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Distributed STOVL Operations and Air-Mobility Support: Addressing the Mismatch between Requirements and Capabilities

Robert C. Owen

DISTRIBUTED STOVL OPERATIONS AND AIR-MOBILITY SUPPORT

Addressing the Mismatch between Requirements and Capabilities

Robert C. Owen

This article examines the logistical support requirements of distributed short-takeoff–vertical-landing (STOVL) operations (DSOs) by U.S. Marine Corps F-35B Lightning II fighters, and alternative solutions to fulfilling those requirements. As presently envisioned by Marine planners, DSOs will improve the operational flexibility, survivability, and lethality of F-35Bs by operating them from constantly shifting networks of mobile forward arming and refueling points (M-FARPs). Current Marine Corps planning calls for deployed Marine expeditionary brigades (MEBs) to support DSOs both from the ships comprising their sea bases and by using their organic ground and aviation transportation assets. Studies show that this "organic" support concept is viable up to a multisquadron scale of operations.

However, this article suggests that a joint logistics approach based on U.S. Air Force (USAF) air-mobility assets can offer significant advantages in the flexibility and sustainability of DSOs and in reducing their risks, particularly in the face of enemies possessing sophisticated antiaccess/area-denial (A2/AD) capabilities. This article also assesses that the addition of a medium-sized tanker/transport aircraft would greatly enhance the capability of the current and planned USAF air-mobility fleet to support DSOs at the widest

Robert C. Owen is a retired U.S. Air Force colonel and current professor in the Department of Aeronautical Science at Embry-Riddle Aeronautical University–Daytona Beach. In this position, he teaches courses in manned and unmanned aviation operations, law, and history and conducts research in national defense policy issues. Professor Owen's military career included operational assignments as a C-130 pilot, Air Force and Air Mobility Command staff assignments, and educational assignments as an assistant professor of history at the U.S. Air Force Academy and as dean of the School of Advanced Airpower Studies. In addition to numerous articles and monographs, his publications include the Chronology *volume of the* Gulf War Air Power Survey *(1995),* Deliberate Force: A Case Study in Effective Air Campaigning *(2000), and* Air Mobility: A Brief History of the American Experience *(2013).*

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possible range of places that Marine Corps and combatant commanders might want to establish M-FARPs. Given the possibility that DSOs may offer the best, or even the only, opportunity to base fifth-generation fighters forward in strong A2/AD environments, the value of assessing these logistical alternatives is clear.

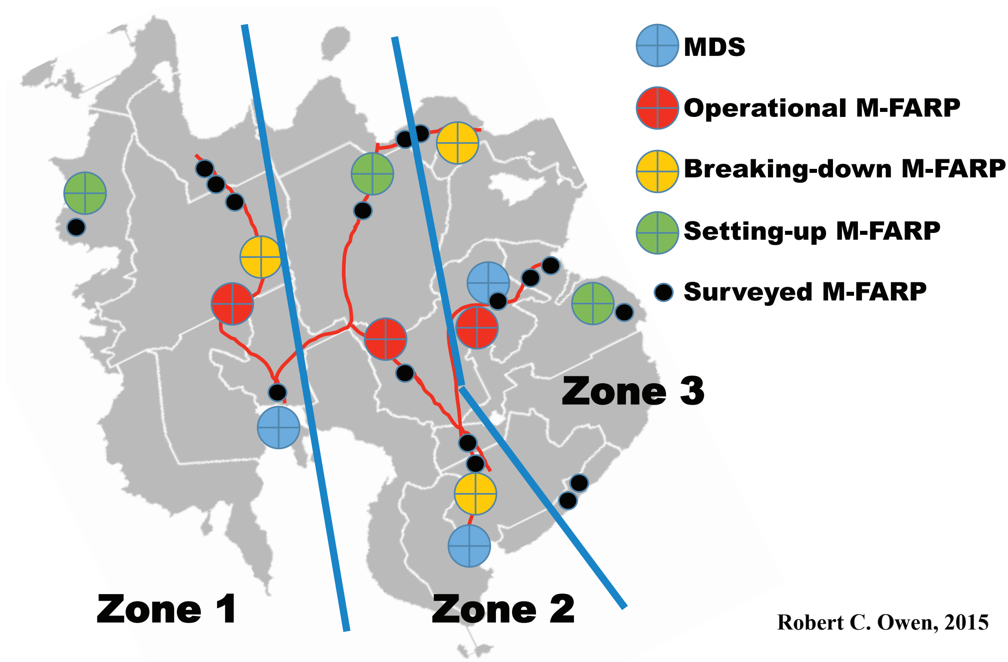
From an operational and logistical perspective, it is important to understand that sustained and successful DSOs will draw on the support of other Marine and joint forces and operations. Deception operations in the form of decoy facilities, along with counterintelligence signals and misinformation, will degrade and delay enemy efforts to locate and target active DSO elements with enough certainty to justify releases against them of high-value, short-supply weapons systems. Marine and host-nation security, combat-engineering, and logistics support will be needed to defend and sustain DSO units in the presence of differing combinations of enemy air and ground threats. F-35Bs operating from M-FARPs will often achieve their best successes as elements of broader air-component information, surveillance, reconnaissance, counterair and air-defense missile, and counterair operations. Although operating F-35Bs from M-FARPs could reduce demands on air-refueling (AR) forces, tanker support also can enhance the operational advantages of forward basing. Thus, while this article focuses on M-FARP logistics, logistical and operational planners should be aware of the full contexts and costs of such operations.

