Intelligent Ground System Survivability: Ways and Means

OPSEC #2690

ABSTRACT:

Ground vehicle survivability and protection systems and subsystems are increasingly employing sensors to augment and enhance overall platform survivability. These systems sense and measure select attributes of the operational environment and pass this measured "data" to a computational controller which then produces a survivability or protective system response based on that computed data. The data collected is usually narrowly defined for that select system's purpose and is seldom shared or used by adjacent survivability and protection subsystems. The Army approach toward centralized protection system processing (MAPS Modular APS Controller) provides promise that sensor data will be more judiciously shared between platform protection subsystems in the future. However, this system in its current form, falls short of the full protective potential that could be realized from the cumulative sum of sensor data. Platform protection and survivability can be dramatically enhanced if all incoming sensor "information" and other system metadata can be synthesized beyond limited situational awareness and into situational understanding. Protective response that is informed with synthesized information and doctrinal context can significantly enhance vehicle survivability beyond the current layered approach that is sought. Intelligent cognitive processing and augmented with doctrinal analysis processing can realize this enhanced state.

In combat situations, platform commanders are overburdened with the tactical execution of their mission and the simultaneous operation and defense of their platform. This creates a significant cognitive burden on the vehicle commander and crew. Intelligent Ground System Survivability can enhance the platform commander and crew's situational awareness toward situational understanding, while developing most- suitable and survivable courses of action for the employment of their vehicle platform. This paper will describe the ends of the Intelligent Ground System Survivability concept and propose ways and means in which these ends can be realized.

FOREWORD:

A Stryker Platoon forms up in person around the outside of their Infantry Combat Vehicles (ICV). An OPORD is provided to all crews and dismount Soldiers. Most take notes, others smoke cigarettes and impatiently wait for the patrol to kick off. All critical mission coordinating instructions are passed to the patrol members; actions on contact, routes, casualty collection points, historical danger areas, helicopter landing zones, rally points, weapons status, etc.

The patrol crosses the line of departure and heads into the coalition-enforced buffer zone where the Donovian enemy forces are templated to be operating. The large trees restrict the platoon's movement to unimproved roads and logging trails. Visibility is limited to 200-300 meters up and down the road and often obscured by the dense fog in the low-lying areas. The Platoon and Platoon Leader is new. He replaced the previous Platoon Leader who was killed during the intense fighting to reestablish the buffer zone between the NATO countries and the Donovians. He seems competent but just inexperienced. The enemy was templated to be operating between Phase Line (PL) PATTON and PL MARSHALL. This was the last report received from the SIGINT cell about an hour prior to the Platoon crossing the line of departure. PL PATTON is approximately 3 km to front of the patrol, and PL EISENHOWER, BRADLEY, MACARTHUR lie between it and the platoon's current position. As the patrol advances through the dense Baltic forest, it approached an open farm field with rolling hills. The route the patrol following passes directly through the middle of the field which is approximately 1 km wide and 2 km in length. PL MACARTHUR is marked by the far end of the farm field. The patrol advances across PL EISENHOWER and PL BRADLEY. PL BRADLEY is associated with a linear ridge lines that obscure the terrain behind it. Behind this ridge lays an open valley that rises back up into another dense wood line of restrictive terrain that is associated with PL MACARTHUR. As the patrol crosses the ridgeline, dense fog could be seen in the open valley floor. The patrol continued cautiously but not expecting enemy contact until past PL PATTON; approximately 2 km to the patrol front. The Platoon Leader considered changing the movement technique to Traveling Over-watch and leaving half his patrol on the ridgeline to provide over-watch and protective fires as the other two ICVs advanced into the fog covered valley. He hesitated fearing his platoon might judge him as being an overly cautious rookie. His train of thought was interrupted by a radio call from higher asking for a SITREP on the patrols progress. He abandoned this consideration and attempted to send up his report, realizing that his patrol had lost FM communications due to the terrain

Unbeknownst to the patrol, the templated enemy operating in the area had established a far side ambush in vicinity of the PL MACARTHUR. The enemy unit had broken radio silence and sent up a situation report to their higher headquarters on their radio. This radio call was intercepted by the SIGINT team who triangulated the enemy position and immediately sent an updated report to the Battalion Headquarters that had command and control of the patrolling platoon. The Battalion Headquarters', knowing the patrol was about to be ambushed, frantically tried to reach the platoon on FM communications. The platoon could not be reached as the valley the patrol had just entered was masking the line of sight communication from reaching them. In anticipation of the ambush they re-tasked an Apache Air Weapons Team operating in the Area to provide support and communications to the ICV patrol.

The Platoon Leader gave up trying to give the Battalion HQ his SITREP, knowing that the patrol would likely be able to send the SITREP in a few hundred meters up the road when the ridgeline ceased obscuring their communications. Still questioning whether he should have switched the patrol movement technique from Travelling to Travelling Over-Watch, the Platoon Leader directed his patrol to increase the spacing between the vehicles as an added security measure. The first vehicle of the patrol entered the dense fog at the base of the valley. The vehicle commander radioed to the rest of the patrol to slow down as visibility into the fog made is difficult to see. The second Stryker, third and finally the fourth Stryker entered the foggy areas. The platforms were outfitted with the latest generation of thermal Driver Visual Enhancement (DVE) system which could peer through the fog and aid in driving. It took a moment for the vehicle driver to switch on the DVE and orient the system to aid in their driving. As the fourth vehicle entered the fog, a bright flash and loud explosion erupted behind the patrol. The Platoon Leader, in the second Stryker could see a large ball of light behind him in the fog. He called for a SITREP from the patrol. ICV 1 and ICV 3 reported in but no response was reported from ICV 4. All of the vehicle's active protection systems gave an alert that a Metis ATGM system had been detected and originated from the west side of the road near the far tree line. The fog obscured all the vehicles view of the origination point. Heavy machine gun fire began impacting on and around the patrol the vehicles. ICV 1, 2 and 3 immediately began suppressing based on azimuths reported by their APS radar systems. Alarms rang out in the rest of the vehicles alerting them to two more inbound ATGMs. The ATGMs missed. The Platoon Leader immediately ordered his platoon to assault forward in to the enemy position and out of the blinding fog. The first vehicle emerged from the fog and was pelted with a burst of fire from an enemy BTR-80 auto cannon fire. The impacts immobilized the Stryker. The immobilized ICV slewed its 30mm cannon, and fired scoring a direct hit neutralizing the BTR-80. The Platoon Leader commanded the remaining vehicles of his patrol to get off the road and dismount the Infantrymen to assault the enemy. He directed the remaining 2 ICVs vehicles to remain in the fog to obscure the enemy's view and ability to visually target then. The commander of the immobilized Stryker that was exposed immediately triggered his smoke obscuration system. In his haste, he fired the smoke canisters directly in line with the enemy position, not taking in to account the strong westerly wind that quickly dispersed what little obscuration the smoke provided. The ICV 2 commander quickly realized his folly and directed his crew and dismounts to abandon the vehicle and retrograde into the concealment of the fog behind them. Upon reaching the his friendly forward line, the ICV 2 Commander immediately ran to the Platoon Leader and gave precise positions of the enemy that was attacking them. The Platoon Leader called for his organic forward observers to direct artillery fires and CAS on the positions indicated by the forward vehicle commander. Within a minute, 120 mm mortar shells pounded the far tree line, followed by the arrival of the Apache Air Weapons Team. However, the enemy had displaced and retrograded before the artillery and Air Weapons Team could effectively engage them. A bad day for the Coalition, a good day for the enemy…

I. Intelligent Ground System Survivability

Definition of Intelligent Ground System Survivability: Intelligent Ground System Survivability (IGSS) is a proposed and conceptual cognitive processing capability that continually assesses operational mission factors, informed by doctrine, mission plans, real-time sensor feeds and user inputs to augment and enhance vehicle crew survivability through the management of routine, doctrinal practices, tactics, techniques and procedures that enhance survivability. The conceptual capability consumes relevant mission factor data from the aforementioned sources, assesses their relevance and implications on the platform and adjacent platform survivability posture, and provides vehicle commander's recommendations and options to maximize survivability. b. Concept: A trained Soldier shoots, moves, communicates, survives and otherwise operates in their environment in a proactive, reactive, and deliberate fashion. The actions performed during operation are informed, shaped and influenced by internal and external signals that are stitched together to define such a suitable state of operation. The primary signals that shape and influence how a Soldier operates are the mission factors. There are six mission factors that are currently recognized by US Army Doctrine; they are mission, enemy, time, terrain, troops available, and civilians

(METT-TC). The mission sets the goals or objectives that the Soldier's operation is to achieve. This mission is often required because of some enemy presence or action that aims to counter the objectives of the mission. Each mission has a time constraint in which the objectives must be accomplished to precipitate operational and strategic ends. The terrain, weather and environment is the setting in which the mission takes place. Troops available specifies the composition of troops and equipment allocated to accomplish the mission. Lastly, civilians and non-combatant activities must be avoided to prevent collateral destruction. These factors drive Soldier and unit operation on the battle field. These factors give context provide situational understanding and influence the decisions that commanders make to maximize survivability.

