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14. ABSTRACT
Over the next decade, Marine TACAIR will transition to two new airframes—the Joint Strike Fighter (JSF) and the Marine Corps Tactical Unmanned Aircraft System (MCTUAS). Both platforms will bring sophisticated tools to the future fight. Yet if operated independently, each one will fail to contend fully with the gaps in operational capabilities and emerging threats that the Marine Corps will face in 2020. Interestingly, no current developments address how these advanced systems will fight together in the same airspace. To meet these challenges, the JSF and MCTUAS must team together and collaborate across TACAIR functions. Conceptual capabilities such as collective cross cueing, mutual mission tasking and exchangeable command and control will enable these platforms to perform cooperative air operations. These principles advance a concept to team manned and unmanned TACAIR aircraft in order to mitigate the challenges encountered over the next several decades.

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Marine TACAIR Challenge 2020: Team the Joint Strike Fighter with the Next Unmanned Aircraft System

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DISCLAIMER

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Some time ago, on a research visit to the Pentagon, by happenstance I crossed paths with a one-star general whom I failed to recognize and whose nametag melted into his dark utilities due to my worsening eyesight. After my requisite respects and his pleasantries, he inquired of my comings and goings. I shared an overview of my Command and Staff College master's paper, and upon sensing his interest, expanded further with a verbal outline. To my surprise, he countered my 'power-point deep' thoughts and offered a few of his own. Not to be outdone or intimidated, I jousted back with an impromptu defense and a heightened sense of vigor. To this day, I remain uncertain whether his young assistant interrupted my escalating bullets in order to preserve my livelihood or to escort the General in to see the Commandant. In either case, it served me well to lock jaw and to listen to the General's departing remarks. Though our perspectives may differ on the topic to follow, Brigadier General Timothy Hanifen, Deputy Commandant of the Marine Corps Combat Development Command, listened to my thesis, challenged my thinking and fired his final rounds which later forced me to reason through arguments more thoroughly. For his time, debate and reprieve, I thank him.

The Marine Corps University and the Command and Staff College provide a professional academic forum with a joint war fighting emphasis. The curriculum fosters an unmistakable balance between doctrine, history and leadership and demands that each student explore the nature of war and the characteristics of warfare through a lens of innovation and forward thinking. I am grateful to Lt.Col. Loretta Vandenberg, Dr. Douglas Streusand, Dr. Edward Erickson and Lt.Gen. (Ret.) Paul K Van Riper for their professional, passionate and provoking styles that served to lure our field grade minds from complacency and mediocrity. To my wife Niki, you are most dear and forever. To my five children, fight the good fight. Semper Fidelis.

EXECUTIVE SUMMARY

Title: Marine TACAIR Challenge 2020: Team the Joint Strike Fighter with the Next Unmanned Aircraft System

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Thesis: As impending challenges coalesce to influence TACAIR and collide with an emerging threat able to fracture today's accustomed air superiority, an essential concept of operation starting in 2020 will be to team the JSF with the next-generation MCTUAS in support of tomorrow's MAGTF commander.

Discussion: Over the next decade, Marine fixed-wing tactical aviation (TACAIR) will transition to two new airframes—the F-35B Joint Strike Fighter (JSF) and the Marine Corps Tactical Unmanned Aircraft System (MCTUAS). Interestingly, as both airframes develop, no aviation doctrine, guidance or concept addresses how these advanced systems will fight together and fulfill the same functions in the same airspace.

Three conditions converge on the TACAIR community circa 2020. They make this timeframe pivotal in Marine aviation and they are cause for deep thought regarding JSF and MCTUAS employment in the decades ahead. The long-term rigid investment in the JSF and MCTUAS programs, the projected deficit of operational platforms and fires, and the emerging threat collectively frame a problem that demands TACAIR attention.

Both the JSF and MCTUAS programs will bring sophisticated tools to the future fight. At the same time, both platforms will fail to contend fully with the problem above. The F-35B will deliver transformational capabilities to tactical circumstances. But, short of distributing global situational awareness, it is unlikely to overcome the challenges of 2020. Like the F-35, expected MCTUAS capabilities are extraordinary. On the other hand, advances in autonomy and remote human interface will not yet replace a pilot's on-station ability to grasp the scenario, exploit opportunity, or interact fluidly. Both the JSF and UAS individually add impressive value to the MAGTF fight, but technological realities reveal that they are not stand-alone solutions.

Marine aviation principally ignores that these two airframes must collaborate to fulfill TACAIR functions. Yes it is detrimental to tie platforms together into a closed system, but it is beneficial to unite like-function aircraft in a complimentary manner. Three concepts of integration form the basis for manned and unmanned teamwork between the F-35 and MCTUAS.

The first is collective cross cueing. These airframes must digitally share sensor items of interest in accordance with mission and threat priorities and with little to no human workload. Therefore a clear vision of fixed components and programmable software that facilitate collective cross cueing is essential. The second concept for cooperative operations is mutual mission tasking. In some scenarios, UAS with long-endurance, high situational awareness, and reach-back connectivity might need to task F-35s. At the same time, other tactical situations may warrant manned aircraft tasking UAS in detail. The third concept enabling collaborative JSF-MCTUAS

operations is exchangeable command and control. F-35 tacticians will possess the operational picture within a single cockpit and will be able implement commander's intent across the MAGTF airspace. Likewise, unmanned systems may become capable of serving in a command and control role. With dispersed operations, network vulnerability, and changes in tempo and complexity, sharing and exchanging command and control responsibilities on station will also facilitate integrated operations between the JSF and MCTUAS.

Conclusion: The JSF and MCTUAS capabilities offer a glimpse of optimism in the years ahead. But closer analysis reveals limitations with both aircraft that will take a bite out of the transformational panacea. While not a cure-all, the principles of collective cross cueing, mutual mission tasking and exchangeable command and control advance a concept to team manned and unmanned TACAIR aircraft in order to collaborate across the functions of Marine aviation and mitigate the challenges of the next two to three decades.

