Innovating Informational Solutions During Operation Inherent Resolve:

Necessity Does Not Have to be the Mother of Invention

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1) Introduction

a. Primer

The Islamic State of Iraq and Syria (ISIS) is a recent example of a threat network that first incubated virtually with limited personnel to build financing and manpower before physically forming en masse. Once coalesced with personnel and equipment, ISIS rapidly gained control of territory within Iraq and Syria before facing significant military opposition. Operation Inherent Resolve (OIR) was the US-led effort to deny ISIS territorial holdings in the physical realm of Iraq and Syria. Within this narrow objective, OIR was a resounding success.[1] Eventually, coalition forces drove the ability of ISIS to hold territory to near zero. However, ISIS as a network continues spreading propaganda, recruiting, and banking funds. Measuring the health of a network is inherently complex, because of the multitude of interconnections among nodes and the exponential possibilities of routing information through these connections. As highlighted at the outset of Operation Enduring Freedom against Al Qaeda and reemphasized a decade later, "it takes networks to fight networks."[2, 3] Applying this concept to air operations, one cannot expect airpower to fight a network-based adversary unless in conjunction with the totality of the US's own networks.

Just as modern conventional militaries are critically dependent upon their industrial complexes to build and sustain military equipment, threat networks thrive on information built from blocks of data. According to Joint Doctrine, "the groundwork for successful countering threat networks activities starts with information and intelligence to develop an understanding of the operational environment and the threat network."[4] The US will win future wars by exploiting information for the networked organization both better and faster than the adversary. Therefore, the minimum threshold for adapting to informational change is the operationally relevant timeline, set by the faster of the adversaries. Whoever exploits data the fastest to produce the most actionable information owns the pace of operations. Therefore, air operation centers must network and situate themselves to solve informational problems better and faster than their adversary so that they may optimally apply airpower tailored to the current conflict.

b. Thesis

In times of exponential change, adequacy in today's fight rapidly becomes inadequate in future competition. The OIR case of modernizing tanker planning for daily aerial refueling is one example among a class of informational problems where the Combined Air Operations Center (CAOC) overcame numerous institutional barriers to innovative problem solving. These barriers were not malign, but developed over the course of decades while sustaining military superiority to streamline the efficient acquisition of physical hardware. The lens of Six Sigma root cause analysis applied to the tanker planning problem suggests that institutional barriers inhibited a competent team with the right skills and defined responsibility from updating a process that was relatively easy to improve and modernize. Such barriers impede innovative updates to processes that exploit operationally relevant data for improved decision making. This analysis recommends several ways for the AF and the CAOC to maintain the leading edge on solving informational problems.

c. Outline

The discussion is organized by first reviewing the tanker planning case study in detail from OIR where analytical systems were available to solve operational problems, but were unable to in a timely manner due to systematic limitations. Several other CAOC processes were updated during OIR, but the tanker planning example is well documented and contains most of the elements that are generic to the wider class of improving informational exploitation using modern technology. Next, this scenario is analyzed from a Lean Six Sigma perspective to identify potential root causes that inhibited faster resolution. Then the root cause analysis leads to and supports the four recommendations presented for CAOC operations beyond OIR and when considering military scenarios affecting multiple geographic Combatant Commands (CCMDs) at once. Finally, the conclusion briefly summarizes the key takeaways of this study.

2. Background Case Study: Whiteboards, Tankers, and Jigsaw

In April 2016 the Secretary of Defense initiated the Defense Innovation Board (DIB) to address the realization that adaptability is crucial to success in future peer conflicts. Whereas, current defense systems are designed to optimize output of existing capabilities. The charter of the DIB is to provide "independent advice and recommendations on innovative means to address future challenges."[5] The DIB is an independent federal advisory committee comprising leaders from the private sector identified as experts in either managing complex organization, identifying and transitioning innovative technologies into operations, or developing new technology concepts. Secretary Carter appointed the executive chairman of Alphabet Inc., Eric Schmidt, to chair the DIB and promptly sent the DIB on a fact-finding tour of military installations. By October 2016 the DIB toured the CAOC in Al Udeid Air Base in Qatar during the height of OIR operations against ISIS territorial holdings.[6] What they saw was underwhelming to the leading innovators of the US private sector; service members operating information systems last updated two decades ago in the 1990s and intricate plans to provide aerial refueling with tankers mapped out on whiteboards with colored magnets and markers, as shown in figure 1. One eraser swipe could ruin eight hours of planning and a day's worth of airborne operations.

Figure 1: Airmen planning tanker refueling to support air operations the following day. (Photo courtesy of the Air Force, taken from the fastcompany.com article in the endnotes.)

