

BUSINESS INSIGHTS

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Charles R. Roberts
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The Unruly Advocate

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ABSTRACT

This case involves the termination of a long-term employee with an excellent work record who was injured on the job and placed on sick leave and worker's compensation. An anonymous phone tip led to surveillance that showed he was fully able to work despite still receiving benefits. This led to his termination. Following termination, the employee filed a grievance that progressed to arbitration. The issue to be addressed in this case study is not the removal action but problems surrounding the unprofessional attitude taken by the Union advocate toward the arbitrator during the first few minutes of the grievance hearing, including rude and potentially prejudicial comments. This type of situation is rarely experienced at a labor arbitration hearing. Advocates sometimes engage in heated arguments that have to be defused by the arbitrator, but an attack on an arbitrator's honesty and integrity is extremely rare. The question is how to address the advocate's negative behavior in an effective manner so the hearing can move forward.

The Case

Robert K. Slick (the Grievant) had worked in the maintenance area at the Harper Valley Regional Medical Center (HVRMC) for more than 10 years and had an excellent work record. He reported an injury to his back at work, was placed on sick leave, and subsequently received worker's compensation. Approximately 13 months later HVRMC Security received an anonymous phone call reporting that the Grievant was assisting in the construction of his new house. The caller stated Slick had been observed climbing, lifting heavy loads, pushing wheelbarrows, and doing other heavy work. The construction site was placed under surveillance. Videos were made and submitted to the human resource management office at HVRMC, confirming what had been reported in the phone call. As a result, Slick was terminated. A grievance was filed contesting the termination and progressed through the grievance process until it reached arbitration.

The arbitrator appointed to this case is fairly

new, having been selected for only one previous case. His excitement about the appointment cools somewhat when he discovers the case is a discipline case that resulted in termination. When reading the appointment letter he does not recognize the name of Management's advocate but realizes he knows the Union advocate, who has been a guest speaker at the Labor-Management Relations class he has taught for the past several semesters at Muskrat Mountain State College. On reflection, the arbitrator realizes that the Union advocate must also be the person who recommended him to the labor panel service responsible for administration of case assignments.

When an arbitrator receives notice of selection for an arbitration case, the assignment letter usually provides only a minimal amount of information. Most letters will provide the names and contact information of the parties that will serve as the primary advocates, the name of the Grievant, and whether the issue is one of a disciplinary nature. If the grievance was filed to protest a collective bargain-

ing agreement (CBA) issue, in many cases the assigned grievance number will be accompanied by a capitol C. If the grievance is to challenge the discipline of an employee, a capitol D may accompany the assigned grievance number. Unless the parties take the unusual initiative of submitting some form of joint statement concerning the case, the arbitrator travels to the prearranged hearing site with very little knowledge of the issue to be arbitrated. As a result, there is no opportunity for the arbitrator to review or study similar cases.

The arbitrator made joint contact with the two advocates and a specific time and site for the hearing was agreed upon. Because either or both of the parties might have conflicting schedules, establishing a satisfactory hearing date can take considerable time. Unlike mediators, arbitrators attempt to avoid individual contact with the advocates to avoid any suspicion or suggestion that the case has been discussed without both advocates being present. The widespread utilization of digital communication has greatly expedited agreeing on dates, hearing sites, etc.

A 9:00 a.m. hearing time was agreed upon. Arbitrators never want to arrive late for a hearing and try not to arrive early. If an arbitrator arrives at the site early and only one of the advocates is present (which in most cases would be Management's advocate), the absent advocate might think parts of the case had already been discussed. The arbitrator attempts to arrive at the location around fifteen minutes prior to start time but will delay his entrance to the room or site where the hearing is to be held until both parties are present.

At the very beginning of this hearing the arbitrator is shocked when the Union advocate assumes an arrogant stance, tone of voice, and demeanor and demands that Management's advocate be dismissed from the hearing and not be permitted to remain in the room. He justifies this request by stating that the Management advocate is the same person who handled the termination action and therefore he believes that the Grievant will not receive a fair hearing. The arbitrator, even though caught off guard by this rude and unexpected demand, collects himself and asks Management's advocate to respond to the request. Management's advocate explains that the human resource management (HRM) office does not maintain a large staff. As a result he fills several different roles, including handling disciplinary actions and serving as chief advocate during labor arbitration hearings

and negotiations. The arbitrator rules that this is not a valid reason to dismiss or remove Management's advocate. In a disgusted tone of voice, the Union advocate requests a break so he can call his business agent. The break is granted.

During the break the Union advocate is the only person who leaves the room. He returns very shortly and stands immediately outside the door while talking loudly on his cell phone. The advocate appears to be reporting to some higher Union official that he and the Grievant are not being treated in a professional or fair manner. He states the deck is stacked against the Grievant, who will not receive a fair hearing because the Arbitrator refuses to dismiss the official who took the termination action from his current role as chief advocate. The conversation can be heard by everyone in the room, including the Grievant. The arbitrator suspects it also has been overheard by other people in the immediate area.

Discussion Questions

1. During pre-arbitration introductions, should the arbitrator have revealed he already knew the union advocate through his involvement as a speaker in his Labor-Management Relations class at Muskrat Mountain State College?
2. Who is responsible for maintaining order at arbitration hearings and what is the origin of this authority?
3. How should the arbitrator deal with the remarks that the advocate made while talking on the phone outside the door? Should the conversation simply be ignored and considered as unfortunate behavior that sometimes will occur?
4. Are these types of rude behavior and inappropriate conversations common occurrences at arbitration hearings? If so, do leading textbook authors and trainers in the field of labor management relations devote a portion of their writing, research, and training energy to dealing with these issues?
5. Why did the Union advocate behave in this manner? Did he think he could gain some type of advantage from this behavior? If so, what could he gain?

Teaching Notes

General Discussion of the Case Elements

This case study provides supplementary material for textbooks and lectures on how management officials in both the public and private sectors can better manage and approach the difficult task of disciplining employees. The case showcases unprofessional behavior from a professional person who, without question, should know better. The case study is appropriate for both college and university undergraduate and graduate classes in the areas of management, industrial psychology, labor-management relations, organizational behavior, ethics etc. The training also would be valuable for management and union officials in the discharge of their everyday duties. It is especially appropriate for officials who are charged with the interpretation and applications of the terms of the CBA when attempting to settle workplace disputes. The case could also be utilized to supplement and enrich employee and management training programs in large and small organizations.

Some Suggested Possible Answers to Discussion Questions

1. The arbitrator is a university professor first and an arbitrator second. Professional arbitrators must walk a thin line to ensure they are viewed as neutral individuals who can and will interpret the CBA in an unbiased manner. The fact that the arbitrator is acquainted with either party in a professional manner should not be a problem. If the relationship were to evolve into a close personal friendship, he should excuse himself from accepting cases where the other person will be acting as an advocate. Attending professional conferences and other professional activities provides an opportunity for the arbitrator to become known and to meet other people as well as help strengthen the arbitration profession. According to Holley, Rosse, and Wolters (2016, p.561), if the arbitrator is in doubt, he should disclose a connection that would affect his objectivity or give the appearance of affecting his objectivity.
2. An arbitrator is the invited guest of both Parties at the hearing. The arbitrator acts as presiding officer and final decision maker at the hearing. The collective bargaining process belongs to the Parties but the hearing belongs to the arbitrator. The arbitrator must make decisions that are often unpopular, such as ruling that certain

evidence or testimony is irrelevant and should not be admitted into the record. He bears the responsibility of keeping the hearing going in a professional and civil manner and preventing inflammatory remarks from all involved. According to Holley, Rosse, and Wolters (2016), both union and management advocates frequently voice concern that arbitrators “cannot control the hearing properly, cannot rule on objections, cannot stop gratuitous hostile exchanges or rambling or redundant testimony” (p. 568).

3. The remarks cannot and must not be ignored. If the arbitrator fails to address the charges and comments in a very forceful and immediate manner, the attendees will wonder if the charges and comments are true. The arbitrator’s honesty, integrity, and personal courage have been called into question in front of all attendees and possibly the people in adjoining offices. These type of comments from the advocate are likely to convince the Grievant that he would not get a fair hearing or decision no matter what type of defense is put forward.
4. This type of behavior is rare and incidents like it are few and far between. Advocates sometimes make charges and inflammatory remarks toward each other, but at the same time normally address the arbitrator with almost obsequious politeness. The type of behavior shown here is somewhat similar to being disrespectful to a police officer who has pulled you over for speeding even though he might smell the 10 gallons of untaxed white lightning in the trunk of your car.
5. Trying to determine why people exhibit certain types of behavior can be fascinating but will always be just speculation. Holley, Rosse, and Wolters (2016, p. 567) note that it is commonly believed that, in some instances, union and management representatives believe that the arbitrator owes them a favorable ruling because these representatives provide financial and professional support. Arbitrators who return rulings against some advocates may be removed from the case or not selected for another case. One arbitrator who was selected to replace another prominent arbitrator was given the following explanation regarding the firing of the previous arbitrator:

“I’ll tell you why we fired him. The last case he had ended here at about 4 p.m. Mr. _____ expressed

considerable concern since he had to make a plane to New York and was running late. I assured him that he would have no problem. I carried his bags to the car, drove in excess of all the speed limits, went through back roads, even proceeded through changing traffic lights. After a hectic ride at and at considerable risk, I got him to the airport just in time to make the plane. I parked my car in a no parking zone. I even carried his bags to the gate. After all this you know, that (deleted) ruled against me” (p. 567).

- 6. Despite these examples and the information provided, we cannot know why the advocate in this case would attempt to upset the arbitrator by making critical remarks in his presence. The following reasons are purely speculation but are offered as possible reasons behind his be-

havior. (1) The advocate wanted the arbitrator to remove himself from the case so a different arbitrator could be obtained. (2) The advocate hoped that the arbitrator would feel threatened by the criticism and would show leniency toward the Grievant to avoid additional rude behavior and comments. (3) The advocate hoped the relatively new arbitrator would feel obligated to rule in his favor to avoid being removed from the panel when present panel members were reviewed and replacements were selected. Later, the arbitrator learned from more experienced arbitrators that the advocate had a reputation of attempting to bully rival advocates and, on occasion, attempting to bully arbitrators.

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Foreign Military Sales Logistics Support: A Case Study

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ABSTRACT

The purpose of this paper is to briefly describe the United States' logistical support program for Foreign Military Sales. Support is generally controlled by the Department of State and administered by the Department of Defense, with the infrastructure delegated to subordinate commands charged with Security Assistance and Foreign Military Sales case management. Due to the reduction of United States defense spending, contractors are increasingly providing logistics support. Increased contracting provides a positive alternative revenue source and serves to preserve production lines for defense contractors. Sub-contracted companies are emerging as significant forces in logistics support as well, with emphasis on foreign military customers. The results of this research indicate that foreign military logistics support will increase through Department of Defense outsourcing, and private industry can anticipate providing an increased level of support.

Background

Department of Defense budget reductions over the last decade have had a detrimental effect on the United States Armed Forces and the defense contracting industry as a whole. Defense contractors rely on the sale of manufactured goods and on sustaining those goods for survival. Logistics is a key component in the sale and maintenance of products supplied by the contracting industry, domestic and foreign. With Department of Defense reforms in place, and more reforms likely on the horizon, contractors began looking for alternate means of sale and support to maintain revenues, production lines, and ultimately to maintain relevancy in the defense industry. The Foreign Military Sales program is a logical and sometimes lucrative alternative.

Security Assistance

Security Assistance is a U.S. government service which encompasses twelve major programs, with seven administered by the Department of Defense. This paper addresses Foreign Military Sales Logistics. The remaining programs all have links to Foreign Military Sales, either direct or indirect, and will be noted as necessary. The Defense Security Co-

operation Agency directs, manages, and supervises all Department of Defense Security Assistance programs under the direction of the State Department.

History

A form of security assistance can be traced all the way back to the earliest recorded military history, when it was known as military assistance or arms transfer. Thucydides' History of the Peloponnesian War, written nearly three thousand years ago, details the transfer of arms and controversies surrounding that. One can draw a direct correlation between his account and today.

Virtually every President has dealt in military assistance or arms transfer. The United States Revolutionary War might have ended differently if it were not for the military assistance and arms transfer from the French to the colonists.

The term "Security Assistance" was introduced into foreign policy in 1947, during the Truman presidency. The policy defined "security assistance" as the transfer of defense-related materiel, services, training, and economic assistance to friendly countries in a calculated effort to strengthen their national se-

curity, and by extension, our own. President Truman addressed Congress in 1947 on the significance of this new foreign policy, stating, "I believe that it must be the foreign policy of the United States to support free people who are resisting attempted subjugation by armed minorities or by outside pressures. The free peoples of the world look to us for support in maintaining their freedom. If we falter in our leadership, we may endanger the peace of the world, and we shall surely endanger the welfare of our nation" (Hovey, 1965). This marked the birth of the Truman Policy which stated that, wherever armed aggression threatened peace, the United States was threatened as well. Every President since Truman has added to the initial Truman Doctrine and most Presidents since Truman have a doctrine relating to Security Assistance named for them as well.

Logistics

Logistics, as defined by the Defense Institute of Security Assistance Management (2013 January), is a fully integrated system which involves four elements: acquisition, distribution, sustainment, and disposal. Another more comprehensive definition, and one more relevant to Foreign Military Sales Logistics, is the science of planning and carrying out the movement and maintenance of forces. In its most comprehensive sense, it involves those aspects of military operations which deal with the "design and development, acquisition storage, movement, distribution, maintenance, evacuation, and disposition of materials" (Defense Institute of Security Assistance Management, 2013).

Given the latter definition, a better term for logistics in this instance might be *Life Cycle Logistics Support Planning*. This form of logistics planning is a cradle-to-grave approach to logistically maintaining a piece of equipment. The planning process has multiple interrelated phases that assist both the Foreign Military Sales customer and the United States government. The primary process in the planning is "Definitization," a process that determines the provisioning requirements and is adjusted to the foreign customers need. This process differs from the United States provisioning process only in the customer requirements based on specific needs and differences in equipment sold due to security reasons or technologies not cleared for release. The primary goal of definitization is to optimize logistics sustenance, at a practical cost, using the most probable projections of needs. Definitization is essential in ensuring satisfactory and individualized support for the purchased

system.

Foreign Military Sales Logistics Support

When a foreign customer has completed the purchase of a system, it is vital that preparations begin immediately to guarantee constant logistical support. A responsive logistical support organization is required to sustain systems at a stated level of readiness and to integrate updated or required modifications to the purchased system as needed. Weapons system acquisition by Foreign Military Sales customers involves configuration management and placement of orders for all associated products and services required for utilizing the system, including monitoring program milestones and tracking deliveries in-country. Initial support is a continuation of the acquisition phase, establishing required maintenance and sustainment capabilities and materiel requirements.

When a customer in a foreign country utilizes the Foreign Military Sales system, contracting is simplified. The Department of Defense becomes the contracting agent for the Foreign Military Sales customer, meaning the customer is not required to solicit a contractor. The Department of Defense is required by law to comply with Federal Acquisition Regulations, making the Foreign Military Sales system less compliant than a commercial or customer contracted system might be.

The United States Foreign Military Sales program is structured to provide "one-stop shopping" for all support requirements for a customer's weapons platform. The larger the amount of varied United States systems that a customer possesses, the greater are the benefits of having a single point of contact for support, providing an economy of scale.

The Total Package Approach

A Total Package Approach guarantees Foreign Military Sales customers will obtain all essential support and services required in the introduction of equipment, and the equipment can be sustained for operation. Initial support is a part of the total package. Other items included in the total package may include spare parts, support equipment, requested training, required publications, technical assistance, ammunition, and follow-on support. Planning of follow-on support, training, and other essentials should take place concurrently while developing the total package.

Follow-on Support

A newly purchased weapon system without follow-on logistics support rapidly takes on the characteristics of a museum piece — impressive, but inert and immobile (Defense Institute of Security Assistance Management, 2013). Follow-on support involves a group of sustainment activities providing subsequent support. It is normally negotiated during weapon system acquisitions in order to accommodate long-lead production times.

Follow-on support is reactive rather than proactive. That is, demands are originated by the customer as needs are determined, not projected. Follow-on support logistics integrates requirements crucial in sustaining an operational weapon system. Follow-on support can include replacement of original spare and repair parts, obtaining support equipment not procured in the initial purchase, repair and return services, replacement of ammunition, updated technical publications and training, etc.

Discussion

The preceding introduction and descriptions of the current Foreign Military Sales program offered by the United States can raise questions regarding the efficiency and effectiveness of the program. The purpose of this research conducted for this study is to identify, articulate, and provide recommendations pertaining to the following questions:

Question 1. What are the unidentified shortfalls in the Foreign Military Sales Logistics program?

The current policies for foreign military sales, although touted as tailored to the customer, allow little deviation from a prescribed template of offerings. Foreign Military Sales Logistics as currently offered is restrictive in part due to the contracting policies of the United States government with defense industry manufacturers. Multiple customers buying the same piece of equipment can realize cost savings through economies of scale and, for the most part, this is an efficient marketing process. However, when a customer country purchases multiple related platforms, the economy of scale skews requirements and can create overages and shortages not normally associated with single-platform purchases. These issues lead to the second question.

Question 2. What is the integration plan for multiple platform Foreign Military Sales Logistics customers?

A 2015 quote from a customer addresses the lack of integration. The customer stated “while there has been much hard work planning Phase I, the initial fielding of (8) UH60M aircraft, the mission was not synchronized and had a number of shortcomings, which created unnecessary challenges in the program...[W]e must identify these shortcomings and layout a synchronized way forward.” The customer added that a plan is needed to ensure that future acquisitions can be implemented successfully.

That quote addressed the first round of deliveries of one platform. In all there were over fifty deliveries of multiple platforms and support equipment that were not synchronized or integrated prior to shipping and delivery. Below is a partial listing of noted discrepancies from these shipments:

- Delivery and set-up of tooling, spare parts, Aviation Life Support Equipment (ALSE), etc., prior to aircraft delivery not accomplished
- Questions of who was responsible for receiving shipments
- Supply distribution system
- OEM representatives mistakenly assumed assistance was in place for set-up and installation of aircraft simulators
- Support requirements, licensing, operation, and sustainment not clear
- Lack of short and long term contractor’s integration

Conclusions

The Foreign Military Sales Logistical support and services program is continuing to evolve. As a highly successful and profitable program in a time of military downsizing in the United States, this program will not only survive, but most likely thrive. However, improvements are necessary. Foreign governments are continually seeking the best value for their respective country and best equipment for their military. In the last two decades a number of mechanized countries have entered the Foreign Military Sales market. One aspect of the United States’ program that sets it apart from competing

countries is the logistical support offered and provided; most other countries do not conduct a high enough volume of business to justify the high level of support offered by the United States.

The cradle-to-grave Total Package Approach, when executed correctly, is a great selling point. This approach is only offered by the United States' Foreign Military Sales program.

Recommendations

Those in government service in the United States Foreign Military Sales program are charged with a very specific task: "be the best steward of the customer's money as possible." In order to fulfill that task, a new view of business is necessary. All the guidance, policies, and regulations mean nothing if not followed. Program managers at every level in the United States Foreign Military Sales program would be well served with a refresher on program integration.

If a customer country is purchasing multiple different but related platforms, such as three different types of aircraft, and expect concurrent delivery, then it is incumbent on program managers to communicate, coordinate, synchronize, and optimize the Total Package Approach. By doing so, overages, shortages, unintentional deletions, and duplication of efforts can be greatly reduced. The cost overrun of duplicated materiel alone is one area where proper management could easily reduce the overall cost to the customer. Defense industry contractors will readily over-supply the customer if the government is not attentive and actively involved in ensuring the proper package is procured and delivered.

Lastly, integration, synchronization, and optimization before, during and after the purchase and delivery of equipment is crucial. This is the weakest link in the United States' Foreign Military Sales program. Too often a task is completed and never revisited for accuracy, timeliness, and ultimate success or failure. This lack of follow up creates voids in the service expected by the customer. The assignment of a "Program Integrator" with direct influence on the entire program, a person responsible and accountable for bringing all the pieces together at the right time and place and delivered on schedule would be a significant cost-saver to the customer. This simple solution has been put forward and tested, but is not yet instituted. Implementing this

solution would help the customer and enhance the usefulness of the Foreign Military Sales program.

Summary

Department of Defense policy is to support Foreign Military Sales customer platforms and associated equipment. This policy dictates that both initial support and follow-on support are included in the total package approach. This ensures that customers acquire all required items of support and services essential for the introduction and operation of major platforms and associated equipment. It is the responsibility of the purchasing country and United States Foreign Military Sales program managers to work together to ensure all needs and expectations are met. If these cannot be met, a plausible explanation should be provided. If the United States Foreign Military Sales program does not adjust policies to ensure that customers are provided with the best value for the money spent, countries seeking assistance will purchase from other mechanized countries. This loss of revenue to the United States government and to defense industry contractors will be detrimental to both.

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Paramedic Ethics v. Orders: A Case Study

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ABSTRACT

Is it ever acceptable to disobey direct orders and deliberately ignore official procedures? This case focuses on a paramedic team that responded to an emergency call and found a serious accident with several grievously injured victims. Another emergency team was already at the accident scene, but welcomed the assistance of the second team due to the extent of the situation. Hearing that a team was already on site, the district communications center ordered the second team to leave the scene and return to the base station. Recalling their training and oath to serve the injured, the team members made the decision to disregard the order and continued to assist the other paramedics. As a result, the second team was charged with insubordination and was disciplined. The question to be considered in this case is whether medical ethics supersede institutional policy and procedures.

Paramedic Ethics v. Orders: A Case Study

An emergency response team consisting of a paramedic and an emergency management technician (EMT) was called to a serious accident involving multiple injuries. They were faced with a scene of carnage – a family trapped in a minivan, two other vehicles with injured drivers and passengers, and several severely injured pedestrians. Two bodies lay in the road covered with sheets. Another emergency team was already on-site, assessing injuries and administering medical care. The second team immediately checked in with the leader of the first team and started working on the victims under his direction. Within a few minutes, while they were already fully involved in providing care, a call from the district communication center was received ordering the second team to return to the base office. The team members quickly decided to ignore the call and stay at the accident site until all victims were stabilized or transported to the hospital. As a result of this decision, the team was disciplined for insubordination and failure to follow orders. Both team members received a twenty-four hour suspension. The letter of suspension stated:

You were assigned an emergency, but the assignment was rescinded because of the earlier arrival of another emergency team. You failed to honor the rescind instructions and without permission remained at the site and proceeded to assist the other unit on duty, failed to notify the command center

of your location and apprise superiors you were assisting another unit.

A grievance was filed and subsequently appealed to arbitration. Both parties were provided the opportunity to present evidence and examine witnesses who testified under oath.

In opening remarks, management's advocate stated that the paramedic fire fighter and the emergency management technician (EMT) were assigned to the emergency call. The call was rescinded just as they arrived on site because of the earlier arrival of another emergency team. The rescind order was not honored and the team proceeded to assist the other unit. The communications center was not advised of the team's location or that the team was providing hands-on assistance to another unit. These actions and inactions, and the fact that proper written documentation was not submitted, hindered the orderly operation of the district as well as violating state law. The violations were serious enough to rise to the level of insubordination and management's actions were in conformance with the CBA. The advocate requested the grievance be denied in its entirety.

