

INVESTIGATOR'S SUMMARY¹

Nomination 2007-03

Investigator: Mike Mutscheller

UNIVERSITY OF PHOENIX STADIUM

The Innovation

The innovation in the University of Phoenix Stadium is its use as a multifunctional facility. While multifunctional facilities are not a new concept, it is in a series of several innovations inside of the project that make the entire stadium innovative.

The series of innovations can be grouped into three points of interest: a rolling grass field, a new mechanization system for the retractable roof, and several Architectural features considering the local landscape and the spatial relationships. All of these points are combined allowing for one building to take the place of many, thus saving communities valuable dollars and space.

First, the stadium incorporates the first US application of a rolling natural grass field that extends outside of the stadium. This allows the stadium to be used for other functions such as a concert hall, convention center, etc. and aides in the growth of the natural grass as it can receive the sun's light while outside the stadium. The 9,500 ton field rides on 13 parallel rails on (542) 15 inch wheels of which 76 are individually powered by electric motors.

Second, the retractable roof utilizes a cable drum drive roof mechanization system. The (32) 7.5 horsepower motors power (2) bi-parting roof panels. This is the first application system "having the drums riding along with the roof so that the cables are in effect laid down as the roof opens, avoiding any dragging of cables as the roof opens." In addition, the project boasts the largest and heaviest combined roof lift for stadium construction at 11,200,000 pounds lifted into place. The roof operating system includes a state of the art computer graphic diagnostic display to continually monitor the open/close procedure ensuring safety of the operator and those workers in the stadium.

Finally, the Architecture of the stadium was designed in a way to utilize the surrounding landscape. "It is the first stadium to traverse an inclined path from the open to closing." Moreover, the exterior shape was designed for both form and function by evoking the image of a barrel cactus, and realizing the possibility for multiple events from the NFL and World Soccer to trade shows and graduations.

¹ November 9, 1999

Application of the Innovation

The innovation is a project itself. The application of the retractable roof is used by giving the feeling of being outdoors watching a football or soccer game, but avoiding the extreme heat of the Arizona climate. The application of the retractable field is used to provide ultimate functionality of the stadium to other venues, such as concerts or expos.

The retractable field is the first of its kind in North America and moves faster than the three counterparts in Europe and Asia. The retractable roof is the first to operate on a slope. The latest motor control technology uses 480 horsepower to travel up the arced rails and then stores the energy to move the panels back down the slope.

Background of the Innovation

The exterior design and layout team of the stadium was a combined effort between Peter Eisenman, Eisenman Architects, and HOK Sport + Venue + Event. They came up with the idea for the stadium to resemble a common cactus that is found in Arizona, the barrel cactus.

The design and build team of the stadium consisted of a joint effort between the steel fabricator, David A. Schuff of Schuff Steel Company, the structural engineer, Larry Griffis of Walter P. Moore Engineers, and the mechanization engineer, Bart Riberich of Uni-Systems Inc.

The retractable roof consists of two arced Brunel trusses, one on the east side and west side of the stadium. The 2 translucent, retractable, fabric panels are supported by 8 transporters/carriers that move along steel rails to the open or closed positions. The cable drums used spool and unspool the cables that are anchored to the Brunel trusses. Using state-of-the-art VFD/PLC technology for the control system, the cable drums are continuously synchronized to ensure the drums equally share the weight of the roof and stay on track. This eliminates the task of re-tensioning cables or re-squaring the roof on the track.

To ensure the roof will operate safely and reliably, the system was designed with built-in redundancies and automatic self-testing. The roof can be stopped using only 28 of the 64 brakes. In the event the roof has a motor or brake failure, the roof will not move due to each of the 64 brakes being automatically tested each time roof movement is started. Extensive prototype testing was done on the cable drum drives' at 115% of the expected operating loads to ensure their ability to be synchronized and ability to stop the roof movement within 180 milliseconds if an error should occur. Prototype testing was also done on the lateral release mechanism over a 6 month period using design storm loads equally 260,000 pounds and testing was done on the rail clamps and uplift clips to ensure the stability of the roof in severe weather conditions.

