DEPLOYABLE INFRASTRUCTURE IN SUPPORT OF SCIENCE AND EDUCATION

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ABSTRACT

P.L.U.G. is a prototypical solution to a highly specialized design problem that emerged in support of remote biological field research in the Mahale mountains of Western Tanzania. In collaboration with researchers from the Virginia Maryland Regional College of Veterinary Medicine's (VM-RCVM) Bush to Base Bioinformatics(B2B) group a team of students and faculty from the Virginia Tech School of Architecture + Design designed, constructed, tested, and deployed the mobile field laboratory which houses up to four researchers and includes clean laboratory space, living accommodation, autonomous electricity generation, and a satellite-based communications network. P.L.U.G. consists of two primary elements, a rigid enclosed laboratory and fabric super structure that are constructed using a series of functionally-complex building components that are designed to be carried and assembled by two researchers, in one day, without the use of tools. (Kaur etal. 2007) The resulting system can be mass produced and utilized in the establishment of infrastructure in remote, environmentally sensitive, and unstable environments and has implication in disaster relief housing, human heath stations, remote research, mobile educational facilities, and any other environment or event that requires rapidly deployable, self-sufficient infrastructure.

The prototype laboratory was successfully deployed during the summer of 2007 and has been field tested by the Virginia Maryland College of Veterinary Medicine (VMRCVM) Bush-2-Base Bioinformatics (B2B) research group. Currently the laboratory program exists as part of a newly developed long-term research initiative surrounding Deployable Infrastructure in Support of Science and Education (DISSed Lab) initiated by the author in response to perceived demand for such accommodation.

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Scales of Modularity

Graduate research was initiated by an interest in the convergence of architecture and industrial design. As a forum for understanding the nature of this relationship my research quickly migrated toward the design of modular and user assembled building and material systems. Investigations into modular building typologies began with participation in the Virginia Tech Solar Decathlon entry in 2005. Programmatic constraints prescribed a single transportable module that could, following extensive off site construction, be readily transported and deployed on site. This method of building allowed for a mobile dwelling that could arrive on site and become operational within a matter of hours. Immediately following the competition an opportunity to directly compare this single transportable unit to a similarly designed modular component system came in the form of an auxiliary structure to *ABC's Extreme Makeover: Home Edition* house in Blacksburg Virginia. This structure, while similar in material and form to the Solar Decathlon entry, differed greatly in assembly type. The garden meditation structure was an assembly of large crane-hoisted modular components that were built on campus and transported to the site for assembly.

Simultaneous, and ongoing research into manufactured, modular building associated with the design, fabrication and deployment of a field-ready mobile research station began in September 2005 as the thesis defended for partial completion of the Master of Science in Architecture, concentration Industrial Design, with an interdisciplinary group of students. The PLUG (Portable Living on Uncommon Grounds) project is primarily focused on the development of a series of laboratories for use in remote and environmentally sensitive areas. PLUG currently exists

FIGURE 1. 2005 SOLAR DECATHLON HOUSE IN TRANSIT. PHOTOGRAPH BY ROBERT DUNAY (WITH PERMISSION)

as a prototype used in the Mahale Mountains of Western Tanzania. The laboratory relies on a group of manufactured components that can be easily carried by two researchers, assembled on site in one day without the use of tools, and upon completion of research, removed with limited site disturbance. To this end research continues in the development of highly adaptable, user assembled Infrastructure that can be deployed for use as disaster relief housing, remote mobile laboratories, human heath centers, educational facilities, and any situation or environment that requires a low impact, rapidly deployable, autonomous infrastructure. The prototype laboratory was successfully deployed during the summer of 2007 and has been field tested by the Virginia Maryland College of Veterinary Medicine (VMRCVM) Bush-2-Base Bioinformatics (B2B) research group. Currently the laboratory program exists as part of a newly developed long-term research initiative surrounding Deployable Infrastructure in Support of Science and Education (DISSed Lab) initiated by the author in response to perceived demand for such accommodation.

