Understanding the connection between the Alternative Response Tool Evaluation System and adoption of innovative oil spill remediation efforts

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ABSTRACT

The National Oceanic and Atmospheric Administration developed the Alternative Response Tool Evaluation System (ARTES) as a tool to evaluate non-conventional oil spill response technologies. During the 2010 Deepwater Horizon oil spill in the Gulf of Mexico, ARTES was implemented on a large scale to aid remediation efforts. Only a small handful of documents exist on this important program, and evaluating its successes during the Deepwater Horizon event will aid in future spill response attempts. I analyze the ARTES program through responses of key actors. In order to analyze the industry and government responses I use document analysis and coding methods. I research vendor response through interviews with vendors whose technologies were evaluated by ARTES during the Deepwater Horizon oil spill. Ultimately, I suggest how ARTES can be advanced for better preparedness during the next significant spill through synthesizing lessons learned and actions for the future.

KEYWORDS

Deepwater Horizon, British Petroleum, clean up technologies, spill response, Gulf of Mexico

INTRODUCTION

The United States is the largest energy consumer in the world and reliance on petroleum for energy is an integral part of the US economy (Li et al. 2009). The transportation of crude oil across oceans is also currently critical to global markets (Mercer and Trevors 2011). Crude oil spills that arise from events such as ruptured ships or deep-sea oil drilling platform malfunctions inflict drastic and prolonged consequences to the environment and wildlife (Belanger et al. 2010). Because of the difficulty of logistics and the massive cost of clean up, oils spill remediation is often a prolonged process and many ecosystems are never returned to their pre-spill state (Ajijolaiya et al. 2007). Technological innovations for the improved treatment of earth's oceans during spills are necessary to maintain global resources and protect aquatic ecosystems (Thibodoux et al. 2011). It is highly important to find remediation techniques that are both efficient and environmentally sensitive (Mercer and Trevors 2011). Significant oil spills often expose weaknesses and limitations in the policy aimed at oil spill mitigation and recovery.

On April 20, 2010, the explosion of the BP Deepwater Horizon oil-drilling platform in the Gulf of Mexico vented persistently for over 90 days, spilling 4.9 million barrels of crude oil into the Gulf (Belanger et al. 2010). Crude oil continuously washed up on coastlines of several Gulf of Mexico states. The spill released over 10 times more volume of crude oil than the Exxon Valdes spill in Alaska (Atlas and Hazen 2011). The explosion of the Deepwater Horizon rig killed 11 workers and triggered what may prove to be the largest spill in history, directly affecting the coasts of Louisiana, Mississippi, Alabama, and Florida (Muralidharan et al. 2011). Data from the NOAA website, compiled in figure 1 below, suggests about 25% of the 4.9 million barrels that were spilled into the Gulf still remain. The government, industry, and vendors were not fully prepared for a spill of this significance, but steps can be taken to be better prepared in the future. The challenge of oil spill remediation is still being felt today as, two years later, ecosystems surrounding the Gulf are yet to be brought back to their state prior to the spill. The future geographic dispersion of the oil and its impact on the marine environment remain difficult to determine because of the variability of the ocean (Mcrea-Strub et al. 2011). The oil that has infiltrated the coastlines and marshes will degrade much slower as it becomes nutrient depleted (Atlas and Hazen 2011). Quick and effective oil spill response remains a challenge to governments and oil companies. Although the topic is widely researched and highly important,

proper advancements have yet to be made to successfully address large-scale accidental oil spills. Extensive research is still needed to develop tools for risk assessment and management (Thibodoux et al. 2011).

The government developed the Alternative Response Tool Evaluation System (ARTES) to evaluate innovative remediation techniques. The need for research and testing of innovative technologies for oil spill remediation has been acknowledged by the Oil Pollution Act of 1990, along with legislation from California and Alaska (Adassi et al. 2011). The severity and length of the Deepwater Horizon spill exposed the need for efficient and thorough review of remediation technologies. ARTES was developed by members of Regional Response Teams of federal response specialists to quickly evaluate alternative countermeasures to spills through technical review and scoring (Cortez and Rowe 2010). It is a system of technology review that quickly tests and suggests appropriate remediation techniques to Incident Command to aid efficient clean-up efforts. The system was designed to better integrate non-conventional oil spill remediation innovations (NOAA 2010). Innovative new technologies, or Alternative Response Technologies (ARTs) typically included all non-mechanical chemical and biological countermeasures used to remediate the damage caused by oil spills (Cortez and Rowe 2010). The terms ARTES, and ART are both used when describing the Alternative Response Technologies organization that was implemented during the Deepwater Horizon oil spill of 2010. ARTES was employed on a large scale after the Deepwater Horizon Oil Spill, and it remains important to investigate the program's success in aiding remediation. Public databases are void of any information highlighting the program. A few papers describing ARTES and how it was employed during the Deepwater Horizon Spill have been published by the government and by members of British Petroleum, yet they are not readily available to the public. The 2011 International Oil Spill Conference proceedings published by Adassi et al. provides a comprehensive overview of the Alternative Response Technologies organization. Another paper published by Michael Cortez and Hunter Rowe of British Petroleum highlights the program and how it was used for the Deepwater Horizon Oil Spill response (Cortez and Rowe 2010). There is a need for an inclusive look at ARTES and how it can be advanced to create a dynamic oil spill response evaluation system. The next iteration of research could benefit future spills by communicating the lessons learned and advances in ARTES.

Through investigation of the lessons learned after the ARTES implementation during the Deepwater Horizon oil spill my study helps advance the process for the future. Through the analysis of the ARTES program, I aim to investigate how the system aids in the challenge of efficient oil spill remediation. Through researching industry, government, and vendor responses to ARTES during the Deepwater Horizon oil spill, I review the system and how it can better be advanced to prepare for the next significant spill. I investigate the strengths and weaknesses of the program by interviewing stakeholders with different perspectives and analyzing available documents on the system. My hypothesis stands that increased research and funding to ARTES will lead to greater benefit to the environment and the efficiency of the spill response process. The counterargument may suggest that the current status quo is sufficient, yet the continuous devastation wrought by oils spills illustrates the need for adoption of new innovations. Persistent spills have long-term consequences that may never be expunged (Belanger et al. 2010). The objective of my study is to tease apart key lessons learned and actions for the future concerning ARTES and add to the slim body of literature on the program.

