# TEXETHICS NEWSLETTER

**COMMUNICATING ENGINEERING PROFESSIONALISM AND ETHICS IN TEXAS**

VOLUME 8 NUMBER 1 SUMMER 1998

*Sponsor*

**TEXAS BOARD OF PROFESSIONAL ENGINEERS**

*Publisher*

**MURDOUGH CENTER FOR ENGINEERING PROFESSIONALISM**

COLLEGE OF ENGINEERING, TEXAS TECH UNIVERSITY, BOX 41023, LUBBOCK TEXAS 79409-1023

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## Thanks to Former Board Members for their Service to the Profession

**Linda Yee Chew**, **Esq**., has completed her term as a board member for the Texas Board of Professional Engineers. A resident of El Paso, Ms. Chew is a partner at the law firm, Douglass, Chew & Chew. She received a Bachelor of Science in Education from the University of Houston, a Master of Arts in Educational Administration from Stephen F. Austin State University, and a Doctor of Jurisprudence from the South Texas College of Law. Ms. Chew also served in many capacities such as a panel chair for the El Paso State Bar Grievance Committee, a legal representative for El Paso Adoption Services and a member of the American Immigration Lawyers Association.

**Derrell E. Johnson, P.E., R.P.L.S.**, has completed his term as a board member for the Texas Board of Professional Engineers. He served as Board chair from 1994 to 1995. Mr. Johnson currently is chief executive officer and senior vice-president of Kimley-Horn and Associates, Inc., in Ft. Worth, Texas. Mr. Johnson has served as president of the Ft. Worth branch of ASCE and as president of the Texas section. He also served as president of the Consulting Engineers Council of Texas (CEC-Texas) and as the national chairman of the planning cabinet of the American Consulting Engineers Council. He is a member of ASCE, NSPE, ACEC, AWWA, the CEC-Texas and TSPE. Mr. Johnson's community involvement includes: Member of the Memorial Baptist Church; Rotary Club of Ft. Worth and Ridglea Country Club. He is also a founding director of the Board of Texas National Bank in Southlake. He holds a BSCE degree from the University of Texas at Arlington. Mr. Johnson lives in Tarrant County with his wife Kitty and their five children: Dolph, Derrellene, Devery, Randy and Melissa.

**Roxanne L. Pillar, P.E.**, of Ft. Worth has completed her term as a board member for the Texas Board of Professional Engineers. She remains active with the Board, being an Emeritus Member, serving on the Board's Industry Advisory Committee, and serving on the NCEES Ethics Committee. Roxanne is now a senior project manager with HNTB. Formerly, she was a lead engineer and project manager for the Federal Aviation Administration and has had previous engineering positions at Freese & Nichols and Rady & Associates in Ft. Worth. Ms. Pillar served as board chair of the Texas State Board of Registration for Professional Engineers from 1995 to 1996. She has also served as president of the Fort Worth Chapter of TSPE and director of the Fort Worth branch of ASCE. The Fort Worth Chapter of TSPE named Ms. Pillar Young Engineer of the Year in 1985. She has authored several papers for ASCE. She holds a Bachelor of Science in Civil Engineering from South Dakota State University. Ms. Pillar has been active in civic activities such as Leadership Ft. Worth, the Adult Girl Scout Network, YMCA and Toastmasters International. She and her husband, Steve Baker, have two children, Renee and Alec.

# Welcoming New Members of the Texas Board of Professional Engineers

Earlier this year, Gov. George W. Bush appointed three new members to the Texas Board of Professional Engineers: **Brenda Bradley, P.E.**, **Joe Paul Jones, P.E.**, and public member **Kathleen Campbell Walker**.

**Brenda Bradley, P.E.**, is president of Alexander Engineering in Houston. She has been a member of the Industry Advisory Committee of the Texas Board of Professional Engineers. Currently, she serves as the chair of Professional Engineers in Private Practice for the Texas Society of Professional Engineers. Ms. Bradley is the chair of the Civil Engineering Academy and the secretary-treasurer of the Civil Engineering Advisory Council at Texas Tech University. She has also been an active member of the Advisory Council to the Association of Water Board Directors since 1991. Gov. George W. Bush selected Ms. Bradley in 1996 to serve as the vice-chair of the Texas On-Site Wastewater Research Council. She also served on the Core Committee for Review of the State of Texas Wastewater Treatment Design Criteria at the Texas Natural Resource Conservation Commission and as the vice-chair of the TNRCC Design Bases Subcommittee. Ms. Bradley earned a Bachelor of Arts in Environmental Studies from Trinity University and a M.S.C.E. in Civil Engineering from Texas Tech University.

**Joe Paul Jones, P.E.**, currently is a vice-president in the Fort Worth firm, Freese and Nichols, Inc. He served as president of the National Society of Professional Engineers from 1991 to 1992 and as president of the Texas Society of Professional Engineers in 1981. He served the Consulting Engineers Council of Texas as a director in 1973 and 1974. Mr. Jones has been named a fellow by the Texas Engineering Foundation, the American Society of Civil Engineers and the Society of Military Engineers. His career and civic activities have centered on improving the quality of life for his fellow citizens. Mr. Jones has taken on a variety of roles in the Boy Scouts of America such as his service as scoutmaster from 1968 to 1971 through Council President from 1988 to 1989. He also led various committees for the Fort Worth Chamber of Commerce. Mr. Jones served as president of the Kiwanis Club of Greater Fort Worth in 1969 and as a Lieutenant Governor in the Texas-Oklahoma District in 1973. A lifetime of public and professional service has resulted in numerous awards for Mr. Jones. He has been honored as Engineer of the Year by the Texas Society of Professional Engineers; Distinguished Engineer by the Texas Engineering Foundation; Silver Beaver by the Boy Scouts of America; and he has been awarded the Service to the People Award from the American Society of Civil Engineers. Mr. Jones' career has encompassed management of a wide range of civil, architectural and transportation projects, including the design and construction of airports, site development and drainage projects. He holds a Bachelor of Science in Architectural Engineering from the University of Texas. He resides in Ft. Worth with his wife, Joanne.

