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The Impact of Observability Constraints on the Planning for Employment of Robotic and Autonomous Systems

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ABSTRACT

Employment of Robotic and Autonomous Systems requires a different paradigm of mission planning. The GTRI Missioneer for Organic Collaborative Kill-Chains (MOCKS) effort was developed to mature the concepts of mission planning in light of autonomy, where the decision making is distributed across the battlespace and each individual entity has limited awareness of global state. The paper presents some initial characterizations of the impact of constraints on periods out of communication, or no-comms windows, on the number of resources required for missions of a certain operational area. This metric, along with the foundational metric of remaining effective range margin are foundational to robust a priori planning.

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1. INTRODUCTION

Georgia Tech Research Institute (GTRI) has been conducting a multi-year research project for the development of a mission planning capability for the employment of robotic and autonomous systems. For the GVSETS in 2025, GTRI published an initial approach for the development of mission plans for Robotic and Autonomous Systems (RAS) [1]. The culmination of this effort was a capability for visualization by the user or commander of the actions to be taken by a swarm of RAS to achieve mission objectives. This visualization capability (shown in Figure 1) would enable the operator to have a bias towards monitoring and/or make adjustments to the mission planning constraints, such as the available resources, to modify the expected execution.

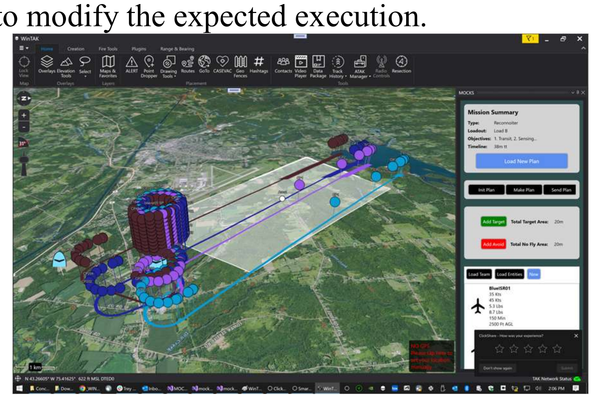

Figure 1: Mission Planning Visualization

For the second year of effort, the research goals included the extension and development of refined mission level metrics for task organizations, or teams. The introduction of autonomy creates a different control relationship among the RAS and the operator than traditional remote piloting. The concept of “command and control” itself is emergent, especially in conditions of degraded or denied communications as each individual entity no longer has awareness of the global state.

To realize the desired properties of a team of human and RAS conducting a mission is to manage not the individual entities but rather the object aggregate that is the team. The “attributes” or the state of the “team” is different but presumably derivable from the state of the robotic and autonomous systems themselves, though the methods for determining the state of the aggregate have yet to be defined.

This paper will present research on one such metric, the observability, or the opportunity for awareness, that exists through the capability of the team to exchange data. Moreover, we will draw conclusions on the relationship between resources planned for the mission as a function of the required observability or the constraints on observability projected through mission execution.

This research on observability is initial, reflecting a first level characterization of the availability of communications. Further research is required for the robust challenge that is communicating entities in a dynamic operational context.

2. BACKGROUND

2.1. Mission Planning for Autonomy

It is assumed that there is a broader understanding of the capability of autonomy in the larger community. In [1], GTRI provided a baseline definition of the capability as developing current or future intent through the selection/commitment to a course of action associated with the perception of desire.

The paper differentiated the capability of autonomy from the performance of a capability autonomously, i.e. without operator intervention. The main difference between these two is that the capability of autonomy is exercised in the presence of an external adversity, requiring the system to refine/modify the course of action to maintain effective execution of the desired result based on the extrinsic motivation which is provided by the operator.

2.2. Emergent Behavior Systems (EBS)

The concept of command and control, can best be expressed using the concepts of emergent behavior systems. This is especially true in the case of autonomous systems, where the decision making in some capacity is deferred to the RAS. In this posture, the criteria for EBS of the individual entities having no global perspective is met, and the macro level system effect of command is only realized through the information flows between and among entities.

In a tasking environment, where the operator merely communicates their objectives and allows the RAS to execute the objective utilizing onboard resources, the operator cannot directly monitor the progress of the execution and is reliant on the observability (achieved through communication) of the system to determine the global perspective.

The RAS itself is subject to other sources of constraint: contextual, inherent, and stigmergic, which, unless designed as such, are not always communicated to the operator. The decision-making process of the RAS from this perspective could be considered opaque to the operator of the system.

The ramification of this is that the likelihood that the operator can reason about the macro-level system of system effects is directly dependent on the availability or quality of service of the communications with the entity(s).