PROLOGUE: MARINE TACAIR TRANSFORMATION

In 1920, the first Marine Corps aviator, Major Alfred Cunningham, asserted that "the only excuse for aviation in any service is its usefulness in assisting troops on the ground to successfully carry out their operations."[1] Nowhere is this Marine air-ground adage more evident than in recent combat experience in provinces such as Iraq's Al Anbar and Afghanistan's Helmand. Much as Clausewitz described the nature of war as immutable, so too do Marines uphold the nature of aviation as supportive of ground maneuver and objective. In contrast to these enduring principals, however, methods of warfare continuously mutate. Similarly, while the purpose of Marine aviation remains absolute, the components of Marine aviation experience endless change and improvement. The late showman and contributor to early aviation, Will Rogers, expressed this with simple clarity in 1929. "You can't say civilization don't advance—for in every war, they kill you in a new way."[2]

Marine aviation currently experiences some of the most challenging, transformative, and opportunistic advances of the past one hundred years. The 2010 Marine Aviation Plan (AvPlan) encapsulates this by charting the sundown of every legacy combat aircraft and the transition of all type/model/series (T/M/S) communities to modern, innovative aircraft within an ongoing and approximate ten year timeframe. Some communities—the AH-1, CH-53, KC-130 and UH-1—replace aging platforms with enhanced versions of baseline designs. Others, like the CH-46 conversion to the MV-22 Osprey, leap into radically different, futuristic airframes. Arguably, the more momentous conversion amalgamates AV-8B, EA-6B, and FA-18A-D fixed-wing tactical aircraft (TACAIR) into a single, next-generation asset known as the Joint Strike Fighter (JSF), also labeled the F-35B Lightning II.[3]

Without question, aircrew get excited over the pioneering progress within the communities listed above, but that list lingers incomplete. The final aviation combat element (ACE) community scheduled for transformation is an unmanned "family of systems."[4] TACAIR's high-end airframe within this series of unmanned aircraft systems (UAS), the interim RQ-7B Shadow, will transition to a new Marine Corps Tactical UAS (MCTUAS) in six to ten years.[5] Though this future model remains undetermined to date, present contributions from and seemingly limitless possibilities for remotely piloted and/or autonomous UAS set the conditions for this airframe transition to become as remarkable as the introduction of the F-35B.

This is not to propose the Marine Corps acquire a MCTUAS airframe tantamount to an unmanned derivative of the Lightning II. It would be grossly cost prohibitive to procure a UAS with an analogous array of uniquely innovative and advanced capabilities which the JSF will add to the Marine Air-Ground Task Force (MAGTF) in 2012. Instead, the evolutionary yet explosive growth of unmanned aircraft offers occasion to develop a Marine system that complements forthcoming JSF implementation. In turn, this may enable manned-unmanned (MUM) collaboration within overlapping airspace and across shared functions of Marine aviation. This paper explores projected F-35B capabilities, proposed MCTUAS capabilities and potential cooperative air operations in order to present a TACAIR vision that rises to the challenge and opportunity of a new era in Marine aviation. In fact, as impending challenges coalesce to influence TACAIR and collide with an emerging threat able to fracture today's accustomed air superiority, an essential concept of operation starting in 2020 will be to team the JSF with the next-generation MCTUAS in support of tomorrow's MAGTF commander.

PROBLEM: TACAIR SITREP 2020

Almost two years ago, the Commandant of the Marine Corps (CMC) released his Vision 2025, a comprehensive roadmap for Marine warfighting through the Long War and beyond. Five years prior to 2025, however, up-and-coming circumstances will confront the ACE with conceptual, organizational, and technological decisions. Three overarching developments converge upon the TACAIR community circa 2020. They make this timeframe pivotal in Marine aviation and they warrant a pressing examination of JSF and MCTUAS employment.

First, these two airframes will remain TACAIR fixtures for the foreseeable future—likely sustaining the fixed-wing force well past 2040. History substantiates a thirty year plus service life for mainstream Marine combat jet aircraft and twenty years of continuous utilization for proven UAS platforms.[6] The Defense Department and Lockheed Martin maintain the 300-plus billion dollar F-35 program will extend upwards of thirty years. Prophecy aside, historical trends and budgetary constraints suggest the JSF and MCTUAS capital expenditures will define TACAIR for the next generation. In layman's terms, 'you get what you get' from 2020 to 2040.

Second, defense experts question whether the number of fighter/attack aircraft, the amount of amphibious shipping and the sufficiency of operational fires can meet MAGTF requirements over the next ten to twenty years. Of these debated shortfalls, a so-called 'fighter gap' snatches the majority of public attention. The Air Force, Marine Corps and Navy continue to retire legacy fighter aircraft—fraught with increasing maintenance, antiquated avionics, and fatigue failure—and seek to replace them with fifth-generation F-22 Raptors and F-35 Lightning IIs. But accelerated retirement rates of fourth-generation airframes, massive cutbacks in F-22 acquisition, and ongoing program delays in the JSF program create a notable "deficit between the services' fighter aircraft inventories and their operational requirements."[7] Even as the

Deputy Commandant for Aviation (DCA) moves to extend the F-18 lifespan and introduce the F-35 on schedule, looming Air Force and Navy shortages that peak around 2020 will likely draw some Marine F-35's away from MAGTF operations to support joint endeavors.[8]

Amphibious shipping shortfalls parallel the 'fighter gap' introduced above. As the Marine Corps and Navy reassert their amphibious relationship—the direct delivery of maneuver warfare from the sea—USMC leaders highlight growing inadequacy of naval shipping to sustain Marine Expeditionary Unit (MEU) requirements demanded by Combatant Commanders. This concern directly affects JSF and UAS concepts of operation, for amphibious assault ships embark and deploy Marine fixed-wing alongside other elements of the MAGTF. Clearly, numbers of ships relate directly to the amount of aviation overhead. The CMC articulates the need for thirty-eight amphibious warfare vessels to provide for necessary naval engagement.[9] In some documents, thirty-three ships provide an adequate, albeit temporary figure.[10] Yet the 2010 Quadrennial Defense Review (QDR) charts only twenty-nine to thirty-one of these ships.[11] As a result, some Headquarters of the Marine Corps (HQMC) staff forecast 2020-2025 as the dark years ahead in amphibious shipping—in terms of raw numbers, tonnage capacity and network-based command and control ability.[12] This deficit will hamper TACAIR presence.

