

The Houston Astrodome: Eighth Wonder of the World?

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Disappointment was evident in Harris County Judge Ed Emmett's voice when he announced the defeat of Proposition 2 after the polls closed on November 5, 2013. Voters had been asked to approve \$217 million in bond funding to renovate and repurpose the Houston Astrodome. Approval of the bond issue would have saved the Dome from demolition. With 53% "against," the future remained precarious for the facility once promoted as the "The Eighth Wonder of the World." Emmett thought he and his staff plus dozens of experts and independent consultants had done a thorough job with the renovation plan. "We looked at every possibility and this was the only plan that made any sense for repurposing and keeping the Dome," Emmett told the group at Reliant Center. (Crocker, 2013)

The defeat of the bond proposal caused conflicting thoughts for Emmett. He could take the easy way out and point to the bond defeat as the reason why he would no longer pursue options for saving the Astrodome. He knew his constituents wanted the Dome saved because they told him so in correspondence and in person. Emmett knew the history of the Astrodome and understood how important it had been as a symbol of the "can-do" attitude and work ethic of area residents. He felt the voters had not really chosen to demolish the Dome; instead, they had voted against any tax increases. Developing a new plan for the Astrodome would require more of Emmett's time, which was time away from many major health and welfare initiatives undertaken by his administration. In some ways, saving the Astrodome seemed to pale in comparison to projects such as flood control that could prevent residents from losing their homes and their lives during the next hurricane. He also remembered discussions from budget hearings earlier in the year when several County Commissioners expressed concerns over the backlog of citizens needing healthcare from the Harris County Hospital District. Yet, he thought the Astrodome could become an attraction for tourists and area residents and that could, in turn, result in jobs and enhance the area's economy. As the first-of-its-kind, domed sports facility, maybe that alone made it worth saving.

Emmett was torn. Should he give up on saving the Astrodome or should he start over and look for new alternatives? If so, at what cost to himself, to area taxpayers, and to other needs of Harris County? Emmett wanted to improve the lives of constituents in both the short- and long-run. And, on a personal level, he certainly did not want his legacy to be as the guy who demolished the "Eighth Wonder of the World."

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Astrodome History¹

Understanding why so many people banded together in an attempt to save the Astrodome requires, in part, understanding the symbolism and history of the facility. It has been an icon for architectural ingenuity as well as economic good times when the aerospace and petroleum industries flourished in the Houston area. It became a reality only because of behind-the-scenes deal-making and political wrangling as well as changes in Texas state law. It also took a rags-to-riches maverick with vision, money and a friendship with a U.S. president.

The Houston Astrodome opened April 9, 1965 with Texas Governor John Connally throwing the first baseball for an exhibition game between the Houston Astros and the New York Yankees. Among the dignitaries in attendance was U.S. President Lyndon B. Johnson. An injured Mickey Mantle was first in the Yankees' line-up and he hit the first-ever home run in the Astrodome. Even with Mickey Mantle in the game for the Yankees, the Astros won the game with a score of 2 to 1 in the 12th inning. More than 47,000 spectators were on-hand to witness the win in the first-of-its-kind, air-conditioned sports facility with a dome that spanned more than 600 feet. Behind the success of opening day was nearly 10 years of planning, political maneuvering, and controversy.²

1950s History of Houston Baseball

Houston can point to 1957 as the beginning for their professional sports teams. In that year, George Kirksey, a former UPI sportswriter, partnered with Craig Cullinan to form the Houston Sports Association (HSA) with the stated purpose of bringing major league baseball to town. Cullinan, a grandson of the founder of what became Texaco, had significant contacts with potential investors. The two men were tireless in their efforts to convince national baseball team owners to allow a team in Houston.

At that time, major league baseball was not played any farther south than Kansas City. In Houston, there was not much interest in funding a baseball stadium because there was no professional team. HSA was in a Catch-22: how to get a team to Houston without a stadium and how to get a stadium without a baseball team.

Using the example of the publicly-funded stadium that enticed the Braves to move to Milwaukee (from Boston), Kirksey pressured Harris County leaders to provide public funding for a baseball stadium. “[Public funding of sports stadiums] was a relatively new phenomenon. Moreover, Texas law [in the 1950s] forbade counties from issuing revenue bonds for that purpose.” (Gast, 2014, p. 27) That obstacle was quickly overcome. With the help of one of Kirksey's former clients, Searcy Bracewell, who was a Texas state Senator a new law was enacted which authorized certain counties to issue bonds for the purpose of constructing sports stadiums. By

¹ Most of the historical facts about the Astrodome are taken from the book by James Gast, *The Astrodome: Building an American Spectacle*, Aspinwall Press, Brookline, MA, 2014.

² A wide variety of historic photographs are available from multiple sources. For example, refer to: www.ballparksbaseball.com/past/Astrodome.htm (Ballparks of Baseball, 2015)

July 1958 a referendum was placed on the ballot and Harris County voters approved \$20 million³ in bonds (\$165 million in 2015 dollars) for constructing a baseball stadium.

Even the \$20 million construction funding did not convince any national league owner to move to Houston and the league itself refused to add a new team in Houston. There had been no new baseball teams since 1901. Luckily for HSA a consortium of minor-league baseball cities (Minneapolis, Denver, Buffalo) joined together in 1959 to form the Continental League (a proposed third major league for baseball⁴) and Houston joined the group. The Continental group used their influence with U.S. Senators, including majority leader Lyndon B. Johnson of Texas, to support a bill that would have ended a 1922 antitrust exemption for major league baseball. The bill was closely defeated in the summer of 1960, but the major league owners realized they had to loosen their hold on baseball. Within a few months both the American and National baseball leagues added teams. One of the two National League's expansion teams went to Houston in 1962 and was dubbed the Colt 45s (renamed the Houston Astros in 1965).

HSA needed additional capital for the Houston franchise. R.E. "Bob" Smith (a former semi-pro baseball player) was brought into their association in 1959. When he joined HSA, Smith was the largest private landowner in Harris County. Smith insisted on adding another member to the HSA group and brought along his long-time business partner, Judge Roy Hofheinz.

Roy Hofheinz, Father of the Astrodome

Roy Hofheinz was a self-described huckster: headstrong and eccentric but visionary. If anyone should have been called the "Father of the Astrodome," it was Hofheinz. He reveled in his flamboyant image and being compared to Cecil B. DeMille and P.T. Barnum. He dubbed his Galveston Bay seaside home "Huckster House" and decorated each room with a theme such as the Gay Nineties, the South Seas, or the Circus (including a genuine circus calliope). His lavish, gaudy taste later influenced the décor of his private suite in the Astrodome.

