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Aligning Needs, Technologies, and Resources for Special Operations

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Abstract: USSOCOM equips its warfighters with cutting-edge technology to ensure they have a tactical edge over their adversaries. Special Forces encompasses a wide array of military operations; as such, they have numerous areas of interest (AoI) for technology investment. Companies submit proposals aligned with these AoIs following a Broad Agency Announcement (BAA). Currently, USSOCOM decides which projects get funded based on the perceived military value. However, this process is arbitrary and does not account for the state of technology. This paper analyzes the BAA from 2019 to identify critical technologies (CT) that will solve USSOCOM's needs. These CTs are analyzed through Technology Readiness Level (TRL) to capture the state of the given technology. A trade space analysis tool plots the TRL against the importance of the technology, which can be leveraged to aid decision making in prioritization. This process provides numerous benefits over traditional approaches; additionally, there is an opportunity to automate this process.

Keywords: Technology Readiness Level (TRL), USSOCOM, Critical Technology

1. Introduction

The United States Special Operations Command (USSOCOM) is a combatant command that oversees a variety of military activities that leverage unconventional tactics, techniques, and modes of employment. These activities include counter-insurgency, counter-terrorism, and covert operations. USSOCOM must equip its operators with cutting edge technology to ensure that they have a tactical edge over their adversaries. The acquisition process starts by having USSOCOM identify capability gaps, tasks that their operators are currently not able to perform. These gaps can be solved through a material solution by integrating new technology onto the battlefield. However, USSOCOM must often fund the development of these technologies prior to them being procured for its operators (USSOCOM: Overview, 2019).

USSOCOM publishes a Broad Agency Announcement (BAA) annually which highlights the
for technology investment. Historically, the Science and Technology (S&T) office will determine which projects to fund based on its perceived military value. This process is arbitrary and is prone to errors. For example, funding could go to an immature technology for a capability gap that needs a solution immediately. Alternatively, funding could develop a technology that industry is developing in parallel; if USSOCOM does not fund the project, they could still leverage the advances in technology. Moreover, USSOCOM could fund two projects that develop identical technologies that address different AoI.

This analysis aligns the needs, technologies, and funding allocations for the USSOCOM S&T 2019 BAA submissions, using CTs, those technologies that are necessary to meet the AoIs addressed in the BAA. The CTs are less abstract than the AoI and allow for more substantive analysis, including addressing the TRL. A plot of the TRL against the relative importance, based on current funding, provides a useful trade space analysis tool that USSOCOM can leverage in prioritizing technology investments. This paper concludes by discussing this new process, its benefits, and opportunities for automation.

2. Methodology

The Department of Defense acquisition process is complex, therefore this analysis is focusing only on the prioritization of USSOCOM S&T investments, which are intended to incubate technology prior to procurement. Figure 1 depicts the methodology used for this analysis. The process is broken down into three major steps – needs analysis, technology assessment, and analysis. These steps align well with the steps of the Systems Decision Process as well as other standard systems engineering processes (Parnell, et al, 2011).

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The needs analysis begins with a review of the National Defense Strategy, which is then used to generate a set of USSOCOM needs. These needs are then used to derive the AoIs, which are the investment areas that will allow USSOCOM to meet their needs. The AoIs can be grouped together to form a hierarchy which displays their relationship (Figure 2).

The AoIs are delivered to industry through the BAA. The BAA does not dictate the technology or the solution, simply the needs, allowing industry to suggest technologies that can be applied to solve a given need. A review of the BAA submissions provides a list of CTs that USSOCOM should invest in to allow them to address their AoIs (SOF AT&L-ST, 2018). Like the AoIs, the CTs can be grouped into a hierarchy as seen in Figure 3. However, unlike the AoIs, the CTs are in the solution space and not the problem space.

Each CT can be further researched to identify a TRL to indicate the level of technology readiness. The TRL of the CT is a crucial factor that should be considered when prioritizing investments. Meanwhile, an importance factor can be determined for each AoI based on how necessary the AoI is for mission success. By mapping the CTs to the AoIs, the importance factor can be determined for each CT. A subsequent plot of TRL against this importance factor for each CT provides a useful plot for trade space analysis.

The process discussed in this paper addresses the BAA submissions to USSOCOM S&T for FY2019, which has already been awarded. Therefore, this analysis has the benefit of knowing which projects were funded. In particular, the funding levels were used for determining the importance factor of each AoI, as opposed to collecting that information from USSOCOM. However, this process can be used in subsequent BAA submissions as a method of prioritizing efforts.

