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14. ABSTRACT

When thinking about the future, the Marine Corps has a major problem. Within the Commandant's initial FRAGO 01/2016: Advance to Contact guidance, he explained that the Service is not organized, trained, and equipped to meet the demands of the forecasted future operating environment. Numerous UAS UUNS/DUNSs submitted by Marines dating back 13 years, to include six over the past 17 months, further highlight the Service's warfighting deficiencies. While these deficiencies are certainly not positive, fortunately, what is increasingly clear is that embracing medium altitude long endurance tactical (MALE-T) UAS can revolutionize how the MAGTF trains, fights, and enables the Naval Service. This paper's over-arching purpose is to explain how, come 2025, whether executing an amphibious assault and/or EAB operation in high-end, contested battlespace, fighting a hybrid threat in urban terrain, to include "eating through a defense," or conducting humanitarian assistance in a permissive environment, organic MALE-T UAS can transform not only how MAGTFs operate, but also how well they operate and enable the Naval Service.

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FUTURE WAR PAPER

Transforming the MAGTF and Naval Service with "Guardian Angel" Unmanned Aircraft Systems

**SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF OPERATIONAL STUDIES**

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Table of Contents

The winner of the robotics revolution will not be who develops this technology first or even who has the best technology, but who figures out how best to use it.

- Paul Scharre, *Center for a New American Security*[1]

When thinking about the future, the Marine Corps has a major problem. Within the Commandant's initial FRAGO 01/2016: *Advance to Contact* guidance, he explained that the Service is not organized, trained, and equipped to meet the demands of the forecasted future operating environment (FOE).[2] The Commandant has since consistently reinforced this message. Numerous unmanned aircraft system (UAS) urgent and deliberate universal needs statements (UUNS/DUNSs) submitted by Marines dating back 13 years, to include six over the past 17 months, further highlight the Service's warfighting deficiencies.[3] *While these deficiencies are certainly not positive, fortunately, what is increasingly clear is that embracing medium altitude long endurance tactical (MALE-T) UAS can revolutionize how the MAGTF trains, fights, and enables the Naval Service. In so doing, this revolution can also help eliminate the MAGTF's warfighting deficiencies.*

Problem Context

In September 2016, the Commandant signed the new *Marine Corps Operating Concept (MOC)*. Reinforcing his FRAGO guidance and the UAS UUNS/DUNSs, the MOC states that the Marine Corps must "develop layers of persistent, armed, multi-spectral, and beyond-line-of-sight (BLOS) UAS above our units to produce responsive intelligence and targeting information, extend our command and control (C2) across a shifting battlespace, and deliver non-kinetic and kinetic fires in support of MAGTF operations."[4] What do these words actually mean though? How should MAGTF training events and standards change to achieve this goal? For example, still today, to execute MAGTF-level training in 29 Palms, California exercise forces routinely

sling-load via CH-53 C2 vehicles onto mountaintops to ensure they have the required communications to execute fire and maneuver. This notional exercise inject is unrealistic and dangerous in combat.[5] What if, instead of having to resort to notional "exercise-isms," no later than 2025 the MAGTF had persistent, armed, multi-spectral, C2 extending and BLOS MALE-T UAS in direct support of Marines down to the rifle company level?

While the prospects for such a transformative capability internal to each MAGTF are excellent, achieving maximum effectiveness with MALE-T UAS requires analysis based on likely mission sets. Looking forward to 2025 and anticipating missions that MAGTFs could be tasked to execute is not an easy undertaking though. This said, the MOC, combined with the Marine Corps Intelligence Activity *FOE 2015-2025 Implications for Marines*[6], provides a helpful point of departure. Both documents make clear that urban littorals are the most likely environment in which MAGTFs will find themselves in – and the most dangerous.[7] Further, both documents highlight that in certain situations enemy forces will seek to deny Marines and Naval Forces access to areas such as ports, airfields, and beach-heads. These area denial attempts will seek to leverage advanced integrated air defense systems (IADS) and anti-ship cruise missile (ASCM) capabilities, as just two examples. Given Russia's recent movement of S-300 and S-400 IADS into Syria, as well as Iranian proxy employment of C-802 ASCMs directed against U.S. and allied naval vessels, these realities should come as no surprise.[8] Beyond these increasing threat capabilities, when seeking to gain entry into a contested battlespace via an amphibious assault and/or through leveraging expeditionary advanced base (EAB) operations, it is also likely that adversaries will look to use counter-space, electronic warfare (EW), and cyber capabilities against MAGTFs. Such scenarios are typically referenced as operating at the "high-end" of the threat continuum. The potential roles for organic MAGTF

MALE-T UAS in such scenarios are many, although they would be different than how such a capability could be used against more "hybrid" threats such as what exists in Mosul today, as well as in more permissive environments.

In an attempt to look forward to the MOC's no later than 2025 target date to realize the concept's vision, this paper has one over-arching purpose: to explain how, come 2025, whether executing an amphibious assault and/or EAB operation in high-end, contested battlespace, fighting a hybrid threat in urban terrain, to include "eating through a defense," or conducting humanitarian assistance in a permissive environment, organic MALE-T UAS can transform not only how MAGTFs operate, but also how well they operate and enable the Naval Service.

MAGTF MALE-T UAS in a High-End Contested Environment

Starting with the Balkan conflict in 1995, and throughout the past 16 years of warfare in places such as Iraq, Afghanistan, Syria, Libya, Pakistan, and Yemen, few, if any, observers would argue against the fact that MALE-T UAS have transformed how the U.S. government wages war.[9] But these conflicts have been against enemies possessing limited to no counter-air, EW, cyber, and IADS capabilities. What if the MAGTF had to fight enemies that possessed some or all of these capabilities?

In such an environment, one of the primary ways in which MALE-T UASs would enable the MAGTF is in C2, specifically through serving as resilient and redundant tactical network extension and relay nodes, thereby facilitating much greater situational awareness across the force. In many ways, the U.S. Missile Defense Agency, as per Figure 1, is already using this approach with specially equipped MQ-9 "Reaper" MALE-T UAS to help counter ballistic missile threats.[10] Currently, the MAGTF has none of these capabilities organic and the joint

Figure 1.

force does not have excess capacity to support Marine Corps requirements, assuming that pre-existing MALE-T UAS have the appropriate radios in the first place, which many do not given that their missions are not to enable the MAGTF.[11] This collective deficiency inhibits MAGTF training and operations, often leaving Marines dependent on high demand and potentially vulnerable satellite networking or more traditional and limited in capability narrow-band, single channel radio communications. Additionally, not having this capability also limits experimentation when attempting to implement emerging concepts such as EAB or distributed short take-off and vertical landing (STOVL) operations with the F-35B.[12] If, however, properly equipped MALE-T UAS capabilities, such as those illustrated in Figure 2[13], were integrated in the MAGTF, C2 potential, redundancy and resiliency would exponentially increase.