The District Fire Chief was management's first witness and stated the team did not have authority to remain on the scene without first obtaining permission from the communications center. The Chief testified that the communications center possesses

complete knowledge of areas requesting response from emergency teams. All employees are aware of the requirements to remain in touch and report their locations. Proper reporting is necessary for both legal and billing purposes.

The union's spokesperson opened by explaining that, because of the chaotic conditions observed upon arrival at the site, coupled with the fact that they heard another call for help on the radio, the paramedic and EMT made the decision to remain on-site and offer help to the first team that responded, considering that team to be in charge. The spokesperson stated that the paramedic and EMT believed that this action would best serve the needs of the injured and the interests and responsibilities of the district, and would provide needed stability and support to the other team. Both members of the emergency team felt that without their help, badly injured people would die. It was requested the grievance be sustained.

The paramedic was called as the first witness. She stated she was a member of the second emergency team to arrive on-site. The team did receive a rescind command, but ignored it because of the gravity of the situation and the number of seriously injured victims. Two victims were already dead when the order was received and others were in critical condition, potentially facing imminent death without immediate treatment. She believed that staying on-site to provide emergency care was the only ethical response to the situation and leaving seriously injured victims would be against medical principles and against the code of ethics she had sworn to uphold as an emergency medical professional. She stated she was fully aware of district operations policy and the requirements to maintain radio contact, to obtain permission to remain on-site after receipt of a rescind call, and to properly document activities. She said she had always obeyed her superiors in previous situations and had never conducted herself in an insubordinate manner. She stated she did not request permission to remain on-site because the critical need did not allow time to make the request and wait for a response. She took a secondary role in administering medical care and followed the direction of the leader of the team in charge.

The union's second witness was the EMT who comprised the other half of the emergency team. He testified the decision to remain on site was a joint decision and cited the same reasons for the

decision previously described by the paramedic. He stated all members of emergency response teams periodically receive training allowing them to make appropriate decisions whenever the need should arise. He stated he and the other team member were putting their training to work when they made the decision to disregard the rescind order and to remain on site and lend assistance to the other team.

The union's third and last witness was the paramedic in charge of the team that first arrived on site and who was officially in charge. He stated he was not aware that the other team had received a rescind order when he made assignments for them to help. He said that the assistance of the second team was instrumental in saving several of the victims who probably would have died without that help.

Consider all of the facts. Make your decision and tell why you decided in the manner that you did.

Supplementary Notes

Collective bargaining agreements almost always contain a Management Rights section. The following is somewhat typical.

The right to hire and discharge employees and the management of all equipment, buildings, vehicles, offices, and all other departments, and all properties is reserved by the Company and shall be vested exclusively in the Company. The Company shall have the right to determine how many employees it will employ or retain, together with the right to exercise full control and discipline in the interest of proper service and production and the conduct of its business except as expressly restricted in this contract.

Collective bargaining agreements in many cases contain an article devoted to handling employee discipline. The following is somewhat typical.

A basic principle is that discipline shall be corrective in nature rather than punitive. No employee shall be disciplined or discharged except for just cause such as, but not limited to, insubordination, pilferage, intoxication (drugs or alcohol), incompetence, failure to perform work as requested, violation

of the terms of the agreement, or failure to observe safety rules or regulations. Any such discipline or discharge shall be subject to grievance-arbitration procedures provided for in the agreement, which could result in reinstatement and restitution including back pay. Many times progressive steps that must be followed during discipline are negotiated and enumerated. The following is an example: counseling, oral reprimand, written warning, letter of reprimand, suspension, termination.

Discussion Questions

It was an undisputed fact that the emergency team disregarded a direct order from management and remained on-site, lending assistance to the emergency team that first arrived at the site.

1. Did management provide consistent testimony in making their case that failure to honor the rescind order was insubordination?
2. Did management's witnesses provide consistent sufficient reasons for the disciplinary action?
3. Did the union witnesses provide viable, believable testimony that the team was justified in disregarding the rescind order?
4. The EMT testified management had provided training to assist teams in on-the-spot decision-making, which they had completed. He stated their decision to stay on-site and assist the other team was justified, in part, by this training. Is this supported by the testimony?
5. The emergency team believed strongly that ethics should take precedence over policies and procedures in this case. Do you feel that this is a clear-cut situation, or is the answer less definitive?

Teaching Notes

General Discussion of the Case Elements

This case study provides supplementary material for textbooks and lectures on how management officials in both the public and private sectors can better manage and approach the difficult task of disciplining employees who are perceived to be errant in following directions. The case also has application for administering discipline in areas other than following directions. The case study is appropriate for both college and university undergrad-

uate and graduate classes in the areas of management, industrial psychology, labor-management relations, organizational behavior, etc. The case study could be utilized in any type of decision-making training regardless of whether the organization is union or non-union. The training is also valuable for management and union officials in the discharge of their everyday duties and is especially appropriate for officials who are charged with the interpretation and applications of the terms of the CBA.

When reviewing the following suggested answers, keep in mind that different arbitrators will sometimes come up with widely differing opinions concerning interpretation and the application of arbitral principles to the same issue. Both parties spend a lot of time, expense and effort in training their officials to properly interpret and apply the CBA, hoping to avoid the expense of arbitration. The parties spend hundreds and sometimes thousands of hours in negotiation of the CBA. In discussions and conversations, both sides often emphasize that the only thing they are concerned about when selecting an arbitrator is that he/she render an unbiased, honest and clear decision on a timely basis.

Some Suggested/Possible Answers to Discussion Questions

Regarding the first two questions, management failed to provide consistent testimony or to address issues beyond the questions of policy and procedures. The inconsistencies and changes in management's testimony would cause an arbitrator to wonder which part of the testimony she or he could or should believe. "It seems clear, however, that material inconsistencies in the testimony of any witness will ordinarily detract much from the witness's credibility" (Elkouri & Elkouri, 2003, p. 415). Since management provided training in decision-making, that should have been considered in the testimony.

Questions 3 and 4 both would be answered yes, which strengthens the union's position. The complete testimony of the emergency team in charge was consistent with the testimony provided by the second team. Arbitration procedures and principles that were once uncertain are now second nature and are widely accepted. According to St. Antoine (1998), "Employees need not immediately obey an order or rule if they (a) reasonably believe it to be illegal, unethical, or immoral; (b) reasonably

believe that obedience would place the employee or others in immediate danger or harm; or (c) would suffer immediate and substantial harm, and would lack any satisfactory remedy after the fact. Even in these cases, however, disobedience will be excused only if the employee has no other feasible way to resolve the dispute” (p. 175). The union and their witnesses provided unrefuted testimony that two people died at the scene and others were critically injured, some requiring immediate emergency treatment. Management failed to produce any testimony or evidence that the second team acted in a reckless or insubordinate manner or that a satisfactory remedy existed that could have been applied after the fact.

The response to Question 5 is a matter of personal opinion, but ethical issues are seldom clear-cut. Since this case concerns life-or-death decisions, it is perhaps easier for many people to come to a firm conclusion, but few situations are as obvious and often no authoritative answer can be given.

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Rapid Prototyping and its Impact on Industry

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ABSTRACT

This paper describes the process of rapid prototyping (RP), also called additive manufacturing (AM) or 3D printing, and the impact it has had on industry. There are three classifications for RP systems. Each of these classifications will be examined. The three main RP processes that will be discussed are selective laser sintering (SLS), stereolithography, and fused deposition modeling (FDM). This paper will examine each process in detail and determine the advantages and disadvantages in relation to their impact on industry. Many of today's industries have benefited from RP. Time and monetary savings are the primary benefits of RP. However, there are many more benefits that will be discussed. As with all newer technologies, there are some limitations. The limitations will be examined as well. Some examples of the wide range of RP capabilities will be given in order to show the revolutionary change that has occurred in industry in recent years. As technology advances, so will RP processes. The possibilities are seemingly limitless. In addition to the current impact RP has had on industry; this paper will provide some insight into how RP could change the future of industry.

Rapid Prototyping and Its Impact on Industry

Industry is always seeking a faster and more economical way to produce their products. "In product development, time pressure has been a major factor in determining the direction and success of developing new methods and advanced technologies" (Chua, Leong, & Lim, 2010, p. 1). Prototyping has become a solution to the problem. A prototype is a fit, form, and functional part that can be used to test a design that is created for a specific purpose. A prototype helps a designer determine if their idea is viable before final design and production begins. Creating a prototype saves time and money in the design process. As technology advances, the need for faster, less expensive, higher quality prototypes will be in demand. One prototyping process that has become increasingly popular and meets this need is rapid prototyping (RP). The RP industry was born in the 1980s. Its pioneer was Charles W. Hull, who invented the first commercial 3D printer (Hull, 2015, p. 26). RP is "a manufacturing process by which a solid physical model of a part is made directly from 3-D CADD model data without any special tooling" (Madsen & Madsen, 2012, p. 160). RP processes can create models faster than the traditional manufacturing processes.

Rapid Prototyping Systems

Classifications and Processes

Lieu & Sorby (2009) describe RP process as constructive processes and conventional manufacturing methods as destructive processes (p. 9-15). RP systems build a part layer by layer while traditional manufacturing methods take stock material and cut, press, and form it to create parts. Chua et al. (2010) offers three classifications for RP systems. They are liquid-based, solid-based, and powder-based (p. 18). Liquid-based systems begin with a material in liquid form. A laser is used to trace and heat in layers to form a part. Each layer is solidified by a process called curing. A common RP system that uses liquid-based processes is stereolithography. The first commercial 3D printer, invented by Charles W. Hull, was a stereolithographic printer called the Stereolithography Apparatus (SLA) (Chua et al., 2010, p. 35). The material used in stereolithography systems is a photo curable liquid resin. The stereolithography process includes a platform, vat of photo curable liquid resin, and an ultraviolet laser. The computer-controlled laser is used to trace and heat a layer of the photo curable liquid resin, hardening it onto the platform. The platform then lowers to begin the next layer. This bottom-up build process is continued until the part is completed.

According to Drazga (2013), stereolithographic printers are one of the more accurate printers with a build layer thickness of 0.06mm (p. 19). Another advantage of stereolithography is speed. Depending on the size and complexity of a part, it could be produced within a day. Currently the only material for stereolithographic 3D printers is the photo curable liquid resin that in its solid-state form is a hardened plastic. The down side to this material is that it is more toxic than material used in other RP processes. Stereolithographic 3D printers cannot produce metal parts. Stereolithography is also more expensive in terms of material cost and machine cost than other RP systems. Another disadvantage to stereolithography is that it requires post-processing and post-curing using an ultraviolet oven which adds to the time it takes to produce a part. Stereolithography is used in industry to produce highly accurate models used for prototyping. It can also be used to create molds used to produce products in higher volumes. An example of this is dental molds for producing dental impressions used to create braces (Drazga, 2013, p. 48).

Solid-based systems encompass all processes that begin with material in the solid form, except powder (Chua et al, 2010, p. 20). Chua et al (2010) classifies solid-based systems into two methods, the fusing method and the joining method (p. 20). An example of an RP system that is a solid-based system and uses the fusing method is fused deposition modeling (FDM). Drazga (2013) documents that FDM was created in the late 1980s by S. Scott Crump (p. 8). The FDM process includes a lowering platform, a CNC-controlled extruder head, and melted thermoplastic or wire. The extruder head heats the solid material, melting it before dispensing it on the platform layer by layer. The melted plastic or wire begins to harden once exposed to the cooler environment. The platform lowers after each layer producing a part that is built in bottom-up design. The materials that are commonly used with FDM systems are thermoplastics like ABS (acrylonitrile butadiene styrene), biodegradable bioplastics like PLA (polyactic acid), PC (polycaprolactone), PPSF (polyphenylsulfone), wax, wire, water-soluble material such as PVA, and fire retardant material such as Ultem. Even more interesting, FDM printers can print with materials such as cake icing, chocolate, and cheese (Drazga, 2013, p. 19).

FDM processes are mostly used for creating prototypes; they can, however, be used for production

and manufacturing, given the correct material is chosen. According to Drazga (2013), “A key benefit of this technique is that objects can be made out of exactly the same thermoplastics used in traditional injection molding” (p. 19). For instance, products created using Ultem material are fire retardant making them useful for aerospace and aviation industries. This means that prototypes can look, feel, and function just like the manufactured part, making them very useful in design processes. FDM processes are also useful in the automotive, construction, medical, and art industries. One of the disadvantages to FDM is that it is slower than other RP processes. However, it is still faster and more cost effective for prototyping than standard manufacturing processes.

Powder-based systems are RP systems that use material that is in powder form. Some powder-based systems use a process similar to liquid-based systems and others use a process similar to the solid-based systems. A common example of a powder-based RP system is selective laser sintering (SLS). This system was created by Dr. Carl Deckard and Dr. Joseph Beaman in the 1980s (Drazga, 2013, p. 8). The process used in SLS is similar to a liquid-based system. The SLS process includes a powder bed, a laser, and powder material. A fine layer of powder is dispensed on the powder bed. The laser uses heat to fuse the powder together to create each layer of a part. The bed is lowered layer by layer and powder material added making this process a bottom-up build process (Drazga, 2013, p. 19). Common materials used in SLS system include “wax, polystyrene, nylon, glass, ceramics, stainless steel, titanium, aluminum and various alloys including cobalt chrome” (Drazga, 2013, p. 27).

An advantage to SLS is that it can produce many parts at one time, making it a more cost effective RP process option. This high-productivity factor means it can be used in “limited-run manufacturing to produce end-use parts” (Drazga, 2013, p. 28). Another advantage to SLS is that it produces little waste. The powder that is not fused during the build process can be recycled and reused. Other advantages include part stability, wide material range, and little post-processing and post-curing (Chua et al., 2010, p. 208). The disadvantages of SLS are printer unit size, high power consumption, and poor surface finish (Chua et al., 2010, p. 208). SLS processes can be used in arguably any industry due to the wide range of materials that can be

used.

Benefits and Limitations

The accuracy of RP processes is “generally equivalent to many high-volume production processes” (Lieu & Sorby, 2009, p. 9-17). The ability to produce a design for fit, form, function, and testing that is within 0.50mm accurate at a lower cost is the main and most important benefit of RP. RP allows engineers to make sure their designs are accurate before spending wasted time and money on production. The other major benefit is the ability to produce these prototypes in a matter of hours, depending on the material and complexity of the part. Standard manufacturing processes can take weeks because tooling has to be created before the parts can be made. Another benefit of RP processes is the capability of producing a component in assembled form, which saves production schedule and labor (Drazga, 2013, p. 13). Sometimes an engineer’s customer can get frustrated by not being able to accurately visualize a part that is presented in 2D drawing format. RP allows the engineer to provide a physical 3D object to the customer that they can touch and examine. The ability to produce these prototypes early in the design phase helps a project avoid significant costly changes late in the design process (Drazga, 2013, p. 39).

A couple of the main areas where RP processes could use improvement is in their strength and surface finish. While the parts produced by RP processes are very close in strength and appearance, they are still lacking compared to the manufactured parts created by standard manufacturing processes. Currently, only a few RP systems, like SLS, have the capability to support high-production. This means that standard manufacturing processes still hold the edge when it comes to mass production. Lieu & Sorby (2009) state that “as parts become larger or more numerous, the time required to form them bit by bit...makes these processes uneconomical” (p. 9-17). However, RP is rapidly becoming the industry choice for prototyping, which is one of the key components in getting a part ready for production. Another area for improvement is the cost of the materials. 3D printing material costs \$60-\$425 while injection molding costs only \$2.40-\$3.30 (Drazga, 2013, p.73). Large scale production cannot support these costs. The limitations of RP processes are being challenged daily. As new technologies emerge, the limitations experienced today will be corrected in the future.

Capabilities

RP processes have vast capabilities and can be used in many different fields. RP processes are used for prototyping and in some cases, manufacturing. They can produce anything from food to highly advanced aerospace components or assemblies. RP processes can use materials from cake icing to metals creating a wide range of possibilities for any industry. The main industries that have been impacted by RP processes are aerospace, aviation, automotive, and medical. According to Matthews (2011), “Aircraft and racecar manufacturers have been among the early adopters of 3D printing (p. 26).

In the aerospace and aviation industries, added weight in an aircraft or spacecraft is a major concern for engineers. Not only does added weight pose a safety risk, it also adds to fuel consumption. Aerospace and aviation industries are using RP processes to create components that are lighter in weight creating safer conditions for pilots and astronauts and saving money by reducing fuel consumption. The automotive industry primarily uses RP processes to create prototypes for small automobile parts. The automotive industry is not stopping there though. They are also experimenting with 3D printing the shells of automobiles. The medical industry has found ways to use RP processes to save lives and provide better health options for the individual. RP processes are being used to create customizable prosthetics. Medical centers are playing an important role in finding new ways to use RP technologies. One such medical center is the Walter Reed Army Medical Center. The center has implanted titanium cranial plates and, in June 2011, implanted a titanium jaw bone (Drazga, 2013, p. 47). Drazga (2013) notes that the implants “perfectly match a patient’s body and provide better fixation, which can reduce time and infection (p. 47). According to Matthews (2011), it was only in 2011 that the FDA approved the titanium hip implant (p. 26). This demonstrates how the accuracy of a prototype is important to the design process in fulfilling the desired outcome.

Future Technology

The automobile industry is not only experimenting with 3D printing the shells of automobiles. They also hope to 3D print the entire automobile. The aerospace industry is studying the effects zero gravity has on 3D printers. A company called

Made in Space has been able to successfully print an adjustable wrench using a 3D printer under zero gravity conditions (Matthews, 2011, p. 28). The medical industry is showing signs of some extraordinary technology in regards to RP processes. Researchers have begun experimenting with the ability to create organs and even bone, utilizing human tissue as a material. This RP technology is still in the beginning stages, but it has the potential to solve problems such as organ donor waiting and provide tissue regeneration solutions.

RP processes are increasingly becoming beneficial to the construction industry. The invention of concrete 3D printers paves the way for the possibility of printing entire buildings in the future (Drazga, 2013, p. 19). In recent years, green technologies have become common place in many different industries. RP inventors and innovators are addressing the issue in their field also. An example of this is the Filabot. It is a device that recycles plastic items such as milk jugs and soda bottles, turning them into useable material for 3D printers (Drazga, 2013, p. 34). Another concept sure to have a drastic impact on the future is cloud computing. Cloud computing allows the average consumer to design a needed item and send it over the Internet to a company that will print your item and ship it to you (Hull, 2015, p. 28).

Discussion

RP processes are still relatively new, but they are rapidly changing and adapting to the technological advances brought about by creative inventors and innovators. Future research for RP processes is now being funded and sponsored by government. Universities and centers are taking advantage of this sponsorship and are effecting revolutionary change with their findings. RP processes have impacted industry greatly, however there are still some limitations to RP. As technology advances, these limitations are sure to be addressed. Known processes will be adapted and new processes will be found, which will spark a great change in the way industry operates.

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SOCERNOMICS

Salaries for World Cup Soccer Athletes

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ABSTRACT

This article explores the problems and relationships involved with the pay differential between male and female athletes in U.S. professional soccer at the World Cup level. The criteria for investigating this contrast explores pay and performance of the U.S. Men's Soccer team in the 2014 World Cup as compared to the U.S. Women's Soccer team in the 2015 World Cup.

The level of professional soccer for both genders were participants in the respective World Cup teams and does not consider the earnings and opportunities to play professionally in various male and female soccer leagues worldwide. Other influences outside the U.S. Soccer Federation, primarily FIFA, are considered when comparing the pay differences.

The conclusion of this review indicates that male soccer World Cup players are paid more than their female counterparts. Implications of these findings may suggest changes in the way remuneration is determined.

"The goal seemed like something more than just a goal, just as the game seemed like something more than just a game. When Carli Lloyd sped past a defender fifteen minutes into the final of the Women's World Cup last July and launched a shot halfway across the field, the long arc of the ball suggested how far women's sports had come. It was a shot that required boldness, strength, and astonishing accuracy. Not a Hail Mary, not a wish or dream, it was a statement of skill and mastery. This is what athletes can do, it said. This is what sports can be" (Thomas, 2016).

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Women in the Workforce

Throughout history, when women entered the workforce in large numbers, it was primarily out of necessity; there was a shortage of males to run the factories to make the equipment that the troops needed while they were at war. After World War II, women enjoyed working in the labor force and many desired to remain employed for several reasons. In 2016, women are running large companies, starting businesses, and doing things in business that 100 years ago, only men were doing. The reason only men could participate in business was not because women were incapable of business savvy, but because women were never given the opportunity. In the early 1900s, men worked in factories or in fields, and the women bore children, raised them, taught them, and performed household duties. Women were still considered property. They did not even receive the right to vote until 1920. When both World Wars occurred, men were drafted and taken away from their families, leaving the women to make a living while maintaining the home. Women realized that they were more valuable to their families and country in the workforce which led them to start comparing pay differences between males and females. Throughout history, men have been paid more, but as women were increasingly doing "men's work" and doing it very well, this differential led to the issue of pay equity (Rosie the Riveter).

Women who were working in the same jobs as men were being paid significantly less. According to Laura Bassett of the *Huffington Post* (2013), in 2012 women made 77 cents on a man's dollar of earnings. Thus, this would lead to women needing to work longer hours to earn the same compensation as men. In the 21st century the divorce rate is higher than in previous centuries. This is related to different factors; but if a woman is making less than men while she is married, she does not feel the strain as much as a woman who is living and surviving from her income alone. This means that if they were not already in the workforce women will likely enter it. To compete with men, women are returning to school to receive a university degree; but when they receive a job in the field of choice, the salary is generally lower than a man in the same entry level position in that field. The gender bias has been alleviated to some degree with structured raises and competency exams, but some women are still seeing the effects of the wage gap.

Gender Stereotypes and Inequities

When Susan Howell (2015) sat down with students, she requested men and women to ask each other questions about different gender stereotypes like men crying, and if women liked having their doors opened for them. The answers are what would be expected. The men said that they do cry, but rarely do they ever cry in public. The women responded with they like it when men open the doors for them, but it's not necessary. However, Schatt (2015) submitted a question for Howell to ask the students that she had not thought about asking, "Do you believe women will ever reach equality with men?" (p. 1). This is what Howell said happened: "without any encouragement each woman in unison shook her head and said no. While most... said they wanted equality, none of them could see it happening, at least not in their lifetimes" (p.1). This indicates that, although women are CEOs of large corporations and holding careers that only men did sixty years ago, we have a long way to go toward equality between genders which is where equal pay and equal worth issues begin. If we can close the gap of inequality between genders in the labor force, most of these issues will also be resolved.