No doubt the Hofheinz extravagance and "living large" was influenced by his deprivation as a teenager. He was born in 1912 in Beaumont, Texas (approximately 90 miles east of Houston). In 1923, when he was 11, the Hofheinz family moved to Houston and his father got a job driving a laundry truck. Only five years later, his father was hit by a car and died, leaving Roy as head of the household. He had recently graduated from high school, at the age of 16, and had earned scholarships to attend the University of Texas in Austin. Hofheinz felt he should not leave his widowed mother; so, he enrolled at Rice Institute (later Rice University).

Hofheinz earned a living for himself and his mother by promoting dance bands, working as a radio disc jockey, and peddling newspapers. College classes at Rice were offered only in the day and that conflicted with his entrepreneurial ventures. So, Hofheinz withdrew from Rice and enrolled in Houston Junior College and later in the Houston Law School. While still in school,

³ \$20 million was the first bond issue (revenue bonds) approved in 1958. A new bond issue (general obligation bonds) in the amount of \$22 million replaced the first one with voter approval in 1961. A third issue for \$9 million was approved by voters on December 22, 1962.

⁴ The Continental League formed in 1959 with the first baseball season scheduled for 1961. The league disbanded in 1960 (without playing any games) after the American and National Leagues agreed to add more teams.

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he obtained court approval to sit for the bar exam, which usually required a minimum age of 21. Hofheinz then passed the bar and established his own law practice at age 19.

The accomplishments of Hofheinz were numerous, and included:

- Elected to the Texas Legislature at age 22
- Won election as Harris County judge at age 24
- Bought oil wells and speculated in land; was a millionaire by age 37
- Elected Mayor of Houston in 1952 at the age of 40
- Censured by Houston City Council in 1955; at first he was impeached
- Desegregated City Hall, Houston city libraries, and public golf courses in the 1950s
- Joined Houston Sports Association, a syndicate formed to bring pro baseball to Houston (in 1959) at age 47.

In 1952, while he was Houston mayor, Hofheinz ended segregation of almost all city-owned buildings⁵ with a very simple approach. He ordered city workers to remove all the “Whites Only” signs. His actions in support of desegregation in the early 1950s helped more than ten years later when Hofheinz needed votes from the African-American community to gain voter approval of public financing of the Astrodome.

The vision for the Astrodome as a domed structure came from Hofheinz. It was his hands-on supervision, as well as a significant amount of politicking, that assured his vision became a reality. Hofheinz’ own identity was inextricably linked to the Astrodome. During construction he incorporated living quarters for himself and his wife. The space included a conference room, a putting green, a shooting gallery, a puppet theatre, a bowling alley, barber and beauty shops, and a Presidential suite for his friend, Lyndon B. Johnson. The five-story space also incorporated a private terrace from which Hofheinz and his associates viewed the playing field.

Within one year after the Astrodome opened, Hofheinz was the only remaining member of the original group of four who formed the Houston Sports Association to bring major league baseball to Houston. He had pushed some members out of the group while others had stepped aside. Roy Hofheinz remained, alone as both the “father” and some might have said “ruler” of the Astrodome.⁶

Understanding ownership of the Astrodome requires understanding the administrative structure and legal authority of Texas counties’ revenue generation. In Texas county business is conducted by a Commissioners Court with the County Judge serving as the chief executive officer. Specific authority must be obtained from the Texas State Legislature (*i.e.*, passage of a law) for counties to establish regulations. (Harris County, 2014, p. 7) Under the Texas Constitution counties are required to operate on a cash basis and may generate cash flow from long-term debt only through the sale of bonds. Voters must approve bond issues via a referendum and state law sets a

⁵ This action was three years before Rosa Parks refused to give up her seat on a city bus in December of 1955 in Montgomery, Alabama.

⁶ Photographs of Judge Roy Hofheinz, Astrodome construction and the surrounding complex can be found at <http://www.highwayhost.org/Texas/Houston/Astrodomain/astrodomain1.html> (Astrodomain)

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maximum amount of bond debt a county may have. (Harris County, 2014, p. 8) Harris County’s primary source of revenue has been a general property tax (*aka*, ad valorem tax); secondary sources include fees, fines, and investment earnings. Bond proceeds provide cash for construction of capital projects such as libraries, parks, and flood control.

Harris County came to be owner of the Astrodome because Hofheinz and other members of the HSA convinced county commissioners that *public* funding was needed to build a sports facility to attract national league baseball to Houston. It was unusual in the 1950s to have public funding of a facility for the use of private investors, i.e., owners of the sports team. In Texas, such financing was illegal. The Houston sports facility was described as a *public works project* and the county’s ability to have taxpayer funding required passage of a law in 1957 by the Fifty-fifth Texas Legislature (Legislative Reference Library of Texas, n.d.). Interestingly, the new state law allowed only certain counties to engage in such funding and those included Harris County.

The law authorized establishment of the Harris County Park Commission (HCPC), a non-profit corporation. This law enabled Harris County commissioners to submit a revenue bond issue to the voters to fund design and construction of a sports facility in Houston. The original \$20 million bond issue was for “revenue” bonds that committed the various revenue streams (lease, concessions, etc.) from the facility to repay the principal and interest.

By the summer of 1960, Hofheinz had decided the new stadium should be built with a domed roof, air conditioning and real grass – all of which added to the construction cost estimates. Hofheinz also determined there would be significant savings if the bonds were changed to “general obligation bonds.” He persuaded Harris County officials to go back to the voters with a referendum for a new bond issue (that replaced the 1958 bonds). As described on the face of the 1961 bonds they were: “For the prompt payment of this bond at maturity and the interest hereon as it becomes due, the full faith credit and resources of Harris County, Texas, are hereby irrevocably pledged. When the voters approved the 1961 bond issue, they were agreeing to an increase in their property taxes. An additional \$9 million bond issue was required due to higher-than-expected costs. The three bond issues for the original construction are shown in **Table 1**.

Date of referendum	Amount and type of referendum
July 26, 1958	\$20 million bond referendum approved by Harris County voters (with a margin of 3 to 1). These were “revenue” bonds secured by revenue generated from Astrodome operations.
Jan. 31, 1961	Another bond referendum was proposed (and approved by voters) that changed the Astrodome bonds to be “general obligation bonds,” secured by tax revenues. This bond issue was for \$22 million and replaced the original \$20 million issue from 1958.
Dec. 22, 1962	\$ 9 million bond referendum approved after excavation work was done. This issue was needed because of the higher cost of building a dome.

Table 1: Original Bonds Issued by the HCPC to Build the Astrodome

Source: compiled by authors

The success of the 1961 bond vote was due, in large part, to voters in the African-American community. Hofheinz requested help from black community leader, Quentin Mease, who agreed to support the bond initiative in exchange for Hofheinz assuring that the new facility would be integrated. In spite of voter approval, opponents of the sports facility filed a lawsuit challenging the bond issue. Ned Gill, a printing executive in Houston, filed a suit in which he alleged Harris County did not have either the constitutional or statutory authority to commit future tax revenues in support of the general obligation bonds.⁷ Because of the legal wrangling, the project was delayed for three months.⁸ The HCPC prevailed and construction began, but the opening date for the new stadium was postponed from 1962 to 1963.