The tanker planning process with whiteboard dependency quickly became the poster child for the systemic problems inhibiting innovation within the CAOC. There were numerous other examples of informational procedures within the CAOC that were outdated, in need of modern innovations, and later addressed. However, the contrast between whiteboarding with magnets and modern cloud-based portable technology stands out as particularly stark. To Eric Schmidt and the DIB, whose continued business success is directly dependent upon innovative ideas, this may seem counterproductive to tolerate a methodology so clearly out of date. To be fair to the multiple staffers of the CAOC over the years, the whiteboard tanker process worked. Tankers routinely rendezvoused with other aircraft in the CENTCOM area and successfully provided aerial refueling. While the tanker process technically worked, lasting incremental improvements and innovations had ground to a halt over the past 20 years of CENTCOM air supremacy.

The program office responsible for upgrading the CAOC treated it as a complete weapon system, comparable to the F-22, where all inefficiencies were to be solved in one monolithic package to prevent unnecessary redundancy and repetition. Such a method, specified by the Federal Acquisition Regulation (FAR), is an efficient way of delivering a complicated technical system with well-defined requirements and a stationary threat environment.[7] Since the adversary's development of the improvised explosive device (IED), the operational threat environment is changing faster than the institutional acquisition systems can produce deliverables. Against this backdrop, Lockheed Martin received an initial contract in 2006 worth $538 million to upgrade all 20 AOCs around the world from system "AOC 10.1" to an updated "AOC 10.2." However, when the Air Force solicited bids in 2013 to perform the majority of the work, Lockheed Martin declined to submit and walked away from the program.[8] The $374 million initial award went to Northrup Grumman, but after only three years of work Congress refused to add funding to the program in 2016 as cost overruns increased by a factor of two at $745 million.[9] Furthermore, the program reported Northrup's progress as three years behind schedule after only three years of performance, meaning that Northrup made zero progress developing AOC 10.2. Those tasked with operating the CAOC made the best of their situation without organic personnel to tackle informational development, limited funding to outsource specific problems, and no mandate to drive efficiency as that responsibility was located externally at the program office.

Separate from the large contract attempts to modernize operation centers, the CAOC partnered with a team from the Naval Postgraduate School (NPS) in 2005, approximately, to write a software package replacing the analog process of magnets on whiteboards.[10] Few details are available on this effort, but what is known is that a software product was delivered to the

CAOC that used computer resources to optimize tanker sorties and refueling routes. However, the partnership did not include a maintenance and software sustainment plan for the planning tool. Therefore, the software tool stopped functioning and became outdated with the next set of operating system upgrades within the CAOC. Shortly thereafter the CAOC staffers were back to using pucks and whiteboards to plan tanker routes. Aerial refueling operations continued regardless so the CAOC resorted back to a proven process, even if labor intensive and suboptimal.

Along with the DIB, Secretary Carter initiated another group within the DoD, called the Defense Innovation Unit experimental (DIUx), tasked to transfer the best technology and innovative practices from the private sector to the DoD.[11] The Director of DIUx, Raj Shah, accompanied the DIB during their visit to the CAOC at Al Udeid and concluded that DIUx was positioned to quickly solve this problem of antiquated tanker planning. DIUx then received concurrence from the AFCENT Commander and tasked one of their teams, led by Lt Col Enrique Oti, already working with a tech company called Pivotal Inc. in Silicon Valley to deliver a rapid solution. Col Oti first built a military team of six by mass soliciting active duty Air Force members with experience writing computer code, regardless of rank.[12] This small group of coding-capable Airmen assembled at the CAOC and worked directly with the tanker planning team. Using Pivotal Inc. as their expert reach-back in software development and iterating with the CAOC, Lt Col Oti and the DIUx team delivered an updated planning tool in four months for an estimated $1.5 million (see figure 2). The software tool increased tanker route efficiency, saved approximately $750 thousand to $1 million per week, and payed for itself in two weeks.[13]