As field testing of the PLUG prototype continues, the design thesis for the first professional Master of Architecture degree surrounded the design, fabrication, and deployment of a series of component based building assemblies. One, the *SEEDS Pavilion At Hawks Ridge*, serves as the home to a local environmental children's field camp. The pavilion continues the investigation of user assembled construction and is based on a component group that can be assembled on-site by camp children. Each building component was manufactured using on campus CNC (Computer Numerically Controlled) and wood working facilities and assembled on site by a group of supervised SEEDS camp student-volunteers during a one-week design build workshop at the Hawke's Ridge Preserve in Floyd, Virginia. The form of the structure is derived, in part, by the limitation of component number, size, and assembly sequence and represents the conflict between a parametrically derived series of prescriptive shapes and the forms that resulted

FIGURE 2. PLUG COMPONENTS ON LAKE TANGANYIKA. PHOTOGRAPH BY AUTHOR.

during the exploration of the physical system itself. This component-based construction is made possible by a series of joint assemblies designed to accommodate a wide variety of local building materials and variations in on-site conditions by providing a 'sloppy detail' that enables a high degree of tolerance.

Evoking Process

Parallel research was conducted surrounding industrialized process and emerging building technologies based on program specific requirements of the projects described. Each structure represents various potential for industrialized fabrication. While the initial two structures carry the promise of off site, factory construction, the PLUG program, in combination with the investigation into user assembled building components, carries the strongest claim for a move into industrialized component production. Plug's chassis was fabricated using numerically controlled manufacturing technology and the components were generated, analyzed, and manufactured using in Computer Aided Design (CAD), Computer Aided Engineering (CAE) and Computer Aided Manufacturing (CAM) environments. Each individual component of the pavilion structure was designed using CAD and, following computational finite element analysis were to be produced using a numerically controlled machines. Related research conducted during the development of the 2009 Solar Decathlon Entry led to the recent fabrication of a mobile building chassis and structural frame for use in the Virginia Tech LumenHAUS. The culmination of this research will serve as a basis for future investigation of CAM technologies and their potential utilization in automated building component manufacturing.

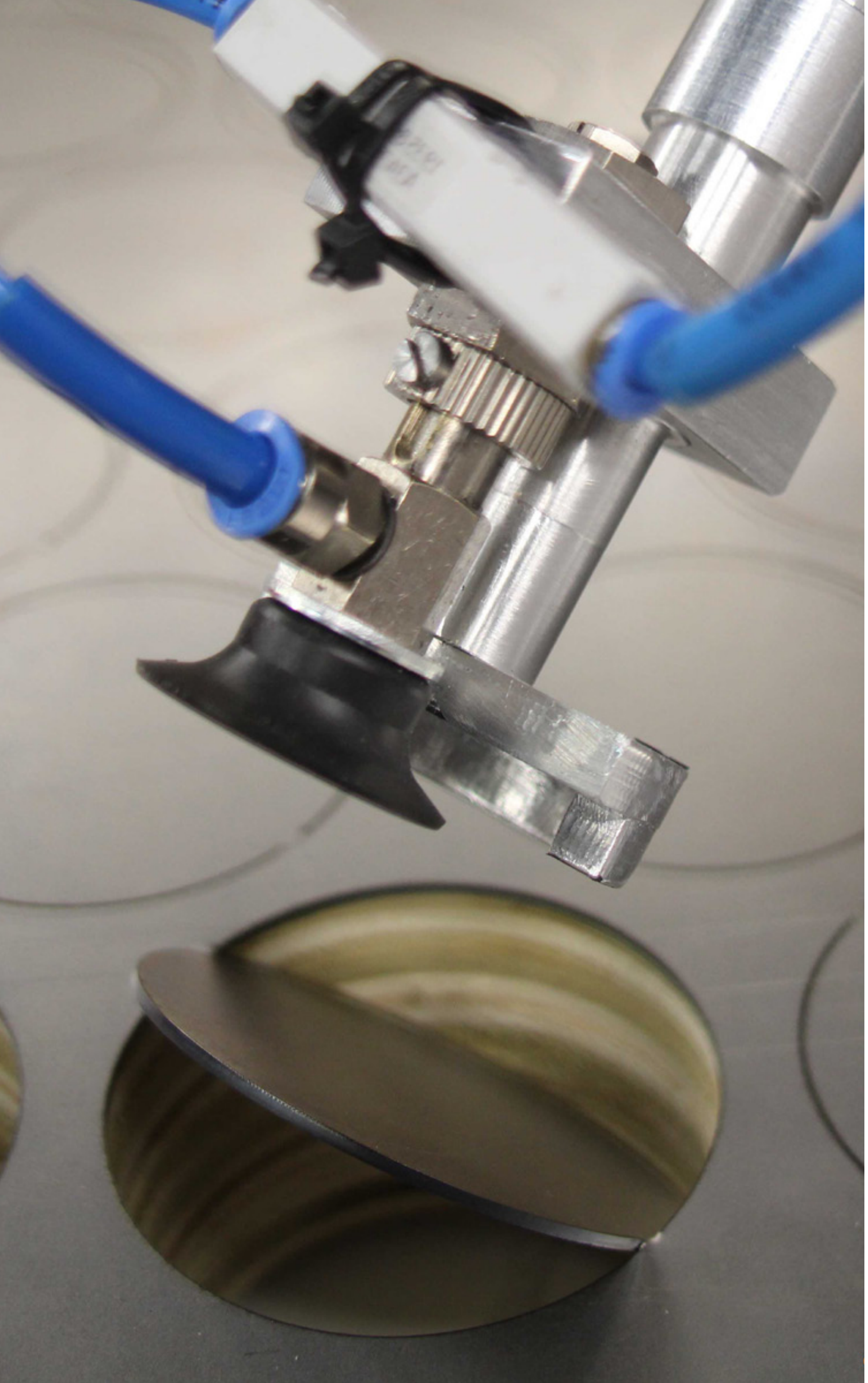
In service to ongoing design-build efforts, existing as individual investigative initiatives, and instantiated in the recently developed Center for Design Research, Design Robotics Laboratory, coincident research was conducted relating to digital design, fabrication, and related material sys-