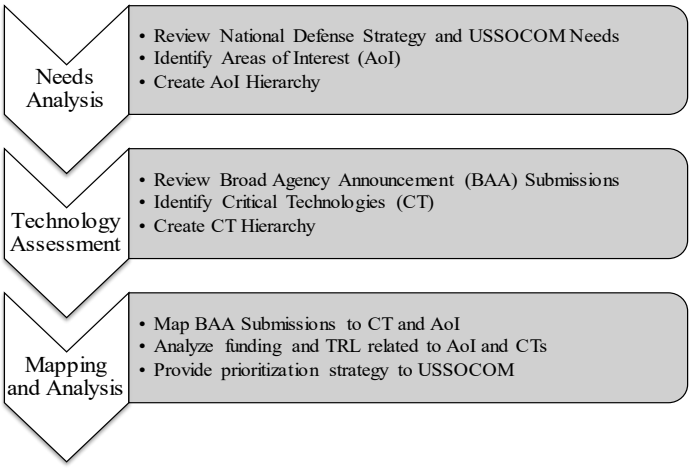


Figure 1. Project Flow Diagram

3. Needs and Technologies

3.1 Area of Interest Hierarchy

The National Defense Strategy dictates what the United States military must be able to accomplish to ensure victory over its adversaries. USSOCOM uses the National Defense Strategy to determine its focus areas for S&T development. For 2019, USSOCOM identified six capability areas that will allow its warfighters to perform their tasks within the National Defense Strategy (SOF AT&L-ST, 2018). These six areas are next generation identification and characterization, strategic and tactical signature management, contested environment situational awareness, countering autonomous systems, tactical communication and navigation, and tactical remote/autonomous systems.

Each of these six objectives can be further decomposed into AoIs. An analysis of the BAA found a total of 20 different AoIs. These AoIs range from destroying naval threats to enhancing the human-machine interface to defeating enemy unmanned systems. The AoIs were grouped together to form the hierarchy shown in Figure 2. Note that with unlimited funds USSOCOM would fund projects to meet every AoI; however, due to fiscal constraints, they must decide which of these areas to invest.

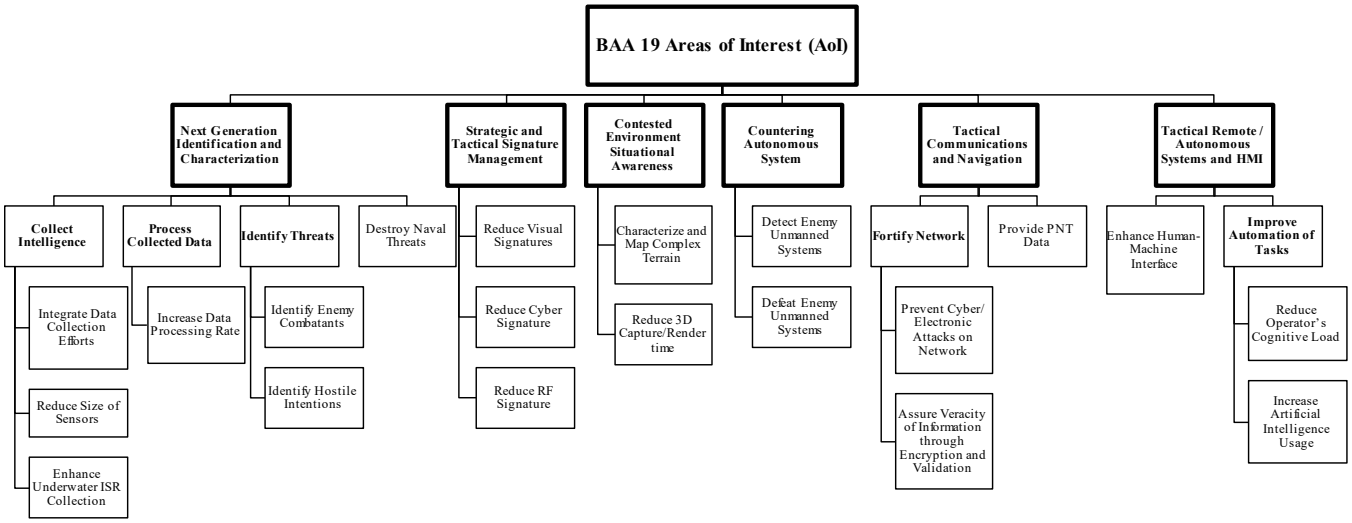


Figure 2. Area of Interest Hierarchy

3.2 Critical Technology Hierarchy

A thorough review of the BAA submissions from industry yielded 31 different CTs that would allow USSOCOM to address their AoIs. The submissions were also reviewed to address the TRL of each submission, allowing for an approximate TRL to be determined for a given CT.