The sufficiency of operational fires are proportional to, but more important than, any given number of 'shadows on the ramp' or ships at sea. And while not as easily quantifiable, air and surface fires may likewise endure a trough of capability next decade. One concern is a corresponding reduction of persistent offensive air support (OAS) associated with fewer numbers of fighter aircraft. LtGen Flynn, Commanding General of MCCDC, described a Marine over-reliance upon carrier-based air support that would grow increasingly ineffective as the Navy faced shortfalls of both fighters and aircraft carriers.[13] Adding to this, naval surface fire support

(NSFS) festers as another scarcity. Just as with assault ships, the Commandant also elevated awareness of unanswered shortages in naval preparatory fires.[14] Regarded as a possible solution, the Navy Littoral Combat Ships' (LCS) "box of rockets" faces several technical hurdles that still lead General Conway to state the "Marine Corps has not found a volume of firepower that can successfully fill the NSFS gap."[15] The remaining fires deficiency is of a non-kinetic nature: electronic warfare (EW). Marine Prowlers, whose sole mission is EW, will decommission at the end of 2019. Though the JSF touts impressive EW attributes, it is not heralded as a comparable replacement due to its multi-role responsibilities. Vice Chairman of the Joint Chiefs, General James Cartwright, expressed that the ability to conduct EW was "one of the highest issues of concern" after the older aircraft sundown.[16] To this extent, HQMC tasked the UAS branch to explore unmanned aircraft design specifically with the full EW mission in mind.[17]

The 2010 QDR speculates that the "future operational landscape could also portend significant long-duration air and maritime campaigns."[18] Yet capability gaps span both these environments—in fighter aircraft, amphibious shipping, and operational fires—and combine to form a second fundamental TACAIR condition amplified at the turn of the next decade.

The final theme to influence Marine TACAIR in 2020 is not internally focused, be it long expected service life of vested airframes or shortfalls in friendly capability; conversely, the third development is an external and precarious threat surfacing around the world that has the capacity to splinter local air superiority over-top MAGTF operations. Dakota Wood, author of the Marine Corps' 2008 "Strategy for the Long Haul," summarized the 21st century enemy as one who focuses "their principal efforts on exploiting asymmetries to gain an advantage." He added that hybrid combinations of regular and irregular warfare matched with a proliferation of advanced conventional weapons distributed across the battlefield might challenge the "global commons" such as air and cyberspace.[19]

Several inexpensive, yet widely circulated threat subsets will influence MAGTF airspace in 2020. Surface-to-air missiles (SAM) turned the corner from Cold War architecture to modern, electro-optical design and present a potent mixture of mobility and lethality. Not only are regional belligerents like Iran purchasing high-end SA-15 and SA-20 systems, but unstable and rogue areas from Africa to Southeast Asia are also beginning to acquire and disperse new, deadly man-portables (MANPAD) such as the Russian produced SA-18 and SA-24. Though current countermeasures work well versus old variants, experts warn that these missiles, and even adversary laser devices, require that aviators revisit equipment and tactics to survive.[20]

Electronic attack (EA) components present another dime-store priced and easily disseminated threat to Marine TACAIR. The electromagnetic (EM) spectrum, internet protocol (IP), and associated bandwidth serve as lifeblood for network-centric American forces, yet this invisible arena proves exceedingly vulnerable. Off-the-shelf technology can deny, degrade, deceive and decrypt functions such as radio, radar, data-link, wireless IP, and global positioning system (GPS) signals. Though large-scale impact is difficult, examples from Iraq such as intercepted UAS video feeds and jammed GPS affirm that simple, focused EA can penetrate air and cyber operations. Again, Dakota Wood points out, "Modern technologies are making it possible for small forces…to field sophisticated capabilities."[21] The ACE should anticipate periods of EM disruption or local denial from enemy EA on future battlefields.

Unmanned aircraft permeate Western operating forces, but they also offer opponents a third cost-effective measure to challenge air dominance. Iran, again, possesses a growing fleet of UAS, but so does Hezbollah, the non-state organization who battled Israel to a draw in 2006.

According to Military and Aerospace Electronics, "more than two dozen countries, including several in the Middle East, already have (UAS) in service and more have indicated a desire to obtain them."[22] Of grave concern is the potential for foes to deliver weapons against Marines on the ground. Even further, reports reveal that China explores tactics, techniques and procedures (TTPs) to target packs of UAS against F-22 and F-35.[23]

Marine aviation will face a future enemy that adapts to changing conditions as combatants have throughout history. But this proliferation of maturing, economical and sophisticated means to challenge local air superiority—SAMs, EA, and UAS—represents a third and final theme for aviators to consider in the forthcoming decade.

The long-term, rigid investment in the JSF and MCTUAS platforms, the projected deficit of fighters, amphibious shipping, and operational fires, and the emerging threat do not serve as a doomsday trio. These three themes outline impending circumstances that demand attention within the TACAIR community in order to ensure Marines remain supported in the Corps' enduring tradition. Albert Einstein announced that if he had one hour to save the world, he would spend fifty-five minutes defining the problem and only five minutes finding the solution.[24] This 2020 TACAIR situation report frames a problem. The next section presents an analysis of the JSF and MCTUAS programs. As retired LtGen Paul Van Riper notes, warfare's widening separation of units places greater responsibility upon those on the scene.[25] Though individually impressive as parts of the TACAIR community, independent employment of these two airframes falls short of meeting this greater responsibility. As a result, the Marine Corps must consider teaming the F-35 and MCTUAS together into a fused concept of operations within future MAGTF airspace. This bid is not a cure-all, nor does it consider all the attributes which the joint force synergistically brings together. On the other hand, it leverages the big blue arrows of the

USMC AvPlan and sustains a warfighting concept of mission-type orders that equips local operators with the authority to make tactical decisions. In the end, teaming the JSF and MCTUAS provides a Marine-organic opportunity to mitigate approaching problems.