CONCEPT AND OPERATIONAL VIABILITY

Marine Corps planners expect DSOs to enhance the depth and power of F-35B operations through frequent and unpredictable relocation of their bases. More specifically, the 2015 Marine Aviation Plan explains that "DSO asymmetrically moves inside of the enemy targeting cycle by using multiple mobile forward arming and refueling points . . . [u]sing existing infrastructure (multi-lane roads, small airfields, damaged main bases) . . . [to provide] strategic depth and operational resiliency to the joint force . . . [and provide] the Marine Air-Ground Task Force (MAGTF) with game-changing strategic access inside of the enemy weapons engagement zone."[1] The success of the concept, therefore, rests on the ability of Marine commanders to shift force elements among networks of austere bases faster than enemies can locate, target, and release attacks against them.[2] These MAGTF assets may include actual and decoy M-FARPs, sea bases, mobile distribution sites (MDSs) linking sea bases to M-FARPs logistically, and the full range of MAGTF air transport, amphibious craft, and trucks to maintain robust supply flows.[3]

Consider a conflict with China in the western Pacific as a potential—although one hopes an unlikely—worst case. This scenario offers insight into the viability of the DSO concept. Most importantly, China's capacity to launch long-range

FIGURE 1
CURRENT-CONCEPT M-FARP LAYDOWN MAP



strikes against fleeting targets *decreases* significantly over distance. (1) Out to about four hundred nautical miles (nm) from its land bases, China can launch powerful, robust, all-capabilities (cyber, space, air, naval, and special-operations) "gorilla" strikes.[4] These capabilities draw on magazines of about twelve hundred short-range ballistic missiles (SRBMs), several hundred medium-range ballistic missiles (MRBMs), hundreds of cruise missiles, and around 2,100 (six hundred modern) combat aircraft. (2) Beyond the "gorilla ring," however, China's strike capabilities shrink to its MRBMs and cruise missiles, a few squadrons of medium bombers, and whatever fighter forces its limited AR fleet can project. (3) Beyond a thousand miles from the homeland, China's standoff strike capabilities are limited to cruise missiles carried by surface ships, submarines, and handfuls of air-refueled bombers, all operating at great risk in contested battle zones and generally far from their weapons-reload facilities.

China's ability to provide timely targeting data for M-FARP attacks also decreases quickly with increased distance from the homeland. Within the range of gorilla strikes, for example, China could search for DSO forces with a layered and robust network of information, surveillance, and reconnaissance (ISR) assets. These would include satellite-borne radar, optical, and other sensors; seaborne and airborne line-of-sight radar and optical systems; special operations forces (SOF); local fifth columnists; and even news reporters looking for scoops. Although some or all of these capabilities would be vulnerable to degradation or destruction by U.S. and allied attacks, they could for some periods provide near-continual, although not always detailed, surveillance of selected areas of interest.

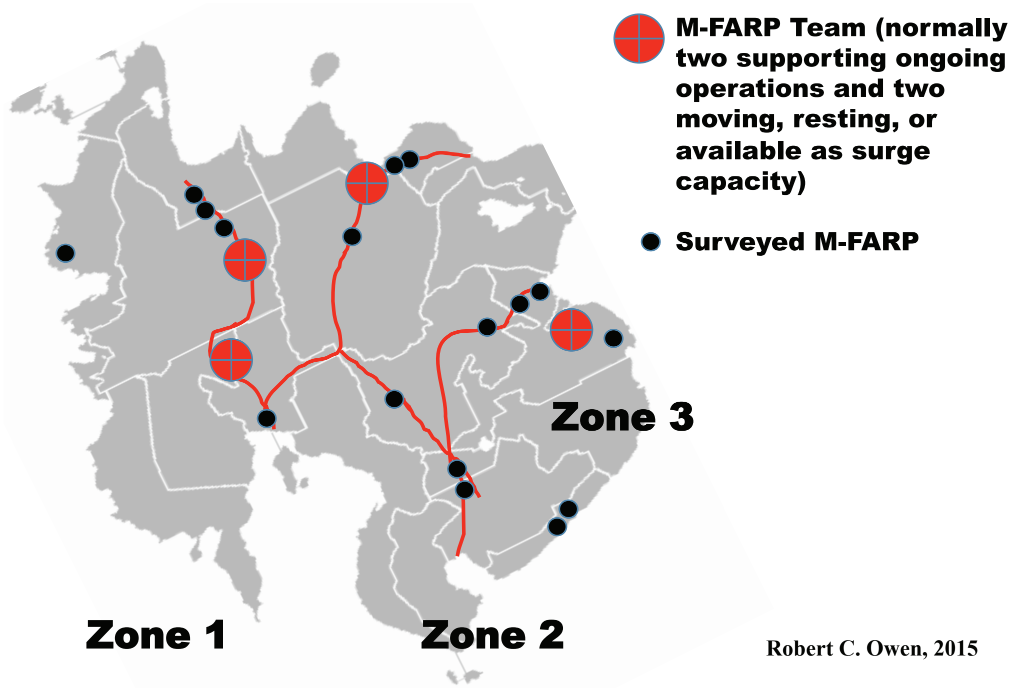
Beyond the gorilla ring, however, China's ISR capabilities would reside in a less-complete array of systems. These would consist of space and airborne systems, which would be sporadic, limited, or both in their ability to detect small and fleeting targets and subject to interference or interdiction; over-the-horizon, high-frequency radars, which are limited in their locational accuracy and target discrimination; and perhaps SOF and fifth-column elements, which would operate under significant limitations on their movements and communications.[5] Even in the face of an enemy possessing a strong suite of these capabilities, such as China, the Marine DSO study anticipates that the daily shifting of actual and decoy M-FARPs could allow them to evade detection for six to nine hours from the time they set up for a new day's operations.[6] Given the frequent relocations of these FARPs, the short ti me spans for which aircraft would occupy them, and the ability of M-FARP ground crews to disperse aircraft service points at random, information that was six to nine hours old would be stale and unusable for targeting long-range systems at M-FARPs with any confidence of actually hitting anything of value. Under such circumstances, DSO forces could do their jobs and survive.

