chose to ignore the existing components completely and went off on their own and designed a totally independent system. This student turned to the ever-popular Legos for precedent.



One student chose to utilize the floor panels as a part of the support structure. The mechanisms to stabilize their positions are yet to be engineered, as are the attachments of the CTBs, but the utilization of existing materials is interesting.



These six designs represent the range of ideas that the class presented. The others that are not shown here were basically variations on these themes. These are also the best graphics of the class and so represent the most readable ideas and most visually pleasing presentations.

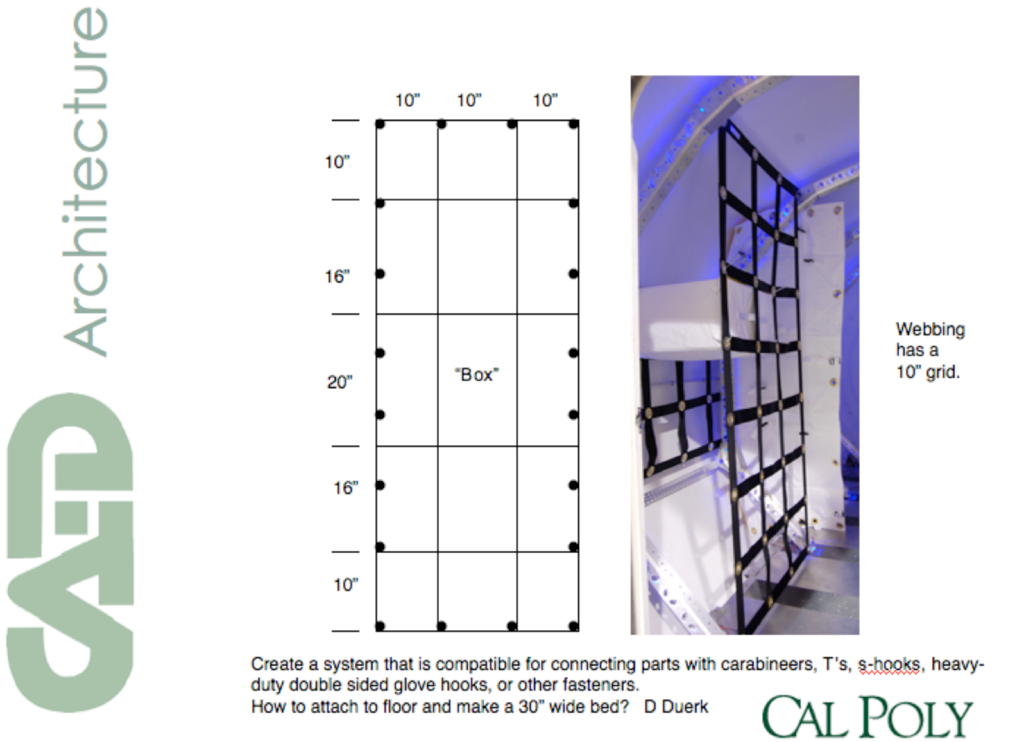
IV. Conclusions

The exercise was vital to the success of the class in terms of enthusiasm and understanding of the levels of design required for habitats in space and on planetary bodies. Hands-on experience of the visit to JPL to see a real habitat, the real ATHLETE mockup, and the real models of projects that the students have seen in the news was vital to their understanding. All of us enjoyed the sight of the full-scale Spirit/Opportunity model. All of us were quite impressed to be in Mission Control. It was a great privilege to be able to touch the ATHLETE and the Microhabs and to be able to stand inside and get a sense of the scale and the fittings and imagine how things might work.

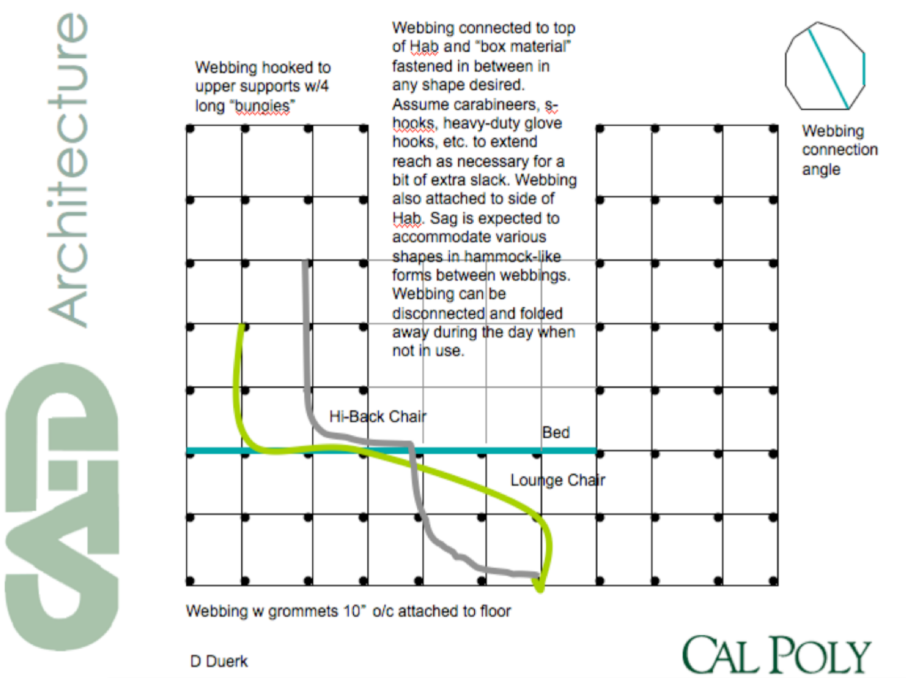
These furniture designs by architecture students raise some very interesting questions about future Microhab furniture from the CTBs:

1. What sorts of furniture are the astronauts most likely to want first?
2. What is the minimum number of parts that will produce the appropriate variety of furniture pieces?
3. What is the minimum number of connections needed/wanted?
4. How many of the furniture features can be built into the CTBs so that the system is virtually plug and play?
5. What is the minimum number of grommets needed in the CTBs?
6. How flexible does the cargo netting system need to be?

The professor could not resist trying to answer one of these questions. It seems that the grommets are currently placed to accommodate the packing system only — without a thought toward any future furniture making. If the grommets are spaced to coordinate with the cargo webbing, there could be connections between the CTBs and the webbing for easily assembled furniture.



Since the CTB "box" is 30" wide when unfolded, some accommodation must be made to use the webbing as a scaffold for a series of different furniture pieces.



Imagine cargo webbing that can be attached to the roof at an angle by stiff rubber bungees and then the CTBs can be attached by bungees, carabineers, or heavy-duty double glove hooks to the webbing so that they sag gracefully, but are resilient to the weight of a person sitting or lying on them. Imagine sitting propped up at just the right angle with your laptop in your lap, your legs supported, and working comfortably for hours at $1/6^{th}$ gravity. This is what's possible.

Acknowledgments

A. Scott Howe was instrumental in arranging the field trip to the Jet Propulsion Laboratory and in guiding the class through a wonderful tour of the JPL campus, as well as providing the design challenge that resulted in this paper. I am very grateful to him for all the information he has provided about the Microhab program and its place in JPL's research agenda. All photographs are by the author or by one of the students. Each Power Point slide was created by a student, whose name appears on the image.

The class and ATHLETE