The retractable field structure includes irrigation and drainage systems to ensure the best conditions of a natural grass playing field. When the field is not being used for football

or soccer games, it is stored outside to receive natural sunlight. The rails that the retractable field drives along are embedded in the concrete and virtually flush with the floor surface. When the field is stored outdoors, Kerf covers are used over the rails to ensure a safe area for other events inside the stadium. The mechanization system of the field includes 76 drive wheels, 42 guide or center row idler wheels, 360 guide rollers, and 424 idler wheels that ride along 13 rails. Extensive testing of the mechanization components were done, over a six month period, using a 100,000 pound, three wheeled test frame that traveled back and forth over a pair of rails to ensure durability of the design. Several prototypes were tested over a one and a half year time frame to achieve an acceptable vibration performance level of the field.

Responsibility for the Innovation

The people primarily responsible for the development of the innovation are:

David A. Schuff, Schuff Steel Company Chairman of the Board developed the roof lift that the whole project evolved around. He conceived the roof lift a year before he actually won the design-build contract with Walter P. Moore and Uni-Systems.

Larry Griffis, P.E., Walter P. Moore Engineers President developed the structural engineering of the project.

Bart Riberich, S.E., Uni-Systems, LLC President developed the field design and mechanization process of the project.

HOK Sport + Venue + Event and Eisenman Architects were the architectural firms for the project.

Hunt Construction Group was the Construction Manager on the project.

All the above individuals and companies should be recognized as being supportive in the implementation of this successful project.

Opinions of Persons Contacted

The responses from Larry Griffis of Walter P. Moore were extremely helpful in understanding the University of Phoenix Stadium innovation. He provided an abundance of articles and information on how the innovation was designed and how it operates.

The overview of the technology used for the University of Phoenix retractable roof and retractable field that Bart Riberich provided were of great help in the understanding of the project also.

Both gentlemen provided timely material to work from in order to gain a knowledgeable understanding of this innovation and compile this report.

Investigator's Comments

During this investigation we found all the contacts to be enthusiastic and cooperative. The jury should consider the stadium as innovative by considering all of its parts. A multifunctional facility is not a new idea, but in this case it is how they became multifunctional that is the innovation. All parties that we contacted were pleased to be a part of this project and truly believe this to be an innovative stadium.

SELECTED INTERVIEW SUMMARIES

Larry Griffis

President – Structures Division
Walter P. Moore and Associates, Inc.
221 W. 6th Street, Ste. 800
Austin, TX 78701
Responses to letter by Mike Mutscheller, July 2, 2007

Pertinent comments by the contact were:

“This unique stadium incorporates several innovative approaches into the architectural, structural and mechanization design of a stadium.”

“The playing field is the first US application of a rolling natural grass field that moves in and out of the stadium to allow outdoor growing of the grass while providing convention center space on the underlying concrete floor.”

“The project incorporates the most technically advanced mechanization system yet utilized on a retractable roof stadium.” “It represents the first US roof moving on an inclined slope (up to 14 degrees).”

Bart Riberich

President
Uni-Systems, LLC
4600 Lake Road
Minneapolis, MN 55422
Responses to letter by Mike Mutscheller, July 30, 2007

Pertinent comments by the contact were:

“It uses the very latest motor control technology which allows it to effectively balance the loads of the eight cables that hold the position of each of the two operable roof panels on their sloped tracks. The operable roof panels use 480 horsepower to travel up the arced rails and then use their stored energy to generate power and put it back onto the power grid when they are moved down the slope.”

“The retractable field is the first of its kind in North America and one of only a few in the world. Its light weight steel frame and its steel wheels riding on steel rails make this field much lighter and faster than its three counterparts in Europe and Asia.”

SUPPORTING EXHIBITS

- 1. Photo samples of the retractable roof and retractable field.**
- 2. Drawing of the retractable roof mechanization elements.**
- 3. Drawings of the retractable roof building sections.**
- 4. Publications on the University of Phoenix Stadium used:**

**The Construction Weekly ENR, cover story by Nadine M. Post,
March 28, 2005. Can be found on enr.com.**

Civil Engineering Magazine, Wide Open article, December 2003.

Retractable roof

SAMPLE

Roof panel

7.5hp motor

Track

OPEN SESAME It takes 64 motors 13 minutes to open or close the roof. While opening, motors feed power into the grid.