In the intense moments of combat, decision makers are cognitively overwhelmed with all that is happening, and in these moments, critical data and information can be missed, overlooked or ignored. This missed information could hold aspects that could change the circumstances or dictate the course of the battle. A system which objectively maintains understanding of the situation, removed from the stressors and distractions that overwhelm human cognition, would prove instrumental in combat.

A. Cognitive Hierarchy:

The term cognitive hierarchy refers to the levels of context an entity bears regarding the level to which data available has been processed and presented to him. The hierarchy has four levels of cognition; data, information, knowledge, and understanding. Data is lowest cognition level and consists of raw unprocessed inputs sensed or collected from the environment. Data, in and of itself, has little meaning or utility to users. It is usually received in a cumbersome form that must be processed achieve some level of utility. Information is the next level and differs from data in that a level of processing has occurred to give the data meaning and utility. [1] Knowledge is the third level of cognition where analysis has been conducted to give the information precise utility, meaning and value. Knowledge is kept, and is often applied in alternate situations as an experiential reference. This is useful for neural networks as archival reference. Understanding is the pinnacle of the cognitive levels. Understanding is knowledge that has been synthesized and applied to a given situation to understand the situation's underlying drivers and relationships. See Figure 1 for a visual depiction of the cognitive hierarchy. Military vehicle crews ultimately seek to achieve and maintain situational understanding in every situation. However, this is very elusive, especially in chaotic and complex situations such as combat. Current vehicle crew must consume data from several sources, digest it, and analyze it, and contextualize it all in an effort to understand what is happening around them and make life or death tactical and operational decisions. Crews are surrounded by countless technologies and sensors that they must simultaneously operate, while also cognitively assessing the stream on data and information they produce. The human cognitive span of control, on average, is stressed beyond three simultaneous activities; while control is lost above eight. [2] This means that a crew of four, can effectively manage approximately 12 simultaneous processes. Between shooting, moving and communicating, little capacity is left for achieving and maintaining situational understanding from the countless sensor feeds. These technologies feed crews information that still require cognitive analysis, synthesis, and contextualization before their products can be fully levied for use.

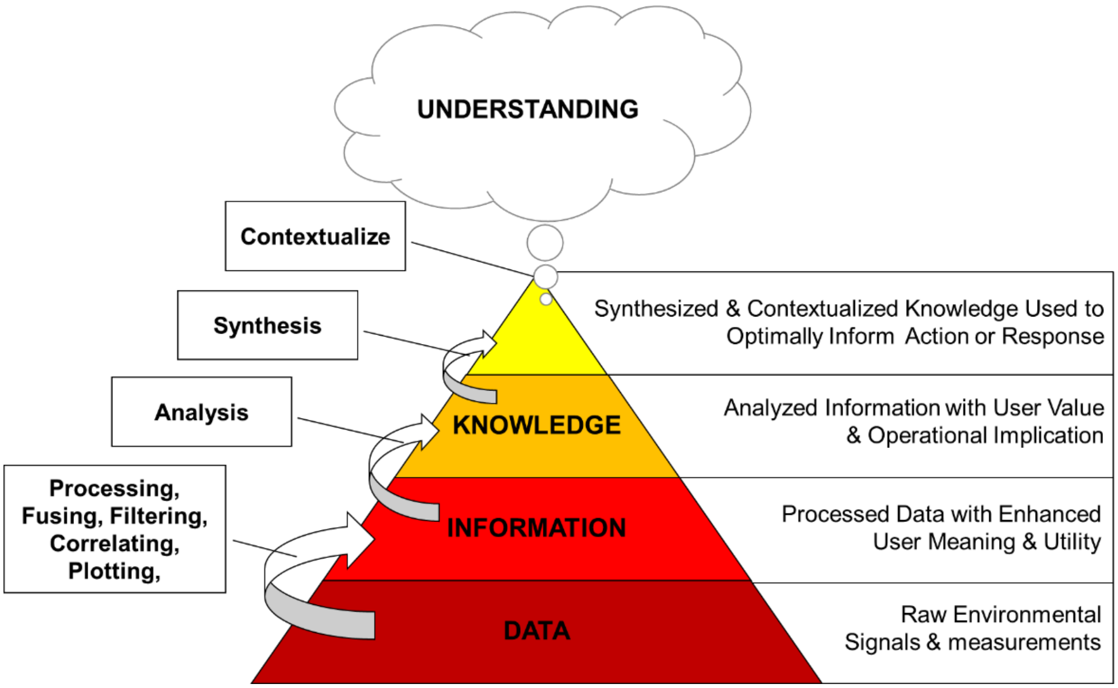


Figure 1. The cognitive hierarchy serves as a model to depict the echelons of cognition between data understanding. Data is raw environmental measurements and signals that when processed, fused, filtered, correlated and/or plotted become useful information. Information can be analyzed to enhance its value, utility and character into situationally relevant knowledge. Knowledge can be synthesized and contextualized to optimally inform actions and responses. This pinnacle state of cognition is understanding. Derived from [1].

These technologies are touted as "situational awareness" technologies, as though one can never have too much situational awareness. Army Doctrinal Reference Publication (ADRP) 3-0 defines situational awareness as the immediate knowledge of the conditions of the operation, constrained geographically and in time. [3] In the context of a vehicle crew, situational awareness is the ability to identify, process, and comprehend the critical elements of information about what is happening to the crew and vehicle with regards to the mission. "Critical elements" is a key part of that definition, for if everything is a critical element, then nothing is a critical element. Therefore, too much situational awareness can become distracting and detract from overall operational effectiveness. The motor pools and container yards of Afghanistan and Iraq were filled with situational awareness technologies that were benevolently aimed at enhancing crew survivability, but quickly discarded because they added little operational or tactical value. What was and is still needed is a capability to wade through all the various situational awareness feeds and convert that information into situational knowledge and understanding.

ADRP 5-0 defines situational understanding as the product of applying analysis and judgment to relevant information to determine the relationship among the mission variables to facilitate decision making. [4] In the tense moments of combat, vehicle crews make decisions with minimal understanding because the causal relationships of the situation have not emerged and there is not time enough to cognitively mature what information comes in. Crews rely on their education, training, and intuition to be effective, this is why so much emphasis is placed on iterative crew drills and training in our military institutions. In its absence, decisive action is still required for combat effectiveness and survival.

Situational understanding is an elusive goal. It's something all who are faced with combat strive for, but rarely achieve. If they do achieve it, it is seldom for very long. This is largely due to the cognitive limitations that humans suffer from. However, machine learning and artificial intelligence technologies are challenging and eliminating these historical limitations. Multi-core computer processing has enabled big data, from many sources, to be quickly and simultaneously processed in operationally relevant timelines.

B. IGSS Logic Operational View

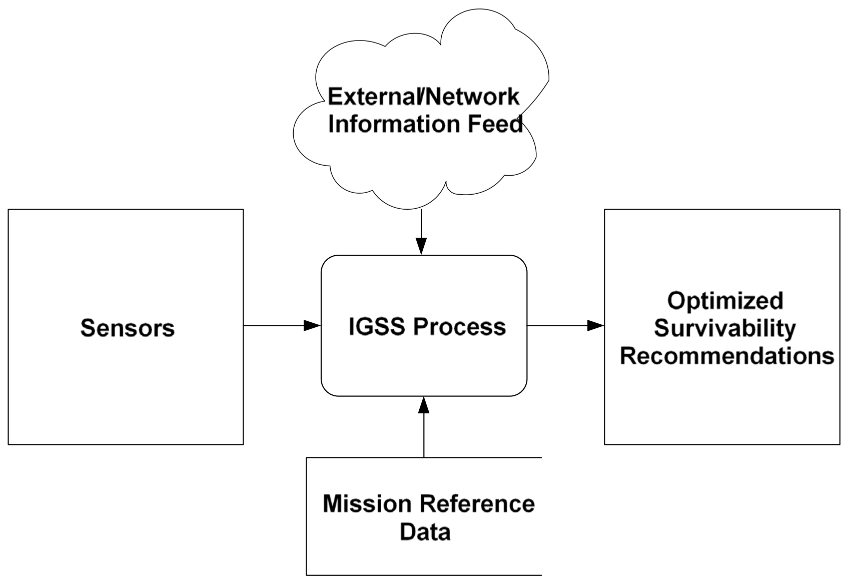


Figure 2. IGSS processes sensor inputs, external information feeds and on-board reference information to inform and generate optimal protective responses for vehicle systems.