**Kathleen Campbell Walker**, chairperson of the International Department of the El Paso law firm Kemp, Smith, Duncan & Hammond of El Paso, is also the president of the El Paso Foreign Trade Association. She serves as a member of the National Liaison Committee with the Department of State for the American Immigration Lawyers Association and as an Advisory Board Member to the Center for Western Hemisphere Trade of the University of Texas at El Paso. Ms. Walker serves on the Director's Advisory Committee of the West Texas /New Mexico Customs Management Center and on the Advisory Board of the Greater El Paso Chamber of Commerce. She is also currently serving on the El Paso District Customer Service Roundtable of the Immigration and Naturalization Service. Ms. Walker is a contributing author to the following books published by the American Immigration Lawyers Association: *Practice and Procedure Under the North American Free Trade Agreement*, *H-1B Toolbox*: *Samples for Representing Professional and Specialty Workers* and the *Visa Processing Guide*. Throughout her career, she has held many leadership roles, chairing the International Law Committee of the Texas Young Lawyers Asso-ciation from 1993 to 1994 and from 1990 to 1991. She served as the Texas Chapter Chair for the American Immigration Lawyers Association, which is a position that includes the bordering states of New Mexico and Oklahoma. She has served on planning committees and as a speaker for conferences concerning immigration and trade that have been sponsored by the Texas Tech University School of Law, the University of Texas School of Law, the State Bar of Texas and the American Immigration Lawyers Association. Ms. Walker holds memberships in numerous organizations with a focus on immigration issues, including her role as a member of the State Bar of Texas' Standing Committee on Laws Relating to Immigration & Nationality. Every year since the recognition of the area of immigration law, she has been listed in the publication, Best Lawyers in America. Ms. Walker received a Bachelor of Arts in 1982 from Texas Tech University and was honored as the Highest Ranking Graduate in the College of Arts and Sciences. Ms. Walker and her husband Mark reside in El Paso with their son Lee.

## William D. Lawson, P.E., Joins the Murdough Center Staff

William D. (Bill) Lawson, P.E., joined the Murdough Center Staff as Deputy Director in August 1998. He is also a Senior Research Associate and Lecturer in Civil Engineering at Texas Tech, and plans to complete his Ph.D. in Civil Engineering with a strong emphasis on engineering ethics.

A native of Temple, Texas, Bill attended Texas A&M University where he earned his BS and MS degrees in Civil Engineering. Since his graduation, he has gained 14 years of engineering practice experience, and has also earned a Certificate of Graduate Studies at Dallas Theological Seminary.

Prior to joining the faculty and staff at Texas Tech, Bill served as a principal geotechnical engineer for with the Dallas office of Law Engineering and Environmental Services. He has also worked for Master Consultants and Trinity Engineering Testing Corporation.

As Deputy Director and Senior Research Associate at the Murdough Center, Bill works on ethics and professionalism projects for the Texas Board of Professional Engineers and the Texas Department of Transportation. He will develop new projects in the area of engineering ethics and professionalism.

## "Professionalism, Then and Now"

William D. Lawson, P.E., Member, ASCE
Deputy Director, Murdough Center for Engineering Professionalism, Texas Tech University, Lubbock, Texas.
Abstract of a paper submitted to the American Society of Civil Engineers
*Journal of Professional Issues in Engineering Education and Practice,* review in progress.

**Abstract**: Professionalism is a changing phenomenon. Sociological literature reveals that the modern concept of "profession" coalesced in the United States from the late sixteenth to the early twentieth centuries. Influenced throughout the stages of its development by the preeminent professions of theology, law, medicine and education, a professional ideal emerged in the 1910s. The characteristics of this professional ideal are (1) a body of functional knowledge, (2) organization into an association, and (3) an ethic of professional service. The field of medicine being representative of the ideal, professions achieved unprecedented levels of prestige, autonomy and success in twentieth century American society.

But commencing in the 1950s, the professions began to decline. Whereas before, professionals had experienced respect and trust, they now became objects of criticism and suspicion. Society generally dismissed the ethic of professional service as a cloak that veiled hidden greed and self-serving attitudes. Changes occurred in other aspects of professionalism too, such as the body of knowledge, code of ethics, and the professional-client relationship. As if that weren't enough, the engineering-professional must also overcome a rather hazy/undefined public image due to engineering's splintered nature, organizational framework, and inherent subordination in the marketplace. Most of these changes tend toward loss of professional autonomy.

Decline in professional autonomy has meant loss of our freedom of self-regulation. It is the reaction of a society conditioned to retain control so as to not be taken advantage of. *The issue is trust.* To stem this decline in professionalism, engineers must re-establish trust, both individually and as an organization. What is at stake is a more cherished autonomy, this time, the freedom to operate within our own spheres of competence. Engineers must respond to professional issues with a clear and informed understanding of the nature, causes, and meaning of the changing character of professionalism, if we hope to serve society, both today and into the twenty-first century.

## Meet the Staff of the Murdough Center for Engineering Professionalism

The Murdough Center for Engineering Professionalism is entering its eleventh year of operation. The staff has grown to include four members:

**Jimmy H. Smith, Ph.D., P.E.** is the Director of the Murdough Center and Professor of Civil Engineering;

**William D. Lawson, MSCE, P.E.**, is Deputy Director and Senior Research Associate in the center and Lecturer in Civil Engineering;

**Mary Benton, Gery Joy, Jimmy Smith, Bill Lawson**

**Mary Benton, BA**, is Assistant to the Director and Research Associate in the Murdough Center, and

**Gery Joy, BA**, is a Research Assistant working primarily on the correspondence course offered by the Center.

**For assistance in engineering ethics education or for information on ethics programs for companies, please contact us at:**
806-742-3525, Fax 806-742-0444, or email: ethics@coe.ttu.edu.