FIGURE 3. SEEDS TRUSS COMPONENTS IN TRANSPORT. PHOTOGRAPH BY AUTHOR.

tems. The previously described, Portable Laboratory on Uncommon Grounds (PLUG) project represents a pedagogical design-build milestone through the integration of Building Information Modeling (BIM) as an enabling mechanism for trans-disciplinary collaboration. The use of BIM allowed students from Industrial Design, Architecture, and Interior Design to collaborate on the design of individual components in response to specific programmatic concerns with in a 3D digital prototyping (CAD) environment. The demand for deployablilty forced a merger of both a top-down architectural design process and bottom up development of functionally complex building components that reduce the complications associated with on-site assembly and enable portability. By addressing complexity at the component level in conjunction with material and process investigation a pragmatic solution emerged that allowed the architectural intention to be realized while solving for a criterion driven design problem.

While PLUG arrived at numerically controlled manufacturing as a pragmatic outcome to a program specific requirement a separate mechanism for experimentation was developed to isolate numeric processes as a generator for, rather than a solution to, a design problem. Through the evocation of numerically controlled processes as an impetus for a series of furniture prototypes entitled Industrialized Furniture, a research trajectory was established that guided thirteen design students in pursuit of opportunities rather than solutions. These prototypes pushed the boundaries of the contemporary digital design methodologies and resulted in the innovative processes and workflow considerations that enabled a series of anthropometric measurements to parametrically control a digital form that could be rationally discretized, manufactured, and assembled. In addition to facilitating process development this research enabled specific material investigation leading to the discovery of conditions as a result of the controlled interaction of material properties and digital processes. The divergent studies of process and condition were reconciled in the recently developed

FIGURE 4. NICK-APPARENT. PHOTOGRAPH BY AUTHOR.



Eclipsis system that enables the creation of specific architectural spatial condition through the integration of digital design and manufacturing processes. Prototypes of the Industrialized Furniture experiments were exhibited in multiple international furniture fairs and exhibitions.