Since World War II, when women entered the workforce, they have been paid less than men for the same job with the same responsibilities. President John F. Kennedy attempted to correct this social injustice with the Equal Pay Act of 1963. This law was an amendment to the Fair Labor Standards Act of 1938, with the goal of closing the gender wage gap by requiring that men and women in the same workplace be given equal pay for equal work. Then in 1964, President Lyndon B. Johnson signed the Civil Rights Act aimed at ending discrimination in the workplace based on race, religion, national origin, and gender (Congressional Digest, 2014, p.1). By 2016 the nation experienced improvements in wages and gender discrimination. Although there are more women earning equal pay now, as a nation we are still working on closing the gap. According to Caroline Fairchild (2015), there are "only 25 companies in the Fortune 500 that have female CEOs." Fairchild goes on to say that twenty years ago, there were no companies run by women in the Fortune 500. This is an improvement; however, is it the final outcome? No, the equal pay effort should not end until all citizens are treated equally. This sounds vague like "I want world peace," but wage equality is a measurable

goal, and over time, should be attainable. If we stop working toward equality, then it won't happen.

Gender Pay Gaps in Sports

The difference between male/female pay in the professional sports world has been an issue for a long time. It is also a very complicated topic. The "Women on Board Organization" is a group located in the UK and Australia. This association advocates for women to have equal access to directorship roles in industry. On September of 2016 this group published a study, "Gender Balance in Global Sport Report" (Tranter, Medd, & Braund, 2016), that found there is a vast gender pay gap within many sports and it was indicated that this was likely to grow larger. While this report primarily focused on sports played in countries which were part of the British Empire, there is evidence that this is a global problem—including sports played in the United States. While this was a single publication, it was one of many articles which appeared in newspapers and magazines during the first part of 2016 commenting on male/female professional wage inequality in sports. Specifically, these articles discussed the issue that five members of the victorious World Cup U.S. Women's National Soccer Team filed a complaint at the end of March 2016 with the federal Equal Employment Opportunity Commission. The members allege that U.S. Soccer Federation engaged in wage discrimination based on gender.

The complaint filed by the Women's National Team (WNT) was, ironically, the second volley of claims between the two parties. In February 2016, U.S. Soccer sued the union representing the WNT players in a dispute over continuing the terms of the old collective bargaining agreement (CBA) which included a "no-strike clause" (Thomas, 2016). Mitchell (2016) states that Edward Williams, who helped draft the Amateur Sports Act, finds the lawsuit unexpected. Williams is cited saying, "The whole concept that a governing body, which is supposed to be supportive of its athletes, would spend money and hire lawyers to sue its athletes is just outlandish" (Mitchell, 2016). As noted by Gillian White of *The Atlantic*, one of the issues involving the WNT during 2016, in which lawsuits were exchanged and the complaint files with the EEOC, relates to the current CBA they are currently operating under which expired in 2012. Rather than renegotiating the contract, the WNT signed a revised memorandum of understanding that kept the terms of their

old CBA until a new one was put in place, at the close of 2016.

This was the first instance where professional athletes formally challenged their governing body, the U.S. Soccer Federation, of pay differences based on gender. This was a unique opportunity to legally claim discrimination under the Equal Pay Act of 1963. The U.S. Soccer Federation is the sole administrator of soccer played in the United States, which includes all age groups, amateur and professional, and both genders. This meant that the elite American male and female professional soccer stars selected to play on the two World Cup teams have the same employer. As reported on "60 Minutes" (CBS), soccer appears to be the only professional sport where the male and female athletes come under the same organization. This is why the Equal Pay Act was uniquely relevant when examining soccer in the United States, and not when discussing other sports because of their two separate governing bodies.

When considering an Equal Pay complaint, it must be demonstrated that males and females perform equal work. As noted in the *New York Times*, in three of the past four years (2012-2016), WNT has played more games than the MNT. The women also have twice as many victories, 88 wins to the men's 44. This means that based on the data the women had to win more games and work harder than the men to earn much less (Das, 2016).

Because of the discussion and interest in the female complaint to the EEOC, the U.S. Soccer Federation was forced to be more transparent regarding salaries and other financial information. It was soon apparent that gender discrimination was related to wage inequality since the issue of "equal pay for equal work" could be clearly recognized by looking at the difference in remuneration of salaries between the two teams. In 2014, the United States Men's Soccer team placed 15th in the World Cup tournament. In 2015, the United States Women's Soccer team won the World Cup yet received less pay from both FIFA and the U.S. Soccer Federation. Mitchell (2016) of the *Daily News* reported that:

To provoke discussion of bias, Rep. Linda Sanchez (D-Calif.), along with Rep. Jackie Speier (D-Calif.) and Sen. Patrick Leahy (D-Vt.) co-sponsored a nonbinding resolution

asking FIFA to address this disparity. 'It very clearly highlights a pay gap just based on gender for people who do the same work,' Sanchez says. 'It's a very concrete example.'

The Organization of Professional Soccer

Before examining the specific data relating to the pay for males and females selected to play on the National Teams, it is important to understand the level and quality of professional soccer players analyzed regarding pay equity. The elite soccer players, male and female, who are offered the opportunity to play on the National Teams are evaluated on their performance in several designated events. Part of the selection process would also be the performance of the athletes playing for professional soccer clubs in established professional leagues in many countries.

It is important to remember that, historically, professional soccer (called "football" in the languages of different countries) has been played for over a century and, prior to the past 20 or 30 years, has been a male dominated sport. In fact, the first Women's World Cup championship was not played until 1991 and female soccer was not played until 1996 in the Olympics. The male leagues have large followings in other countries and the best players in the clubs are paid hefty amounts of their respective currency. The elite players make their huge sums of money from the clubs and the salaries are market determined and form a major part of their earnings. Bill Conerly stated that, "Top athletes play for 'club and country.' Club refers to their regular jobs for teams in the premier soccer leagues around the world. The most talented also play for country, their national team. Most earnings come from club salaries, with national teams paying less money, for fewer games" (Conerly, 2016).

The dominance of male players in the salary scale is further encouraged by FIFA, the international governing body of soccer which has always been a boy's club, and is responsible for the allocation of vast sums of money generated by the soccer leagues and World Cup competition. Julie Foudy is quoted by Elizabeth Mitchell (2016) as stating, "(FIFA officials) come from cultures where women don't play, or it's even a joke. Anytime you interact with them, the reality is that it's not on their radar."

Because Woman's professional league soccer is

relatively young and has lacked the full support of FIFA and the U.S. Soccer Federation, the opportunity for female soccer players to receive equal payment and comparable playing conditions is limited at all levels of the sport. Mitchell (2016) stated, "It's up to U.S. Soccer and FIFA officials to show that they respect what the women on the U.S. team and other teams have done on the field" (Mitchell, 2016). Therefore, much of the pay the elite WNT players earn currently comes from either FIFA or the U.S. Soccer Federation, which is precisely why they are fighting for higher/equal pay with the MNT.

In fact, many members of the WNT could go overseas to earn more money playing for other foreign leagues, but the WNT coach wants the best American female players to remain in the United States for two reasons. One, the coach can better judge the quality of play for females who are on teams in the National Women's Soccer League (NWSL), which is run by the United States Soccer Federation. In fact, the U.S. Soccer Federation pays the club salaries of the females selected to play on the WNT. Secondly, the coach and U.S. Soccer Federation want to build interest in female soccer teams to attract other potential players to start playing soccer. Keeping the "stars" at home helps to better promote the NWSL, which is the third attempt to start a women's professional league. In the case of the WNT, "it has been fighting discrimination in FIFA, soccer's international governing body; arguing against inequities in the United States Soccer Federation, the sport's national custodian, while defending itself against a lawsuit filed by the organization" (Mitchell, 2016).

Therefore, in the following analysis of male versus female pay in the United States WNT will not include "market rates" of pay to male soccer players in the Premier Soccer Club League play. This means that females playing soccer worldwide experience a pay disadvantage at both the National Team and the Club levels. The basis of this study is on "equal pay" of females versus males which is basically under the control of the FIFA and the U.S. Soccer Federation, and is the reason the WNT is making two different appeals, one is legal through the EEOC and the other appeal is about social justice (Thomas, 2016).

Analysis of Male v. Female Pay

Although this analysis does not include "market rates" of pay for the males, there is no doubt that

the enormous salaries paid in the premier leagues would have considerable influence on the distribution of earnings by FIFA in the form of the prize money (bonuses) to the teams participating in the tournament. While this might appear as gender discrimination between the males and females, it is the economic reality of the differences in “market driven” salaries between males and females playing for the elite clubs. As noted in *Forbes*, “The major consideration is that people with higher base earnings will demand more money for their time than people with lower base earnings. The bottom line is that the men on the national soccer team make a lot of money from their clubs, but the women don’t. Some of the men might not bother to show up for paltry pay, but the women are likely to be less particular—because their regular jobs pay so little” (Conerly, 2016).

The gender gap paid by FIFA for teams participating in the Men’s and Women’s World Cup can be seen in Table 1, and it is clearly biased toward the male’s teams. Despite FIFA’s motto “PLAY FAIR,” the world governing soccer body has been ac-

cused of this type of gender pay discrimination for a long time. The U.S. Female National Team won the World Cup in 2015 and received \$2 million. Germany was the winner of the Male National World Cup in 2014 and received \$35 million. The U.S. Male National Team reached the “Sweet 16” where teams received \$9 million. It should be noted that FIFA does not directly pay the players in an official capacity. Instead, FIFA pays the national organizations, and lets the nations’ governing soccer bodies decide how much they wish to pay the players (Meha, 2016).

“As far as World Cup pay, the USSF said that prize money is allocated to both the men’s and women’s teams by FIFA, not U.S. Soccer, and that the international soccer governing body allocates different amounts based on the commercial value of those two events to FIFA” (Gurrieri, 2016). This statement reinforces FIFA’s intention to completely ignore the “equal pay” argument to use revenue or the economic value of men’s soccer as the primary determinant of allocation of resources to the national organizations of the members of FIFA. It also

TABLE 1

WORLD CUP PRIZE MONEY (WOMEN VERSUS MEN) ALLOCATIONS OF FUNDS BY FIFA BASED ON FINAL POSITION IN THE WORLD CUP TOURNAMENT		
	WOMEN'S 2015 Prize Money	MEN'S 2014 Prize Money
Winners	\$2 million (USA)	\$35 million
Runner Ups	\$1.4 million	\$25 million
Semi-Finalists	\$700,000 each	\$19 million each
Quarter Finalists	\$400,000 each	\$14 million each
Round of 16	\$200,000 each	\$9 million each (USA)
Group Stage	\$100,000 each	\$8 million each
Participation Bonus	\$200,000 each	\$1.5 million each

(Total Sportek, 2015) [Women FIFA World Cup 2015 Prize Money (Doubled), 2015]

suggests that FIFA does not want to make the necessary investment in women's soccer which would be needed to bring the interest in women's soccer to the same level enjoyed by the men's soccer team. Also, the United States Soccer Federation's blame of FIFA for gender discrimination does not excuse them for promoting a national team pay scheme for the men and the women where much of the higher pay of the men has no real justification.

Unfortunately, the WNT members have no direct claim to the \$2 million prize money they earned by winning the 2015 World Cup. They have to rely on the U.S. Soccer Federation to distribute the funds based on agreements between the U.S. Soccer Federation and the collective bargaining units of the WNT and MNT. Although the two World Cup teams come under the U.S. Soccer Federation as a common employer, each team has their own bargaining agent which negotiates for the members of the respective teams. Therefore, in addition to having to deal with FIFA and U.S. Soccer Federation, the males and females each have their unique col-

lective bargaining agreements which are different, and the contracts for the two national teams expire at different times. This makes comparing pay between the two genders difficult and complex.

Table 2 shows the payment of different amounts to members of the Men's and Women's national team with payment of prize money (bonuses) by the U.S. Soccer Federation. Table 2 shows the 2014 Women's World Cup and the proposed bonuses for the 2018 Men's World Cup Championship. At this point, the bonus is given directly to the members of the two national teams. It is obvious that the practice of paying the MNT players greater amounts than the WNT continues. It is difficult to understand why the men's team that places in the top sixteen received \$3.6M to be spread out among the male players, and the female team and members were paid \$1.8M (2014). Why would the Women's championship team be paid so much less than the males who did not reach the quarterfinals? This appears to be the discrimination that probably caused concern for the members of the WNT and the main reason they filed a complaint with the EEOC. It

TABLE 2

US SOCCER FEDERATION MONEY (WOMEN VERSUS MEN)		
ALLOCATIONS OF FUNDS BY US SOCCER FEDERATION BASED ON FINAL POSITION IN THE WORLD CUP TOURNAMENT		
	WOMEN'S 2015 Prize Money	Proposed MEN'S 2018 Prize Money
Finish 1st World Cup Team	\$1.8 M	\$9.4M
Finish 2nd	\$780,000	\$6.25 M
Finish 3rd	\$480,000	\$1.25 M
Finish 4th	\$240,000	N/A
Semi-Finalists (team)	N/A	\$4.5 M
Quarter Finalists (team)	0	\$5 M
Round of 16 (team)	0	\$3.6 M
Group Stage (team)	\$345,000 each	\$2.5 M
Participation Bonus (team)	\$15,000 each	\$76,000

NOTE: This table is very misleading and the amounts paid show a greater pay inequality between the men and women. The men's performance bonuses aggregate if the men move further up the table. Women receive just the amount of final finish, starting with round of 16 (Santhanam, 2016).

would be surprising if the EEOC did not rule in favor of the females and declare the process violates the Equal Pay Act, and require the US Soccer Federation to address this discrepancy and adjust the way in which the prize money is divided between the males and females. This will likely upset the male members of the national team and result in a countersuit that will try to bring this matter into the discussion when the current contracts expire. One other thing that is apparent in the table is that the men's earnings in the earlier games relatively higher. It almost appears that the list is constructed to reward the men's success early in the rounds, while they are still in the chase, with the likelihood they will not progress further up the ladder. This has typically been the case of the U.S. Men's National Team.

Other Inequalities

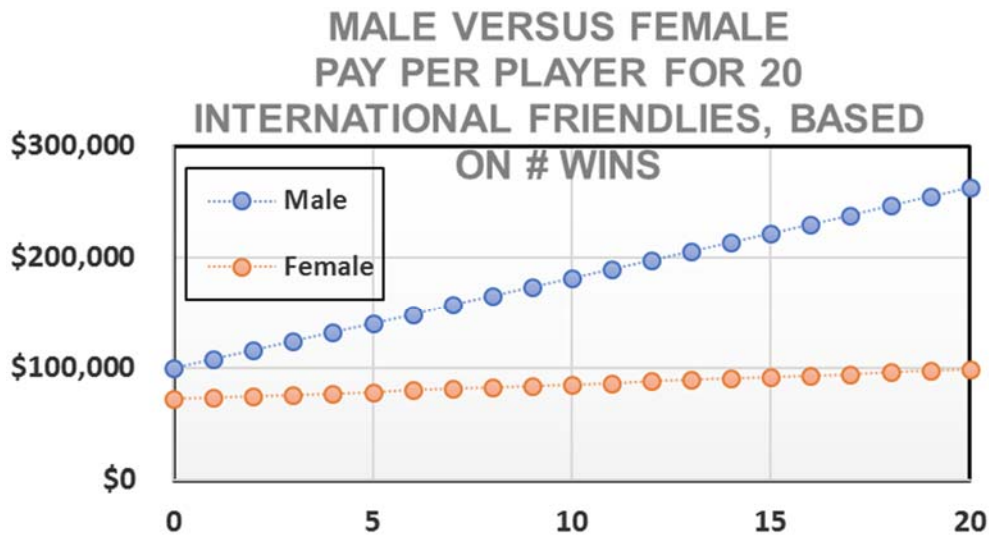
There is also another source of pay for both the male and female national teams—the international friendly matches or exhibitions against teams from other countries. The intent of these games is to allow the national team members to practice together in a less stressful environment, allow the coaches to experiment, and further stimulate interest in the sport of soccer at the highest professional level.

Given that women's professional soccer is a more recent spectator sport as compared to the men's game, this would be an important venue for the U.S. WNT to generate more interest in the sport and encourage young females to consider playing soccer at the youth level. However, since these games are primarily controlled by the U.S. Soccer Federation and other countries' governing bodies, the pay between the men and women national teams suffers the same gender discrimination. The males and females are required to participate in 20 of the friendly matches each year. Because of the two separate collective bargaining agreements negotiated by their respective unions, compensation of the players in the national team are structured differently, but the pay earned during the year depends on how many games the teams win. The men are "paid-for-play" receiving a per-game bonus of \$5,000/game if they are called in for a match and an average bonus of \$8,166 per win. Each female player receives a base salary of \$72,000/year which is increased with a \$1,350 bonus for each win. As shown in Table 3 and Graph 1, assuming players (male and female) participate in all 20 matches, the men will individually earn more money during the year, even if they lose all 20 games than the females can earn by winning all 20 of their games (Yourish, Ward, & Almukhtar, 2016).

TABLE 3

PAY PER PLAYER FOR 20 INTERNATIONAL FRIENDLIES					
BASED ON # WINS					
# Wins	Male	Female	# Wins	Male	Female
0	\$100,000	\$72,000	11	\$189,826	\$86,850
1	\$108,166	\$73,350	12	\$197,992	\$88,200
2	\$116,332	\$74,700	13	\$206,158	\$89,550
3	\$124,498	\$76,050	14	\$214,324	\$90,900
4	\$132,664	\$77,400	15	\$222,490	\$92,250
5	\$140,830	\$78,750	16	\$230,656	\$93,600
6	\$148,996	\$80,100	17	\$238,822	\$94,950
7	\$157,162	\$81,450	18	\$246,988	\$96,300
8	\$165,328	\$82,800	19	\$255,154	\$97,650
9	\$173,494	\$84,150	20	\$263,320	\$99,000
10	\$181,660	\$85,500			

GRAPH 1



NUMBER OF WINS — 20 GAMES/YEAR

The gender bias in pay is partially offset by the different approaches between the men's pay-for-play and the female's salary. If a member of the MNT does not play in an international friendly match for any reason, he does not receive any pay for that game and can effectively lose \$5,000 and, potentially, an average of \$8,166 winning bonus. Despite losing a considerable sum of money, the men on the national team have a security net of falling back on a lucrative salary from his professional club. The women's salary is a contractual agreement with the U.S. Soccer Federation and is more flexible in paying in the event a female cannot play in a game. The women have limited health benefits, payment in the form of severance pay if they are cut from the team, and maternity leave at half pay (Yourish, Ward, & Almukhtar, 2016).

There are also other forms of payment to the members of the WNT and MNT which are much smaller in value but still have the appearance of gender discrimination. The women receive \$50 per diem pay for travel in the United States and \$60 while traveling to foreign countries. The men receive \$62.50 and \$75 respectively for per diem pay. Additionally, men receive \$3,750 for a sponsor appearance while the females are paid only \$3,000 for each appearance. There is no doubt that the "fringe" payments are probably the most difficult numbers for the U.S. Soccer Federation to explain,

since there is no real justification. Ironically the per diem payments and appearance payments were equal before 2015 when an adjustment was negotiated into the men's CBA. As mentioned earlier, the WNT decided to enter into a memorandum of understanding to extend their CBA and did not have a chance to bargain for this increase. It is possible this discrepancy will be removed when the women negotiate the next CBA, and after all the legal issues are resolved. It is also possible that the females may decide to negotiate a "pay-for-play" scheme similar to the men's and give up the more stable, but lower rate of pay, salary scheme. The "pay-for-play" scheme would likely result in the higher pay the females are currently advocating as "equal pay" (Gaines, 2016).

Several other differences in the benefits between the two national teams are that the men travel first class and stay in top quality hotels while traveling away from home. The WNT cannot see any justification for the difference in travel and hotel arrangements. Finally, there is the issue of the WNT having to play on artificial turf in many of their games while the MNT always plays on natural grass. There are ample photographs of the injuries resulting from playing on artificial grass.

Up to now the discussion has focused on the payments made to female national team players as

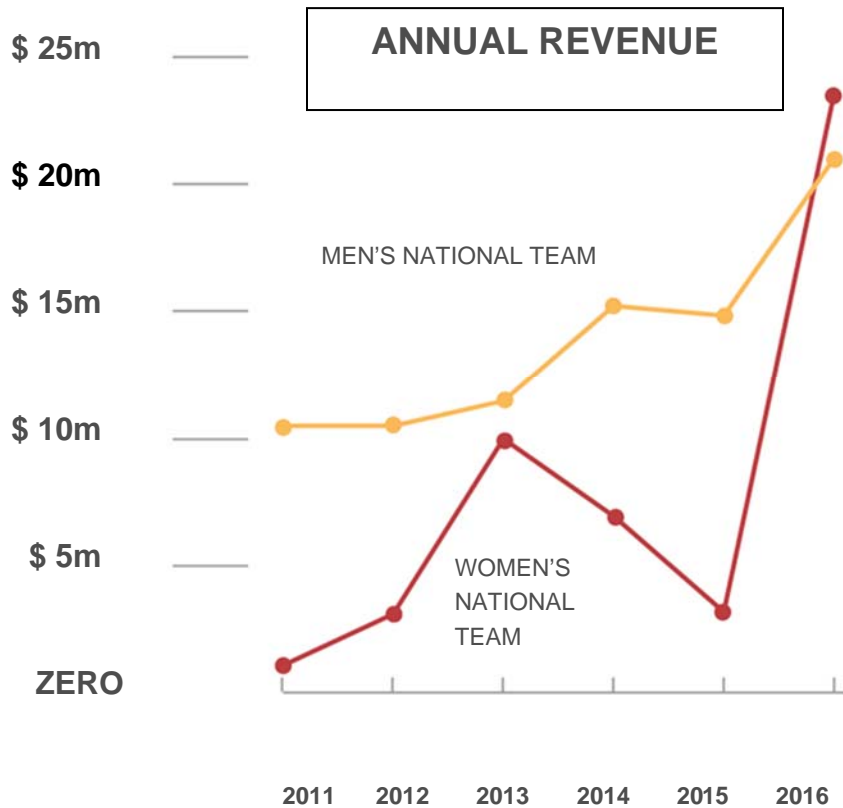
compared to the pay made to the men. It has been shown that at all levels of FIFA and U.S. Soccer Federation, starting at the top of the hierarchy (FIFA) and down, there is evidence that there exists a gender discrimination of various magnitudes with little, if any, rationale for the differences in pay between the men and women. However, there is a strong argument that the pay should be reflected in the revenue each national team earns during the year. In fact, in a statement made to *Sports Illustrated* several years ago, Sunil Gulati, the president of the United States Soccer Federation, challenged the use of “deserve” when asked whether the women deserved more pay than the men. He said: “I don’t want to use the word deserve in any of this, I’d reverse the question. Do you think revenue should matter at all in determination of compensation in a market economy?” (Thomas, 2016).

In 2015, as seen in Graph 2, the WNT produced more revenue than the MNT (\$23 million) which was approximately \$2 million more than the males. Guilati pointed out that the revenue generated by the female team was inflated by the final rounds when they won the Women’s World Cup in 2015. He further stated that, excluding revenue produced during a year in which a World Cup championship

is not played, the men’s team consistently draws bigger audiences in stadiums and on television. As noted in *The New York Times*, the long-established men’s game has brought in higher game revenue in the past which is also shown on Graph 2 (Das, 2016). Looking at this from the WNT’s perspective, they argue that the women will continue to produce a large share of domestic revenue which is reflected in the U.S. Soccer’s budget projections which shows that: “Thanks to the Women’s World Cup, the women are expected to generate more revenue than the men in both 2016 and 2017” (Gaines, 2016).