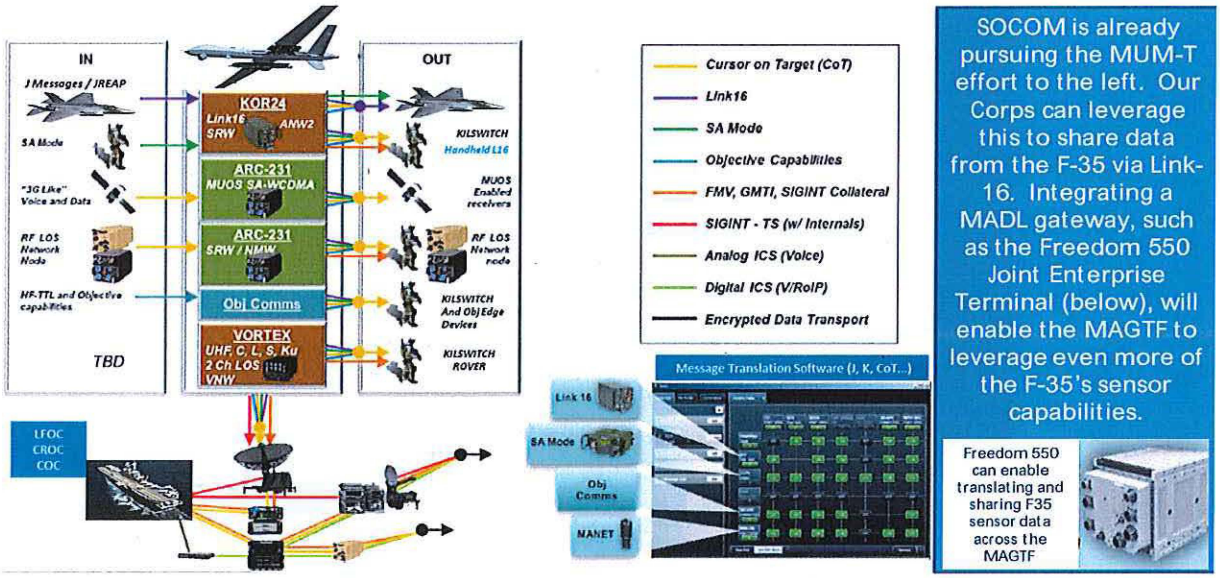

Figure 2.

Figure 2 addresses only a small part of MALE-T UAS network potential; in this case, multiple ways to leverage, extend the range of, and translate information between a variety of ground / sea networks and the F-35's proprietary multifunction advanced data link (MADL). Given existing MALE-T UAS' 45 kilowatt payload power available, and nearly 4,500 pound internal and external payload capabilities, the aircraft can also easily carry and operate additional radios to enable using waveforms such as tactical targeting network technology (TTNT) and Trellisware's TSM-X.[14] TTNT is a secure, high speed, high capacity, low latency, multi-hundred mile networking waveform that in addition to enabling traditional C2 functions has also already demonstrated the ability to control high power, stand-off EW payloads on MALE-T UAS.[15] TSM-X is a secure, self-forming, self-healing, and high capacity, networking waveform that is ideal for harsh radio frequency environments such as the urban littoral that the MOC describes as most likely and dangerous for future MAGTFs.[16] TSM-X is also simple to use and can be scaled to more than 200 network node participants, including sharing each node's position location information. Thus, instead of the current reality of having thousands of Marines

operating in urban areas with little to no total force understanding of unit locations without extensive LOS or satellite dependent voice communication position updates, a properly equipped MALE-T UAS can enable MAGTFs to have this critical information real-time for fires and maneuver coordination. Additionally, if in a heavily satellite degraded or even denied operating environment, a MALE-T UAS equipped with TTNT, TSM-X, and the waveforms highlighted in Figure 2 can still be flown through secure and jam resistant non-satellite dependent waveforms. In an absolute worst case scenario, where all potential waveform control options are inoperable, MALE-T UAS can operate autonomously (based on pre-programming) for more than 24 hours, while still serving in a local network extension role.

Tied closely to enabling enhanced networking capabilities, MALE-T UAS EW potential in high-end threat environments is particularly important given current and projected MAGTF deficiencies. The MAGTF's primary EW platform today is the EA-6B "Prowler." However, this platform completes its "sun-down" in 2019.[17] When the decision was made to "sun-down" the EA-6B, the goal was to have a future MAGTF EW strategy that diversified potential EW delivery platforms. For example, with the right EW pods and networking capabilities, instead of only EA-6Bs able to provide electronic support or attack, the thought was that these capabilities would extend to Group III UAS platforms such as the RQ-21, as well as other manned platforms such as F/A-18s, AV-8Bs, UH-1Ys, and even MV-22 and KC-130J assault support aircraft.[18] Unfortunately, this plan's goals have encountered major obstacles due to the RQ-21's payload, power, range, endurance, and weather limitations, along with severe Marine aviation maintenance issues.[19] These maintenance and parts availability issues, which are projected to continue for years going forward, are making it extremely challenging for flight crews to sustain their most basic flight qualifications, not including the additional requirements to conduct EW

missions in any environment, much less against a high-end threat.[20] At the same time, due to the RQ-21, or what is often described as a low altitude, medium endurance (LAME) UAS, system limitations, the Marine Corps currently has three active-duty and one reserve component unmanned aerial vehicle squadrons providing little to no support to any MAGTF.[21] Providing these Marines with properly equipped MALE-T UAS, with existing EW pods such as the high power, stand-off jammer used in a tactical demonstration to enable a manned aircraft strike against an enemy IADS in 2014 (see Figure 3[22]), would greatly increase the MAGTF's warfighting capabilities.

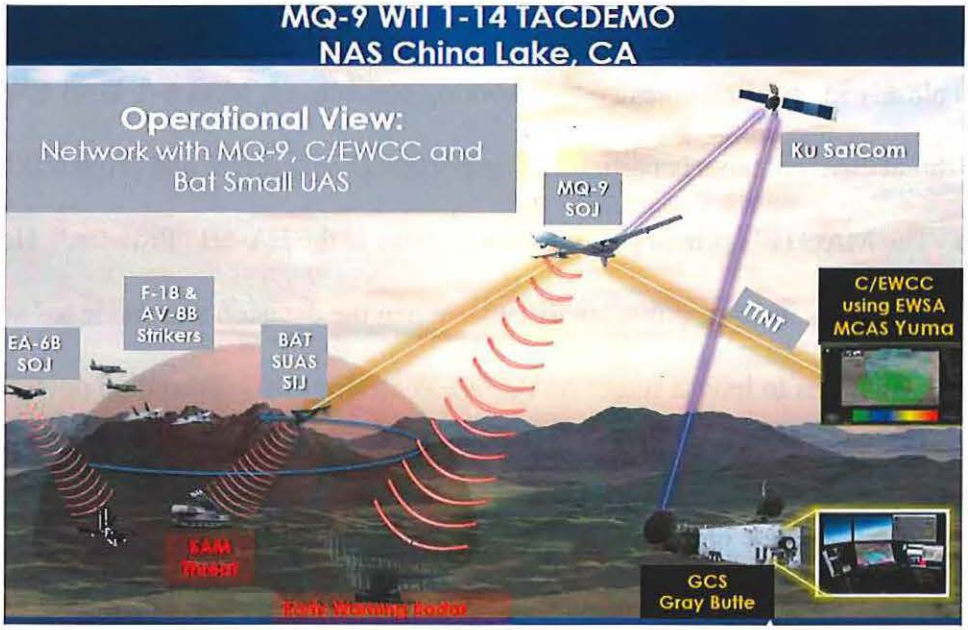

Figure 3.