# PEPL Case of the Month – May-July, 1998

**From the Web Site of the "Ethics Case of the Month Club"**

http://www.engr.washington.edu/~uw-epp/Pepl/Ethics/

**Professional Engineering Practice Liaison Program**

By Dr. Ron Buckman

College of Engineering, University of Washington

## "The Fetid Favor Fiasco"

**May-July 1998**

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You are an architect with a 10-person firm in Placidville, in the central part of the state. Placidville is a small city with a population of 83,576, based on a 1996 census. It also is the location of the state's largest university (about 23,000 students). Due to the business and recreational opportunities in the state, the population has been steadily increasing over the past 15 years, and an aggressive building program was initiated at the university five years ago to construct and equip approximately 16 new classroom and laboratory buildings over the following 20 years.

Last weekend your wife invited mutual friends, Ted and Alice Hammer, to spend the weekend with you at your cottage on a lake in the northern part of the state. Ted is a senior project manager with Quality Construction Co., a local commercial and institutional building construction firm. His wife, Alice, is an activist in the Placidville community, and generally known for her on-going campaign for integrity in government.

**This is the most recent ethics case on the "Ethics Case of the Month Club" Web site:**
**http://www.engr.washington.edu/~uw-epp/Pepl/Ethics/**

**You will enjoy viewing this web site and vote on the alternate responses to this case listed on page 5. Also, you may see the voting results of previous ethics cases. Later, you will be able view the results of this current case.**

During the weekend, Alice mentioned that at a recent zoning board meeting, Gus Olson, one of the other board members, told her that the construction company he works for as a carpenter (Shreud Contractors) has assigned him as the construction foreman for a garage being built for Ray Vandergrafft. Alice recognized the name and knew that Ray is one of several project managers for the Capital Construction Projects Office at the university. Gus laughed and said that something as small as a wood-framed garage was an unusual project for Shreud Construction, since they normally were involved in heavy steel erection projects for large structures in the region.

Ted interjected that he had heard Shreud Contractors recently was awarded a contract with an estimated budget of $500,000 to make remedial repairs to the steel superstructure of the university's aging football stadium. He understood the contract had been awarded directly to Shreud on a time-and-materials basis to avoid the expense to the university of preparing extensive bid documents and going through a competitive selection process. He said it was interesting that the garage construction for Vandergrafft was going on at the same time as the remedial work on the stadium.

In fact, Ted said, he had learned a few years ago that his own firm had previously been involved in a similar situation when they were the contractor for a new engineering test facility at the university and at the same time had built a large addition to Ray Vandergrafft's kitchen because his wife, Olga, was a gourmet chef. Ted said he had decided not to make an issue of it, since the project had been completed for some time, and he had been told that the construction materials and appliances for the kitchen had come from surplus materials from the new lab site and incentive gifts from the laboratory equipment suppliers. He also had learned that the construction crew worked on the kitchen when there was not enough to do at the new engineering test facility site.

At that point your wife said she had driven by Fred Facade's house a few days ago, saw a Shreud pickup truck parked in the driveway and noted that there was remodeling going on at the house, apparently to raise the roof and add more space on the second floor. Fred is the University Architect.

You have done architectural design work for the university over the years and have contributed to their alumni giving campaign. In the past, you suspected that some contractors and architects received favored treatment from the university, especially the Office of the University Architect, but this is the first time you have heard anyone detail a specific situation. You know the University President on a first-name basis, as well as the Vice President for Finance, to whom the University Architect reports. You have also known Fred Facade on a casual basis for more than 18 years.

**What, if anything, do you do?**

(See page 5 for possible options.)

# Alternate Approaches to "The Fetid Favor Fiasco" Case

**You can vote and/or discuss this case on the web (see Ethics Case of the Month URL on previous page)**

**1.** Do nothing. You do not know that there is anything illegal or underhanded going on based on what you have heard so far. Just because Ted Hammer's firm participated in the construction of Vandergrafft's kitchen a number of years ago, things have changed in the industry and it is highly unlikely anyone would do that kind of thing in this day and age.

**2.** Leave it alone. This sounds like a case of sour grapes on the part of Gus Olson for having been put on such a small project while the really interesting remedial work on the stadium is being carried out by others in Shreud Construction. Also, Ted Hammer is not about to say anything supportive of Shreud Contractors anyway, since Shreud got the stadium remedial repairs project handed to them directly without bidding. After all, Quality Construction and Shreud Construction are competing contractors in the same town and often go after the same construction projects.

**3.** Do nothing. It is commonly recognized that this sort of thing goes on all the time, and making an issue about it is not going to put you in a positive position for more architectural design work with the university.

**4.** You are outraged! Call Vandergrafft at his house and tell what you have heard. Also tell him that if you ever hear of his doing such a thing again, you'll raise such a stink that he will be forced to resign from his position as a project manager with the Capital Construction Projects Office at the University and will have difficulty finding another job within 2,000 miles, if then.

**5.** Do nothing until you can get verification from someone else that Shreud Contractors are working on Vandegrafft's garage without charging for the labor and/or materials. It may be that Shreud has a contract with Vandergrafft to build the garage and Gus Olson, not being part of the Shreud management group, may be assuming things that are unwarranted or unsubstantiated.

**6.** Arrange with Ted Hammer to have one of his people ask around the local carpenters, teamsters and laborers union halls to gather as much information as possible about Shreud doing both the stadium project and Vandergrafft's garage at the same time so that you and Ted can put a coherent case together before talking with anyone else.

**7.** Make some discreet inquiries around town, particularly among lumber supplies, to see if either Vandergrafft or Shreud Contractors has recently purchased lumber and had it delivered to the Vandergrafft home.