Study System

An overview of the ARTES as a system is central to understanding my study. The National Oceanic and Atmospheric Administration (NOAA) developed ARTES traditionally to evaluate non-conventional alternative countermeasures to spills (NOAA 2010). During the Deepwater Horizon event the ART organization worked with the National Contingency Plan product schedule to evaluate response tools and provide feedback to Unified Command (Adassi et al. 2011). It was then Command's decision whether to implement the tool. The triage process includes four stages: 1) a trained team of evaluators review proposals for feasibility (Adassi et al. 2011); 2) submittals are put into categories based on if they aid remediation at the source or after the spill, and if they are dispersant, chemical, or mechanical, 3) Specialized technical experts review, score, and prioritize for testing based on operational needs; and 4) Projects that were formally evaluated and tested are held in Stage Four. ARTES acts as an overarching management system to address the high level of proposals submitted by vendors during a spill (NOAA 2010). Specifically during the Deepwater Horizon event, the ART team received about 120,000 proposals, with 40,000 relevant to spill control and evaluated (Cortez and Rowe 2010).

Ultimately 100 suggestions were formally evaluated and about 25 have proved significant in the Deepwater Horizon response. ARTES was a crucial tool in aiding remediation during this spill, yet it was difficult to be prepared for a spill of its scope and significance. My study investigates the ARTES implementation during the BP spill to gain a better understanding of how the organization can aid remediation for the next significant spill.

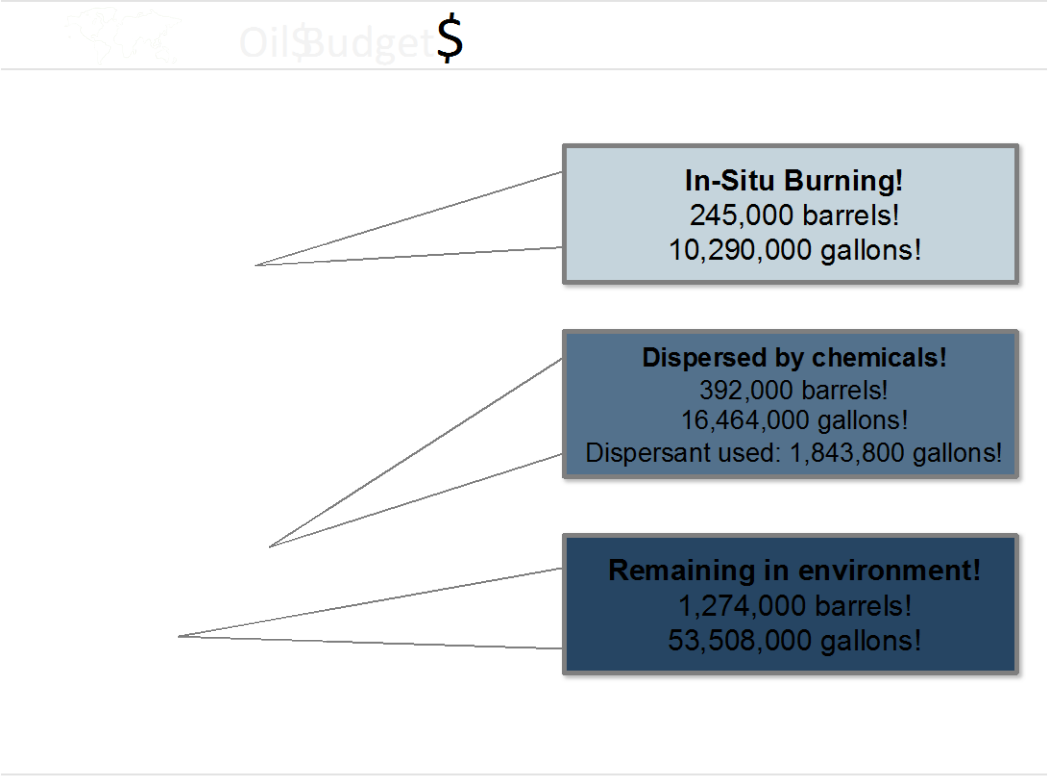

Figure 1: Oil Budget after the Deepwater Horizon Spill Source: NOAA. 26% of the 4.9 million barrels still remain in the sea, proving justification for adoption of innovative spill remediation techniques

METHODS

Data types and data collection

The data collection serves the purpose of answering the research question, how can ARTES be advanced and improved to create a more dynamic oil spill recovery plan. Intrinsic in this question is fully understanding the system of ARTES and how it was used during the

deepwater horizon oil spill. The documents and interviews provide insight into government, industry, and vendor responses to the program in order to understand and improve upon the system.

Government and industry response

I analyzed the 2011 International Oil Spill Conference Proceedings (Adassi et al. 2011) along with the National Oceanic and Atmospheric Administration website (NOAA) to understand the government perspective on ARTES. I also obtained documents and PowerPoint presentations from British Petroleum to understand the industry response to ARTES and adoption of new innovative oil spill remediation technologies. Similarly, I analyzed BP's paper on ARTES written by their head of Gulf Coast Restoration Mike Cortez (Cortez and Rowe 2010).

Vendor response

To collect information on vendor responses to ARTES I interviewed vendors of technologies that were evaluated by ARTES. I completed five interviews by phone with technology representatives from major innovations that were evaluated by ARTES. The first vendor was Opflex solutions whose technology was considered by ARTES program and implemented during BP spill. It was successfully recommended by ARTES. The second vendor was Cytosol whose technology was considered by ARTES program and not recommended. I also interviewed technology representatives for Matter of Trust Hair Boom, Organic Products, and BeachTech. The interviews were used to identify experiences and lessons learned from different perspectives. I collected as much information as possible from vendors whose technologies were evaluated by ARTES after the Deepwater Horizon oil spill.