Through affinity diagramming, the 31 CTs were grouped into five top-level technology groupings: sensing, algorithms and processing, communication, human-machine interface, and system level technologies. A major underlying push from USSOCOM is to reduce the time of the Observe-Orient-Decide-Act (OODA) loop across all mission sets (Bachmann, 2018). These top-level technology groupings align well with advancing each component of the OODA loop.

The sensing technology group collects data from the environment that can be used to help characterize the environment and detect threats. As such, it aligns with the observe function of the OODA loop. One subgrouping, enabling technologies, focuses on those technologies that allow for smaller and more efficient sensors, including MEMS and distributed sensing. The other subfunction focuses on the sensors themselves and include cameras, microphones, and antennae.

The algorithms and processing technology group process the data collected from the sensing technology group to produce actionable intelligence. This technology group aligns with the orient function. The enabling technologies allow for faster and more efficient processing and includes machine learning and distributed processing. The algorithms subgroup focuses on the actual software and includes tracking, behavioral modeling, 3D mapping, and image fusion.

The communications group looks at non-standard technology to encrypt and enhance the security of information. This technology also aligns with the flow of information between each stage of the OODA loop. Within this group are methods of using non-standard frequencies to transmit data to decrease detection and allow for larger data to be transferred over a long distance through novel frequencies. The group also includes adaptive/resilient networks that work towards expanding autonomous networking to transform static networks into dynamic ones.

The human-machine interface integrates information to allow the information to be readily conveyed to the warfighter, helping them to make a combat decision. The automation CT coordinates robotic machines and other autonomous systems to advance maneuvering and processing for data collection at advanced levels. Augmented reality and transparent displays generate visual information to provide better interfaces for the warfighter without reducing warfighters' visibility. Both provide the warfighters with a simpler means of accessing necessary information without interfering with the focus towards the target.

System Level Technologies encompasses those technologies that allow the operator to more effectively act on the information provided, including tactical weaponry and protection technology. Tactical weaponry develops weapon systems within different areas like naval, air, and surface so that weapons can be improved to be more effective against targets.

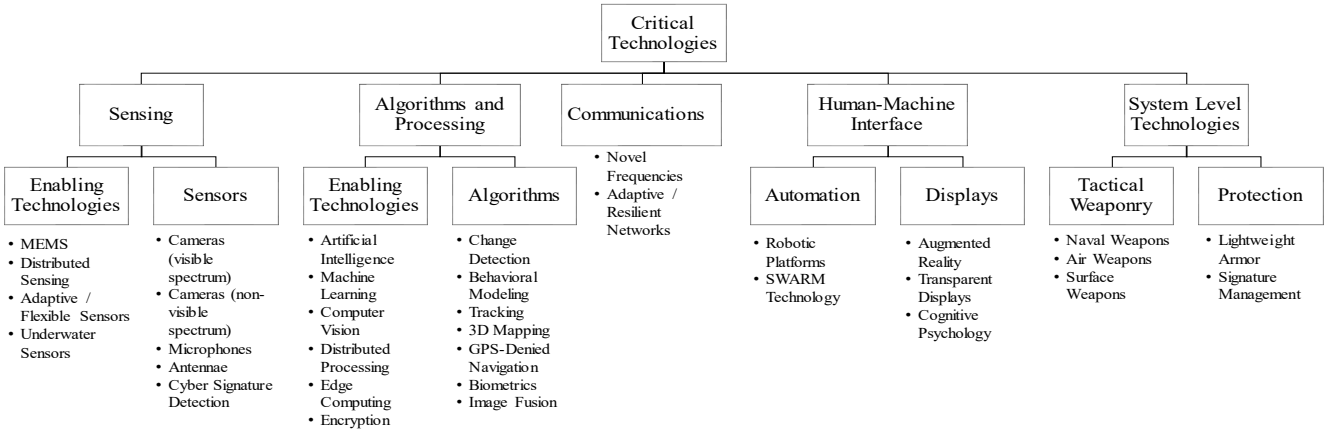


Figure 3. Technology Hierarchy

4. Mapping and Analysis

Information from the BAA submissions, CTs, AoIs, and USSOCOM funding priorities were compiled into a Microsoft Excel document to allow for analysis to provide insight into the opportunities. A pivot table was then created to identify funding levels for each AoI and CT. Additionally, pivot tables allowed for analysis of the TRL for each CT. These tables provided insight to better understand the state of technology and the funding priorities of USSCOCOM.