In combat operations, the vehicle crew must contextually process incoming information from adjacent or external vehicles and entities, countless sensors, and relate that information to the given mission and appropriate doctrinal templates to inform actions and operational decisions. All of this incoming information and processing requirements can quickly overwhelm the most seasoned of crews. The problem is not that the information has no value but rather the crew lacks the cognitive capacity to effectively sort through it all. Much of this information can processed through automated processes and, with the right cognitive processing algorithms, can be synthesized with doctrine and mission data to present the crews and users with clear and concise knowledge and even protective responses to maximize vehicle and crew survivability. The cognitive processing algorithms processing the information remove the tedium and procedural/process delays that inhibit and overwhelm humans. They would also reduce errors. Take for example an enemy anti-tank guided missile (ATGM) engagement with a main battle tank (MBT). An enemy ATGM team uses a laser to target and guide a threat onto the targeted MBT. Given the engagement distance the ATGM has a five second flight time. In that time, the human crew can do little but launch obscuration smoke, maybe dash out of the way, and hope that the APS and armor systems of the vehicle protect them in case of impact. The same could be much different with a machine learning algorithm at play fusing, analyzing, synthesizing, and contextualizing the data. In that same five second flight time the proposed IGSS system could detect the threat point of origin with extreme precision, classify the threat and type of unit associated with launching it, calculate and execute the optimal methods to avoid being hit by the threat, launch optimally placed obscuration smoke, pass the engagement metadata to the on-board lethality systems for counter-fire, and relay all that critical metadata to adjacent and higher entities for their situational understanding and support. This is just one simple example of the cognitive processing benefits of an intelligent ground system survivability capability could offer in an operational scenario.

C. IGSS System Model and Data Flow

There are many ways that an IGSS system could operate. A proposed model is shown in Figure 3. External to the host vehicle would be adjacent entities, networks, and the environment in which real-time data, information, and knowledge would be transferred, sensed and received. The host platform would consist of the IGSS processor that would ingest the real-time environmental feeds of the lethality, communication, mobility and survivability sensors. This information is fused, analyzed, synthesized, and contextualized with regard to on-board, mission information, geospatial reference data, threat libraries, and doctrinal vehicle tactics to generate indicators, suggestions and even executable options for the vehicle system to perform to increase or enhance the probability of survivability. The options and suggestion are then passed to appropriate system for execution, reference or notification. These outputs are also passed through the appropriate means to adjacent vehicles and higher echelon mission command systems for reference.

A proposed cognitive processing data flow approach for the IGSS capability would employ 5 major processes; sensor fusion, analysis, synthesis, contextualization and generation. This is shown in Figure 3. Sensor fusion is the stitching of disparate sensor data and information to meaningfully enhance and represent the measured data and information in a useful and more precise fashion.

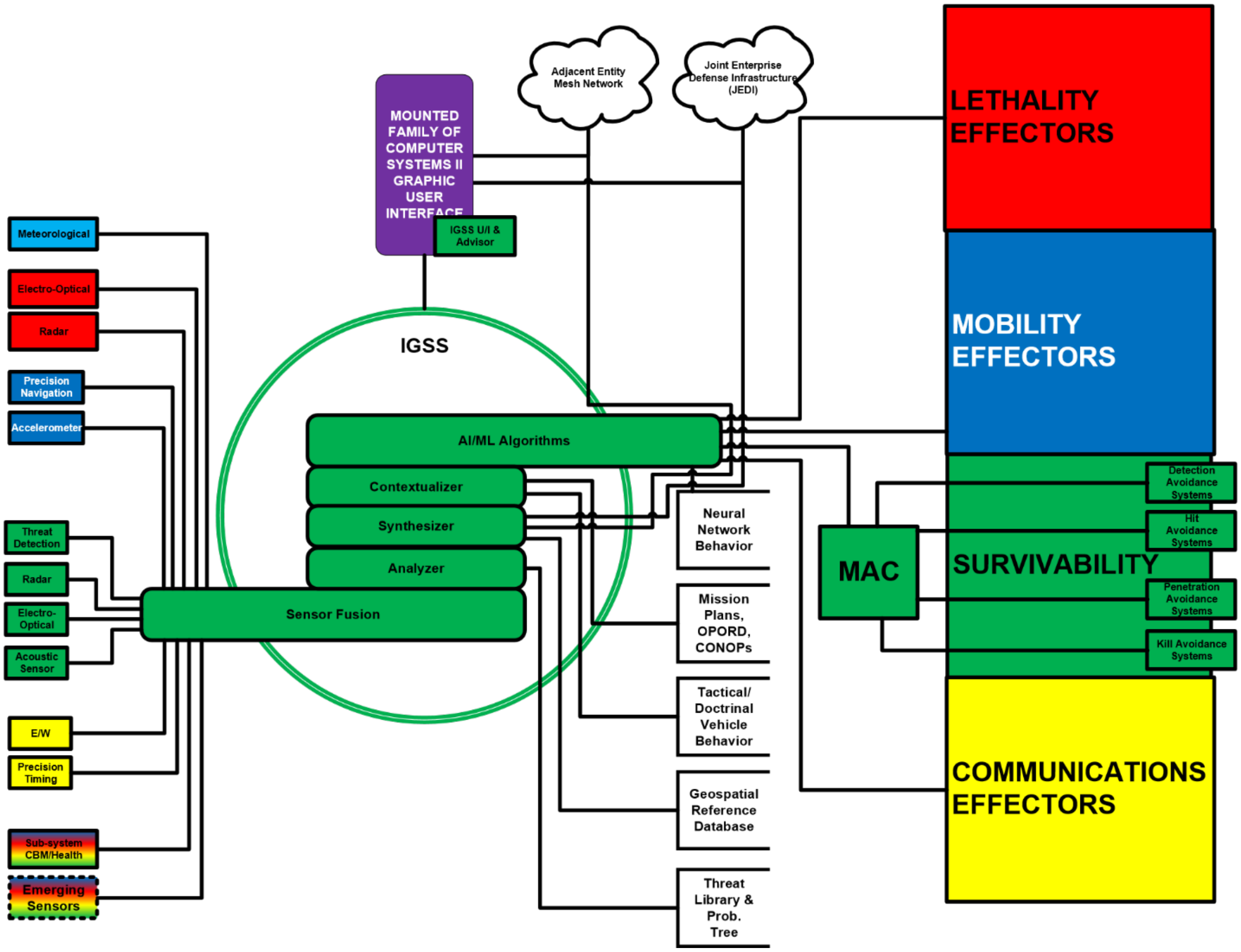


Figure 3. Most vehicles are outfitted with a compliment of sensor suites which can be used to feed relevant environmental information to the IGSS. The IGSS can use this information, processed with external information and knowledge, on-board reference data and doctrinal references to generate maximums situational understanding and optimal survivability and protective responses. The above figure depicts “a way” data, information and knowledge might flows between adjacent sensors, databases and subsystems/effectors and the IGSS capability.

An electro-optical sensor might detect an entity and give an azimuth to its location, but fall short in precisely defining its location. Fuse the electro-optical sensor feed with measurements from a laser range finder, and a precise observer reference location and all the pieces are present to meaningfully describe the entity location. Add an infra-red thermal camera and a trained eye and the entity can be characterized as a friend or foe. See Figure 4 for a graphical depiction of this concept. In other words, sensor fusion removes uncertainty and ambiguity from presented sensor data and information and presented information of greater utility to the user. This fusion of multiple sensor feeds lays the foundation for the IGSS concept to begin cognitive processing and advance from situational awareness to situational understanding.