Even more, these MALE-T UAS can also be equipped with miniature air-launched decoy (MALD) and MALD-jamming (MALD-J) systems such as those illustrated in Figure 4.[23] In this case, enemy IADS operators would have to contend with hundreds of tracks on their screens, and distinguish rapidly between manned Naval Service aircraft and the tactical decoy jammers to employ their limited numbers of surface-to-air missiles, while simultaneously being jammed. A definitive "horns of a dilemma" problem!

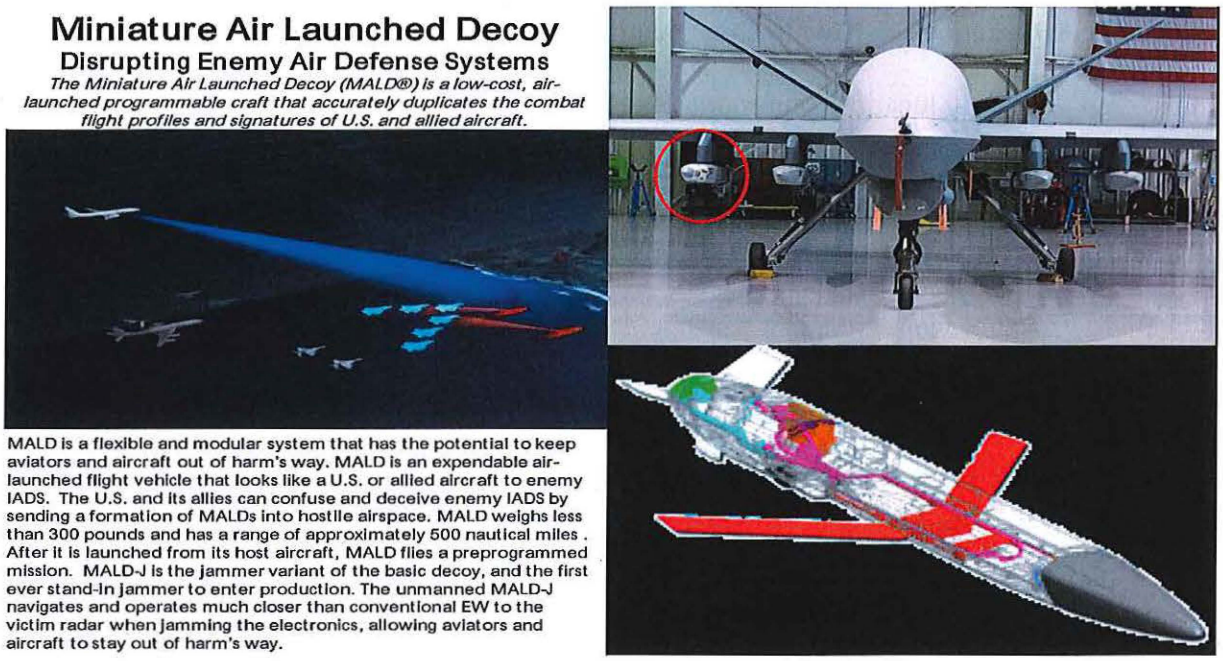

Figure 4.

Teaming MALE-T UAS, with the appropriate networking and EW capabilities, along with the MAGTF and Naval Service's low observable F-35B/Cs, can also transform how forcible entry operations are conducted. Current manned-unmanned teaming (MUM-T) paradigms are typically focused on sharing full motion video sensor information between platforms, or enabling a pilot in an Apache helicopter, for example, to control the payload(s) of an unmanned aircraft operating nearby.[24] With organic MALE-T UAS, the MAGTF can develop even more revolutionary MUM-T paradigms, specifically for operating in contested battle-space environments. Consider, for example, a future scenario where F-35B/Cs operating from a combination of ship flight decks and EAB locations are tasked to conduct defensive counter-air (DCA) and offensive counter-air (OCA) missions. While the F-35 is a potent aircraft, among the major challenges in DCA and OCA missions, particularly in an extended duration mission requiring hours, if not days, of operations, is the lack of MAGTF and Naval Service redundant, resilient, and thereby reliable C2, particularly over long ranges measuring in the hundreds of miles, both between the aircraft and their primary operating areas, as well as between flight

decks and EAB locations.[25] Now imagine that in proximity of the F-35 launch, recovery, re-arming, and re-fueling locations, appropriately equipped MALE-T UAS are operating constantly outside of enemy missile and weapons engagement zones. These MALE-T UAS, to include in satellite-degraded environments, are frequently receiving situation updates from the DCA and OCA flight packages via secure, jam resistant and multi-hundred mile capable waveforms and then simultaneously sharing this information with MAGTF and Naval Service headquarters elements, both ashore and afloat. Then, this collective system, all enabled with much greater situational awareness from the MALE-T UAS "Guardian Angel," appropriately tasks subsequent F-35 flight packages as they launch and/or as they continue into their objective areas. Further, this MALE-T UAS "Guardian Angel" then enables the same type of situational awareness post-F-35 mission when directing pilots to specific ships or EABs to re-fuel and re-arm before launching again, with real-time situation updates, for subsequent missions. Put another way, this collective MUM-T "Guardian Angel" paradigm enables F-35s by providing information on where to go, when, with what ordnance, to strike specific enemy targets, and then on where to go to land, re-fuel, and re-arm so that with the maximum tempo possible, they can then proceed back into the fight to defeat the adversary.[26]

In addition to revolutionizing DCA and OCA operations, MALE-T UAS can do the same for close air support (CAS). Given how MALE-T UAS, such as MQ-9 Reapers, MQ-1B Predators, and MQ-1C Gray Eagles, are employed in CAS scenarios in relatively airspace permissive environments today, specifically with reliance on satellite network connections, it is not uncommon to hear observers suggest that such platforms would be extremely limited or worse in electromagnetic spectrum and/or cyber degraded or denied environments.[27] Are such claims accurate though? Consider, for example, a scenario where enemy counter-air capabilities

have been eliminated, although the enemy maintains the ability to interfere with satellite communications. Further, consider in such a scenario a MALE-T UAS, such as an MQ-9 Reaper, equipped with the persistent, precise, and prompt close air support (PCAS) technologies illustrated and described in Figures' 5 and 6.[28]