2.3. Joint Requirements

Because the tasking of the RAS has contextual value, value to the operator and the force that he is a member of, the operator needs some means of establishing the global perspective. Because the RAS and the operator are working together there are joint requirements for the task, requirements that relate to the interdependence of their activities [2].

For a simple example, consider that an operator has given a task that would fall under the category of suppression of enemy air defenses (SEAD) to a RAS. Unbeknownst to the RAS, the intent of the mission is to allow for manned rotorcraft assets to route through the area that is protected by the Air Defense Systems. The aviators will be operating with some level of confidence of their own security because of the expected performance of the RAS. If the RAS operator has not received any communication from these RAS in a given period of time, his confidence that they are performing the task as expected will start to degrade. Because the task has interdependence, we would expect some communication between the aviators and the RAS operator either to indicate that it is safe to traverse the route or that it is not.

This condition of interdependence is completely unknown to the RAS unless the operator has given the system the information or established communications requirements associated with its performance of the role. Moreover, if the operator does not provide these communications requirements prior to employing the system, the RAS may make a decision that precludes communication, resulting in no way for the operator to adjust these requirements. There are any number of sources of constraint that preclude this macro level effect of awareness of task performance from being realized.

2.4. Planning

Planning refers to the development of a plan or a set of tasks. A task is one of the operators that make up a plan, a step in the sequence or an intermediate action taken by one of the entities to achieve some increment towards the end result. A valid plan is one that achieves desired effects and is executable in whatever domain or context it is developed for. Plans can be developed to various levels of abstraction and granularity of tasks.

2.5. MOCKS

GTRI has developed an initial planning capability under IRAD for a Missioneer for Organic Collaborative Kill Chains (MOCKS) for the purpose of studying the dynamics of human and autonomous systems interactions and collaboration (HASIC). The technical approach will discuss the extensions of MOCKS performed under this year of development.

The guiding framework for development of MOCKS, for the identification of relevant functional boundaries, and for status tracking of progress towards this goal has been the automation of the Military Decision-Making Process (MDMP) [3], and, to a lesser degree, the Rapid Decision Making and Synchronization Process (RDSP) [4].

Most of the functionality that has been encoded into MOCKS and has been planned to be encoded into MOCKS can be traced, conceptually, to the steps of the MDMP:

- Receipt of Mission
- Mission Analysis
- COA Generation
- COA Analysis
- COA Comparison
- COA Approval
- Orders Production, Dissemination, and Transition

MOCKS is designed to host one or more modified implementations of actual autonomy software that can be exercised in an *a priori* mode and can support task queries. The baseline product incorporated this functionality for GTRI's Locust Autonomy stack, and this modified hosted capability is referred to as an Oracle. During year two, additional Oracles were partially integrated, including one for GTRI's Golden Hoard Autonomy (GHA), and a simplified oracle that was built as an enabling test element for quadcopter type platforms

Efforts for MOCKs in year 1 included creation of the necessary tooling and infrastructure to support COA generation, with limited capabilities for receipt of Mission and manual inspection of a created COA for COA Analysis.

Efforts for MOCKs in year 2 have been focused on the Mission Analysis and COA Analysis aspects of the MDMP, with the desire to posture for COA Comparison and further receipt of mission tooling in year 3.

3. TECHNICAL APPROACH

In general, the sequence of MOCKS execution is:

- Development of High-Level Objectives by the Operator
- Specification of Mission Constraints
- Development of the Abstract Plan
- Invocation of Task Organization Level Planning (Swarm Level Planning via the Oracle(s))
- Synthesis of the Concrete Plan
- Mission Evaluation
- Mission Optimization

3.1. Task and Motion Planning

In the reference paper [1], the authors discussed the concept of an abstract plan and a concrete plan, nomenclature developed for the project that roughly reflects the concepts of task and motion planning in robotics. The task planning, related to task decomposition, sequencing, and allocation to resources provides an abstract representation of the sequence of events to be carried out. The motion planning, related to the sequence of actions to be taken by the RAS cognizant of the RAS's physical constraints, provides a higher fidelity prediction of the behavior during execution.

The development of each representation of the planning problem to be solved lacks aspects of the overall problem. For the task planning, the problem is simplified, removing some of the details of timing and performance of the platforms. For the motion planning, the global perspective is lacking.

To solve this problem, the motion plans that are generated are further synthesized and evaluated against the desired macro level system of system attributes. As this this results in predicted estimation of these macro level metrics, this could be considered an expectation of different macro level metrics.