Ultimately, the cost of the structure itself was closer to \$20 million with a total cost of the project that exceeded \$40 million, financed from multiple sources:

- \$31.6 million from two county bond issues (\$22 million general obligation bonds approved by Harris County voters January 31, 1961 plus another bond issue for \$9 million approved by voters on December 22, 1962 (after excavation was completed).
- \$ 3.75 million from Texas Highway Department and Houston for streets, bridges, etc.
- \$ 6.0 million from the Houston Sports Association for apartments, restaurants, cushioned theatre-style seats, and a scoreboard which cost \$2 million. (Texas State Historical Association, 2010)

The Houston Sports Association (HSA) signed a 40-year lease and agreed to pay Harris County \$750,000 per year. (Leahy, 2013). See Error! Reference source not found. in Appendix A lists several non-profit and governmental entities, some of which were formed to facilitate construction of the Astrodome and others that, ultimately, contributed to its demise.

Designing and Building a Dome

By the summer of 1960 Hofheinz was personally overseeing design and construction of the Harris County Domed Stadium. Because of his concerns about heat, humidity, and mosquitoes, Hofheinz decided the new stadium should be covered and air-conditioned with a field of *real* grass. He was told by east coast architect Buckminster (Bucky) Fuller that a domed stadium could be built to hold 65,000 people.

The Harris County Board of Park Commissioners had already hired the Houston architectural firm of Wilson, Morris, Crain and Anderson to design the new sports facility. Hofheinz let the

⁷ Houston Area Digital Archives, <http://digital.houstonlibrary.org/cdm/ref/collection/archival/id/1976> Originally reported in the *Houston Post*, 02/03/1961.

⁸ In addition to the legal wrangling, Hofheinz spent some time in the summer and fall of 1961 chasing federal dollars for some of the financing for the Astrodome. Based on a July 25, 1961 speech by President John Kennedy about the Cold War threat of the Soviet Union, Hofheinz thought the Department of Defense (DOD) might pay to have a portion of the Astrodome constructed as a fallout shelter. The DOD wanted \$2-\$8 million in construction changes in exchange for \$750,000 in funding. Hofheinz scuttled that plan.

architects know if they did not design a domed stadium, he would hire Bucky Fuller to do it. Wilson/Morris committed to designing the dome.⁹ Design challenges included:

- 642 feet spans without supporting columns across the diameter of the facility
- 4,596 skylights incorporated in the roof to provide sunlight for two acres of real grass
- Adequate acoustics inside the facility with more than 50% of the roof in skylights

Even after experts at the Texas A&M University Extension Station spent two years to research and identify grass that might grow inside the Dome, Hofheinz' plan for real grass failed. By the time the Astrodome opened, most of the grass was dead and had to be covered with green paint for most of the first season. Ultimately, it was replaced with artificial turf which became known as Astroturf. The grass died largely because of a lack of sunlight after Hofheinz ordered the 4,956 skylights covered with off-white acrylic paint.

The skylights had to be painted because too much glare blinded outfielders and they could not see baseballs when they looked skyward. After Hofheinz ordered all the skylights painted, the lack of sunlight doomed the natural grass.

A Legacy of Firsts and More

In addition to being the first domed multi-use sports stadium, the Astrodome created a legacy of "firsts," in large part, due to the vision and showmanship of Roy Hofheinz. Among those were:

- first major league baseball game held indoors (opening night, 4/9/1965)
- first air-conditioned professional sports facility (opening night at 67°)
- first scoreboard which incorporated a television display (30 x 35 feet)
- first luxury suites for professional sports; became known as "skyboxes"
- first major sports facility to feature artificial turf (*aka*, Astroturf)

The first homerun in the Astrodome was hit by Mickey Mantle of the Yankees during an exhibition game on April 1, 1965. The facility was also the site of the first college basketball game televised during prime time (1968) with the University of Houston beating UCLA.

It is historically significant that the Astrodome seating, dining facilities and restrooms were fully integrated when it opened in 1965. This came from the deal Hofheinz struck with black community leaders to get voter support for the bond issue to construct the Astrodome. Integration of the Astrodome complemented the full (and peaceful) integration of Houston's hotels. This was due, in part, to pressure from the Houston Sports Authority to ensure that African-Americans on visiting athletic teams were allowed to lodge in the same hotels as their teammates. (Gast, 2014, p. 126)

⁹ Refer to the Appendix B for a detailed description of how the domed roof was designed and related engineering challenges.

Making the Numbers

Major league baseball was not enough to make the Astrodome financially viable. Tickets for Astros games sold for \$1.50 to nearly \$5 per seat. The opening day crowd totaled 47,879 but not all were paying customers. The baseball season consisted of 81 games, but attendance levels varied. The approximate payroll costs of the Astros baseball team was less than \$5,000,000.¹⁰

HSA had exclusive rights to sublet the Astrodome and Hofheinz negotiated agreements with the Houston Oilers and the University of Houston. That revenue was inadequate to cover all of HSA's costs. In addition to the \$750,000 annual lease payments to Harris County, HSA incurred \$2,000,000 per year in maintenance and upkeep costs. HSA needed at least 125-150 non-baseball events every year in order to achieve break-even. (Gast, 2014, p. 146)

Hofheinz pursued conventions, trade shows, concerts, and other attractions to make the Astrodome financially viable. In 1965, a one-day preview of the annual Houston Boat Show was held there, complete with live country music and a Miss Mermaid contest. Hofheinz never lacked for ideas to bring people to the Dome.

In 1972 and 1973, the Houston Jazz Festival featured dozens of jazz greats that included Ike and Tina Turner, B.B. King, Roberta Flack, and Dizzy Gillespie. In subsequent years performances were held there by the Rolling Stones (1981), Michael Jackson (1984) and Madonna (1987). In 1992, the Republican National Convention was held in the Astrodome.

One of the most universally appealing and successful at attracting large crowds to the Astrodome (and the adjacent Astrohalls) was the annual Houston Livestock Show and Rodeo (sometimes described as being equivalent to the New Orleans Mardi Gras). Held over a 20-day time period, the Livestock Show incorporated traditional rodeo events as well as livestock exhibitions and auctions plus popular musical stars. In 1982, general attendance was 1,095,155 and rodeo attendance was 646,735; both figures were only headcounts (*not necessarily paid*). The Livestock Show and Rodeo was held at the Astrodome facilities from 1966 through 2002. During the last year there, general attendance was 1,563,662 and paid rodeo attendance was 1,091,955.

