HPM and UAV Integration for Air to Air and Air to Ground Operation

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How can the U.S. military more effectively and efficiently project power into contested theaters in the face of massed or mobile precision attacks (e.g. guided cruise and ballistic missile salvos, cyber-attacks, etc.)?

Technology is growing at a rapid rate, and other countries are trying to quickly grow their capabilities. In a contested environment, the US military must first answer how are we currently being contested and then how we will be contested in the coming decades. Current technology denies access using surface to air missile (SAM) sites and Air to Air (A/A) fighter aircraft. Additionally, the SAM sites themselves are also becoming more advanced, making them harder to strike. Soon, we will see strategic mobile SAMs that are capable of tracking and shooting while on the move; RT.com states, in addition to videos on Youtube.com showing, the SA-22, a tactical SAM, is already capable of this. Additionally, Russia is looking into invest heavily in UAV technology. Defensetech.org states in an article published on 13 July 2016 that "Vladimir Mikheev, an adviser to the deputy head of Radioelectronic Technologies Concern… said the aircraft [the new Russian 6th generation fighter which will operate in conjunction with drone swarms armed with electromagnetic cannons] will be unveiled in 2025, fly at speeds of up to Mach 4 or 5 and reach near space[.]" In the not so distant future, it is not unlikely to think that when we employ our air to ground (A/G) munitions that we will be met by a large unmanned aerial vehicle (UAV) A/A force, more commonly known as a UAV swarm, pushing our forces back even further. A seminal report from 2000 by John Arquilla and David Ronfeld defines swarming doctrine as a "deliberately structured, coordinated, and strategic way to strike from all directions, by means of a sustainable pulsing of force and/or fire, close-in as well as from stand-off positions. UAV swarming then is a pulsing of drone forces following the same definition. Current and future threats can be overcome by integrating high powered microwaves (HPM) into our attack and defense platforms. HPM is a directed energy weapon that uses electromagnetic radiation to disable electronics for a range within a designated azimuth. HPM is essentially a directional form of an electromagnetic pulse (EMP) capable of disabling missiles, UAVs, and all current A/A platforms. HPM itself is not a complete answer; in order for it to meet our strategic needs, it needs to be paired with other technology. To project power effectively and efficiently in a contested environment, the US military must invest in HPM and UAV integration for A/A and A/G operations.

According to Defensenews.com, the Air Force breaks UAV capabilities into three categories: Teaming, Loyal Wingman, and Swarming. Teaming is two or more assets, operated by ground commanders, cooperating with one another. Loyal Wingman is a host platform, for instance a manned fighter aircraft that directs multiple small UAVs. Lastly, Swarming is a large number of minibots that work together in a collaborative, or "meshed," network. The most dangerous of these is swarming because it could incorporate all of the strengths of others in larger quantities. There are three ways to defeat a UAV swarm: attack the swarm with a larger swarm, a more capable swarm, or attack the swarm's governing force. To generate a larger swarm, you have to first solve the issue of cost. While initial research and development may be costly, due to the sheer number of UAVs required the cost would be driven down. This would also drive down the cost for parts and therefore the cost of maintenance. As a prior maintainer, I know that the majority of time spent doing maintenance is getting access to the part that needs to be fixed. A UAV in a swarm would have to be significantly smaller and simpler in design, which inherently solves this problem, thus saving man hours. Although there will be more aircraft to work, the time spent will be less and the amount of larger host aircraft at a base would be less, which would allow us to more strategically spread out our forces. In order for it to be effective two different approaches to UAV creation needs to be used. The first is a cheap disposable version, where the UAVs themselves do not cost much more than a missile. The second is a UAV that is just as, if not more, capable as its host.

The reason that cost is specifically the highlight for these types of UAVs is due to flexibility and UAV apathy. The cost allows you to have the flexibility to destroy these UAVs for a tactical advantage. That is why I

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call this concept UAV-FM (UAV-Flying Missile), which is a UAV that can act as a missile but is capable of taking off and landing. UAV apathy is the behavioral result of UAVs being inherently deniable, combined with no loss of life being associated with the loss of the UAV. Those characteristics lead to state actors being more willing to take risks that they would not normally take. By creating a UAV that costs as much as a missile, the UAV itself can be used as a missile, which leverages the financial repercussions of UAV apathy while providing a kamikaze capability. The Israeli military has developed something similar called the Harop. The Harop is launched from a ground station and then is guided by a human operator to its target. Harop is known as a "loitering munition", because it is currently unable to land. That means that once the munition is launched it has to be used. This approach would be wasteful for our needs. This munition works for Israel because of their proximity to their enemies.

