EGS 4034 - ENGINEERING ETHICS AND PROFESSIONALISM
TEAM 3 – LIST OF PARTICIPATING MEMBERS:
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ASSIGNMENT 4

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1. **The technical engineering issues around the Challenger and Columbia disasters are different. However, there are a number of similarities between the cases, from an engineering ethics perspective. Discuss those engineering ethical similarities.**

The Software Engineering Code of Ethics and Professional Practice

4.01 *Temper all technical judgements by the need to support and maintain human values.*

First, there are similarities with judgement calls on both the Challenger and Columbia disasters. Bob Lund, Vice President for engineering at Morton Thiokol reversed his decision to proceed with the Challenger launch after Jerald Mason said, "Take off your engineering hat and put on your management hat." That specific instance was key in forgetting to support and maintain human life because there was no data to support or disprove that launching in the cold weather would cause the O-rings to fail. While Morton Thiokol tried several times to redesign the O-rings, NASA denied the request. The solid rocket boosters had video and physical evidence of gases escaping from the O-rings. Just the slightest amount of evidence should have been enough to warrant a redesign or at least a fix.

For the Columbia disaster, contentment was a factor of not addressing the ceramic shields that had fallen off during launch. Management in NASA saw that if this had happened before and nothing had gone wrong, the chances of something going wrong this time seemed to be minimal. In hindsigh, addressing the damage to measure what repair or recovery options were necessary should have taken place.

5.01 *Ensure good management for any project on which they work, including effective procedures for promotion of quality and reduction of risk*.

Both the Challenger and the Columbia shuttle disasters could have benefited from better management decisions on the side of Morton Thiokol and NASA. Proper managerial decisions can both save the lives of the astronauts and support the engineer's data. Contentment for the ceramic tiles coming off the Challenger in several instances should have been enough to investigate the causes and render a fix. Management should have addressed the ceramic tiles as a design flaw. Even if they were unable to determine a cause, an investigation, at the very least, is worth the human life of the passengers to minimize the risk.

3.06 *Work to follow professional standards, when available, that are most appropriate for the task at hand departing from these only when ethically or technically justified.*

Since the Space Shuttle program was new, everything was a learning experience. However, Morton Thiokol and NASA had standards for design, testing, and implementation. It is those standards that needed enhanced scrutiny to ensure the safety of the astronauts. In both cases, Columbia and Challenger, these standards were disregarded.

First, Challenger's launch was not delayed because Morton Thiokol did not do testing of its O-rings below 53 degrees Fahrenheit. That is a plausible reason since the launch site in an area of constant warm weather and suitable launching conditions. This is the same site where all the previous Apollo launches were made. However, to decide based on no test data was not a justifiable decision to make. In this case, no data should result in no action.

In addition, by being content with small pieces of the heat shield coming off at each launch was not a technically justified reason to ignore. To have a reason of if it had happened before with no consequences, then it can happen again with the same result is ludicrous. Reasoning such as this is guarantying something catastrophic will eventually happen, as it did with Columbia. A small statistical analysis could have shown the likelihood of failure to eventually happening.

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3.1 *Ensure that the public good is the central concern during all professional computing work.*

While neither of the Columbia or Challenger disasters were caused by software, but the few astronauts were not the central concern. For Bob Lund to reverse his decision and send the Challenger into launch with the temperature below freezing can be viewed as not having the astronauts good as a central concern. Each decision should have been made as if management were the ones going into space. Testing solid rocket boosters with suspect O-ring performance at below freezing temperatures just was not justifiable in Florida due to the very nature Florida does not have freezing temperature. This was an ideal place to launch given the weather. However, given the pressures of the media, Vice President Bush being at the launch site, should have enabled management to be extra cautious in making decisions that place human life at risk.

This same ethical point is apparent with the Columbia disaster. Given the fact that ceramic tiles come off during launch and did not affect the re-entry, should not have given managers in NASA assurance that it would not happen again. An evaluation of the damage at the very least should have been made while in space. Contingency plans should have already been devised to address this issue or even fixed the issue before the launch.

2.2 *Maintain high standards of professional competence, conduct, and ethical practice.*

Professional conduct in this ethical provision is where the mistakes of Challenger and Columbia are similar. In both instances, management disregarded the advice of engineers to fix problems. For Bob Lund to first support his engineers and then reverse his decision to put on a managerial hat was not acting in good professional conduct. Support the advice of the experts, those that act in their competence. By changing his decision, it placed all the blame on himself.

