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14. ABSTRACT
The future operating environment for the warfighter is rapidly changing based on technology available in a manned unmanned-teaming (MUM-T) capacity. This research analysis focuses on capturing the roles of MUM-T in terms of capability and capacity on the battle field. Followed by a brief MUM-T primer, a historical synopsis of an aircraft MUM-T design developed to handle a complex problem set will be analyzed, followed by a future MUM-T concept and employment methodology abstracted from a group of subject matter experts within the USMC Command Staff College Program.

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MASTER OF MILITARY STUDIES

TITLE:

A HISTORICAL APPROACH OF MANNED, UNMANNED-TEAMING AND APPLICATION TO FUTURE DESIGN CONCEPTS: AN AIRPOWER PERSPECTIVE

SUBMITTED IN PARTIAL FULFILLMENT
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DISCLAIMER

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Finally, I would like to thank the Advanced Studies Program (ASP) students for sharing their collective insights and recommendations towards my historical case and operational decision game/design, as well as all the USMC Command Staff students who participated in the event. I have learned a tremendous amount from their personal experiences as warfighters across the air, land, sea, and cyber domains.

Executive Summary

Title: A Historical Approach of Manned, Unmanned-Teaming and Application to Future Concepts: An Airpower Perspective

Author: Major Max "Efes" Cover

Thesis: The lethal complexity of the modern battle space has surpassed a warfighter's ability to operate and win without reliance on unmanned platforms and sensor fusion. This thesis attempts to highlight the importance of pairing manned platforms with unmanned systems in the form of Manned, Unmanned-Teaming (MUM-T) by using a historical case and pulling out enduring principles of warfare, and then applying them to future concept and design in regards to airpower.

Discussion: In the late 1960's, the Cold War was creating uncertainty, fear, and panic between the US and the Soviet Union regarding strategy, weapon development, and future intent between the two nations. This fear from the US was driven by a lack of credible intelligence gathering was a byproduct of the Soviet Union's ability to establish an anti-access, aerial-denial (A2-AD) environment putting conventional intel collection platforms at risk. Prior to the KH-4 and KH-7 satellite collection systems coming online, the US was in need of a capability that could penetrate the Soviet Union's A2-AD environment in order to gain pertinent intelligence.

This paper covers in detail a historical airpower case and endeavor brought upon by the US in order to gain advantage over a peer threat through development of a reconnaissance platform utilizing a manned/drone aircraft team capable of A2-AD penetration during the Cold War period. The lessons learned from this case was then applied to conceptualize future methods of MUM-T employment and design by building an operational decision game using existing concepts currently in design by Lockheed Martin and Defense Advance Research Project Agency (DARPA). This operational decision game was played by a select group of military subject matter experts in the land, air, sea, and cyber domain in order to establish a nexus of concept, design, and methodology of future MUM-T in the role of air power.

Conclusion: Tomorrow's fight will inevitably be more challenging, more complex, and more uncertain than today's. Although each generation of fielded technology on the battlefield poses increased risk to a warfighter in terms of lethality, there are enduring principles of warfare that can be utilized to create successful MUM-T design to counter these risks. Through continual application of operational decision games which stress tests these principles in order to support concept design methodology in creating future MUM-T, the US warfighter will maintain the advantage on the battlefield, even against its most lethal peer.

1. Introduction:

"Thus, what is of supreme importance in war is to attack the enemy's strategy…"[1]

- Sun Tzu (Art of War)

Today's warfighter is faced with a multitude of complexity on the battlespace. From fifth-generation technology dominating the air domain flying at supersonic speeds and reduced signatures to highly skilled battlefield soldiers on the ground equipped with technology capable of massing combined arms on multiple target sets- the operating environment is becoming increasingly lethal. This rapidly evolving environment therefore requires a thorough understanding of the roles of human-machine collaboration in the battlespace as a military professional. As technology progresses, which will inevitably present future capabilities that either augment or replace a warfighter entirely in a specific warfighting domain, it is vital to reach back in history to gather appropriate lessons learned that are arguably enduring in nature in order for future concept development and design.

This thesis attempts to capture this nexus of what air power human-machine collaboration could look like in the form of manned, unmanned teaming in the future air domain against a lethal integrated air defense system. In addition to this, although substituting a warfighter for a machine on the battlespace can greatly enhance a campaign's success, moral implications may arise if a nation state becomes reliant on this form of war fare due to the very nature of its ease of use to for failed politics. Following this synopsis of human-machine collaboration to include this moral facet, this paper will provide an in-depth analysis of a historical manned, unmanned teaming case which involves the application of airpower during the Cold War period.

The application of manned and unmanned teaming is not a new concept in military application. The purpose of *how* it is used in a synchronized fashion in which a warfighter operates via an augmented state is the essence of what is captured from the historical case presented. During the Cold War period, the Soviet Union and the US were not only at an arms race with each other, their borders were sealed off preventing the collection of intelligence pertinent for US national level decision making which included the potential use of military force. This anti-access environment caused a significant intelligence gap resulting in a creative US interagency response to develop a manned, unmanned teaming solution that attacked the Soviet's strategy instead of the problem it was faced with.

Following this synopsis, a future concept of manned, unmanned teaming based off the historical case in this paper was built in the form of an operational decision game, and then played by a group of highly skilled warfighters across the joint services. The collective responses were then categorized in parallel with current US joint doctrine in order to highlight the enduring nature of the character of war guised through warfighting functions. This format of binned responses allowed for the author to create a future manned, unmanned teaming design concept using methodology that incorporates current air vehicle platform concepts being tested by leading US manufacturing corporations.

The recommendations brought about with future concept and design in this analysis is relevant across all the joint services, and especially for the United States Marine Corps (USMC) with a new future Operating Concept. As a smaller, middle-weight fighting force with an embedded Air Command Element (ACE), the USMC will undoubtedly rely heavily on its single fifth-generation air platform (F-35B) in a future fight. Based on that assumption of being limited in terms of capacity, there are significant lessons learned both in the historical case presented as well as development of future concepts and design regarding the application of future airpower in a manned, unmanned teaming role.

2. Manned-Unmanned Teaming Utilization and Methodology: *A Brief Primer*

Manned-Unmanned Teaming (MUM-T) is paving a new path of warfare complexity on the modern battle field. From semi-autonomous computer systems aiding in fusion of sensor collection reducing the targeting cycle timeline or the physical unmanned aerial systems conducting strikes on this collection, today's operating environment has changed. Although unmanned systems in military history is not a new concept, the evolution of pairing robotic systems side by side with a warfighter in a synchronized manner presents a new challenge for the enemy. This brief synopsis will focus on capturing the recommended nexus of MUM-T at its conceptual core with consideration of the moral element that is often overlooked amongst military and scholarly professionals.

MUM-T, as defined in 2014 by the US Army Unmanned Aerial System (UAS) Project Management Team is *the doctrinally-supported merger of manned air and ground capabilities with current and emerging unmanned system capabilities that provides the synchronized employment of soldiers, manned and unmanned air and ground vehicles, robotics and sensors.*[2] In essence, it is the missing link between man and drone on the battlefield, and more importantly how the two complement each other's capabilities in order to defeat an enemy force. Although somewhat vague of a definition, the MUM-T concept can be envisioned in many ways in terms of usage and methodology in any of the warfighting domains. However, if the envision does not increase both lethality and situational awareness to a warfighter on the battlefield, then it should not be pursued or procured as a viable method to conduct military operations.