3.2. Derivation of Projected Global State

In a traditional command and control posture with RAS, the operator has access to detailed state data on the entity, and thus can develop internal estimations of task performance, completion time, and likelihood of success. In the case where the state data is less detailed, the operator has less information to draw from for the derivation of projected global state. Alternatively, in some desired use cases, the operator could be presented with solving multiple problems of this kind simultaneously when dealing with the command and control of multiple RAS elements. One can imagine a desired future where the level of complexity of employing RAS is such that we would not expect an operator to continuously maintain the global perspective as a derived estimate based on monitoring the detailed state of every entity that is in his/her purview.

Much as we often desire that computer systems annunciate faults for the user, this complexity problem will likely require the system(s) itself to identify when there is an anomaly that requires the attention of the operator. This presents challenges with the amount of information required to be communicated to the operator to help reconcile the fault [5], especially in a bandwidth limited environment.

The prefix of a plan provides another means of reconciling the global state in that if the joint requirements for task interdependence can be provided to both the RAS and the operator, then the operator can monitor the fulfillment of the joint requirements. This is complimentary to the monitoring of annunciation from the system. Since the system does not have the global perspective, it cannot evaluate all of the impacts of its behavior. Also, it is likely the case that the full scope of considerations is beyond the capability of the system to monitor.

The information needed to perform this task, that of evaluating if the joint requirements for task interdependence are being fulfilled, can be established (and needs to be established) in the plan itself.

3.3. Evaluation Methodology for Mission Execution

To evaluate the joint requirements of the task, we require a way to synthesize the individual entity plans back into the macro level perspective.

Post processing of the mission takes each individual entity plan and reconciles them to a single mission timeline. Once this is structured as such, there is a means to simulate the full mission plan and utilize the relative positions of the individual entities to derive information about the execution.

The two computed aspects of the overall plan currently include resource utilization and observability.

Resource utilization is computed as the percent usage of the available resource over the course of the mission. For example, the utilization of the mobility capacity of the system is the distance traveled over the effective combat range.

$$U_{Mobility} = \frac{Distance\ Traveled}{Effective\ Combat\ Range}$$

For our initial purposes, we were concerned with the overall "mobility" usage of the individual RAS entities. For air platforms, the fuel/battery of the system and the rate of power consumption to travel constrain the overall ability of the platform to move a certain distance. By computing the movement of each individual asset and determining the percentage of overall available travel, we can determine the remaining "margin for mobility" as a result of this estimated mission path. The margin, is the amount of mobility held in reserve should this course of action be taken.

For autonomous systems, the amount of mobility held in reserve is particularly important because it could be considered the *freedom of maneuver* of the autonomy that is available without potentially sacrificing mission objectives.

Consider a plan where there is margin in mobility. We might say that if the platform encounters a threat that was not planned for in mission planning, it has the opportunity to route around the threat without having to sacrifice some of the final waypoints in the projected path. A plan without this margin would force a "hard choice" for the autonomy between sacrificing objectives and increasing the overall risk of mission success.

Figure 2 shows an example output of a littoral mission that was planned by MOCKS. In it, multiple platforms were allocated objectives via the abstract plan and then motion plans for task fulfillment were created by the oracle component, the hosted instantiation of the autonomy logic that can be run at a faster than real time rate. Of note, this mission was planned with different kinds of platforms with varying combat ranges.

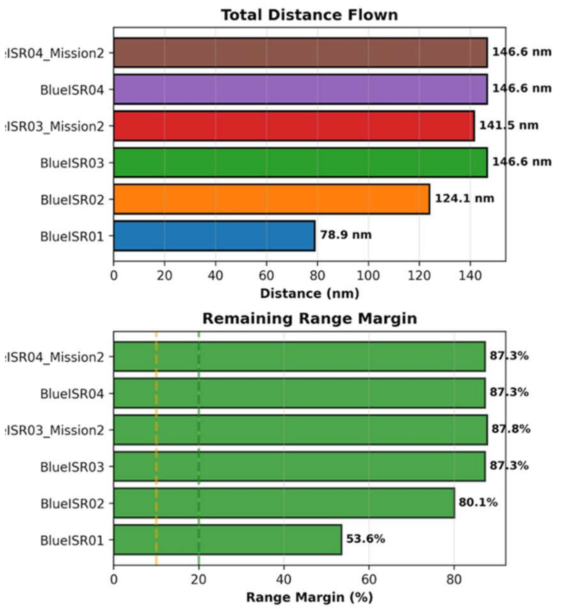

Figure 2: Distance Traveled for a Plan and Remaining Margin

The second metric used in this study is "observability". This should not be interpreted as a physical line of sight for the operator of the system. Observability is realized through the explicit communications among the members of the team. Figure 3 describes how Joint Requirements create a state of interdependence which is facilitated by observability, predictability, and directability [2].