Document Analysis

To analyze responses by the industry to ARTES I used document analysis on the peer reviewed and grey literatures and other materials such as power-point presentations from key

actors in the field. All documents available on the subject were read and analyzed for opinions and lessons learned from ARTES. Responses were organized into flow charts that focused on key words and phrases that suggested the positive and negative aspects of ARTES. Common lessons learned and suggestions for the future were researched in order to understand how ARTES could be advanced for better spill response.

Interview Analysis

To analyze vendor responses I coded the interviews for key words and phrases relating to the improvement of adoption of innovative oil spill techniques. To investigate the importance of advantages of innovative technologies from a vendor perspective, I totaled how many times the most important categories were mentioned. The categories were chosen based on which attributes the vendors stated were most significant in aiding remediation. Nine categories were analyzed: 1) **Renewability/reusability (Re):** signifies capability of the technology to be used more than once; 2) **Biodegradability (Bio):** denotes the capability of decaying through the action of live organisms; 3) **Speed/efficiency (Eff):** suggests the quickness of completion; 4) **Costliness:** is how competitive the price is compared to mainstream technologies; 5) **Toxicity (Tox):** is the relative degree of being toxic; 6) **Environmental safety:** signifies the degree of harm to environment and ecosystems; 7) **Organic (Org):** denotes the product is derived from living organisms; 8) **Adaptive:** denotes the ability to change to best fit the situation; and **Ease/accessibility (Eas):** is the ease of application.

To understand the vendor's response to the ARTES process, positive and negative reactions were paraphrased and presented in charts based on the vendor's evaluation of the program. In order to analyze the interviewee's suggestions for improving the adoption process, the most important actions were put in a table showing how many vendors mentioned the action and paraphrasing what their comments suggested. Ultimately the vendor responses were integral in investigating what could be changes about ARTES. To analyze these codes were grouped by subject and analyzed for frequency.

RESULTS

Government and industry response

I analyzed 5 main documents to compile the government and industry responses to ARTES. These documents and PowerPoints were the unique pieces of media I found concerning the industry perspectives on ARTES. Important conclusions and suggestions to advance ARTES to a more dynamic oil spill recovery plan were found in the media presented in Table 1.

Table 1: Documents Analyzed. Industry responses include viewpoints from British Petroleum and the government documents come from the Office of Spill Prevention and Response.

Title	Author	Year	Format
2011 International Oil Spill Conference Proceedings	Yvonne Najah Addassi, Ellen Faurot-Daniels, Kurt Hansen, Mark Van Haverbeck, Mark Wilcox, Charles Hall	2011	Article
Deepwater Horizon Incident Response: Actions and Expectations	Mike Cortez Manager, Technology BP Gulf Coast Restoration	2011	PowerPoint presentation
ART: Mechanical and Non-Mechanical Technology Review during the Deepwater Horizon Response	Ellen Faurot-Daniels OSPR/Chevron Oil Spill Response Technology Workshop	2011	PowerPoint presentation
Deepwater Horizon Response	NOAA	2010	PowerPoint presentation
Alternative Response Technology Program for the Deepwater Horizon in the Gulf of Mexico – An Overview	Michael J. Cortez and Hunter G. Rowe	2010	Article

Evaluation of ARTES

Lessons learned and suggestions for the future were the key pieces of information I found when analyzing the media on ARTES. Ultimately the government and industry had strong positive responses towards ARTES along with many important suggestions for how ARTES can

be advanced. The most significant topics that the government and industry found needed improvement were: Correctly identifying innovative technologies, Structure and Leadership, Review Process, and External Interactions. Suggested actions are a compilation of information from the documents in Table 1. I organized these suggested actions for a more comprehensive and efficient ARTES program into flow charts highlighting significant recommendations (Figures 1, 2, 3, and 4).

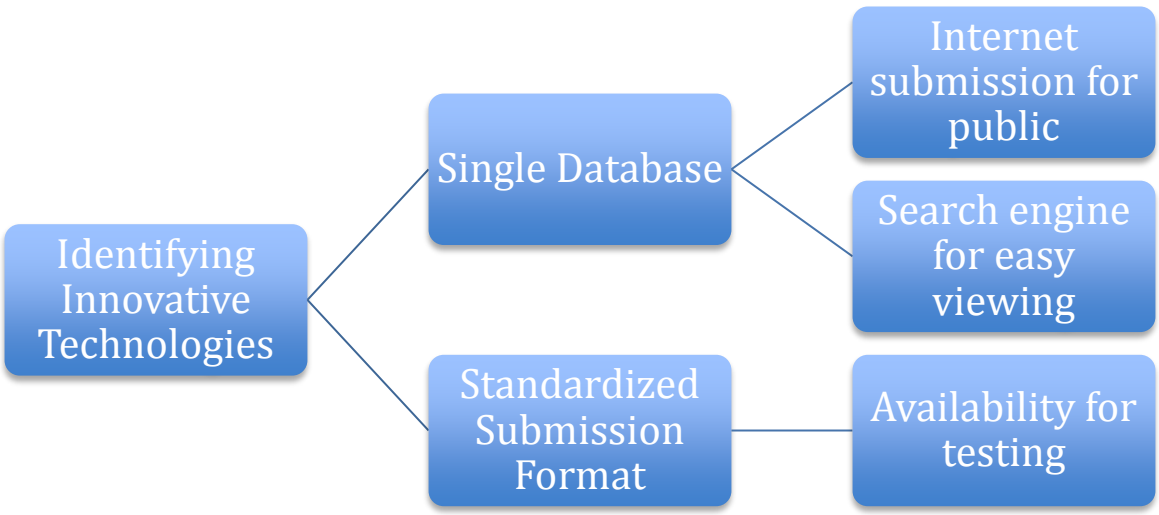

Figure 2: Identifying Innovative Technologies through ARTES

All suggestions organized into the flow charts are synthesized from document analysis concerning government and industry response to ARTES. This topic focuses on how new technologies are submitted and the process for selecting the proper submissions. Correctly identifying and receiving new technologies was a significant focus area (Addassi et al. 2011). The stakeholders suggest that there should be a single database for every entry. This process should be standardized for efficiency (Cortez and Rowe 2010). This means when each vendor submits their technology for review, it will be important that each submission is in the same format with clear limits on size of photo attachments and document size. The public should be able to submit their entries through the Internet in an easily accessible fashion and there should

be a search engine for efficient viewing of the entries. Vendors should know that their products must be available for testing at their own expense.