During graduate study a Virginia Tech a transdisciplinary investigation into modular construction began with a project involving a complete, transportable, housing unit and has led to the generation of form based on groups of small construction modules. Through this design research an ability to evaluate the nature of modularity and the appropriateness of specific aspects surrounding this notion has emerged in parallel to a growing understanding of material systems. The potential exists for a unique opportunity to make immediate advancements through the merger of architecture, building practice, computational design, manufacturing, and material systems into a product-based architecture that enables appropriate and rapid solutions to growing demands for high-performance low-cost construction while maintaining the ever important ability to realize architectural intention. If an opportunity to re-purpose labor and infrastructure to the task of manufactured building components is aligned with the presence of knowledgeable design professionals and tested methods, immediate impact could be made on the nature of building and design.

The prototypes presented in this collection are designed objects ranging from small custom fasteners to fully operable portable housing units across many disciplines. In all cases the designed objects became a forum for research and are both the result of and impetus for, further investigation. Each project should be seen as a process study in the context of design research to be evaluated not only by their effectiveness as a designed object but by their ability to evoke and sustain a community of conversations, ideas, and research efforts. This experimentation now serves as a foundation for a new series of continuing research efforts realized through collaboration with the Virginia Tech, School of Architecture + Design, Center for design research and during doctoral studies at the Harvard Graduate School of Design.

FIGURE 5. ROBOTIC FOLDING OF ECLIPSIS FACADE PROTOTYPE. PHOTOGRAPH BY AUTHOR.

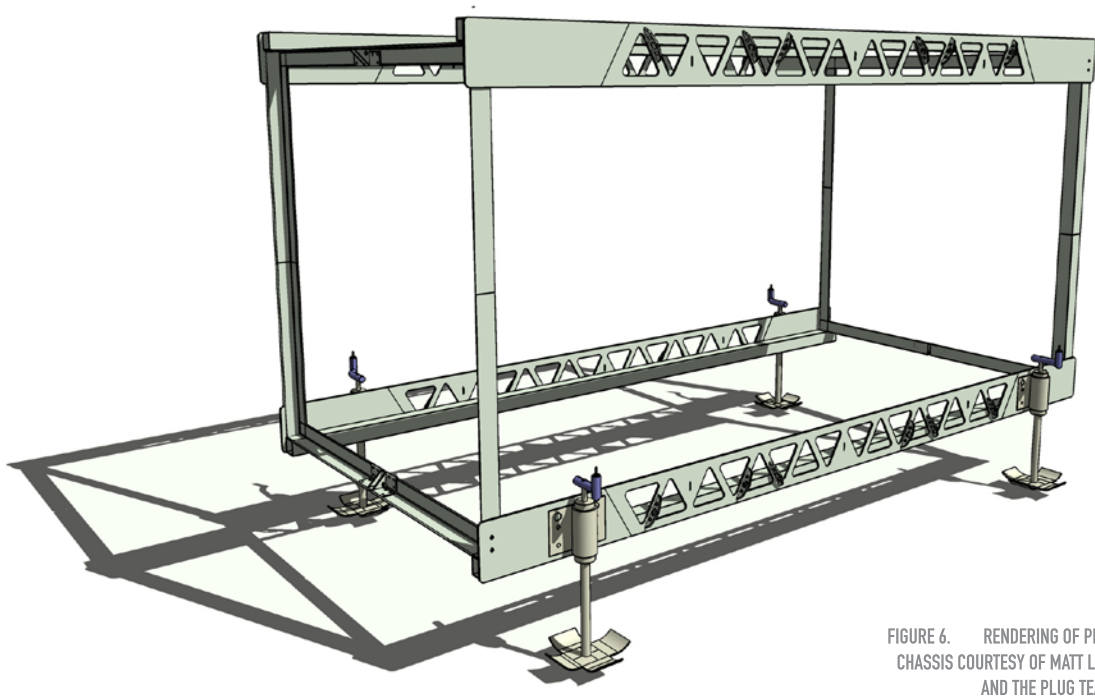
* PLUG is an acronym developed by Nathan King in the fall of 2005 to refer to the prototypical laboratory developed and presented here. The 'Deployable Infrastructure in Support of Science and Education' initiative is ongoing and was developed by Nathan King in 2009 as a wholly distinct effort. Quoted coauthored text was previously published as a poster submitted to the Virginia Tech-Dean's Forum on the Environment in 2007, by authors: Dr. Taranjit Kaur, Matthew Lutz, Dr. Jatinder Singh, and Nathan King and is used under fair-use guidelines. Every effort has been made to insure appropriate documentation. Official citation, below, can also be found in the references section of this document.