In the same paper, the authors define:

*"**Observability** refers to how clearly pertinent aspects of one's status—as well as one's knowledge of the team, task, and environment—are observable to others. This is commonly referred to as "transparency," but we prefer the term "observability." The complement to making one's own status observable to others is being able to observe status."*

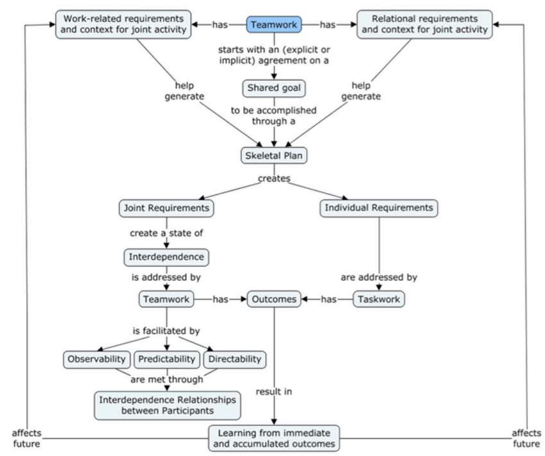

Figure 3: Teamwork and Its Related Concepts [2]

To truly analyze the observability of a system in the way that is described would require an analysis of the knowledge of each individual entity in the team, the ability to see how information is encoded and processed by each individual, something that is not available during pre-mission planning. However, what can be computed during the mission plan is the opportunity for observability. That is, given the assumptions made in the *a priori* plan, do the RAS and operator have the opportunity to communicate "pertinent aspects of their state to others" and "to observe pertinent aspects of others' state"?

The efforts of MOCKS in year two were driven towards creating a means to parameterize mission planning with this metric in mind. Again, the observability of RAS during operations is a macro level effect, not something that can be computed in the individual entity.

Toward that end, additional capability was added to the user interface to define "command nodes" in the task organization/team structure. A command node can be either another RAS within the team or a geographically relevant point of interest (POI). In an operational setting, the host of the user interface might be a command node. In addition, several settings were exposed for study within the mission planning algorithm. Figure 4 shows a post processing of a particular mission, showing the percentage of time during execution that the platform physically could be expected to communicate with an identified command node based on the position of the platform and the nominal comms range of the device on the RAS.

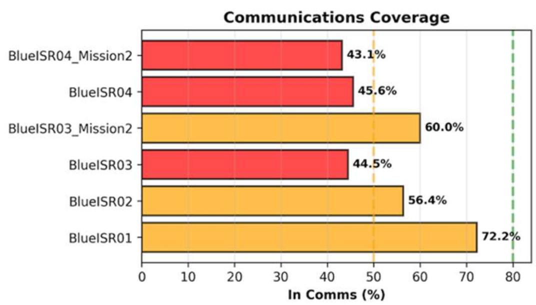

Figure 4: Percentage of Candidate Mission in Communication with an Identified Communications Node by Platform

The concept of establishing "windows for communications", commo windows, is well established in military tactics, techniques, and procedures (TTPs). In the case of a degraded, denied environment, a commo window can serve the purpose of relaying information and status of a force to the larger command structure. Rather than define the periods when comms *should* be available, in light of our desire to manage by exception, we instead sought to perform mission planning from the perspective of "when is the platform unobservable".

Sufficient communications opportunity, is integral to the concept of control as distinguished from command in Army Doctrine [6]. A period of no-comms is a period of the execution that will be precluded from feedback to the commander for monitoring and influencing the actual situation.

To identify insufficient communications opportunity, we enabled the operator to set key parameters for how long the RAS are allowed to be outside of communications range with a defined "maximum" and a desired "average". In effect this allowing the operator to determine how much observability of the systems is required by setting the threshold for which the lack of observability is unacceptable. Knowing that in legacy UAS operations there is the presumption of communications, it would seem that the question we want to ask is how long can an operator tolerate lacking observability without a degradation in mission execution and performance.

In the future, this information could be more granularly defined. It could be associated with a task itself or with a particular team member (if there is some governance structure of the team). Future constraints could also be more detailed, allowing the operator to increase or decrease the level of information that should be relayed in the conduct of a task or in a certain formation of RAS. For example, if the information gathered in the task is necessary for targeting data, the task itself could require enough capacity of communication to relay a visual image of the target. If the task was intended to be operated in radio silence or in an emissions-controlled (EMCON) mode, then the task could be planned with no comms requirement at all, or perhaps requirements for only certain periods of time.