Demise of the Astrodome

Several events came together to commence the demise of the Astrodome and to put the facility at the center of a controversy as to its fate. In 1996, a special sports task force issued a report that recommended Houston and Harris County build a new baseball stadium, a new downtown arena for basketball, and renovate the Astrodome for football and the rodeo. The price tag for all elements of their recommendation was \$628,000,000. The report suggested the source of revenue to pay for the expenditures could be sales tax plus new taxes on cigarettes and mixed beverages. The owner of the new facilities would be an entity named the Harris County-Houston Sports Authority (HCHSA). This entity was created in 1997 with an agreement among Houston, Harris County and the Houston Astros Baseball Club. See Appendix A.

¹⁰ The earliest estimates available are for 1985 with payroll of nearly \$10 million which climbed to \$55 million in 1999 (when the Astros left the Dome).

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The Astros baseball team began making plans to move out of the Astrodome and into the soon-to-be-constructed Minute Maid Park. Cost of the new baseball park and use of public funding for construction later contributed to taxpayers' reluctance to provide any new financing to renovate the Astrodome. Cost and financing information fir Minute Maid Park are: (Ballparks.com, 2015)

- Owner: HCHSA (original 23-member board appointed by Harris County Judge in 1966)
- Cost: \$250 million
- Public Financing: \$180 million (68%) from a 2% hotel tax and 5% rental car tax
- Private Financing: \$52 million (20%) from Astros owners
- Lease: 30 years (2000-2029); \$7.1 million per year (\$4.6 million rent and \$2.5 million for a capital improvement fund).

Construction of Minute Maid Park as the new home for the Astros was funded with municipal bonds with revenue sources from a hotel tax and rental car tax. Even though Harris county taxpayers' property taxes were not involved, the high cost and use of the phrase "public funds" could have easily confused residents into thinking they were paying for the Astros' new park.

Houston Oilers

Just as the Astros were making plans to leave the Astrodome, the same was occurring with the Houston Oilers. From 1968 through 1997, the long-term home for the Oilers was the Astrodome. From the mid-1970s through the mid-1980s, Bud Adams as owner of the Oilers, complained about the lack of seating and threatened to move his team away from Houston. To appease Adams and keep the Oilers in Houston, in 1987 the Astrodome was renovated at a cost of \$67 million. The renovation was financed with two bond issues. The project involved adding more than 10,000 seats, but also involved removing the two-acre sized scoreboard and demolishing what had been Hofheinz' opulent personal suite (replaced with 72 luxury boxes). These changes kept Adams appeased, but only for ten more years. In 1997 the Oilers played their last game in the Astrodome and the team was moved to Tennessee (becoming the Tennessee Titans). Financial difficulties forced Hoffheinz out of the Houston Sports Authority and his position of power over the Astrodome in 1976. He died at age 70 in 1982.

Houston Livestock Show and Rodeo

After departure of the Astros (1999) and the Oilers (1997), the Houston Livestock Show and Rodeo remained the lone "big attraction." Rodeo officials looked to the future and construction of the new NRG Stadium next door which was being built for Houston's new NFL franchise, the Houston Texans. They determined that 2002 would be their last year in the Astrodome.

After departure of the Rodeo, the Astrodome had no major tenants or sources of revenue. A summary of the major occupants and dates of occupancy is presented below.

Major Tenants	Years of Occupancy
Houston Astros (major league baseball)	1965 opening of Astrodome to 1999
Houston Oilers (NFL football)	1968 to 1997
Houston Livestock Show & Rodeo	1966 to 2002

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The last game of the Houston Astros in the Astrodome was a bittersweet event for many fans. The team clinched its third straight National League Central Championship in its last regular-season game and its last ever game ever in the Astrodome.¹¹

Fire Code Violations

After departure of the Livestock Show and Rodeo, the Astrodome continued to provide office space for 36 employees of SMG, a firm that managed all of Reliant Park (the Astrodome, the new football stadium next door, and Astrohall). In mid-2008, the Houston Fire Marshal's Office issued citations to Harris County as owners of the Astrodome for nine fire code violations, with the primary concern being inadequate water pressure in the sprinkler system. Those repairs had a price tag of \$250,000 (in addition to an annual maintenance figure of \$500,000 every year). (Latson, 2008)

The sprinkler system was repaired but the following year in the spring of 2009 -- because of more fire code violations -- the Houston Livestock Show and Rodeo was not allowed to hold their customary nightly country-western dances inside the Astrodome. Cost estimates for repairs needed just to hold rodeo-related events on the playing field of the facility neared \$3 million (Peterson, 2009). To avoid such a large expenditure, the Rodeo held their event outside under several large tents.

The fire code violations were not serious enough to condemn the Astrodome. Misinformation circulated in the news about the impact the Fire Marshal citations would have on the Astrodome. Some said the entire facility needed to be brought up to current fire code (which had not previously been the case). Houston officials said they were told the Astrodome was "grandfathered" (because it was built in 1965) and was not required to meet 2008 building and fire codes. Some estimates for bringing the entire Astrodome up to current codes were as high as \$30 million. The city of Houston, reportedly, took a hard line and wanted to see a Certificate of Occupancy (typically required when a building is initially completed and after it has been inspected and determined safe for occupancy). After 43 years of occupancy of the building, Astrodome officials were unable to produce the original copy of that document. (Peterson, 2009)

More Number-Crunching

It was hard to get a handle on which cost figures were valid for evaluating whether the Astrodome should be demolished or renovated. In financial terms, some of the costs (whether accurate or inaccurate) were sunk costs. That concept was not explained in any news reports. Some reporters who favored saving the structure were critical of county officials for letting it fall into disrepair. There was criticism that Harris County Commissioners did nothing to preserve revenue -- even before the fire code violations in 2008 -- that could have been used to pay annual maintenance and operating expenses. One reporter offered the following financial analysis:

¹¹ For photographs of the celebration of the National League Central Championship of the Astros can be found at www.astrosdaily.com/history/19991003/ (Astrosdaily, 1999) and <http://www.citylab.com/politics/2013/11/will-astrodome-survive-todays-referendum/7473/> (Byrnes, 2013).

From 2002 to 2008, income fell each year from over \$3.5 million to \$103,596 the year before it was closed. The total event-related net income for all seven years was \$5,801,256.... In 1999 the Dome was fully operational... It was still in good enough shape for the Rodeo until they moseyed over to Reliant Stadium in 2003. ... And it was safe enough to hold 23,000 Katrina evacuees in 2005. (Neeley, 2012)

Such analysis was helpful in understanding where the Astrodome finances had been; but, did not help in developing a plan for how county officials should move forward. Refer to **Table 2** for a timeline of Astrodome events and estimated income, from 2001 through 2008.