To add supportive evidence to this stance, one need not look any further than what is perhaps the oldest form of military doctrine and philosophy currently taught at top level US military institutions- Clausewitz' *On War*. Carl Von Clausewitz, a notable military practitioner during the Napoleonic era believed that danger, physical exertion, and intelligence are the primary friction elements that coalesce to form the atmosphere of war, which then turns into a medium that can impede all activity and efforts.[3] Warfare is exhausting both physically and psychologically, which can turn a theory of victory to favor the army that is most capable of withstanding the stress and duration of conflict. Incorporating use of robotic drones that can lighten the physical workload acts as a force multiplier on the battlefield. Every component of MUM-T planned integration should account for this element to ensure reduction of stress on the warfighter, which will increase lethality on the battlefield in return.

Intelligence, Clausewitz' second friction point in the atmosphere of war, is vital to operational success in any campaign. Without it, a warfighter is left in the dark relying on his/her own tactics, techniques, and procedures without knowledge of the enemy's center of gravity or vulnerabilities, hindering success on the battlefield. Incorporating MUM-T concepts that are capable of collecting critical data from onboard and off board sensors and be able to collectively fuse it into a common operating picture that reduces the cognitive task load of the warfighter needs to be accounted for in any paired teaming design. In today's fight, there is often an information overload that is poured into the planning cells- being able to have a MUM-T pair that can process data faster than the human mind and prioritize target lists or other pertinent information is paramount. This is perhaps the second most important design feature that will enhance lethality on the battlefield.

Finally, Clausewitz' final friction point and most important aspect to consider with MUM-T design/utilization is *danger*, and for purposes of discussion, relabeled as *risk assessment*. Modern military service doctrines utilize different approaches with risk assessment, which often appear in the form of a force ratio calculation used by warfighters during periods of anticipated contact with the enemy. By anticipating an enemy to friendly force strength, acceptable courses of actions will emerge as options to maximize lethality and survivability in the battlespace domain. Every MUM-T design should account for this in creation and teaming methodology- any time a warfighter can reduce risk posed on him/her and pass that risk off to a drone the better. This can be in the form of a swarm drone technique to mask the manned warfighter through oversaturation, a form of a low observable technique in order to maintain surprise on the enemy, or simply an "extra wingman" in a warfighter's immediate battlespace to shape the fight to an advantageous state.

When factoring for Clausewitz' elements that create friction in the atmosphere of war, perhaps an over looked element that is worth considering with MUM-T usage is the *moral* element. Just because a nation can use drones to fight its battles doesn't mean it always should, or does it? War is a gruesome endeavor that no soldier should have to bear on their shoulders which would make for a large appetite for an arsenal of drones to fight in their place. There are certainly arguments for drone warfare taking the place of a warfighter on the battle-field in order to eliminate exposure to violence, however, this methodology can be a slippery slope. Should this effort to replace a warfighter with a drone be in all domains of the battle space or equally spread throughout the air/land/sea domain? It could be postulated that the more a drone is used to conduct warfare operations instead of a nation's sons and daughters, the easier it will be for operational decision makers to employ them more and more, challenging the morality of what is right and wrong in the conduct of war.

As a quick example, let's briefly look at the US' own MUM-T usage regarding UAS/target cell airstrikes on high value targets. On October 7, 2001, the CIA had conducted the first US operational drone strike in a remote region of Afghanistan. Limited somewhat in both capability and capacity at the time, this was a true measure of MUM-T integration and sensor fusion on the battlefield of months of intelligence collection from numerous actors to pulling the trigger stateside on a remotely operated platform to take out a high value target.[4] Fast forward fifteen years (one generation of warfighters) and one will see the remarkable expansion of drone hunting by the US in Afghanistan, Iraq, Syria, Libya, Pakistan, Yemen, and Somalia.[5] The amount of drone strikes conducted by the US has literally increased tenfold in the past decade, which may raise an eyebrow on the morality of conducting "war" abroad. The easier the methodology to kill a target with a decreased footprint of the country conducting the strike, the more it is being utilized, which in turn creates a higher demand for this capability.

If nation states continue down this path, there is potential risk that future battlefields will consist heavily of drones conducting operations based on preset employment criteria which can eventually eliminate the "moral check" that combat aviators/ground operators ensure prior to weapon release or trigger pull. When conceptualizing future MUM-T utilization and design methodology, it is necessary to account for this moral element as to what is right vs wrong in terms of employment when determining the design implementation of the system. Hitting the easy button by remotely operated strikes every time the opportunity presents itself can have a dangerous side to it that can shift a country's mindset of becoming an everyday norm, as proven with the dramatic increase in US drone operations over the past decade. Now that a brief primer on the nexus of what MUM-T should encapsulate using Clausewitz' three elements of friction with the addition of the moral facet, a historical case of MUM-T design will be analyzed in detail. Throughout this historical analysis, it will be evident that Clausewitz' three elements identified in this synopsis are in fact enduring and evident in the historical case's design features of the manned aircraft/drone pair.

3. A Historical Case of Manned Unmanned-Teaming: *The Curse of Icarus*

Imagine being on a mission, staring through the canopy glass of a cockpit at the curvature of the earth overflying Soviet Union territory at 72,000' MSL and at a speed greater than eight nautical miles per minute. At this altitude, there is no "blue sky" above you, only darkness as you surf across the bright atmospheric haze staring down at foreign soil twelve miles below. The only thing keeping the body's blood from boiling is a pressurized space suit strapped to a highly secretive, black world aircraft developed for the CIA by Skunkworks Corporation. The aerial mission being conducted is so sensitive to US national security that all aspects of the mission were conducted in absolute secrecy- an eight-hour mission trespassing into the unknown, alone and unafraid.[6]

Everything is going as planned until the aircraft missile launch indicator inside the cockpit illuminates with multiple indications from Russian surface-air-missile (SAM) systems. Visual pickup of the SAMs are acquired from the smoke trailing the missiles and out of habit, years of training take over. After multiple attempts to defeat the threat by maneuver, one of the missiles still guides on the aircraft and detonates inside the missile's kill radius. Numerous pieces of shrapnel rip through the fuselage, and the aircraft starts to depart flight, presenting that rare event in life where the mind slows seconds in to what seems like eternity, a surreal moment of clarity that can only be experienced when faced with a true life or death situation. A split-second decision needs to be made to locate and ingest the standard issue liquid potassium cyanide pill (standard issue courtesy of the CIA), or attempt an ejection not knowing if there is a possibility of survival at such extreme altitude, high potential exists to be tortured and hung as a spy if captured by the Soviets once you hit the ground.[7]

Former United States Air Force Pilot Gary Powers was faced with this exact dilemma on 01 May 1960 while covertly piloting a CIA U-2 reconnaissance aircraft over the skies of the Soviet Union during a routine reconnaissance mission. His aircraft was operating in a robust A2-AD environment, was struck by a Russian SAM, and forced him to eject at high altitude over foreign soil. The US government had grossly underestimated the Soviet Union's advancement of anti-access aerial denial A2-AD capabilities and sent Powers into the teeth of enemy's defense with false confidence. Whether this underestimation was due to lack of knowledge on the developed capabilities of the Soviet Union's defenses or rather the overconfidence of Power's U-2 technological capability to deny a SAM engagement remains unknown to this day. The reliance on three vital joint functions and principles of warfare (movement and maneuver, security, and surprise) had failed. Nonetheless, the intelligence collection taking place during a period of heightened tension had been compromised, and the US was now faced with a two-fold dilemma: a downed, captured pilot operating a plane that in theory doesn't exist, and an urgent need for future technology to collect intelligence on the Soviet Union's nuclear missile and space development. Little did Powers know that this fateful mission would lead to one of the most technological MUM-T concepts of US airpower history- Project OXCART.