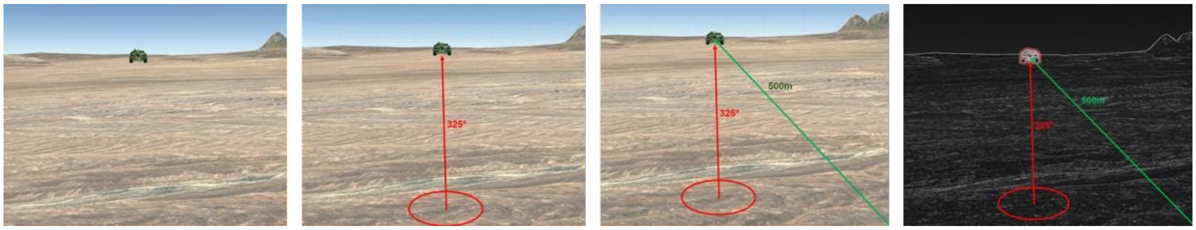


Figure 4. The above figure depicts an electro-optical sensor feed (HD camera) progressively can be enhanced with the fusion of additional sensors and analyzed to create information with enhanced utility and value. The narrative of this progression is as follows: ***I see something; I see something at 325° magnetic; I see something at 325° magnetic and 500m or I see something in vicinity of grid FQ XXXX YYYY; I see an enemy tank with a similar thermal pattern of a T72-B3 directly facing me at grid FQ XXXX YYYY.*** As the different sensor feeds are fused, more knowledge can be attained about the environment. With more knowledge about the environment more understanding is realized and better tactical and operational decisions can be made.

The analysis process of the proposed IGSS concept analyzes the fused sensor information with regard to a prioritized logic tree of threat data and probabilistic survivability questions to be answered. Analyzer logic and algorithms examine the available fused sensor information for defined patterns, signatures, and other characterized metrics that can be interpreted into valuable protection knowledge. Figure 5 depicts this concept.

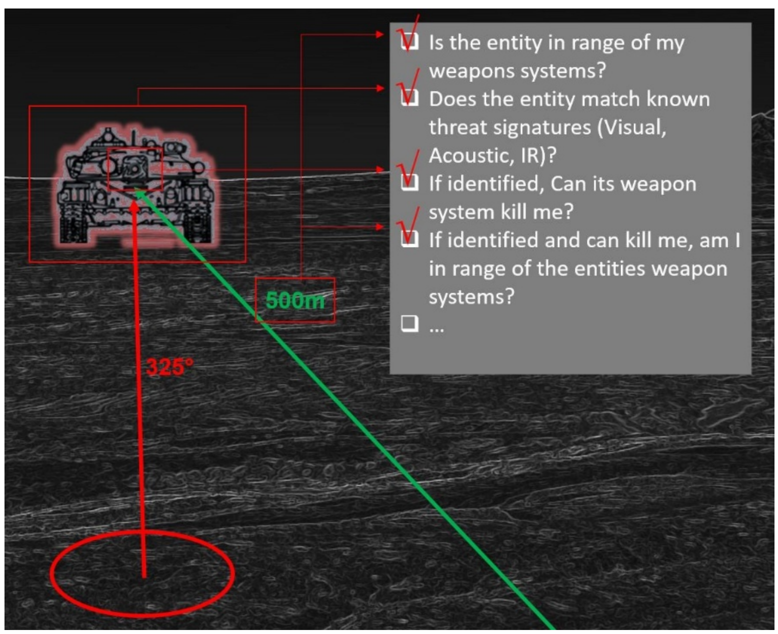


Figure 5. An analysis of the fused sensor information by the analyzer function of the IGSS evaluates the information for threats patterns, signatures and consistencies. Findings are resented as probabilistic knowledge and handed off to next cognitive processing function for synthesis and contextualization.

The synthesis and contextualization process is the final computational process. This process consumes the synthesized executable options and adjudicates their efficacy toward maximizing the probability of survivability and probability of achieving mission success. This occurs through a calculated survivability probability function that employs parameterized mission factors (METT-TC), synthesized executable options, mission plans, OPORDS, CONOPS, real-time mission command data and adjacent entity data iterated through Monte-Carlo simulations to identify the optimal executable options with the highest probability of survivability and mission success. These prioritized options are then presented to the commander of the platform for selection and subsequent selection or disregard. The synthesis and contextualization processes are depicted in Figure 6.

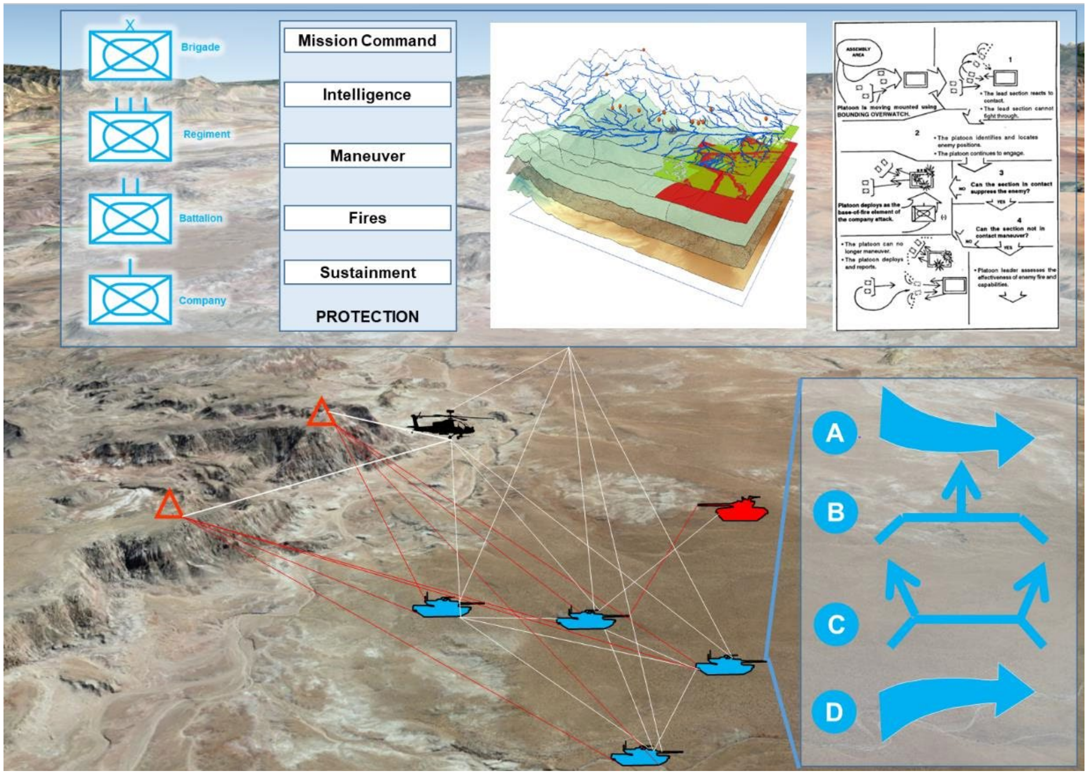


Figure 6. This figure operationally depicts the synthesis and contextualization of knowledge created by the IGSS. A tank platoon moves through the valley and detects an enemy scout tank. The IGSS assesses real time data and knowledge feeds from higher echelon commands. The feeds are synthesized with the real-time IGSS knowledge feed, warfighting functional knowledge, geo-spatial reference data, and doctrinally correct tactics, techniques-procedures to generate executable options that achieve mission ends in the most protected and survivable fashion. IGSS Narrative: Based of analyzed senor fusion data, synthesized from Higher and echelon intelligence, contextualized off of the terrain reference data, mission factors, and war fighting function parameters; the most survivable course of action, is (A) to assault the right flank the T72-B3 on its left side to avoid restrictive terrain, avoid enemy observation posts, and linearize the battlefield to allow CAS and other means of attack and neutralization to have clear fires.