Fiscal Year	Total Attendance	# of Events	Event Net Income
2001-02	1,179,492	127	\$3,658,181
2002-03	451,415	86	\$1,076,778
2003-04	309,051	56	\$598,476
2004-05	81,857	18	\$295,034
2005-06	9,866	4	\$69,191
2006-07	22,777	7	\$103,596
2007-08	3,279	1	\$0
Total	2,057,737	299	\$5,801,256

Table 2: Timeline of Astrodome events, attendance and net income

Source: (Neeley, 2012)

Privatization Efforts

As owner of the Astrodome, Harris County officials solicited proposals for private redevelopment of the facility in order to minimize the cost for area taxpayers. After several years of reviewing proposals, Harris County signed a letter of intent with Astrodome Redevelopment Corporation (ARC), an entity formed solely for the project. ARC's plan included a 1,300-room hotel, restaurants, a food court, and amusement rides. (Klump, 2006) That \$450 million redevelopment plan was nixed in October 2007 by opposition from the Houston Texans and the Houston Livestock Show & Rodeo. Under a lease signed years earlier, both the Texans and the Rodeo had pre-emptive rights (such as for food concessions on the property) that caused the two organizations to have concerns about the hotel development. They were also fearful a hotel might hinder the flow of traffic in and out of adjacent Reliant Center.

"Not until we saw their plans recently did we realize that this project has the ability to cannibalize our operations," said Leroy Shafer, the rodeo's chief operating officer. "Every dollar spent that is spent there [at the proposed hotel] is one that might not be spent at the rodeo... Shafer said restaurants that pay to operate at the rodeo could stop leasing if business was siphoned off by the hotel's food court ...

[and the hotel could decrease] the value of exclusivity rights at the rodeo. Coca-Cola, for instance, buys the right to sell its products exclusively at the rodeo. (Murphy, 2007)

Opposition from the Texans and the Rodeo was unfortunate on many levels. The Texas Historical Commission had previously approved ARC's development plans. That state agency's approval qualified the project for a federal tax rehabilitation credit which was integral to making the project financially viable. The tax credit could have been as much as \$70 million.

Texans and Rodeo Want Demolition

In March of 2013, the Texans and the Rodeo released a report which had been jointly commissioned. The report was prepared by two local firms, Linbeck Construction and Walter P. Moore and Associates (engineers). Their report included three options and associated cost estimates for demolition of the Astrodome. The costs ranged from \$7.3 million for implosion to \$11.8 million for partially dismantling the structure and imploding the remainder.

One year later (July 2014), the Texans and the Rodeo put forth another proposal dubbed the "Astrodome Hall of Fame" which would have involved demolishing the Astrodome. This plan proposed creating a green space that could be ready in time for Houston to host Super Bowl 2017 at nearby NRG Stadium (home of the Texans). There was even optimistic conjecture that the NFL might contribute some funds to help pay for the project with a proposed cost of \$66 million.

Other cost estimates came from a variety of sources and included \$29 million to implode the Astrodome and build a 1,600 space parking lot. This contrasted with a study done in 2010 that estimated the cost of demolition, asbestos removal, and construction of a plaza would total \$78 million. With so many proposals and so many cost estimates publicized, it was no wonder the taxpaying public had mixed feelings about the Astrodome. If the Astrodome was to survive, it needed a champion.

Ed Emmett, Judge and Astrodome Champion

"Silly" was the one word Harris County Judge Ed Emmett used to describe the Texans and Rodeo position that the Astrodome be demolished. Early in 2013, he asked stakeholders for proposals to redevelop the Astrodome. An April 2013 resolution by the Harris County Sports & Convention Corp. (CSCC) board formally solicited proposals to redevelop the facility. Emmett made his position publicly known that the Astrodome should *not* be demolished. To detractors of the Astrodome, he pointed out it was a county-owned building which was structurally sound and paid for. "It's a unique asset that you couldn't recreate from scratch." As Judge of Harris County, Ed Emmett headed up the Commissioners Court, which was responsible for administering county business, including ownership of all capital assets.

His career in both the private and public sectors provided evidence of a strong commitment to fulfilling his fiduciary duties in protecting assets of the nation, the state, and Harris County. He began his career in public service in 1979 when he was first elected as a Texas State Representative and subsequently served on the Interstate Commerce Commission. He had broad

experience before assuming the position of Harris County Judge in early 2007 and had wide-ranging responsibilities in that position. Emmett was respected for his expertise and abilities, as evidenced by the positions he held and recognition he received. See **Table 3**.

Date	Accomplishment
11/4/2014	Harris County Judge; re-elected to a term that extended through 12/31/2018
2010	Harris County Judge; won general election
3/6 2007	Harris County Judge; appointed by the Harris County Commissioners Court to fill the term (almost four full years) after resignation of Robert Eckels
Current	Chairman of the Houston-Galveston Area Transportation Policy Council
Current	Director of Harris County Office of Homeland Security and Emergency Management
Current	Chairman, Harris County Juvenile Board
2008	Presidential "Call to Service Award" for emergency preparation efforts
2005	Transportation Person of the Year by Transportation Clubs International
2003	Top 20 Logistics Professionals by the Logistics Forum
1989-1992	State Representative, Texas House of Representatives; included serving as Chairman of the Committee on Energy and as a member of the Transportation Committee. He was 29 years old when first elected in 1978; served four terms.
1979-1987	Commissioner, Interstate Commerce Commission (federal agency)

Table 3: Judge Ed Emmett abbreviated list of accomplishments

Source: (Texas State Cemetary, 1998)

Emmett was born in 1949 in Overton, Texas, a town of 2,000 in the eastern part of the state where his father worked in the oilfields and his mother was a housewife. His family had not yet moved to Houston when the Astrodome opened on April 9, 1965. Emmett's family had moved to Houston when he was a teenager, and he later graduated from Bellaire High School, less than 10 miles from the Astrodome.

Emmett was the first college graduate in his family. He won a scholarship to Rice University where he began his studies in 1967 and graduated in 1971 with a bachelor's degree in economics. Emmett was accepted at three different law schools, but was uncertain whether a career in law was what he wanted. In 1972, he began a master of public administration at the University of Texas in Austin. In 1974, Emmett served as chief of staff for a State Representative Herman Lauhoff. He later returned to Houston, got married, and he and his wife Gwen moved to Washington D.C.

Emmett was soon hired into a temporary position which resulted in a presidential appointment at a federal agency as the special assistant to the Secretary of Health Education and Welfare. In early 1976, he moved his family back to Houston where Emmett worked as the campaign coordinator for U.S. Senate candidate, Alan Steelman and later in the public affairs department of Exxon. He also served as president of TranSystems Advisors and then as president and chief operating officer of the National Industrial Transportation League. In 2003, Emmett founded his *Journal of Applied Case Research*, Vol 15, No. 1.

own international transportation consulting and marketing firm The Emmett Company. His expertise and professional reputation were evidenced by honors such as being named in 2003 by the Logistics Forum as one of the Top 20 Logistics Professionals and as the recipient of the “Transportation Person of the Year” award in 2005 from the Transportation Clubs International.” Because of their ability to work with people on both sides of an issue, Emmett cited Sam Houston, Lyndon Johnson, and Ronald Reagan as political leaders he respected. Sam Houston was a real hero because he went so far as to resign as Texas Governor in 1829 based on his position against slavery and not wanting Texas to secede from the United States. During a public presentation about leadership, Emmett noted it required both judgment and conviction, but also flexibility to change. He also said, “Leadership is about getting different people behind you to get good things done for the most number of people.” (Levine, 2014)

Within a year of becoming Harris County Judge in March of 2007, Emmett had to deal with the highly publicized fire code violations at the Astrodome (early in 2008). That was only a short-run issue. The real challenge related to the Astrodome was what to do with it for the long-run. Emmett was sensitive to his responsibility for the financial viability of Harris County. An important aspect of his State of the County address was “financial strength.” Did the financial costs of saving the Astrodome outweigh other considerations? Should the once-grand, first-ever domed stadium be demolished to make way for a parking lot and park? Or, should it be renovated and repurposed to provide other public spaces for visitors and citizens? Was there a way to make renovation financially viable?