Some people state that the overwhelming gap in compensation between male and female sports is due to there not being enough people watching. This statement was shattered when the Women’s 2015 World Cup championship match was the “most watched soccer match in American history” (Tuttle, 2015). Shane Ferro (2015) has something very interesting to say on this issue. He states that the reason he believes men make more as well as earn more “bonuses” for winning larger tournaments comes down to revenue. He goes on in the article from *Business Insider* to state that sponsors revenue was significantly lower in the women’s

GRAPH 2



World Cup than the Men's (\$17 million vs. \$529 million). He asked a very interesting question "...why fans and sponsors are less interested in supporting women's sports..." (Ferro, 2015). This stems to an even bigger issue than equal pay. The men and women's teams are playing the same sport against the same countries in a tournament of the same name. So why is there a difference in pay? It comes down to the fact that there are still basic gender gaps in the world as simple as men are more interesting to watch play sports than women.

It might be possible that the outstanding success of the Women's National Championship World Cup Team in 2015 will result in the female team continuing to produce more revenue than the men well into the future, which would tend to dampen the "revenue" argument. The WNT is starting to develop a dynasty. The WNT has gained worldwide respect because of their work, dedication, and contribution to the growth of U.S. Soccer in the United States. Rather than marginalizing the achievements of the WNT, FIFA and the U.S. Soccer Federation should be very proud of them and what they have become. The success will only help soccer grow in the United States no matter the gender.

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A Brief Risk Assessment of Amelia Earhart's Attempted Flight Around the World

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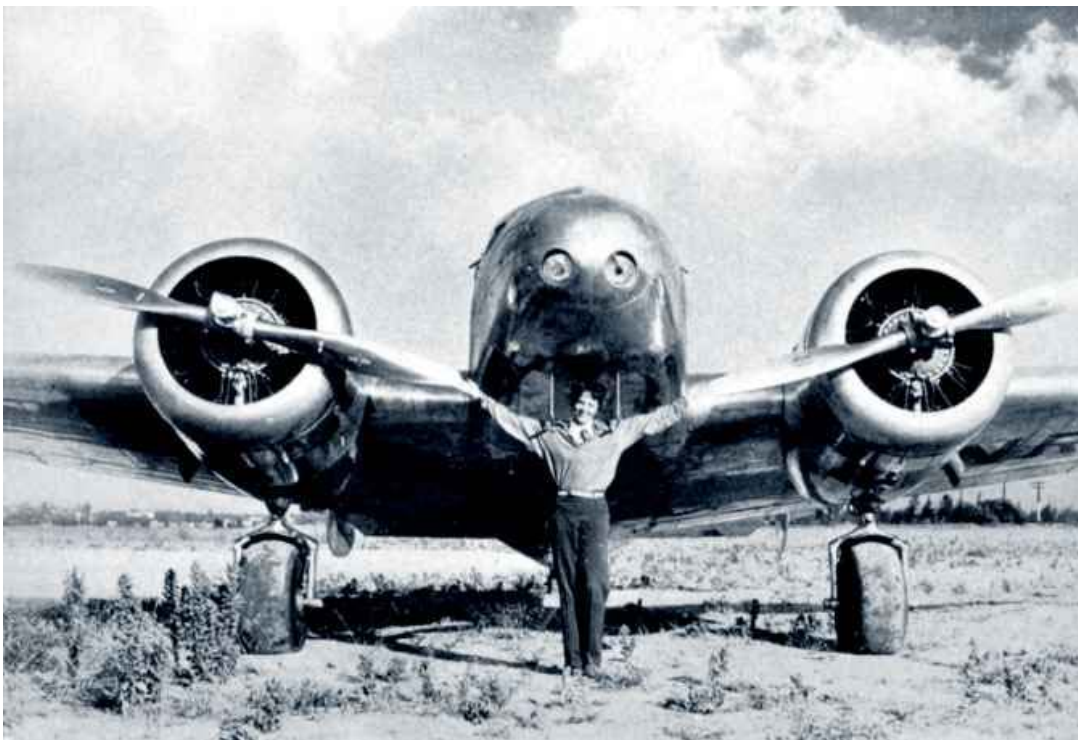
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ABSTRACT

This research presents a brief discussion and analysis of Amelia Earhart's 1937 attempted flight around the world. It examines critical factors that contributed to a concatenation of risks that resulted in the 'mysterious' loss of Amelia and her navigator Fred Noonan. Covering a brief history of her life and how it shaped her entry into aviation, it includes a look at the aircraft she chose, the equipment on the aircraft for support, and possible causes and effects of her becoming lost. Three plausible reasons for the tragedy are reviewed with pertinent facts in the context of modern-day Risk Management. Finally, the most likely explanation for her loss during the last leg of this historic flight is discussed along with supporting rationale. A brief outline for a Risk Management Plan (RMP) is also put forth, which if implemented, could have saved their lives and rewritten history!



Amelia and her 'Flying Laboratory' Lockheed Electra Model 10E

1. History

Amelia Earhart was born July 24, 1897 in Atchison, Kansas. She was the daughter of Samuel Edwin and Amelia Otis Earhart (see Figure 1.1). Amelia was named after her grandmother, and it seems to have been a family custom on her mother's side to name the first daughter after their grandmother (Earhart biography).



FIGURE 1.1—Amelia Earhart's Parents' Wedding Photo (Earhart Biography)

During the early twentieth century, the Earharts moved around and lived in many different places—Atchison, Kansas; Des Moines, Iowa; St. Paul, Minnesota; and Chicago, Illinois. While living in Chicago, Amelia graduated from Hyde Park High School. Even with all the moving, she still was considered a good student and made excellent grades (Earhart Biography). Figure 1.2 shows her high school portrait.



FIGURE 1.2—Amelia's High School Graduation Photo (Earhart Biography)

The first time young Amelia saw a bi-plane, she was not impressed and was heard saying, "It is a thing of rust and wood and not at all interesting." By 1920, though, Amelia got her first real taste of flying with her father and became hooked. One month after that flight, she enrolled in a pilot training course and six months later bought her first aircraft becoming the 16th woman in the history of aviation to receive a pilot's license. She called her first plane "Canary" due to its yellow color (Earhart Biography). Figure 1.3 shows Amelia's "Canary" Bi-Wing.



FIGURE 1.3—Amelia's "Canary" Bi-wing Airplane (Earhart Biography).

From that point, aviation was Amelia's life. For the next fifteen years, she dedicated herself to the promotion of aviation and women in flight. She was the first woman as a pilot to fly across the Atlantic Ocean and the first woman to fly solo across the Atlantic Ocean. In 1937, she had decided to be the first woman pilot to circumvent the world.

Her first attempt at the flight ended in her damaging the Lockheed Electra during takeoff in Hawaii and she scrubbed the attempt due to that damage (see Figure 1.4). After repairs, she decided to fly east instead of west due to winds and a change in seasonal weather patterns. The Western flightpath is shown in Figure 1.5.



FIGURE 1.4—Damages Sustained on First 'Western Route' Attempt (TIGHAR)



FIGURE 1.5—Amelia’s ‘Eastern Route’ for Around-the-World Flight (TIGHAR)

For the most part all went well crossing the United States, the Atlantic Ocean, and Europe. It wasn’t until crossing the Middle East did she have problems with the onboard equipment. She had to stop in India for repairs before going any further. Repairs were made and the flight continued. On what was to be the last leg of her flight from Lea, New Guinea to Howland Island in the South Pacific, she was lost at sea and never seen again. Following is a critical technical review of the Lockheed 10E Electra, its systems, and how their operation support the facts before, during, and after her disappearance.

2. Lockheed 10E Electra

The Lockheed 10 Electra normally has a crew of two, and supplies seating for 10 passengers. The model that Amelia Earhart flew was the 10E, modified for only 2 persons and having much more fuel for longer flight time, as shown in Figures 2.1 and 2.2 (TIGHAR). The engines on the 10E were the more powerful Wasp S3H1 Design which produced 550 horsepower, making 100 horsepower more than the standard Pratt and Whitney Wasp Jr. SB on earlier Electra models (TIGHAR, Sept. 2015). These engines were rugged and a very reliable design. Earhart’s plane was modified to carry a total

of 1150 U.S. gallons of fuel, giving the performance of the Electra: a cruising speed 190-194 mph, an estimated flight range of approximately 1620 miles, and a flight duration of approximately 20 hours (Houston).



FIGURE 2.1—Amelia’s Lockheed Electra Model 10E (TIGHAR)

The avionics aboard the Electra 10E were: a Western Electric short wave transmitter 13c, a 20b receiver, and a beat frequency oscillator (BFO) added to the receiver for CW operations (Morse code). She also had a new device for the time called an Automatic (Radio) Direction Finder (ADF) as shown in Figure 2.3 (TIGHAR, July 2015). The ADF was a Bendix Corporation design and was considered very high tech for the time (Houston).

The transmitters operated in 3 bands with a RF range of a low frequency 500 KHz mode and normal operating RF range 2500 to 6500 KHz. The ra-

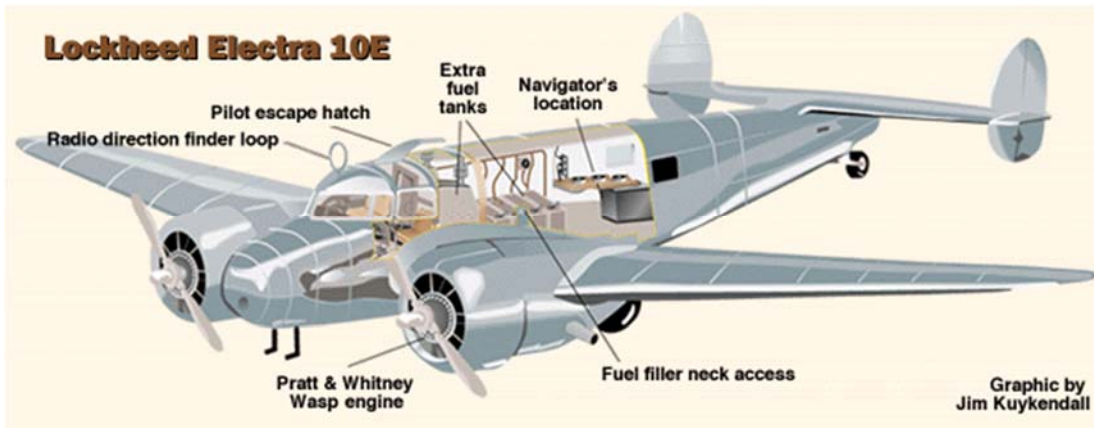


FIGURE 2.2—Amelia’s Lockheed Electra Model 10E Cutaway (TIGHAR)

dios were crystal controlled (state of the art at the time) and used multi-ganged switches to accomplish channel shifting and tuning (TIGHAR, July 2015). A note should be made that this radio was labor intensive to operate and required a clear mind to use correctly and effectively.

Antenna/Receiver (TIGHAR)

The receiver 20b was a 4 band radio receiver. These bands were: Band 1, 188-420 KHz (beacon and Marine); Band 2, 550-1500 KHz (standard broadcast); Band 3, 1500-4000 KHz; and Band 4, 4000-10000 KHz (TIGHAR, 2011). But, due to the need of operations in the 500 KHz ranges of Earhart’s Transmitter, Band 2 of the receiver was factory modified to 485-1200 KHz (TIGHAR, 2015). A remote control box for the receiver was located at the flight station designated Model 27A remote control box. This allowed band switching, tuning and volume control of the receiver at the flight station of the aircraft (TIGHAR, 2011).



FIGURE 2.3—Direction Finding (ADF) Loop

The antennas for the short wave systems were located as follows: the transmitter antenna was located on top of the airframe, starting from a single mast just aft of the flight station along two wires connecting to the leading edge of each vertical stabilizer; the receive antenna was located along the bottom center line of the aircraft; and the ADF loop antenna was located just above the flight station of the air craft (see Figure 2.4).

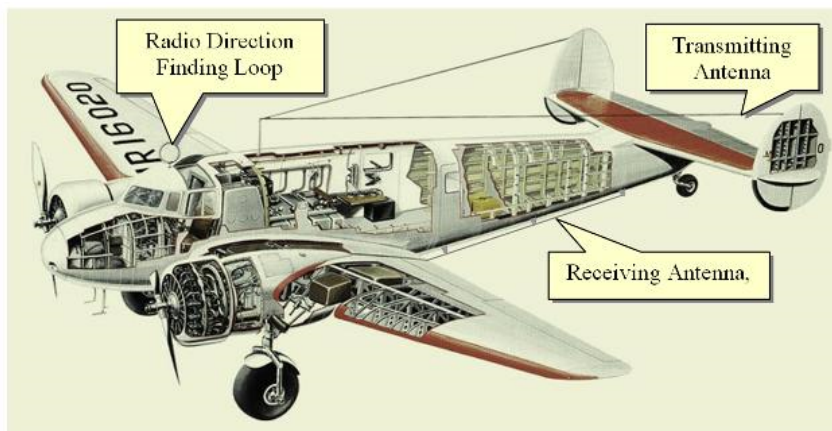


FIGURE 2.4—Electra Cutaway with Antenna Locations (TIGHAR)

3. The Mystery, Theories and Facts

There have been multiple theories of what happened to Amelia Earhart during the last leg of her world flight. They range from: lost due to poor weather conditions and ditched in the ocean, captured by the Japanese and held as a prisoner until death, or landing on a deserted island only to be stranded until death. Which is right and which is wrong? What factual evidence is there (not just hearsay), and can analysis of the equipment aboard her plane help corroborate the known facts to find the most likely solution to the mystery?

The facts are: Amelia left Lea, New Guinea on June 30, 1937. Prior to take-off, repairs to the ADF system were done and she was recovering from a bout of dysentery contracted while in India. Earlier, there was a problem with the long distance communications equipment which required repair in India. This shows evidence that the trip was putting wear and tear on the aircraft and its equipment prior to the New Guinea-Howland flight. Also due to the excessive weight load of the aircraft during take-off from New Guinea, critical damage was done to the short wave receive antenna located on the belly of the aircraft as shown in Figure 3.1. It was ripped off!

Prior to the last leg of the flight, there was good reception to and from the aircraft, but poor replies to transmit messages sent to her after takeoff from New Guinea, suggesting that she was having serious reception issues with the receivers due to the antenna damage mentioned above. If indeed the

antenna was ripped off during the Lea takeoff, no reception could occur.

When nearing Howland, they flew below the cloud layer at about 1000 ft. In order to see (unobstructed by clouds or distracted by cloud shadows) the ocean. This would limit their distance to see Howland Island and also increase their fuel consumption. Their last official transmission reported they were following the 337 degrees/157 degrees line to find Howland Island as shown on Figure 3.2 (TIGHAR, May 2015). After this, no other radio receptions were monitored from Amelia's aircraft in flight.

On July 2, 1937, the Battleship *Colorado* (BB45) shown in Figure 3.3 conducted an aerial search with its O3U Corsair float planes (See Figure 3.4). It ended its search on July 12, 1937, covering 25,490 square miles, and finding nothing. On July 12, 1937, the *USS Lexington* (CV2) (See Figure 3.5) arrived in the area and conducted limited aerial searches north and west of Howland Island (NNAM). A search grid of 600 by 400 miles was explored with no sightings. By July 18, the search was abandoned having found nothing (Sherman).

Since the U.S. Navy found no trace of the aircraft or its occupants as a result of the cursory aerial search, they assumed Earhart had ditched and was lost at sea. However, there is no proof of this, only speculation. Analysis of the aircraft or its equipment gives no support for or against this scenario. The same can be said for the theory of being captured by the Japanese and held prisoner.

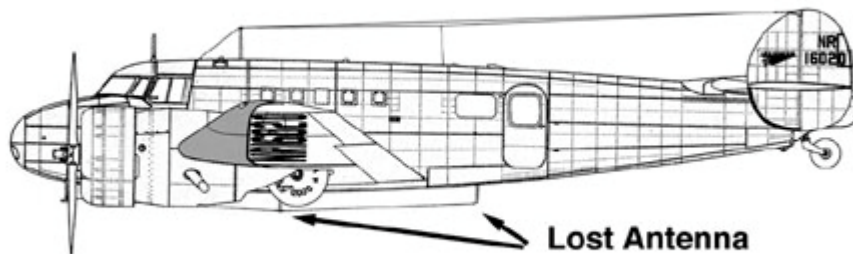


FIGURE 3.1—Location of Receiving Antenna Lost at Takeoff from New Guinea (TIGHAR)

As before, analysis of the aircraft or its equipment gives no support for or against that scenario either. Just looking at the military's findings, the same can be said about the possibility Amelia and Fred becoming deserted on an island. But there is an un-

official documentation that radio transmissions were heard that could have been Amelia Earhart and Fred Noonan still alive on land after June 31, more than 24 hours since she was pronounced 'lost at sea.'

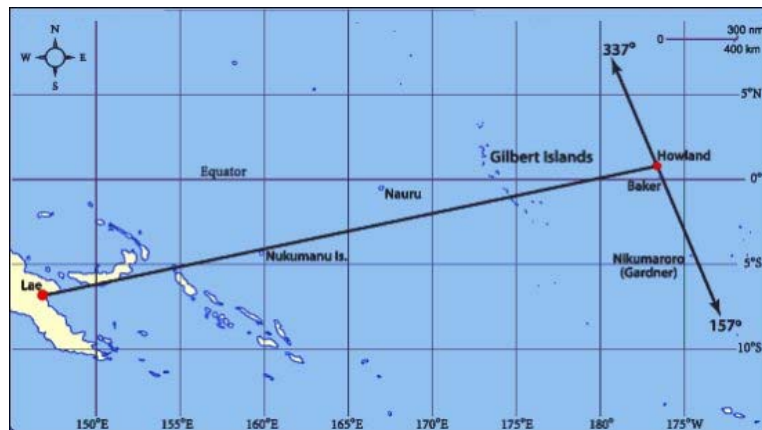


FIGURE 3.2—Earhart's Route of Flight to Howland Island



FIGURE 3.3—Battleship *Colorado* (BB45) [U.S. Navy]



FIGURE 3.4—O3U Corsair Float Plane from the *Colorado* [U.S. Navy]

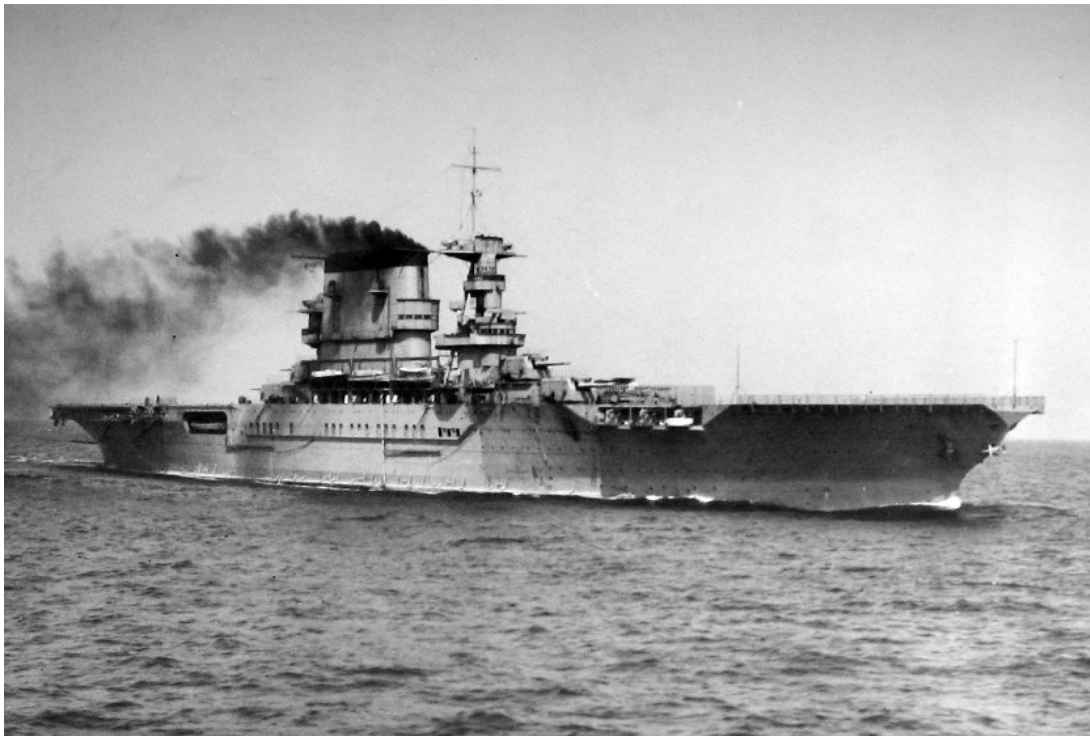


FIGURE 3.5—U.S.S. *Lexington* [U.S. Navy]

4. Radio Equipment Operational Life

One has to remember that salt air and water are highly corrosive to metal, electrical, and electronic gear. With that in mind, let us look at the possibility of operations after a ditch or landing on an island like Gardner. If the aircraft landed intact and the engines were not damaged, remaining fuel could be used to keep the DC batteries charged for radio operations. If the inside of the aircraft stayed dry for the most part, the life of the equipment could be several weeks. Corrosion from the salt air would eventually destroy the radios and navigation gear, but remaining fuel would have been expended before that.

There is one puzzle regarding her equipment—the ADF system. It was designed to “home-in” on an AM carrier signal. Being somewhat lost and not sure where they were, why didn’t they call the Cutter *Itasca* and ask for a signal to home in on? There’s no answer for this and one may never be known. They did have problems with it prior to the Howland Island leg of the flight, but it was reported to have been fixed. Possibly, the system failed again during the Howland Island flight. Another possibility is that with it being such a new type of technology, Amelia lacked the skills to use it effectively. Given the stress they must have been under during the last leg of flight, this is more than just a strong possibility.

5. Post Flight Radio Transmissions

Looking at all the supposed radio transmissions sent by Amelia after being declared lost at sea would fill a book. The hard part is finding those which have validity and those which do not. The only radio receptions that can be supported by any reasonable analyses are the DF logs of HF DF stations that recorded direction and signal strength of said transmissions.

These DF “cuts” plotted on a map of the South Pacific show that they originated from waters south of Howland Island (TIGHAR, May 2015). When making a direction finding bearing of a transmitted signal, more than one bearing must be made. This is quite easy to do if the DF station is moving as each cut will be from a different location and time. But when taken from a fixed station like those that received Amelia’s signal, multiple station cuts need to be combined to get a good triangulation yielding an accurate location. By examining Wake Island’s cut, the Pan Am station’s cut, with Hawaii’s and Howland’s DF cut, one finds that they roughly converge on the Gardner Island area, just south of Howland (Figure 5.1) (TIGHAR, May 2015).