Columbia's disaster was due to low professional conduct. Many different arguments can be made as to why an inspection of the damage was not done. However, to do whatever it takes to bring astronauts back to Earth safely was a short coming. Once again, the decision to not view the damage to the heat shield showed a lack of professional conduct. While engineers cannot plan for every instance, cost of accounting for every instance can be expensive, but implementing emergency plans early in the design phase for an even such as this should have been priority. Safety should always come first.

2. **While the general purpose computers (GPCs) were not responsible for either of the disasters, given the requirements outlined in the article, if you were a**

software engineer working/leading software development for the GPCs, evaluate and explain (defend) the non-duplicative principles and responsibilities from both the codes of ethics that you believe would mostly impact your attitudes, behaviors, and work results. Be sure to clearly identify the designation of each provision as it is listed in the applicable codes.

Given the incredible importance of general-purpose computers (GPC) to work in the context of space shuttle navigation, it's important to discuss and implement the underlying principles that goes into the design, development, and deployment of the product. The lack of cohesive and harmonious principles may lead to the disasters outlined in the text, costing the lives of several people. As was mentioned in the Space Shuttle Era article, the reliability of GPCs are crucial to the operation and safety of the crew, with only a 120 millisecond difference between a vehicle that is in control and one that is not. With this in mind, striving for a high-quality product would be one of the more important factors as outlined in the:

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2.1 Strive to achieve high quality in both the processes and products of professional work.

Only a fraction of a second could jeopardize the safety of crew members. Further, if there are software errors and the crew are currently stationed in orbit, the cost of fixing an error could increase dramatically by sending a qualified individual to the vehicle. Another principle to consider:

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2.6 Perform work only in areas of competence.

It's self-evident that technology that plays a critical role in the safety and well-being of others should be operated, developed and maintained by those who are competent. This also includes the team setting reasonable goals within a reasonable timeframe. This may also extend into the decision-making process of management, where an engineer's perspective on early deployment could be vital. This was seen during the *Challenger* incident. To ensure that an engineer is working within their area of competence, we can look at another principle from

Software Engineering Code of Ethics and Professional Practice

3.07. Strive to fully understand the specifications for software on which they work.

There are a lot of things to take into consideration with spacecraft and it is probably one of the most complex operations humans do. With that said, it was mentioned in the article that Microsoft Windows is *probably* more complex than the GPC used in spacecraft. Even so, working with operating systems can be very complex and a lot can go wrong. Therefore, it is imperative that a thorough understanding of the underlying software of critical technology is understood before implementation.

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4.03. Maintain professional objectivity with respect to any software or related documents they are asked to evaluate.

Remaining objective on the quality or deplorability of a product may be hard to achieve if there is outside pressure to release an unfinished product. This was shown during the *Challenger* incident where Bob Lund was told to take off his engineering hat and put on his manager one when deciding to launch the space craft or not. This led Lund to reverse his position on launching. If Lund were to remain objective when "switching hats", then he would have likely concluded that the concern from the engineers and the consequence of what would happen if something did go wrong would yield a high-risk situation.

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3.01 Strive for high quality, acceptable cost and reasonable schedule, ensuring significant tradeoffs are clear to and accepted by the employer and the client, and are available for consideration by the user and the public.

To undertake the endeavor of designing and building the space shuttle is to completely invent a new vehicle that is capable of all the design parameters that NASA set forth to Congress. First, the parameters in which NASA sold to Congress were very ambitious. At the time, they thought they were feasible. However, hindsight shows that the expectations of several flights a year as well as being a competitively cost-efficient program were not realistic.

First, the priority of leading the development of the general-purpose computers (GPC) would be to clearly state to NASA the time for testing and developing. Setting the expectations up front of using extra time for development and testing is essential. Designing computers to with stand radiation and the extreme vibration of the shuttle is not easy. In addition, setting the expectation with NASA to develop a process in which upgrades, software patches, or even a complete overhaul should be seamlessly implemented. Scheduling this time can allow for design changes in between flights. It can also account for the unexpected. Setting the expectations up front with NASA of possible design changes in between flights, ensuring there is a process in which the changes can seamlessly be implemented and having a plan in place for the unexpected can help eliminate problems. If a problem occurs, even without incident, it is still essential to fix. Problems experienced to and from space are exacerbated. Being ready for the unexpected can ensure confidence in NASA, the astronauts and the company supplying the product.