Demolition or Renovation

Without considering the financial costs of renovation, both current and former residents were sentimental about the Astrodome as evidenced by online blogs that described their fond memories of attending Houston Astros baseball games and Houston Oilers football games as well as the Houston Livestock Show and Rodeo. Some writers and architectural experts compared the structure to the Eiffel Tower in Paris, originally built for the 1889 World’s Fair and expected to last only 25 years. What if that structure had been torn down? Others compared it to the Roman Coliseum.

Yet, saving the Astrodome was not just about nostalgic feelings for activities and events that people had attended in the Astrodome. Nor was it only about the architectural uniqueness of the facility. To some people, the Astrodome represented more. It was about what Houston (and, to a large part, Texas) had been able to achieve. *Doing what others said couldn’t be done.* It was not just about building the first-of-its-kind domed sports facility. The Astrodome also stood for the area’s contribution to the space race in the 1960s and NASA’s Mission Control which put a man on the moon. From Apollo 11’s landing, people around the world recognized the famous 1969 report back from the moon, “Houston, Tranquility Base here. The Eagle has landed.” It was, in fact, the space program which inspired Roy Hofheinz to rename Houston’s Domed Stadium the “Astrodome.”

When Judge Emmett spoke with constituents, there was generally consensus the Astrodome should be saved. Opposition developed when *costs* and taxes were discussed. There needed to be

a thorough analysis and identification of revenue sources¹² as well as costs so the county could develop a plan that would make the Astrodome renovation financially viable. Emmett and the Harris County Commissioners hired a consulting group, CSL (Convention, Sports and Leisure) from Plano, Texas, to study options and develop recommendation for renovating and repurposing the Astrodome. Their report entitled *Reliant Park Master Plan Analysis* was issued in May and formally presented at a meeting of the Harris County Commissioners on June 25, 2013. (Convention, Sports & Leisure International (CSL), 2012) The group's report included four options for the Astrodome and surrounding area. These ranged from continuing the status quo to what they called a "Renaissance" facility which involved overlaying the Multi-Purpose Facility with STEM programs.

As described by the consultants, the four options analyzed in their proposal were:

- (a) Status Quo – This option would maintain the Astrodome in its current condition. The building will remain unusable and the cost of maintenance will continue to rise as the building ages and systems further deteriorate
- (b) Reliant Park Plaza - This option demolishes the Astrodome, fills the existing site to grade and constructs Reliant Park Plaza with perimeter support facilities for outdoor events.
- (c) Astrodome Multi-Purpose Facility - This option would renovate the Astrodome into a multi-use indoor event facility. A new event floor would be constructed at grade, existing seating would be removed, systems would be upgraded or replaced and improvements would be made to the roof and exterior skin.
- (d) Astrodome Renaissance - This option would overlay the Multi-Purpose Facility with Science, Technology, Engineering and Mathematics (STEM) programs and/or privately funded concepts, including retail, dining and entertainment (RD+E) and attractions. Approximately 400,000 square feet of new space would be created within the Astrodome to house the overlaid components. Funding for the new entity would be derived from tenant leases, philanthropic sources and other Astrodome Renaissance revenues. While all options require public funding, the Astrodome Renaissance option as considered herein may only be pursued if the Astrodome Multi-Purpose Facility option is selected. Further, this option would only be considered if private sector and/or philanthropic funding can be found to support construction and operations. The Astrodome Renaissance option could be executed concurrently with the construction of the Astrodome Multi-Purpose Facility or at a point in the future. However, it should be noted that future construction costs would be higher.

The costs of these four options are shown in Table 4.

¹² Some Astrodome supporters conjectured the National Football League might contribute financially to efforts to save the facility, in part because of its historical significance and also because of the Super Bowl would be held next door at NRG Stadium in early 2017.

Astrodome – Options (Cost Estimates in Millions)	(a) Status Quo	(b) Reliant Park Plaza	(c) Astrodome Multi- Purpose Facility	(d) Astrodome Renaissance
<i>Harris County Funding</i>				
Project Cost	--	\$ 63.9	\$270.3	\$385.4
Less: Other Funding (private)	--	--	--	(115.1)
Total Harris County Funding	--	--	--	\$270.3
Annual Repair & Replacement	\$ 1.0	\$0.7	\$2.0	\$2.0
<i>Operating Estimates</i>				
Revenue	--	\$0.5	\$1.7	\$1.7
Rent from Third Party Operations*	--	--	--	\$12.5
Expenses	--	(1.2)	(3.6)	(3.6)
Net Operating Income	--	(\$0.7)	(\$1.9)	(\$1.9)
Incremental Expenses	--	--	--	(\$4.6)
Incremental Debt Service	--	--	--	(\$8.9)
Total Income (Loss)	--	(\$0.7)	(\$1.9)	(\$2.9)
<i>Economic Impact (incremental)</i>				
Tax Revenue	--	\$0.1	\$0.8	\$8.1
Direct Spending	--	\$0.8	\$6.8	\$77.9
Total Output	--	\$1.3	\$10.8	\$125.5
Personal Earnings	--	\$0.5	\$4.3	\$52.6
Jobs	--	18 added	153 added	2,221 added
* This line item was included in the consultants' presentation as a negative expense.				

Table 4: Astrodome – Future Use Options Analysis

Source: *Reliant Park Master Plan Analysis* (presentation), (Convention Sports & Leisure International (CSL), 2012, p. 62) and the complete study by the CSL consulting group, *Reliant Park Master Plan Analysis* (Conventions Sports & Leisure International (CSL), 2012, p. 222)

The CSL consulting group recommended the third option which they referred to as a “Multi-Purpose Facility” at a cost of \$270.3 million (exclusive of outstanding amounts owed on previous bond issues). This option relied heavily on the food and beverage concessions planned for the new facility and the report went so far as to state this revenue component was essential for the financial viability of the project.