**8.** Arrange for a quiet lunch away from the campus with the *Vice President for Finance* at the University to discuss what you have heard, and to express your concerns about what appears to be kickback incentives in the form of labor and materials for the Vandergrafft garage. Indicate that you are concerned because you have contributed to the University's fund raising campaigns on a regular basis for years and *feel that your firm has not been getting their fair share of the architectural design work at the university.*

**9.** Arrange for a quiet lunch away from the campus with the *Vice President for Finance* at the University to discuss what you have heard, and to express your concerns about what appears to be kickback incentives in the form of labor and materials for the Vandergrafft garage. Indicate that you are concerned because you have contributed to the University's fund raising campaigns on a regular basis for years and *do not like to see the money spent on personal projects for selected faculty or members of the university's administration.*

**10.** Arrange for lunch with the *University President* to discuss what you have heard, and to express your concerns about what appears to be kickback incentives in the form of labor and materials for the Vandergrafft garage. Indicate that you are concerned because you have contributed to the University's fund raising campaigns on a regular basis for years and *feel that your firm has not been getting their fair share of the architectural design work at the university*.

**11.** Arrange for lunch with the *University President* to discuss what you have heard, and to express your concerns about what appears to be kickback incentives in the form of labor and materials for the Vandergrafft garage. Indicate that you are concerned because you have contributed to the University's fund raising campaigns on a regular basis for years and *do not like to see the money spent on personal projects for selected faculty or members of the university's administration.*

**12.** Fred Facade is a fellow professional and respected in the community. He undoubtedly has not realized the appearance he has created, nor the harm it could do to him personally and professionally. You owe him the courtesy of letting him know that you know, and giving him time to clean up his act. Take Fred to lunch and have a heart-to-heart chat. Let him know that it is wrong to accept kickbacks and suggest he find a quiet way of terminating his relationship with the contractors.

**13.** You have absolutely no respect for Fred Facade. He has tarnished the stature of architects in the community and deserves severe sanctions. You vow to collect as much incriminating evidence as you can over the next couple of weeks, then send it off to the state Board of Registration for Architects, as well as the American Institute of Architects, and accuse Fred of unethical practices. You will also demand that his license be suspended pending a full and thorough investigation.

**14.** You know that the administration at the university would probably not admit the situation, especially if it is a case of kickbacks and doing work under the table for selected university personnel without payment from these individuals. Therefore, you should call the local newspaper publisher and confidentially transmit the information you obtained last weekend at your cottage about Shreud Contractors, without giving the names of your sources, but indicating that these individuals are usually reliable sources of information.

**15.** Write a letter to the local newspaper for publication on the Letters to the Editor page recounting the information you received last weekend (but not naming your sources), and registering a heartfelt concern about the way the university shows favoritism and does business in the local community, at the expense of the fund donors and taxpayers.

# Space Shuttle Challenger: Mission 51-L Launch Decision

Prepared by:
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On January 28, 1986, the Space Shuttle Challenger was launched for the last time. The decision to launch the Challenger was not simple. Certainly no one dreamed that the Shuttle would explode less than two minutes after lift-off. Much has been said and written about the decision to launch. Was the decision to launch correct? How was the decision made? Could anyone have foreseen the subsequent explosion? Should the decision-making procedure have been modified? These questions are examined in this case study.

## Background on The Space Shuttle:

The Space Shuttle is the most complicated vehicle ever constructed. Its complexity dwarfs any previous project ever attempted, including the Apollo project. The Apollo project possessed a very specific goal, to send men to the moon. The Space Shuttle program has a wide variety of goals, some of which conflict. The attempt to satisfy conflicting goals is one of the chief roots of difficulty with the design of the Space Shuttle. Originally, the design was to be only a part of NASA's overall manned space transportation system, but because of politics and budget cuts, it was transformed from an integral component of a system to the sole component of the manned space program.

The Space Shuttle was the first attempt to produce a truly reusable spacecraft. All previous spacecraft were designed to fly only a single mission. In the late 1960's, NASA envisioned a vehicle which could be used repeatedly, thus reducing both the engineering cost and hardware costs. However, the resulting vehicle was not as envisioned. It had severe design flaws, one of which caused the loss of the Challenger.

## NASA Planning and Politics:

NASA's post-Apollo plans for the continued manned exploration of space rested on a three-legged triad. The first leg was a reusable space transportation system, the Space Shuttle, which could transport men and cargo to low earth orbit (LEO) and then land back on Earth to prepare for another mission. The second leg was a manned orbiting space station which would be resupplied by the Shuttle and would serve as both a transfer point for activities further from Earth and as a scientific and manufacturing platform. The final leg was the exploration of Mars, which would start from the Space Station. Unfortunately the politics and inflation of the early 70's forced NASA to retreat from its ambitious program. Both the Space Station and the Journey to Mars were delayed indefinitely and the United States manned space program was left standing on one leg, the space shuttle. Even worse, the Shuttle was constantly under attack by a Democratic congress and poorly defended by a Republican president.

To retain Shuttle funding, NASA was forced to make a series of major concessions. First, facing a highly constrained budget, NASA sacrificed the research and development necessary to produce a truly reusable shuttle, and instead accepted a design which was only partially reusable, eliminating one of the features which made the shuttle attractive in the first place. Solid Rocket Boosters **(SRBs)** were used instead of safer liquid fueled boosters because they required a much smaller research and development effort. Numerous other design changes were made to reduce the level of research and development required.

Second, to increase its political clout and to guarantee a steady customer base, NASA enlisted the support of the United States Air Force. The Air Force could provide the considerable political clout of the Defense Department and had many satellites which required launching. However, Air Force support did not come without a price. The Shuttle payload bay was required to meet Air Force size and shape requirements which placed key constraints on the ultimate design. Even more important was the Air Force requirement that the Shuttle be able to launch from Vandenburg Air Force Base in California. This constraint required a larger cross range than the Florida site, which in turn decreased the total allowable vehicle weight. The weight reduction required the elimination of the design's air breathing engines, resulting in a single-pass unpowered landing. This greatly limited the safety and landing versatility of the vehicle.