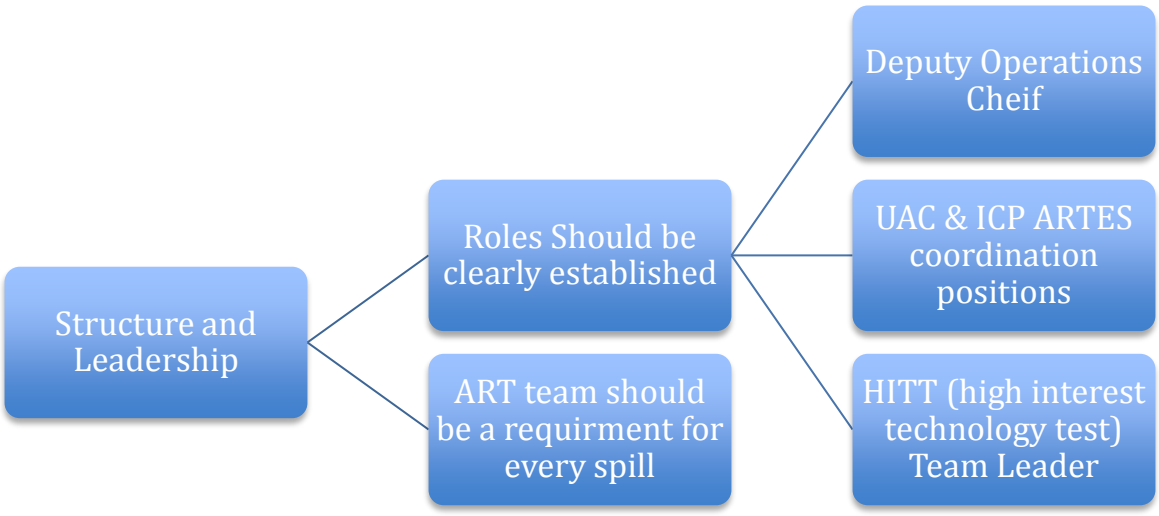

Figure 3: Structure and Leadership within the ARTES organization

In terms of structure and leadership, the government and industry suggest that for any significant spill, an ARTES team should be a feature of the Incident Command System (ICS) (Cortez and Rowe 2010). The Incident Command System is the organization that leads the government spill response efforts. It is important that leadership roles are clearly established before the spill (Addassi et al. 2011). Each Incident Command Post for any spill should establish a deputy operations chief to lead evaluations. This deputy operations chief would review all ARTES ideas and aid the connection between meeting operations needs and new technologies (Cortez and Rowe 2010). A technical manager for the ARTES response team should report to an executive sponsor in Unified Area Command (UAC). Within UAC a single High Interest Technology Testing (HITT) team leader should establish HITT teams as necessary for testing purposes only (Cortez and Rowe 2010). The HITT team is responsible for field testing of the innovative technologies.