The Harris County Sports and Convention Corporation (HCSCC)¹³ received a total of 19 proposals with plans for what to do with the Astrodome. HCSCC did not feel any one plan met all their requirements. They leveraged ideas from the outside proposals and developed their own plan. To renovate and repurpose the facility, HCSCC proposed changes both inside and outside the Astrodome to create a multi-purpose event space. Their proposed changes are presented in Table 5.

Inside	Outside
Remove interior seating structures	Refresh the exterior
Raise event floor to street level	Add green spaces and shade
Create signature entry at southern point	Add utilities for outdoor events
Install energy-efficient building systems	Create an exterior streetscape at the base of the Dome
Consider sustainability initiatives	Eliminate exterior ramp towers, ticket buildings
Create centralized event command post	Eliminate substation and high voltage transmission lines
Add features for emergency operations	

Table 5: HCSCC Proposed Changes

Source: (Leonard, 2013)

The HCSCC plan carried a price tag of \$194 million for converting it to a multi-purpose event center.

The Commissioners decided to send the proposals to other county offices for further study. The Harris County budget office was tasked with financial analysis. The county attorney’s office was asked to study the legality of the proposals and timing of placing a bond issue before voters. Financing either demolition or renovation required new funds. Judge Ed Emmett pointed out, “If there is a bond, there will be a tax. Everybody needs to understand that, but the level of that tax right now is still undetermined.” (Leonard, 2013)

Critics quickly took issue with cost estimates in the proposed plans as either being entirely too expensive or unreliable. Other experts unofficially said the cost for demolition could be \$25 to \$30 million. There did seem to be general agreement that at least \$10 million of any demolition cost would be required for asbestos abatement.

¹³ HCSCC was a local government corporation formed by the Harris County Commissioners Court in 2007 to manage and develop NRG (Reliant) Park which included the Astrodome. This entity acts on behalf of Harris County for managing, maintaining and developing the complex. (NRG Park, 2015)
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After months of study, Harris County Commissioners agreed to place a referendum on the November 2013 ballot for voters to determine whether they would fund \$217 million in bond financing for renovation of the Astrodome. The renovation plan incorporated changes to the Astrodome that would turn it into a multi-use facility for conventions with 350,000 square feet of exhibition space. To accomplish that, all the interior seats would be removed and the floor would be raised to street level. Outside there would be 400,000 square feet of place and green space. The plan had a name, “The New Dome Experience.”

Emotions on both sides ran high prior to the vote for new bonds to fund the Astrodome renovation. Many area residents expressed concerns about the already-heavy tax burden in Houston and surrounding Harris County. Comparisons were made to New York City which tore down Yankee Stadium where Babe Ruth made baseball history. (Glassman, 2013) An editorial in the *Houston Chronicle* urged citizens to vote “yes” for the bond issue, comparing the Astrodome’s importance to Houston as being comparable to the arch in St. Louis and the opera house in Sydney, Australia. (Holeywell, 2013)

Financial Misinformation

As they planned for the November 2013 bond referendum, Harris County officials were dismayed at the amount of misinformation disseminated by the press about the annual maintenance and upkeep for the Astrodome as well as whether the original bond debt from the 1960s was paid in full. The published financial data were difficult for officials to decipher, much less for the voting public. Some of the problematic information (with notations as to accuracy), per the Harris County budget office were:

- \$2.4 million cited as the annual maintenance and debt-service to keep the Dome in its current, non-operational state
 - **INCORRECT**
- ~5% remaining balance of debt balance for work done in 2002 and 2003 [*The Houston Chronicle* estimated that amount to be \$6 million, but unconfirmed by the county.]
 - **CORRECT**
- Annual expenses for insurance and maintenance personnel
 - **UNAVAILABLE**

One reporter cited Judge Emmett’s office as saying there was no breakdown for the annual maintenance costs of the Astrodome, separate and apart from other aspects of NRG Park because “it’s all subsumed [combined] into the total costs for the multi-facility venue...including both NRG Stadium and NRG Center.” (“Keeping Astrodome Around is Cheaper...”) In other words, those were sunk costs that would continue regardless of whether the Astrodome was operational or not. Further explanation from the Harris County Budget Office indicated the primary maintenance costs for the Astrodome were keeping it dry. Electricity costs of approximately \$165,000 per year were needed to operate pumps that kept water out of the below-ground playing field plus a flood insurance policy of nearly \$6,000 per year. If a portion of the insurance for the entire NRG facility was allocated to only the Astrodome, annual insurance plus electrical costs were estimated to be about \$500,000.

Also, there was conflicting information as to how much debt remained for previous bonds issued to finance the original construction and subsequent renovations to the Astrodome. Some news reports indicated the Astrodome debt had been refinanced so many times no one would be able to sort out the amount owed. In fact, some sources indicated there had been 17 bond packages related to the Astrodome and Reliant Park. That was in contrast with Harris County officials who described there being only three “Astrodome-specific” bond issues: the original 1961 construction bond and two 1988 bond packages (both of the latter having been necessary to encourage the Oilers football team to stay in Houston).

In June of 2013, one Houston newspaper reported that an estimated \$3 million of Astrodome bonds issued in 2004 would mature that year and that another \$5 million was owed as part of a Reliant Park bond package. See Table 6.

Date of Bond Issue	Bond Maturity & Status	Bond Face Amount	Purpose	Source of Payments
			ASTRODOME	
1961	2001 Paid off	\$27 million	Original Construction	General Obligation Bonds
1988	Some paid off & some refunded	\$33 million (estimated \$6 million as of 2013)	Improvements to keep Oilers in Houston	
2004	2013	\$3.1 million		Hotel occupancy taxes
2 issues between 1997 and 2009 (voter approved)		\$28 million	Refunded debt originally issued for improvements to Dome; to keep Oilers football team in Houston	
			RELIANT PARK and a portion for ASTRODOME	
2002		\$245 million BALANCE \$240 – Reliant \$5 – Astrodome	Construct Reliant Center and a cooling plant	
Quotes are from Harris County Budget Officer, Bill Jackson. There are also references to Harris County Assistant Attorney as sources of information for the article.				

Table 6: Summary of Bond Debt related to Astrodome

Source: (Collier, Money Still Owed on Dome less than Previously Stated , 2013)

Financial analysis was complicated by indications that some Astrodome-related capital improvements had been combined with Reliant Center (NRG Park) bonds issued under that name. Additionally, a review of a widely-used government securities database (EMMA) revealed that some “Astrodome Improvement” bonds had a payment due date as recent as October 1 of 2012. See **Error! Reference source not found.** and **Error! Reference source not found.**

With incorrect figures such as \$2.4 million for annual upkeep and confusion as to the amounts still owed (some said \$6 million or more) circulating in the media and among voters, Harris County officials faced an uphill battle to convince area voters to approve the November bond referendum.

Bond Referendum Defeat

Supporters of the Astrodome had thought the best outcome from the November 5, 2013 bond referendum would be a “close” vote. However, even the most optimistic supporters were disheartened by the proposal’s defeat with 53% of Harris County voters against it.