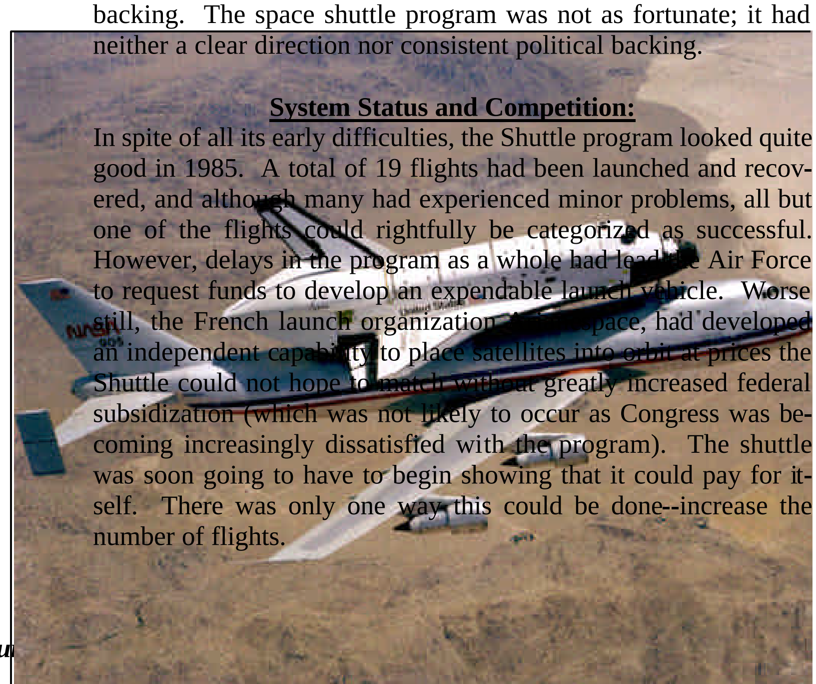
## Factors Affecting the Launch Decision

### Pressures to Fly:

As the year 1986 began, there was extreme pressure on NASA to "Fly out the Manifest". From its inception the Space Shuttle program had been plagued by exaggerated expectations, funding inconsistencies, and political pressures. The ultimate design was shaped almost as much by politics as physics. President Kennedy's declaration that the United States would land a man on the moon before the end of the decade had provided NASA's Apollo program with high visibility, a clear direction, and powerful political backing. The space shuttle program was not as fortunate; it had neither a clear direction nor consistent political backing.

### System Status and Competition:

In spite of all its early difficulties, the Shuttle program looked quite good in 1985. A total of 19 flights had been launched and recovered, and although many had experienced minor problems, all but one of the flights could rightfully be categorized as successful. However, delays in the program as a whole had lead the Air Force to request funds to develop an expendable launch vehicle. Worse still, the French launch organization, Arianespace, had developed an independent capability to place satellites into orbit at prices the Shuttle could not hope to match without greatly increased federal subsidization (which was not likely to occur as Congress was becoming increasingly dissatisfied with the program). The shuttle was soon going to have to begin showing that it could pay for itself. There was only one way this could be done--increase the number of flights.



Dryden Flight Research Center EC82-21135 Photographed 4 JUL 1982

For the shuttle program, 1986 was to be the year of truth. NASA had to prove that it could launch a large number of flights on time to continue to attract customers and retain Congressional support.

Unfortunately, 1986 did not start out well for the shuttle program. Columbia, Flight 61-C, had experienced a record four on-pad aborts and had three other schedule slips. Finally, on mission 61-C, Columbia was forced to land at Edwards Air Force Base rather than at Kennedy Space Center as planned. The delays in Columbia's launch and touchdown threatened to upset the launch schedule for the rest of the year.

***The Space Shuttle Orbiter Challenger atop NASA's Shuttle Carrier Aircraft (SCA), NASA 905, after leaving the Dryden Flight Research Center, Edwards, California, for the initial delivery ferry flight , on July 4, 1982, that took the Orbiter to the Kennedy Space Center in Florida for its first launch. (Photo taken from NASA Web Site)***

Not only did Columbia's landing at Edwards require it to be ferried back to the Cape, but several key shuttle parts had to be carried back by T-38 aircraft for use on the other vehicles. These parts included a temperature sensor for the propulsion system, the nose-wheel steering box, an air sensor for the crew cabin, and one of the five general purpose computers. At the time of the Challenger explosion, NASA supposedly had four complete shuttles. In reality there were only enough parts for two complete shuttles. Parts were passed around and reinstalled in the orbiters with the earliest launch dates. Each time a part was removed or inserted, the shuttles were exposed to a whole host of possible servicing-induced problems.

In addition to problems caused by the flight 61-C of Columbia, the next Columbia flight, 61-E, scheduled for March also put pressure on NASA to launch the Challenger on schedule. The March flight of Columbia was to carry the ASTRO spacecraft which had a very tight launch window because NASA wanted it to reach Halley's Comet before a Russian probe arrived at the comet. In order to launch Columbia 61-E on time, Challenger had to carry out its mission and return to Kennedy by January 31.

**<u>Politics:</u>**

NASA had much to gain from a successful Flight 51-L. The "Teacher in Space" mission had generated much more press interest than other recent shuttle flights. Publicity was and con-tinues to be extremely important to the agency. It is a very important tool which NASA uses to help ensure its funding. The recent success of the Space Shuttle program had left NASA in a Catch 22 situation. Successful shuttle flights were no longer news because they were almost ordinary. However, launch aborts and delayed landings were more news worthy because they were much less common.

In addition to general publicity gained from flight 51-L, NASA undoubtedly was aware that a successful mission would play well in the White House. President Reagan shared NASA's love of publicity and was about to give a State of the Union speech. The value of an elementary teacher giving a lecture from orbit was obvious and was lost neither on NASA nor on President Reagan.

## <u>Sequence of Events</u>

**Monday, January 27, 1986:**

On Monday NASA had attempted to place Challenger in orbit only to be stymied by a stripped bolt and high winds. All preliminary procedures had been completed and the crew had just boarded when the first problem struck. A microsensor on the hatch indicated that it was not shut securely; it turned out that the hatch was shut securely and the sensor was malfunctioning, but valuable time was used determining that the sensor was the problem.