Finally, some assessments of China's decision-making and command-and-control (C2) cultures offer additional hope for the success of DSOs. Given the limited supply and strategic importance of China's long-range missile and aircraft-attack systems, there is good reason to anticipate that the country's leaders would be reluctant to expend them on elusive M-FARPs that might or might not have aircraft on them when their warheads struck. They might think it better to hold back those weapons for use against targets of greater operational and strategic value, such as C2 centers, major air bases, aircraft carriers, supply ships, and fixed surface-to-air missile sites. Also, a number of experts on Chinese strategic issues recognize significant disconnects in trust, understanding, goals, and coordination between and within Chinese civil and military elites. These disconnects could delay or block weapons-release decisions against difficult or lesser-value targets.[7] For instance, civil leaders determined to preserve the deterrent value of the few hundred DF-21 MRBMs in their arsenal might refuse military requests to use them in speculative attacks against troublesome M-FARPs. In a major conflict, these weapon-management and civil-military disconnects probably would not provide reliable sanctuary for DSO units, but they might help delay or minimize the frequency, weight, and timeliness of attacks against them.

LOGISTICAL CHALLENGES

Given reasonable expectations that DSOs can be executed successfully, logistics emerges as a critical challenge to the concept's viability. DSOs involve a lot of

FIGURE 2
AIR MOBILITY–SUPPORTED M-FARP LAYDOWN MAP



moving parts, substantial supply requirements, and shifting lines of communication. The recent Marine Corps study of the organic transportation assets available to a MEB to support DSOs reveals just how big and complex the logistical challenge can be (see figure 2).

The study was based on a reinforced complement of thirty-six F-35Bs operating from a MEB sea base or an expeditionary airfield and supported by an onshore network of three MDSs, each supporting an operational M-FARP, plus one setting up and another breaking down.[8] For logistics-planning purposes, the study postulated that the air-combat element would launch twenty-eight aircraft daily, each flying an initial combat air patrol sortie, refueling and rearming at an M-FARP, flying another sortie, resetting again at an M-FARP, flying a third sortie, and then recovering to the sea base. Each F-35 would load missiles and six tons of fuel after each sortie. Together, then, the three M-FARPs would require resupply of 336 tons of fuel and up to 280 tons of containerized munitions each day.

Depending on the number of transportation and other vehicles deployed ashore to connect the MDSs to their M-FARPs, and on whether the F-35s bedded down on the sea base or an expeditionary airfield ashore, the total tonnage of fuel required to support the ground and air elements of DSOs would range from 544 to 1,337 tons per day, plus the nonfuel sustainment requirements of shore complements ranging from eight hundred to eighteen hundred personnel.[9]

FIGURE 3
NOTIONAL F-35B COMBAT AIR PATROL SCHEDULE

Source: System Planning and Analysis, "STOVL Operations," p. 37.

Whatever the basing model, satisfying these requirements likely would consume the lift capacity of almost all of a MEB's rotary-wing transport aircraft (CH-53Ks and MV-22s), amphibious craft, and trucks.[10]

Consequently, relying on MEB organic transportation assets to support DSOs could pose significant operational risks for Marine and joint commanders. Most importantly, tying DSOs to organic capabilities could limit the operational flexibility and overall responsiveness of the MAGTF in an unfolding campaign. Tailoring the MAGTF to support such an unusually large complement of F-35s likely would require leaving some of its normal complements of air- and ground-combat and support assets and personnel ashore to make room for additional F-35Bs and their support equipment and personnel. That, and the debarkation of so many vehicles and personnel ashore, could increase the time needed for the MAGTF to reconfigure and deploy for other missions elsewhere in a theater of operations.

An "organic" approach to DSO support also would increase the vulnerability of sea bases and transportation connectors to detection and attack. Trucks driving perhaps hundreds of miles between MDSs and shifting M-FARPs would be subject to the normal hazards of travel on sometimes primitive road systems, and vulnerable to long-range attacks at choke points and to harassment by SOF and locals sympathetic or beholden to the enemy. The short operating ranges of amphibious craft and CH-53 and MV-22 rotary-wing aircraft carrying externally slung loads of fuel bladders and missile containers would restrict the maneuver space available to ships in the sea base to within twenty-five to fifty nautical miles of their supported MDSs.[11] Thus, enemies detecting the presence of M-FARPs in an area would not have very far to look for their support ships, MDSs, and choke points along surface lines of communication. Reasonably, they would realize that striking those relatively fixed and thus vulnerable targets would be a more remunerative strategy for shutting down DSOs than expending precious ISR and long-range strike assets to snipe at elusive M-FARPs.

OPTIONS FOR MITIGATING LOGISTICAL RISKS

There are at least three options for reducing the logistical risks inherent in DSOs.

First, the Marine Corps could increase the size of supporting sea bases. For example, adding the twenty-aircraft capacity of an *America*-class amphibious assault ship (LHA) to a sea base could allow a MEB to support expanded F-35B operations with minimal reconfiguration of its other ships. The MEB, consequently, would remain ready for quick application to other missions.

Second, the Marines could allocate KC-130Js to carry some or all aviation sustainment supplies directly into supported M-FARPs. The KC-130s' ability to operate on multilane highways, damaged air bases, or unpaved airstrips would allow them to deliver support directly to or very near almost any location employed by F-35Bs. The advantages of this approach would be a reduction in shore complements and the risks associated with surface transportation between MDSs and M-FARPs.

The third option would be for Marines to draw on Air Force air-mobility assets to provide direct or near-direct support to the M-FARPs. The obvious advantage of this is that the air component's tanker and transport forces have greater range and capacity than organic Marine lift assets.

Each of these options offers significant advantages to DSO planners; but they also present significant concerns.

Expanding sea bases to support F-35B operations would present commanders with several operational and risk challenges. The first is finding a "spare" LHA and supporting ships somewhere in the world that could arrive on the scene of DSOs in a timely manner without imposing offsetting risks on the readiness of other MAGTFs. However, even presuming that operational urgency justified such a move, expanding a sea base would not mitigate the vulnerability of its ships or of the MEB's transportation assets ashore to long-range attack. In short, bringing in additional ships would be more about preserving the flexibility and responsiveness of the MAGTF than about improving the viability of DSOs.