As Judge of Harris County, Ed Emmett had a tough decision to make. Should he accept the results as the final word from voters that they were not willing to pay to renovate and repurpose the Astrodome? That would mean almost certain demolition of the once-grand facility. Or, should he and his staff members start over and look for new alternatives for saving the Dome? Did the architectural significance and symbolism for the city of Houston make it worth continuing the fight to save it? If it was worth saving the Astrodome, then what maximum financial cost should the taxpayers bear? Also, what personal and professional cost for Judge Emmett would be “too much”?

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Appendix A: Various Sports Organizations Related to the Astrodome

Formed in	Entity Name, Purpose & Organizers
1960	Houston Sports Association (HSA)
Purpose	To bring major league baseball to Houston. After the Astrodome opened, HSA also operated the facility.
Organized by	Private syndicate comprised of four businessmen, including Roy Hofheinz
1997	Harris County – Houston Sports Authority (HCHSA)
Purpose	A non-profit entity formed with the purpose of constructing and operating a new baseball stadium for the Houston Astros. Their lobbying in the 1997 Texas Legislature resulted in legislation that permitted a county-wide sports authority that would utilize public revenue to finance the sports stadium.
Organized by	Harris County, City of Houston and Houston Astros Baseball Club & Sports Facilities L.P.
Board	Chairman & 12 Directors, appointed by Harris Co. Judge and Houston Mayor
2007	Harris County Sports & Convention Corporation (HCSCC)
Purpose	To manage NRG Park (including the Astrodome)
Organized by	A government corporation formed by the Harris County Commissioners Court; structured as a component of Harris County
Financing	Hotel and rental car tax along with parking and sales taxes at the stadium. Public cost was 71.4% (\$287 million) of the total cost of \$402 million for the football stadium. Opened in 2002.
Other	Initially named ‘Reliant Park and Astrodomain’; Reliant Stadium cost \$474 million financed with 39% private funding and 61% public funding. Included: 2% increase in County hotel/motel tax, 5% increase in County auto rental tax, 10% parking tax, \$1.00 per ticket surcharge. Source: (Convention Sports & Leisure International (CSL), 2011)

Source: compiled by authors

Appendix B: Design and Engineering Challenges

Source: (Bass, 1965)

Houston's new domed stadium.. is a domed circular concrete and steel framed building with an adequate playing field for both baseball and football. Covering an area of over nine acres, the structure has an outer diameter of 710 ft. with a clear span of 642 ft. The roof rises to a height of 202 ft. above the center of the field. Seating up to 66,000 can be arranged to accommodate any type of sport or meeting from rodeos to national political conventions. 10,428 seats at field level are in two stands which rotate 35 degrees from baseball position to parallel for football position. Movement is on tracks with power by motors.

Engineering problems were monumental and included some entirely new ones... Stratified heat will occasionally require heating of the lower areas and cooling of the upper ones... An older problem was how to span a distance of 641 ft. 8 in. without interior supports... [It] was determined...that the basic design would be a steel lamella-type trussed roof structure. This system had previously been employed successfully on several dome spans up to 285 ft.

Thirty seven erection towers were necessary... The tallest tower...was 212 ft.

The stadium is circular in plan and has six levels of seating. The playing field is set 25 ft. below grade. Movable sections of seats rotate over the playing-field level, from baseball position to football position.

Skylights The roof contains nearly 4,600 skylights and the pattern of skylights... with 50 percent of the roof covering above the field available for the admission of light.

The stadium is cooled and heated using equipment with approximately 6,000 tons of cooling capacity. Altogether 2,000,000 cu ft. of air per min is circulated, of which 250,000 cu ft. per min is fresh air. Smoke and hot air are expelled at the top of the dome.

Some other interesting problems for the architects and engineers were:

Mechanical controls are completely automatic, and necessarily so since it is a half mile around the building, and to check thermostats would be a long task. A fire-alarm system will continuously scan detectors throughout the building, making one complete circle each minute.

Model testing Roof Structures, Inc., decided to set up a research project headed by the author, their vice-president in charge of engineering, to analyze mathematically the complex framed dome and then to build a test model to verify the analysis. It was also necessary to determine the wind forces applicable to the roof surface when a dynamic wind force of 40 psf is applied by the occasional hurricanes prevalent in the Houston area. Dr. G. R. Kiewitt of Roof Structures, Inc. decided that a wind tunnel test should be made. A 1/8-in. scale model was tested by McDonnell Aircraft Company of St. Louis for 48 different conditions of opening positions and angle of attack by the wind. The data gathered support a strip method application of the ASCE Subcommittee Report No. 31, "Wind Forces on Tall Buildings." The building is designed to withstand hurricane wind gusts of 165 mph with continuous forces of winds of 135 mph.

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The architects, Lloyd and Morgan associated with Wilson, Morris, Crane and Anderson, secured the services of Roof Structures, Inc., in St. Louis Mo., for the engineering design of the lamella roof. Praeger, Kavanagh and Waterbury, engineering consultants in New York, were retained to check all structural engineering, and they in turn engaged Dr. Henri Marcus, F. ASCE, to check the roof calculations. Further, Roof Structures, Inc., consulted Dr. Z. S. Makowski of London University for theory validity in addition to the normal checks by Walter Moore, structural engineer in Houston--a case of consultants who had consultants who had consultants!

**Appendix C: Outstanding Bonds and Payments for Astrodome Improvements as of
October 2012**

CUSIP	Maturity Date	Interest Rate %	Principal at Issuance	Security Description
414003MF7	10/01/1993	6.40		CTFS OBLIG-Astrodome IMPTS PJ
414003MG5	10/01/1994	6.60		CTFS OBLIG-Astrodome IMPTS PJ
414003MH3	10/01/1995	6.80		CTFS OBLIG-Astrodome IMPTS PJ
414003MJ9	10/01/1996	7.00		CTFS OBLIG-Astrodome IMPTS PJ
414003MK8	10/01/1997	7.20		CTFS OBLIG-Astrodome IMPTS PJ
414003MJ4	10/01/1998	7.30		CTFS OBLIG-Astrodome IMPTS PJ
414003MM2	10/01/1999	7.45		CTFS OBLIG-Astrodome IMPTS PJ
413003MN0	10/01/2000	8.60		CTFS OBLIG-Astrodome IMPTS PJ
414003MP5	10/01/2001	7.75		CTFS OBLIG-Astrodome IMPTS PJ
414003MQ3	10/01/2002	7.85		CTFS OBLIG-Astrodome IMPTS PJ
414003MR1	10/01/2008	8.10	\$16,870,000	CTFS OBLIG-Astrodome IMPTS PJ
414003MS9	10/01/2012	8.15	\$16,755,000	CTFS OBLIG-Astrodome IMPTS PJ

Source: (MSRB, 2015)