PARTS: 'GAME CHANGERS' & 'FORCE MULTIPLIERS'

As challenging conditions lie ahead for the aviation combat element in 2020, Marine TACAIR brings two superior systems into the mix. The Joint Strike Fighter and the future Marine Corps Tactical Unmanned Aircraft System will each draw attention to technological progress over recent years. Nevertheless, both programs will also confront realities when individually matched against the responsibilities to support Marines in contested airspace.

Field-grade infantry officers often poke humor at the 'savior-like' descriptions that air power enthusiasts attribute to the 5th generation F-35. "Oh, we know it's the game changer!" they remark in jest. Though sarcastic in expression, their experience bears truth in that any single system or technology rarely revolutionizes combat. Yes, the JSF represents a capability leap by order of magnitude over legacy, 4th generation aircraft. On the other hand, underlying constraints suggest its presence will not likely transform the entire battlefield as some imply.

In his 2008 article titled "Don't Cherry Pick the MAGTF," Colonel Robert Loynd articulately outlined what the JSF brings to the fight. He highlighted that the F-35 combines "multi-spectral intelligence, surveillance, and reconnaissance (ISR),...advanced electronic attack" and "low-observable, penetrating strike capabilities" within a single "system of systems," multi-role fighter.[26] In many regards, the JSF is labeled a 'flying sensor' because of its fused radar, electro-magnetic (EM) and electro-optical (EO) collections. Although reduced in scope, these sensors present airborne and surface friendly, threat and target indications that mimic the strategic command and control pictures offered by the E-3 AWACS and E-8 JSTARS.[27] In no way will the JSF replace or compete with these two airborne battle management platforms, but it can provide an impressive semblance of situational awareness (SA) at the tactical level. In effect, the enhanced SA transforms the pilot from a tongue-in-cheek 'stick-monkey' to a battlefield tactician. Lockheed Martin Vice-President, Mr. Frank Cappuccio, described F-35 aircrew as an "engagement manager" because the amount of data and quality of data so surpasses that of any previous weapons systems.[28] Even though designated a fighter-attack aircraft, these unprecedented capabilities allow the JSF to also serve in a command and control function, defined as "control of aircraft and missiles" in Marine doctrine.[29]

Equally important, Colonel Loynd continued, is a professed ability for the aircraft to exchange and distribute information. He emphasized that the F-35 will be capable of "distributing a single, integrated air-ground operational picture" and drastically improve the "commander's decision cycle."[30] No doubt enhanced information will be provided via data link protocols such as LINK-16. And yet-to-be standardized future data links—LINK-22, Tactical Targeting Network Technology (TTNT) or others—will further enable JSF information sharing. But wide-scale transmission of a common operational picture (COP) encounters several inhibiting limitations.

First, the only full-synthesis method designed to pass along JSF data is called Multi-function Advanced Data Link (MADL). Though this waveform broadcasts near-complete own-ship SA, it is constrained by both the number of participants and the transmission range. In essence, only a handful of fellow flight members located within double-digit mileage ranges may expect to enjoy detailed exposure to individual F-35 information.

Second, the bandwidth and time slot allocations provided by the joint, interoperable data links previously mentioned do not and will not facilitate JSF-centric mass broadcasts. LINK-16 and others, though ideal to transmit critical bites of information across long distances back to commanders, are ill-suited to pass along all-inclusive, real-time overlays from multiple platforms.[31] Variable Message Format (VMF), the structure selected for data communication between attack aircraft and ground-based joint terminal attack controllers (JTAC), provides for detailed coordination of close air support (CAS) to ground operations; however, it is likewise incapable of pushing a thorough aerial picture to ground maneuver units.

Lastly, great amounts of JSF collected information will require security classification higher than most real-time data sharing protocols. Though these waveforms accommodate command and control pictures, many—other than MADL—are restricted by either encryption or audience to security levels lower than F-35 standard operating procedures.

The JSF will greatly contribute to a common operational picture (COP). Nevertheless the quantity of, fidelity of and classification of its disseminated data will inhibit universal distribution more than some believers anticipate. As a result, the Lightning II will absolutely bring transformational capabilities to tactical circumstances, but it is unlikely to single-handedly overcome the operational challenges of 2020. Short of presenting a panacea of 'global SA' to all shooters and all decision makers all the time, this 'game changer' alone will be unable to make up for the combined effects of friendly shortfalls and enemy developments next decade.

Unmanned aircraft increasingly and deservedly attract devotees akin to F-35 disciples. With tens of thousands of sorties and hundreds of thousands of flight hours in support of the worldwide struggle against totalitarian extremists and insurgents, it is no wonder civilian and military leaders categorize these UAS as an "effective force multiplier."[32] Almost daily, media reports showcase successful 'drone' attacks or critical surveillance footage, and deployed commanders rarely bypass a public appearance to emphasize a need for more unmanned assets.

In this vein, Marine aviation is right to aggressively promote and pursue UAS assimilation on the battlefield. Unmanned Aerial Vehicle Squadron Three (VMU-3), deployed in support of Marines in Helmand Province during the winter 2009-2010, fulfills any number of critical tasks during their daily six-hour missions. From reconnaissance, surveillance and target acquisition (RSTA) actions with their optical and infrared targeting system, to consolidation of video feeds, friendly position indicators (Blue Force Tracker) and radio communication, VMU-3 operations and innovations convey "more SA in [their] Combat Operations Center (COC) than nearly [anywhere else] in theatre."[33] Clearly, Marines continue to implement UAS with the same vigor as previous generations employed older instruments of warfare.