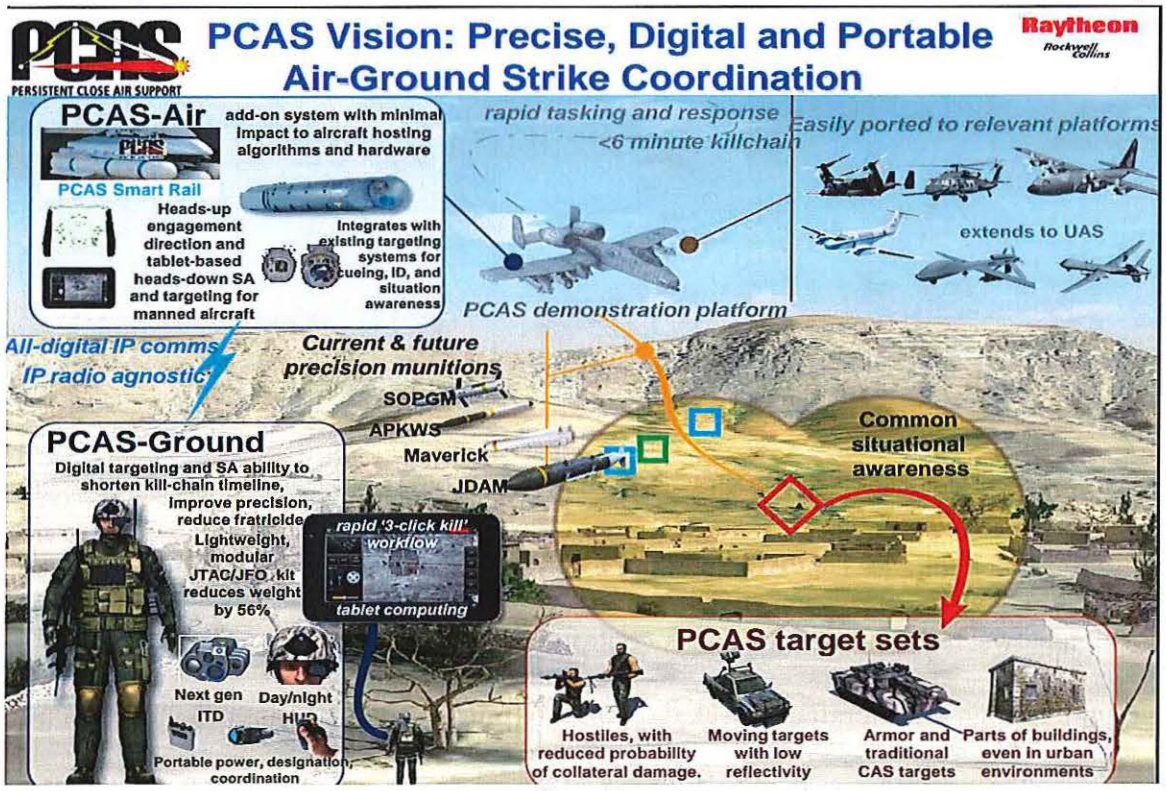

Figure 5.

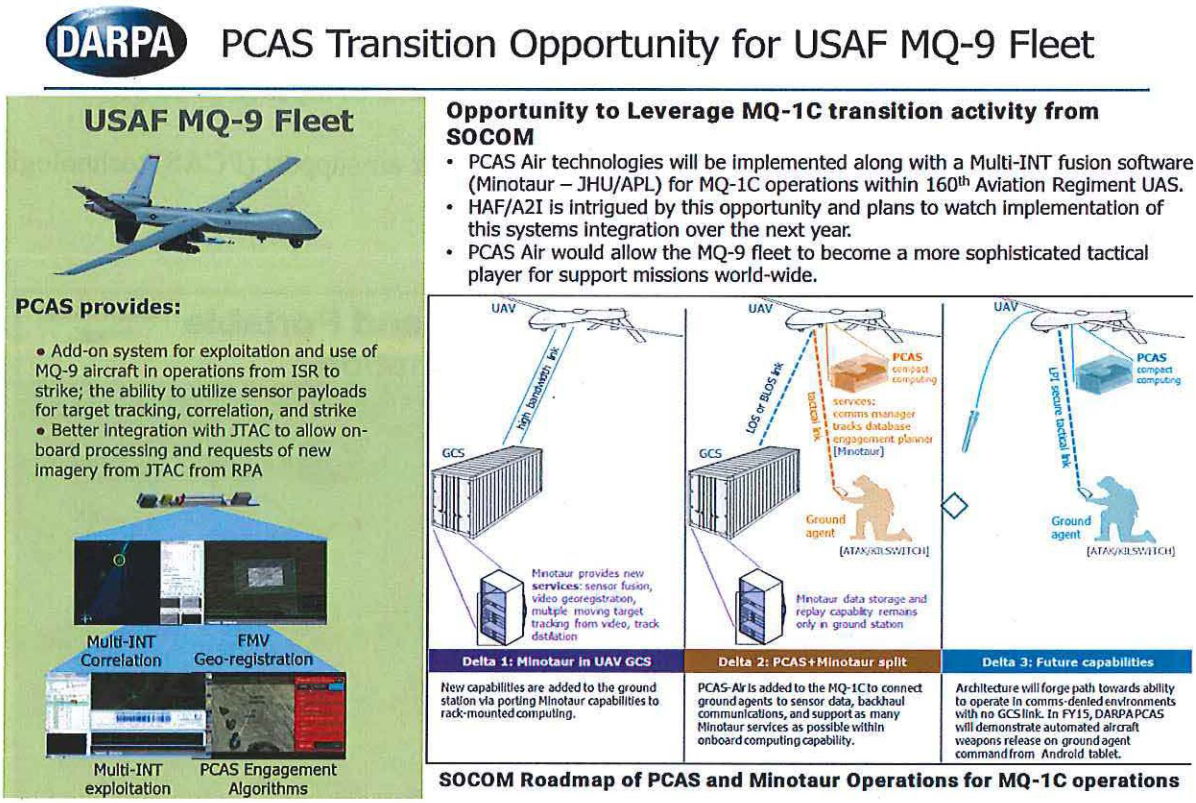

Figure 6.

PCAS technologies can work in multiple ways, from seamless integration and network connection between a joint terminal attack controller (JTAC) or joint forward observer (JFO) on the ground through the aircraft and back thousands of miles away to a pilot in a ground control station in the United States, to the likely employment concept required in a high-end threat environment, where such capabilities might not be an option. In this case, through PCAS-ground software, such as KILSWITCH, the JTAC or JFO would simply, in less than 10 seconds, send a digital 9-line CAS request to the PCAS-air system on the MALE-T UAS, which would then use algorithms onboard the aircraft to route itself to the best launch point for the geometry and munition requested by the JTAC or JFO, at which point the weapon would be released autonomously. Put another way, in a satellite degraded or denied environment, the PCAS-enabled MALE-T UAS would destroy targets requested by a JTAC or JFO without a pilot in the loop (illustrated on the right side of Figure 6). While such an employment concept is considered

non-doctrinal and arguably unsound today, in a future high-end CAS scenario, where data and possibly even voice communications with ground control stations and possibly even fire support coordination centers could be blocked, such an employment concept might just be the only option available to enable providing support for Marines on the ground. Fortunately, should such a scenario ever occur, American taxpayers have already spent more than $80 million to develop PCAS to work effectively across all potential threat environments. Further, given MALE-T UAS payload and power give capabilities, the PCAS system onboard the aircraft can easily be linked to simultaneously leverage multiple frequency agile waveforms that operate across the communications spectrum, thereby making it much harder for potential adversaries to deny CAS to Marines on the ground.[29]

MAGTF MALE-T UAS in a Hybrid Threat Environment in Urban Terrain

The ongoing clearing operation in Mosul illustrates many of the forecasted hybrid threat environment characteristics described in the MOC.[30] Thousands of combatants are mixed in with more than a million non-combatants. The city has tens of thousands of structures, many multi-stories. Avenues of approach via main highways are limited and what might be considered side roads are narrow in width, often congested, and not easy to maneuver through. The thousands of structures throughout the city pose severe challenges to ground force predominately LOS communications. The environment is flooded with commercial technology, be these "smart" devices, satellite phones, and even an increasing assortment of commercial drones, to include armed.