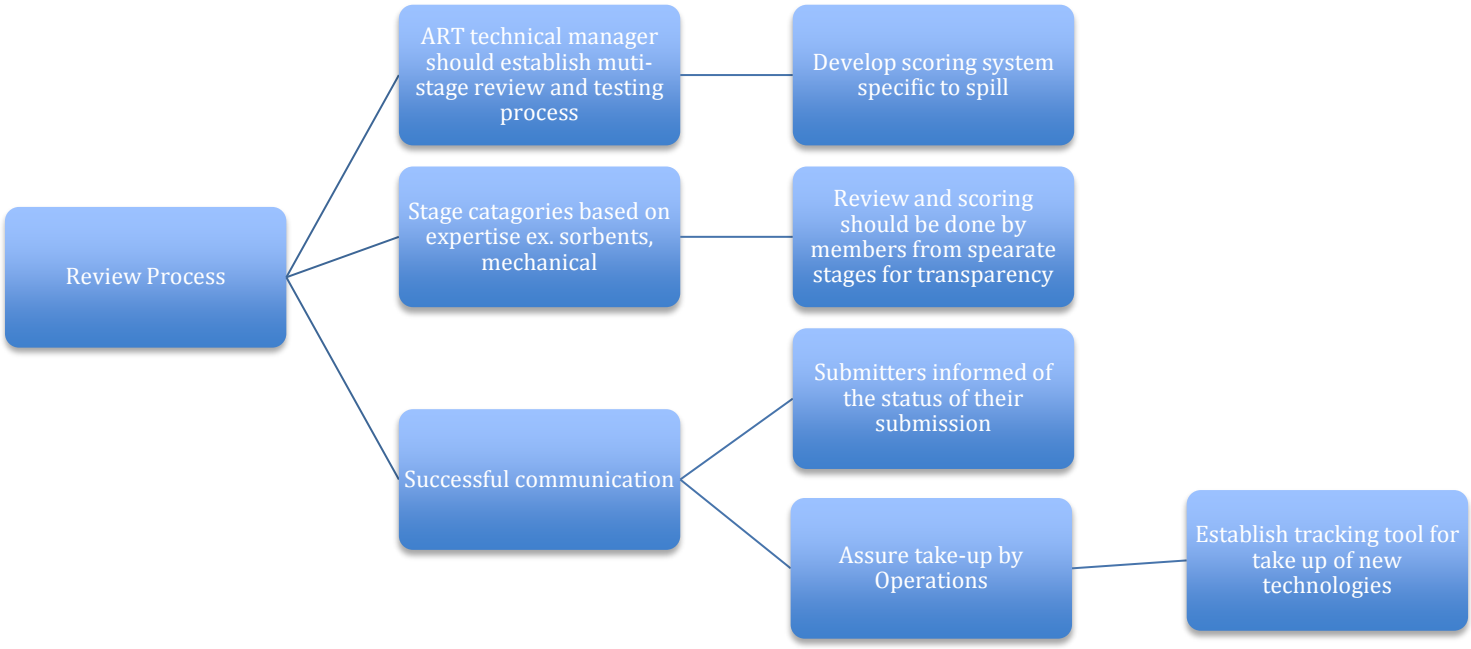

Figure 4: Review Process of innovative technologies

The industry and government suggests that in terms of the review, vetting, scoring, and scheduling process, the ART technical manager should establish a multi-stage review and testing process (Addassi 2011). Stage 2 reviewers should be established by stage categories based on area of expertise. These reviewers should be points of contact for the whole process for that category. Review and scoring should be done by team members separated from testing for transparency (Cotez and Rowe 2010). Submitters should be informed when their product moves between stages. Communicate with Operations and Logistics using many methods to maximize linkage between operations needs and technology successes.

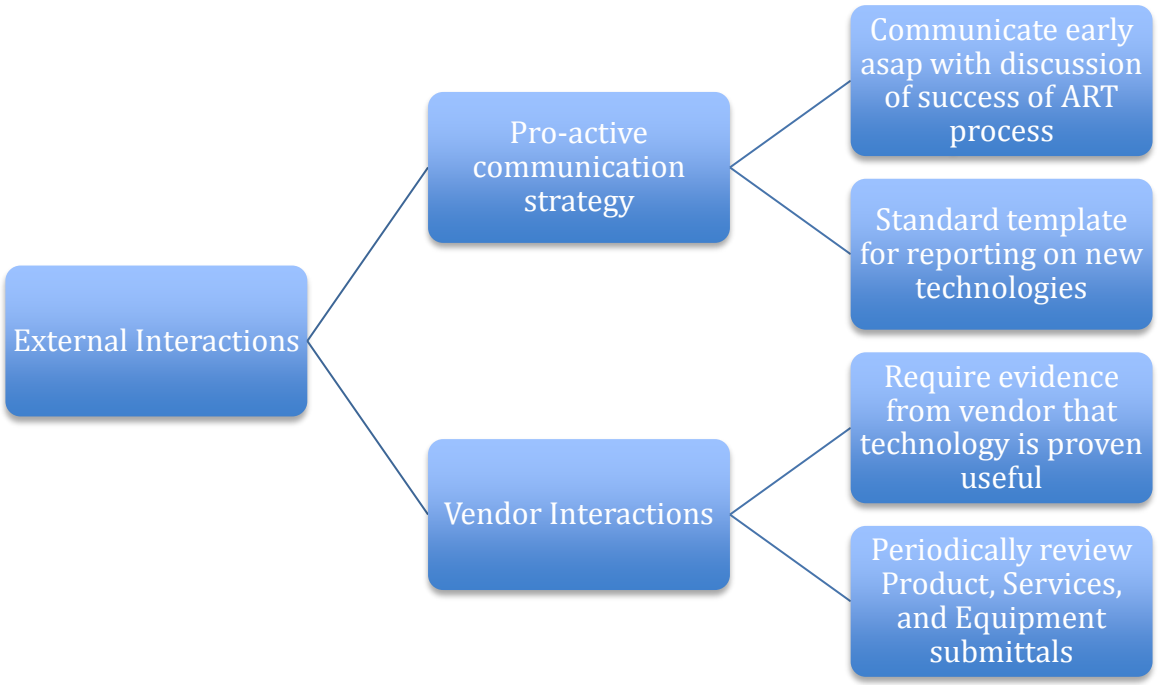

Figure 5: External Interactions with the media and vendors

For external communications, the government and industry documents illustrate the importance of a pro-active strategy for promoting the success of the ART process. The ARTES team should use anecdotal success in communications within and outside of the response organization. In terms of the validity of Product, Services, and Equipment claims by vendors, the industry suggests including in the submittal evidence from the vendor that their technology is proven effective.

Vendor Response

I completed 5 interviews with technology representatives from major innovations that were evaluated by ARTES:

Table 2: Vendor Interviews

Interviewee	Product	Description of Technology
Scott Smith	Opflex Solutions	Open celled polyolefin foam sorbent that is reusable and biodegradable
Randall VonWedel	Cytoculture	Cytosol biosolvent for

		dissolving and releasing weathered oil
Charlie Fahrmeier	Organic Products	Miracle Sorb sorbent made from processed sugar cane bagasse
Lisa Craig Gautier	Matter of Trust Hair Boom	Natural fiber booms made from hair and fur clippings
Scott Merrill	BeachTech	Beach cleaning machines through raking and sifting the sand, with hydrollically controlled raking and blades for penetrating the sand

Advantages of innovative technologies

Throughout the interviews, nine major categories were mentioned in describing the advantages of innovative technologies for spill clean up. The number of times each category was mentioned throughout the interviews illustrates the importance of these aspects of innovative technologies from a vendor perspective (Table 3). The counts are totaled at the bottom of the table to discover which topics are most significant to the vendors.

Table 3: Major Advantages of Innovative Technologies mentioned in Interviews. The figures refer to the number of times each vendor mentioned the topic. Reusability, Speed/Efficiency, and Environmental Safety were mentioned the most.

	Re	Bio	Eff	Cos	Tox	Env	Org	Ad	Eas
Opflex	4	2	3	1	0	4	0	0	0
Cytoculture	0	3	1	1	5	2	0	0	2
Organic Products	2	2	1	1	0	3	3	0	0
Hair Boom	2	0	1	2	0	0	3	0	3
BeachTech	0	0	2	1	0	0	0	1	0
Total*	8	7	8	6	5	9	6	1	5

Through interviewing vendors of innovative oil spill response technologies, I found that the most important aspects of their technologies are the possibility for reusability, efficiency, and

environmental safety. These findings are based on coding the number of times each category was mentioned throughout the 5 interviews.