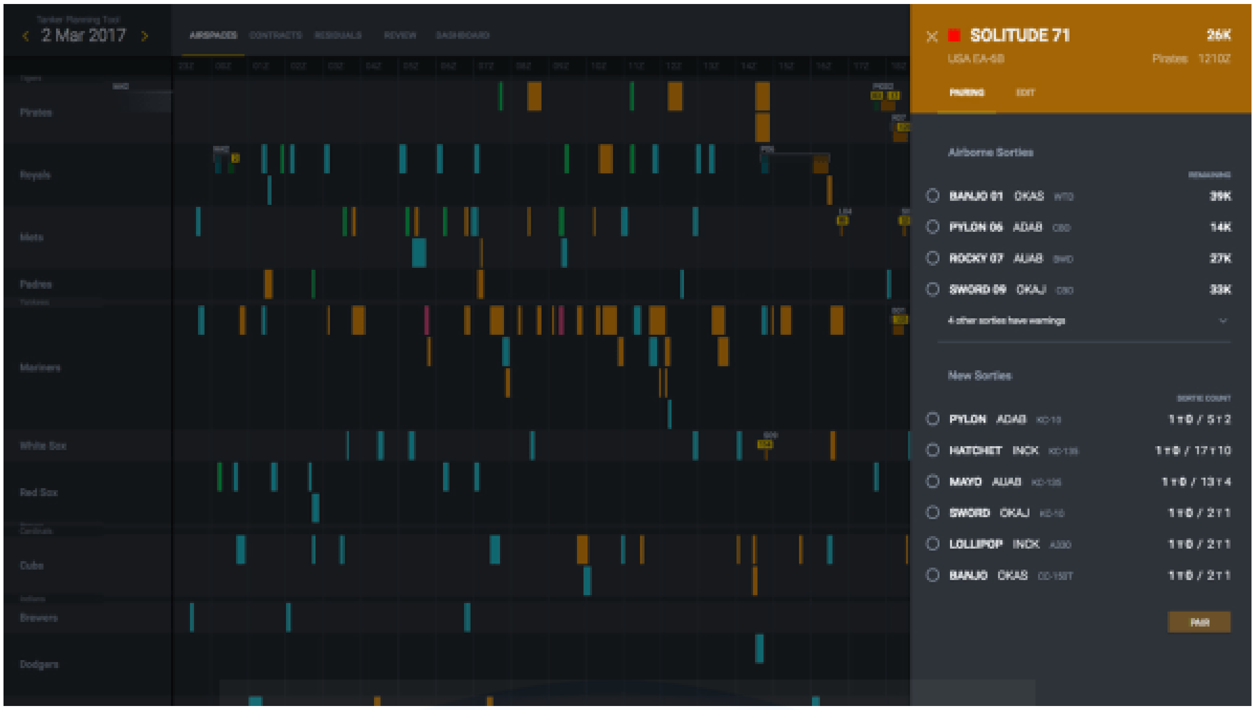

Figure 2. The resulting tanker planning tool, named Jigsaw, developed by the DIUx team working with Pivotal Inc. to improve the planning process shown in Figure 1. Image taken from Fastcompany.com article listed in endnotes.

The tribulations and subsequent success of the Jigsaw story caught the attention of senior leaders, including the Secretary of Defense and Secretary of the Air Force. With support from the top levels of the DoD, the team assembled by Lt Col Oti repositioned to Boston, grew in size, and refocused into an "agile" software production center now called Kessel Run.[14] This group later delivered several more software tools to the CAOC for operational use, focused primarily on streamlining planning processes. Currently Kessel Run represents a broader scope than technical problem solving within the CAOC and presents an alternative paradigm for how the Air Force could use developmental operations for rapid and iterative delivery of software instead of conventional acquisitions. However, not all information-based technical problems require production-quality operational software, even if they are 80% solutions delivered in a timely manner. Kessel Run expanded their purview and currently appears to becoming the agile software production center for the Air Force. The focused technical problem-solving cell DIUx deployed to the CAOC returned stateside and evolved into something bigger in both size and scope.

The story of Jigsaw breaks down into generalized steps found in any number of information-based operational problems as follows:

- Deployed servicemembers established a planning or operational method that worked sufficiently for the mission at the time of creation.
- The method slowly becomes outdated as technology progresses.
- Attempts to modernize the process fail numerous times because the attempted solution is overly ambitious and ill-defined for the classical acquisition construct.
- Successful modernization attempts are short-lived, because the effort lacks a defined sustainment plan to continually update the *delivered* product to work in concert with other technology upgrades, e.g., operating systems and firmware, rapidly changing on a yearly basis.
- Operators accept the status quo knowing the method is outdated, because it works, they maintain operational superiority for the immediate phase, and those working in the operations center are not specifically tasked to improve it. A cycle reverts back to the first bullet item and repeats until broken.
- A group, whether internal or external, provides constructive feedback and spurs action by pointing out of the antiquity of the method while garnering senior leader support. External feedback in particular may be crucial for breaking through barriers entrenched in bureaucratic procedures.
- A leader assumes responsibility and risk for fixing the problem and designates a dedicated and specific team with the right skill set for the task.