FIGURE 4

Two J-35Bs prepare to refuel from a Marine KC-130J

USMC photo

Although applying Marine KC-130Js to M-FARP support could both enhance MAGTF readiness and reduce risks, the Marine airlift fleet generally is inadequate to the task. C-130J payload-distance characteristics often will fall short of need in theaters that are geographically expansive, such as the Asia-Pacific and Africa. For illustration, "Js" flying unrefueled, 2,800 nm round-trip missions between Tinian, an island outside the range of China's current MRBMs and land-based cruise missiles, and M-FARPs on the Philippine island of Luzon could deliver a maximum load of fifteen tons per sortie. C-130s operating from expeditionary bases outside the range of Chinese gorilla strikes but within range of heavy missile attacks—say, over the 1,380 nm round-trip between General Santos Airport in southern Mindanao and the Luzon M-FARPs—could deliver twenty-two tons per sortie. From a conservative estimate that air transports would have to deliver about 666 tons of cargo per day (336 for aviation fuel, 280 for munitions, fifty for all else), the impact of the distances involved and the C-130's payload-range performance becomes clear. On the basis of the data in table 1, a presumption of only one sortie per day per aircraft, and an 80 percent aircraft availability rate, the Marines would have to deploy fifty-six of their worldwide fleet of around sixty KC-130Js to support the Luzon M-FARPs. Assuming the same data, except now a two-sortie-per-day rate, twenty-eight C-130s would be needed to support the mission from Mindanao. Moreover, those C-130 units probably would have to conduct their own version of DSOs to survive operations within the enemy missile ring, with all the logistical burdens that would imply.[12]

It is also worth considering that, while the cargo decks of KC-130s would be capable of accommodating all the sustainment supplies and most of the vehicles M-FARPs would need, they would not be capable of handling some critical assets. These would include LVSR SIXCON refuelers (critical for getting fuel across rough terrain), fully assembled seven-ton trucks, and all-terrain forklifts. They also could not carry slat-armored light assault vehicles and some civil engineering equipment that might be needed to open and defend M-FARPs and lines of communication. The reality is that the Marine C-130 fleet is too small and limited in its cargo-handling features to deploy and sustain DSOs fully under the circumstances discussed above.

At first glance, the big transports and tanker/transports in the Air Force's global fleet appear to be a ready solution to the problem of reducing risks to sea bases and personnel during DSOs. Consisting of around 220 C-17 and 350 C-130 transports and fifty-nine KC-10 and four hundred KC-135 tankers, with KC-46 tankers to be added soon, the gross capacity of the mobility fleet dwarfs the most ambitious DSO requirements. Ten KC-46s flying 1.5 missions per day out of Tinian, for instance, could satisfy the 666-ton logistical requirements of the notional Luzon M-FARPs, and offer the added flexibility of aerial refueling.[13]

TABLE 1

Performance Specification	C-17A	C/KC-130J	A400M	KC-46A	KC-135R
General Aircraft Characteristics					
Maximum takeoff weight (MTOW) (lbs.)	585,000	164,000	310,850	415,000	322,000
MTOW for unsurfaced airfield (lbs.)	447,000	135,000	286,600	N/A	N/A
Maximum cargo load (short tons), surfaced runway	82	24	41	60	18
Tactical takeoff distance over 50′ obstacle, sea-level conditions	4,200	2,600	3,700	8,000 (normal MTOW field length)	11,000 (normal MTOW field length)
Tactical takeoff roll, no payload, fuel for 1,000 nm + reserve, standard sea-level conditions	2,500	1,700	1,640	N/A	N/A
Aircraft Classification Number, MTOW, concrete pavement, high-strength subgrade	52	27	18	44	37
Cruise fuel burn (pounds per hour)	21,000	5,500	8,500	10,500	11,200
Cruise speed (knots)	440	340	433	460	460
Length	174′	122′9″	148′	165′6″	136′4″
Wingspan	169′10″	132′7″	139′	157′8″	132′6″
Wheelbase	33′8″	14′3″	20′5″	30′6″	22′1″
Range (nm), MTOW, Normal Fuel Reserves + 1-Hour Refueling-Track Fuel When Operating as Tankers					
100% payload/fuel transfer (tons)	2,400 (80)	800 (22 cargo) 1,480 (30 fuel)	1,700 (41 cargo) 0 (69 fuel)	0 (106 fuel)	0 (100 fuel)
50% payload/fuel transfer (tons)	4,000 (40)	3,200 (12 cargo) 3,200 (15 fuel)	3,500 (20 cargo) 2,300 (35 fuel)	4,556 (52 fuel)	3,600 (50 fuel)
25% payload/fuel transfer (tons)	5,600 (20)	3,500 (6 cargo) 4,100 (7.5 fuel)	4,350 (10 cargo) 3,650 (17 fuel)	5,900 (26 fuel)	5,600 (25 fuel)

Flying the same profiles, seven C-17s could do the job, although without offering the AR option. In combination, then, relatively small numbers of Air Force air-mobility aircraft could obviate the need to keep sea bases close to shore and to put hundreds of Marines at risk driving and protecting trucks between MDSs and M-FARPs.

Unfortunately, the interplay of the payload-range and airfield infrastructure requirements of the Air Force's current and planned air-mobility fleet would limit its ability to support directly the austere M-FARP clusters favored by DSO planners. The big C-17s in the fleet can bring a lot of fuel and supplies into short and unsurfaced or weakly paved runways; however, just a few landing and takeoff passes will render such airstrips unusable through rutting and gouging.[14] Air Force C-130s could get into most M-FARPs, but they would suffer the same range, payload, and cargo-dimension limitations as their Marine cousins. Even worse, from a DSO perspective, all Air Force long-range tankers are modified airliners. As such, they are efficient load carriers, but capable of operating only from first-class airfields possessing long, hard-surfaced runways, taxiways, and parking areas. In many cases, therefore, joint air components will not be capable of transporting adequate amounts of cargo and fuel over theater distances and delivering them directly into M-FARPs. To the extent that these shortfalls in direct delivery capacity oblige MAGTF commanders still to put people and vehicles on the ground to move supplies from MDSs and big airfields to M-FARPs, the opportunities offered by air mobility to enhance operational flexibility and reduce risks will be lost.