Evaluation of ARTES

I received differing responses to interview questions in terms of evaluation of ARTES. The interviews revealed a lack of awareness about the program from a vendor perspective along with relevant suggestions for the future of adoption of innovative oil spill remediation technologies.

Awareness. It is important to note that all five of the interviewees were not directly aware of ARTES. Most interviewees discussed either Incident Command or the US Coast Guard when asked who evaluated their product. The category mildly aware signifies those who stated they had heard of the program but were not aware of how it worked and how their product was evaluated. In Table 3, I rated how well the vendors understood the ARTES program based on their interview response.

Table 4: Vendor Awareness of ARTES. Those that stated in their interviews that they had heard of the program still did not know that their product was evaluated by ARTES.

Awareness	Number	Percentage
Aware and understand ARTES	0/5	0%
Mildly aware/heard of ARTES	2/5	40%
Never heard of ARTES	3/5	60%

Although most of the vendors were not directly aware of the ARTES program, they had relevant and significant suggestions for the improvement of spill response that I include in my results.

Illustrative Reactions. I found that identifying the direction of vendor reactions toward ARTES revealed problems with the system from a vendor perspective (Figure 5). Below are paraphrased responses from vendor interviews.

Positive	Negative
• My product was fairly evaluated but why ultimately it was not used is a **mystery** to us (Fahrmeier) • Coast Guard and BP evaluated our product fairly, especially the BP boom department was helpful (Gautier) • BP and the Coast Guard definitely evaluated fairly (Merrill)	• No technology was evaluated fairly because the **spill contractors** did not want to see new technologies (Smith) • The Coast Guard did not attempt to **understand the technical aspect** of our product (VonWedel) • Seems like **information** never gets to the oil companies (Gautier)

Figure 6: Vendor Responses to technology adoption during the Deepwater Horizon spill

Actions for the Future. The key pieces of information extracted from the interviews with vendors of innovative technologies for oil spill remediation were suggestions for how the process of ARTES and adoption of new technologies could be made better in the future. Three actions were most discussed by the vendors: take control between spills, regulate contractors and allocation of money, and increase funding to alternative measures. The meanings of these topics are synthesized in Table 5. Responses were paraphrased and listed in Table 45 to identify important actions for the future.

Table 5: Vendor suggested actions for the future

Action	Mentioned by (%)	Vendor Comments
Take control between spills	60%	- Alternative countermeasures need to be evaluated between spills because it is chaos to implement during a spill.

		- The Coast Guard and EPA should have a system to allow research data and field test demonstration results to be consistently available at all times. - Results of evaluations should be organized and available between spills and formally reviewed on a regular basis.
Regulate contractors and allocation of money	40%	- It seemed the contractors were interested in having the clean-up process last as long as possible to squeeze the most money out of it. - Oil spill companies have their own technologies and they attempt to use those first for their own profit. - Contractors have no incentive to efficiently remove the oil because they get paid by how quickly they fill the landfills, not how thorough and efficient of a job they do.
Increase funding to alternative measures	20%	- Funding towards green and alternative countermeasures to spills should be more seriously considered.

DISCUSSION

ARTES was implemented on a large scale during the Deepwater Horizon event and proved to be a critical tool in the improvement of adoption of innovative oil spill clean up techniques because the program successfully reviewed and recommended non-conventional technologies that aided remediation (Cortez and Rowe 2010). I studied the Alternative Response Tool Evaluation System's implementation during this significant spill to gain a better understanding of how adoption of innovative oil spill remediation techniques can improve the clean up process. To gain understanding through a wide variety of perspectives, I investigated industry, government, and vendor response to the system. I compiled suggestions and actions for the future of ARTES to synthesize information to be better prepared for the future. Investigating ARTES and the lessons learned from its implementation during the Deepwater Horizon oil spill will aid future remediation efforts by gaining a better understanding of how ARTES can be advanced for better spill response.

The ARTES Process

ARTES did not fail when it was implemented during the Deepwater Horizon event, but there are changes that can be made to improve the system. After researching industry, government, and vendor response to the program in order to better understand its strengths and weaknesses, I found that the ARTES program is a key resource in the continued improvement of oil spill remediation. In the framework of innovation research, it is extremely important for enterprises to find ways to increase adoption and diffusion of innovations (Banyte and Salickaite 2008). The ARTES process does just that by reviewing, scoring, and recommending innovative technologies for major oil spill clean up. Because the BP spill was so large and significant, the program was not prepared for the sheer amount of clean up needed. A total of 123,000 individual ideas were submitted, while around 30 were eventually deemed significant for use (Cortez 2011). Through taking a closer look at government, industry, and vendor responses to the application of ARTES during the BP spill, I drew conclusions on how the system could be improved.

Government and Industry Evaluation

I compiled government and industry responses to ARTES and organized them into flow charts to reveal perspectives on the system. Both British Petroleum and the government made sound suggestions for the betterment of the ARTES program. The flow charts identify the most significant categories mentioned by industry and government: Correctly identifying innovative technologies, Structure and Leadership, Review Process, and External Interactions. There seemed to be complete agreement on the suggestions recommended by the literature from both the government and industry. After reviewing the 2011 International Oil Spill Conference Proceedings published by members of the US Office of Spill Prevention and Response and documents from BP's head of the Gulf Coast Restoration Mike Cortez, it was apparent that the authors had either met with each other or read each other's work. Because there was so little literature on ARTES published on public databases, the documents from Addassi and Cortez make up the bulk of the government and industry suggestions. Although there are not many similar studies to situate this one in, many articles have examined quality management and process improvement in government. A case study on municipal government found in order to facilitate process and quality improvement in a government system open communication and defined leadership roles are critical (Howard et al. 2005). External communication and internal leadership were both key topics developed in the government and industry suggestions. The most important take home messages from the document analyses on responses to ARTES are the synthesized actions for the future.