As this all relates to the enemy, his thousands of fighters are arrayed in an elaborate defense-in-depth, taking full advantage of the city's complex structures and tunneling systems. Enemy counter-attack forces appear to be assigned by sector to re-seize territory, or at a

minimum, to inflict maximum casualties on coalition forces, all the while slowing their movement. The enemy fully leverages cheap, commercial technology for communications, intelligence, surveillance, and reconnaissance (ISR), and precision strike purposes. The enemy also has a variety of mobility assets ranging from tanks, to high mobility multi-purpose wheeled vehicles, to mine-resistant ambush protected vehicles, to motorcycles, to common automobiles. Any of these mobility assets can be, and multiple variants have been, rigged as improvised bombs. Additionally, the enemy has a full assortment of surface-delivered fires assets, including artillery and multiple calibers of different mortar systems. Further, the enemy has a myriad of man-portable air defense systems (MANPADS)[31] and anti-tank guided missile systems (ATGMs). Finally, enemy formations are equipped with the typical array of small arms, machine guns, and rocket-propelled grenades employed on battlefields for decades.

The combination of the environment described above has led to a situation where coalition forces have in a seven-month period only been able to clear around 80 percent of the city, despite possessing a more than 10:1 manpower, overwhelming surface-delivered firepower, and, aside from arguable commercial drone parity, a clear airpower advantage. Coalition forces have also suffered thousands of casualties.[32]

Fast forward to anytime between now and 2025 and imagine that instead of the tens of thousands of ground forces involved in the clearing operations in Mosul being Iraqis that they are instead Americans. The Marine Corps' last major clearing operation in a densely populated urban environment was in Fallujah in 2004. Perhaps not coincidentally, the first UUNS request for a MAGTF organic MALE-T UAS capability was submitted 13 years ago, immediately after this operation.[33] Assuming that the MAGTF finally has organic MALE-T UAS capabilities the

next time that Marines are thrust into the MOC's forecasted most likely and most dangerous operating environment, what are the optimal ways to employ them?

Similar to the previous high-end threat environment discussion, one of the primary ways in which organic MALE-T UAS can benefit the MAGTF in an urban hybrid threat scenario is through enabling C2. The main difference from the previous high-end scenario is that there is a higher likelihood that military SATCOM systems will be available, but even in this reduced threat scenario, frequency diversity and anti-jam capabilities are desirable. Thus, beyond all the capabilities highlighted in Figure 2, as well as leveraging waveforms such as TTNT and TSM-X, the most likely additional SATCOM capability enables increasing situational awareness across many agencies throughout the world. Such agencies could range from high-demand, low-density personnel such as signals intelligence and cyber specialists to targeteers who specialize in kinetic weapons effects in dense urban terrain. In the case of EW and cyber personnel, they can leverage this increased situational awareness and digital networking capability by listening to, jamming, or injecting into enemy communications with already existing pods designed specifically for MALE-T UAS.[34] The targeteers can leverage the advanced C2 capabilities, combined with the MALE-T UAS's high fidelity, multi-spectral electro-optical and infrared sensors, to increase speed in approving fires in support of maneuvering forces all the while decreasing the probability of both friendly and civilian casualties, which are both ever-increasing concerns in urban combat and required by Presidential Executive Order[35] and multiple Chairman of the Joint Chiefs of Staff Instructions.[36] Near simultaneously, these targeteers, along with public affairs personnel, can record the truth of what happens on the ground with any given strike to help counter the anticipated enemy information operations narrative.[37] As the MOC

highlights, these capabilities are already and will increasingly become vital to enable MAGTFs to fight effectively.

Beyond the aforementioned enhanced fires capabilities, another key way that MALE-T UAS can enable the MAGTF in this type of hybrid threat environment is through serving as persistent "arsenal ships" that operate well above advanced MANPADS maximum effective range. Already today, despite very limited capacity relative to manned, strike-capable aircraft, MALE-T UAS are responsible for approximately 15 to 40 percent of all kinetic strikes in the ongoing fights against ISIS in Iraq and Syria and for more than 50 percent in Libya.[38] The appeal for MALE-T UAS from Marines on the ground, even with very limited exposure due to limited availability, has also been clear. For example, following an Afghanistan deployment in 2010-2011, an infantry battalion JTAC stated when asked about the best CAS asset:

> The deadliest asset was the UK Reaper. This was due to extended time on-station, diverse precision-guided munition load-out, high fidelity sensor, video downlink capability, reliable communications, imagery analyst as part of the flight crew, and stable and reliable terminal guidance operations.[39]

These MALE-T UAS accomplishments are from today and the past though. Imagine what the feedback from Marines on the ground would be if these same aircraft, in addition to having four low-collateral precision-guided missiles and two precision-guided bombs, also carried dozens of precision-guided 81 millimeter mortars optimized for employment in danger-close, urban CAS scenarios. This exact capability is going through testing today and will be available by 2025, if not much sooner.[40] Combining persistent MALE-T UAS, armed with dozens of munitions, networking capabilities to share situational awareness, including position location information for tens of distributed units, along with PCAS capabilities, would fundamentally change how the

MAGTF fights. All together, these capabilities would also revolutionize urban CAS for Marines on the ground. Additionally, these capabilities would enable preserving precious and much more expensive F-35 flight hours for more high-end threat environments, thereby helping prevent another aviation readiness crisis similar to the one that exists today.[41]

Beyond enhanced C2 and fires capabilities, another crucial way that MALE-T UAS can enable the MAGTF in hybrid threat environments is through logistical efficiency gains. During Operation PHANTOM FURY in 2004, the logistics community built what became known as "iron mountains" around Fallujah. These "iron mountains" were filled with every conceivable re-supply item that Marines would need to continue fighting in the city.[42] This logistics concept benefitted from a mature operating environment, where the U.S. military had been operating for 18 months beforehand. This logistics concept also benefitted from the enemy's lack of longer range, surface-delivered fires systems, as well as ISR assets to enable said systems to become more lethal. In contrast to the realities on the ground during Operation PHANTOM FURY, the MOC emphasizes the importance of Marines being able to operate in austere, expeditionary environments, as well as against enemies who have longer range weapons and ISR systems that can easily target fixed concentrations of U.S. personnel and/or supplies. Ongoing combat operations in Iraq and Syria, as well as in eastern Ukraine, all highlight why the MOC is correct and thus why it is essential for the MAGTF to find alternatives to concepts such as the "iron mountain."[43] Appropriately equipped MALE-T UAS can prove decisive in these areas due to their ability to enable a C2 architecture that provides constant updates on unit logistical expenditure rates and re-supply needs. Imagine, for example, battalions clearing Fallujah all being tracked digitally and reports being sent autonomously via MALE-T UAS back to logistics command centers highlighting when Marines are running low on certain types of ammunition.

At the same time, instead of requiring lengthy voice communications between chain-of-command layers about where to deliver ammunition re-supply, imagine the Marines on the ground only having to tap a few buttons on their "smart" devices to identify this information, which is then instantly visually displayed to the appropriate logistics units. Then, whichever logistics unit is responsible for delivering the ammunition can simply confirm with the Marines in need via a text and/or quick voice check, at which point the Marines can move the ammunition via ground convoy or, better yet, precisely drop it via re-supply UAS.[44] These types of situational awareness and precise delivery capabilities would have been great combat multipliers in Fallujah. Undoubtedly, the same will apply in future hybrid urban threat scenarios.