Gardner was checked by only one OSU float plane off the *USS Colorado* who reported to have seen nothing. Looking closer at that flight, the aircraft was only over the island during high tide, spending

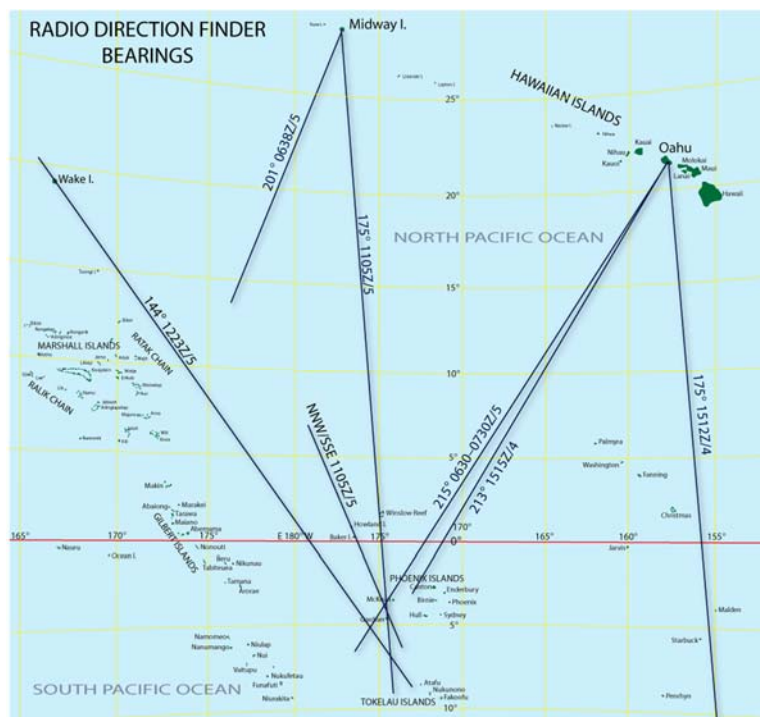


FIGURE 5.1—Post-Flight Radio Signal Bearings Intersecting Near Gardner Island (TIGHAR)

10 minutes overflying it, at flight level 1000 feet (NNAM). Given these details of the aircraft's search, the real possibility of seeing any aircraft in the surf during high tide at that altitude is unlikely at best. No signal fire or signs on the beach were seen. But the possibility of Amelia knowing how to erect these without training is remote. When the *USS Lexington* took over the search, they only looked north and northwest of Howland Island, never returning to Gardner Island where she would have been based on the radio bearings (NNAM).

6. Gardner Island

Gardner Island lies approximately 425 miles due south of Howland Island, near the 157 degree longitude line. It is typical of sea mountain top atolls seen all across the South Pacific Ocean. It has an outer reef with a land mass between it and an inter-lagoon area (See Figure 6.1). The only indigenous life forms on the island are coconut crabs and sea birds. These huge crabs have a reputation of being territorial/aggressive and undoubtedly would pose a threat to other life forms around them. Figure 6.2 shows a crab encounter with a trash can—can loses!

No one was living on Gardner Island in 1937. The only sign of human existences on the Island during



FIGURE 6.2—Coconut Crab ‘Attacks’ Garbage Can on Nikumaroro Island (TIGHAR)

Amelia's flight was the *SS Norwich City* which had run aground on the reef during a storm in November 1929 (see Figure 6.3) (TIGHAR, 2013). There was no fresh water and very little shelter on the island. Overall, it could sustain life only if supported from an outside source. Today the island is known as Nikumaroro and is part of a sea-life preserve.

The reef of Gardner/Nikumaroro Island is different



FIGURE 6.1—Then Gardner Island (Now Nikumaroro) Likely Landing Site (TIGHAR)



FIGURE 6.3—The *Norwich City* Freighter on Gardner's Reef at the Shoreline (TIGHAR)

from most atolls. It is long and very shallow in some areas, add that on the northern side the reef is very flat for hundreds of feet, not much different from a runway (See Figure 6.4). It is such that an aircraft could quite easily land during low tide with very little damage to the aircraft's undercarriage.

The tides on the island are such that at low tide, an aircraft on one of the flat areas on the reef could still be functional at low tide for days (See Figure 6.5). However, the damage inflicted due to high tide, salt air, and water would eventually corrode and disable the aircraft.



FIGURE 6.4—Artist Rendering of Earhart's Plane on Gardner Island Reef (TIGHAR)

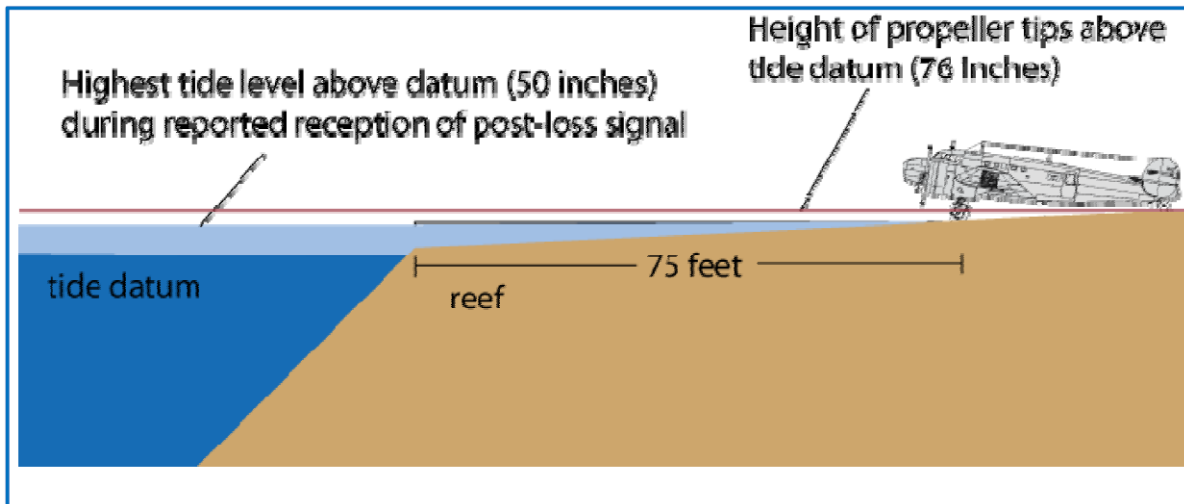


FIGURE 6.5—Water Distance from Aircraft Propellers on Gardner Island Reef (TIGHAR)

7. Physical Well-Being of the Crew

It is quite well documented that most aircraft mishaps are due to pilot or crew error caused by fatigue which has some bearing on Amelia's flight. Even with the rest she was getting having to stop for repairs in India and New Guinea, it was quite obvious that fatigue was showing signs of degrading abilities of Amelia and Fred. One must remember that during their stay in India, she contracted dysentery and was still not over its effects on the June 30 flight. Dysentery in itself is very debilitating and, accordingly, flying a long leg like the Howland Island flight should not have been attempted (Sherman). Given the long flight time, stress of having to fly low to find Howland Island, new and complicated communications equipment, and the possibility of flying with a degraded mental awareness due to fatigue, it could only enhance their path to disaster.

8. Weather

Not much is said about the South Pacific weather during the Earhart flight. The cloud layer normally thickens in the afternoon in this area of the Pacific Ocean. This is due to solar heating of the water at sea level, thus causing the air to rise with sea moisture, producing clouds. If the cloud layer is

thick enough, anyone flying at 10,000 feet would have a hard time spotting. Hence, why Amelia flew at 1,000 feet—to find Howland Island (Sherman). The drawbacks to this are: one has far shorting viewing range on the horizon and fuel consumption is greater. Flying low drastically reduced their chances of seeing Howland at a distance.

9. Conclusions

Consideration of the evidence, factual and circumstantial, yields an educated hypothesis of what might have happened to Amelia Earhart in 1937. By combining known radio transmissions prior to becoming missing, post search reception reports from the U.S. Navy, post HF DF station bearing cuts of possible radio transmissions, along with analysis of the aircraft and its equipment, and given the possibility of degraded mental and physical health of the crew (and of course the Gardner/Nikumaroro Island location and terrain) yield one most likely scenario for failure of Amelia's around-the-world adventure.

In the morning of June 30, 1937, Amelia Earhart, with Fred Noonan as her navigator, took off from Lea, New Guinea. Due to high take-off weight, damage was caused to her receive antenna on the bottom of the aircraft. This was not known until lat-

er and the flight continued after take-off. All throughout the flight there was good ground reception of the aircraft's transmissions, but poor to no response from Amelia to ground station transmissions. The probable cause of this was due to the aircraft's receive antenna damage. Up until the late afternoon, all seemed well. As the stress of poor communications weighed on them, the weather also became worse as they drew closer to Howland. As they approached the target area, Amelia descended to 1000 feet to put them below the cloud layer and enable sighting of the island. Unfortunately, this descent also lessened their chances of seeing it from a distance—a situation that would have surely added to their already soaring stress levels.

In their last one-way radio transmission, it was quite obvious that Amelia knew they were lost and in trouble. They had reached the longitude line 157/337 degrees in line with where Howland should be and were flying north and south to find it (Sherman). The problem was that they did not know their latitude, thus whether they were north or south of Howland. They flew south, away from Howland. Stresses of the flight severely affected their critical thinking—what was needed to save them. The only recourse left to them in the end, was to land at the first island they found, or ditch in the ocean. That night they were reported as lost.

If they had known that they were south of Howland Island and would have kept going north, they would have found either Baker or Howland. But by going south, they eventually found Gardner/Nikumaroro Island. Running low on fuel and finding darkness upon them, they opted to land on the shallow reef at Gardner (fortunately it would have been low tide).

For the next 7-10 days, at low tide Amelia waded out to the Electra, started its engines using what fuel was left and radioed for help. Having no receiver antenna, all hopes of receiving a message

was lost. She must have known by this time about the damaged receiver antenna, but probably lacked the skills or resources to repair it. Her post flight transmission signals were heard all around the world, but were either viewed as crack-pot hoaxes or the signals were too weak and/or unreadable. Even the documented HF DF station reports were not fully followed up on. After 10 days, with no food except for birds or small fish, and no fresh water, Amelia Earhart and Fred Noonan most likely died of dehydration.

There are so many events during this flight where **if** they had been done differently, the outcome could have been totally different. **If** the Navy had been more thorough in their search; **if** a timely report was given on the analysis of the HF DF cuts received; **if** the proper use of a new technology like the ADF system was used, it could have saved them. **If** crew had been in better mental and physical state and had survival training, the outcome would have been different. But that is the way of most aircraft mishaps. It is not just one thing that usually brings a plane down, but a series of things that fail (concatenation in risk terms). **If** any one of these issues had been corrected by Amelia or Fred in a timely manner, it may have sufficiently mitigated the risk and averted their loss.

From a Risk Management perspective, it is not apparent that Earhart's team had any resemblance of a formal Risk Management Plan (RMP). Hindsight is 20-20, as they say, but many of the circumstances that were allowed to develop should have been addressed formally and most likely would have been by a more experienced aviator. The single most damning behavior/event appears to be Amelia's lack of familiarity with the radio equipment, its set-up for her flight mission, and its operation in general. An experienced radio operator would have sought to find a cause for non-reception post takeoff from New Guinea and made some attempts to rectify it, even while in flight. ***The lack of two-way communication between Amelia's plan and***

the awaiting ship (USCGC Itasca) at Howland Island was the critical, broken link in the flight's risk management that resulted in their loss.

10. A Risk Management Plan

One can speculate that if a formal Risk Management Plan (RMP) has been developed and followed, it is likely that the tragic loss of Amelia and Fred might not have occurred. RMPs had not been conceived at that time, but prudent airmanship would have warranted attention to what should have been obvious critical detail. As indicated in the conclusions above, while weather certainly played a part in their failure to arrive at Howland Island as planned, successful communication with the USCGC Itasca anchored at the Island, would have allowed corrections to be made based on bearings taken on the Earhart plane. Additionally, reception of the ship's signal by Amelia could have served as a 'beacon' to guide them closer to the intended target. While at some point, the serious nature of communicating with the ship was undoubtedly discussed, it apparently was not emphasized as it would have been in a formal RMP.

Generally, a RMP identifies potential risks, assesses their probability of occurrence, and assigns priority based upon the anticipated outcome if the adverse event occurs.

A Risk Priority Number (RPN) is often calculated based on such factors that position the most serious risks to receive the lion's share of resources, attention, and contingency planning (see Figure 10.1) as part of the formal RMP. For example, if the probability of losing receive capability was assessed at ten percent [Risk Determinant Factor (RDF)=0.10] and if that loss would result in missing Howland Island/loss of the mission and pilot/navigator (e.g. rank=100), the calculated RPN might be: $RPN=RDF \times Rank = 0.1 \times 100 = 10$. This number would be used to establish this risk's importance relative to others. Mitigation of this risk might have included additional training for Amelia, a spare antenna for receiving (e.g., a trailing-wire antenna) or more formal procedures between Earhart and *Itasca* being developed and followed (less confusion as to which frequencies, what transmission mode (voice vs. CW), and a more formalized transmission schedule. ***Lack of formal contingency***

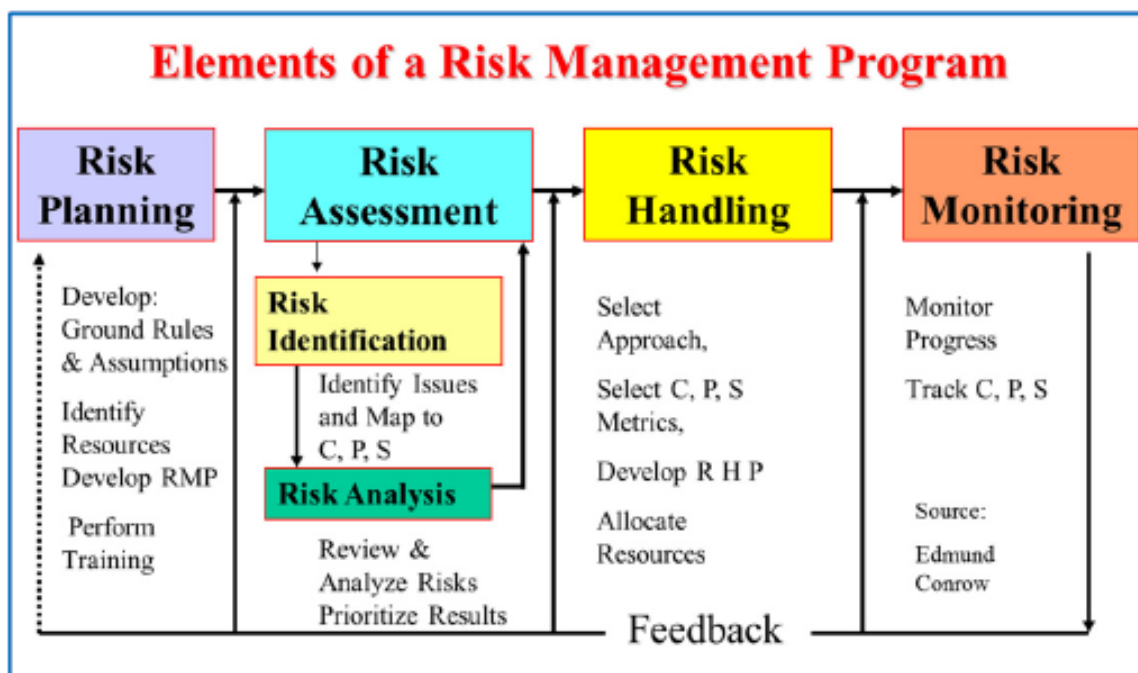


FIGURE 10.1—Risk Management Program/Plan Diagram (Conrow)

planning for communications played the major role in Amelia and Fred's failure in finding Gardner Island, and ultimately, lead to their death as a result.

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****Note: Special recognition and credits are expressed to Ric Gillespie, the major author and editor for TIGHAR. His name was used in place of "no author registered" for many TIGHAR articles.***



Humans to Mars Reliability Model Using Monte Carlo Analysis

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ABSTRACT

The planet Mars has been the inspiration for mankind's dream of interplanetary human spaceflight for centuries. After decades of automated orbiters and landers, mankind is poised to make a concerted effort for humans to visit the surface of Mars and return safely to Earth. A common concern is assessing the probability of crew survival and mission success. This research sought to develop a simplistic reliability model employing a risk network and Monte Carlo simulation that might provide a top-level "sanity check" of commonly proposed mission profiles to be used in management decision making leading to improved probability of mission success. While numerical results are presented, this paper emphasizes the methodology foremost. The modeling is based on a hypothetical crewed mission to Mars as proposed by graduate students from the Florida Institute of Technology, to formulate and define the system infrastructure required to support the first human landing on Mars by the year 2030.

Introduction and Mission Summary

The planet Mars has been the inspiration for mankind's dream of interplanetary human spaceflight for centuries. While inhospitable to human occupation on initial examination (a good day on Mars might be compared to the worst of days on a barren, frozen Siberian desert void of breathable air and life-sustaining ambient pressure!), the red planet holds the highest promise of harboring past, present, and future life of any major body in our Solar System. Placing humans on Mars may finally answer the rhetorical question of "are we alone" in the Universe and whether mankind is capable of or even deserving of the ability to spread life as we know it beyond Earth. After decades of automated orbiters and landers, we are poised to finally make a concerted effort for humans to visit the surface of Mars and return safely to Earth during the next decade. Whether to use existing and near-term hardware or develop advanced propulsion and other paradigm shifting technologies remains controversial; one common concern is assessing the probability of crew survival and mission success

given the overall task at hand.

This research sought to develop a simplistic reliability model employing a risk network and Monte Carlo simulation that might provide a top-level, 'sanity check' of commonly proposed mission profiles to be used in management decision making and mission design/refinement. The model was designed to aid in ranking various mission scenarios and improving probability of success by understanding reliability drivers. While numerical results are presented, this paper emphasizes the methodology foremost. The modeling is based upon a hypothetical crewed mission to Mars, the Human Space Flight Mars -1, or HSFM-1 as proposed by graduate students from Florida Institute of Technology (MTB, LLC group), to formulate and define the system infrastructure required to support the first human landing on Mars by the year 2030.

Premise

The HSFM-1 Mission is an effort to 'travel to a des-

tion—Mars’ rather than serve as justification for an advanced technology development program (See Table 1). As such, this approach utilizes a high percentage of existing and near-term technology to achieve the overall mission goals while maintaining a reasonable cost, a doable schedule, and acceptable risks. These program characteristics (upon which the reliability model was based) are summarized in the forthcoming pages. The HSFM-1 is a simplified, straightforward, and risk

adverse plan to fulfilling the requirements for a crewed mission to Mars by 2030. A common SpaceX launch vehicle (Falcon Heavy-ER) will be employed for each of the five launches required to complete the overall mission. The Falcon Heavy-ER is the same configuration that will be test flown by SpaceX later this year with the exception of increased performance enhancements to the second stage. In addition to employing the use of chilled propellants in all stages to increase performance

TABLE 1—Baseline Mission Concept

The HSFM mission baselines the following mission characteristics:

- ⇒ **Common Launcher for all mission sorties (Falcon Heavy-ER);**
- ⇒ **Hohmann Transfer Orbits to and from Mars to economize on required propellants;**
- ⇒ **ISRU to fuel the Mars Ascent Vehicle (MAV) propulsion stage;**
- ⇒ **Common crew spacecraft based upon the SpaceX Dragon V2;**
- ⇒ **No provisions for artificial gravity during Earth-Mars/Mars-Earth transfers;**
- ⇒ **13-month on surface crew stay time allowing for substantial crew exploration;**
- ⇒ **Landing site selection based on maximizing crew safety and enhancing exploration;**
- ⇒ **Dual Mars Excursion Rovers (electric) providing safe haven for crew in emergencies;**
- ⇒ **Utilization of NASA Deep Space Network for Communication and Data along with Mars orbiting comm/data relay satellites;**
- ⇒ **One Earth-trailing satellite to minimize communication ‘gaps’;**
- ⇒ **High level of redundancy for all hardware/software;**
- ⇒ **Maximized diversification of training of crew to handle unforeseen contingencies;**
- ⇒ **Female and Male crew members (tentatively, 2 of each); and**
- ⇒ **Quarantine of crew and Mars return samples for back contamination prevention.**

These mission prerequisites for the HSFM were chosen to help assure overall success and result in manageable risks for the crew of 4.

(already demonstrated by SpaceX in 2016), the ER second stage will include stretching of the LOX and fuel (RP-1 or Methane) fuel tanks to achieve an overall +50% increase in the second stage total impulse. Commonality is continued with the payloads in that the same stage PL adapter and composite shroud are used in all of the cargo flights (CSFM 1-4). The final crewed flight (HSFM-1) will not carry a shroud. The SpaceX Dragon V2 crew capsule will be employed as the main human carrier and will double as a provisions trunk on the CSFM 1 and 4 flights. Likewise, an inflatable habitat will be flown on all flights to allow additional provisions and other hardware to be stowed inside during transit. The habitat is based on the BEAM (Bigelow Expandable Activity Module) now being tested on the International Space Station (ISS).

Each of the flights will carry the Falcon Heavy ER Second Stage to Mars where it will first be used to conduct transit course corrections using the re-ignitable Merlin 1D engine. Later, it will provide the Mars Orbit Insertion Burn (MOIB), and finally will be separated from the Dragon V2 on the crewed Flight HSFM-1 before executing an Entry-Descent-Landing (EDL) maneuver to the Martian surface with the attached hab and other payloads. The first Cargo sortie (CSFM-1) will carry the Dragon Mars Ascent Vehicle (MAV) which will be landing at the chosen site (see Figure 1) where In-Situ Resource Utilization (ISRU) techniques will be used to refuel the second stage to act as the MAV ascent booster (see Figure 2).

The Dragon V2 will be a common building block (in



FIGURE 1—Jezero Crater, MTB Chosen Landing Site for HSFM-1 [NASA]

set in Figure 1) to serve as the Mars Descent Vehicle (MDV) with the Earth crew, the Mars Ascent Vehicle (MAV) upon Mars departure, and finally the Earth Return Vehicle (ERV). All but the ERV will accomplish EDL maneuvers, whereas the ERV will remain in Mars orbit until the Earth return phase. The MAV will rendezvous and dock with the ERV after ascent from the Martian surface for Earth return.

Mission Modeling & Risk Assessment

The importance of Risk Assessment in complex aerospace flight operations and projects has been underscored over the last few decades, beginning with the tragic loss of the Space Shuttle *Challenger*, where a real-time loss experience was shared by millions of space enthusiasts, both from live TV

broadcasts and the ensuing investigation that essentially pointed to human failure via poor risk assessment/mitigation and failed communications and management decision making. After reacting to the lessons learned from the *Challenger* accident and successfully returning the Space Transportation System (STS) to flight, human attention span and poor risk management once again blossomed in view of the whole world when the *Columbia* Orbiter Vehicle was lost for non-similar technical reasons but VERY similar management failure. For a Human Mars Mission, the odds of failure are increased considerably due to the very long times and distances involved, the increase in human exposure to solar and cosmic radiation, and the need for super reliability or redundancy in system design and performance. Mission Risk Modeling, addressed in Figure 3, is a basic requirement in order to get our minds around this colossal task.