After closing the hatch the external hatch handle could not be removed. The threads on the connecting bolt were stripped and instead of cleanly disengaging when turned the handle simply spun around. Attempts to use a portable drill to remove the handle failed. Technicians on the scene asked Mission Control for permission to saw the bolt off. Fearing some form of structural stress to the hatch, engineers made numerous time consuming calculations before giving the go-ahead to cut off the bolt. The entire process consumed almost two hours before the countdown was resumed.

Misfortunes continued. During the attempts to verify the integrity of the hatch and remove the handle, the wind had been steadily rising. Chief Astronaut John Young flew a series of approaches in the shuttle training aircraft and confirmed the worst fears of Mission Control. The crosswinds at the Cape were in excess of the level allowed for the abort contingency. The opportunity had been missed and the flight would have to wait until the next possible launch window, the following morning. Everyone was quite discouraged especially since extremely cold weather was forecast for Tuesday which could further postpone the launch.

**Tuesday, January 28, 1986:**
After the canceled launch on Monday morning there was a great deal of concern about the possible effects of weather. The predicted low for Tuesday morning was 23$^{o}$ F, far below the nominal operating temperature for many of the Challenger's subsystems. Undoubtedly, as the sun came up and the launch time approached both air temperature and vehicle would warm up, but there was still concern. Would the ambient temperature become high enough to meet launch requirements? NASA's Launch Commit Criteria stated that no launch should occur at temperatures below 31$^{o}$ F. There was also concern over any permanent effects on the shuttle due to the cold overnight temperatures.

All NASA centers and subcontractors involved with the Shuttle were asked to determine the possible effects of cold weather and present any concerns. In the meantime Kennedy Space Center went ahead with its freeze protection plan This included the use of anti-freeze in the huge acoustic damping ponds, and allowing warm water to bleed through pipes, showers, and hoses to prevent freezing.

The weather for Tuesday morning was to be clear and cold. Because the overnight low was forecast at 23$^{o}$ F, there was doubt that Challenger would be much above freezing at launch time. The Launch Commit Criteria included very specific temperature limits for most systems on the shuttle. A special wavier would be required to launch if any of these criteria were not met. Although these criteria were supposedly legally binding, Marshall Space Flight Center administrator Larry Mulloy had been routinely writing waivers to cover the problems with the SRBs on the recent shuttle flights.

Engineers at Morton-Thiokol, the SRB manufacturer in Utah, were very concerned about the possible effects of the cold weather. The problems with the SRBs had been long known to engineers Roger Boisjoly and Allan McDonald, but both felt that their concerns were being ignored. They felt that the request by NASA to provide comment on the launch conditions was a golden opportunity to present their concerns. They were sure that Challenger should not be launched in such conditions as those expected for Tuesday morning. Using weather data provided by the Air Force, they calculated that at the 9:00 am launch time the temperature of the O-rings would be only 29$^{o}$ F. Even by 2:00 PM, the O-rings would have warmed only to 38$^{o}$ F.

The design validation tests originally done by Thiokol covered only a very narrow temperature range. The temperature data base did not include any temperatures below 53$^{o}$ F. The O-rings from Flight 51-C which had been launched under cold conditions the previous year showed very significant erosion. This was the only data available on the effects of cold, but all the Thiokol engineers agreed that the cold weather would decrease the elasticity of the synthetic rubber O-rings, which in turn might cause them to seal slowly and allow hot combustion gas to surge through the joint.

Based on the these results, the engineers at Thiokol recommended to NASA Marshall that Challenger not be launched until the O-rings reached a temperature of 53$^{o}$ F. The management of Marshall was flabbergasted, and demanded that Thiokol prove that launching was unsafe. This was a complete reversal of normal procedure. Normally, NASA required its subcontractors to prove that something was safe. Now they were requiring their subcontractors to prove that something was unsafe. Faced with this extreme pressure, Thiokol management asked its engineers to reconsider their position. When the engineers stuck to their original recommendations not to fly, Thiokol management overruled them and gave NASA its approval to launch.

Rockwell, the company which manufactured the Orbiter also had concerns about launching in cold and icy conditions. Their major concern was the possibility of ice from either the shuttle or the launch structure striking and damaging the vehicle. Like Thiokol, they recommended against the launch, and they too were pressed to explain their reasoning. Instead of sticking with their original strong recommendation against launch, the Rockwell team carefully worded their statement to say that they could not fully guarantee the safety of the shuttle.

In its desire to fly out its manifest, NASA was willing to accept this as a recommendation. The final decision to launch, however, belonged to Jesse Moore. He was informed of Rockwell's concerns, but was also told that they had approved the launch. The engineers and management from NASA Marshall chose not to even mention the original concerns of Thiokol. Somehow, as the warnings and concerns were communicated up each step of the ladder of responsibility, they became diminished.

Late Monday night the decision to push onward with the launch was made. Despite the very real concerns of some of the engineers familiar with the actual vehicle subsystems, the launch was approved. No one at NASA wanted to be responsible for further delaying an already delayed launch. Everyone was aware of the pressure on the agency to fly out the manifest, yet no one would have consciously risked the lives of the seven astronauts. Somehow, the potential rewards had come to outweigh the potential risks. Clearly, there were many reasons for launching Challenger on that cold Tuesday morning; in addition a great deal of frustration from the previous launch attempt remained.

**Pre-Launch Events:**
Although the decision to launch on Tuesday had been made late on Monday night, it was still possible that something might force NASA to postpone the launch. However, the decision to launch had been made, and nothing was going to stand in the way; the "press on" mentality was firmly established and even if all of Florida froze over, Challenger would launch.