Utilizing the locations of each entity on the same time domain and the geographic positions of command nodes we can determine the no-comms windows, the periods of time when the platform is outside of communications range and thus does not have the opportunity to support observability through communications.

For our purposes, and to demonstrate the impact of these constraints on planning, the periods of out of comms window that exceed the maximum generate a new iteration of planning. If the average value of time out of comms exceeds the desired average, the comms out windows are analyzed for the highest statistical contributors to the average and then these are identified for derived tasks in an iterative plan.

4. Closed Loop Iterative Planning

The impact of too large or too many no-comms periods is not necessarily a failure of the planning algorithm. For one, the identification of no-comms windows is entirely predicated on the motion planning of the vehicles. In the abstract task plan, the geographic positions of the entities are not considered. If we consider the commo window concept in TTPs, the commander who specifies the commo windows considers the execution of the operation, the points of risk, and the timeline of events, then derives the communications requirements to ensure he can monitor the progression of the mission.

Similarly, the no-comms windows become a further input to the planning process codified as derived tasks for the consideration of the planner. This requires a second iteration of the task and motion planning for the individual RAS elements to fulfill comms enabling tasks. In the case of RAS, we assumed them to have the capability to relay the state of the platforms that violated the maximum no comms time to support the observability of the operator.

To realize this goal, MOCKS provides a closed loop between the detailed mission planning and the abstract plan representation of the problem. This affords a number of opportunities for planning refinement.

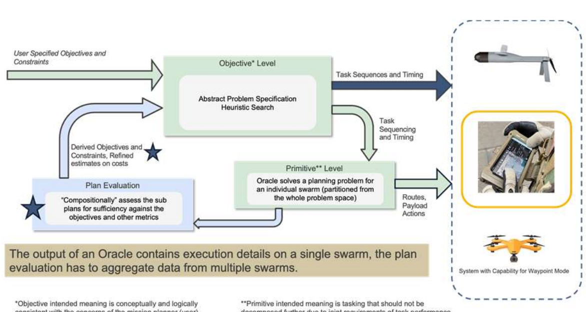

Figure 5: Closed Loop Iterative Planning

For the purpose of comms, the output of the feedback is identified communications relay tasks that, if implemented in the mission plan, should reduce the expected periods of times when certain platforms are out of communications. We identify these tasks both on the basis of exceedances (periods where the time out of comms is greater than the allowed time) and when the average time out of comms is longer than the desired average, based on the largest contributors to periods out of communications utilizing the z-score function.

The result of the communications analysis is identification of the platforms and their associated tasks that require derived associated comms relay tasking to mitigate the violation of the operator's communications objectives/constraints.

As a note, for our purposes and to demonstrate this concept, we only were able to consider the communications range of the vehicle. A more robust communications and networking model, terrain data, and red force characterization could enable the identification of no-comms windows for other reasons.

The planning of communications tasks is an anticipated growth area of both autonomy and of our mission planning capability. It was a desired goal in year 2 for the team to successfully implement a "Comms Oracle", which took tasks of the type "connect two nodes with a desired bandwidth capacity" and created motion plans similar to the ISR motion plans to afford communications. Unfortunately, due to the technical limitations of the communications oracle capability, this functionality has been deferred to the third year of research efforts. In the interim, to display the value of this function, a surrogate module that planned comms relay tasks was inserted.

The current derived tasking is simplistic. To realize the comms relay, the post processing module takes identified exceedances, uses the nominal radio range of the comms relay assets, and identifies loiter points with a specified overlap to specify loiter tasks that should afford the opportunity for a communications chain. Figure 6 shows the output of the planning prior to the comms analysis.