Reliability (1-Risk) Modeling For Humans To Mars

Qualitative & Quantitative Modeling Are Both Useful In Mission Planning

- Qualitative Via Observation, Experience, & Intuition

COLOR	ASSUMED RDF*
Low (Green)	0.00005
Moderate (Yellow)	0.001
High/Severe (Red)	0.025

*RDF - Risk Determinant Factor (probability of failure)

Magnitude of Failure Effect Definition (E0)	
Risk Magnitude of Failure Effect	Quantitative Rank (R0)
None - no measurable effect on the project	1
Low - only slight effect on the project	2-5
Moderate - outcomes will notice and experience a moderate level of dissatisfaction	4-6
High - high degree of customer dissatisfaction	7-8
Very High - failure mode will cause failure of project in the eye of the customer	9-10

RISK RANKING (RPN) MATRIX					
Severity / Likelihood I	Minimal	Minor	Major	Serious	Catastrophic
Near Certainty	5	10	15	20	25
Highly Likely	4	8	12	16	20
Likely	3	6	9	12	15
Low Likelihood	2	4	5	8	10
Extremely Unlikely	1	2	3	4	5

Risk Priority Number (RPN): LOW: RPN < 10 (Green Cells) MEDIUM: 10 > RPN < 12 (Yellow Cells) HIGH: RPN > 12 (Red Cells)

- Quantitative Via Component/System Testing & Analysis (e.g. Relx, etc.)

- Point Estimates: Discrete Calculations Using Probability Assessments

$$RDF_{mission} = 1 - [(1-0.01)(1-0.0001)(1-0.00001)(1-0.001)]$$

$$RDF_{mission} = 1 - [(0.99)(0.9999)(0.99999)(0.999)]$$

$$RDF_{mission} = 1 - [0.9889012] = 0.0110988 \text{ Failure Probability}$$



- Stochastic Estimates: Simulation Such As The Monte Carlo Technique (e.g. Palisades @RISK)

FIGURE 3—Monte Carlo Process Steps and Example Outputs

Qualitative, Point-Estimate, and Simulation risk modeling is considered in this paper. A typical modeling process starts with the Qualitative assessment, proceeds into a Quantitative, Point-Estimate task which support the more versatile Simulation effort. Monte Carlo analysis is an accepted methodology for generating a probability distribution-based model allowing more accurate final results and predictions based on a large number of simulations (iterations).

Qualitative Risk Assessments

The Qualitative Risk Assessment (QRA) seeks to:

- Identify and categorize the various risks which can be expected on the project,
- Determine the probability of occurrence of each risk, and
- Establish the impact to the project for each risk occurrence.

The major risks in the Mars Mission QRA were identified using currently available project-related information. The primarily major threats to the HSFM-1 Project identified for this study included Technical, Cost, and Political.

As new project details emerge, further risk analysis should occur. A higher-detailed risk analysis effort

(including quantification) and overall Risk Management Plan should be developed as part of the HSFM-1 Project Planning phase. Table 2 categorizes the Risk Breakdown Structure for the HSFM-1 Project.

Overall mission risk is divided into five Level I categories, and each of these is further defined in Level II. Probability of occurrence and project impact for each Level II risks are categorized and qualified as shown in Table 3. These estimates lead to the development of a Quantitative model with succinct values for each mission event element's reliability used in the model.

There are 13 defined mission phases in the HSFM-1 Project, from launch to the return to Earth. While some risk categories apply "across the board" for the entire mission, or for multiple phases, each phase can present its own combination of specific risks and levels of probability and/or severity, as seen in the following descriptions of each:

- 1. 4 Crew Launch to LEO:** There is a programmatic risk during the launch of the crew for the Mars mission. The probability of Loss of Crew is about 1/100 for launch to LEO. The overall risk for launch is dependent on all phases prior to launch. A risk mitigation plan should be in effect

TABLE 2—Category Risk Assumptions

COLOR	ASSUMED RDF*
Low (Green)	0.00005
Moderate (Yellow)	0.001
High/Severe (Red)	0.025

*RDF – Risk Determinant Factor (probability of failure)

TABLE 3—Mission Qualitative Risk Estimates

Mars Mission Qualitative Risk			High =	0.025
			Moderate =	0.001
			Low =	0.00005
	Level I	Level II	Occurrence Probability	Project Impact
Project Risk	1. Technical	1.1. New Technology Development	Green	Yellow
		1.2. Performance Expectations	Green	Green
		1.3. System Complexity	Yellow	Red
		1.4. Interfaces	Yellow	Red
		1.5. Requirements Changes	Yellow	Yellow
		1.6. Manufacturing Issues	Yellow	Red
		1.7. Modeling	Green	Green
		1.8. Quality	Yellow	Yellow
	2. Schedule	2.1. Technical Risk Issues	Red	Red
		2.2. Cost Risk Issues	Red	Red
		2.3. Mission Milestones	Yellow	Red
		2.4. Testing	Yellow	Yellow
	3. Cost	3.1. Technical Risk Issues	Yellow	Yellow
		3.2. Schedule Risk Issues	Yellow	Yellow
		3.3. Resource Allocations	Green	Yellow
		3.4. Inflation	Green	Green

TABLE 3—Mission Qualitative Risk Estimates (Concluded)

	4. Programmatic	3.5. Requirement	Yellow	Green	
		Changes	Red	Red	
		4.1. Political	Yellow	Yellow	
		4.2. Environmental	Green	Green	
		4.3. Regulations	Yellow	Yellow	
		4.4. Logistics	Red	Yellow	
		4.5. Command/Control/Comms	Green	Green	
		4.6. Personnel	Yellow	Yellow	
		4.7. System	Yellow	Yellow	
		4.8. Integration	Yellow	Yellow	
		4.9. Suppliers	Green	Yellow	
		4.10. Security	Green	Yellow	
		4.10. Force Majeure	Yellow	Red	
		5. Safety	5.1. Survivability	Green	Yellow
			5.2. Human	Green	Yellow
5.3. Factors	Green		Red		
	5.3. Mission Duration	Green	Red		

to allow the PM to decide if the launch is going to be a go, or no-go;

2. **Depart Earth Orbit:** The risks for leaving Earth's orbit include anti-gravity and more exposure to radiation. Space is an unforgiving environment that does not tolerate human errors or technical failure. For humans leaving Earth's orbit for extended periods, there are even more dangers. One is the near absence of gravity in space; the presence of high-energy, ionizing cosmic ray (HZE) nuclei is another. Because both zero gravity and cosmic rays would have severe health implications for astronauts on a Mars-bound spaceship, we first need to investigate their effects on cells, tissues and our hormonal and immune systems. Enormously important roles in assessing the health dangers for humans in space should be defined, and in the development of potential countermeasures for these risks;
3. **Dragon MLV Cruise to Mars:** The Dragon V2 Mars Lander Vehicle (MLV) cruise to Mars will

use the Hohmann Transfer with Interplanetary navigation. The Hohmann transfer orbit is an elliptical orbit used to transfer between two circular orbits of different radii in the same plane. With this transfer, the alignment of the two planets in their orbits is crucial. The destination planet and the spacecraft must arrive at the same point in their orbits around the Sun at the same time. Because of this rendezvous, there will be a risk with human error and natural causes that may be out of our control;

4. **Adjust Transfer Orbit:** Orbit insertion is a general term for a maneuver that is more than a small correction. It may be used for a maneuver to change a transfer orbit or an ascent orbit into a stable one, but also to change a stable orbit into a descent. There is a potential for many different risks associated with adjusting transfer orbit and midcourse correction burn;
5. **Mars Arrival:** Although human space exploration is dangerous at all levels, particular risks arise during the arrival to Mars, as initial orbit around the planet is to be established. Addi-

tional precision is necessary during this phase, as even a small mistake, miscalculation or accident can result in large failure, injury, and death. Every component must work perfectly. Every system (and its backup) must function without fail or the mission is at risk of being aborted and human life becomes at risk. Manufacturing and quality risks come into play, as aerodynamic and thermal protections built-in to the MLV are needed for safe insertion into orbit;

6. **Mars Orbit Capture:** The precisions necessary during the Mars Arrival phase are also applicable to this mission phase. Every component must work perfectly in order to maintain the precision of this highly-elliptical orbit for at least 48 hours, and to achieve the necessary slowdown. Risks increase in the area of Command/Control/Communications, as there will be more of a need for Earth-to-MLV comms, as adjustments and interaction with crew become more necessary with the impending Entry-Descent-Landing;
7. **Dragon MLV Entry-Descent-Landing:** The current plans to land humans on Mars will require approximately 40 to 80 tons of support equipment. After orbit has been achieved around Mars, currently there are two options for the terminal descent: propulsive or parachute deceleration, followed by a propulsive descent segment. The density of the atmosphere of Mars will be a challenge based upon the time of year, day, dust level and latitude. The entry vehicle shape should be designed with the challenges of the Martian atmosphere variables. The trajectory from orbit to land on Mars will have challenges of heat and deceleration that must be calculated. New technologies will be needed because of the required mass to land, as current robotic systems are insufficient;
8. **Mars Ascent to Orbit:** The Mars Ascent Vehicle (MAV), represents a formidable engineering challenge. When fully loaded with fuel, it's too heavy to launch from Earth and land safely on Mars. The MAV must be built tough enough to remain fully operational despite being pummeled by massive dust storms and punishing UV radiation. Also, the MAV will have to create the fuel required to launch from the Mars atmosphere. Additional challenges concerning contamination need to be addressed prior to the launch from Mars. When the MAV takes off, it needs to sustain the astronauts for days, as they maneuver to rendezvous with the orbiting vessel;
9. **Depart Mars Orbit:** The spacecraft navigation/control system and propulsion system are the highest risk items for this flight phase. It is crucial these systems operate properly to establish the appropriate trajectory to reach Earth. A malfunction or complete failure to one or both systems would strand the crew in space with little chance of rescue. If problems were encountered in this flight phase, the crew would likely have to return to Mars, if possible;
10. **Cruise to Earth:** The spacecraft navigation/control system and propulsion systems are high risk issues for this flight phase, but not as much as during the previous phase. This part of the mission is long duration and the crew would have a longer time period to develop alternate procedures. By this time, the ship is getting closer to Earth every day. The crew-related issues of water, food, atmosphere, and temperature are high risk items. Significant degradation of any of these could lead to crew loss. The risk of issues of long duration zero gravity and radiation exposure are the same as the flight to Mars;
11. **Adjust ERV Transfer Orbit:** At this point of the mission, the MAV performs a rendezvous with the ERV, in which the crew will transfer to the Earth Return Vehicle (ERV). The ERV will consist of two stages. The upper stage which will comprise the living accommodations for the crew and the lower stage will contain the vehicles rocket engines. In this phase, there will be some risk of single point failure with docking the MAV with the return vehicle, the engine burns during this process, re-entry into Earth's atmosphere with speeds higher than we have ever seen before. The likelihood of these risks happening are low to moderate, however, and would be very dependent on the amount of risk mitigation that would be done before the mission. With a mission of this magnitude, the risk assessment would be one of great detail. There are numerous test runs that are done that would ensure that all of the thrusters are functional, docking maneuvers would be gone over time and time again. Even though the risk associated are low to moderate that they would happen, the consequences of these risks taking

place could mean loss of crew, time added to the mission, or mission failure;

12. **Earth Arrival and Capture:** In this phase, we are dealing with the risk of the ERV entering Earth's atmosphere at greater speeds than yet experienced. This is a very high risk, and the likelihood of this happening is very high unless, during the mitigation phase, the engineers figure out a way to slow the vehicle down, or somehow mitigate the speed in some other way. The consequences behind this risk could be damage to the vehicle, crew loss, and mission failure. Some of the other risk associated with this phase would also be heating and accuracy of rendezvous and impact. Both of these risks are moderate-to-high; and

13. **Rendezvous & Dock ISS:** This is the final phase of the mission and there are critical risks that have to be taken into consideration. There are critical windows that need to be caught in order for a successful rendezvous with the International Space Station (ISS) to take place. These risks could also be connected to the

phase, such that by entering the atmosphere at a greater rate of speed beyond predicted reductions, the rendezvous window could be missed. This is a moderate risk; however the consequences would definitely affect the timeline of the mission greatly. Both crew and returned Martian samples will be quarantined aboard the ISS (Figure 4) to guard against back contamination from Mars. This strategy will greatly reduce the likelihood of dangerous alien bio-chemical contagion/toxin encounters.

Quantitative Mission Risks and Mission Success Probabilities

The Monte Carlo simulation technique is often used to generate an overall probability distribution representing a mission, a sub-mission, individual or groups of tasks, or single events of interest to the mission. Figure 5 shows the steps in this model development. Each element of the model is represented by an 'input' probability distribution (e.g., normal, triangular, beta, etc.) and the simulation engine randomly picks values from these for each

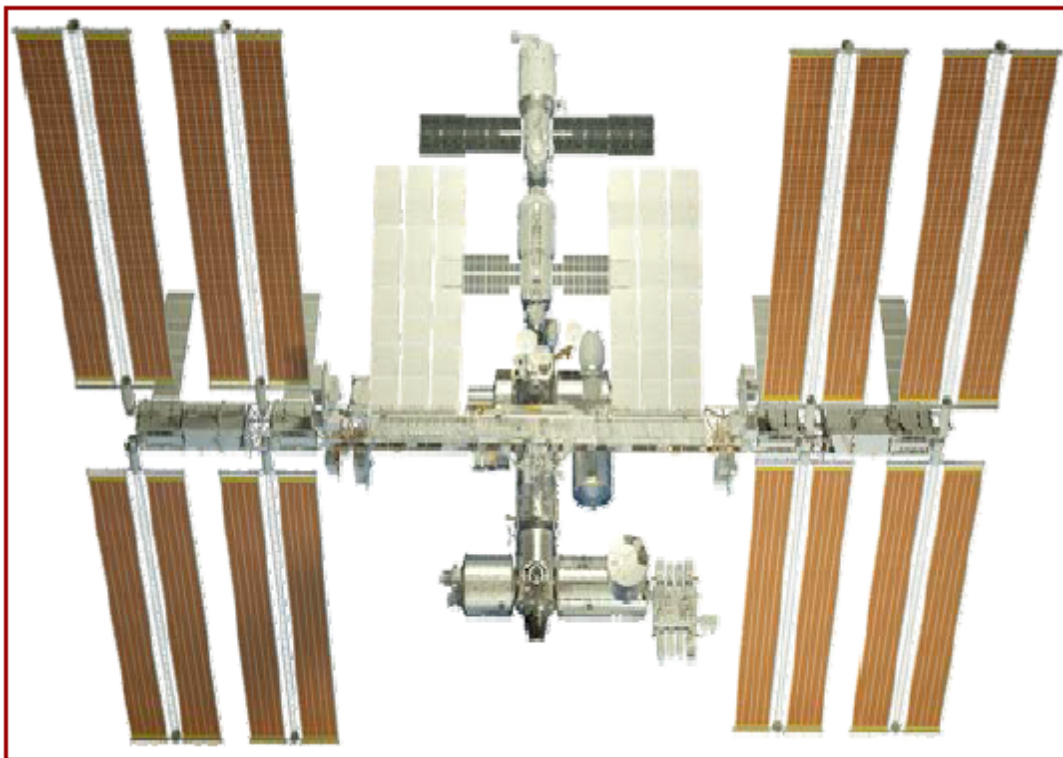


FIGURE 4—The returning HSFM-1 crew and returned samples will be quarantined aboard the ISS for six weeks to detect and help prevent any back-contamination from Mars.

iteration (objective function calculation). A large number of iterations (1000 used herein) produce the 'output' distribution. This output PDF is then used to analyze and predict performance or outcomes of the scenario.

Table 4 lists typical values for events in aerospace processes. Subjective selection based upon industry experience is sometimes used to place discrete events or processes in the 'proper' category OR an industry database can be utilized for such purposes. Both point estimates and Monte Carlo simulations were prepared for the HSFM-1 mission utiliz-

ing this process as described, including the Cargo missions (CSFM 1-4) and the crewed HSFM-1 flight. Point estimate analyses indicate a probability of success of 0.93658 for the CSFM 1-3 cargo sorties (includes Mars EDL) and 0.97522 for CSFM -4 which puts the ERV in a Martian parking orbit with no EDL. The crewed HSFM-1 sortie is predicted at a 0.93869 probability of success which includes the EDL, ascent, and 13 month stay with exploration. The sub-missions (CSFM 1-4) are designed to lead to overall success through stepwise progression where the crew is not launched from Earth until all the cargo missions have succeeded.

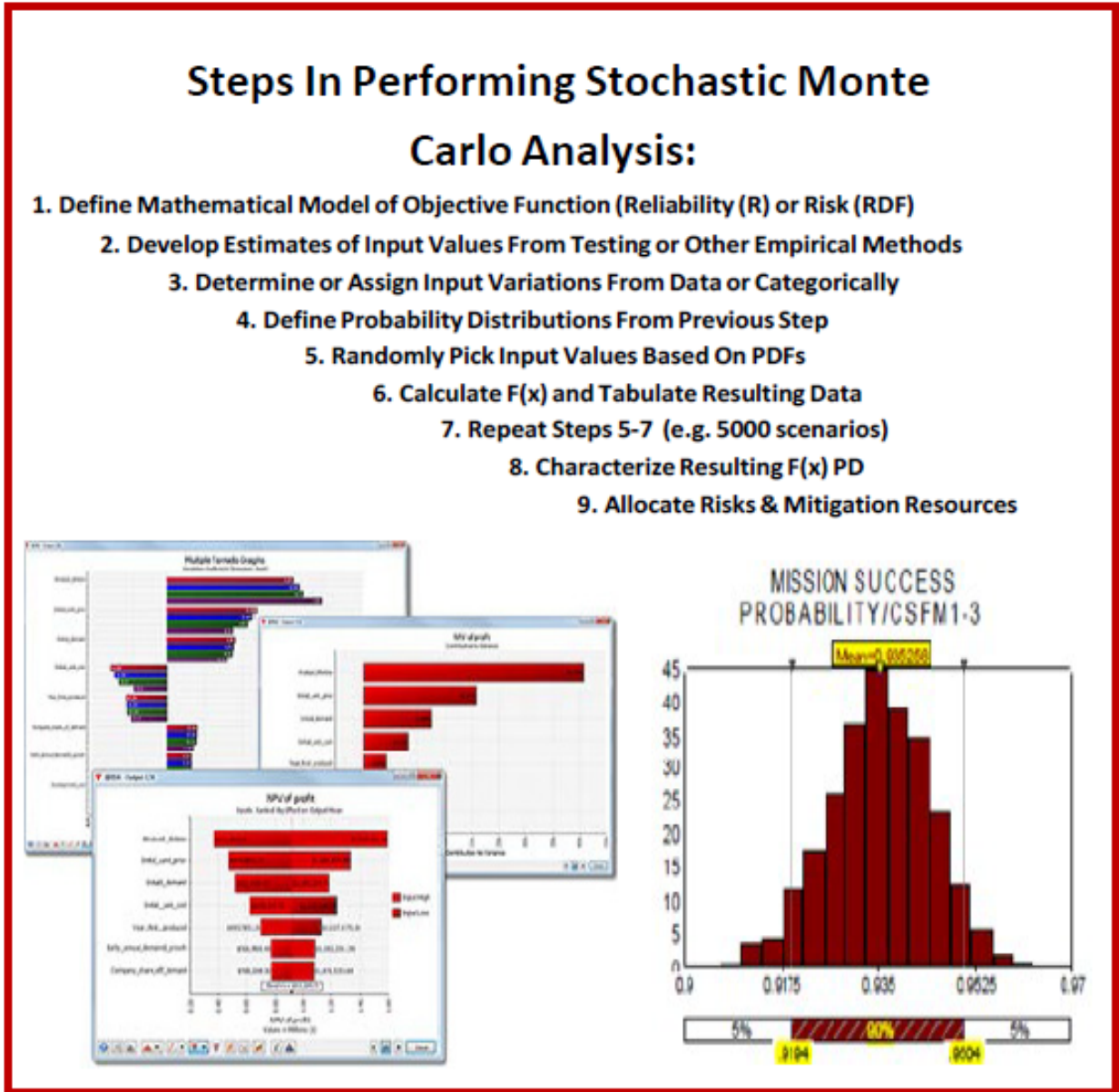


FIGURE 5—Monte Carlo Process Steps and Example Outputs

TABLE 4—Occurrence & Detection RDFs

Probability of Occurrence (RDF) Definition	
Probability of Occurrence (RDF)	Quantitative Value
Remote (occurrence is unlikely)	Approx. 1 in 1,000,000
Low	Approx. 1 in 20,000
Low to Medium	Approx. 1 in 4,000
Medium (occasional failures)	Approx. 1 in 1,000
Medium to High	Approx. 1 in 400
High (repeated failures)	Approx. 1 in 40
Very High (occurrence is predictable)	Approx. 1 in 2

Probability of Detection Definition	
Probability of Detection	Quantitative Value
Remote (detection is impossible)	< 1%
Very Low (detection is unlikely)	Approx. 1%-10%
Low	Approx. 10%-30%
Medium (detection possible)	Approx. 30%-50%
Medium to High	Approx. 50%-70%
High (good chance of detection)	Approx. 70%-90%
Very High (detection is predictable)	Approx. 90%-100%

Figure 6 shows the Table 4 data along with a Risk Magnitude (RM) ranking based on judged consequences [failure effect(s)]. Once the probability of failure (Risk Determinant Factor, RDF) is developed, the RM factor is used in establishing a product of RDF x RM (and often other factors such as

Probability of Detection, POD) to generate a Risk Number (RN), which is basically a ranking number used to compare analyzed risks, rank them according to the RN, and then allocate risk mitigation resources accordingly.

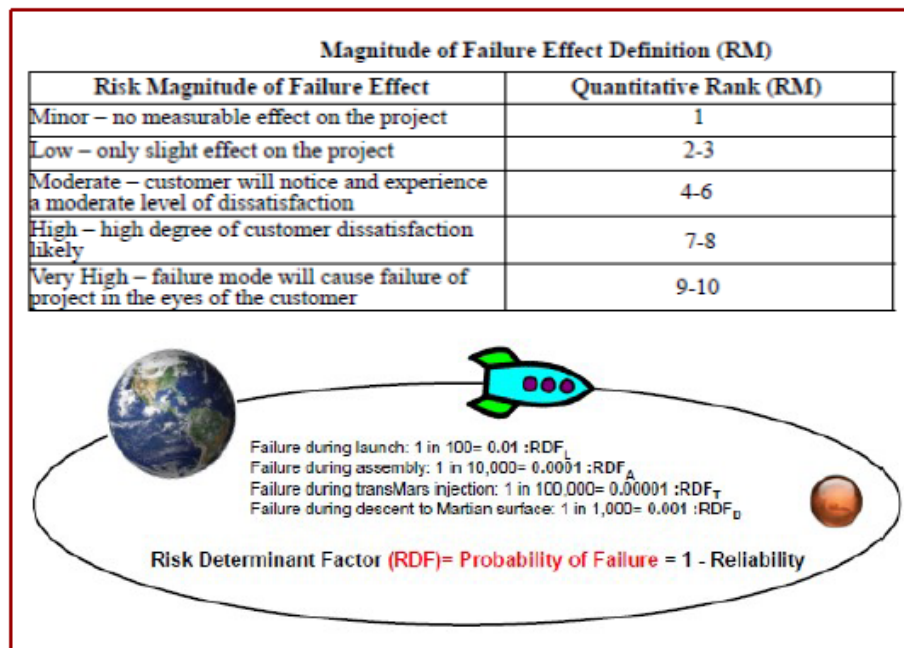


FIGURE 6—Typical Mission Failure Probabilities [SMAD]

Figure 7 shows how, for an individual series of mission events, an equivalent RDF can be determined (minus the POD or other factors here) to arrive at a probability of success. The equivalency is determined using a 'logic array' analogy of AND/OR gates and the simple rules of combining reliabilities as shown in the figure. This technique is used not only to develop a subsystem equivalent reliability, but also in modeling an overall mission. Whereas the subsystem may have tens or hundreds of logic elements, a full-up mission analysis could consist of thousands of individual logic gates that are developed based on the physical characteristics and interrelationships of the system elements as regarding operation, failure, and the resulting reliabilities.