- The team focuses on the problem, works directly with the operational customer, navigates bureaucratic hinderances, and delivers a product significantly better than what existed before.
- Refinement and sustainment of the product continues. The development team revisits the product periodically to assess its effectiveness and suitability as a solution to the evolving operational problem.

3. Root Cause Analysis and the Drive to Innovate

The case of the suboptimal tanker planning process is an excellent example of the barriers to innovation when an organization maintains superiority over its functional domain. Generally speaking, there are two main drivers of innovation within an organization. First, defeat in competition forces the loser to either innovate or accept their lower status. Second, the desire to become more efficient and effective overcomes resistance barriers to innovation and the organization reaps the resulting rewards; which may be extrinsic, intrinsic, or a combination of the two.[15] In the case of air operations during OIR, coalition airpower maintained not only air superiority, but held air supremacy against ISIS. The combined air components operated with impunity when and how they desired over Iraq and Syria regarding ISIS. With such a power advantage comes a reluctancy to assume the risk of failure when pursuing innovation. Not all attempts to improve efficiency are successful. Consider, as a recent example, the 2020 Democratic Caucus in Iowa where a plan to streamline voting summaries using a smart phone application failed spectacularly under public scrutiny. Therefore, this section attempts to dissect the barriers of accepting innovation risks by the CAOC during OIR as shown in the longevity of the suboptimal tanker planning process leading up to the solution provided in 2017.

a. What is Root Cause Analysis?

Root cause analysis is a concept within the Six Sigma lexicon for improving industrial processes that focuses on a stated problem and performs a holistic review of possible root issues that caused the problem.[16] Such analysis is not definitive, but often proves helpful in identifying which set of hypothesized causes enabled the resulting problem. The analysis starts by first defining the problem, preferably in the form of a why question.[17] In the case of tanker planning during OIR, the problem is written as follows: **Why was it so difficult to update the whiteboard-based tanker planning method by leveraging current technology?** For an organization as intricate as the USAF there is not just one answer to this question, but a multitude of roots with varying importance and causation. Of course, the AF community already knows that the software prototyping team from DIUx solved the problem and delivered a modern technical tool that improved the process.

The interesting results from root cause analysis are seldom the direct solution itself, but rather the second and third order relationship compounding the difficulty of the solution delivery. Therefore, the aim is to identify the other major institutional problems solved on the path to delivering the tool. To help partition potential problems by topic, causation groups are written down in a structure known as an Ishikawa, or fishbone, diagram shown in figure 3. These groups are generally annotated as people, process, equipment, materials, procedure/method, and environment.[18] Some ideas may arguably fit into more than one category as described.

1. People refers to anyone who enacts, enables, or interacts with a process.
2. Process refers to the direct process where inputs before outputs.
3. Equipment includes the technology or machines required to handle the work.

4. Materials are the inputs into the process. For example, jet fuel is a material necessary for physical flight, while accurate weather data is also a material necessary for safe flight operations.
5. Procedure or Method refers to the way things are done; either explicitly written down as in law, doctrine, or manuals or implicit institutional norms reflective of the "culture."
6. Environment is the immediate area that surrounds the process.

One benefit of binning potential root causes into groupings is the potential of identifying a solution that solves (or collapses) a whole group of the fishbone. The next step in the root cause analysis would be to drill deeper into each individual item listed in figure 3 by asking further why questions until common roots become apparent. These why questions may go five levels deep or simply stop at the first level. For the sake of brevity for this study, cause and effect analysis stops with the first level in figure 3 as it is sufficient to support the conclusions presented in this paper.

b. Ruling out Roots with Negligible Causation

Not all items brainstormed on a fishbone diagram are necessarily causes leading to the specific problem statement. First, identifying which items clearly do not apply helps to draw focus on the topics with causation. In the case of tanker planning during OIR, the branches of the fishbone in figure 3 with negligible impact upon the problem are crossed out for visual reference. Notice that the entire branches of equipment and materials are crossed out. Equipment in this case represents the information technology (IT) required to carry out the planning process to include computers, an IT network, supporting software not specific to the planning process, and potentially the actual tankers with supporting equipment themselves. One unique character of this problem is that none of these equipment components appear to have been a limiting issue.

There were plenty of computers available running modern operating systems, a functional network, and a robust operational system for the airframes themselves. No new physical equipment was required to improve tanker planning. The delivered solution was entirely software based, loaded onto the existing hardware system.