MITIGATING THE AIR-MOBILITY SHORTFALL

Despite its present limitations, the potential of air-mobility support to mitigate the operational and logistical risks of DSOs justifies a search for ways to mitigate its inadequacies in support of M-FARPs. Of course, to be useful in the current financial environment, any opportunity considered must prima facie promise to improve operational capabilities significantly while imposing minimal or even reduced burdens on defense budgets.

These considerations suggest at least two courses of action worth pursuing.

First, Marine and Air Force logistical and operational experts must figure out how to get the most from the existing air-mobility fleet in the DSO context. This effort must include studies, discussions, and exercises that examine the full operational, logistical, and threat contexts of DSOs in the presence of moderate-to-high A2/AD threats. Such a learning process would improve the ability of all parties to use creative combinations of Marine and Air Force lift assets to conduct DSOs in a wider range of places than currently possible, and burden the budget only with the costs of thinking and training.

Second, the joint community should consider adjusting the air-mobility fleet to include an increment of aircraft better suited to support DSOs. At minimum, such an aircraft should have payload-range and cargo cabin dimensions suitable for transporting all DSO logistical requirements over strategic distances (meaning from bases outside the range of all, or at least most, enemy missile and aircraft strikes) and delivering them directly to or very near M-FARPs. Support from such an aircraft would allow Marine commanders to conduct maximal DSOs from the widest range of locations. Such aircraft also would improve the mobility fleet's capacity to support other operations requiring logistical throughput directly to points of need/employment, such as Army and Marine deep-maneuver operations, and resupply of air bases damaged or under the threat of damage by enemy A2/AD operations.[15] The utility and survivability of such a system would be further enhanced if it also possessed AR capabilities.

CASE STUDY

This section presents a case study to illustrate the leverage provided by a medium-weight, austere airfield–capable tanker/transport aircraft to DSOs. It is simplistic; clearly a full analysis of all the relevant mobility options available is beyond the scope of this article. But by providing an analysis of the effect of integrating Airbus A400Ms into DSOs, it should at least illustrate the value of this type of aircraft to operations in regions characterized by sparse airfield infrastructures.

The A400M is an "outsize" military transport/tanker aircraft capable of operating into virtually any airfield or multilane highway strip usable by the C-130.

FIGURE 5

A400M in flight

Courtesy of Airbus

FIGURE 6

A400M refueling F-18s

Airbus Defense and Space 2015; Photo by Master Films / A. Doumenjou, used with permission

In airlift parlance, *outsize* refers to an aircraft that has larger cargo deck cross-section dimensions than a standard military 463L cargo pallet. In this case, the A400's cabin, including the loading ramp, is 74′ length × 13′ width × 12.6′ height (minimum), while a standard-length Marine Corps C-130J's similar dimensions are 50′ × 10′ × 9′, including the loading ramp. The A400M's greater internal volume and up to forty-one-ton payload enable it to carry all the logistic vehicles, engineering equipment, and combat vehicles that DSOs are likely to require.

A400s provide a valid—and, realistically speaking, an unavoidable—baseline for this analysis, not because it is impossible to imagine a better design for DSO support, but because A400s offer the only option in this class of aircraft likely to be available to the U.S. Air Force for the next twenty or more years. The moribund Antonov AN-70 and the developmental Xian Y-20 are in the same class as the A400M, but are not likely candidates for the United States to acquire. For its part, the Air Force abandoned successful programs to develop outsize, short-takeoff-or-landing transports, the YC-14 and YC-15, in the late 1970s in favor of developing the C-17, a design that represented a greater trade-off of short-field capabilities for increased range and payload. While the service has studied the issue numerous times since, it has taken no concrete action to develop a new type of theater airlifter. Similarly, tanker aircraft based on repurposed airliner designs are not suitable. Importantly, one of the Air Force's most recent assessments of options for acquiring a new theater airlifter found that even a modest acquisition program carried thirty-year life-cycle costs of $62–$128 billion. The Air Force's study also found that purchasing an outsize "conventional takeoff and landing" aircraft (one possessing performance characteristics similar to those of the A400M) was the least expensive near-term option for enhancing support for Army deep-maneuver forces, apart from simply buying more C-17s and C-130s.[16] So, the analysis below is based on the A400M, in full awareness that the other option—building a new aircraft—remains on the table, although the experience of acquiring the C-17 suggests it could take ten to fifteen or more years from program approval to get the first squadron operationally ready.

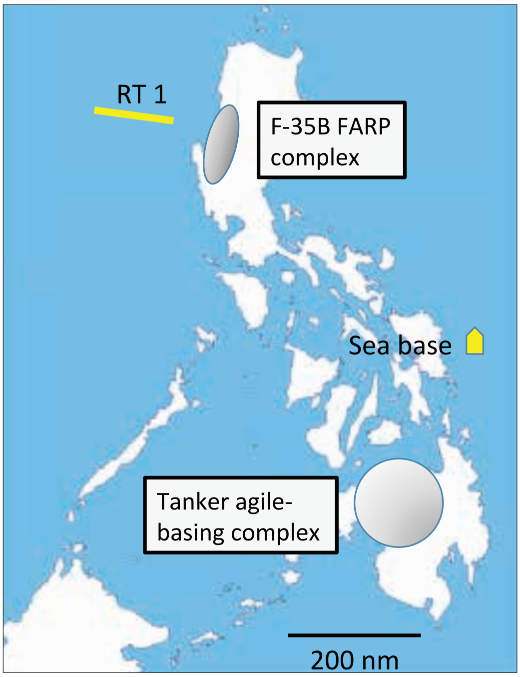
The case examined here is postulated on an escalating conflict over Chinese base building and oil drilling in the South China Sea, and efforts by the commander of U.S. Pacific Command (CDRUSPACOM) to deter Chinese action. In such a situation, if deterrence fails, CDRUSPACOM will want to have forces postured to seize the operational initiative anywhere along the Pacific Rim. Accordingly, CDRUSPACOM orders his Marine component commander to posture his on-scene MEB to support a reinforced component of thirty-six F-35Bs for high-intensity DSOs from a network of M-FARPs (see figure 2) on the island of Luzon. These operations could range from presence patrols over the central South China Sea to strike operations on its periphery. The PACOM commander further orders that the F-35Bs available be deployed as rapidly as possible, even as the MEB continues its organization and embarkation activities at Guam. Seeking further to preserve the readiness of the MEB for rapid movements in response to unfolding events, CDRUSPACOM directs his air-component commander to deploy an expeditionary group of A400Ms to an agile base complex around the Bohol Sea area to deploy and sustain DSO units and operations to the north.[17] As part of this commitment, the A400M force also will conduct AR operations in the vicinity of refueling track 1 (RT 1), west of the F-35B FARP complex. As soon as possible, the MEB and its sea base position themselves in a relatively secure maneuver area east of the central Philippines, from where rotary-wing assets can move relief personnel, fresh food, aircraft parts, and other light items to and from the M-FARPs.