Figure 7 has employed the scenario and values from the lower half of Figure 6 to calculate the resulting reliability using the extremely simplified model (illustration only). As shown, were the values shown employed and the interrelations shown reality, the overall probability of success calculates to be 0.9889 or a $(1-R) = 0.011099 = \text{RDF} = \text{probability of failure}$.

Given that the Figure 7 model is much too simple to create a meaningful illustration of a Monte Carlo simulation for the HSFM-1 mission, a slightly more realistic model was used as shown in Figure 8. While still a very low fidelity model, this illustrates typical interdependencies common in such a mission. Three main mission elements include the Earth Launch-Mars Transit portion of the mission, Mars Entry, Descent, Landing (EDL) and Surface Exploration, and finally, Mars Departure-Earth Transit and docking with the International Space Station in Low Earth Orbit. Each of these top-level mission phases have various numbers of identified failure opportunities with RDF picked based on realistic values (SMAD and Saleh). This model was used to calculate Point Estimates for each of the 3 different types of sub-missions envisioned: Cargo with EDL, Cargo w/o EDL, and the crewed flight with EDL and Mars Ascent/Departure. As stated earlier, Point estimate analyses indicated a probability of success of 0.93658 for the CSFM 1-3 cargo sorties (includes Mars EDL) and 0.97522 for CSFM -4 which puts the ERV in a Martian parking orbit with no EDL. The crewed HSFM-1 sortie is predicted at a 0.93869 probability of success which

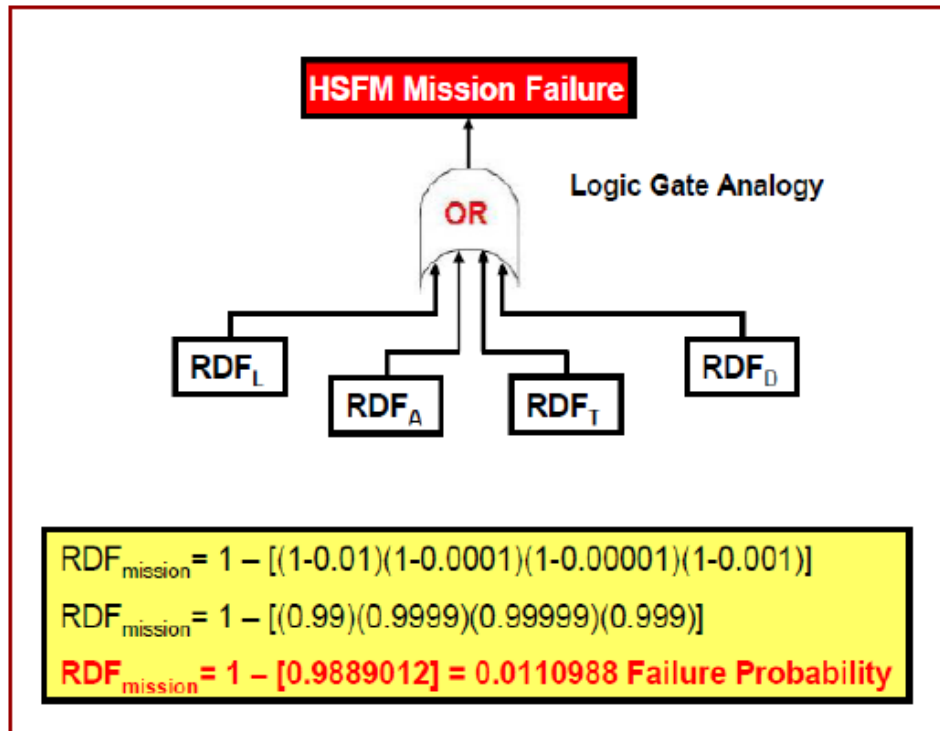


FIGURE 7—Logic Gate Risk Analogy & Calculation.

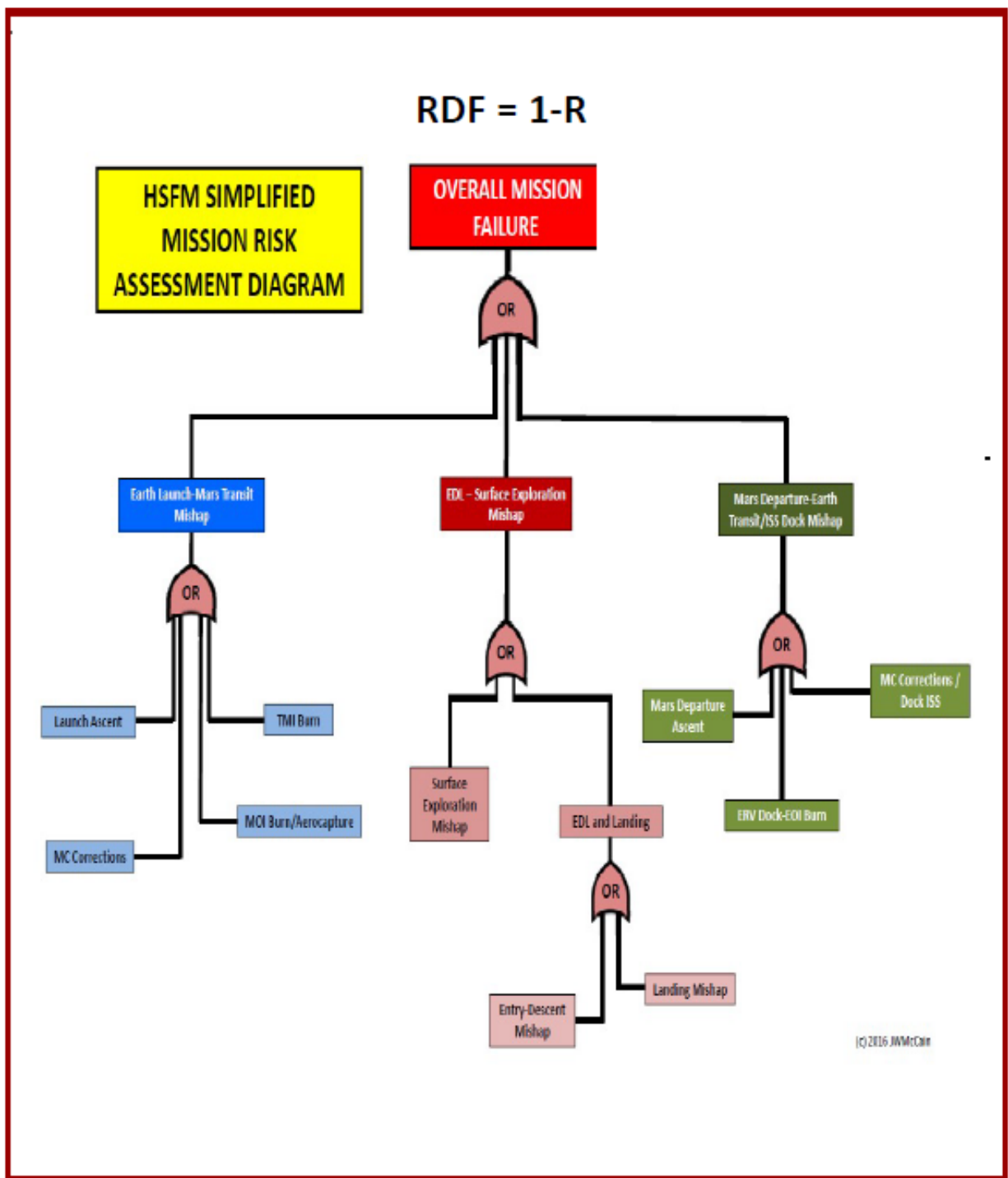


FIGURE 8—Simplified Mission Risk Assessment Diagram

includes the EDL, ascent, and 13 month stay with exploration. The Monte Carlo Analysis used these estimates (see Figures 10-11) and reasonable variations within a triangular distribution (generally 10%) to generate the simulation results shown in Figures 12-15. To further illustrate the

utility of the Monte Carlo Methodology, Figure 12 shows a predicted HSFM-1 Mission Cost PDF where it is 95% probable that the mission could be completed for less than or equal to \$6.07B, a fraction of what the NASA program estimates are!

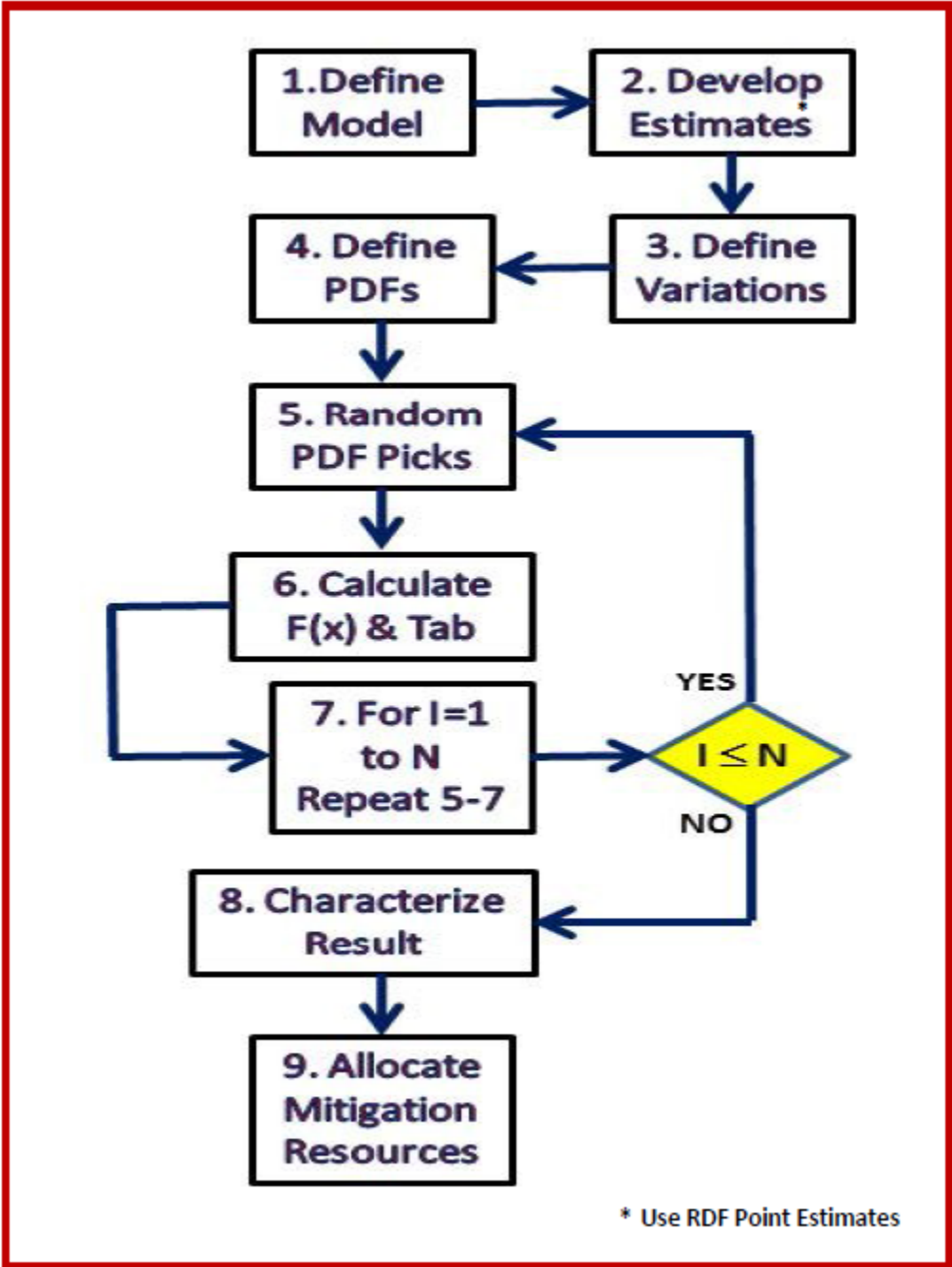


FIGURE 9—Monte Carlo Analysis Flow Diagram [McCain]

CSFM 1-3 Cargo Missions Risk Overview				
J. Wayne McCain				
Roll Up - MISSION SUCCESS PROBABILITY		0.93658		
Roll Up - MISSION FAILURE PROBABILITY		0.06342		
Failure Probability Inputs		INPUTS	Reliability	OUTPUTS
		*	(1-RDF)	RDF
Roll Up - Earth Launch-Mars Transit Failure	0.02475874			0.02478
Assent Launch		0.01	0.99	
TMI		0.005	0.995	
MC Corrections		0.005	0.995	
MOI Burn/Aerocapture		0.005	0.995	
Roll Up - EDL and Stasis on Mars Surface Failure	0.039625			0.03963
On Surface Exploration		0	1	
EDL Activities				0.03963
De-orbit		0.015	0.985	
Landing Mishap		0.025	0.975	
Roll Up - Mars Departure-Earth Transit/ISS Docking Failure	0			0.0000
Mars Assent		0	1	
ERV dock-EOI Burn		0	1	
MC Corrections/Dock ISS		0	1	

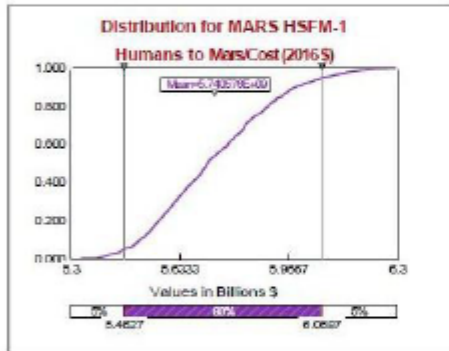
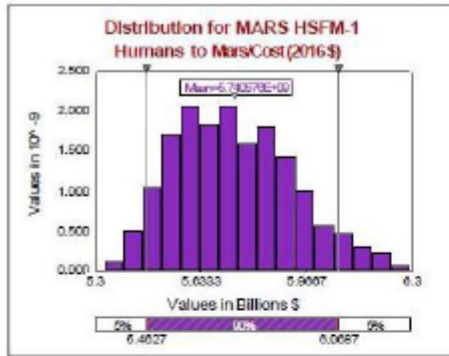
CSFM-4 Cargo Mission Risk Overview (ERV Mars Orbit)				
J. Wayne McCain				
Roll Up - MISSION SUCCESS PROBABILITY		0.97522		
Roll Up - MISSION FAILURE PROBABILITY		0.02478		
Failure Probability Inputs		INPUTS	Reliability	OUTPUTS
		*	(1-RDF)	RDF
Roll Up - Earth Launch-Mars Transit Failure	0.02475874			0.02478
Assent Launch		0.01	0.99	
TMI		0.005	0.995	
MC Corrections		0.005	0.995	
MOI Burn/Aerocapture		0.005	0.995	
Roll Up - EDL and Stasis on Mars Surface Failure	0			0.0000
On Surface Exploration		0	1	
EDL Activities				0.0000
De-orbit		0	1	
Landing Mishap		0	1	
Roll Up - Mars Departure-Earth Transit/ISS Docking Failure	0			0.0000
Mars Assent		0	1	
ERV dock-EOI Burn		0	1	
MC Corrections/Dock ISS		0	1	

FIGURE 10—CSFM1-4 Cargo Missions Risk Point Estimates

HSFM-1 Crewed Mission Risk Overview				
J. Wayne McCain				
Roll Up - MISSION SUCCESS PROBABILITY		0.93869		
Roll Up - MISSION FAILURE PROBABILITY		0.06131		
Failure Probability Inputs		INPUTS	Reliability	OUTPUTS
		*	(1-RDF)	RDF
Roll Up - Earth Launch-Mars Transit Failure		0.024775874		0.02478
Assent Launch		0.01	0.99	
TMI		0.005	0.995	
MC Corrections		0.005	0.995	
MOI Burn/Aerocapture		0.005	0.995	
Roll Up - EDL and Stasis on Mars Surface Failure		0.02581136		0.02581
On Surface Exploration		0.015	0.985	
EDL Activities				0.01098
De-orbit		0.008	0.992	
Landing Mishap		0.003	0.997	
Roll Up - Mars Departure-Earth Transit/ISS Docking Failure		0.01195505		0.01196
Mars Assent		0.005	0.995	
ERV dock-EOI Burn		0.005	0.995	
MC Corrections/Dock ISS		0.002	0.998	

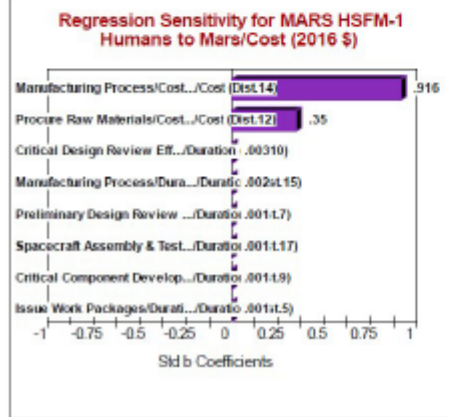
FIGURE 11—HSFM-1 Crewed Mission Risk Point Estimate (MDV Mars Entry, Descent and Land)

Simulation Results for MARS HSFM-1 Humans to Mars/Cost



Summary Information	
Project Name	MARS_HSFM-1_TOPLEVELS
Number of Simulations	1
Number of Iterations	1000
Number of Inputs	18
Number of Outputs	6
Sampling Type	Monte Carlo
Simulation Start Time	4/12/2016 8:00
Simulation Stop Time	4/12/2016 8:00
Simulation Duration	00:00:36
Random Seed	1

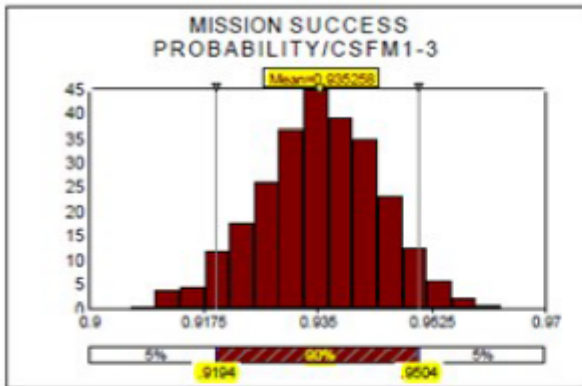
Summary Statistics			
Statistic	Value \$	%tile	Value
Minimum	333421304	5%	3462723218
Maximum	6294974902	10%	5512070898
Mean	5746671761	15%	6546179684
Std Dev	383177851.8	20%	3970389488
Variance	1.469082E+16	25%	5595681332
Skewness	0.399611886	30%	563186624
Kurtosis	2.624009798	35%	5846299138
Median	5719851960	40%	5672073264
Mode	5825646502	45%	5693551336
Left X	5482729218	50%	5719851960
Left P	5%	55%	5746671761
Right X	6068679160	60%	5761665334
Right P	25%	65%	5800581056
Diff X	605846952	70%	5835721820
Diff P	30%	75%	5864793138
Filters	0	80%	5890882922
Filter Min		85%	5916452592
Filter Max		90%	5950823338
#Filtered	0	95%	6068679160



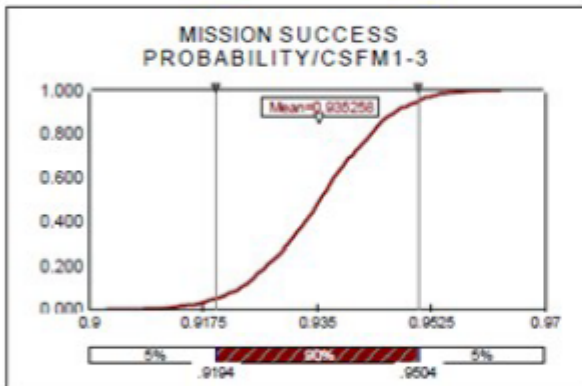
Sensitivity			
Rank	Name	Regr	Correlation
#1	Manufacturing Process/Cost (Dist.14) / Task 16	0.916	0.936
#2	Procure Raw Materials/Cost (Dist.12) / Task 15	0.350	0.388
#3	Critical Design Review Effort/Duration (Dist.10) / Task 13	0.009	0.017
#4	Manufacturing Process/Duration (Dist.15) / Task 16	0.002	-0.006
#5	Preliminary Design Review Effort/Duration (Dist.7) / Task 10	0.000	-0.009
#6	Spacecraft Assembly & Test/Duration (Dist.17) / Task 17	0.001	0.044
#7	Critical Component Development Testing/Duration (Dist.9) / Task 12	0.001	0.096
#8	Issue Work Packages/Duration (Dist.5) / Task 8	0.001	-0.056
#9	Spacecraft Assembly & Test/Cost (Dist.16) / Task 17	0.000	0.012
#10	Procure Raw Materials/Duration (Dist.13) / Task 15	0.000	-0.024
#11	Prepare & Let Subcontracts/Duration (Dist.4) / Task 7	0.000	-0.060
#12	Update Project Plan/Duration (Dist.1) / Task 4	0.000	0.009
#13	Develop Resource List/Duration (Dist.3) / Task 6	0.000	-0.041
#14	Flight Control Simulated Test/Duration (Dist.19) / Task 20	0.000	0.005
#15	Flight Readiness Review/Duration (Dist.18) / Task 18	0.000	0.005
#16	CDR Meeting/Duration (Dist.11) / Task 14	0.000	0.002

FIGURE 12—Mars HSFM-1 Human to Mars / Cost

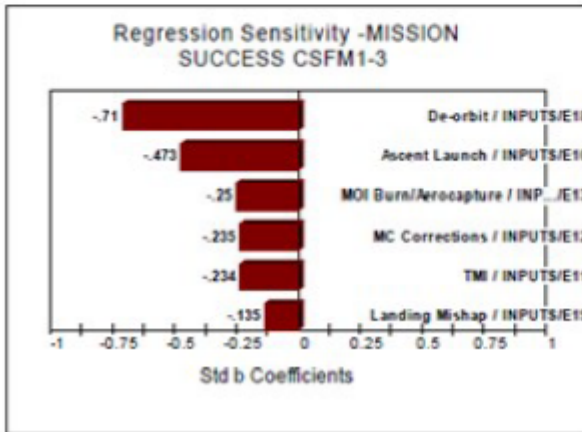
**Simulation Results for
MISSION SUCCESS PROBABILITY / CSFM1-3**