GRAHAM MURDOCH

WALTER P. MOORE ENGINEERS/UNI-SYSTEMS UNIVERSITY OF PHOENIX STADIUM

A STADIUM THAT GOES FROM INDOORS TO OUTDOORS IN A FLASH

THE NEW 63,400-SEAT, \$455-million Cardinals stadium in Glendale, Arizona, features two of the largest moving parts in sports history: the country's first completely retractable grass field

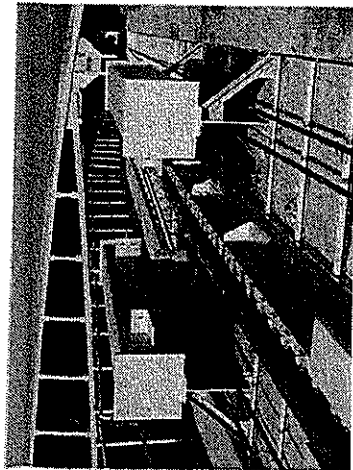
and the first inclined retractable roof. At the press of a button, the 2.2-acre field, which spends most of the year outdoors in a giant steel tray, can be wheeled in on tracks in just over an hour. And the two 550-ton

retractable panels that make up the stadium's roof pump juice back into the electrical grid as they slide open. Now, if only the long-suffering Cardinals can match the performance. azcardinals.com/stadium

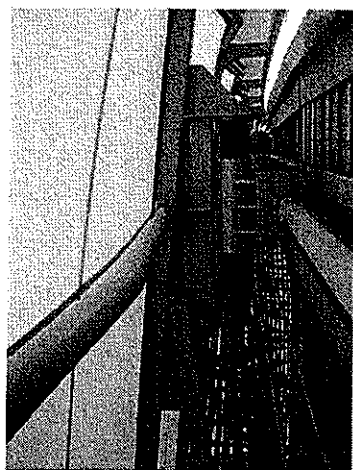


Mobile field

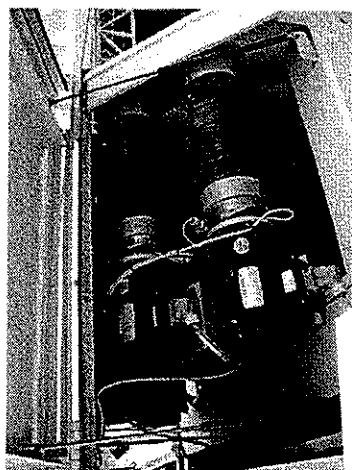
FRESH GREENS Automated tracks roll the Cardinals playing field in and out of the stadium in about an hour. [Other retractable fields can take half a day.]