Similarly, since the output of the tanker planning process was the operational plan itself, the input materials of the process were primarily data; such as, but not limited to air tasking orders, prerequisite campaign plans, weather forecasts, regional intelligence, tanker status and supply data, and other input data and their derived information. Note that this analysis only considers data affecting the ability to plan effective tanker routes, not data and information affecting operational success in the broader sense of advancing strategic goals. This input path is so critical to successful air operations that any errors within would show immediately in flights the next day. Operational failures from informational sources are intolerable during combat and are normally followed with intense pressure to rectify the problem. Therefore, this work assumes that problems within the material branch of the fishbone diagram are data and informational based and negligible given the success rate of pairing tankers to operational airframes on a daily basis.

Furthermore, it is important to point out that this analysis rules out both network protocols and leadership support as root cause problems for specific reasons. First, the CAOC in CENTCOM operates an IT network within its own microcosm. The Combined Forces Air Component Commander (CFACC) has approval authority over the network the CAOC operates within so that changes to network protocols and software additions to operational systems are locally authorized.[19] Of course, developed software must adhere to DoD standards for information assurance and security testing. The CFACC does not have authority to circumvent

DoD mandated best practices. However, within DoD guidelines, no external coordination or approval is required aside from concurrence of the CFACC. Additional approving authority may be delegated by the CFACC to lower levels if desired. Second, the cited articles and discussions with previous CAOC members make it clear that CAOC and CENTCOM leadership supported improvements and increased efficiency in the overall operational planning process. In fact, CAOC leadership guided the DIB during their visit to view the whiteboard system for tanker planning. However, leadership faced the same problems as everyone else in the CAOC. They were told that AF acquisitions were solving these problems through defense industry contracts and to wait for delivery of AOC 10.2. Paired with relatively short deployment cycles and low continuity, CAOC leaders were rotated out of CENTCOM before they could internalize the fact that AOC 10.2 as a holistic system was trapped in development.

c. Analysis and Discussion

Planning is a process, thus the items listed under the process group are the direct first-order problems that were addressed by the Jigsaw application. As mentioned earlier, the tanker planning process was heavily dependent upon human engagement, calculation with multiple iterations, and manual data entry. Impressively, the planners within the CAOC mastered this process and ran through it every day with minor and infrequent errors. However, computers are more accurate and exceedingly faster than humans at these repetitive optimization tasks. In just a few months, the DIUx team solved this branch of problems with their software application. The subtler and more pervasive root problems preventing the AF from addressing the process branch are found in the people, procedure, and environment branches.

There are three characteristics of the environment surrounding the CAOC during OIR that were factors inhibiting innovative improvements; the CAOC is geographically isolated from the US populous, deployments tend to be short and last between four months to one year, and the US and coalition partners maintained air supremacy over ISIS throughout OIR. These characteristics create a situation where those working in the CAOC may find it difficult to sustain a motivational drive to innovate. First, the convergence of air supremacy and a short countdown calendar before returning home nurture complacency and reluctance to challenge the status quo. The AF member may get trapped in the tempting rationale that the status quo is good enough to win and that their problems will shortly become someone else's problems. In other words, the operators felt little pressure to challenge the existing process and improve. Next, isolation from one's peers, whether DoD of private sector, further enables feelings of apathy. When an employee identifies an area that could be improved, they may need a sounding board and a little confirmation and encouragement from a peer outside the organization to tip the scale towards action. Isolation from external peer feedback creates a situation where the innovative member may be reticent to discuss their thoughts with an internal peer, because their idea may actually increase the workload of their internal peer or even make such work redundant. Therefore, these potential problems due to environment are actually sources of friction that feed into the *desire to improve* item under the people branch of figure 3.

The visit and feedback from the DIB performed at least two crucial functions. They spurred consensus across multiple levels of leadership to increase both the desire to improve and tolerance for risk. Recall that the tanker planning process was just one example of numerous CAOC processes already identified as outdated by the AF community. However, existing acquisition procedures failed to provide viable improvements to the CAOC. When the DIB independently assessed that tanker planning on whiteboards was clearly outdated and a relatively easy fix, they did not add any new perspective on the problem, but constructively reinforced to

AF leadership the areas for improvement self-identified by the CAOC. The DIB juxtaposed the fact that the AF tolerated several analog and arcane processes in the midst of a technology explosion, to include ubiquitous smartphones and cloud-based computing. This independent review created its own pressure separate from the environment and directly increased the desire to improve from the CAOC leadership to the Secretary of the Air Force. Secondly, the will to innovate must compete with the reluctance to accept risk. When trying something fundamentally new, not all risk can be reduced, transferred, or avoided. Moving tanker planning to an automated software-based process meant accepting a level of risk. The DIB visit created a situation where AF and CAOC leadership simultaneously accepted risk while confirming their desire improve.