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6.04 Support, as members of a profession, other software engineers striving to follow this code.

As a lead or developer of the GPC, it is essential to support colleagues who are striving to support the Software Engineering Code of Ethics and Professional Practice, as well as the ACM Code of Ethics. Supporting your colleagues to mention anything that is wrong with a release that can impact human lives, as with the Space Shuttle, is vital. Support is the backbone to others that another engineer believes in them. This has a positive impact in the attitude to produce accurate and timely results. When engineers, in general, are supportive, it relieves the negative stress and burden a person can carry. This negative stress can affect the attitude of the engineer. If the attitude is compromised, then corners can be cut, results can be altered or even given a misleading interpretation.

Setting the attitudes of the GPC engineers to know that fixes will have to have fast turnaround times, expectations of results are crucial to be accurate, even if the results are disappointing. Providing a positive lead by example to the engineers to ensure that their expertise is utilized in the most efficient manner can affect the attitudes of the engineers. This behavior is essential to not install an autocrat type leadership, but a leadership in which engineers are enabled to prevent premature releases of the GPC. It is also imperative to set the expectations of the GPC engineers to openly disclose any bugs without repercussions. Testing hardware and software on Earth is far different than testing the equipment in space. To test for every possible event is not possible, however, being ready for an unforeseen event is crucial.

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2.2 Maintain high standards of professional competence, conduct, and ethical practices.

A good leader and manager can enable other engineers to be the project manager of their expertise. In the case of designing and developing the GPC for NASA, separate engineers can oversee the different stages. An engineer can take charge of the testing, developing, implementation, and design. This will allow engineers to perform in their areas of competence. Further, this will develop engineers to be leaders themselves to promote ethical conduct. Engineers' attitudes, behaviors, and strive for excellence will follow a positive path. Enabling engineers to develop in the area they are most talented promotes positive behaviors, positive results, and pride in their work. This can also create a positive working environment in which when things do go wrong, colleagues are there to help to fix the problem and produce the best fix possible.

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2.5 Give comprehensive and thorough evaluations of computer systems and their impacts, including analysis of possible risks.

At this stage, evaluating the GPC's to determine the risk of failure is imperative to be accurate and thoroughly tested for human safety. Document the expected behaviors of the GPC to compare with testing and design. A test-based development is one way to make sure development passes the tests set before development. However, this approach can lead to development of those specific instances. Therefore, a comprehensive evaluation of the computer system is needed to determine the amount of risk the system has given certain situations. If the GPC's are developed and then put under a separate testing scenario, this could help find holes in the development and the design.

Risks can be determined in tiers, low-medium-high. Analysis of radiation failure, vibration failure, memory failure, or even software failure must be thoroughly evaluated. It is obvious that the level of risk for the GPC's must be low for NASA astronaut's safety.

Designing this process to ensure seamless implementation with NASA to resolve any issues is vital to ensure risks are minimized.

3. **Discuss your team perspectives about your future engineering professional responsibilities in relation to both being loyal to management and protecting the public welfare.**

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Following established protocols set by management and protecting the public welfare by using due care is at the core of engineering ethics. Furthermore, company loyalty should never breach our ethical duties. Likewise, taking shortcuts and bad decisions could not only lead to career failure, but possible jail time. More importantly, as engineers, we must consider public welfare throughout manufacturing and design process. Although engineers could never account for every possible use and misuse, logical errors should be caught by competent engineers. Therefore, engineers should work in sectors that they are competent and feel comfortable within. Engineers interact with the society that they provide services to. Considering that, engineers must be as diligent as possible in order to make sure there are no potential issues throughout designing and implementations. Furthermore, the public safety is our utmost priority. Engineers use due care to protect and take care of the public's safety, wellbeing, and health. Potential breaches include job loss, license cancellation, or even potential prison time; if ethical breaches are discovered. Corporate loyalty should never interfere with our moral and ethical duty to do the right thing.

TEAM 3 PEER AND SELF EVALUATION MATRIX

ASSIGNMENT 4	Jordan Roysdon	Joshua Main-Smith	Stephen McDonald	Troy Crawford	**TASK MGR.(Y/N)**
Jordan Roysdon	100	100	100	100	N
Joshua Main-Smith	100	100	100	100	N
Stephen McDonald	100	100	100	100	N
Troy Crawford	100	100	100	100	Y
AVERAGE	100	100	100	100	