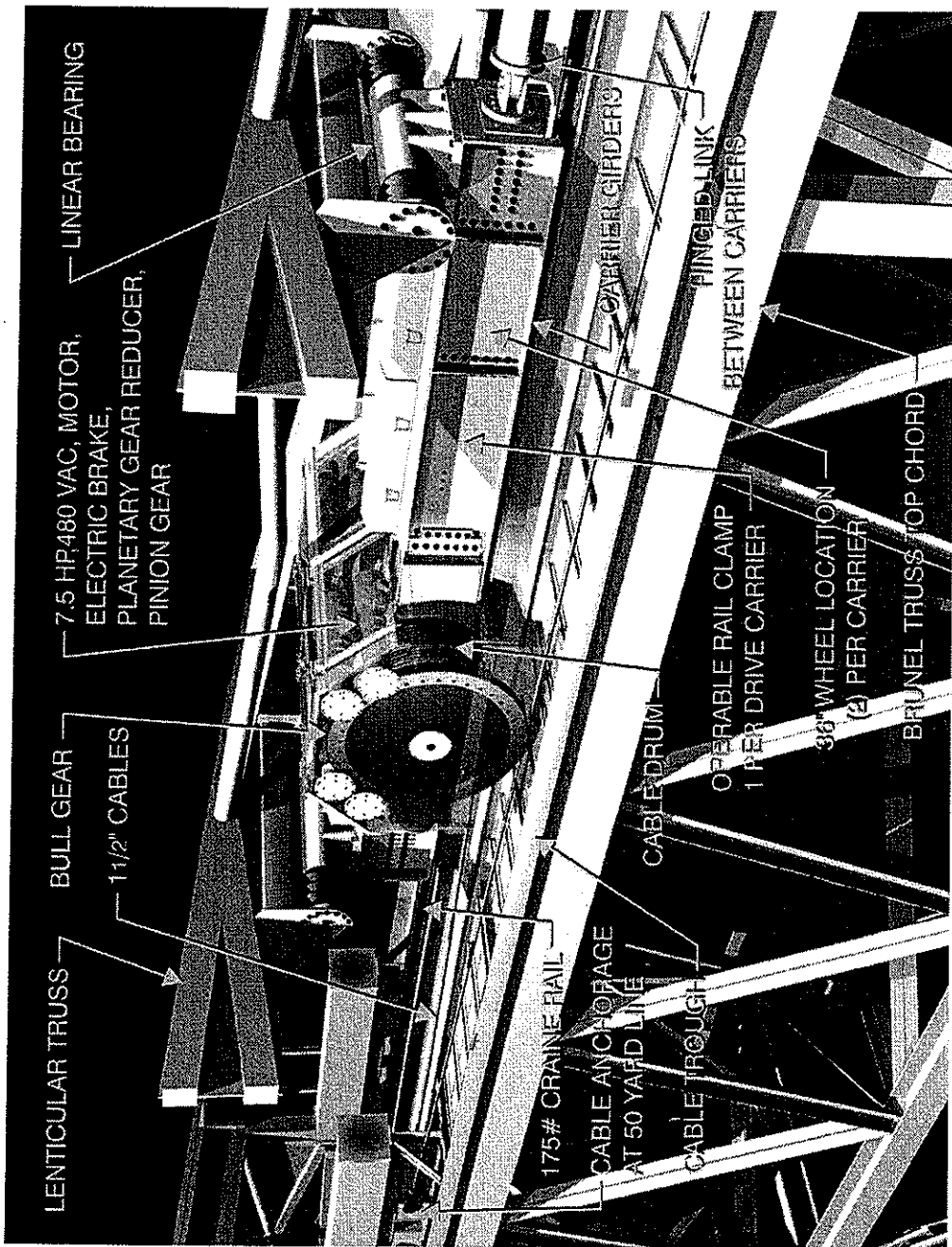
Roof Rail and Cable Anchorage



Roof Thrust Isolation
Using Linear Bearing

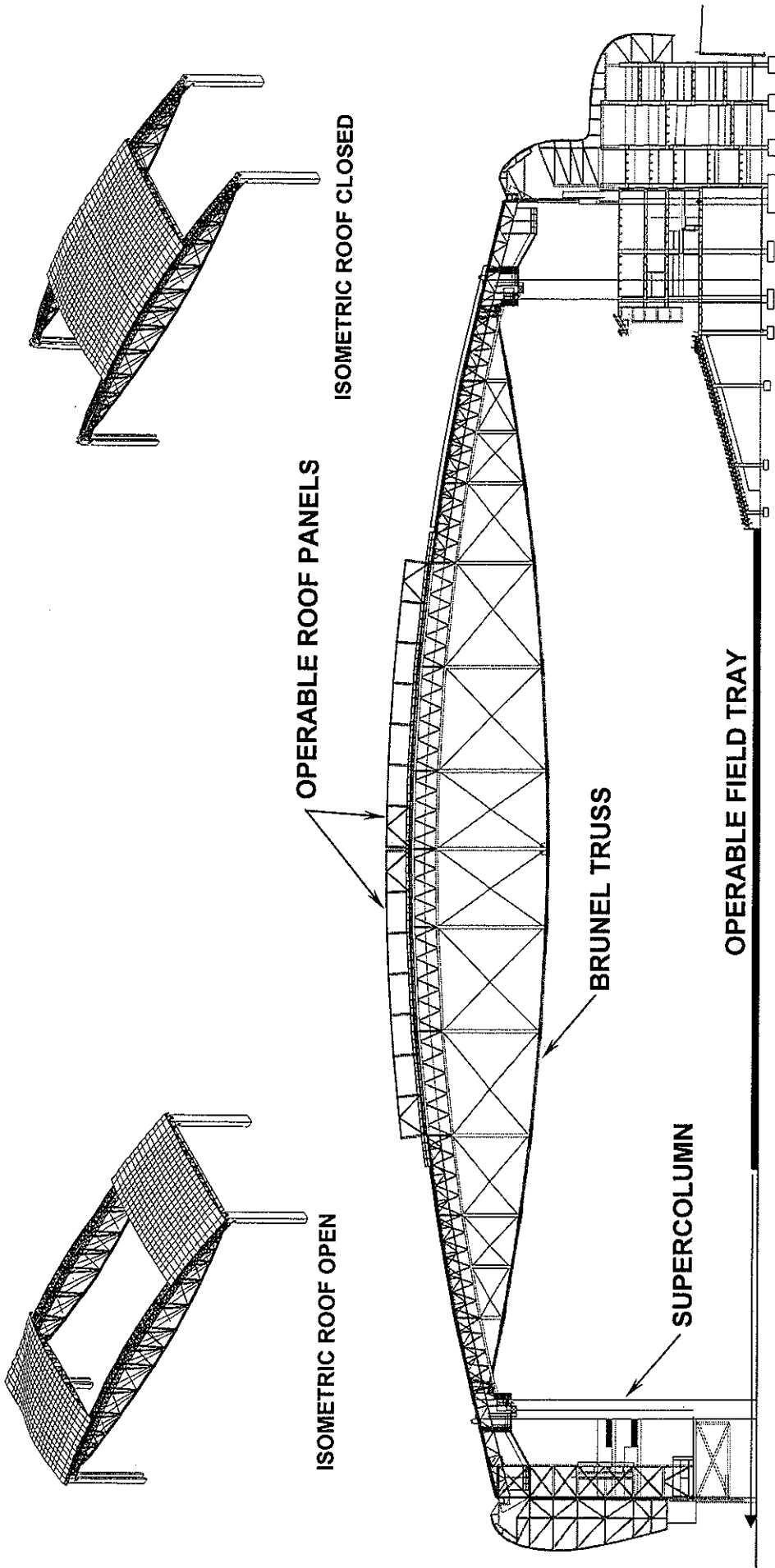


Cable Drum Drive



Roof Mechanization System

Retractable Roof Mechanization Elements