Next, those working within the CAOC could not create a software-based solution on their own, because they had neither the requisite skillset nor the defined responsibility to solve the problem. This is where DIUx played a crucial role in this story. Defined responsibility is crucial in these types of problems to avoid the bystander dilemma, where everyone assumes that someone else has the responsibility to solve the issue at hand and the organization is paralyzed by confusion. Raj Shah accepted responsibility for solving the problem on behalf of DIUx. Then Lt Col Oti was tasked to form a team with the right skillset to create a tailored solution specifically for the tanker planning process. He cast a wide net and assembled a technically competent team of active duty services members and private sector employees, all with some level of programming experience. Finally, the DIUx team physically travelled to the CAOC, breaking through the geographic separation issue, for a face-to-face assessment of what the tanker planners and operational users required from an automated software solution. For the next three months the DIUx team iterated solutions with the tanker planners, while simultaneously refining their specified requirements, until they delivered a viable operational solution. Normally, requirements flow across numerous levels and organizations within DoD, while competing with other priorities and subjective assessments by non-operational executives. Typical requirement procedures resulting in funded acquisition projects may take over a year at the fastest to initiate let alone complete. Lt Col Oti and the DIUx team delivered a working solution in three months by forming a team with the right skillset, defined responsibility, and operational focus.

Finally, the procedure branch of figure 3 represents the classical federal acquisitions procedures to contract and fund defense industry performers to develop a solution for the operational warfighter. The DoD acquisitions framework was developed to leverage the US industrial base in order to build and deliver large scale instruments of war; such as airframes, tanks, and munitions. Therefore, congress wrote the FAR to ensure fair competition among contractors, robust systems engineering, efficient manufacturing, and sustainable supply chains. The FAR is optimized for big programs delivering physical hardware products. None of these factors are top priorities in information-based technical problems, such as the tanker planning process. Treating the CAOC as a giant system and outsourcing innovation to large defense contractors created a procedure that failed with two different contractors in four years and squandered over one billion dollars combined.[20]

The systemic problems regarding acquisitions require executive federal level modification to the FAR and were clearly beyond the scope of what the DIUx team could address. Therefore, they avoided the classical procedure altogether by using Other Transactional (OT) authority to fund contractor support from Pivotal Inc. OT contracts are not new; they were created by the NASA Space Act in 1958 to provide an alternate funding vehicle for the federal research and development (R&D) community to pursue rapid innovative partnering with non-traditional federal contractors.[21] Federal authorities granted DoD permission to use OT authorities for R&D in 1989 and prototyping in 1994. Since DIUx already partnered with the Army Contracting Command - New Jersey to issue OT contracts prior to the DIB's visit to the CAOC, Pivotal Inc. was already on contract with DIUx working similar tasks for C2 R&D. The combined AF/Pivotal team developed the Jigsaw software application with government purpose rights to the application so that other governmental teams may continue modifying and improving the tool beyond their partnership with Pivotal. Note that government purpose rights are not required with OT contracts. Intellectual property rights are normally formalized during the contract negotiation process, whether using OT or FAR contracts. In summary, DIUx rapidly funded Pivotal Inc. with flexibility to begin software prototyping without delay and avoided the problems listed in the procedure branch of figure 3. Had DIUx started a FAR-based contract to assist with software development, it would not have been awarded for at least a year at the fastest.

d. Note on Linking Networks: Ports and Protocols

Deconflicting network protocols and accessing ports were not an issue in the Jigsaw/tanker planning case study, because the CAOC operates within its own CENTCOM ecosystem where the CFACC has responsibility over the network with authority delegated to subordinate levels. Of course, the CENTCOM network must adhere to DoD policies regarding information technology, but maintains decisional authority within that framework. Port and protocol differences become significant problems if developing applications meant to reach across numerous geographical and combatant commands. The virtual handshake required to create an operational data thread between two different networks is subject to scrutiny from numerous DoD parties. For example, imagine a software application is meant to share analyzed results regarding weapons of mass destruction in real-time between CENTCOM and Northern Command (NORTHCOM). Not only must the A6/J6 offices coordinate between CENTCOM and NORTHCOM to agree upon common standards, protocols, and which ports to open, but the Defense Information Systems Agency (DISA) must also concur now that connections and routing fall within their purview. Three separate groups, each with their own layers of approval, must agree unanimously on how to create this data thread. If just one group non-concurs with the plan, then the port and protocol process return to ground zero. It is unlikely the Jigsaw application would have been unanimously approved for operational use in such a disjointed situation with numerous peer IT stakeholders.

e. Recommendations

Based on the underlying issues either addressed or avoided by the Jigsaw case study, this work recommends the following considerations in order from most to least pressing:

- Embed a small team of diverse technical experts within the CAOC (referred to here as Mission IT), empowered to write computer algorithms and solve data-centric problems.[22] Such a team would enable the CAOC to innovate at the operational timeline against a technically savvy adversary. The MIT team should be composed of a balance of technical members, such as but not limited to, 17D Cyber Operators, 61A Operational Analysts, 61C/D Scientists, 62E Developmental Engineers, and 63A Program Managers to incorporate a knowledge base spread across numerous technical disciplines. All must have at least an intermediate knowledge of computational programming. The Chief of the MIT team should also be empowered to push algorithm products from the developmental partition to the operational side for routine use as needed. The key component of the MIT team is that they work in close proximity with the operators and battle managers, having daily interactions with each other. This team is **not** meant to produce operational software, but to solve technical information problems which may be one-off occurrences or persistent hinderances to operational efficacy. Longer-term algorithmic development for more difficult projects should be pushed to a reach-back production cell, like Kessel Run, through a rapid-requirements process with the MIT team dual-hatted as the operational customer representatives.

- Rather than abstractly advocate for a "combat cloud," this work recommends a well-defined, ground-up approach where two CAOCs on separate networks, perhaps the CENTCOM CAOC and the Shadow AOC (ShAOC) at Nellis Air Force Base, install a developmental server at each location utilizing virtual machine protocols so that the two servers act as one computer with redundant shared storage. This way software developments get pushed to both servers simultaneously and exist redundantly on both. With this setup, software keeps functioning separately on the individual servers when communications are broken and then synchronize once the connection is restored. The proposed development model is to start small and manageable, and build out from there. Think of this step as digging a lake, starting from a pond. The difficulty here is not technical, but in the administrivia required to navigate the ports and protocols between the two networks. All steps to connect the two networks should be documented along the way so that the action team may conduct a root cause analysis of networking problems upon conclusion, like in figure 3, but specific to linking various AOCs through a distributed cloud system.

- Locating the CAOC within the continental United States (CONUS) may solve many of the root issues found in the environment branch, but it may also introduce new unforeseen problems yet to be discovered. If the CAOC continues to reside within a stable CENTCOM country like Qatar, then consider extending deployments from one year to accompanied tours of 18 months or two years for key CAOC leadership. Core positions for CAOC staffers could be extended to short tours of one year in duration rather than the typical four to six months deployment. Longer tours of duty will enable greater continuity and ownership of operational problems. This will also allow members to develop their specific duty skillset through longer on-the-job training not possible with short deployments less than one year in duration.
- The tanker planning problem is but one example within a class of informational problems solved with improved computer algorithms funded through rapid contracting vehicles. Operational teams will continue to use OT contracts more frequently as the rate of change within competition increases. Therefore, the AF should create an equivalent group specializing in OT contracts similar to the group within Army Contracting Command – New Jersey, simply because one cannot expect Army Contracting to handle the entirety of DoD OT contracting demands. Army Contracting will rightly prioritize Army requirements when they become overburdened with OT work. The AF needs its own shop specializing in OT contracts. Such an OT contracting shop could handle Space Force requirements as well.