Actions for the future

Through synthesizing government and industry recommendations for the improvement of ARTES, I found the following strategies most important. In terms of identifying technologies, analysis of the government and industry responses illustrated that creating a single database with a standardized submission format will be critical to the advancement of ARTES. For every significant spill, an ARTES team should be a requirement and leadership roles should be clearly established immediately for well-organized structure and leadership. In comparison, a study on strategic planning to develop a culturally competent health network found that in order for planning strategies to be successful, there must be a clear vision, a purpose, and action steps to

achieve optimal implementation of the program (Gertner et al. 2010). Along the same lines, stakeholders in the government and industry agree about the importance of clearly defining leadership roles. A take home message for the next implementation of ARTES is to improve upon the program through specifically defined roles and processes. In terms of the review process, successful communication will be key to ensuring take-up by operations. Through synthesizing the literature from the government and industry, I extracted that an ART technical manager should establish a multi-stage testing and review process. Finally, to improve external interactions, there should be an immediate pro-active communication strategy with the media and vendors. Research into innovation practice suggests that communication between both the leadership team and the outside enterprise is an essential factor to determine the innovation's success (Banyte and Salickaite 2008). Through comparing the different perspectives through literature and interviews, the importance of improved communication strategies for the future of ARTES is a common suggestion. In all these were the most important future actions drawn from the government and industry responses. I agree with these important suggestions for the future; if theses actions are set in motion before the next significant spill, ARTES had the potential to greatly aid the remediation process.

Vendor Evaluation

Interviews with vendors whose products were evaluated by ARTES during the Deepwater Horizon event allowed for a closer look into the system. Because there was so little literature on ARTES, it was advantageous to look at the program from a vendor perspective. These vendor interviews were relevant and helpful because they shed light on areas where ARTES could be improved. The lack of awareness of the program even by vendors whose products were evaluated by ARTES reveals a serious need for the program to be advertized and communicated to the outside world. External communication is critical to the success of many environmental programs. An Austrian paper on the importance of public relations in recycling systems concluded that for a collection system to operate successfully it must have the motivated support of its users, which can be influenced by external advertizing (Salhofer and Isaac 2002). The vendor interviews were critical because their participation in ARTES is integral to the programs success.

Advantages of innovative technologies

Table 3 in the results section charts the major strengths of innovative technologies that the vendors mentioned were most important. Responses were coded based on the number of times each category was mentioned. Through these interviews I found that reusability, efficiency, and environmental safety were mentioned most by the vendors of innovative technologies as key attributes for innovative spill response technologies. This may suggest the direction that remediation techniques are headed in the future, towards a more sustainable and environmentally friendly approach to cleaning up oil. Because remediation techniques are often energy intensive and create their own pollutants, it is necessary for more environmentally, socially, and economically sustainable technologies to be widely used (Holland 2011). The ARTES can aid in moving in the direction of sustainability by continuing to evaluate and suggest innovative non-conventional remediation techniques to Unified Command.

Awareness

In Table 4 in the results section I identified which vendors understood the ART program and knew how it worked. The results illustrate that 60% of the vendors interviewed had never head of ARTES, and the other 40% had heard the name but were not aware of how the system works. This problem aligns with the government and industry recommendation for pro-active external communication (Adassi et al., 2011, Cortez and Rowe 2010). For the next significant spill it will be important to make sure ARTES is publicized and vendors know how to submit and how the system works to ensure maximum participation.

Actions for the future

Although the vendors did not have a full understanding of ARTES, they made suggestions for the improvement of adoption of innovative oil spill remediation techniques, which may be applied to the ARTES system. 60% of the vendors suggested that there should be a system to take control between spills. The vendors suggested that the Coast Guard and EPA

should evaluate alternative measures between spills to avoid chaos, and have testing and reviews consistently available. Authors analyzing the Deepwater Horizon event from a different perspective came up with similar findings on the importance of preparing for response emergencies prior to the spill. In a study using influence diagrams to minimize risk from oil spills on ecosystem services, Carriger and Baron suggest a modeling framework for assessing ecological risks and trade-offs from the Deepwater Horizon response. They illustrate how their influence diagrams could help prepare for future spills prior to the event to make a variety of potential outcomes be considered and prepared for (Carriger and Baron 2011). In the same way, vendors suggest that the government and industry should prepare for the next future spills by evaluating non-conventional technologies between spills to allow for efficient and timely remediation from the start. The vendors also suggested allocation of money should be better regulated and funding to alternative measures should increase. I agree that these suggestions are in alignment with the direction ARTES should head in the future. With more funding ARTES could establish a database with rolling submissions and be better prepared for the next significant spill. A study in Poland found that the Polish National Fund for Environmental Protection and Water Management significantly supported Polish State Forests concerning management, protection, and public education (Kaliszewski 2007). Similarly, increased governmental funding towards ARTES could support management of the program and allow maximum participation and external communication.

Lessons and Opportunities

The ARTES system has the potential to be greatly advantageous to the advancement of oil spill remediation. It's implementation during the Deepwater Horizon event revealed both how critical the system is for the future of spill clean up, and where preparedness can increase before the next major spill. In Figure 2 I have synthesized the lessons learned from government, industry, and vendor perspectives, as well as added my conclusions based on my research into the system. Through comparing findings from the government perspective (Addassi et al. 2011) and the industry, or BP perspective, (Cortez and Rowe 2010), and the vendor perspectives I found that there was agreement between the literature and interviews and between the interviewees on how ARTES can be advanced for the future.