4.1 Technology Readiness Level of Critical Technologies

Though the AoIs are easy to prioritize based on USSOCOM's needs, they do not readily lend themselves to evaluation regarding technical maturity. This is due mostly because they are in the problem space and not the solution space. Additionally, they lend themselves to duplication of effort, where they fund two identical technologies for different AoIs. However, the use of CTs avoids duplication of effort while also accounting for technological maturity when determining project funding.

The common scale used for categorizing technological maturity is TRL. TRL values range from 1 to 9, where 9 indicates a fieldable solution, and a 1 indicates a conceptual idea that has been theoretically proven (Dunbar, 2015). Table 1 organizes CTs into groups based on their TRL. Note that the CTs indicated are the variants that most closely align with the needs of USSOCOM. For example, the bulk of camera technology would be TRL 9, since it is commercial off-the-shelf; however, the small, high-resolution, multi-frequency cameras needed by USSOCOM to meet their objectives average a TRL of 4.6. Additionally, since the list of CTs were derived from proposals that were requesting 1 to 3 years of funding, the CTs will have already passed a feasibility screening, so a TRL value of at least 3 would be expected. The CTs for this analysis all had TRL values that ranged between 3 and 6, with the bulk of them being between TRL 4-5.

A few trends based on the TRLs are readily visible from the analysis of the results of Table 1. First, technologies that have strong commercial applications, such as augmented reality and encryption, have higher TRLs than purely military applications, such as naval weapons. Second, many of the software solutions related to algorithms and processing tend to have higher TRLs than those related to other top-tier CT categories.

4.2 Prioritizing Critical Technologies

Each CT can be assigned a relative importance score based on its impact on USSCOCOM needs. For this analysis, the importance score is determined through funding levels, since the contracts are post-award. However, in practice, this process will be done prior to the awarding of contracts. Therefore, this importance score can be determined by mapping the CT back to its supporting AoIs. The AoIs can be readily rank ordered to determine their relative importance to the overall SOF mission.

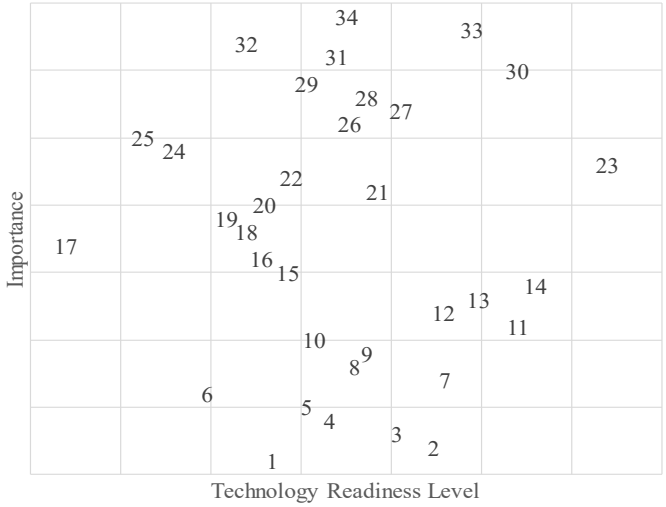
The TRL for a given CT also plays a significant role in project funding. A higher TRL indicates that an industry or other government entity has already begun development of the technology without funding from USSOCOM. Therefore, the technology does not demand funding from USSOCOM for development. Although funding will be essential for continued development in adapting the technology to specific needs. Meanwhile, a lower TRL technology would indicate that other entities are not advancing the state of that technology.

Table 1. TRL Levels of each Critical Technologies as extracted from the Broad Agency Announcements

TRL 3-4	TRL 4-4.5	TRL 4.5 – 5	TRL 5-6
Naval Weapons	Behavioral Modeling	Novel Frequencies	Tracking
Swarm Technology	Adaptive/Flexible Sensors	Cameras	Edge Computing
Signature Management	Cognitive Psychology	Antennae	Augmented Reality
Cyber Signature	Change Detection	Computer Vision	Image Fusion
Lightweight Armor	GPS-Denied Navigation	Transparent Displays	Biometrics
	Artificial Intelligence	Microphones	3D Mapping
	Machine Learning	Surface Weapons	Distributed Processing
	MEMS	Robotic Platforms	Distributed Sensing
	Underwater Sensors	Adaptive Networks	Encryption
	Air Weapons		

Figure 4 plots the TRL against a notional importance for each CT. Since the actual prioritization of the AoIs is sensitive and not available, a notional importance was defined based on how much funding was allocated to each CT by USSOCOM. The plot allows for a more thorough trade space analysis when determining which projects to fund. For example, signature management (6) has a low TRL relative to augmented reality (7), though both have relatively similar levels of importance. Therefore, USSOCOM should prioritize funding to signature management over augmented reality.