The pre-launch inspection of Challenger and the launch pad by the ice-team was unusual to say the least. The ice-team's responsibility was to remove any frost or ice on the vehicle or launch structure. What they found during their inspection looked like something out of a science fiction movie. The freeze protection plan implemented by Kennedy personnel had gone very wrong. Hundreds of icicles, some up to 16 inches long, clung the to launch structure. The handrails and walkways near the shuttle entrance were covered in ice, making them extremely dangerous if the crew had to make an emergency evacuation. One solid sheet of ice stretched from the 195 foot level to the 235 foot level on the gantry. However, NASA continued to cling to its calculations that there would be no damage due to flying ice shaken lose during the launch.

**The Launch:**
As the SRBs ignited, the cold conditions did not allow the O-rings to properly seat. Within the first 300 milliseconds of ignition, both the primary and secondary O-rings on the lowest section of the right SRB were vaporized across $70^o$ of arc by the hot combustion gases. Puffs of smoke with the same frequency as the vibrating booster are clearly present in pictures of the launch. However, soon after clearing the tower, a temporary seal of glassy aluminum-oxides from the propellant formed in place of the burned O-rings and Challenger continued skyward.

Unfortunately, at the time of greatest dynamic pressure, the shuttle encountered wind shear. As the Challenger's guidance control lurched the Shuttle to compensate for the wind shear, the fragile aluminum-oxide seal shattered. Flame arched out of the joint, struck the external tank and quickly burned through the insulation and the aluminum structure. Liquid Hydrogen fuel streamed out and was ignited. The Challenger exploded.

When the remains of the cabin were recovered, it became apparent that most of the crew survived the explosion and separation of the Shuttle from the rest of the vehicle. During the 2-minute 45-second fall to the ocean at least four of the personal egress packs were activated and at least three were functioning when the Challenger struck water. The high speed impact with the water produced a force of 200g and undoubtedly killed all the crew.

**Post-Crash Events:**
Since the crash of Challenger, NASA and external investigators have taken a look at both the shuttle and the sequence of events which allowed it to be launched. The SRBs have gone through significant redesign and now include a capture feature on the field joint. The three Marshall administrators most responsible for allowing the SRB problems to go uncorrected have all left NASA. Following the recommendations of the Rogers commission, NASA has attempted to streamline and clean-up its communication lines. A system for reporting suspected problems anonymously now exists within NASA. In addition, the astronauts themselves are now much more active in many decision making aspects of the program. The current NASA Administrator, Admiral Richard Truly, is a former shuttle astronaut.

## Safety and Ethics Issues

There are many questions involving safety and/or ethics which are raised when we examine the decision to launch the Challenger. Obviously, the situation was unsafe. The ethics questions are more complex. If high standards of ethical conduct are to be maintained, then each person must differentiate between right and wrong, and must follow the course which is determined to be the right or ethical course. Frequently, the determination of right or wrong is not simple, and good arguments can be made on both sides of the question. Some of the issues raised by the Challenger launch decision are listed here:

1. Are solid rocket boosters inherently too dangerous to use on manned spacecraft? If so, why are they a part of the design?

2. Was safety traded for political acceptability in the design of the Space Shuttle?

3. Did the pressure to succeed cause too many things to be promised to too many people during the design of the Space Shuttle?

4. Did the need to maintain the launch schedule force decision makers to compromise safety in the launch decision?

5. Were responsibilities being ignored in the writing of routine launch waivers for Space Shuttle?

6. Were managers at Rockwell and Morton Thiokol wise (or justified) in ignoring the recommendations of their engineers?

7. Did the engineers at Rockwell and Morton Thiokol do all that they could to convince their own management and NASA of the dangers of launch?

8. When NASA pressed its contractors to launch, did it violate its responsibility to ensure crew safety?

9. When NASA discounted the effects of the weather, did it violate its responsibility to ensure crew safety?

## References

**1.** *Actions to Implement the Recommendations of the Presidential Commission of the Space Shuttle Challenger Accident.* National Aeronautics and Space Administration. Washington, DC July 14, 1986.

**2.** *Challenger: A Major Malfunction*. Malcolm McConnell. Doubleday & Company, Inc. Garden City, NY. 1987

**3.** *Prescription for Disaster*. Joseph J. Trento. Crown Publishers Inc. New York, NY. 1987

**4.** *Report of the Presidential Commission of the Space Shuttle Challenger Accident.* The Presidential Commission of The Space Shuttle Challenger Accident. Washington, DC June 6, 1986.

## Challenger Launch Decision Assignments

The problem faced by NASA managers on January 28, 1986, is simply stated - Given the existing weather conditions, the recommendations of the various engineering and operational groups, and the political pressures, should Challenger be launched?

Many conflicting factors were considered in reaching the decision to launch. Those responsible for high risk programs such as Challenger must attempt to identify and evaluate the risks. Specific questions which needed to be answered were:
(1) What level of risk was acceptable for launch?, and
(2) Did the current conditions meet this standard?

Even properly identifying and evaluating all risks is not sufficient, because the potential benefits of taking each risk must be considered. Greater risks can sometimes be justified given the possibility of greater rewards. In the case of the Challenger, the people with the ultimate authority to launch came to the conclusion that the potential rewards justified what they believed to be relatively minor risks. The belief that the risks were minor, however, was not shared by many of the engineers further down the chain of responsibility.

### ASSIGNMENT A:

Read the General Information provided on the Space Shuttle Challenger launch decision. Consider each of the following questions carefully in light of that information and write a complete and grammatically correct paragraph answering each.

1. Why did NASA decide to launch Challenger?
2. How safe is safe enough? How does one determine what is an acceptable risk?
3. Is it possible to develop a methodology for quantifying risks, or must each particular situation be addressed individually?
4. Were NASA administrators justified in writing Launch Commit Criteria Waivers for Challenger and previous shuttle flights?
5. At the time of the Challenger accident there was a general feeling among both NASA and the public that the space shuttle was no longer an experimental vehicle, but was now a fully operational vehicle, in the same sense as a commercial airliner. Was this a correct perception and why was it common?
6. Should someone have stopped the Challenger launch? If so how could an individual have accomplished this?
7. If you were on a jury attempting to place liability, whom would you say was responsible for the deaths of the astronauts? Are several individuals or groups liable?
8. How might the Morton-Thiokol engineers have convinced NASA and their own management to postpone the launch?
9. How might an engineer deal with pressure from above to follow a course of action he knows to be wrong?
10. How could the chains of communication and responsibility for the shuttle program have been made to function better?