MAGTF MALE-T UAS in Humanitarian Assistance and Disaster Relief Operations

While Marines must be prepared to fight in high-end and the forecasted most likely and most dangerous hybrid urban threat environments, MAGTFs will continue to routinely execute humanitarian assistance and disaster relief (HA/DR) operations. Marines execute such missions annually, often times multiple times per year. Recent examples include the response to the 2016 tragedy in Haiti,[45] as well as the humanitarian disaster in 2015 in Nepal.[46] In both of these situations, appropriately equipped, organic MALE-T UAS would have greatly enabled the MAGTF.

Responding to the tragedy in Nepal required Marines to move on short notice, multiple thousand miles into one of the most inhospitable operating environments imaginable. Due to limited amphibious shipping and the response time required, Marines predominately used land-based assault support aircraft such as organic KC-130Js and U.S. Air Force C-17s to move personnel and equipment into Nepal. C-17s, for example, flew First Marine Air Wing (1st MAW) UH-1Y helicopters into Nepal.[47] Once flown into the country, these helicopters were

used for multiple purposes, to include ISR support missions. Tragically, during this high altitude HA/DR mission, one of the UH-1Ys crashed into a mountainside, killing the aircrew inside.[48] Finding the aircrew and aircraft proved to be a significant challenge, ultimately extending a period of multiple days. Mountainous terrain, relatively low cloud ceilings, and LOS communications were major obstacles that had to be overcome during the search effort, just as they were throughout the entire mission. Upon reflecting on this mission and the likelihood that MAGTFs will be asked to conduct similar ones in the future, what if, the next time that such a mission is required, the MAGTF had a MALE-T UAS capability similar to what the British military recently purchased in the MQ-9 "Protector?"[49]

Twenty "Protectors" will enter British military service over the next few years.[50] These aircraft will both replace the 10 initial block MQ-9s employed by Britain since 2008 and increase their MALE-T UAS capability and capacity. The "Protector" can self-deploy thousands of miles. It has de-icing capabilities to enable operating at high altitude in extreme cold temperatures. Its sensors can see through low cloud ceilings. Its endurance is around 40 hours, meaning if it flies from 1st MAW's headquarters in Japan to Nepal it can subsequently stay on-station for approximately 12-20 hours upon arrival, or touch down briefly to re-fuel and then remain on-station for 40 hours. Further, the "Protector" has advanced communications capabilities ranging from jam-resistant military SATCOM, to Link-16, to multiple means of encrypted and unencrypted video downlink, to dual very-high and ultra-high frequency radio capabilities. The "Protector" can also easily incorporate existing 4G LTE to enable creating an immediate cell phone network. If, in the future, the III Marine Expeditionary Force (MEF), "fight tonight" MAGTF had such an organic capability, it would be able to be on-station above a similar crisis within 12-20 hours from a start point multiple thousands of miles away. The assets

enabling this rapid response could then, using their exceptional sensor and advanced communications sharing capabilities, vector in follow-on forces, including those executing search and rescue missions. Such a MUM-T approach to HA/DR in U.S. Pacific Command, using the same aircraft highlighted in the high-end scenario, would make the MAGTF an exponentially more capable crisis response force.

The response to the recent tragedy in Haiti, a nation located approximately 1100 miles from II MEF's headquarters in North Carolina, had multiple similarities with the III MEF crisis response mission in Nepal. Specifically, it took multiple days from the natural disaster striking for the Marine Corps to start having an impact.[51] Part of the reason for this delay was due to the time required to get assets in place to respond, including, in this case, Marines and aircraft embarked on amphibious shipping deployed from the east coast of the United States. Similar to the mission in Nepal, among the capabilities needed most at the start of the crisis were assets that could help locate survivors and then share information about their location, routes leading to their positions, and recommended potential search and rescue options. The Marine Corps did not have such assets to bring to this crisis. Imagine instead, if and when the next humanitarian disaster strikes Haiti, II MEF had within 2d MAW MALE-T UAS such as those previously described. Upon notification, these aircraft can launch immediately from North Carolina and be overhead in Haiti four hours later, relaying time-sensitive, life-saving information back to response centers at II MEF, Expeditionary Strike Group Two, U.S. Southern Command, the U.S. State Department, etc. These aircraft can then stay on-station for a day or more before flying back to North Carolina or one of dozens of U.S. bases in Florida to re-fuel before checking back-in overhead, all the while other organic MALE-T UAS continue to provide persistent coverage.

Across every warfighting function, such a MALE-T UAS capability would transform how MAGTFs execute HA/DR.

Conclusion

Between now and 2025, whether executing an amphibious assault and/or EAB operation in contested battlespace, fighting a hybrid threat in urban terrain, or conducting HA/DR operations, organic MALE-T UAS can transform not only how MAGTFs operate, but also how well they operate and enable the Naval Service. Realizing this transformative capability, however, requires a clear understanding of how MALE-T UAS can enable the MAGTF across all warfighting functions in each of these environments, as well as collective and unified action to turn this understanding into reality. The time to start this unified action is now.