Given this complex set of requirements, the Marines would posture their DSO force to reflect the robust air-mobility support available. Accordingly, the force laydown does *not* include MDSs and long road lines of communication between them and the M-FARPs. Few or no dedicated long-haul transportation assets go ashore. Instead, the Marine commander plans on air-deploying four complete M-FARP teams from Guam to Luzon, each postured to support up to twenty-four F-35B sorties per day from highway airstrips, and possessing the organic transportation assets needed to be fully mobile, including rolling storage of a day's supply of fuel and munitions. With all assets and supplies on vehicles, each M-FARP team is capable of breaking down and departing an M-FARP site in one hour, driving up to twenty miles to a new site in another hour, and setting back up for operations in a third hour. Thus, each M-FARP is expected to shift locations at least daily. Generally, any two M-FARP teams can support the pace of sustained F-35B patrol operations while the others are in motion or resting their personnel. All might be required to support offensive and defensive surges, but only for a few hours per day. The general complement of each M-FARP team is 150–60 personnel, four heavy LVSR SIXCON refueling trucks, sixteen seven-ton cargo trucks, eight MK970 five-thousand-gallon refueling trailers, thirty-three vehicles of the high-mobility multipurpose vehicle type, a large all-terrain forklift, and about a dozen miscellaneous trailers.[18]

The A400Ms working out of the Bohol Sea area turn out to be well suited to the mission of supporting DSOs. About twenty-eight A400M sorties suffice to move the 750 tons or so of vehicles and supplies needed to put an M-FARP in place and ready for the first day's operation.[19] A modest commitment of twenty A400Ms based around the Bohol Sea area could transport the first M-FARP team from Guam to Luzon in twenty-four hours, and move all four teams in just over three days. Once full-scale operations began, as few as ten to twelve A400M sorties per day could deliver the 666 tons of daily replenishment supplies needed by the M-FARP teams to support a combined daily tempo of twenty-eight F-35B missions, each stopping twice at an M-FARP to pick up full loads of fuel and munitions (see figure 3). Further, since these aircraft deliver their loads directly to, or very near to, the FARPs, their use eliminates the need to keep sea bases close inshore for their short-range amphibious and rotary-wing connectors to supplement the bulk logistics flow, and they eliminate the need for long, potentially vulnerable overland supply routes.

In comparison with the scenario laid out above, an effort to move and sustain this force by a combination of C-17s and C-130s would be more complex, would involve more sorties, and would increase operational risk. Moving the four M-FARP teams from Guam directly to their initial operational locations would require approximately 176 KC-130 sorties, plus a significant number of A400Ms or C-17s to move vehicles too large or too heavy to fit into a C-130.[20] Relying on C-17s to deploy the M-FARP teams and their daily supply requirements would greatly reduce the required sorties for the mission; but there are only eight developed airfields on Luzon capable of handling C-17s on a sustained basis; all are in or near major cities; and most have limited parking areas.[21] So aircraft flying into them on a repetitive basis would be visible to hundreds of thousands of people with cell phones, including many enemy nationals, and they would park at easily predicted and targeted spots.[22] Conducting sustained resupply operations into those airfields would undermine the flexibility and security of the MAGTF and its sea base by obliging it to debark substantial numbers of vehicles and personnel to transport supplies out to M-FARPs that could be a hundred miles or more away from an active aerial port of debarkation. A DSO logistics concept based on even minimal use of major airfields, therefore, might force sea bases back inshore to support the increased supply flows incumbent in the enlarged ground transportation effort, or drastically increase the amount of airlift required. In either case, much of the logistical, operational, and security benefits to be gained by bringing Air Force air-mobility aircraft into the picture would be lost.

FIGURE 7
FARP SCENARIO MAP



An additional benefit of operating outsize transport/tankers from the agile base network around the Bohol Sea would be the availability of AR support for the F-35Bs. Presuming, as an example, a sequence of three four-plane formations taking off at one-hour intervals to provide continuous coverage in one area, and potentially expending their advanced medium-range air-to-air missiles (i.e., AMRAAMs) on each sortie, the operational profile could look like this: each formation would depart the sea base, top off its fuel from A400Ms at RT 1 (see figure 7), patrol for one hour, proceed to an M-FARP for fuel and reloads, proceed back to its patrol area for an hour, return again to the M-FARP, patrol again for forty-five minutes, top off at RT 1, and then fly back to the sea base. Flying this pattern, the three formations would produce 2.8 hours of on-station time for each flight and cover the patrol area for 8.5 hours. For their part, the tankers would land at the M-FARPs as necessary to off-load munitions and recharge fuels-support vehicles. The basic logistics effort would be as follows.

Munitions required at M-FARPs	117 tons
Fuel required at M-FARPs	106 tons
AR fuel required (before first orbit and after last)	77 tons

Using the data in table 1, the chart below reflects the comparative capabilities of the A400M and the KC-130J to support this scenario from the Bohol Sea area.