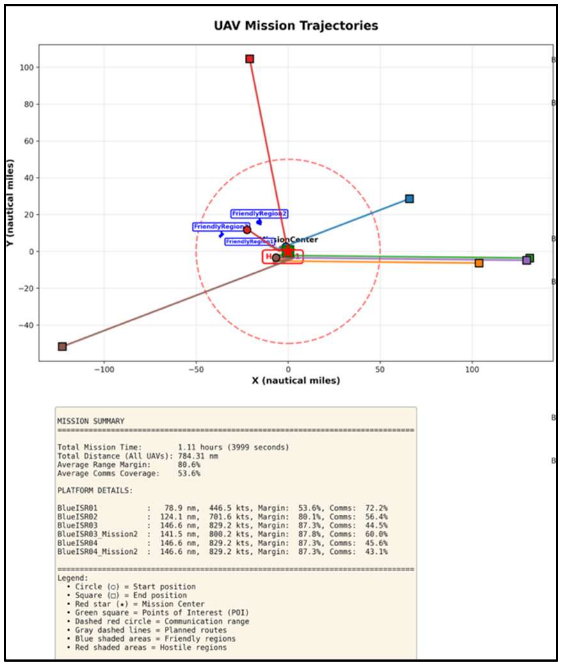

Figure 6: Post Processing Visualization of the Flight Trajectories for each RAS

To demonstrate the derived communications tasking, the post processing evaluated comms from a position in region 3 from the original definition of the situation and objectives. The nominal communications range for the assets was set at 50 nm and the maximum time allowed out of comms was determine to be 15 seconds. This threshold was set arbitrarily low to demonstrate the functionality of the derived communications tasking. The result, shown in Figure 7, is a set of derived "comms relay" tasks specified as loiters during execution.

It is evident in this image that further refinement of this approach could yield reductions in the number of required assets to achieve the satisfaction of the communications constraints. For example, depending on the timing of the mission, one set of communications relay chains could probably provide coverage for multiple ISR assets. This, in effect becomes another planning problem where the "node" of interest in a second iteration on the plan is the relay bird itself. Steps were taken in the post processing module to allow for the execution of these refinements in future efforts, but further development of this capability has been deferred to the next year to allow the insertion of the communications oracle and all of the advanced capability for motion planning in comms that it affords.

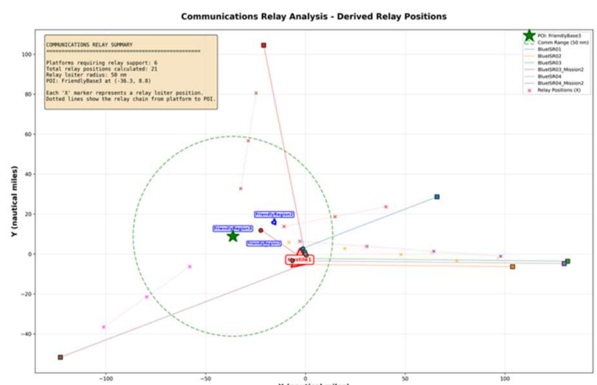

Figure 7: Derived Communications Relay Tasks

As was mentioned about, the initial charts were created using an arbitrarily low maximum allowable time out of communications. When the time is increased to 90 minutes (longer than the flight times of the vehicles) there is no requirement for comms relay.

For a given mission, the impact of communications constraints can have a significant effect on the number of required assets. While, as mentioned before, a more robust communications planning tool than our simplified approximation here could provide some efficiencies, parameterization of the communications constraints (the allowable time out of comms) was conducted to see, for this given mission area and nominal communications range, what the impact of communications constraints has.

To analyze this relationship more directly, the team performed similar analysis of a mission with a smaller operating area. The figure below shows another littoral mission area with routes for reconnaissance for four aircraft.

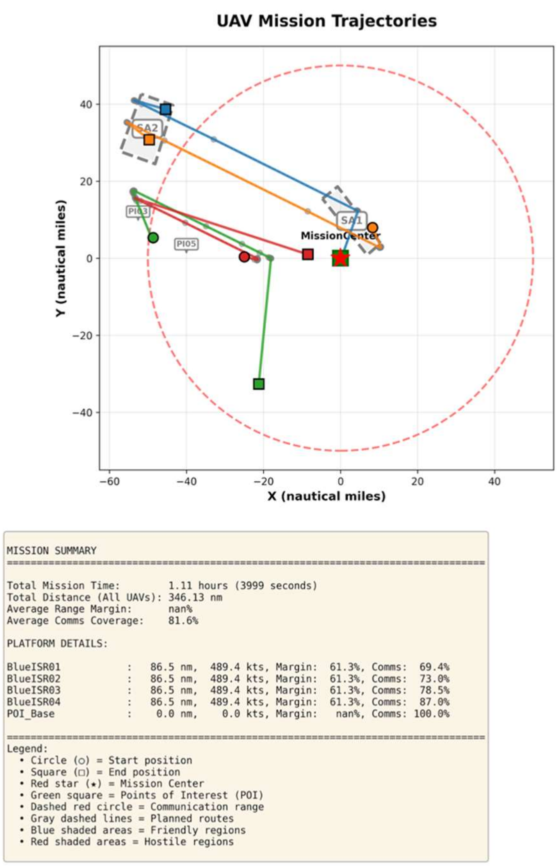

Figure 8: Mission 2 with Planned UAV Routes

In this mission, the routes and tasking allocation were optimized for even distribution of resource loading across all of the platforms. The legend for the chart is included in the bottom table as text.