II. IGSS Ways and Means

A. IGSS Subsystem: Intelligent Position/Posture

1. OCOKA: The Considerations of Position; Two Sided Coin

2. Means: Critical Subsystems: GPS, Inertial Navigation System, Electro-Optical Sensor, LIDAR, Radar, GeoSpatial References,

3. Ways: Precise Position to know where you are at. GPS/INS. ELOP/LIDAR/RADAR data fused, synthesized and contextualized from GPS/INS and On-Board/Network Geo-spatial Data, Protected maneuver recommendations are generated by assessing Blue and Red OCOKA factors and METT-TC

For example, a vehicle patrol is driving along a ridgeline road. Based off navigation sensor information, electro-optical sensor information, templated enemy positions from pre-loaded and networked mission data; the IGSS deduces that the current position of the vehicle has an 85% probability of being visually detected. The IGSS system generates executable suggestions to the vehicle operator that shifting the vehicle ten feet to the right side of the road would maximize the use of terrain inter-visibility lines and reduce visual detection to 25%. The operator accepts this suggestion which passes the information from the IGSS to a graphic user interface depicting the better path. The IGSS also passes this executable to adjacent vehicles in the patrol for their acceptance and employment. This ability is also beneficial to autonomous and semi-autonomous vehicle operation which could pass this executable to the autonomous vehicle navigation and autonomous mobility sub-systems for reference and execution. This notional example shows how seemingly inconsequential considerations could cumulatively enhance overall mission survivability.

IGSS Subsystem: Intelligent Threat Detection

While improvements to the physical hardware and capability of sensors have been made, it is the ability for greater data fusion and big data processing techniques which will allow for enhanced threat detection. Data fusion, or the ability to combine multiple sensors and sensor types to portray a situation no single sensor could, is essential to provide the much needed awareness of a foreign environment. Raw environmental data can be thought of as the first level of data fusion, with the following levels derived from it (Steinhauer H. J., 2019):

- Level 0: Signal Assessment
- Level 1: Object assessment
- Level 2: Situation assessment
- Level 3: Impact assessment
- Level 4: Process refinement

In accordance with the Observe-Orient-Decide-Act (OODA) approach, threat detection encompasses the Observe and Orient portions and would be capable of presenting solutions to the end user. By using sensors to search the raw landscape (level 0), assess objects of interest (level 1), be capable of presenting the situation (level 2) to the occupant, and then how such a threat may impact them (level 3). Having such a capability to do all of these steps without the constant use of human monitoring and interpretation of raw data into insightful information would greatly reduce the cognitive burden upon the Soldier and allow them to focus more on tasks which require their full attention.

In situations where the action is non-lethal and requires quick movement (e.g. move the vehicle five feet to avoid an oncoming threat), the vehicle could do this automatically and inform the occupant as to why. By automating such a task the human-delayed reaction time would not be an issue. However, if a sensor detected a threat coming to the side of the vehicle which would require lethal countermeasures, the Soldier could be alerted in a graphic similar to Figure 1 of where the threat is coming from and options which would require the user to choose how to counter the threat. At least for the foreseeable future, potentially lethal or expensive tactics would require user approval as the use of such force for a false threat could prove to be problematic.

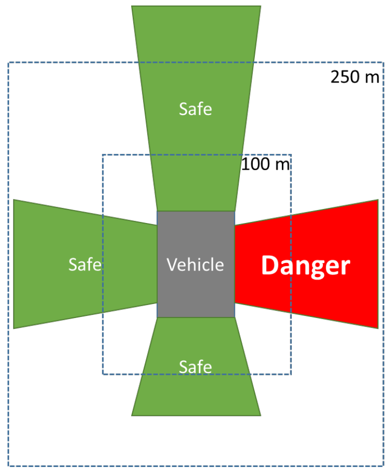


Figure 7: Graphical Example of Threat Location

Beyond sensors' ability to easily and quickly take in raw data and transform it into actionable intelligence is how sensors can combine their data using data fusion. Taking in visual and/or auditory data from multiple sources not only yields different perspectives (e.g. multiple vehicles, satellites, UAVs, etc.) but can also create a higher likelihood that a detected object is indeed an object of interest (e.g. detecting exactly what type of weapon an enemy possesses). For example, if one vehicle determines there is a 61% chance that a threat is present, then that data alone may not be sufficient. However, if a UAV also detects the same threat at a 73% level of accuracy, then that information combined with the vehicle's data may be considered sufficient enough to recognize the threat and respond appropriately. Particularly for urban environments, where there are numerous areas to hide and lethal threats can come from a much closer range, the ability to know what multiple vehicles, UAVs, and satellites can see and/or hear is of paramount importance in a ground battle.

Consistent with the idea of an Observe-Orient approach, combining large sets of raw data that could be changing every second and presenting it to the end user in a helpful way would be of great significance. Figure 2 provides an example of displaying how "Blue vs. Red" team information could be displayed to keep the Soldier aware of the most pertinent information. In the example below, the visibility would be low for the Blue team (which is good hence the green color bar) and high for the Red team (which again is good if you are on the Blue team). Same idea for recognizing the lethality and maneuver capabilities of each team, which could be identified by what vehicle or weapon is detected by the sensors. Furthermore having sensors on one's own vehicle or team of vehicles could keep the Soldier aware of what weapons are still functional. This could be especially useful in the case of having a team of autonomous vehicles fighting alongside occupant-occupied vehicles.

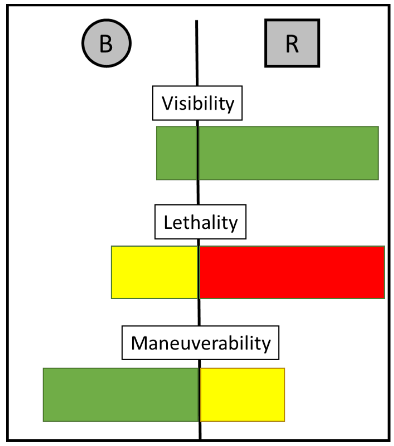


Figure 8: Example of Blue vs. Red Team Capabilities Graphic

1. OODA: Threat Detection and Response

2. Means: Critical Subsystems: GPS, Inertial Navigation System, Electro-Optical Sensor, LIDAR, Radar, Threat References, Enemy Order of Battle

IGSS Subsystem: Intelligent Obscuration

Intelligent Obscuration focuses on the Decide and Act functions of the OODA loop. Historically, this use of obscuration by combat platforms has relied on the judgement and training of the vehicle crew based on their perception of the environment around them or the maneuver they wish to employ. While this method can be effective it does not make the most efficient use of the countermeasures and cannot react to inbound threats. Ground vehicle survivability and protection systems and subsystems are increasingly employing sensors to augment and enhance overall platform survivability. These systems sense and measure select attributes of the operational environment and pass this measured “data” to a computational controller which then produces a survivability or protective system response based on that computed data. This response can be combined with selectable, or slewable, obscurants to further enhance combat operations.

There are two major elements that limit the effectiveness of a platform crew: Sensing Ability and Cognitive Burden. Due to the nature of combat a platform crew is only able to perceive their environment through the narrow straw that is afforded to them by the protection required to fight the enemy. As we enhance our platforms with cameras and other sensing equipment this straw is getting wider, but it is still limited in scope. Even if the crew is able to perceive an imminent threat it lacks the ability to rapidly factor in all relevant information to most effectively survive an engagement. If the crew sees an enemy tank that is in position to fire they likely will deploy obscuration in the direction of the threat, not knowing that the current wind conditions will render that obscurant ineffective. IGSS provides the ability to utilize additional information not known to the crew while realizing the intention of the crew’s action in order to provide an optimum solution (i.e. firing obscuration upwind for maximum effect). IGSS is also able to use information from other platforms and networks to rapidly disseminate threat information in order to coordinate a rapid response.