Aircraft	A400M	KC-130J
Sorties required	9	18
Aircraft required	7	15
Fuel consumed by tanker/transport aircraft (thousand lbs.)	333	384
Ratio of fuel consumed / delivered to F-35Bs	.86	1.06
Required tanker/transport parking spots at each M-FARP	1	2

LIGHTNING RAIDS

Before summarizing the implications of this discussion of the integration of common-user air-mobility support into the DSO concept, it will be valuable to consider an important variation on that theme: the raid. There is a long history of air forces extending the practical depth of their offensive operations by teaming transports and tactical aircraft to establish temporary operating locations from which to conduct small-scale raids deep into enemy territories. The Marines, of course, are zealous practitioners of the art. Recently, the U.S. Air Force and Royal Air Force (RAF) have revived their interests in this concept. USAF experiments with the "Rapid-X" concept involve pairing two to four fighters with a single C-17 carrying the personnel, equipment, fuel, and munitions needed to generate sorties from isolated locations. Often this team would conduct operations in a "flex basing" mode: sitting at a particular airfield just long enough to launch a few sorties, then moving on to another location—always a step ahead of an enemy's targeting cycle.[23] Similarly, the RAF has received briefings from Airbus Defense and Space Corporation on using A400Ms to support forward fighter operations. In the Airbus scenario, an individual A400M or teams of them would deploy to austere, forward airfields, each with enough fuel and munitions to regenerate two to four fighters for an additional strike sortie. By eliminating return trips to distant main bases for rearming, this concept can nearly double the number of strike sorties available from a given force of F-35Bs over given spans of time, while nearly halving the amount of fuel burned.[24]

Once again, medium-weight, short-field tanker/transport aircraft offer attractive opportunities to exploit these linked transport-fighter and forward-operating-location concepts. Teams of A400M-equivalent aircraft and F-35Bs could operate into and from asphalt and concrete runways and highway strips of four thousand feet in length or less, presuming the fighters used vertical-rolling-takeoff-and-landing (VRL) procedures.[25] A pairing of C-17s and conventional-takeoff-and-landing F-35As and Cs, in comparison, would need runways approximately seven thousand feet in length for conventional fighter takeoffs and landings, and with high load-bearing capacities to accommodate the heavy transports. C-130s can match the airfield performance of the A400M, of course, but their operational radii generally would be smaller in support of DSOs, and they would require more sorties to support a given effort.

IMPLICATIONS

Particularly if they are augmented by medium-weight, austere airfield–capable tanker/transports, the potential benefits of using Air Force air-mobility forces to support DSOs include these:

1. Providing a flexible and reliable option for supporting DSOs in a wide range of situations
2. Preserving the operational readiness of an embarked MEB by substantially reducing the size of the onshore forces needed to support DSOs
3. Reducing the vulnerability of the sea base and onshore forces to A2/AD threats
4. Reducing the need to move carrier battle groups into forward threat zones to extend their strike range, contribute to extended deterrence, or protect Marines ashore
5. Facilitating flexible deterrence by permitting the placement of strong and survivable air forces inside enemy threat rings; indeed, air mobility–supported deployments of DSO forces may in many cases be the only effective means to exploit the short windows of opportunity available to deter enemy actions that might convert confrontations into wars
6. Improving the effectiveness of the overall air-mobility fleet in support of DSOs and other important missions, such as supporting land force deep-maneuver and battle-damaged air bases

The way forward seems clear. For a start, Marine DSO and Air Force mobility planners need to meet, learn each other's "language" and operational issues, and then rigorously examine the ability of the program-of-record fleet to support DSOs in a resilient and operationally effective manner. This discussion should include Marine and Army ground-warfare experts, since the final answer on whether the Department of Defense should acquire a new transport aircraft will rest in part on its relative value to requirements in addition to DSOs.[26] Finally—and particularly if an international design comes into the spotlight—it would not hurt to involve interested congressional, Defense Department, and civil experts in the discussion from the start. In the quest for offsets and trade-offs to finance a new fleet segment, the support of those experts will be important to the outcome of the unavoidable political fights with the stakeholders and proponents of existing aircraft programs. In other words, this is a big issue, but one that is strategically important to the warfighting capabilities of the Marines and, indeed, all the service components.

NOTES

1. U.S. Marine Corps, *Marine Aviation Plan 2015* (Washington, DC: November 2014), p. 2.3.7.
2. The term "austere airfield" has many meanings in defense literature. In regard to support infrastructure, the term generally implies very

limited or nonexistent facilities for storing fuel, housing personnel and maintenance activities, parking aircraft on paved surfaces, and the like. In regard to runways, the term here indicates paved or unpaved surfaces characterized by length and load-bearing features that restrict the types of aircraft that can use them or that require "tactical" landing and takeoff procedures by the aircraft that do use them. A three-thousand-foot-long stretch of highway, for example, is "austere" because it offers no aircraft support facilities, and the F-35Bs using it would have to employ short-field landing and takeoff procedures to use it.

3. Bill Sweetman, "Fast Movers: Marines Push Shell-Game Plan for JSF Survival," *Aviation Week and Space Technology* (15/22 December 2014), p. 42.

4. "Gorilla" is a standard U.S. military brevity code for a "large force of indeterminate numbers and formation of unknown/nonfriendly aircraft." See Air Land Sea Application Center, *Brevity: Multi-service Brevity Codes,* June 2005. The four-hundred-nautical-mile boundary of the gorilla ring reflects a reasonable guess that the unrefueled combat radii of Chinese J-20 and J-31 fighters will be roughly equivalent to those of weapons-laden F-16s and F-18s, respectively. However, China's SRBMs have ranges of three hundred nautical miles or less. See U.S. Defense Dept., *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2015* (Washington, DC: April 2015) [hereafter DoD, *Annual Report 2015*], pp. 8–15, 34, 39, and 87–89 for details on China's air and missile orders of battle.

5. Jonathan F. Solomon provides a useful discussion of the theoretical limitations of long-range ISR systems in support of long-range attacks in "Defending the Fleet from China's Anti-ship Ballistic Missile: Naval Deception's Roles in Sea-Based Missile Defense" (master's thesis, Georgetown University, April 2011). For those with a deeper technical curiosity about the propagation and control of backscatter signals, see Gary S. Sales, "OTH-B Radar System: System Summary," U.S. Air Force Systems Command, Phillips Laboratory, May 1992.