Summary Information	
Workbook Name	MissionRiskAnalysis.xlsx
Number of Simulations	1
Number of Iterations	1000
Number of Inputs	28
Number of Outputs	8
Sampling Type	Monte Carlo
Simulation Start Time	4/9/2016 15:17
Simulation Stop Time	4/9/2016 15:17
Simulation Duration	00:00:03
Random Seed	1395948882



Summary Statistics			
Statistic	Value	%tile	Value
Minimum	0.90258	5%	0.91942
Maximum	0.96313	10%	0.92317
Mean	0.93528	15%	0.92545
Std Dev	0.00929	20%	0.92721
Variance	8.62787E-05	25%	0.92919
Skewness	-0.117845939	30%	0.93055
Kurtosis	2.956462043	35%	0.93190
Median	0.93539	40%	0.93316
Mode	0.93663	45%	0.93450
Left X	0.91942	50%	0.93539
Left P	5%	55%	0.93661
Right X	0.95045	60%	0.93746
Right P	95%	65%	0.93888
Diff X	0.03102	70%	0.94028
Diff P	90%	75%	0.94176
#Errors	0	80%	0.94327
Filter Min		85%	0.94461
Filter Max		90%	0.94606
#Filtered	0	95%	0.95045



Sensitivity			
Rank	Name	Regr	Corr
#1	De-orbit / INPUTS	-0.710	-0.731
#2	Ascent Launch / INPUTS	-0.473	-0.497
#3	MOI Burn/Aerocap	-0.250	-0.267
#4	MC Corrections / INPUTS	-0.235	-0.270
#5	TMI / INPUTS / \$E	-0.234	-0.268
#6	Landing Mishap / INPUTS	-0.135	-0.167
#7	Ascent Launch / INPUTS	0.000	0.012
#8	TMI / INPUTS / \$E	0.000	0.012
#9	MC Corrections / INPUTS	0.000	0.005
#10	MOI Burn/Aerocap	0.000	0.004
#11	De-orbit / INPUTS	0.000	-0.050
#12	Landing Mishap / INPUTS	0.000	0.009

FIGURE 13—Cargo Missions Success Probability [CSFM1-3]

**Simulation Results for
MISSION SUCCESS PROBABILITY (R) / CSFM-4 ERV**

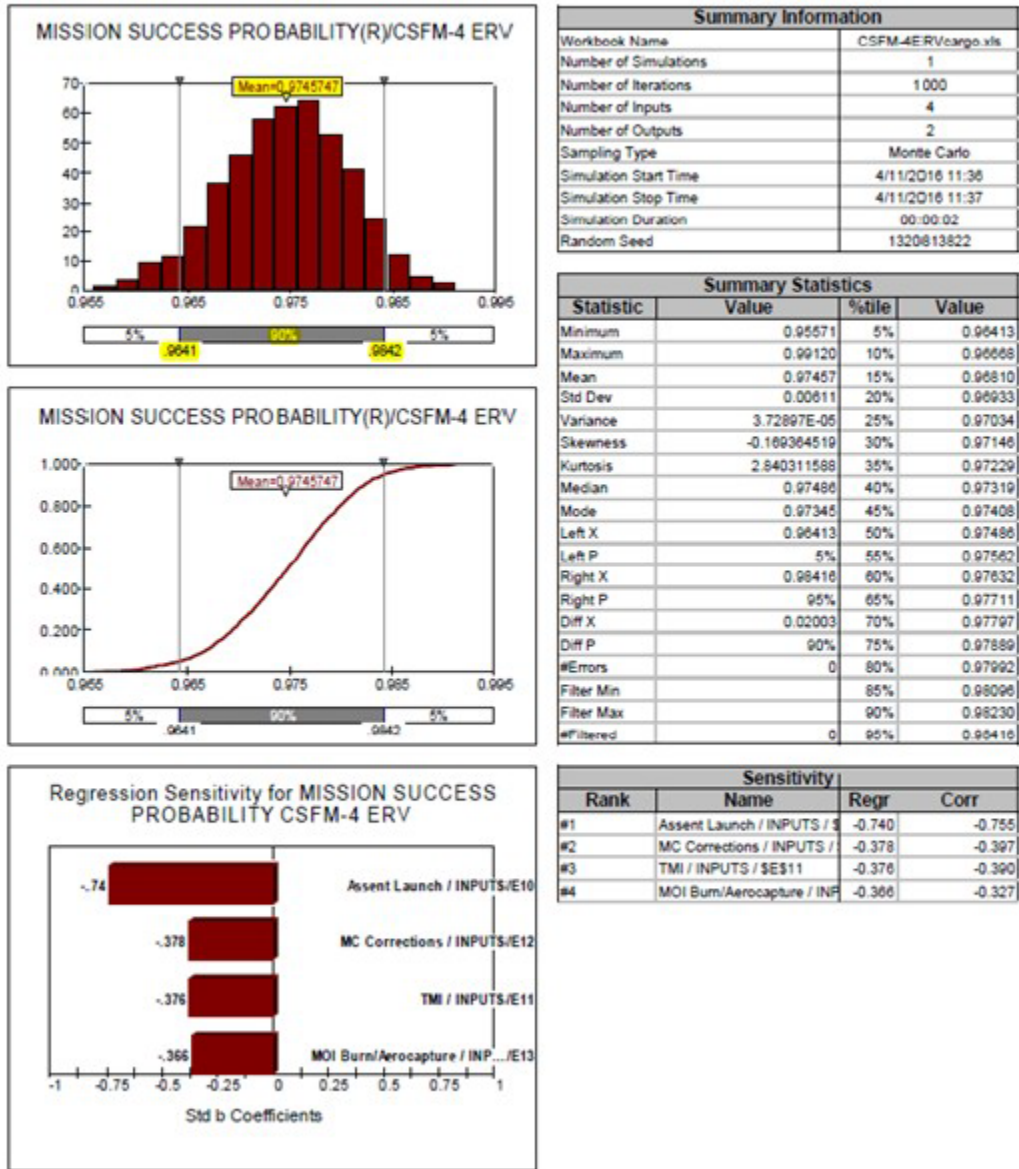


FIGURE 14—Mission Success Probability (R) / CSFM-4 ERV

**Simulation Results for
MISSION SUCCESS PROBABILITY / HSFM-1 CREWED**

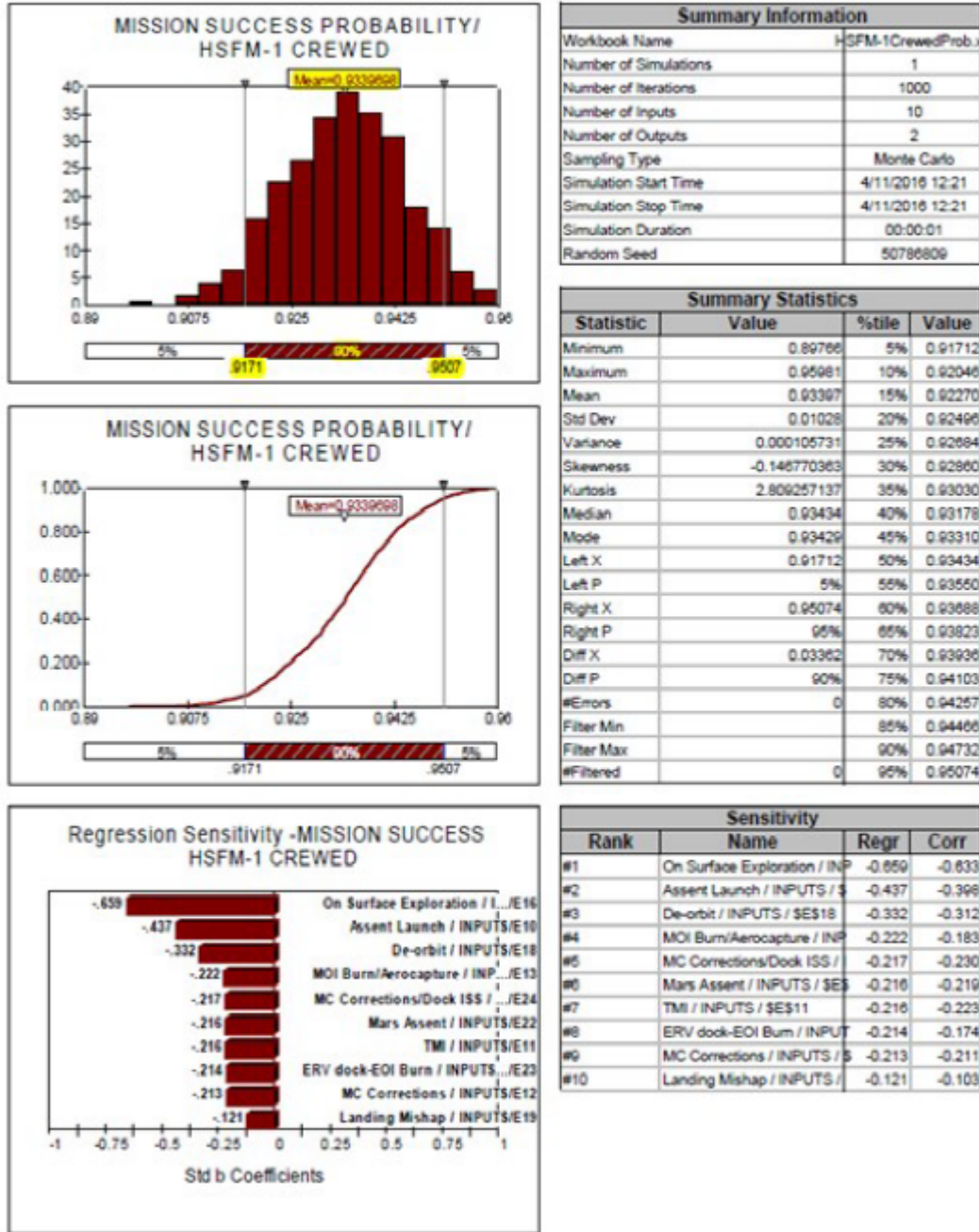


FIGURE 15—Mission Success Probability [HSFM-1 CREWED]

RESEARCH SUMMARY AND CONCLUSIONS

- Mission Preliminary Risk Analyses Can Be Undertaken Using Simplified Qualitative & Quantitative Methodologies
- Risk Point Estimates Can Be Generated Using Previous Mission Success Criteria and/or Industry Standardized Data (SMAD)
- Further Expansion of Risk Assessments Can Be Achieved Using Monte Carlo Analysis and Data From Point Estimates
- As Mission Details Evolve, Analyses May Be Updated and Accuracy Improved
- Commercial Risk Analysis Packages (e.g. Palisades @Risk) Can Be Employed Without Large Code Development Costs



FIGURE 16—Research Summary & Conclusions

Summary and Conclusions

In order to insure success in the effort to successfully send Humans to Mars and return them to Earth, every engineering and analytical tool at man's disposal must be utilized. This research has shown the utility of mission reliability modeling and several different, yet complimentary approaches. Qualitative risk analysis can be useful in determining major areas of concerns based on observed issues, experience, and intuition. These techniques may identify where the brunt of risk mitigation resources should be applied, yet do not normally supply precise details yielding precise calculations and predictions of risk impacts. These Qualitative models are generally simplistic, straightforward, and easy to construct.

Quantitative modeling is considered a step up in the fidelity of the risk assessment technique. Discrete, deterministic calculations yielding point estimates of various mission scenarios, processes, and tasks improves the mission planning to more properly allocate limited resources used in risk mitigation. These estimates may be modeled using actual reliability data from similar and/or previous missions, or the large available data base of typical aerospace performance and reliabilities (e.g., the SMAD).

Since risk and mission failures are considered stochastic, probabilistic events, further fidelity of mission modeling can be achieved using the Monte Carlo Analysis technique which uses random picks of parameter values and multiple iterations to generate a 'probability density function' of a given scenario, task or submission. Continued evolution and refinement of mission details will allow continuous update of the models, thus improving fidelity and accuracy. Commercial Risk Analyses packages, such as @RISK allow these achievements without huge code developments. These points are summarized in Figure 16.

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Performance-Based Coaching: Navigating Change, Improving Business Practices, and Driving Organizational Sustainability

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ABSTRACT

The greater the degree an organization is capable of self-correction, adaptation and growth, the more it is evidence of the monumental and substantive influence of change. Monitoring performance to effectively and efficiently meet organizational goals and continuous feedback and adaptation becomes a life line for organizational sustainability. To the degree to which organizational embedded systems and cultures resist such feedback and self-monitoring, facilitate a more closed system and susceptible to negative outcomes and consequences. As organizations, both not-for-profit and for profit seek to improve business and performance in the current dynamic business climate, there is a significant demand for tools and practices that facilitate and lead to better performance. In this review, the role of Professional Coaching will be examined as a tool that allows coaches to provide a conduit for the coachee business client to find the right answers for the situation at hand.

Business Improvement and Sustainability: An Argument for Coaching and Change Management

There is one indisputable and unequivocal expectation that we can have in world today---change. It will and does happen. The law of change suggests like time itself, nothing ever remains constant and stagnant. This fundamental concept can certainly find relevant application in effectively managing organizations today. Those managers that embrace the idea that change will indeed occur, with or in absence of them, understand that planning must account for this phenomena both at an operational and strategic level. They can proactively plan for change or reactively adjust to environmental forces, both internal and external, to an organization. How an organization's culture is entrenched in core values, stated and integrated philosophies and observed actions can best position the organization for the most optimal outcomes in this dynamic environment of today. This speaks to the uniform criticality of strategy and the vital role and function of organizational culture.

In 1979, Michael Porter broached the idea that forces both internal and external to an organization

are important considerations in business decisions and must be carefully guided. Porter's Five-Force model argues this contention in that all business planning must anticipate and proactively plan for the forces that influence it. In his article titled "How Competitive Forces Shape Strategy," he purported how effectively an organization plans and manages these forces driving change, the more power and optimal market position an organization can best realize the intended strategy (Porter, 1979). **Porter's Five Force Model** suggests the diversity of influences that must be carefully considered as a context for making sound business decisions (**Figure 1**).

Supplier power, buyer power, competitive rivalry, threat of substitution and new entrants keep an important emphasis on planning, assessing factors that influence change, and make educated decisions about what might be expected and translating that into an organizational strategy and operational goals that are nimble, flexible, and adaptable to the business climate in which an organization operates (Rice, 2010). One might ask, what is the role of organizational culture and chosen business practices in making business decisions and the results realized?

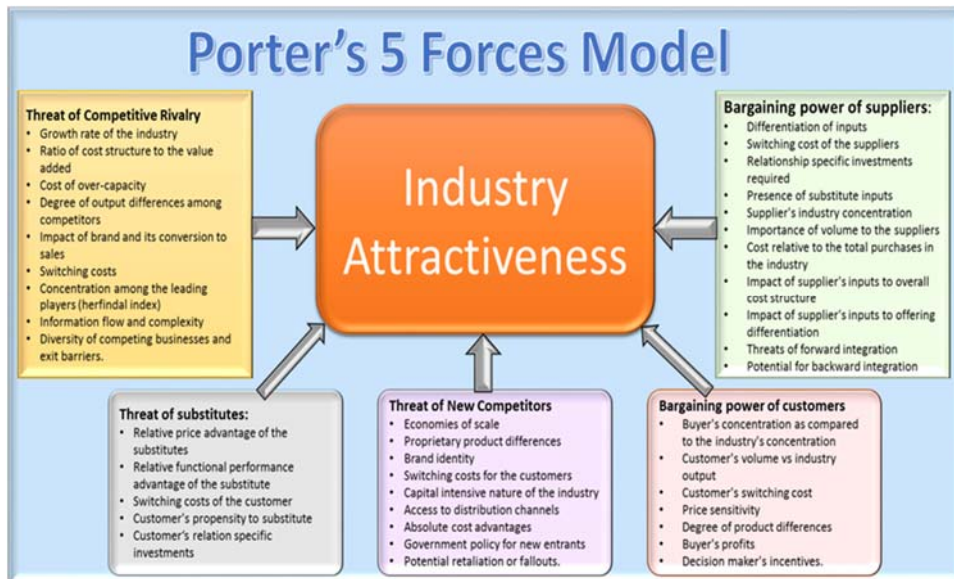


FIGURE 1—Porter's Five Forces Model

The greater the degree an organization is capable of self-correction, adaptation and growth; the more it is evidence of the monumental and substantive influence of change. Monitoring performance to effectively and efficiently meet organizational goals and continuous feedback and adaptation becomes a life line for organizational sustainability. The degree to which organizations resist such feedback and self-monitoring, they are more closed and susceptible to negative outcomes and consequences. Consider the story of the VASA, a Swedish built ship that made its maiden voyage in 1628. The King of Sweden, Gustavus Adolphus, wanted to build a premier ship that portrayed his expansionist aspirations, so he spared no expense in building this spectacular vessel. There were meticulous details ordered by the king to be followed in constructing the ship, and the construction crew carefully followed the specifications the king himself had approved for the ship's assembly. This ship was the largest and most heavily armed warship of her period, with three levels of cannon arms. It was elaborately adorned with hundreds of sculptures, and painted with brilliant colors. The vessel represented the pride of the King of Sweden and his country. However, when the vision was brought to reality and the ship was launched on its inaugural voyage in all its grandeur, it quickly sank. The architects in their effort to strictly abide by the king's wishes in designing the craft, failed to fully assess the influences that would affect the buoyancy of the ship, its weight and ability to stay afloat in water. The ship was a grand vessel, but since engineering standards were not considered from a marine perspective, there was ultimate failure.

Changes necessitated for the project's success had been completely ignored. The culture under the King's rule, as with this project team, led to the narrow view and unexpressed relevant concerns that led all involved to accept the unilateral direction of the King. It was a perfect storm that led to calamity.

In the previous example, the leader sought to be self-guided. Neuroscience speaks to this risk that can distort a leader's decisions. Campbell, Whitehead, and Finkelstein (2009) describe such a propensity as leaders may sometimes make decisions through unconscious processes references to as pattern recognition (misleading or distorted memories) and emotional tagging (self-interests or distorting attachments). Therefore, managers can benefit from systematic ways and methods to recognize these biases and design safeguards that allow for more analysis, clearer idea generation, and ultimately better judgment. Oftentimes, even the brightest leaders can make missteps if they ignore the advantage of guided reflection and analysis.

Agents of Change: The Coaching Profession

As organizations, both not-for-profit and for profit seek to improve business and performance in the current dynamic business climate, there is a significant demand for tools and practices that facilitate and lead to better performance. Professional Coaching is a tool that allows coaches to provide a

conduit for the coachee business client to find the right answers for the situation at hand. It is based on the premise that the coachee already has the best answers but can benefit from the guidance of inquiry by the coach (Casey & Wuestman, 2015). Therefore, coaching is a dynamic process that engages the coach and coachee interdependently for desired outcomes and solutions. Executive coaching has consistently been found to be effective in driving business results (Bower, 2012). Spence and Grant (2007) concluded that when business clients participated in a formal coaching relationship with a professional coach, they were more likely to successfully reach their goals and experience greater levels of self-reflection and insight, while enjoying the advantage of lower levels of depression, stress, and anxiety. It is a process that embraces lean leadership where investing time in coaching organizational members helps navigate through continuous improvement with sustainable business results (Casey & Wuestman, 2015).

The Coaching Profession: Transition from Remediation to Proactive Organizational Learning

There is tremendous growth potential and opportunity to integrate professional coaching into improving leadership capabilities and business outcomes today. If this is the case, why have not more organizations sought to integrate the use of professional coaching into guiding business decisions in the past, but now are turning to the use of these resources? The answer to this question must be answered holistically and includes three primary reasons. First, professional coaching underwent a transition from being used for leader skills remediation a couple of decades ago, to its present state of proactive business investment and advantage to increase and optimize leadership capabilities. This idea has been largely embraced as businesses cultures acknowledge coaching professionals can be especially relevant in assisting them to grow and develop executives and leaders that demonstrate exceptional levels of emotional intelligence and insight (Page & deHaan, 2014). The second reason for the renewed interest in professional coaching is that the profession has shifted from embracing solely unilateral views and frameworks about how to coach to more eclectic models that embrace varied styles and methods that will work for a particular person, at a particular moment, and with the particular business issue at hand. Finally, there has been a significant in-

crease in the use of professional coaches as the industry has become more professional, mature, and regulated. A Global Coaching Survey in 2009 indicated that the coaching industry has grown to a market of \$2 billion annually worldwide (Segers, Vloeberghs & Henderick, 2011) and half of that revenue (\$1 billion) is generated in the United States alone (Page & de Haan, 2014). Of particular note is that while there has been substantive utilization of coaching in businesses both domestic and internationally, only two of the 162 countries represented in the survey suggested that it had reached its maturity in the growth life cycle (Segers, Vloeberghs & Henderick, 2011). Those who are entering the field are from very diverse backgrounds, such as clinical psychology, senior management, organizational development, and counseling. Their coaching frameworks also are just as varied as their occupations and include coaching models that range from the GROW-model, solution-focused brief therapy, positive psychology, and person-centered counseling. These coaching professionals bring an eclectic view to solve real business problems based on their respective background, theoretical orientation and interests tailored to meet the individual client.

Executive Coaching: Implications for Organizational Success

Evidence suggests that 92-96% performance based coaching results are found to be 'effective' or 'very effective' based on the resulting actionable information, instruction, and advice (de Haan, Duckworth, Birch & Jones, 2013). Creating a performance driven culture of accountability is realized when an organization is anchored on four interrelated factors: 1) performance leadership, 2) performance management, 3) effective employee engagement human resource practices, and 4) measurements against key performance indicators (KPIs). There is an interdependent nature of performance leadership, performance management, employee engagement, and a culture of accountability in any robust Human Capital Management Strategy (HCMS). These interrelated organizational elements have an interdependent, synergistic relationship as presented by *LaFavor's Human Capital Management Strategy* outlined in **Figure 2**.

To achieve enhanced levels of accountability, these measures must be tied directly to an employees work and defined outcomes. The performance coaching process provides a conduit to assist managers to

strategize how to ensure strategic and operational goals and related tasks are both relevant and attainable for organizational viability and sustainability. The overarching objective is to create results that matter.

Number = 502

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Figure 2—LaFavor's Human Capital Management Strategy

Contributors



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She has been married to husband, Kenny, for thirty years and has four adult children, all of which are in various phases of college or early stages of career.

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Dr. J. Wayne McCain (shown with daughter Amelia) has been a practicing engineering manager for over 30 years and a college educator for over 20 years of that time. Dr. McCain graduated from Auburn University with a Bachelor of Science in Aerospace Engineering and has MBA and PhD (in engineering) degrees from the University of Alabama at Huntsville. He recently earned a Master of Space Systems degree from Florida Institute of Technology in Melbourne, Florida. He has worked Army and Air Force related defense programs for Thiokol Propulsion and Martin Marietta (now Lockheed Martin) in Denver. Dr. McCain also worked on automated test equipment for the Space Shuttle Program while at United Space Boosters, Inc. Dr. McCain has been involved in college education since the late 1970s and has witnessed first-hand the influences had on the trade by evolution of the 'information age', personal computers, and the Internet. He is a member of SARA and is participating in the JOVE and SuperSID Projects.



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