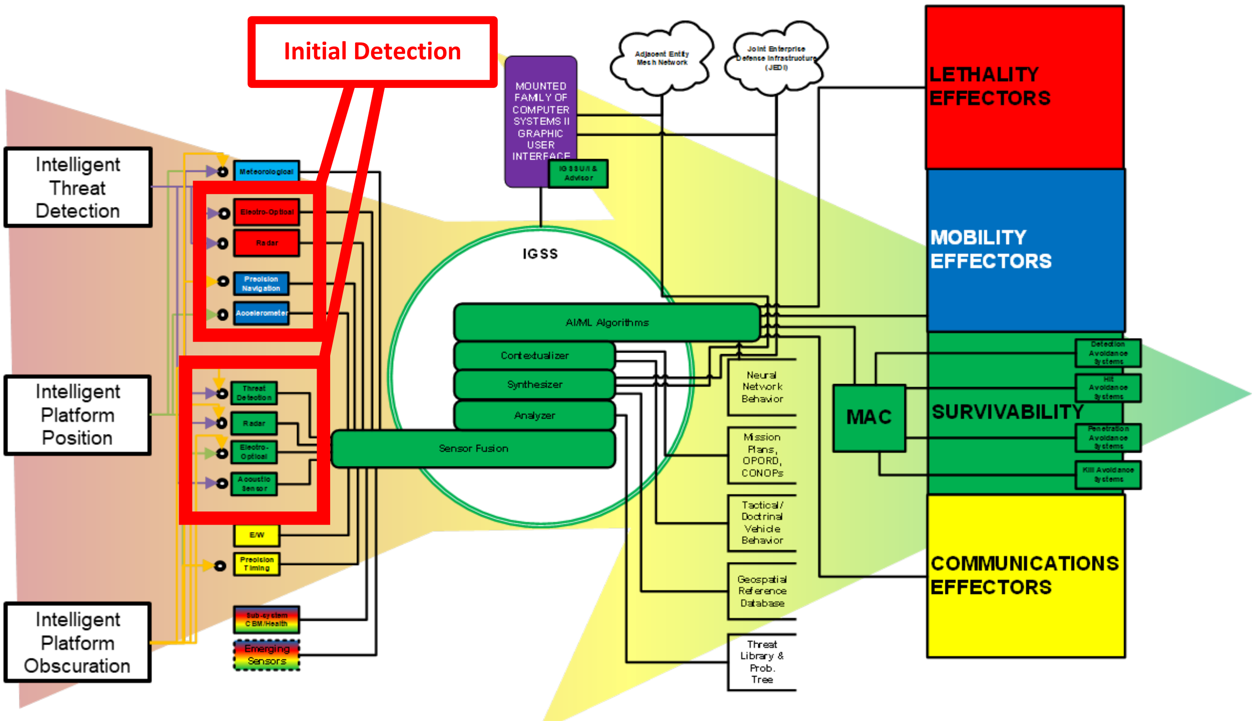


Figure 9: Threat Detection

Utilizing the intelligent threat detection methods listed above it is possible to increase the warning time available once a threat is perceived. This valuable time can offer the crew additional options to neutralize the threat. Intelligent threat detection will also allow for more information to be available about the specific threat identified. This knowledge will be used to inform IGSS in order to provide the most effective solution given the current state of countermeasures. In order to accomplish this, the data provided by threat detection will be put into metrics in order to provide a decision point for the system to take further action. Depending on the category of data these metrics can either be a 1, a 0 or a decimal based on sensor accuracy and system computations.

Data	Weight	Description
Pos. Threat	.93	Odds of a real threat launch vs a false alarm
Hostile	1	Determine if hostile activity based on knowledge of US forces
Inbound	.9	Track is moving towards platform
On Target	.75	Likely hood of hit based on sensor data

Example 1: Inbound Threat Detection

Through the sensors on a platform IGSS is made aware that a threat may have been launched. It quickly works to determine the probability that it was a real launch versus a false alarm. Through the system knowledge of friendly forces it will determine if that threat is hostile (and disseminate that information). Use its sensors to determine if the threat is moving towards the platform so it can be aware that further action is needed and then determine the initial likelihood of a hit.

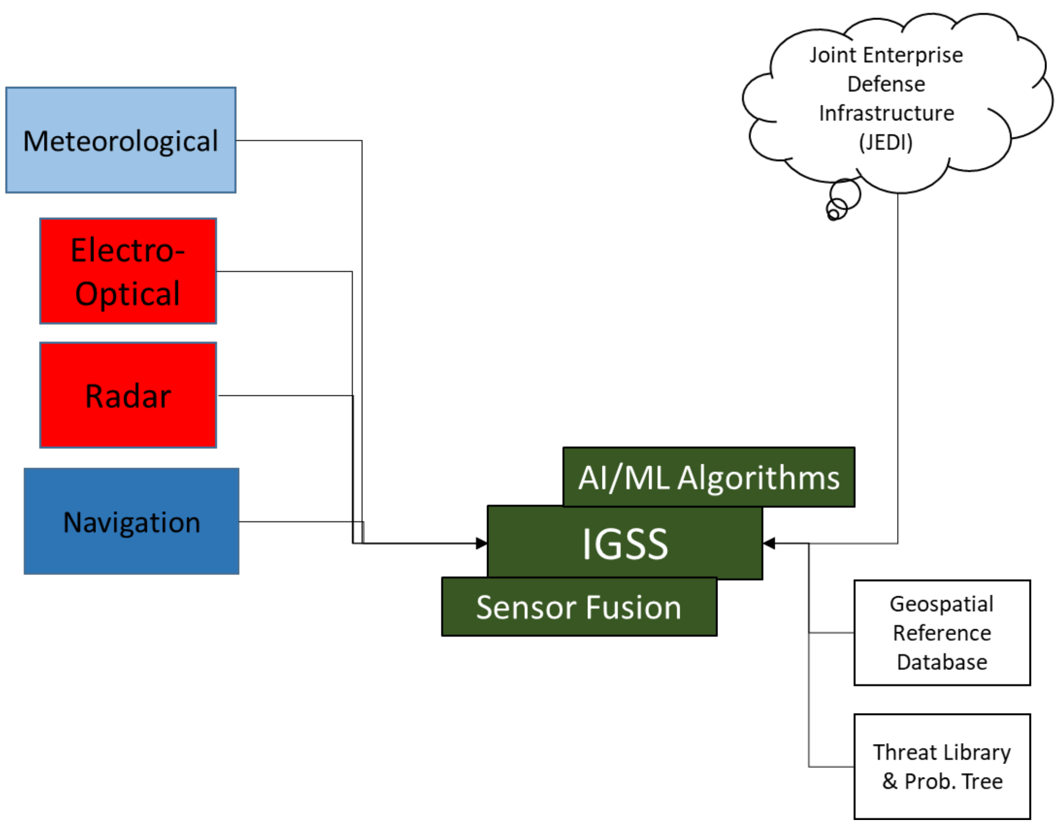


Figure 10: Positive Threat Determination

In the above example the system needs to determine if an actual threat has been launched so it can efficiently only track those items that pose a threat to the platform or its partners. To do this IGSS utilizes sensor fusion (including sensors on other vehicles) to get the best picture of the potential threat. It further uses meteorological and terrain information to weed out possible sources of false positives. It can then reference a threat library and well as previous information passed down from JEDI to get the best possible picture of what it has seen. In this case, IGSS determines that the composite information relates to a .93 positive rating for the incoming threat. This analysis will be completed for each metric that will be utilized to enhance platform survivability. This information is constantly updated as more information I gathered on an inbound threat. Once a threshold is met the information is moved into the Solution Development phase of IGSS.