Little information has surfaced regarding the CIA's role in air reconnaissance over Soviet Union territory following World War II aside from the missions of the U-2 spy plane. It wouldn't be far-fetched to say that an average individual outside of military or government occupational background would have knowledge that the CIA was behind the creation of the U-2 program or any of the aircraft's other follow-on replacements in the OXCART family. The idea of the US president turning to an agency such as the CIA instead of a military service (US Air Force) to develop three reconnaissance platforms (U-2, A-12, D-21/M-21) demonstrates the magnitude of the situation President Eisenhower was faced with when balancing mission requirements, capability, surprise, and timeline to meet national security in relation to gathering intelligence over foreign soil. The need for reconnaissance over foreign soil brought about a tremendous imprint in the CIA's role regarding US Air Power history, and it could be argued that it was the persistent efforts of the Agency to not only develop a platform that would deliver the needed capability to provide rapid reconnaissance, but also responsible for bridging the gap of MUM-T from concept to reality.

It is necessary to recognize the political landscape taking place following World War II between the US and Soviet Union. Tensions had risen between the two super powers ranging from advanced nuclear weapon development in the form of inter-continental ballistic missiles (ICBMs) to the great space race which had the entire world on the edge of its seat to see who would declare victor in being the first to launch a vessel into outer-earth orbit. This competition created a massive void of uncertainty regarding current and future capabilities that a near peer threat could have and more dangerously, use as a weapon. Throughout the 1950's especially, this void drove the U.S. to the belief that it needed to have reliable, accurate intelligence, surveillance, and reconnaissance (ISR) on the Soviet Union's endeavors in order to maintain a military advantage and first strike opportunity. This study therefore, narrowly analyzes the CIA's innovative response to this dilemma by not just the use of the U-2 reconnaissance plane, but primarily that of the A-12, and the M-21/D-21 MUM-T concept known as Project OXCART by highlighting joint principles and functions of warfare doctrine that pertain to the program. What is significant about all three of these covert platforms during this phase in US history is that they were all designed for one purpose- Anti-Access, Aerial-Denial (A2-AD) penetration to collect intelligence.

Although the OXCART program has been heavily overshadowed throughout history by the U-2, which was primarily causal from the Soviet U-2 shoot down declassifying much of the U-2 program, it was nonetheless a phenomenal achievement of airpower innovation regarding MUM-T concept and design during a time of need. This paper additionally addresses the dire situation the US was faced with at the time, forcing the US to rely on the CIA to develop three extremely technical reconnaissance platforms within a seven-year timeframe to get presidential decision quality intelligence. By shedding light on the U-2 program and the follow-on OXCART family reconnaissance platforms, it will provide a clear historical picture that shows an original high altitude concept and design to collect ISR, to evolving towards a manned/drone operated program out of necessary requirement to fulfill US national security requirements.

Fifty-nine years after the inception of the OXCART program, a large amount of information regarding the program is still classified to this day. By attempting to capture the little information on OXCART that has been declassified by the CIA an attempt can be made to tie its significance of MUM-T concept into modern day principles of war application and future US reconnaissance platform design on the near horizon. By doing so, it will hopefully substantiate the claim that not only is A2-AD an age-old problem, but the concepts and design requirements in this historical case are forged based on an assessed threat or lack of intelligence to an enemy's capability, which in-turn drives the A2-AD threat to become more advanced as a response, thus creating a repetitive cycle of increased lethality with each round of evolution. It will also show that the concept of M-21/D-21 reconnaissance platform exceeded the capability of technology at hand by the U.S. government, much like the strategic bombing concept during the interwar period which took decades to fully reach intended operational capability.

Leading Up to MUM-T: The U-2 and A-12 Aircraft

"So -- our readiness to meet and defeat this kind of possible attack is forced upon us, both as a potent preventive of actual war and to insure survival in event of attack. This alertness to danger has to be translated into specific policies and activities in the several parts of the world where our rights -- our way of life -- can be seriously damaged. Work of this kind occupies my days and nights."

- *Letter from DDE to Hallock Brown Hoffman, February 7, 1955*[8]

The dicta by President Dwight D. Eisenhower above was penned in a letter regarding the concern of the Soviet Union's nuclear weapon development and risk to national security a decade after WWII. Four months following this letter, President Eisenhower personally approved the secret development of a covert spy plane spearheaded by the CIA. Following WWII, the Soviet Union had insidiously sealed off intelligence access to its land borders and skies, severely limiting the data collection by U.S. reconnaissance assets. Soviet Union Anti-A2-AD rapidly emerged as a legitimate threat to U.S. military forces after the Navy lost three reconnaissance planes conducting missions either on or near Soviet Union territory throughout 1950-1951 from surface-air and air-air engagements.[9]

It is important to note that the U.S. and Soviet Union were in near parity with each other in terms of military technology following the end of WWII. After the US demonstrated the use of a nuclear weapon twice on Japan, the ability to harness such power was quickly sought by the Soviet Union, thus putting the U.S. at grave danger if the technology were able to be harnessed with first strike capability. With fear of the Soviet Union developing a nuclear missile capability, the U.S. was desperate to find ways to collect intelligence information, and could not afford to lose another reconnaissance plane in the process. Instead of looking to the US military for answers, President Eisenhower instead turned to the newly formed CIA to develop a rapid solution. Within a year of Eisenhower approving the development of the covert U-2 spy plane (code named “Angel” by the CIA due to its high altitude flight capability), the program was ready for its first operational mission over Soviet Union territory in July of 1956.[10] The U-2 program was initially a profound success with numerous operational missions conducted deep into Soviet Union territory with its ability to overfly the A2-AD threat which engaged the US navy aircraft years prior, however it was only a matter of time until the CIA had assessed that the U-2 would be at risk with more advanced SAMs.

The CIA had actually predicted that the U-2 would inevitably be vulnerable to a Soviet Union SAM threat, however the assessment was that it would take the Soviets years to harness the technology to be able to find, fix, track, target, engage, and assess (F2T2EA) the aircraft.[11] This vulnerability threat assessment by the US was first predicted in 1956 (four years' prior the shoot down of Gary Powers) by the CIA which drove a new platform requirement from Skunkworks that would be capable of advanced A2-AD penetration to collect ISR and come closer to a MUM-T concept- the A-12. The A-12 (see attachment 1 photo) was the next generation reconnaissance air platform concept which would be designed by Skunkworks for the CIA by the same team that designed the U-2. The “A” designation of “A-12” stood for *Archangel* which represented the name of the covert follow-on aircraft, and was designed to be able to penetrate an A2-AD environment where a U-2 was previously vulnerable.[12] Designed, tested, and operated in complete secrecy, the footprint of this program was extremely close hold by the CIA. Unlike the initial requirements of the U-2 of only needing to operate above 70,000', the A-12 aircraft had four requirements that Skunkworks would have to obtain in order for the platform to be fielded operational: Be able to successfully fly at altitudes greater than 90,000', operate at speeds greater than Mach 3.0 (2,302 mph), have a low observable design and skin coating to become difficult for SAM radar acquisition, and be air-refueling capable.[13]

These requirements were all extremely difficult to achieve, especially during the 1950's when supersonic flight capability was less than a decade old.[14] The sheer notion of Skunkworks being given a requirement to not only travel at three times the speed of the Bell X-1 aircraft which first broke the sound barrier in 1947 piloted by Chuck Yeager, but to be able to sustain this speed for multiple hours was a challenging task. To further put this speed requirement in perspective, traveling at speeds more than Mach 3.0 (3,376 feet per second) well exceeds the velocity of a bullet fired from a high-powered rifle such as a 30.06 or equivalent.[15] In addition to this, flying at altitudes in excess of 90,000' had never been attempted before either and the air density characteristics on aircraft flight surfaces were unknown. The effects on the human body even with a space suit and at the speeds listed previously were also unknown variables, to include the heat friction induced from thermal heating from such high speeds.[16] By 1959, the CIA had been given the go ahead to pursue the approved reconnaissance platform, the A-12 which had demonstrated that all requirements could be met.