Kaur, Taranjit, Matthew Lutz, Jatinder Singh, and Nathan King. "PLUG: An Inter-disciplinary Faculty-Student Collaboration at Virginia Tech." Poster presented at the Virginia Tech Deans Forum on the Environment, Blacksburg, Virginia, February 2007.

DEPLOYABLE INFRASTRUCTURE IN SUPPORT OF SCIENCE AND EDUCATION

P.L.U.G Portable Laboratory on Uncommon Grounds*

Note: The written description of the PLUG project has been removed from the electronic submission of this document. For further documentation please contact the author or reference previously published text.



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Three distinct programmatic functions

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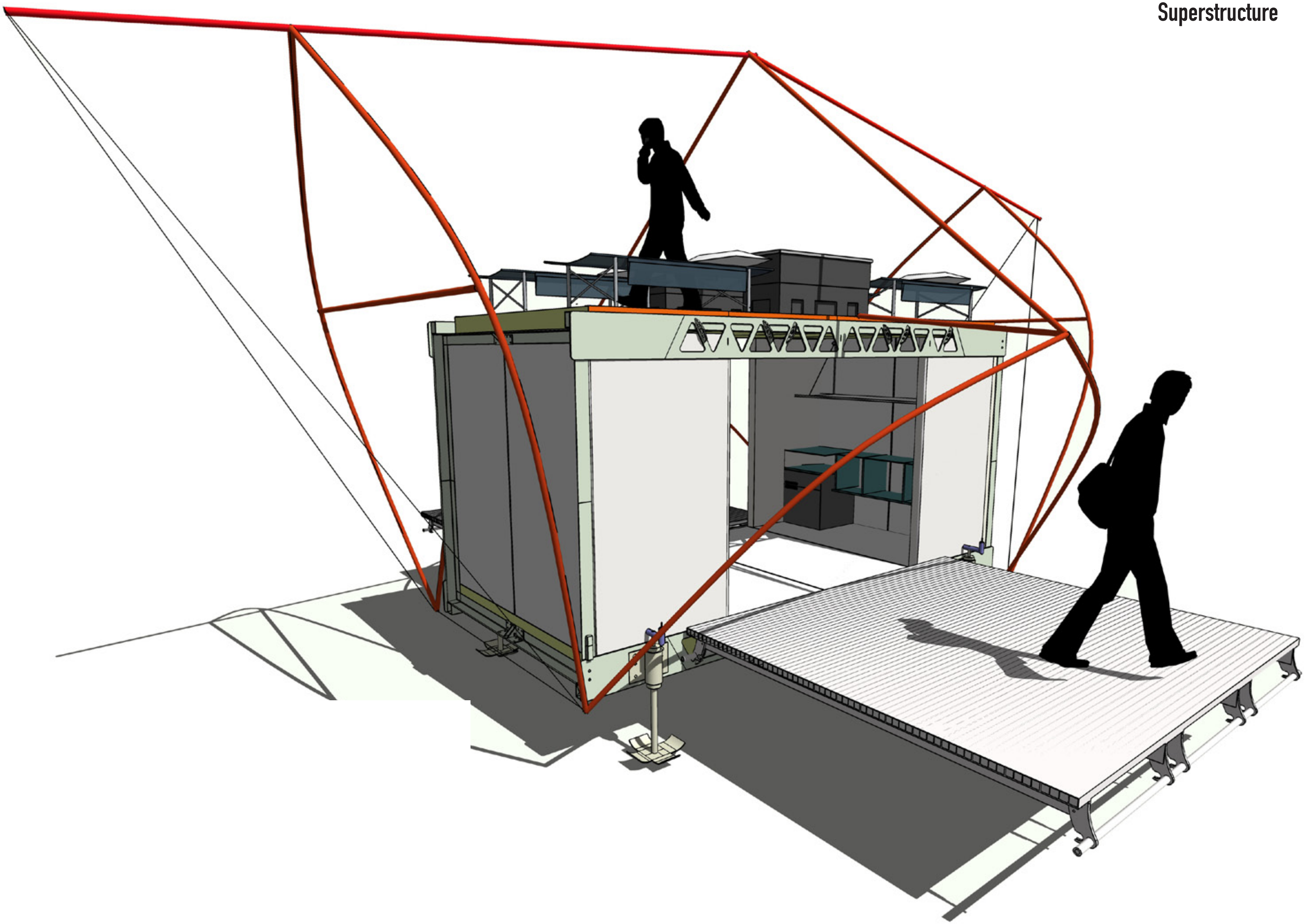