Given the tremendous historical and ongoing applications of UAS in combat operations, HQMC released a series of documents that chart the course ahead for Marine unmanned aviation. At the forefront, the November 2009 UAS Concept of Operations (CONOPS) details the collective points of both the FY2010 AvPlan and the UAS Campaign Plan. This UAS "Family of Systems" CONOPS provides the pathway to acquisition across the unmanned community through 2025.[34]

Briefly introduced earlier and now expanded upon from the UAS CONOPS, the future MCTUAS platform will be developed to replace RQ-7B Shadows and provide the ACE with a "larger, multi-mission UAS in approximately the 2016-2020 timeframe."[35] The list of intended MCTUAS capabilities is truly extraordinary. Requirements include a 1350 mile combat radius, 6-12 hour loiter time, strike weapons, multi-spectral sensors, numerous video feeds, beyond line-of-site and multi-channel communication, electronic attack suites and key command and control enablers.[36] Be it not for its stipulated modular payload design, one might imagine the MCTUAS a magically cheaper, multi-role but unmanned JSF offshoot. In fact, shy of only anti-air warfare, the MCTUAS implied functions encompass the same as those of the JSF—aerial reconnaissance, offensive air support, electronic warfare and command of aircraft and missiles.

As impressive a system as the MCTUAS may become, two significant hurdles within the unmanned community will linger still at introduction. Most prominent is the intelligence saturation which occurs as a result of collections far outpacing analysis. With expanding technologies such as Gorgon Stare, UAS operators and end users become "deluged in information."[37] Categorized as Wide Area Airborne Surveillance (WAAS) and identified as a requirement for the MCTUAS, Gorgon Stare allows a single sensor to survey large territorial swaths and provide multiple zoomed-in video angles, thus allowing upwards of 64 distinct feeds to interested parties by 2014. Add to this the planned signals intelligence (SIGINT) and other electronic order of battle contributions from MCTUAS and any resultant network, command center, or group of analysts may become inundated with information. LtGen David Deptula, the top Air Force Intelligence Officer, suggested the UAS community may soon be "swimming in sensors and drowning in data."[38]

Along with information overload, the unmanned community faces hurdles in autonomy and on-location human interface. Overseas operations lead many observers to glorify the prospects of unmanned forces to increasingly perform missions in lieu of manned aircraft. While no one questions UAS contributions, fundamental limitations do exist which will not yet foster their dominant role. In his November 2009 Armed Forces Journal article, Col James Jinnette reminded the defense establishment that remote operation and artificial intelligence cannot yet write off "network vulnerabilities, [ordnance] release consent judgment and, most importantly, creative capacity during air combat and close air support missions."[39] This is to say that ground control stations (GCS), as the Marine Corps describes remote operations hubs, and programming of autonomous mission capacity are not advanced enough to supplement a pilot's presence. Jinnette concludes that UAS technology over the next several decades will simply not replace a pilot's ability to grasp complex scenarios, exploit immediate opportunity, or interact fluidly with all on-station participants. By 2020, robotic systems will not "replace a pilot's gut instinct."[40]

Like the JSF, the up-and-coming Marine Corps Tactical UAS promises extensive capability; however, a couple critical constraints highlight near-term drawbacks. Unmanned systems offer value added to the MAGTF fight, but they are not a stand-alone, remedy force multiplier in early 21st century airspace.

Both the F-35 and MCTUAS bring in a large number of tools to support Marines in tomorrow's fields of fire; on the other hand, both systems possess associated weaknesses which do not fully accommodate the problems for which TACAIR readies. Interestingly, as both these airframes materialize above Marines in the coming decade, no aviation doctrine, guidance or concept—from either the strike-fighter or unmanned communities—addresses how these advanced systems will fight together to accomplish the same missions in the same area of operations. The UAS CONOPS briefly mentions terms such as manned-unmanned teaming (MUT), cross cueing, and information fusion. JSF presentations show lightning bolt connections between F-35s and other platforms, to include UAS. But comments and sketches do not complete a concept of operation, and they fall further short of identifying adequate requirements. The theory of 'network centric warfare' esteemed compatibility and interoperability across all platforms as a crown jewel for commanders and operators alike. But most warfighters attest that communication does not ensure collaboration and information exchange in no way guarantees integrated execution. Commanders and coaches alike emphasize that individual parts rarely make certain success. Truly, as with combined arms, it is the synergistic integration of parts that allows the whole to be greater than the sum. When Marines weigh the challenges of 2020 against the individual strengths and weaknesses of these two primary TACAIR platforms, the Corps' combined arms instinct prompts one to consider how the JSF and MCTUAS will integrate on the battlefield.

POTENTIAL: 'ALL IS NOT LOST' & REQUIREMENTS REDEFINED

Yes, as capability gaps and threat developments loom over the horizon, the TACAIR community exhibits signs of developing parallel, yet isolated 'game changers' and 'force multipliers.' Current wave-top speculation and power point briefs do little to conceptualize cooperative application between the F-35 and UAS. In the same way, both platforms' acquisition requirements appear limited in scope, spanning merely own-ship capabilities and air-ground coordinating tools such as previously mentioned VMF. Given that the F-35 and MCTUAS form the TACAIR treasury from 2020 to 2040, Marine aviation principally ignores that these two airframes must collaborate with one another to fulfill TACAIR functions. Yet all is not lost, and a momentous opportunity to realign efforts and synchronize TACAIR employment may be ahead.

Time is short. JSF initial operations capability (IOC) is merely two years away, and MCTUAS requirements must be cemented during roughly the same span in hopes of a 2020 IOC. On an acquisitions stopwatch, two years may equate to minutes. But both the F-35 and future unmanned systems are designed to use 'open architectures' and 'software reprogrammable payloads'—meaning capabilities and components may be added, upgraded or replaced simply by reprogramming or changing circuitry. In other words, the airframe and its hardware become ancillary compared to its software and associated programs. Moore's law, which describes the trend of processing speed and memory capacity doubling every two years since 1970, facilitates this framework and adds inherent flexibility into both platform design and upgrade.