The idea of transitioning reconnaissance platforms from the U-2 to the A-12 was not only a phenomenal achievement in airpower history, but also a paradigm shift in ISR collection as a whole in relation to maneuver and surprise- two key joint principles of warfare. No longer was the idea of collection on intelligence over foreign soil by being able to penetrate an A2-AD environment through overflight. High altitude was not enough stay out of the kinematic reach of an enemy's weapon system. The new concept and design requirement from the CIA had now transformed to an era where speed and stealth was just as, if not more important than altitude. The US intelligence community was no longer focused on just one piece of the A2-AD environment that the Soviet Union had (SA-2), but future A2-AD capabilities to include aircraft as well.[17] Joint Publication 3-0 (JP 3-0) discusses movement and maneuver, protection, are critical principles at all operational levels of war, which makes it necessary to discuss the new changes the CIA's A-12 platform brings.[18]

As mentioned previously, the US had conceived to the notion that it was only a matter of time for the Soviet A2-AD defenses to catch up with the U-2 operating altitude, and the US was behind timeline on presenting a fix with the A-12. With the extremely difficult requirements to achieve in order for the A-12 to be developed, seven iterations of models and design concepts were presented the US government for approval which extended the timeline for development significantly from what was first postulated by the CIA.[19] In order to harness the unmatched advantage of speed and maneuver in order to collect ISR, significant challenges regarding thermal dissipation and engine development became an immediate obstacle. This resulted in a delay in the development and testing phase, as well as an increased budget requirement that exceeded the original approved amount.[20] This resulted in slipping the first aircraft completion to December 1961, and first flight of February 1962. It is postulated that these technical hurdles of meeting the requirements for design of the A-12 led to the vulnerabilities and exposure to the Soviet defense systems that Powers was faced with on his final mission.

Gary Powers capture on 01 May, 1960 created a plethora of challenges for the US intel community, specifically as to how future ISR would be collected over Soviet territory. With not only capturing Gary Powers on Soviet soil, but having pieces of the downed U-2, the Soviets could now make credible accusations against the US of spying to the rest of the world. The U-2 was also now considered to be compromised, forcing Eisenhower to openly acknowledge both the aircraft and the program's existence. To further create friction against the US and the Soviets, the US had initially thought that Powers was killed during the incident, and publicly stated that the U-2 air vehicle was a weather plane that had drifted into Soviet territory due to a hypoxic event leading the pilot to become unconscious. Powers was sentenced to three years of imprisonment and seven additional years of hard labor after being tried as a US spy.[21] The US could no longer afford the risk to continue U-2 flights over Soviet territory, and had to rely on the future of the A-12 to fulfill the ISR role.

MUM-T Makes Its Debut: The M-21/D-21

It was believed that the A-12 (Project OXCART) wouldn't be susceptible to the threat envelope that the U-2 was based on the altitude ceiling of 70,000' and subsonic speeds. An additional constraint given to the US from the shoot down of Powers is that the Soviets offered to release him on the agreement that the US would cease all manned overflights over Soviet territory. Although Eisenhower refused to cancel the U-2 program, there was a rapid need to develop a new form of ISR technology that would prevent further escalation between the US and the Soviets. This led to a new innovation effort of Skunkworks and the CIA to develop a MUM-T concept that would in theory tackle the ISR requirements, be utilized in conjunction with the new A-12 platform, and also comply with the Soviet Union's demand of no manned overflights over their territory.

The new MUM-T concept was designed inside the Project OXCART program with the idea of creating a drone vehicle to be used in conjunction with the A-12 (See attachment 2 photo). The CIA opted to name this MUM-T pair the M-21 and D-21 ("M" for Mother and "D" for Drone), and reversing the numeric digits from the A-12 to "21" as to not confuse the community of the program development. Although there have been several concepts and usage of drones in aviation history prior to this period, the idea of having a paired manned vehicle with an unmanned vehicle was transformational in the concept of operation. In order to discuss whether or not the M-21 and D-21 pair was successful in terms of intelligence and maneuver, it is vital to look at two important factors- the timeline in which the concept was needed to be fielded, and how the paired teaming was designed to be implemented.

With the shoot-down of Powers lingering over the CIA's head, a rapid need to develop a drone option to collect ISR emerged. It is important to recognize that not only were A2-AD systems getting more complex, the uncertainty on developing capabilities continued to increase with the US' decrease in ability to collect surveillance and intelligence. In addition to this, the idea of pairing a drone vehicle to a manned aircraft also introduced complexity as to how the two would operate via command and control (C2). The concept blueprint of the D-21 was designed to be attached to the top of the M-21, in which the M-21 would take off and depart to altitude after air refueling. The design requirement for this to be successful required not only for the D-21 to be light enough and aerodynamic to not induce parasitic drag on the M-21, but fuel from the M-21 aircraft had to be cycled through the drone to keep thermal cooling down at speeds in the Mach 3+ range.

Once at operating altitude, the M-21 aircraft had to find a way to separate from the drone and allow the D-21 to execute its mission. A unique concept that Skunkworks came up with for this design was that the D-21 needed to engage its ramjet engine and have it fully operating in afterburner before the M-21 aircraft would release it. This would allow the paired vehicle team to get enough thrust to match the drag during separation at speeds in excess of Mach 3.0 to successfully disengage from each other. A signal would be sent to the reconnaissance control operator onboard the M-21 once the D-21's engine had been started once engine thrust was sufficient for a successful separation from the aircraft. Once this launch cue had been met, the pilot had to fly a very precise profile that allowed safe separation of the drone from the aircraft. The crew onboard the A-12 would then operate the drone and monitor it during its profile to fly a pre-planned route, collect ISR with the systems on board, and navigate to a safe area in order to be recovered by CIA personnel. This safe separation profile, alongside with the recovery of the drone, led to the demise of the program.

A major hurdle that the CIA and Skunkworks struggled to overcome during the testing phase of this new MUM-T concept was the recovery of the ISR data from the D-21 platform. The drone itself was considered a sunk cost due to the inability to safely recover back to the manned aircraft, and technology didn't exist at the time to be able to successfully recover a drone like modern day data-link architecture and land based recovery systems. This sunk cost was included in the production count of the drones with only 38 built, thus making each planned flight a high priority payoff in terms of ISR gathering.[22] The design for ISR recovery consisted of the drone descending to a lower altitude once making its way to friendly airspace, releasing the ISR film pod from the vehicle at medium altitude and then self-destructing while still airborne. Once the film pod was ejected from the drone, a parachute would deploy slowing down its flight, which would then be recovered airborne by a CIA owned and operated C-130 transport aircraft modified to intercept catch the chute during its descent (see attachment 3 photo). Although the ability to successfully recover the film pod was intermittent during the testing phase, and posed challenges to the operational requirements, the primary reason why the D-21/M-21 never reached full operational capability was due to the ability to successfully disengage from the aircraft.