6. System Planning and Analysis, Inc., *Distributed Short Take-Off Vertical Landing (STOVL) Operations: An Initial Look at Concept Development and Feasibility Final Report* (Washington, DC: 13 February 2014) [hereafter System Planning and Analysis, *STOVL Operations*], pp. 45–56.

7. The conflicting perspectives and barriers to communication among China's civil and military leadership groups are discussed in Michael Kiselycznyk and Phillip C. Saunders, *Civil-Military Relations in China: Assessing the PLA's Role in Elite Politics* (Washington, DC: National Defense Univ. Press, 2010), pp. 6–7, 11–28; and in DoD, *Annual Report 2015,* p. 32. See also James Mulvenon, "Rearranging the Deck Chairs on the *Liaoning*? The PLA Once Again Considers Reorganization," *China Leadership Monitor,* no. 43 (14 March 2014), www.hoover.org/.

8. System Planning and Analysis, *STOVL Operations,* pp. 36 and 59.

9. Ibid., pp. 59–60, 64, 70–72.

10. Ibid., p. 36.

11. Ibid., p. 64, estimates that moving the sea base out to one hundred nautical miles from the M-FARPs would reduce its support capacity to 57 percent of the fuel and 21 percent of the ordnance needed by DSO units.

12. I explored the possibility of using ships to support distributed and agile basing for air-refueling operations in "Sea-Land Basing of Air Refueling Forces: A Concept for Resiliency and Efficiency," *Air and Space Power Journal* 29, no. 2 (March–April 2015), pp. 5–28. The concept is viable, but the return on investment is directly proportional to the capabilities of the aircraft supported and the number of airfields they are capable of using.

13. Estimates based on KC-46s with an 80 percent availability rate and flying the 2,800-mile round-trip at 460 knots, taking off with 106 tons of fuel, burning thirty-two tons getting to and from their refueling orbits, allowing for another fifteen tons for two hours in a refueling orbit and an hour of flight reserve, leaving a maximum fifty-nine tons of off-load fuel per mission. These estimates are close approximations based on Boeing 767 data available in Boeing, "767 Airplane Characteristics for Airport Planning," September 2005; *Air Mobility Planning Factors,* Air Force Pamphlet 10-1403, 18 December 2003; and

"Boeing 767-300ER," in *Jane's All the World's Aircraft 2012–13,* ed. Paul Jackson (London: IHS Global, 2012), p. 998.

14. Air Force Civil Engineer Support Agency, "Engineering Technical Letter 97-9: Criteria and Guidance for C-17 Contingency and Training Operations on Semi-prepared Airfields," 25 November 1997, p. 10; Lockheed Martin Corporation, "C-130J Super Hercules: Whatever the Situation, We'll Be There," n.d., p. 18, retrieved from cc-130j.ca/. See also Erik W. Hansen, "Evaluating the C-17 Semi-prepared Runway Capability—An Off-Road Map" (graduate research project, Air Force Institute of Technology, Wright-Patterson AFB, Ohio, June 2002), p. 6, for a well-reasoned argument that the C-17's semi-prepared runway capability "is not as routine as many interested parties would think."

15. Robert C. Owen, "Theater Airlift Modernization: Options for Closing the Gap," *Joint Force Quarterly* (4th Quarter 2014), pp. 13–18.

16. Air Mobility Command, *Joint Future Theater Lift: Technology Study Final Report,* 20 February 2013, p. 125.

17. For discussion of this concept, see Owen, "Sea-Land Basing."

18. These personnel and vehicle numbers are derived from data in System Planning and Analysis, *STOVL Operations,* pp. F-2–9, with extrapolations to allow for increased rolling fuel-storage capacity.

19. Estimate based on moving the vehicle and personnel complements and first-day supplies of fuel and munitions described and the loading information provided in Airbus Industries, "A400M: Combat Delivery to the Point of Need" (briefing, 2012), slides 4–9.

20. Estimates based on C-130 load data provided in Lockheed Martin Corporation, "C-130J Super Hercules," pp. 4, 7, 8–12, and bits and pieces of data extracted from other sources. While these estimates certainly are not definitive, they should be close enough to reality to support comparisons between the aircraft involved.

21. These are Bagio, Clark, Fort Magsaysay, Laoang, Ninoy-Aquino, San Fernando, Subic, and Tuguegarao airports.

22. There were 28,750 Chinese nationals residing in the Philippines in 2010, along with 29,959 U.S. citizens. "Foreign Citizens in the Philippines (Results from the 2010 Census)," *Philippine Statistics Authority,* 19 November 2012, psa.gov.ph/. There also are about thirty million Philippine citizens of Chinese descent, including two million of pure Chinese ancestry. *Wikipedia,* s.v. "Chinese Filipino," en.wikipedia.org/.

23. Earlier experiments in this concept were conducted with F-22s, and hence the concept was called "Rapid Raptor." Blake Mize, "Rapid Raptor: Getting Fighters to the Fight," *Pacific Air Forces Public Affairs,* 20 February 2014, www.pacaf.af.mil/; Robert D. Davis, "Forward Arming and Refueling Points for Fighter Aircraft: Power Projection in an Antiaccess Environment," *Air and Space Power Journal* 28, no. 5 (September–October 2014), pp. 5–28.

24. Airbus Defense and Space, Inc., "A400M Forward Arming and Refueling: An Illustrative U.K. and Coalition U.K./U.S. Somalia Air Strike Scenario" (briefing, 26 February 2015).

25. VRLs involve the use of thrust vectoring to shorten takeoff and landing rolls, while minimizing or eliminating damage to asphalt and concrete surfaces. In theory, VRLs would enable F-35B operations on hard-packed unpaved airfields as well, but I am not aware of the Marines' testing that concept.

26. Owen, "Theater Airlift Modernization," p. 18.