The US needs to create a munition similar to Harop but slightly less capable in some areas and more capable in others. If the weapon can receive target updates from an airborne or ground based host (downed aircrew, special forces, etc.) there is no need to have optical guidance. Optimally, it would be best if these could also carry at least one A/A missile each that way there is an increased possibility of bringing them home post engagement, but this should only be added if it makes fiscal sense. Some obvious benefits of this strategy are being able to mass firepower while decreasing loss of life, the decreased cost in case one of the UAV-FMs is shot down, and the kamikaze capability gained from the cost being equal to that of a munition. Kamikaze mode would ignite its missile propulsion system and could be used against air or ground targets. To create a more secure connection and eliminate lag all of these would be connected to a manned "host" in the battle space via a datalink like Link-16. Satellites would not be optimum for this because the signal is weak and seconds matter in A/A combat. Furthermore, the distance from the receiver and transmitter can influence the signal's jam resistance. Datalink works best for this because it is significantly harder to jam and requires a large amount of power to do so. Additionally, for political concerns a human would still be making all of the target and kill decisions. All general commands sent to the swarm would be reactionary commands based off of the host already established single ship aircrew procedures. The result, however, would follow something similar to multi-ship procedures. This equates to multi-ship tactics with little to no additional tasks required by pilots. These general commands would be processed internally by the UAV-FM based on on-board and collective data. For example, when the host platform designates a target, the swarm automatically designates it as a target as well. Additionally, using a wingman -like mentality it would search for other enemies with a predetermined hostile association distance. If those possible targets do not meet friendly criteria, they ask the host for target permissions. With one button push the host is able to identify all of those targets as hostile. It is important to reiterate, however, that all connected UAVs would require kill commands from the host prior to being able to shoot or execute a kamikaze attack. Because the UAV-FM design would be focused around simplicity, they would only have the capability to be used for little more than tracking and destroying targets.

Arming these UAVs with HPM technology would create a more capable swarm. Although you lose the benefit of keeping them cheap enough to use as munitions themselves, what you gain is a platform capable of executing electronic protection (EP) and offensive counter air (OCA). Pairing these more capable UAV's with UAV-FMs creates a mass of not only fire power but capabilities as well. In 2012, Boeing successfully demonstrated the use of HPM in a weaponized electronic pulsed weapon called the Counter-electronics High Power Microwave Advanced Missile Project (CHAMP). CHAMP was designed to disable multiple predesignated targets and then self-destruct. While this capability is a leap forward in its own right, it lacks

flexibility required for strategic use. Today there are threats capable of shooting the CHAMP down prior to it reaching its designated targets. While the technology used in CHAMP is effective at disabling electronics, its application only works in an area where we have eliminated all major air and ground threats. If we have accomplished that, there is little reason to use CHAMP in the way it has been advertised. If this same technology was equipped to create an Enhanced UAV(E-UAV), or even added to some of our current platforms (F-22, F-35, F-15, etc.) through a multi-stage improvement program, you would be able to disable the electronics within the swarm itself and cut off any communications to its host. For instance, this technology could replace the Internal Countermeasures Set in the F-15E, giving the fourth-generation aircraft a sixth-generation skill. E-UAVs would essentially be unmanned fighter jets operating in relation to it host using a Loyal Wingman concept. The goal is to have the operation of these E-UAVs largely invisible to the host or manned aircraft. Using the pilot's already established internal commands, the E-UAVs will act based on the pilot's actions. This prevents overtasking the pilot but allows him to instantly increase his platform’s capabilities.

The third way to destroy a swarm is to destroy the host. However, locating the host would be difficult unless the host is airborne and among the swarm itself. You would have to differentiate between the signals environment and the host’s governing signal and then track it. Even if you were able to locate the host, you probably would not be able to attack it until the swarm was destroyed. Hypersonic weapons, with the exception of lasers and HPM, and fifth-generation aircraft are not invisible visually, on infrared, or on radar. Both HPM and lasers would be effective against HPM, but HPM is the better option because HPM can disable multiple targets with one burst. As for kinetic weapons and stealth fighters, if they can be tracked, then they can be shot or blocked. SAMs currently are capable of shooting Small Diameter Bombs (SDBs) out of the sky, in a decade we can assume that they will have the capability to shoot a missile in flight from an A/A platform. That means that the strategy of punching a hole and rushing the host is not going to work. In summary, the best way to disable the governing force is to destroy the governed or their ability to receive governance. Although you did not attack the host directly, you attacked its ability to communicate with its peripheral assets, thereby negating the host as a governing force. The best strategy is to use a combination of E-UAVs and UAV-FM to disable and overwhelm the enemy. Moreover, after the swarm is destroyed, the host is exposed and so is the path to the target.