Although there were several successful attempts to disengage the D-21 from the M-21 aircraft, it was one of the most dangerous maneuvers ever conducted in aviation. Due to the extremely low air density from operating at altitudes near 90,000 feet, and coupled with speeds in excess of Mach 3.0, the pilot of the M-21 was required to use the excess thrust created from the D-21 once the drone's engine was operating to conduct a parabola maneuver in order to establish a fleeting launch window of time. When the M-21 reached the tail end of the maneuver in its decent, the pilot had to ensure zero gravity was maintained in order to allow the drone to separate and not get caught in the aerodynamic Windstream of the manned aircraft during separation. On 30 July 1966, a catastrophic test flight of the M-21/D-21 concept took place which cancelled the program. During the drone separation phase from the M-21 aircraft, an unforeseen airstream anomaly occurred causing roll coupling of the drone (lost flight from a wing dip) and collided back into the M-21.

The collision from the drone which was only a few feet above the aircraft right prior to impact was devastating to the mothership due to the speed and altitude envelope in which it occurred, and was unfortunately videotaped from another M-21 aircraft flying formation next to it. When one of the drone's outer wing lost airflow due to the slip stream of the mother aircraft during separation, it descended back into the M-21 and cut right through the lightweight surfaces causing separation of the aircraft into two pieces. Both the pilot and reconnaissance control officer were helpless at Mach 3.0, tumbling seventeen miles on the edge of space downward to the earth's ocean. The pilot managed to survive the ejection and was later recovered, however the reconnaissance control officer drowned. As with the Greek legend of Icarus flying too close to the sun and plummeting to the ocean due to wing melting, the crew of this final flight shared a similar fate. The aftermath of this event was devastating on the MUM-T program and all of the crew involved, and further integration and testing was cancelled by the CIA director due to severity of risk associated with the separation phase of the MUM-T M-21/D-21 pair.[23]

Analyzing the "*So What…?*" Why the MUM-T Concept Failed

The MUM-T concept developed by Skunkworks was ahead of its time. The idea of sending a drone operated by a man in the loop system in an A2-AD environment where it is too risky for a manned platform was genius. Using low observable technology and speed that can't be matched by an enemy weapon system is equally genius. Had the CIA/Skunkworks had more time to develop this MUM-T concept, specifically the carriage and separation phase, it is probable that the M-21/D-21 would have been an outstanding success. This MUM-T concept had flown higher and faster than any other aircraft before it. Perhaps it was due to such extreme altitudes and lack of air density that caused the separation phase of the drone to fail, or perhaps it was a just a malfunctioning servo in one of the drone's wings. Nevertheless, it plummeted back to the earth's surface, and with drowning the operator in the process, forced the US government to go back to the drawing board with the program. The drone concept would eventually become operational; however, it was heavily modified and launched at a much lower altitude from a B-52 bomber under an Air Force owned program, and was limited in success.[24]

Several important takeaways from the CIA's valiant effort of developing three revolutionary advancements in air power for the US in such a short amount of time. First, it is clear after the extensive analysis above that the A2-AD environment of a threat country can pose grave risk on service military aircraft, which is why the CIA was given the responsibility from the president to develop an airframe that could penetrate and retrieve ISR in a time of need. With the shift in development from a high altitude, long orbit capable platform such as the U-2 to a faster aircraft with stealth technology of the A-12, the US was clearly reacting to a potential adversary instead of being proactive in nature. It is safe to assume that nobody predicted to include the US government, that the CIA would lose a pilot over foreign soil operating a plane that in theory didn't exist, or let alone be able to be shot down from a SAM operated by a country that it is not at war with. The second order effects of Gary Powers' shoot down forced monumental innovative efforts by the US to develop an alternative unmanned solution to be able to accomplish the mission. Had the technology existed for a safer separation of the drone from the M-21 aircraft, and perhaps a more precise way to recover the drone instead of being a sunk cost, it can be postulated that this program would have been an overwhelming success.

Second, it is equally important to fast forward to modern day and compare a current A2-AD environment to this historical case. If the US had to respond to Russia which required manned overflight to gather ISR, would the US be able to conduct successful flight operations in a modern SAM engagement zone without getting shot down? Is it safe to assume that satellite ISR capability will always be there for the US? Will modern stealth technology alone be able to afford a pilot the luxury of not being tracked and shot down by an advanced SAM system? All of these are critical questions that the US government is faced with to ensure that it always maintains the military edge against any potential adversary. The A-12, later adopted by the USAF with renaming the aircraft to the SR-71 was tracked and engaged by numerous of SAM operators throughout its operational tenure yet was never shot down.[25] It wasn't the aircraft's stealth technology alone that allowed the aircraft to escape the fate of its U-2 predecessor, but speed and altitude in which it operated. Speed allowed the aircraft to maneuver in a manner that the enemy simply couldn't keep up with. The SR-71 still holds the manned speed and altitude record to this day after over fifty years since inception.

Finally, it is vital to tie this analysis of historical application to the modern day Marine warfighter's future operating concept. As potential adversaries become more capable in terms of A2-AD development, it is vital that a thorough assessment of the US Marine Corps role in how the service would respond to a crisis if it had to penetrate an adversary area defense. If the USMC had to launch and conduct missions in the littorals off the coast of a near peer adversary that has modern day SAMs such as an S-400 or HQ-9, would it be successful? Is it possible that there may be an over reliance or false sense of security by service leadership that the USMC's new F-35 will be able to survive in this type of environment? The A-12 and M-21/D-21 had both stealth and electronic countermeasures that were never before seen on the modern battlefield and considered state of the art at the time, yet the aircraft was still tracked and engaged numerous times by SAMs during operational missions- speed is what allowed it to survive. Had the aircraft not been able to get left of the enemy's decision/targeting cycle through movement and maneuver, the outcome of the aircraft's phenomenal success would have been drastically different.

As the USMC and all US military services go forward in developing military technology for the warfighter to be successful in tomorrow's fight, it may be worth heeding the lessons the OXCART program provided regarding A2-AD penetration and overflight in a crisis scenario. Given the current timeline of fielding a fifth-generation fighter from current inception may raise an eyebrow as to how well the US could innovate and develop a rapid requirement that was demonstrated with the OXCART program if a situation presented itself like it did during Eisenhower's presidential term. Out of absolute necessity, the CIA was tasked by the president to develop three different aircraft concepts in a ten-year period that would be able to successfully operate in an A2-AD threat ring via movement and maneuver capability (overflight or speed). It is hopeful that the MUM-T M-21/D-21 concept that Project OXCART conceptualized along with unmatched movement and maneuver in terms of altitude and speed provide a foundation of future US innovation regarding A2-AD penetration.