[1] Paul Scharre, *Robotics on the Battlefield Part I: Range, Persistence and Daring* (Washington, DC: Center for New American Security, May 2014), 9.
[2] Robert B. Neller, Headquarters U.S. Marine Corps, *FRAGO 01/2016: Advance to Contact* (Washington, DC: Headquarters U.S. Marine Corps, 2016), 3.
[3] First Marine Regiment submitted the most recent of these UUNS on 7 April 2017. A few months earlier, on 4 November 2016, U.S. Marine Corps Special Operations Command (MARSOC) submitted a related UUNS. A few months prior to this, on 8 August 2016, U.S. Marine Forces Europe-Africa (MFEA) submitted another related UUNS. On 4 November 2015, U.S. Marine Corps Forces Pacific (MFP) submitted a DUNS very similar to MFEA's UUNS. This DUNS followed a previous 11th Marine Expeditionary Unit UUNS. The first UAS-specific UUNS identified by the author was co-authored by MFP's current Deputy Director for Air Operations, who stated, "When Rob Terellis and I returned from Camp Fallujah in '04, we wrote an UUNS for a Predator-like capability. It left I MEF (Air/Fires) in late '04 or early '05."
[4] Headquarters U.S. Marine Corps, *Marine Corps Operating Concept: How an Expeditionary Force Fights and Wins in the 21st Century* (Washington, DC: Headquarters U.S. Marine Corps, 2016), 22.
[5] For more information on why this approach to C2 is both unrealistic and dangerous, see, for example, Phillip A. Karber, "Lessons Learned from the Russo-Ukraine War," personal observations presented to a historical lessons learned workshop on behalf of John Hopkins Applied Physics Laboratory and U.S. Army Capabilities Center, 2 July 2015, *Potomac Foundation*, 12 and 17.
[6] Headquarters U.S. Marine Corps, *Marine Corps Intelligence Activity Future Operating Environment: 2015-2025* (Washington, DC: Headquarters U.S. Marine Corps, 2016).
[7] See, for example, p. 22 in the *Marine Corps Operating Concept* which states, "We recognize that operations in urban areas are the most likely to occur and the most dangerous."
[8] See, for example, Jonathan Marcus, "Russia S-400 Syria Missile Deployment Sends Robust Signal, *BBC News*, 1 December 2015 (https://news.usni.org/2016/10/12/pentagon-respond-appropriate-manner-new-missile-attack-uss-mason-yemen) and Sam LaGrone, "Pentagon Pledges to Respond in Appropriate Manner After New Yemen Missile Attack on USS MASON, *USNI News*, 21 October 2016 (https://news.usni.org/2016/10/12/pentagon-respond-appropriate-manner-new-missile-attack-uss-mason-yemen).
[9] For further background on MALE-T UAS history in combat dating back to 1995, see Richard Whittle, *Predator: The Secret Origins of the Drone Revolution, (*New York: Henry Holt and Company, 2014). Additionally, for more on MALE-T UAS in more recent combat, to include being responsible for "roughly 15 percent of all the airstrikes in the war against the Islamic State in Iraq and Syria," see Paul D. Shinkman, "The Drone Age: A Controversial Technology Has Solidified Its Place in Modern U.S. Wars," *U.S. News*, 16 November 2016, http://www.usnews.com/news/world/articles/2016-11-16/us-drones-are-here-to-stay.
[10] For more on how the U.S. Missile Defense Agency has and is using MALE-T UAS to serve as network extension, and relay (and sensing) nodes, see Andrea Shalal, "U.S. Aegis System Zaps Cruise, Ballistic Missile Targets in Test," *Reuters*, 6 November 2014, https://www.google.com/amp/mobile.reuters.com/article/amp/idUSKBN0IR00Y20141107, Bill Carey, "Predator Bs Tested for Ballistic Missile Defense," *Aviation International News Online*, 16 August 2016, https://www.google.com/amp/www.ainonline.com/aviation-news/defense/2016-08-16/predator-bs-tested-ballistic-missile-defense%3Famp, and "Predator B Detects and Tracks Ballistic Missile in Pacific Dragon Exercise," *UAS Vision*, 17 August 2016, http://www.uasvision.com/2016/08/17/predator-b-detects-and-tracks-ballistic-missile-in-pacific-dragon-exercise/.
[11] These facts have been validated most recently at the Marine Corps Component Command level in August and November 2016, respectively, with MARSOC and MFEA's UAS UUNSs.
[12] The author experienced these limitations when conducting a series of experimentations with the F-35B in 2014 and 2015, as well as when serving as the co-lead planner for a DSO wargame in 2014. Additionally, for more information about the EABO and DSO concepts, see the *Marine Corps Operating Concept* and Che Bolden, Scott Cuomo, James Foley, and Kevin Murray, "Manned/Unmanned Teaming to Transform the MAGTF," *Marine Corps Gazette,* June 2016, 71.
[13] The information in Figure 2 is from a combination of a demonstration that the author observed in Huntsville, Alabama in January 2016 and follow-on analysis focused on the F-35's networking capabilities and deficiencies.
[14] The power and payload information were taken from a General Atomics Aeronautical Systems, "Predator B Comparison Brief," PowerPoint presentation, 10 June 2016. The waveform capability potential information was gained from the January 2016 demonstration, as well as a separate tactical demonstration conducted as part of the Marine Corps Weapons-Tactics Instructor (WTI) Course 1-14. For more information on this demonstration, see

Joey Cheng, "Demonstration Features Reaper's Electronic Attack Capability," *Defense Systems*, 27 January 2014, https://defensesystems.com/articles/2014/01/27/reaper-uav-electronic-warfare.aspx?m=1.

[15] Information gleaned from a 2009 Rockwell Collins:Tactical Targeting Network Technology PowerPoint Brief titled "Dynamic, Robust Waveform Enabling NetCentric Communications for Today's Warfighter," as well as the author's personal experience employing the waveform during multiple experiments.

[16] Information gleaned from the author's personal experience using TrellisWare radios, as well as an October 2016 TrellisWare Technologies TSM waveform capabilities overview brief.

[17] Headquarters U.S. Marine Corps, *2016 Marine Aviation Plan* (Washington, DC: Headquarters U.S. Marine Corps), 48.

[18] Ibid.

[19] For the most recent example of the RQ-21 limitations and failures, see MARSOC's most recent UAS-UUNS, Headquarters U.S. Marine Corps, Combat Development Command, "UUNS for ORGANIC Group 2 UAS for MARSOC" (Camp Lejeune, NC: Marine Special Operations Command, 4 November 2016).

[20] Andrew deGrandpre and Jeff Schogol, "The Marine Corps' Aviation Fleet is in Peril, *Marine Corps Times*, 26 April 2016, https://www.marinecorpstimes.com/story/military/2016/04/26/fleet-peril-how-congressional-budget-cuts-are-crippling-the-marines-air-power/81974498/, Kevin F. Murray, "Marine Aviation Readiness: Solving the Problem," *Marine Corps Gazette*, December 2016, 51-57, and Cory D. Radcliffe, "Embrace UAS 'Guardian Angels' Immediately: Our Corps is 15 Years Behind," *Marine Corps Gazette*, December 2016, 43-50.

[21] Radcliffe, "Embrace UAS 'Guardian Angels Immediately."

[22] Image taken from a General Atomics Aeronautical Systems after action report and confirmed in Joey Cheng, "Demonstration Features Reaper's Electronic Attack Capability."

[23] Image of the MALD on the MQ-9 provided by General Atomics Aeronautical Systems and detailed information about the MALD and MALD-J capabilities located at http://www.raytheon.com/capabilities/products/mald/.

[24] For more on the current MUM-T paradigm, see Richard Whittle, "MUM-T is the Word for the AH-64E: Helos Fly, Use Drones," *Breaking Defense*, 28 January 2015, http://breakingdefense.com/2015/01/mum-t-is-the-word-for-ah-64e-helos-fly-use-drones/.

[25] This long-range and distributed C2 deficiency has been validated in all of the aforementioned DUNS/UUNSs. This deficiency is also illustrated in the 2016 AVPLAN in the Marine Command and Control System (MACCS) section, when on page 28 it shows an E-2D aircraft serving as the critical network gateway and relay node to enable MAGTF distributed operations. Unfortunately for the MAGTF, the U.S. Navy has a limited number of E-2Ds and these are assigned to carrier strike groups, which often operate separately from amphibious ready groups, particularly in high-end threat environments scenarios.

[26] For more on this potential MUM-T employment paradigm, see Che Bolden, et al., "Manned/Unmanned Teaming to Transform the MAGTF."

[27] See, for example, Michael Peck, "UAS in Contested Skies: A Primer on Survivability," *C4ISRNET*, 22 September 2015, http://www.c4isrnet.com/story/military-tech/uas-isr/2015/09/22/unmanned-aerial-systems-contested-skies/72572484/.

[28] Figure 5 was taken from a Raytheon PCAS PowerPoint brief provided to USASOAC on 27 January 2016. Figure 6 was taken from a Defense Advanced Research Projects Agency (DARPA) PowerPoint brief on PCAS given to a U.S. Air Force CAS conference on 2 March 2015. Additionally, for a further explanation and video explaining PCAS capabilities, see the DARPA video located here: https://youtu.be/weRz7bbIdfo.