On a larger scale, Figure 4 allows USSOCOM to look at technologies that are dominated, such that they have low importance coupled with a high TRL. For example, tracking (2) algorithms has a low importance score, but a relatively high TRL. As such, minimal funding should go to this technology. Meanwhile, swarm technology (25) has a high level of importance and a low TRL; therefore, a significant amount of funding should go to this technology.



1 GPS-Denied Navigation
2 Tracking
3 Adaptive/Resilient Networks
4 Novel Frequencies
5 Machine Learning
6 Signature Management
7 Augmented Reality
8 Transparent Displays
9 Cameras (Visible)
10 Underwater Sensors
11 3D Mapping
12 Edge Computing
13 Biometrics
14 Distributed Sensing
15 Artificial Intelligence
16 Change Detection
17 Naval Weapons
18 Behavioral Modeling
19 MEMS
20 Cognitive Psychology
21 Robotic Platforms
22 Cyber Signature
23 Encryption
24 Microphones
25 Swarm Technology
26 Computer Vision
27 Air Weapons
28 Surface Weapons
29 Lightweight Armor
30 Distributed Processing
31 Cameras (Non-Visible)
32 Adaptive/Flexible Sensors
33 Image Fusion
34 Antennae

Figure 4. Matrix plotting importance against the Technology Readiness Level for each Critical Technology

5. Recommended Process

5.1 Overview of Recommended Prioritization Process

The process outlined in this paper provides valuable insight into how to prioritize investments based on both importance as well as the maturity of the associated technology. This process consists of the following six steps:

1) Determine Objectives and derive AoIs
2) Put out BAA and/or conduct market research
3) Define CTs
4) Determine TRL of CTs
5) Map CTs to AoIs to determine the importance of each CT

6) Plot TRL value to importance to provide a tool for trade space analysis

This approach provides numerous advantages over traditional methods which tend to be based primarily on the AoIs. It allows USSOCOM to better capture technology readiness when prioritizing their funding efforts. Every acquisition office in the Department of Defense includes an S&T directorate whose job is to advance the state of technology to allow for acquisition offices to procure and field that technology. As such, the TRL of the technology is a critical factor that should be directly considered.

5.2 Opportunities to Automate Process

One issue with the process is the amount of time and effort that is involved with defining the CTs. The CTs are best defined through reviewing all BAA submissions, learning about the technology described in these submissions, and then grouping these technologies into clusters to produce a hierarchy. This process can take many man-hours; for example, reviewing the 200 BAA submissions for this analysis required over 200 man-hours.

However, the use of natural language processing and latent Dirichlet allocation (LDA) can automate this process. Engineers from USSOCOM wrote an LDA algorithm and processed the 200 BAA submissions to identify key technology terms that would allow for the submissions to be grouped (Kenning, 2019). They found that the BAA submissions could be grouped into five categories; these five categories had a strong alignment with the top tier technologies in the CT hierarchy (Figure 3). Further tests are underway to decompose those five top-level groups into the lower-level technologies and has yielded promising results.

6. Conclusion

Technology provides USSOCOM operators the tactical edge necessary to defeat their enemies. As such, USSOCOM must incubate different technologies to ensure that they can become fieldable systems. They publish their needs in a BAA, receive responses from industry, and fund projects based on the importance of filling that need against the USSOCOM mission sets. This process is arbitrary, poorly structured, and does not account for the state of technology. A new process is outlined that uses the concept of CTs—those technologies whose development will allow USSOCOM to address their needs. This paper analyzed the BAA from 2019 to identify CT areas. These CTs are analyzed regarding the TRL to capture the state of the given technology. A trade space analysis tool then plots the TRL against the importance of the project, which USSOCOM can leverage to aid decision making regarding technology priorities. This process provides numerous benefits over traditional approaches. First, it allows decision makers to account for TRL when making their decision. Second, it reduces the likelihood that USSOCOM funds multiple projects that develop identical technologies to address different AoIs. The process outlined currently requires significant manpower; as such, research is underway to automate this process.

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