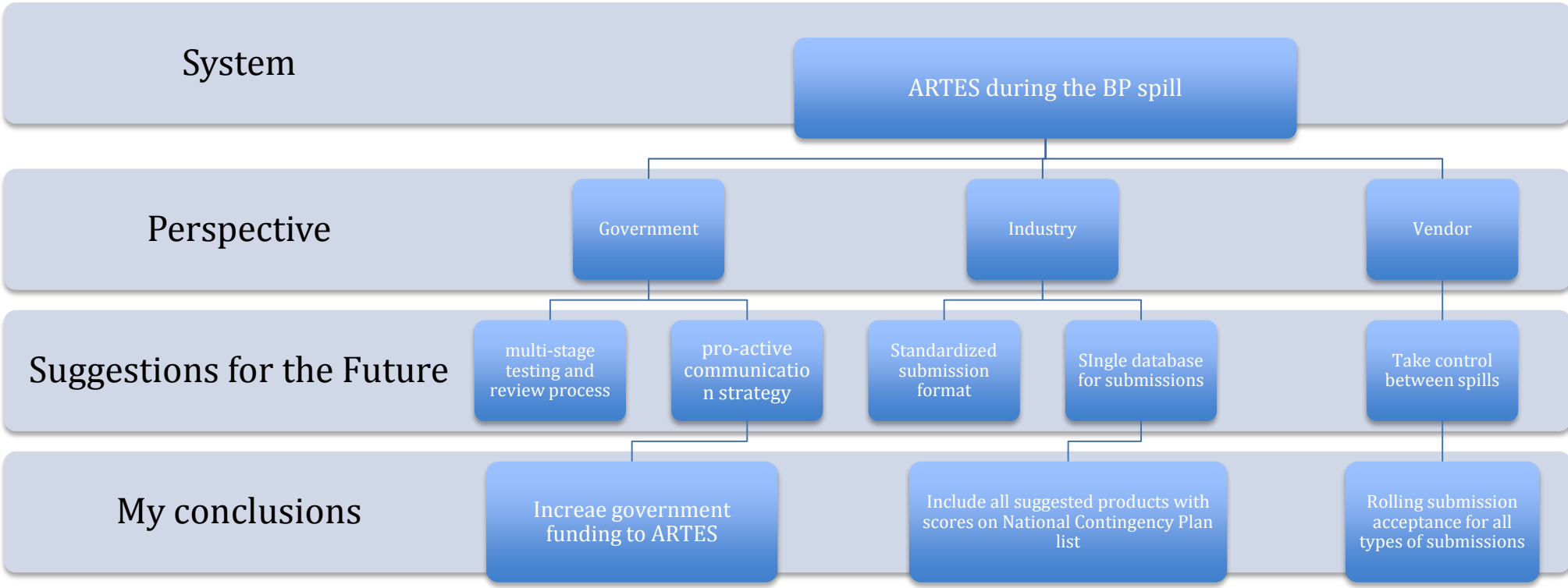

Figure 7: Conclusions on the advancement of ARTES

Limitations

A major limitation to this study remains the lack of peer-reviewed literature evaluating ARTES. The lack of relevant information also served as a justification for the study. The only industry and government information came from Mike Cortez and BP, while the only government information came from Yvonne Addassi, Ellen Fourot-Daniels, and the 2011 International Oil Spill Conference Proceedings. Time constraints also made it difficult to complete as many vendor interviews as might have been advantageous. The final limitation that may have affected the results of the project was the response rate for vendor and government interviews. Many possible contacts did not return emails and phone calls, and although snowball sampling was attempted, it did not yield any results.

Future Directions

The findings, which centered on the lessons learned and future actions for the betterment of ARTES, suggest there are concrete steps that can be taken to improve the program and adoption of innovative oil spill remediation techniques. Before another significant spill takes place, it will be important to organize ARTES so all leadership positions and processes are understood (Cortez 2011). On the same vein, the ARTES program should be publicized so stakeholders understand the process (Addassi 2011). This paper could be taken one step farther by calling on senators to back legislation advocating increased funding to ARTES. Ultimately, the ART system is a critical tool in the betterment of oil spill response, and further funding to allow the system to be fully prepared for the next significant spill is crucial.

Broader Implications

Historically, cleaning up crude oil after significant spills has proved complex and inefficient. Quick and effective oil spill response remains a challenge to governments and oil companies, as evidenced by the Deepwater Horizon Oil Spill of 2010 (Mcrea-Strub et al. 2011). The Oil Pollution Act of 1990 states that the damaged resources after a spill must be restored to

the state they were in pre-spill (Barbier 2011), yet the environment around the Gulf has yet to be completely restored. One study, which modeled the oil removing process during the BP spill, found that 3 months after the incident, 25% of the oil still remained in the water column (Mariano et al. 2011). Beyond the sheer number of gallons of oil still in the environment, one must consider how remediation techniques affect living things and their ecosystems. A study on how oil spill remediation techniques affect living organisms compared crude oil, dispersed crude oil, and burnt crude oil and found that health effects vary significantly based on which spill response technique is used (Cohen et al. 2006). Not all current oil spill remediation techniques are equally efficient or environmentally sound. All of these elements call for a better system of oil spill remediation. Ultimately the ARTES program has the ability to greatly aid the future of oil spill clean ups by evaluating the most innovative new technologies. Being immediately prepared at act on an oil spill is critical to efficient mitigation (Walpert et al. 2011). With enough funding and preparedness between significant spills, ARTES had the potential to provide easy evaluation of and access to the most efficient remediation techniques for the spill at hand. Fine tuning the ARTES program and increasing government and private funding to support it could mean less dangerous spills in the future.

ACKNOWLEDGEMENTS

I gratefully acknowledge the contributions of the ES 196 instructors: Patina Mendez, Kurt Spreyer, Seth Shonkoff, and Melissa Eitzel. Their astute grading and immense hours of editing work were critical in completing this yearlong project. I would like to especially thank Seth Shonkoff for his insightful comments during Office Hours. My mentor Thomas Azwell proved invaluable in getting this project started. I would also like to thank the vendors I interviewed: Scott Smith, Randall VonWedel, Charlie Fahrmeier, Lisa Craig Guatier, and Scott Merrill. Finally I would like to thank the entire ES 196 class for their continued support.

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