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(WITH PERMISSION)

FIGURE 9. RENDERING OF PLUG LAB
COURTESY OF MATT LUTZ AND THE PLUG TEAM.
(WITH PERMISSION.)

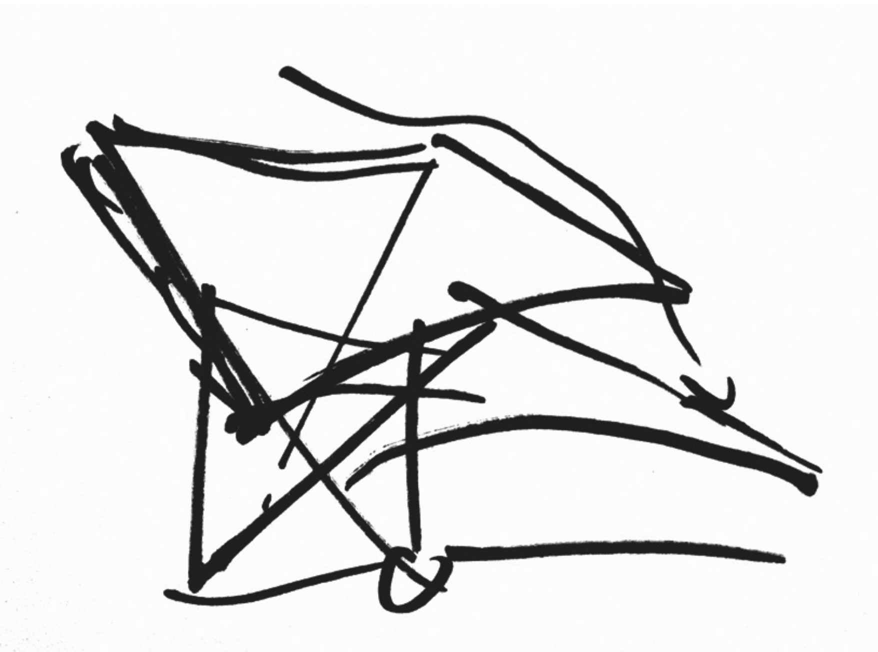
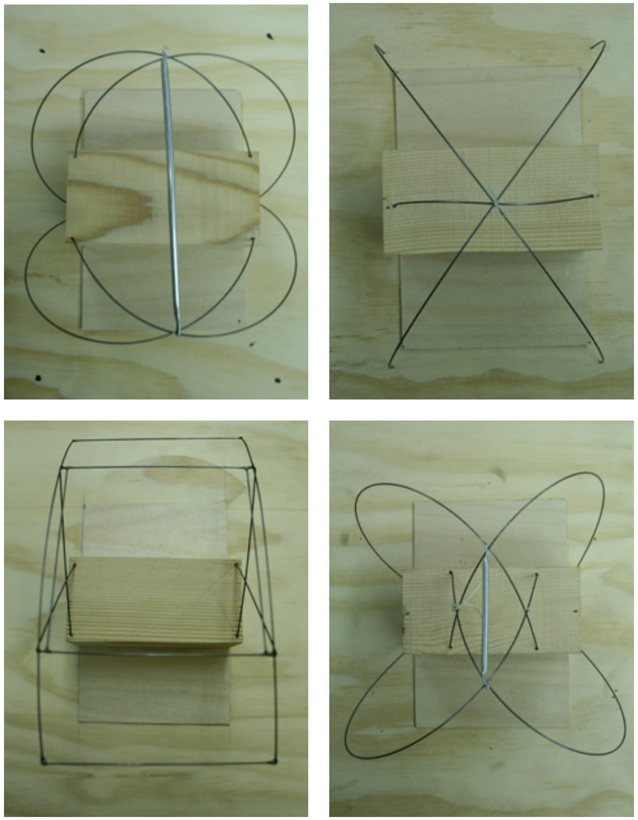


FIGURE 10. CONCEPTUAL SKETCH OF PLUG LAB. CREATED BY THE AUTHOR.