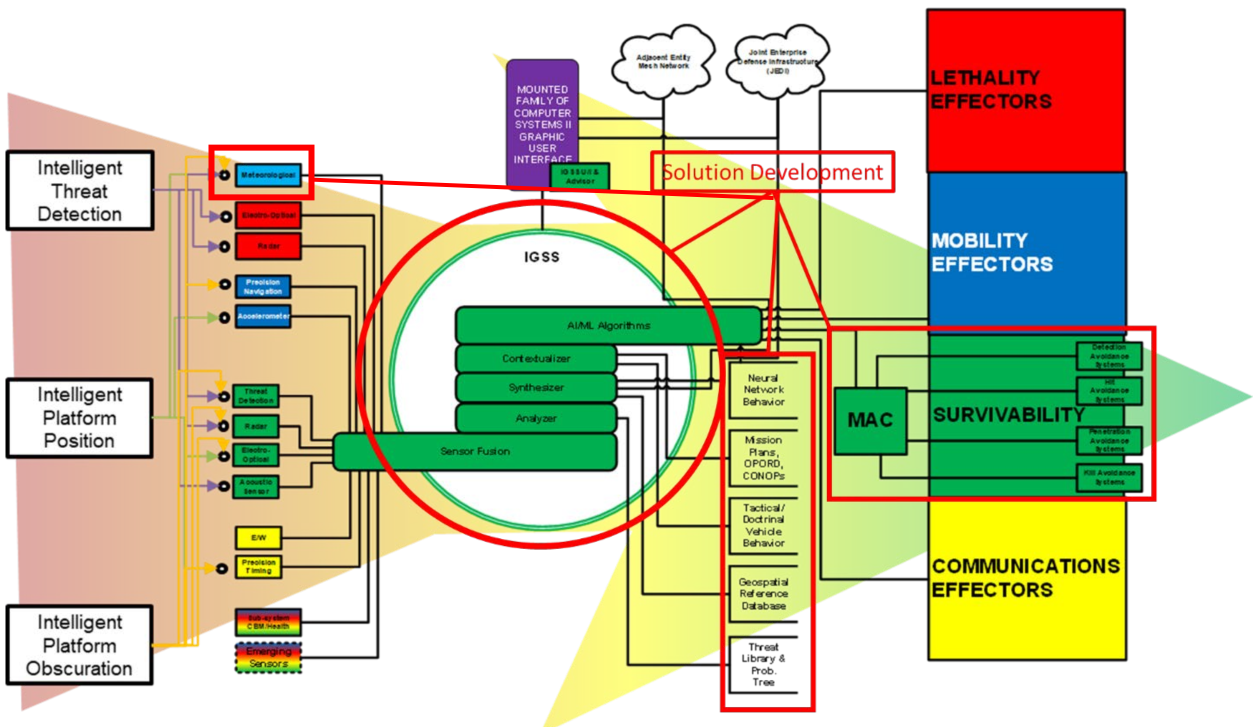
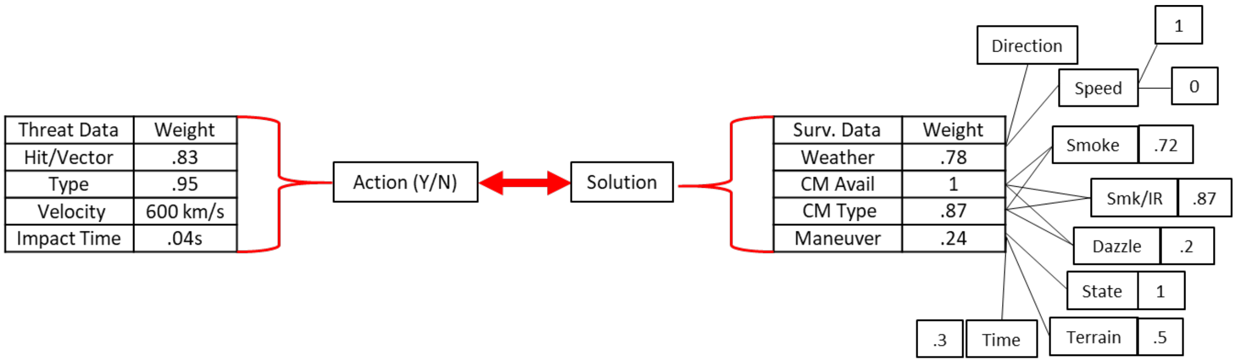


Figure 11: Solution Development

IGSS will take the information provided by threat detection and analyze it to determine information such as threat type, velocity, odds of impact, time to impact etc. IGSS will simultaneously evaluate the status of vehicle systems to determine what counters to the threat may be available. The solutions that IGSS works through will have been simulated numerous times in the past in order to refine actions for the best possible solution. As constantly updated threat information is relayed to IGSS the optimum solution is updated as well. Factors such as the current meteorological conditions will be taken into consideration so that obscurant disbursement can be optimized. While the solution is being determined the threat data that has been passed to IGSS will be sent out the rest of the unit to not only inform them of the location of an enemy threat, but to also use their IGSS to determine if their platform may be in a better position to launch defensive countermeasures.

There are two separate metrics for Solution Development (Threat and Survivability) that are calculated at the same time in order to determine the most effective means of countering a threat. The calculations are constantly weighed against each other to determine the most efficient counter to the threat until action much be taken.



Example 2: Laser Beam Rider (LBR) ATGM fired against a Stryker

In the above example, the threat type is between 0 and 1. If it were to be a 0 (small arms) the solution could be to do nothing. In this case IGSS has determined that a LBR has been fired and is tracking with an 83% likelihood of impact. The system knows that the LBR has penetration of 1,200mm which is an overmatch for the Stryker armor given its current vector and some action must be taken. The threat information is compared to what defensive solutions are currently available. It is determined that maneuver along will not be effective. There are 3 types of countermeasures available (Smoke, Smoke & IR and Dazzle). Smoke with IR obscuration is determined to be the most effective countermeasure against a LBR. There threat is coming in from an angle of 285˚ and the wind is blowing at 12kmh out of 225˚. This wind is within the threshold to be effective and the system automatically adjusts the aim point in order to effectively deploy against the incoming threat. The system preps the engine to automatically drive in the best direction given the terrain and threat vector.

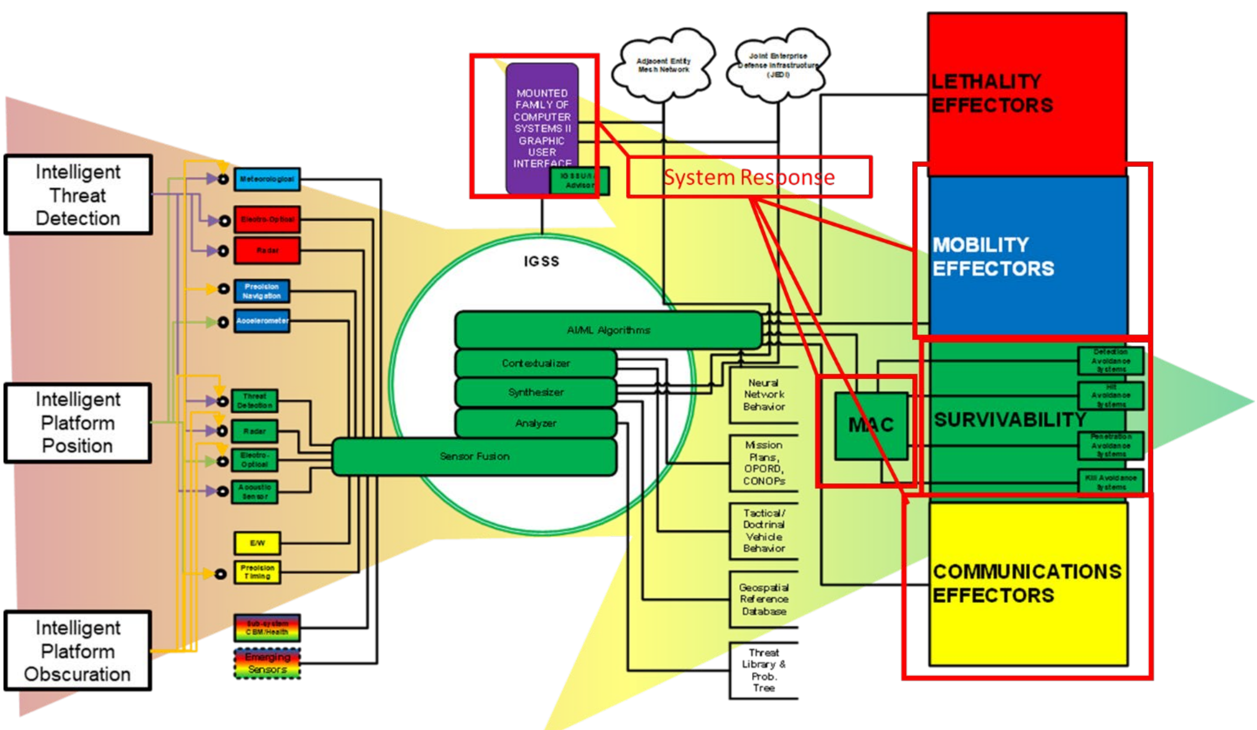


Figure 12: System Response

If time permits the crew may be notified of the incoming threat prior to an action being taken by the system. However, it will not be necessary for the crew to act for the system to take defensive action. IGSS will inform the subsystem of the optimal launch location and timing. If a threat is identified by a PreShot subsystem, a dazzle countermeasure can be slewed to obscure the optics of the gunner while the vehicle maneuvers away. Inbound threat information will inform which type of slewable obscurant countermeasure to use. If time allows and the correct threat is identified, a long range smoke obscurant could be used to break the signal from the launcher to the missile rendering it uncontrollable. Since IGSS will have knowledge of the terrain around a vehicle, if a time critical threat is identified it will have the ability to launch obscurant and take over automated control of the vehicle moving it in the safest direction. IGSS will also have knowledge of the current vehicle status. If the vehicle is unable to be driven at the time of launch it will know to hold onto is smoke obscurants and only try to dazzle the incoming missile in hopes of affecting control of the missile. As noted above, all these responses will have been simulated countless times before with IGSS, learning how to more effectively operate in each situation.