The enemy UAV swarm in this scenario was not only used to establish air superiority, but to also aid in area denial. However, even with the swarm eliminated, tactical and strategic SAMs still pose a significant threat. Cruise missiles and bombs that are capable of jamming or disabling radars they detect are the way forward. Moreover, it is only a matter of time before SAMs are able to track and shoot while in motion. In order to strike these kinds of threats, we need to have a munition that can update its guidance in the terminal phase (UAV, datalink, etc.). If the munition senses radar tracking or missile guidance it will release a directional HPM pulse within the spherical error of probability of the missile or radar, which will disable the electronics and force the missile to go unguided. This allows the missile to protect itself while proceeding to the target. If the missile loses target updates and is not able to refine a target location within the lethal radius of the weapon: it will slow to conserve fuel, circle the last known targets area, and then fire HPM pulses into the circular area of probability (CEP) until it runs out of fuel or reacquires guidance. If it reacquires the target, it will exit its orbit to orient for an attack and use the reacquired median azimuth to proceed to the target for a kinetic kill. In a populated area that will prevent it from hitting a build instead of the target. If it doesn't reacquire the target prior

to running out of fuel, the munition will self-destruct. This approach solves a couple of problems. The first is, what if the munition loses its guidance updates prior to reaching to target and the threat is mobile? As soon as the munition gets an update it is no longer traveling to its pre-planned coordinates, which means any CDE that was calculated is no longer valid. To prevent the munition from missing its target and hitting a church instead, the munition sends out multiple HPM pulses within the CEP of the target and then detonates. Secondly, by slowing down, the munition reduces its turn radius (this can also be accomplished using thrust vectoring); this allows the pulses to cover less distance and maintain its effectiveness. Lastly, target re-acquisition will have to run through a positive identification (PID) and CDE matrix but upon positive completion the munition can accomplish the original desired weapons effects. After its initial use, the technology will be exposed and the race to maximize this technology's potential will begin.

The use of UAVs and HPM, whether separate or together, has many benefits and also some drawbacks. The biggest being that unprotected UAVs are susceptible to HPM themselves. To be clear, this is not a new issue. All platforms currently in use would be affected by HPM technology, which is why these UAVs should be created with that in mind and our current fleet should become protected from HPM as soon as possible. The benefits of incorporating UAVs into the air to air combat realm are both financial and strategic. Financially, UAVs simply cost less and provide more capabilities for that cost. The F-22 Raptor costs approximately 340 million dollars, the RQ-4 Global Hawk costs approximately 130 million dollars, and the MQ-9 Reaper cost approximately 15 million dollars. However, UAV technology is no longer new and UAV-FMs and E-UAVs would not need to be the same size nor would it require the same flight time as the Global Hawk. The E-UAV would most likely cost somewhere in between the MQ-9 and the RQ-4. Whereas, the UAV-FM will cost less than the MQ-9 due to its simple design. All of these factors combined with plug and play technology and production size would drive down the costs. Strategically, this also helps solve the fighter pilot crisis. Currently, the Air Force is having trouble holding onto its fighter pilots. While fighter pilots would still be required to act as hosts in this scenario, the number of pilots required would be significantly less. This would mean less training costs, less pilot bonuses, less post service healthcare, and less retirement pay. Additionally, using a plug and play approach for the E-UAVs allows the US to remove or swap capabilities between E-UAVs, essentially meaning that an E-UAV whose primary role was to jam with the swap of a box can be switched to a different role. This increases our flexibility and allows us to use the same asset for multiple roles. Furthermore, HPM technology has higher research and development cost, however, the operational costs will be significantly less because it is, essentially, a munition that can be reused multiple times and could even take out multiple threats per pulse. Boeing as well as other government organizations have been conducting HPM research. Strategically, HPM allows us to reach targets unobstructed and gives us an additional weapons effect capability. Furthermore, this would no longer require us to overwhelm the strategic SAM sites in order to disable or destroy them, saving us millions in munitions costs.

The sooner we start to incorporate UAVs into how we fight, the more of an advantage we will have in the future. They are more capable, they require less maintenance, and they don't experience fatigue. Combining UAVs and kinetic munitions with HPM technology will empower us to do even more than we are currently capable of doing, not only in capability but also in scale. All of the technology mentioned in this recommendation already exists; what makes the difference is how we are going to combine and implement that technology. In order to efficiently and effectively project power into contested theaters the US needs to not only invest in UAV and HPM technology but also apply it correctly.

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