PLUG L-SERIES VERSION 1.0

Design and Deployment

The following series of images are intended to provide a snapshot of the extensive design and testing process as well as begin to introduce the story of PLUG's deployment in the Mahale Mountains in western Tanzania. Both accounts are better, and often, told at the Three Penny Taproom or over a campfire and the author welcomes this opportunity to share our story. Additional documentation regarding the development and deployment can be found in the forthcoming book surrounding the project which will be available from the author or by way of the School of Architecture + Design Library.



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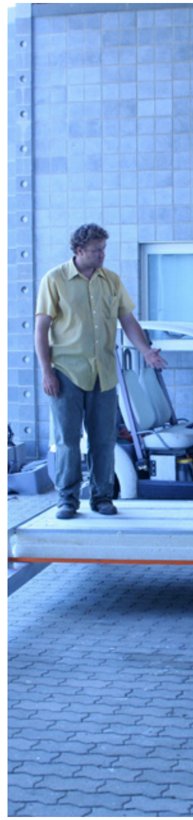

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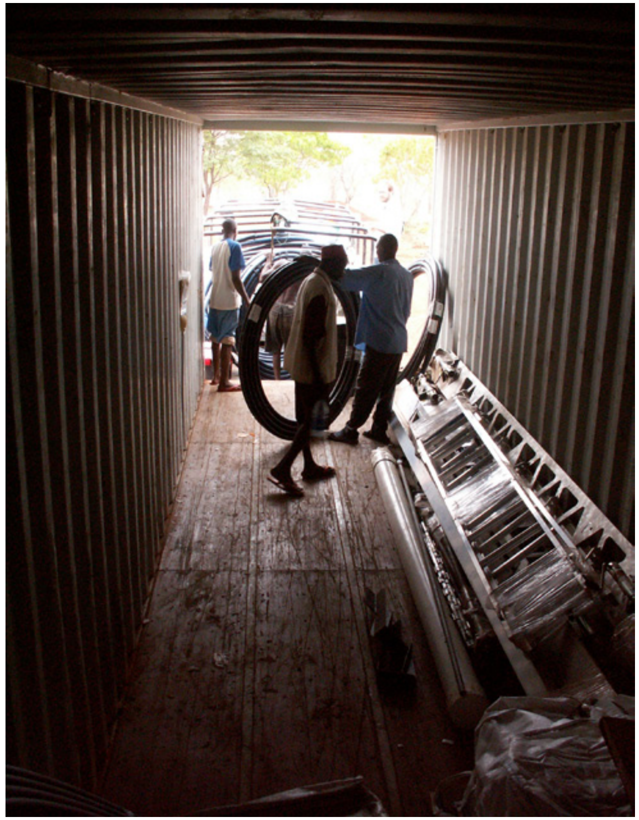

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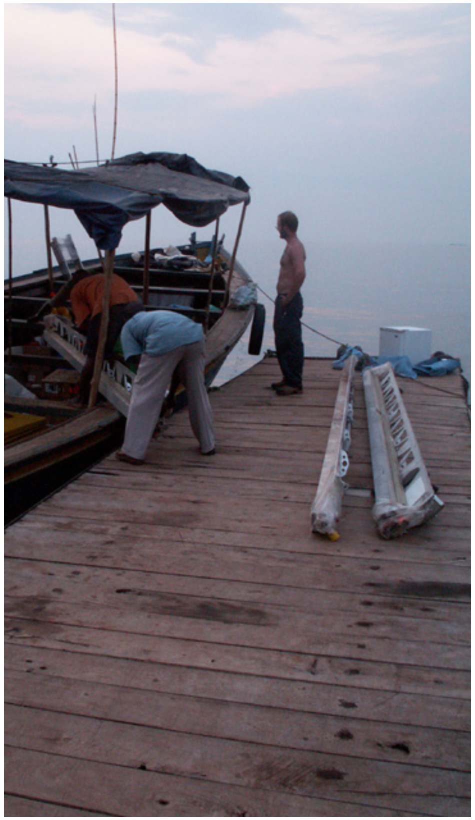