As a result, two important events enable Marine TACAIR to unite F-35 and MCTUAS concept of employment going into next decade. The first is JSF software update schedules. Labeled as 'blocks', these upgrades occur on roughly two to four year intervals. Current test aircraft fly with block 0.5, and 2012 IOC will occur with block 3.0. Each block update adds notable improvements to weapons, sensors and interoperability. At this time, contractors and tacticians invest vast amounts of manpower, money and time to perfect the attributes of block 4.0 software, projected for release around 2015-2016. Witness to this process, characteristics of and requirements for block 5.0 software, envisioned to implement in 2020, ought to be articulated now so they become prioritized, funded, programmed and realized to completion.

The second opportunity rests with MCTUAS design, but it largely follows the same line of reasoning. Initial software architecture outlined by forthcoming design requirements will likely secure MCTUAS interoperability for its first several years, potentially half a decade. To suggest this airframe will possess data-link terminals such as LINK-16, and will therefore be 'integrated' with F-35, is an oversimplification which misses the mark. Positional awareness and nominal data sharing, two results of data-link connection, are an important start for collaborative warfighting in TACAIR airspace, but it falls well short of the opportunities to team these systems together. With major software design set to occur for both these platforms in the next two years and ramifications from these to be exploited in the crucial 2020 time period, employment ideas must be cast upon the drawing board today.

If these aircraft are to work together in MAGTF airspace, and a fleeting opportunity exists in the next two years to redefine requirements, three capabilities need to be developed to merge these platforms into a cohesive concept of operations. These three capabilities will form the basis for manned and unmanned collaboration between the F-35 and MCTUAS and consequently redefine requirements for software development within these two systems. These capabilities, just like the separate airframes themselves, do not solve all problems facing TACAIR in 2020. Nonetheless, they do serve to optimize each airframe, minimize one another's weaknesses, and multiply their effects on the battlefield, thus best mitigating the problems ahead. In our age of capital platform investment, impending operational shortfalls, proliferating enemy and decentralized operations, teaming the JSF and the next unmanned aircraft with these three capabilities best outfits tactical operators and informs operational commanders.

The capabilities required to team these systems together are as follows: collective cross cueing, mutual mission tasking, and exchangeable command and control. Each of these is distinct from the other, yet they form a building block approach. To begin therefore, collective cross cueing is the foundation for the three.

Cross cueing refers to the "passing of detection, geolocation and targeting information to another sensor without human intervention."[41] By design, both the F-35 and MCTUAS will perform internal cross cueing. Information from all available sensors—collected in the visible, infrared, or radio portions of the EM spectrum—will fuse to provide consolidated characteristics for any single subject of interest. For example, an F-35 might detect, locate and gather information on an emitting radar surface-to-air missile site from a multitude of onboard sensors, yet the pilot will see a single, fused display of that particular threat.

UAS will also internally cross cue, yet they will frequently be outfitted with fewer and potentially different sensors. Designed with modular payloads in mind, some systems will missionize with electronic attack pods and SIGINT collections boxes, while additional airframes will arrive on location with infrared targeting pods and laser-guided or GPS weapons. A third like-model might carry sophisticated communications relays, wide area surveillance cameras, data routers, and command and control packages. This payload modularity brings flexible options to the battlefield, yet it may limit available sources for any single unmanned airframe to synthesize information of, or even to be aware of, a specific item of interest.

Reason follows that each airframe requires subject information pertinent to its assigned mission or modular capability, but both JSF and UAS may also need to relay unused bits to other airframes or command centers. Therefore, these airframes must all reciprocate, or collectively share items of interest—regardless of payload or sensor—in accordance with mission and threat priorities and with little to no human workload. For this to occur, both platforms must possess common data link which accounts for various sensors to share various pieces of information. LINK-16 certainly provides rudimentary examples of this today, but it will not process and pass along minutiae compared with that of MADL on the JSF. Should the MCTUAS incorporate MADL into its assortment of built-in components? If so, can airframe design support MADL alongside other high priority systems? If not, by what other method or component can these airframes assimilate critical details real-time over the battlefield? Further yet, what organic sensors should the MCTUAS carry in order to consistently contribute to collective cross cueing? An optical targeting pod is essential for conventional targets, but synthetic aperture radar is required for longer range acquisition or bad weather days, and electronic surveillance equipment is necessary to participate in locating and/or targeting electronic signatures. Each of these capabilities resides to some extent within the F-35, but the UAS cost, size and weight limitations demand interchangeable options. In other words, organic UAS design will determine with whom and to what degree detailed cross cueing will occur, while variable modular setups will determine what sensors contribute to cross cueing on any particular flight. Specific payloads will be situational dependent, but a clear vision of fixed components and programmable software that facilitate collective cross cueing is essential. As a discussion panel of experts concluded at a December 2009 conference, "effective cross cueing" is a prerequisite for "seamless manned-unmanned integration."[42]

Fully reliant upon collective cross cueing, the second principle capability to enhance warfighting is mutual mission tasking. Simply stated, some scenarios may require that manned aircraft assign tasks to unmanned aircraft, while other situations may dictate unmanned aircraft task piloted Lightning IIs. It is not hard to imagine a remotely piloted aircraft providing strike coordination forward of the battlefield coordination line (BCL) and directing heavily loaded F-35's to quickly target enemy armor on the move. Passing coordinates via data link and relying upon digitally-aided TTPs, the long-endurance MCTUAS might leverage rapid ordnance turnarounds and expeditious manned sortie rates in order to digitally task, authorize, and employ F-35s to quickly disrupt enemy maneuver.[43]

Alternatively, forward thinking military minds see a circumstance in the years ahead when piloted aircraft might directly task unmanned platforms. Often described as the 'quarterback' in these situations, the JSF might assign tasks to unmanned aircraft in accordance with the tactical scenario. For example, F-35 radar warning receivers (RWR) might triangulate a surface-to-air threat that disrupts the safe flow of incoming MV-22 Osprey assault support aircraft. As the JSF provides over watch of and suppressive fires near the landing zone for the inbound raid package, the pilot re-roles an EA configured UAS from a nearby reconnaissance mission to now jam specific radar frequencies detected from the SAM threat. In essence, the F-35 'quarterback' called an audible and directed the actions of an unmanned 'player.'