[29] Information on PCAS investment to date, as well as networking capabilities, is from the PCAS brief provided to the U.S. Air Force CAS conference.

[30] For detailed descriptions of the ongoing fight for Mosul, see Kimberly Dozier, "Inside an ISIS Bunker," *The Daily Beast*, 30 December 2016 (http://www.thedailybeast.com/articles/2016/12/30/inside-an-isis-bunker.html), Loveday Morris and Mustafa Salim, "'Tragedy' Inside Mosul as Food Runs Out and the Battle Against ISIS Drags On," *The Washington Post*, 18 December 2016 (https://www.google.com/amp/s/www.washingtonpost.com/amphtml/world/middle_east/tragedy-inside-mosul-as-food-runs-out-and-the-battle-against-isis-drags-on/2016/12/18/689198d0-bbe9-11e6-ae79-bec72d34f8c9_story.html), Mohammed Tawfeeq, "Iraq: Death Toll Climbs as Urban Warfare Slows Battle for Mosul, *CNN*, 2 December 2016 (https://www.google.com/amp/s/amp.cnn.com/cnn/2016/12/02/middleeast/iraq-mosul-battle-isis/index.html), and Charles Winter, "How the Islamic State is Spinning the Mosul Battle, *The Atlantic*, 20 October 2016 (https://www.google.com/amp/www.theatlantic.com/amp/article/504854/).

[31] Laura Grossman, "Islamic State Uses MANPADS to Shoot Down Iraqi Helicopter Near Baiji," *The Long War Journal*, 8 October 2014, http://www.longwarjournal.org/archives/2014/10/islamic_state_shoots_down_iraq.php.

[32] See Tawfeeq, "Iraq: Death Toll Climbs as Urban Warfare Slows Battle for Mosul."
[33] MFP's current Deputy Director for Air Operations confirmed submission of this UUNS in an email to the author on 3 February 2016.
[34] Dozens of such pods already exist. While the pods' capabilities are classified, the main take-away for the MAGTF is that they are readily available today to help eliminate pre-existing capability gaps.
[35] See "Executive Order - United States Policy on Pre- and Post-Strike Measures to Address Civilian Casualties in U.S. Operations Involving the Use of Force," 1 July 2016, https://obamawhitehouse.archives.gov/the-press-office/2016/07/01/executive-order-united-states-policy-pre-and-post-strike-measures.
[36] See Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 3160.01 "No-Strike and the Collateral Damage Estimation Methodology," 9 January 2009 and CJCSI 3505.01A, "Target Coordinate Mensuration Certification and Program Accreditation," 1 March 2009.
[37] See, for example, Winter, "How the Islamic State is Spinning the Mosul Battle."
[38] Shinkman, "The Drone Age: A Controversial Technology Has Solidified Its Place in Modern U.S. Wars," Tim Ripley, "U.S. Reapers Flew Majority of Strikes Against Islamic State in Libya," *IHS Jane's Defence Weekly*, 6 March 2017, http://www.janes.com/article/68455/us-reapers-flew-majority-of-strikes-against-islamic-state-in-libya, and Christian Clausen, "MQ-1, MQ-9 Aircrews Help Liberate Manbij," *U.S. Air Force Official Website*, 6 April 2017, http://ww3.safaq.hq.af.mil/News/Article-Display/Article/1143799/mq-1-mq-9-aircrews-help-liberate-manbij/.
[39] These comments were made by Capt Scott Jones, one of 2/8's forward air controllers/JTACs in Afghanistan. They were referenced by Capt Adam Weathers in an Expeditionary Warfare School paper titled "UAVs and the Appropriate Balance with Manned Aircraft," available at https://www.mccll.usmc.mil.
[40] Information provided in a UTC Aerospace System PowerPoint brief titled "Extended Range Air-dropped Munitions Capability Briefing" for the U.S. Air Force Association from 19-21 September 2016.
[41] For more on the importance of finding ways to preserve precious F-35 flight hours, see Kevin Murray, "Marine Aviation Readiness: Solving the Problem," and Mike Pietrucha, "Maladjusted, Part II: How the U.S. Air Force Went from Eagle to Chicken," *War On The Rocks*, 6 March 2017, https://warontherocks.com/2017/03/maladjusted-part-ii-how-the-u-s-air-force-went-from-eagle-to-chicken/.
[42] See, for example, John F. Sattler and Daniel H. Wilson, "Operation Al Fajr: The Battle for Fallujah – Part II," *Marine Corps Gazette*, July 2005, 12-24.
[43] See, for example, Robert H. Scales, "Russia's Superior New Weapons," *The Washington Post*, 5 August 2016 (https://www.google.com/amp/s/www.washingtonpost.com/amphtml/opinions/global-opinions/russias-superior-new-weapons/2016/08/05/e86334ec-08c5-11e6-bdcb-0133da18418d_story.html), and Robert Scales, *Scales On War: The Future of America's Military at Risk* (Annapolis: U.S. Naval Institute Press, 2016), 162.
[44] For an example of how this could work, see Arjun Kharpal, "Amazon Wins Patent for a Flying Warehouse that will Deploy Drones to Deliver Parcels in Minutes," *CNBC*, 30 December 2016, http://www.cnbc.com/2016/12/29/amazon-flying-warehouse-deploy-delivery-drones-patent.html.
[45] Jordan Cochran, "24th MEU Arrives in Haiti, Delivers Aid to Storm-Ravaged Region," U.S. Marine Corps public website, 13 October 2016, http://www.marines.mil/News/News-Display/Article/972404/24th-meu-arrives-in-haiti-delivers-aid-to-storm-ravaged-region/.
[46] Jeff Schogol, "U.S. Sending Ospreys, Hueys, and other Aircraft to Nepal," *Air Force Times*, 2 May 2015 (http://www.marines.mil/News/News-Display/Article/972404/24th-meu-arrives-in-haiti-delivers-aid-to-storm-ravaged-region/) and Gina Harkins, "Corps Identifies 6 Marines Killed in Nepal Helicopter Crash," *Marine Corps Times*, 17 May 2015 (https://www.marinecorpstimes.com/story/military/2015/05/17/marines-identified-nepal-helo-crash/27483577/).
[47] Schogol, "U.S. Sending Ospreys, Hueys, and other Aircraft to Nepal."
[48] Harkins, "Corps Identifies 6 Marines Killed in Nepal Helicopter Crash."
[49] Gareth Jennings, "UK's Protector UAV Revealed to be the Certifiable Predator B," *IHS Jane's 360*, 26 April 2016, http://www.janes.com/article/59789/uk-s-protector-uav-revealed-to-be-the-certifiable-predator-b. Additional information on this aircraft's capabilities can be found in a General Atomics Aeronautical Systems, "Predator B Comparison Brief," PowerPoint presentation, 10 June 2016.
[50] Ryan Maass, "Britain Signs Off on General Atomics' Protector Program," *UPI*, 5 December, 2016, http://www.upi.com/Defense-News/2016/12/05/Britain-signs-off-on-General-Atomics-Protector-program/3201480944274/.
[51] Jordan Cochran, "24th MEU Arrives in Haiti, Delivers Aid to Storm-Ravaged Region."

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