4. Future Concept and Design- Creating an Operational Decision Game

Now that a thorough analysis of this historical MUM-T case has been conducted, it is necessary to take the lessons learned identified in the D-21/M-21 design and apply it towards a future concept. One need not look any further than Lockheed Martin's website with an advertised creation of a follow-on replacement to the SR-71, the SR-72.[26] The SR-72 is nicknamed by Lockheed Martin as the "Son of the Blackbird" with an advertised speed capability in the hypersonic (greater than Mach 6.0) realm. With only a few conceptual rendition photos (see Annex 1) and vague information posted on their website due to the classification of this ongoing project, the SR-72 appears to incorporate many of the same joint functions of warfare demonstrated with the Oxcart and D-21/M-21 concept design- *Movement and Maneuver, Protection, and Intelligence.*[27]

In addition to Lockheed Martin's newly advertised SR-72 hypersonic air vehicle, the US Defense Advanced Projects Research Agency (DARPA) has developed and tested a similar future concept air vehicle, named the HTV-2 "Falcon." It is unknown if DARPA has teamed up with Lockheed Martin to combine efforts in these concepts, but actual test data was released by DARPA on a hypersonic flight. On 22 April 2010, DARPA conducted a test flight of the HTV-2 to see if the air vehicle could reach speeds of greater than Mach 6.0 and still maintain two-way data link, GPS, and tested use of the reaction control system built into the platform. The HTV-2 reached an astounding speed of Mach 22+ (nearly 4 miles per second) and splashed down into the ocean after a 9-minutes of valuable test was flight captured by DARPA.[28]

Finally, a third option of future MUM-T application involving the employment of "swarm" methodology captures the same joint warfighting functions that the M-21/D-21 tried to incorporate, but through different design. This concept consists of the idea of numerous micro drones used to saturate a battlespace. Instead of a D-21/M-21 drone pair to survive an A2-AD environment via extreme speed, this swarm technology could in theory allow one to survive through extreme numbers in terms of target saturation. Instead of stealth technology to mask a signature from a SAM threat which was a main feature of the M-21/D-21, swarm technology may in theory accomplish the same outcome through masking signature by overwhelming numbers. This concept is currently being pursued by the US military as a viable future option, and so therefore was included in the scenario in to maximize creativity and employment concepts in an A2-AD environment.

Using all three of these concepts developed by leading US aircraft and technology design corporations, a conceptual design and future employment methodology regarding MUM-T was developed to bring forward the enduring lessons of joint warfare functions demonstrated with the CIA M-21/D-21 historical case. This concept and future employment framework was developed in the form of an *Operational Decision Game* (ODG) which is used extensively by the US Army and US Marine Corps in the academic environment. In other words, the timeline of design implementation and teamed employment of manned/unmanned design was put to the drawing table incorporate the HTV-2 Falcon, SR-72, and swarm technology in order to handle a future conflict situation.

The ODG was carefully structured to look forward into the future operating environment ten years from present day focusing on the same two countries listed in the historical case which incorporated an A2-AD threat considered to be too risky for a US conventional military response. Using open source advertised future Surface-to-Air missile ranges of a potential threat country, a significant problem emerged with Russian forces accomplishing a *fait accompli* into Latvia (a neighbor Baltic country) protected under the NATO treaty. This ODG dilemma then offered the ability to use any and all ways and means of current US military assets in the air, land, sea, and cyber domain as a response without the constraints of having to adhere to current US military doctrine. In addition to these response options, the members who participated in the ODG were also allowed to use the historical M-21/D-21 platform presented in this paper as well as future swarm technology, the SR-72, and the HTV-2 Falcon however he/she deemed appropriate. For a detailed synopsis of the ODG scenario and what was presented to the team that participated, please reference Annex 2 in this paper.

The ODG team that participated in this endeavor to capture future concepts of MUM-T employment consisted of top tier subject matter experts across the joint services- US Air Force, US Navy, US Army, US Marine Corps, and Interagency. Career specialty fields of these warfighters consisted primarily of fixed and rotary wing tactical aviation, special forces, cyber, intelligence, surface warfare, infantry, acquisitions, logistics, and command/control (C2). In addition to this, two USMC Command and Staff College professors who have a combined forty years of military/academic experience in warfighter curriculum and doctrine also participated in the event. This combined collective effort of professional view points allowed for a creation of a future operating concept and employment consisting of past, present, and future technology listed in this paper with unrestricted limits on employment or concept design.

The intent was to have the experts in the room use their personal experiences as warfighters and craft a MUM-T response in however he/she felt appropriate to the ODG problem. Given the problem and a plethora of available response options, the team was asked to frame the problem, develop a course of action graphic and narrative, and create a theory of victory that would incorporate MUM-T design. The team had several hours to generate a response after a brief synopsis of the historical D-21/M-21 case and was explained.

5. Operational Decision Game Results

The primary goal for conducting this decision game was two-fold: To see how historical, current, and future US technology can be used to solve a complex problem set using MUM-T, and how a group of dedicated military subject matter experts with vastly different backgrounds would solve a problem using MUM-T design through their eyes consisting of years of experience. With these two goals in mind and over a dozen detailed responses, it is remarkable how similar the train of thought regarding MUM-T employment and design amongst warfighters. The synopsis of the decision game results from the participants will be briefly summarized using current US joint warfighting functions.

Command and Control (C2): Command and Control is the future of warfighting integration that relies on sensor fusion and distribution of information to the warfighter on the battlefield. A nation state can have all the weapons in its arsenal, but without effective C2 giving a warfighter an effective operating picture, it is destined to fail. Multiple participants in this wargame opted to use either the SR-72 or HTV-2 Falcon as a C2 platform that allowed effective transfer of information over the battlespace to the combatant commander to make decisions. In addition to this, a C2 platform capable of orbiting in or near an A2-AD environment could allow conventional forces to receive updated information of the battlespace and conduct military operations in a cohesive manner. If the SR-72 or HTV-2 Falcon's C2 capability reached a degraded state, the swarm drones could pick up a limited role.

Intelligence: As with C2, operating in an environment without proper intelligence poses grave risk to any warfighter. Given the complex problem set of a potential threat country establishing a true A2-AD environment where no over-fly option exists, target intelligence on the battlefield was identified as absent. Several members who participated in the game chose to use either the mother ship (SR-72) or swarm technology to act as a breathable sponge to collect intelligence. With the swarm drones being deployed from either directly overhead the battlefield from the SR-72 or from a standoff platform at range and the synchronization of hundreds of drones collecting intelligence across the spectrum was conceptualized with communicating this intel to the SR-72 in order to fuse together into a common operating picture for the warfighter.

Fires: Fires is perhaps the most effective form of warfighter function application on an enemy. The majority of the users who participated in the decision game envisioned either one of the three concepts or all three of the concepts having a kinetic or non-kinetic fires capability inherent in the concept design. One of the MUM-T conceptual designs consisted of the SR-72 acting as the “mothership” (much like the M-21 design) that carried a mini HTV-2 Falcon that has a kinetic weapon capable of honing in on a priority target identified by the SR-72. Another design concept from a participant went one step further and incorporated swarm technology within the HTV-2 Falcon body that would act as a hypersonic canister delivering hundreds of micro-drones that are capable of carrying a payload that can hone in on designated targets. Non-kinetic fires was also conceptualized with having the ability to use directed energy on targets that could potentially be in urban environments where collateral damage is a factor.

Movement and Maneuver: Movement and Maneuver was the bread and butter of the MUM-T concept and design. Much like the historical case with the M-21/D-21 reliance on speed and altitude to evade an enemy SAM, similar reliance on speed and altitude was evident amongst the participants in the game. The ability for either the SR-72 or the HTV-2 Falcon to be able to penetrate a robust A2-AD environment and survive was considered paramount. Movement at speeds greater than 3.5 miles per second allowed the vehicle to communicate pertinent information to the warfighter in a MUM-T manner while staying outside of the enemy’s decision cycle by being able to target it. Also, with the incorporation of swarm technology allowed not only the mother aircraft to penetrate the SAM envelopes of a threat country, but employ numerous drones that could potentially outmaneuver enemy threats by over saturation of the battlespace.