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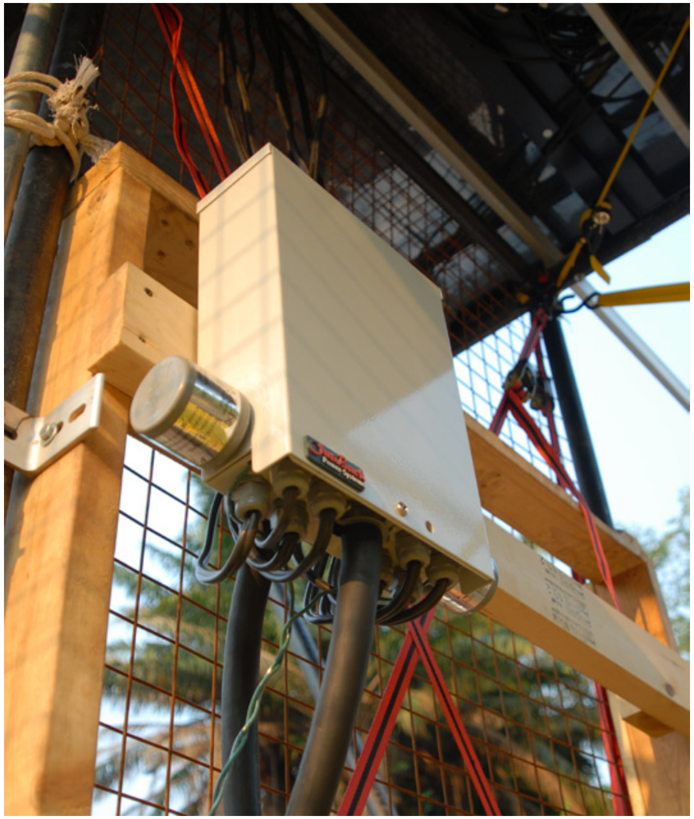

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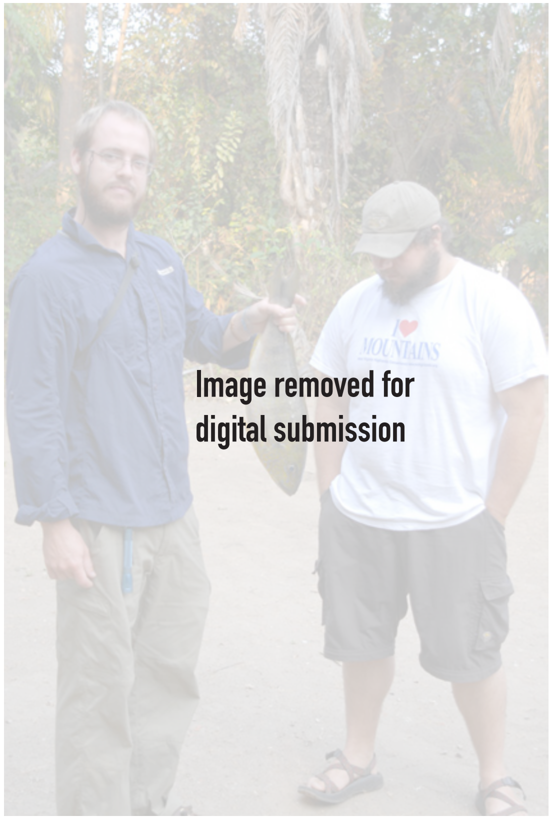

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Kaur, Taranjit, Matthew Lutz, Jatinder Singh, and Nathan King. "PLUG: An Inter-disciplinary Faculty-Student Collaboration at Virginia Tech." Poster presented at the Virginia Tech Deans Forum on the Environment, Blacksburg, Virginia, February 2007.