Conclusions and Proposed Future Research

Technology is and always will be limited in its ability to protect and enhance platform, crew, and occupant survivability. The biggest contributing factor to survivability is how the platform, crew and occupants are employed in an integrated fashion. Reams of doctrine and tactics are published in every environment on how to best employ vehicles and units to maximize their survivability. The problem is that during the heat of the battle, these tactics are forgotten and instinct takes over. This is why units continually rehearse the most critical crew drills and tactics until they can be executed in an instinctual fashion. But time does not allow every tactic and drill be realized at the instinctual level. Situations do not always allow for detailed analysis, synthesis and contextualization of sensory data. This is where technological augmentation of a system with the capability of the proposed IGSS can assist. The individual technological capabilities that enable platform survivability are mature, but are not employed in an intelligent, efficient and integrated/synergistic fashion. Sensor fidelity, processing power, and analysis algorithms have the all the available sophistication to achieve this end.

In order to realize the conceptual description of the IGSS capability, investments must be made in the cognitive processing algorithms that create situational understanding. The processing power and sensor fusion capability exists in many forms now. Analysis, synthesis, and contextualization algorithms as they pertain to protection and survivability functions need to be developed. Additionally, methods and approaches to integrate the IGSS products in to a comprehensive mission factor model is also needed. This requires a framework and model to parameterize prescribed mission factors into a function that can be shaped and influenced by real-time IGSS cognitive processing inputs. These products, if developed, could dramatically enhance combat and tactical vehicle survivability and overall mission effectiveness.

Afterword

The Stryker Platoon forms up in person around the outside of their Infantry Combat Vehicles (ICV). An OPORD is provided to all crews and dismount Soldiers. At the same time technicians upload a mission profile package into the IGSS data store. All critical mission coordinating instructions are passed to the patrol members and the IGSS system; actions on contact, fire coordination measures, routes, casualty collection points, historical danger areas, helicopter landing zones, rally points, weapons status, etc. The patrol loads into their respective vehicles and switch on their mission command systems. All critical mission data is presented to crew and occupants for their reference and consumption when needed.

The patrol crosses the line of departure and heads into the coalition-enforced buffer zone where the Donovian enemy forces are templated to be operating. The old growth forest in the area of operations restricts the platoon's movement to unimproved roads and logging trails. Visibility is limited to 200-300 meters up and down the road and often obscured by the dense fog in the low-lying areas. The Platoon Leader is new. He replaced the previous Platoon leader who was killed during the intense fighting to reestablish the buffer zone between the coalition countries and the Donovians. The enemy is templated to be operating between Phase Line (PL) PATTON and PL MARSHALL. This was the last report provided from the SIGINT cell about an hour prior to crossing of the line of departure. The patrol was out of FM communication range with the SIGINT operating cell, but this was no problem since the updates from the SIGINT Cell would still flow through the new Joint-Enterprise Data Infrastructure (JEDI) operational data cloud. PL PATTON was approximately 3 km to the patrol's front, and PL EISENHOWER, BRADLEY, MACARTHUR lie between it and their current position. As the patrol advanced through the dense Baltic forest, it approached an open farm field with rolling hills. The route the patrol was following passed directly through the middle of the field which was approximately 1 km wide and 2 km in length. PL MACARTHUR marked the far end of the farm field. The Patrol advances across PL EISENHOWER and PL BRADLEY. PL BRADLEY is associated with a linear ridge lines that obscured the terrain behind it. Behind this ridge lay an open valley that rises back up into another dense wood line of restrictive terrain that is associated with PL MACARTHUR. As the patrol crossed the ridgeline dense fog could be seen in the open valley floor. The IGSS, recognizing the state of the terrain and last known enemy position, cued the Platoon Leader and all vehicle commanders with a recommendation to switch the movement technique to Travelling Over-Watch. The Platoon Leader confidently directed his 2 rear vehicles to stop on the ridgeline and provide over-watch while his vehicle and the point vehicle advanced into the fog filled valley.

Back at the Battalion Headquarters, the current operations section monitored the patrol metadata through the status uplink that the patrol IGSS systems were digitally sending to the JEDI cloud, despite having lost FM communications ten minutes prior. The command to switch movement technique, as well as individual vehicle state data, were being updated in relative real time and monitored in the CP. Unbeknownst to the patrol, the templated enemy operating in the area had established a far side ambush in vicinity of the PL MACARTHUR on either side of the route the patrol traveling on. The enemy unit had broken radio silence and sent up a situation report to their higher headquarters on their radio. This radio call was intercepted by the coalition SIGINT team who triangulated the enemy position and immediately sent an updated report to the Battalion Headquarters and the JEDI cloud. Enemy position icons popped up across all GUI's in the AOR clearly informing all that the enemy had established a new ambush position near PL MACARTHUR.

The patrol maintained the over-watch position on the ridgeline while the Platoon Leader's vehicle advanced into the fog. Seeing the enemy icons appear on the GUI the Platoon Leader ordered the two ICVs to halt in the concealment of the fog. The Platoon Leader then directed his JFO's to unleash the Air

Weapons Team (AWT) that was waiting in holding area to begin engaging the marked enemy positions in vicinity of the far tree line. AWT conducted three passes destroying two battle positions and one of the enemy ATGM pads. Black on ammo, they disengaged to return to base for rearm and refuel. Across the valley, the assault element comprising of the point ICV and PL ICV crept up to a suitable assault position and ordered the two over watch vehicles to begin suppressing the far tree line with their 30mm autocannons. The Assault Element dismounted its troops and began assaulting across the objective. The enemy ATGM team had targeted the Point Stryker with a LBR ATGM. The LWR system immediately detected the laser beam of the threat sent the azimuth and elevation data to the vehicle IGSS. The IGSS system, in a split second, sent a SALUTE report to the JEDI cloud, engaged the smoke obscuration system, activated the APS system radars and countermeasure for incoming fires, presented the driver with optimal routes options to minimize probability of hit, presented the vehicle gunner and commander with defensive response options. The SALUTE report was presented on every adjacent entity GUI that could affect the enemy position; adjacent Strykers, Battalion Mortars, Brigade artillery, AWT, CAS, etc. The smoke obscuration system calculated an optimal smoke canister launch that calculated wind and terrain conditions into effect. The APS countermeasures slewed to azimuth of likely attack from the LBR. The driver and commander was presented with a high-risk, high-payoff assault option which put the vehicle in optimal position for 30mm autocannon attack-by-fire; and was presented with a low risk, medium pay-off movement to a nearby defilade position that would protect the platform but obscure the sensors that detected the threat. The commander selected the high-risk high payoff option and the vehicle driver moved to position, gunner immediately began suppressing the detected enemy position with his 30mm cannon. The enemy gunner fired his LBR missile, just before being ripped apart by the 30mm cannon fire. The LBR tracked and barreled toward the point Stryker. The APS system, cued and slewed by the IGSS, was already waiting for its chance to intercept the threat. With perfect precision the APS system engaged the threat destroying it at extended range, enabled by the early notification and warning by the IGSS.

The remaining enemy began to retreat. Their retrograde was detected by the advanced threat detection algorithms of the IGSS which communicated targets to the assaulting and suppressing platoon elements. After a violent barrage of fire from the Stryker platoon the battlefield fell silent. Every enemy position that was detected and engaged was recorded, the munitions fired and launched were all recorded by the IGSS. The slight damage sustained by one of the Strykers was already reported up to the Battalion headquarters, who had already submitted a work order to have the damaged part replaced. The Company, Battalion and Brigade headquarters all had a complete and objective understanding of what had transpired before the Platoon Leaders could even report what had happened.

The IGSS system enhanced the survivability of the platoon. The Platoon Leader's inexperience was mitigated by the enhanced situational understanding created by the IGSS recognizing the terrain and enemy posture. The higher echelons of command massed resources based on real-time updates from the IGSS such as where the enemy was, what vehicles were damaged, all without making a single disruptive radio call to the Platoon Leader fighting the mission. All threats were mitigated with precision and minimal error. Enemy positions were presented to all who contribute supporting fires enabling their rapid destruction and neutralization. The platoon decisively and intelligently survived and accomplished the mission.

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