The phrase 'a loyal wingman' is another mission tasking idea similar to the 'quarterback.' In this framework, unmanned aircraft would fly in the immediate locality with piloted Lightning IIs in order to provide mutual support in much the same way a wingman might. Continuing the storyline from above, while the flight lead's actual wingman detaches forward to destroy enemy aircraft alerted of the incoming raid package, the lead F-35 transitions to close air support for the Marines now disembarked in the landing zone. Lead also tasks a second MCTUAS, this one carrying a targeting pod and laser-guided munitions, to join overhead as small arms engagements escalate below. As the pace of events and confusion increase, the JSF acquires several enemy fire positions and, by clearance from a forward air controller (FAC), digitally tasks the UAS to release weapons which the F-35 then guides with laser energy. All the while, the unmanned platform's sensors simultaneously survey the wider area in search of enemy reinforcement and movement, or plumes from enemy surface-to-air shots—fulfilling the very mutual support responsibilities normally performed by loyal wingmen.

Numerous examples come to mind when unmanned aircraft with long-endurance, high situational awareness, and reach-back connectivity to commanders might need to or elect to task F-35s. At the same time, the 'quarterback' and 'loyal wingman' vignettes above illustrate possible tactical-level actions when it becomes optimum that manned aircraft task unmanned aircraft in detail. For both sides of this equation, two key sub-concepts and requirements must be developed to facilitate mutual mission tasking.

First, increased focus on autonomous control must be incorporated into UAS CONOPS and design. Automatic computer programmed flight is a rapidly expanding characteristic of unmanned aircraft. The Air Force, Army, Marine Corps and Navy each openly endorse the need for further reliance upon automation. Right now, most every large UAS relies upon a ground control station (GCS) manned with two to four individuals; however, military and industry agree that "the capability to operate multiple unmanned vehicles from a single operator is a powerful capability."[44] Advancements in sense and avoid technology, programs which allow UAS to 'see and avoid' other aircraft, along with "path planning" navigation and task modeling suggest autonomous technology will easily support tedious, long-duration, clear-cut actions that UAS routinely perform.[45] UAS flights at Edwards Air Force Base demonstrated further automated independence when aircraft executed automatic evasive and rerouting maneuvers after encountering pop-up threats.[46] Current unmanned systems already leverage fair amounts of autonomy, with takeoff, landing and some navigation occurring without direct real-time human control. The USMC would be wise to take advantage of autonomous developments in order to maximize actively controlled focus on the unmanned assets encountering fluid tactical scenarios or participating in high-level, decisive actions.

Transferable control is the other characteristic necessary for mutual mission tasking to occur. The UAS CONOPS highlights an innovation known as the "hub and spoke" method. Unmanned aircraft launch and recover under control of a hub, or home base ground station. This hub then "electronically hands off" the airborne system to a spoke GCS. This transition permits "split site" operations and encourages the station with closer proximity to the fight to control aircraft actions.[47] Mutual mission tasking demands that this control spoke expand to include airborne manned aircraft as well. Massachusetts Institute of Technology studies of tactical scenarios and military aircrew concluded in 2004 that giving control of UAS to manned aircraft is a good idea. Pilots not only needed to be kept 'in the loop' with respect to concurrent UAS operations, the study concluded, but they also desired to influence "the flow of the battlefield" by quickly tasking unmanned aircraft. In addition, manned aircraft control of unmanned systems reduced data link vulnerability, decreased data transmit time and therefore action and reaction time, and cultivated immediate confirmation of UAS actions and task accomplishments.[48]

Experiments and demonstrations over recent years reveal numerous methods to exercise control of a UAS from an F-35. Techniques such as voice commands and software control tools both provide viable options, and Air Force studies on human performance and systems integration continue to explore JSF airborne control of UAS.[49] As Robbin Laird explained in Defense Horizons, "the computer systems of the F-35 will manage new robotic systems" that will become part of the 21st century air order of battle.[50]

Technology developments support impressive steps towards unmanned autonomous flight operations and transferable control of unmanned aircraft from ground stations to manned aircraft such as the F-35. Like most any advances, this process is evolutionary as opposed to a binary off-now-on capability. For this reason, the Marine Corps must implement existing autonomous and control transfer technologies into MCTUAS requirements to lay the foundation for mutual mission tasking.

Exchangeable command and control is the final principle enabling collaborative JSF-MCTUAS operations. Cross cueing and mission tasking both demand concerted attention to implement technological advances into the JSF and MCTUAS software designs. Command and control exchange, on the other hand, relies primarily upon cultural acceptance of tactical platforms potentially serving in operational roles when properly delegated from the Tactical Air Command Center (TACC). Marine Corps Doctrinal Publication Six (MCDP 6), Command and Control, affirms a mission-oriented command and control mindset that exercises commander's intent to push decision-making to lower thresholds so the decision cycle becomes faster.[51] Described earlier in the section explaining baseline F-35 capabilities, the sensors and computing functions onboard allow this 5th generation airframe to operate independent of strategic air management assets such as the E-3 AWACS.[52] In effect, the F-35 tactician possesses the operational picture within a single cockpit and will be in a position to implement commander's intent across the MAGTF airspace. Tasking various UAS and providing cross cueing to those platforms is one tool the JSF pilot might exercise with appropriate situational awareness and delegated command and control authority. Likewise, unmanned systems may quickly be capable of serving in a command and control function. A MCTUAS equipped with a modular command and control suite might fuse information from nearby F-35s and autonomous operating UAS to enable a forward-based ground control station to serve as a command and control focal point.