Protection: Being able to operate in a robust A2-AD environment with self-defense or signature masking capability is paramount, which was recognized by the preponderance of decision game participants. MUM-T concept and design of future employment regarding protection was primarily through method of speed. It is unknown what future enemy technology capability will be in terms of intercepting a highly maneuverable target, but speeds in excess of Mach 22+ as demonstrated with the HTV-2 Falcon were used as a primary advantage point in the decision game, which paralleled the successfulness of the M-21/D-21 historical case. An important cyber function incorporated the conceptual use of a cyber defense that allowed the MUM-T design to have countermeasures capable of cyber-attacks to disrupt and or deny enemy attempts to hinder the successfulness of employment.

With the results of the decision game encapsulated in the form of joint warfighting functions through empirical data, a recommended MUM-T concept regarding the three future air vehicles presented in the paper can now be made. A hypothesis of requirements and capabilities can be drawn by using the participant's responses in order to develop a theory of victory based on an operational problem set a warfighter could find themselves in. With a clear problem set, a theory of victory at the campaign level which focuses on an operational response, empirical data from a wide field of subject matter experts across joint services, and actual future air vehicles currently being tested by US, a realistic concept that focuses on MUM-T capability and capacity can be identified.

6. Future MUM-T Concept and Design Considerations

Although hypothetical in design, there are real life lessons learned that can be drawn from the Operational Decision Game in regards to the campaign level. The operational problem set in the game forced the participants to think how three future concept vehicles could be utilized and in what capacity. This capture of melded thought presents a theory of victory as to what an end state looks like to accomplish an objective in the form of a “win.” One could substitute the threat country in the decision game with any formidable threat, and replace the future A2-AD envelope presented with any situation that requires a capability to immediately respond to a situation embedded with strategic implication. As with the historical M-21/D-21 case, there was vast strategic impact on attempting to overfly Soviet territory in secrecy to gather intelligence during the Cold War period.

The primary objective in the form of a desired end state using the three future MUM-T concepts is the ability to use a capability to stay outside of an enemy’s decision cycle when put in a square corner. Speed and surprise coupled with a kinetic or non-kinetic fires capability works as long as the intelligence gathered was efficient and effective for C2 dissemination and execution. The ability to maintain continuity in C2 architecture and dissemination of intelligence to the warfighter in an environment where conventional platforms are not survivable is what an ideal end state looks like for this future MUM-T concept. Now that a theory of victory at the campaign level to solve an operational problem has been identified, it is necessary to briefly discuss a proposed operational design and MUM-T integration of the concept.

It is unknown if the SR-72 will be a manned or unmanned platform. From the limited information posted by Lockheed Martin, the conceptual design photo shows an air vehicle without a glass cockpit, which may elude to the idea that will be unmanned. The same goes for the design testing of DARPA's HTV-2 Falcon platform. It can therefore be postulated Lockheed Martin has learned from the lessons of the M-21/D-21design and that hypersonic speed and extreme altitude is too dangerous for a warfighter to find themselves in over the battlespace. Another assumption with these two future air vehicle concepts are that based on the extreme amount of costs associated with the research and development of hypersonic employment, this concept will be an extremely high capability with an extremely low capacity. Given these assumptions, the fusion of intelligence collected from these concept platforms and the dissemination of intelligence is the center of gravity of this MUM-T concept. Therefore, dependent on the role of the HTV-2 or SR-72, if it is going to operate as a drone vehicle, it is important to think about what autonomy it will have to operate in a narrow artificial intelligence (AI) capacity.

With every advantage that a capability brings to the battlespace, there is inevitably a trade-off that takes place. In the case of this future MUM-T concept design, hypersonic flight could drastically reduce the friendly decision making cycle in terms of F2T2EA. Today's fighter pilots are trained to think and operate at nine miles per minute (tactical speed in which they fly missions). With hypersonic speeds demonstrated by the HTV-2 Mach 22+ flight profile, a warfighter would have to think at nearly three times the rate of today's fighter pilot. Couple this challenge with a significant increase of data to process of traveling at such speeds can also present a challenge to operate in this manner. The SR-71 had a turn radius greater than eighty nautical miles due to operating at Mach 3.0, which may be two to three times that with these future concepts based on the operating speed. If this is the case, a two-hundred nautical mile turn radius could pose an issue with a continuous presence and or overflight situation to gather required intelligence for a decision maker, which would have to be considered in the MUM-T design.

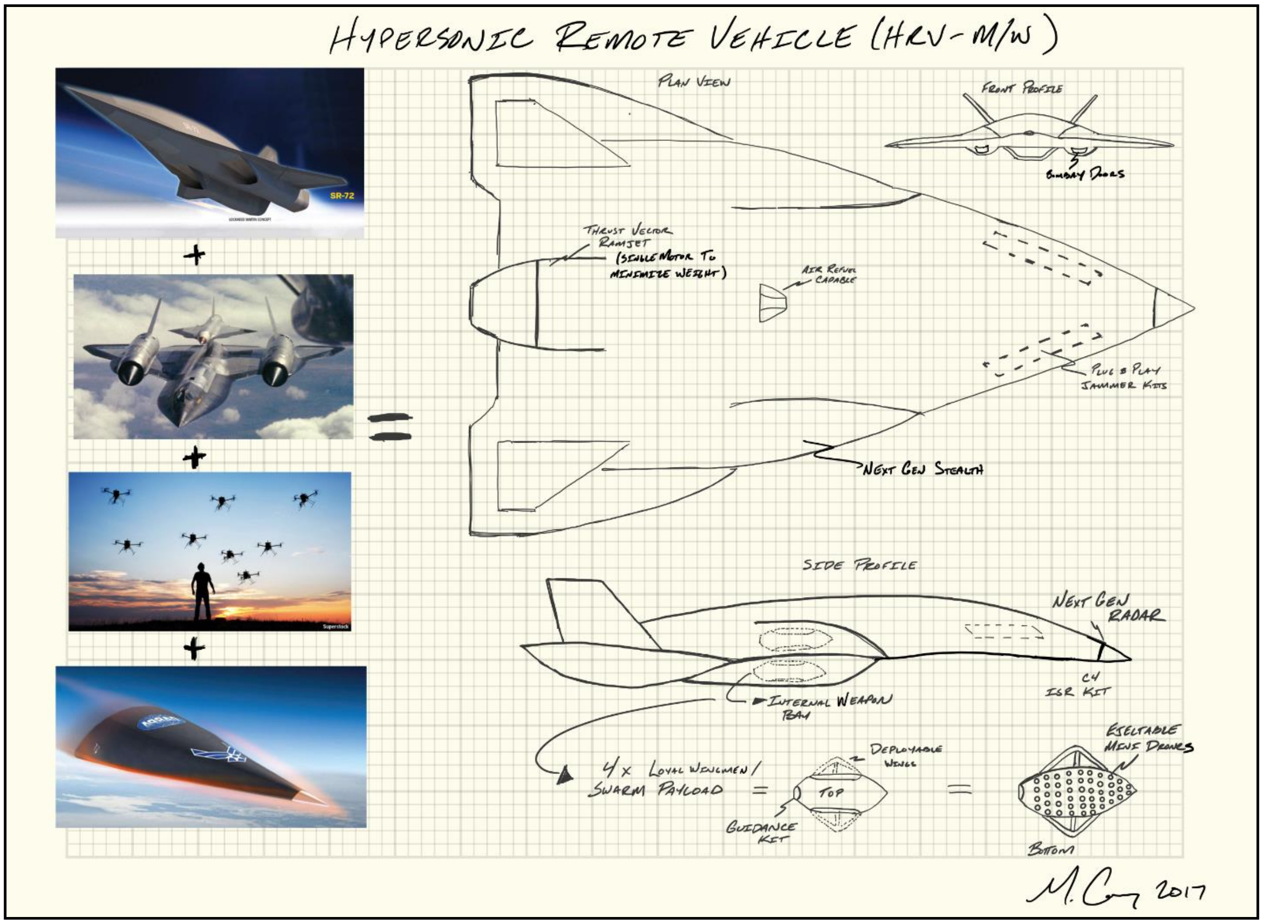
Additionally, the incorporation of swarm technology with a hypersonic platform can also present significant challenges if employed as an unmanned team. Whether used as a fires capability in a lethal/non-lethal capacity or as an intelligence gathering platform, the integration of the micro drone swarm and hypersonic vehicle would need to be addressed. The manned portion of this concept will need to account for a massive collection of data to either disseminate to conventional warfighters or to take on the role of a hunt and destroy mission. Identifying synchronized priority target sets and controlling the swarm of drones to hone in on these targets during terminal phase may in theory be too overwhelming in terms of task saturation for a warfighter to handle. This task saturation overload may then require a swarm drone tactic to operate in a full/near full AI manner which could then challenge the moral element of taking the warfighter out of the loop in engaging a target end game.