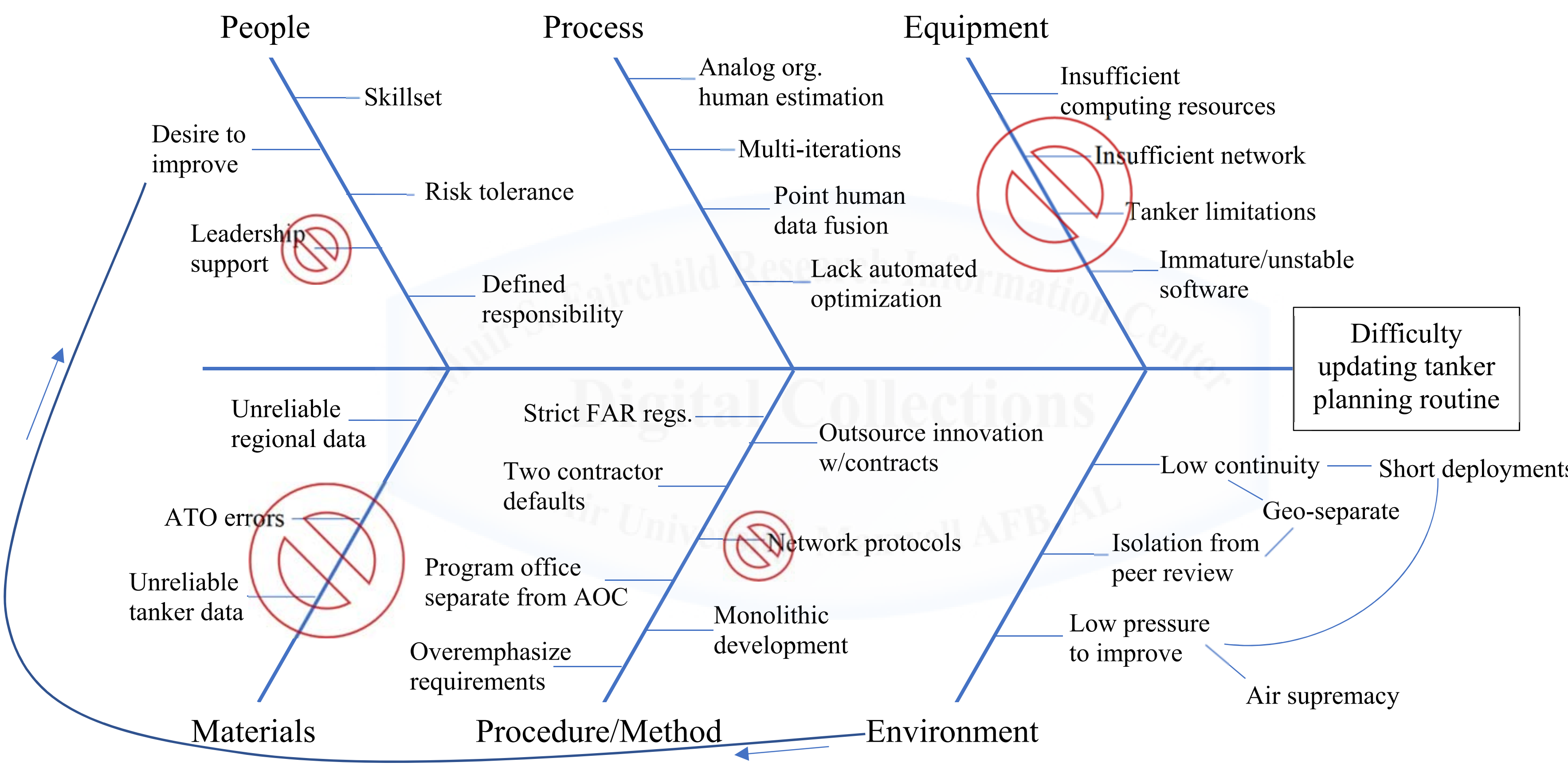

Figure 3. A proposed Ishikawa (fishbone) diagram of the state of the tanker planning process before the DIB visit to the CAOC that spurred the rapid programming team from DIUx to create a software-based improvement.

4. Conclusion

Future conflicts will be won and lost based on the speed and efficacy of one's ability to collect data, analyze the data to produce estimates, and exploit the resulting information for enhanced operational action. To gain the leading edge, all AOCs must shift towards orienting themselves to maximize innovation for informational problem solving, as opposed to the classical configuration of efficient application of physical mass. Making this shift can be difficult, especially when the status quo provides operational superiority, because innovation introduces a level of risk that must be accepted. Sound developmental practices and robust testing reduces overall risk, but there is always a baseline of risk present when attempting something fundamentally new. Therefore, institutional barriers to change may be as difficult, or more, to solve than the direct information-based problem itself.

Updating the tanker planning process during OIR provided an excellent example of solving informational problems, even when the status quo enabled superiority. The general characteristics of this case study are applicable to the broad category of exploiting information for operational gain. A root cause analysis of the tanker planning process suggests that the CAOC will improve its orientation for innovating solutions by; 1) imbedding a small technical team within the CAOC with diverse skills and defined responsibility to solve information-based problems, 2) networking IT resources with other AOCs by starting small between two operations centers and documenting institutional barriers encountered along the way, 3) extending assignment lengths at the CAOC to encourage ownership of organizational impediments and improve continuity of knowledge, and 4) for the Air Force to identify a lead contracting office within the service to specialize in Other Transactional authority contracts that are critical to expediently fund innovative solutions. These recommendations may improve the ability of operation centers to rapidly solve problems and incorporate solutions that are primarily based upon exploiting information.

Notes:

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11. The Defense Innovation Unit experimental (DIUx) is now simply called the Defense Innovation Unit (DIU).

12. Colonel Enrique Oti, in discussion with the author, 9 December 2019.

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18. *Six Sigma: Step-by-Step*, 207.

19. Oti, discussion.

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22. Credit for the name and concept attributed to the Mission Information Technology (MIT) Branch of the Joint Improvised Defeat Organization's (JIDO) J6 Department. JIDO is now a directorate within the Defense Threat Reduction Agency (DTRA).