With both platforms increasingly capable of serving in a command and control role, sharing or transitioning between the two will fully integrate their functionality. Stepping back to the earlier vignette, prior to the F-35's arriving on station before the raid package, two MCTUAS were positioned in the area of operations for hours ahead of time. One of these, likely the EA equipped airframe, could easily have served as the conduit for command and control initiating this mission. As the F-35s arrived on station, updates, guidance and tasks were passed based upon UAS situational awareness and commander's assessment. However, as threats emerged, the tactical situation complicated, and the timeline compressed, the lead F-35 retained greater battlefield understanding and could then accept a battle handover and command and control responsibilities. With dispersed operations, network vulnerability over long distances, and exponentially more situational awareness from the combination of these two airframes in the airspace, accepting and exchanging command and control responsibilities is the final step to facilitate integrated operations between Joint Strike Fighters and the Marine Corps' next unmanned aircraft system.

Over the next two years, both the F-35 and the MCTUAS programs have a window of opportunity to explore and implement capabilities which will synergize integration in MAGTF airspace. For these platforms to prepare for this conceptual cooperation, however, three fundamental capabilities must be developed and translated into program requirements. Collective cross cueing, mutual mission tasking and exchangeable command and control lay the foundation for this road ahead. Described as a "manned-robotic strike and situational awareness wolf pack," teaming the F-35 and MCTUAS together provides an ACE commander the most effective method to counter the challenges facing the TACAIR community in the year 2020.[53]

PARADIGM: TEAM CONOPS

> "The human factor will decide the fate of war, of all wars. Not the Mirage, nor any other plane, and not the screwdriver, or the wrench, or radar or missiles, or all the newest technology and electronic innovations. Men—and not just men of action, but men of thought. Men for whom the expression 'By ruses shall ye make war' is a philosophy of life, not just the object of lip service.
>
> —IDF-AF Commander, Ezer Weizman, On Eagles' Wings.

In ten short years, Marine TACAIR will streamline to two airframes that will define fighter-attack airspace until 2040. Coincident with this transition, the need for strike-fighter aircraft, amphibious shipping and operational fires will combine to strain TACAIR's ability to fulfill TACAIR responsibilities. Add to this a "fiendish and complex array of threats" that "directly threaten US command of the skies," as Secretary of Defense Robert Gates described, and few professional officers will hesitate to classify these events collectively as a problem.[54]

The transformational characteristics of the 5th generation Joint Strike Fighter and the impressive lineup of intended MCTUAS capabilities offer a glimpse of optimism and an initial counterbalance to these challenges ahead. But closer analysis reveals limitations with both aircraft which take a bite out of the transformational panacea. Traditionally, Marine combined arms thinking drives integration between systems so that the whole exceeds the sum of all the parts. In this case, the aviation community ignores this mindset and thus far fails to compose a concept of operations integrating the very two platforms which overlap in function and airspace.

Even so, near-term opportunities within the F-35 upgrade and MCTUAS acquisition cycles provide Marine TACAIR a window to implement a new paradigm—a re-created CONOPS that teams these platforms and redefines requirements to integrate their warfighting tools over the battlefield. Important potential capabilities such as collective cross cueing, mutual mission tasking and exchangeable command and control provide a foundation for cooperative TACAIR operations in subsequent decades. These capabilities can only be achieved if important, albeit sometimes controversial, technological advances receive funding lines and get incorporated into software builds. The intent is not to tie or connect these platforms together in a closed system, but rather to unite parallel aircraft in an integrated and complimentary manner.[55] This 'open architecture' style of collaboration merges previously 'stove-piped' systems and puts a "premium on flexibility and adaptability," as future warfare strategist and author Colin S. Gray described in his 2005 book titled Another Bloody Century.[56,57]

Colonel Robert Loynd reminded aviators that "It's not about Marine TACAIR—it's about the power of the MAGTF."[58] Major Alfred Cunningham, peering down from "Heaven's scenes" now 100 years later, undoubtedly agrees.[59] It will not be a game changer or a force multiplier that holds the line in 2020. It will be tacticians who stretch their minds and advance a team concept of manned and unmanned TACAIR aircraft that collaborate across functions of Marine aviation to support the MAGTF commander in 2020 and beyond.

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ABBREVIATIONS

ACE – aviation combat element
AVPLAN – Deputy Commandant for Aviation annual Marine Aviation Plan
BCL – battlefield coordination line
CAS – close air support
CMC – Commandant of the Marine Corps
COC – combat operations center
COP – common operational picture
CONOPS – concept of operations
DCA – Deputy Commandant for Aviation, USMC
EA – electronic attack
EM – electromagnetic
EO – electro-optical
EW – electronic warfare
FAC – forward air controller
F-35B – Joint Strike Fighter short take-off and vertical landing variant
GCE – ground combat element
GCS – ground control station
GPS – global positioning system
HQMC – headquarters Marine Corps
IOC – Initial operational capability
IP – internet protocol
ISR—Intelligence, surveillance, and reconnaissance
JSF – Joint Strike Fighter
LCS – littoral combat ship
MADL – multi-function advanced data link
MAG – Marine air group
MAGTF – Marine air-ground task force
MANPAD – man-portable air-defense system
MCCDC – Marine Corps Combat Development Command
MCDP – Marine Corps doctrinal publication
MCTUAS—Marine Corps tactical unmanned aircraft system
MEU – Marine expeditionary unit
MUM – manned-unmanned
MUT – manned-unmanned team(ing)
NSFS – naval surface fire support
OAS – offensive air support
QDR – quadrennial defense review
RPA – remotely piloted aircraft
RSTA – reconnaissance, surveillance, and target acquisition
RWR – radar warning receiver
SA – situational awareness
SAM – surface-to-air missile
SIGINT – signals intelligence

STOVL – short take-off and vertical landing
TACAIR – tactical aviation, usually referring to marine fixed-wing aviation
TACC – tactical air command center
T/M/S – type/model/series of aircraft
(ex: type, fixed-wing fighter-attack; model, FA-18; series, FA-18C)
TTP – tactics, techniques and procedures
UAS – unmanned aircraft system(s)
USMC – Unites States Marine Corps
VMF – variable message format
VMFA – Marine fixed-wing fighter-attack squadron
VMU – Marine fixed-wing unmanned aircraft squadron
WAAS – wide area airborne surveillance

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