### ASSIGNMENT B:

Choose one of the following statements, research the topic, and write a two page paper in which you explore the impact of the topic on the Challenger explosion.

1. Following Apollo, the manned space program suffered from lack of funding and direction.
2. The design for the space shuttle is a series of compromises driven by poorly timed allocations of funds from congress.
3. To minimize R & D costs, only part of the shuttle system was made reusable and solid boosters were used instead of the safer liquid boosters.
4. NASA was under intense pressure at the time of the Challenger accident to prove that the shuttle was a viable launch vehicle.
5. A significant delay in launching Challenger would have upset the launch schedule for the rest of the year.
6. Flight 51-L (Challenger) was scrubbed the previous day leaving all involved frustrated and determined to launch as soon as possible.
7. No test data on any of the shuttle components existed for the low overnight or launch temperatures.
8. Problems with the seals on the SRBs had been known for several flights and waivers had been written for each flight.
9. Concerns about the O-rings were never revealed to the NASA administrators who had the final launch authority.
10. Morton-Thiokol initially recommended against launch, but when pressured by NASA reversed its decision.
11. The anti-freeze plan left large sheets of ice and icicles all over the launch structure. An analysis done at Houston showed no danger at lift-off due to falling ice.
12. Rockwell could not guarantee the shuttle's safety, but did not veto the launch. Their ice analysis showed some possibility of danger.
13. The ice-team recommended against launching, but was overruled by Mission Control.

## ASSIGNMENT C:

Divide the class into small groups, no more than three to a group. Each group is to choose one of the four roles outlined below and develop a statements outlining the position represented by those in your role on January 28, 1986. Develop two statements:
(1) what you think was the position of those in your role, and (2) the position that those in your role should have taken.

(1) NASA Management: You want to launch the Challenger as soon as possible. The delays are not only embarrassing, but threaten your funding and customer base. Challenger must launch on Tuesday to preserve the schedule. An analysis done by your engineers at Houston shows that the ice on the pad should not strike the Challenger when it lifts-off.

(2) Thiokol Engineers: You believe it is not safe to launch, but have no hard data to back this up. Limited data from a previous cold weather flight indicates that temperature is important. Basic physics tells you that the O-rings will lose elasticity with decreasing temperature. You feel that both NASA and your own management are trying to solve the problem with a bureaucratic solution, when an engineering solution is called for.

(3) Thiokol Management: You must listen to your engineers, but at the same time you must please your primary customer. There is talk in Congress of awarding a second source contract. The last thing you want to do is admit that your product is defective. NASA is pressuring you to launch. If would be very damaging for your company if a delay is blamed on your SRBs.

(4) Rockwell Management: You are concerned about the amount of ice on the pad. Analysis by your engineers does not entirely agree with that done at Houston. Like Thiokol you must satisfy your customer. You would prefer not to launch, but are not sure that your reason to delay is good enough. Your objective is to try to convince NASA to delay without them pointing a finger at you as the cause.

## ASSIGNMENT D:

Working in three person groups, develop a realistic procedure for making launch decisions which would have avoided the Challenger accident. Remember that the procedure must create a consensus among individuals and organizations with different objectives, backgrounds, and priorities. Part of your work will require that you develop a methodology to determine potential risks and benefits for launching the shuttle in less than ideal conditions. Remember that in the real world, personalities are often the dominant factor in a decision.

## ASSIGNMENT E:

Working in three person groups, consider the problems of Allan McDonald and Roger Boisjoly. Develop a strategy to convince Thiokol management and NASA management that your safety concerns were valid. Consider the points of view of all of those who are pressing to launch. Remember that management often tends to view engineers as extremely competent in a specific area, but lacking a good understanding of the big picture.

**The editors of "*TexethicS*" express their appreciation to Mr. Kurt Hoover, Dr. Wallace Fowler, Dr. Ronald Steadman, the Aerospace Department, and the College of Engineering at the University of Texas at Austin for providing this valuable source of educational information on engineering ethics.**

For more information about the Challenger and other shuttles, see the NASA web site: NASA.gov or
http://www.ksc.nasa.gov/shuttle/missions/51-l/docs/rogers-commission/table-of-contents.html

## An Excellent Web Site for Engineering Ethics is: www.niee.org

**This web site has an abundance of information related to engineering ethics, including over 130 Engineering Ethics Cases from NSPE/Board of Ethical Review. It also has links to many other web sites and several links to Codes of Ethics and Ethics Centers.**

## "Uses" of *TexethicS* and "Request for Input" for Future Issues

**This issue of *TexethicS* has been devoted primarily to educational materials that may be copied and used by faculty to present students some food-for-thought about ethical issues. Also, engineers in companies may want to copy the material and use it for discussions within their organization. This type of use is highly encouraged!**

**This philosophy of providing educational material will continue in future issues of *TexethicS*. If you have cases, articles, or materials of an educational nature that would be appropriate to include in the newsletter, please email the information to Jimmy Smith at jhsmith@coe.ttu.edu. If you don't have the material in digital form, you may fax it to us at 806-742-0444. *Thanks in advance for your assistance and guidance!***

**TexethicS** is distributed at no charge to engineering faculty members within the State of Texas and to others within the engineering profession who request to be included on the mailing list. **TexethicS** is one element of the Professional Development Program of the Texas Board of Professional Engineers and is sponsored by that Board.

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***Note to Readers:*** *Articles on engineering ethics and/or professionalism, and suggestions for future topics for the **"TexethicS"** Newsletter will be welcomed.*