The red ring in the figure shows the communications range of the "command node" an identified entity location that all of these assets are desired to communicate with. This is located at the first waypoint of one of the UAVs. The post processing analysis shows the percentage of time of the mission that each UAV is in communications range, Figure 9.

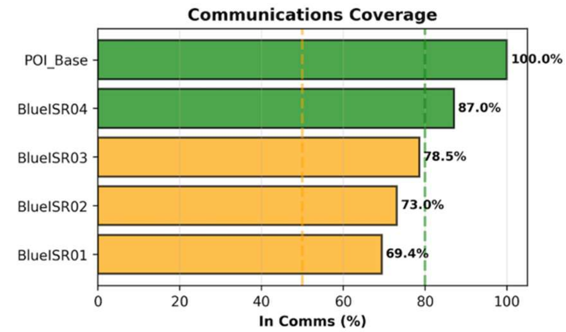

Figure 9: Percent time within Communications Range by Platform (POI_Base is the Identified Comms Node)

The application of communications constraints was parameterized to determine the relationship between the maximum time allowed out of comms and the number of relay resources required (per the simplistic comms planning), shown in figure 10.

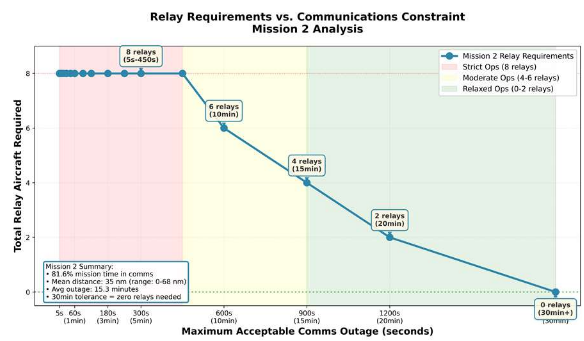

Figure 10: Declining Required Assets with Relaxed Communications Constraints

What is evident from the chart is that a constraint on Max Time Allowed out of communications of approximately 7.5 minutes ensures that the aircraft basically are required to be connected at all times and that the most assets are required, 8 relay aircraft vs 4 ISR aircraft. At 15 minutes allowed outage the number of relay aircraft drops considerably to 4, and at 30 minutes, 0 relay aircraft are required. The mission execution time is approximately 30 minutes.

A similar chart was produced for Mission 1, shown in figure 11. In this chart however, the anomalies of our simplistic comms planning algorithm and calculation are more evident.

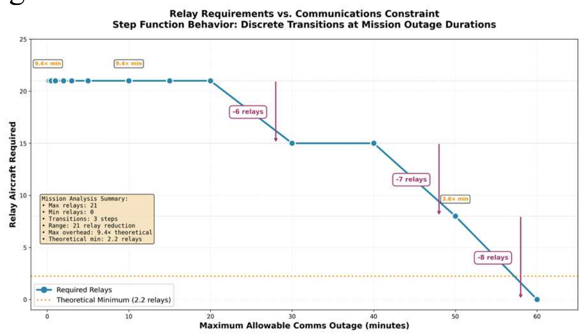

Figure 11: Comms Relay Constraint Parameterization from Mission 1

With more time and study, the GTRI team believes that this curve could provide some utility in the form of coarse "rules of thumb" for the number of required comms relay assets to support operational planning for commanders. As it stands currently in a resource constrained environment it provides information to the commander to understand what is an over constraining observability requirement given the number of assets on hand.

Additionally, this could provide an opportunity to study communications planning algorithms from an efficiency perspective. With our simplistic comms planning for Mission 2, we had effectively a 2:1 comms to ISR asset ratio. A more efficient comms plan could lower the number of required assets for comms and thus the "peak" of the curve.

5. Macro Level Metrics

While there are still some improvements to be done to the MOCKS tooling, there is greater fidelity in the considerations for the "quality" of a COA that has emerged as a result of creating the MOCKS platform.

This post processing is driving towards the emergent properties of a task organization. If the individual entities have freedom of maneuver to make decisions in response to changes in the operational context, the task organization itself could be expected to be adaptive during execution. However, there are other factors related to the organization being adaptive rather than just each individual having freedom of maneuver however.

Observability, predictability, and directability also relate to the task organization being adaptive in the sense that the operator can reason about the situation, predict what will happen in the future and direct the entities to do something different, thus adapting to the changes as they unfold. One might also suggest that sufficient comms enables control as was discussed prior. This might fundamentally force the community to rethink the concepts of control of RAS. Whereas, we traditionally think of a positive link with an individual aircraft, it might be more appropriate to say that there is sufficient observability, predictability, and directability of the task organization itself to monitor and influence the performance against the commander's intent.