ISOMETRIC ROOF CLOSED

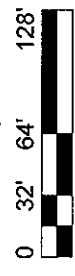
OPERABLE ROOF PANELS

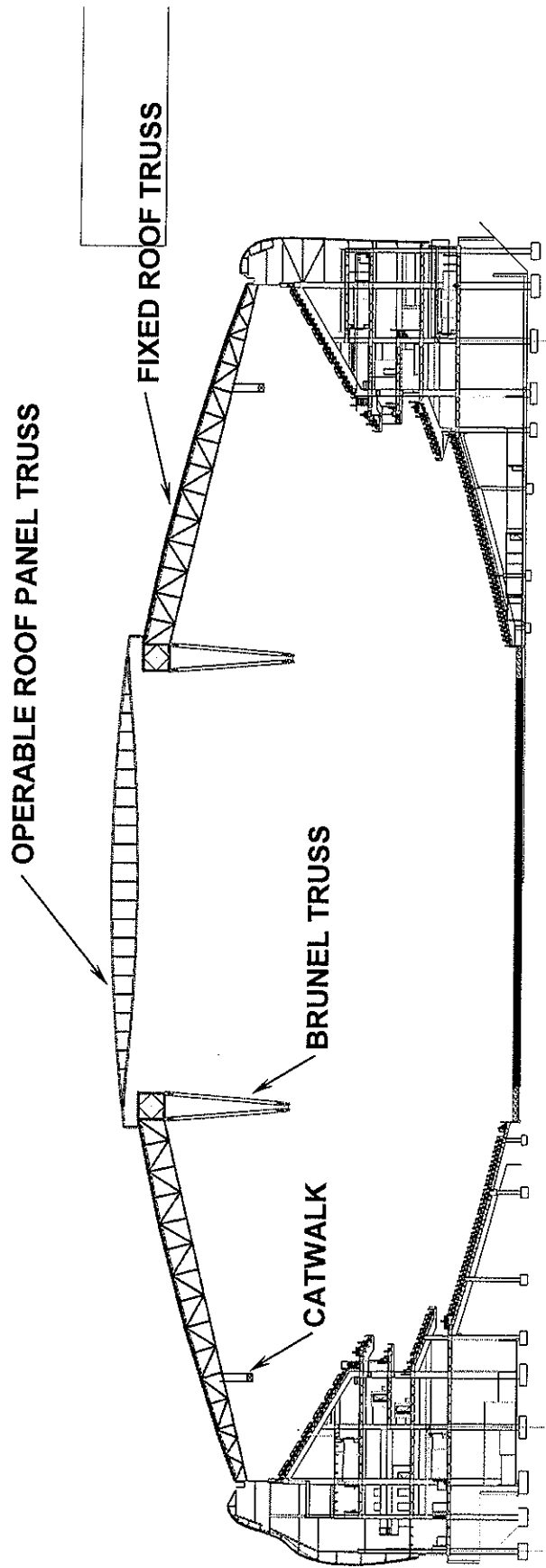
BRUNEL TRUSS

SUPERCOLUMN

OPERABLE FIELD TRAY

NORTH-SOUTH BUILDING SECTION





EAST-WEST BUILDING SECTION