One might say that in the case of lacking resource margin a task organization is "rigid". One might say that if there is lacking observability, then there is probably a lacking understanding of the global state or the state of each individual entities, suggesting that the task organization is "disjoint".

The calculation of these metrics across many different plans should enable to automation software to perform COA comparison, one of the next steps in the MDMP.

The thinking regarding resource margin and observability, is directly attributable to the concepts expressed in the Army Universal Task List (AUTLs), applied in the domain of RAS. ART 1.8.3 Conduct an Area Reconnaissance defines the Measures of Performance (MOPs) and the Measures of Effectiveness (MOEs) for a Recon task [7]. Included in the Effectiveness are additional considerations outside of "if reconnaissance was performed for the area" including:

Table 1: Excerpt for ART 1.8.3 Conduct an Area Reconnaissance

No.	Scale	Measure
02	Yes/No	Reconnaissance Force oriented on the reconnaissance objective.
03	Yes/No	Reconnaissance Force Reported all information rapidly and accurately
04	Yes/No	Reconnaissance force maintained its freedom to maneuver
05	Yes/No	Reconnaissance force gained and maintained enemy contact.
06	Yes/No	Reconnaissance force rapidly developed thee situation
07	Yes/No	Unit reported to higher headquarters area reconnaissance tasks not performed.

In effect, from the Task description, this could be read as overall the intent is to satisfy the objective: Area reconnaissance accomplished its task or mission, such as finding, reporting, and clearing all enemy forces in the designated area of operations (AO) within the capability of the unit conducting reconnaissance, but it is also a measure of the effectiveness of the performance of the task that "the force maintained its freedom of maneuver".

With the opportunities presented for employment of RAS at scale (100s of systems), it will probably always be the case that the objectives CAN be accomplished based on the *a priori* situation knowledge. To drive up the quality of the employment, the efficiency with which we utilize these assets and the effectiveness of *our* forces against our adversaries, we will need to look at these other measures of effectiveness as well.

In reality, these macro level estimations for the task organization probably are not as simple as maximization and minimization. Maximizing resource availability results in a costly over expenditure and waste of resources. The team envisions a recommended threshold and objective for resource utilization informed by simulation of certain scenarios and through operational execution and data collection. The same could be said of determining the "right" level of communications availability or observability.

6. CONCLUSIONS

The preliminary results shown for this analysis communicate the approach of MOCKS and demonstrate the necessity of *a priori* mission planning as an enabler for the envisioned employment of RAS at scale. The MOCKS platform greatly extended its capabilities in this year of effort, expanding from COA generation in year one to introduce further COA Analysis and Mission Analysis in year 2.

The modular architecture of MOCKs and the federation of these functional processes enable a greater opportunity for refining different techniques and approaches to mission planning and its subtasks. The COA analysis framework and post processing provides a platform for the refinement of concepts associated with mission planning for RAS, while still supporting the initial use case of allowing the operator to visualize the operational approach prior to execution and during execution.

Further effort in the third year will focus on exercising the tooling that has been built and ensuring its operational relevance through simulation and, hopefully, data collection in a relevant scenario. Further details regarding mission variables for planning inputs will be considered, such as threat locations and risk.

7. REFERENCES

[1] Spratley, Michael; Schooley, Andrew; Dickerhoff, Trey, "Planning for the Employment of Robotic and Autonomous Systems," In Proceedings of the Ground Vehicle Systems Engineering and Technology Symposium (GVSETS), NDIA, Novi, MI, Aug. 12-14, 2025.

[2]Johnson, Bradshaw, "How Interdependence Explains the World of Teamwork", Florida Institute for Human and Machine Cognition, proceedings Engineering Artificially Intelligent Systems, 2021

[3] Department of the Army, "Military-Decision Making Process: Organizing and Conducting Planning", Center for Army Lessons Learned, 17 Nov 2023

[4] Department of the Army, "The Operations Process", Army Doctrine Publication 5-0, July 2019

[5] Lowe, Michael, "The Unintended Effects of Information/Decision Superiority", presentation, 2022.

[6] Department of the Army, "FM 6-0, Command and Staff Organization and Operations", May 2022

[7] Department of the Army, "The Army Universal Task List", ADRP 1-03, October 2015

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10. ACRONYMS

EUD	End User Device
GTRI	Georgia Tech Research Institute
HASIC	Human Autonomous Systems Interaction and Collaboration
MOCKS	Missioneer for Organic Collaborative Kill Chains
NAI	Named Area of Interest
SEAD	Suppression of Enemy Air Defenses
RAS	Robotic and Autonomous System
POI	Point of Interest
EBS	Emergent Behavior Systems