In addition to this analysis, of all of the decision game responses included a moral element that was either consciously or subconsciously inherent in the conceptual design of the decision game responses. Not a single US warfighter who participated conceptualized future MUM-T design where a drone operated in a 100 percent autonomous state or kinetic employment through solely machine-learning technology. When employment of kinetic or non-kinetic fires was crafted as a response option, there was always a warfighter in the loop of the decision cycle to verify the information passed from the sensors over the battle space. It is recommended that this moral element be considered in the concept design. With the unknowns of the current design concepts in development by Lockheed Martin and DARPA to include the future use of drone swarm technology, a final concept of future MUM-T design can be done.

7. Author’s Concept of Future MUM-T: From an Air Power Perspective

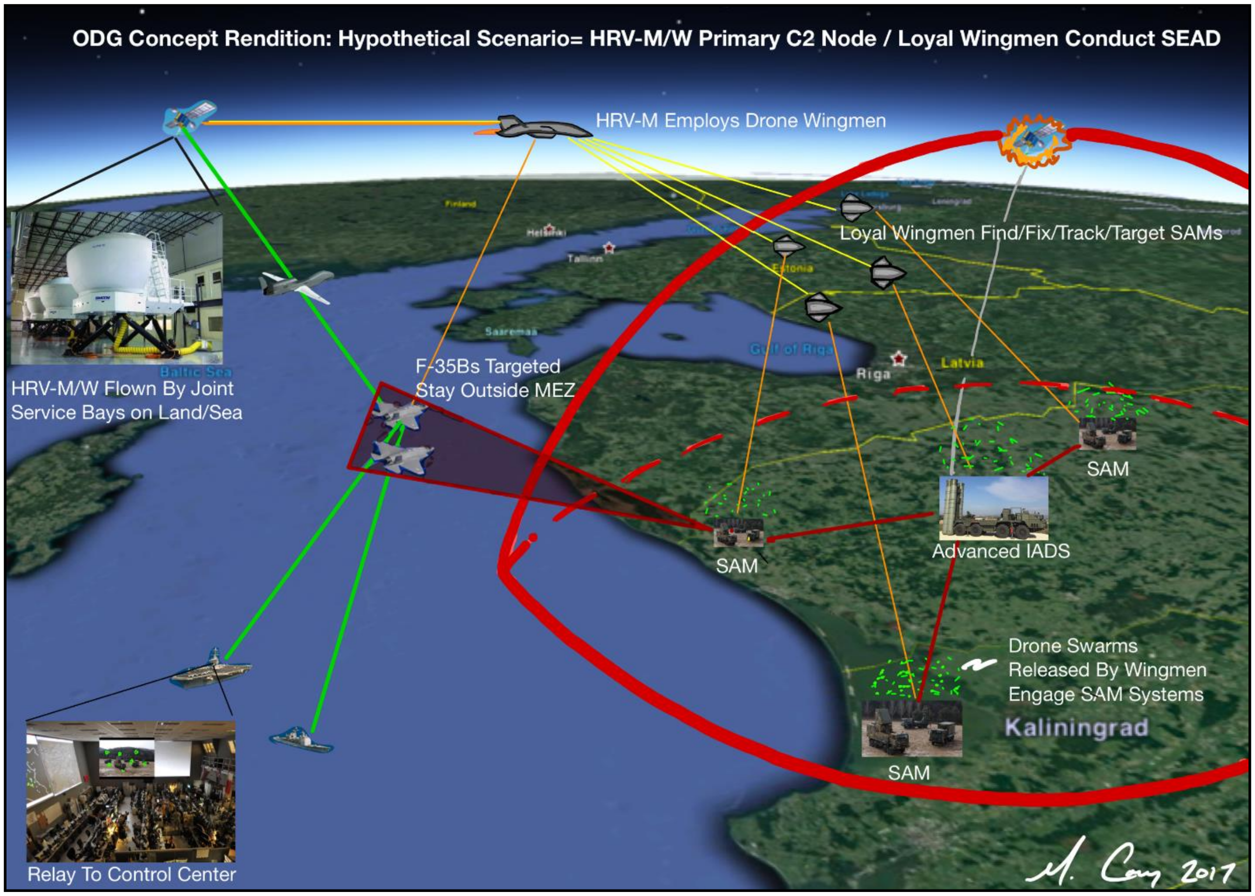
- Author’s rendering of the Hypersonic Remote Vehicle Mother/Wingman (HRV-M/W) at altitude

With the considerations of the historical case and the operational decision game presented in this paper along with current concepts being pursued by Lockheed Martin and DARPA, a future design regarding MUM-T in the air domain can be made. The concept includes an unmanned hypersonic remote vehicle “mother” (HRV-M) similar to the M-21 historical concept yet more capable. This platform would be capable of not only the hypersonic, high-altitude and low observable requirements identified in the decision, but would also be able to control smaller hypersonic remote drones acting as loyal wingmen (HRV-W). These drone wingmen would be carried internally and released by the mother vehicle at operating altitude (>90,000’ MSL) and perform additional mission sets while the mother vehicle commands and controls the operation.



- Author's MUM-T design concept: Single-engine hypersonic vehicle with internal wingmen

The idea of this concept is to provide a capability that not only flies higher, faster, and longer duration than any air vehicle ever made, but also be able to integrate internally as a family of drones or communicate and pass information to other manned platforms in a larger battle space. By capitalizing on altitude and speed, the HRV-M and HRV-W formation of drones could in theory penetrate a future integrated defense network utilizing altitude, speed, and stealth to its advantage and remain outside of an enemy missile defense capability. The networking and sharing of information collected by these drones could would be passed to the warfighters remotely controlling them from either land based or sea based operating centers. These operating centers would be a joint service venture to enable a better fusion of joint networking and operating across the battlespace domain.



- Author's rendition of HRV-M/W operating concept in an integrated air defense take down scenario

The HRV-W drones would carry an internal payload of drone swarms that could be released as required to hone in on and engage enemy SAM systems once detected, and could potentially have the ability to land on the ground and collect intelligence to the mother drone above. An additional option for the HRV-W drones is that they could either saturate the airspace to cause targeting issues for the enemy or be programmed on a seek and destroy mission to hunt priority targets. Also, the HRV-W released from the HRV-M would have deployable lift surfaces that would enable longer loiter time at altitude, which would further enable its capability to act as a surveillance team or for deep strike options. Finally, the HRV-W would also be capable of different payloads, to include larger kinetic effect options instead of micro drones which would also expand its capability and provide more options for target selection.

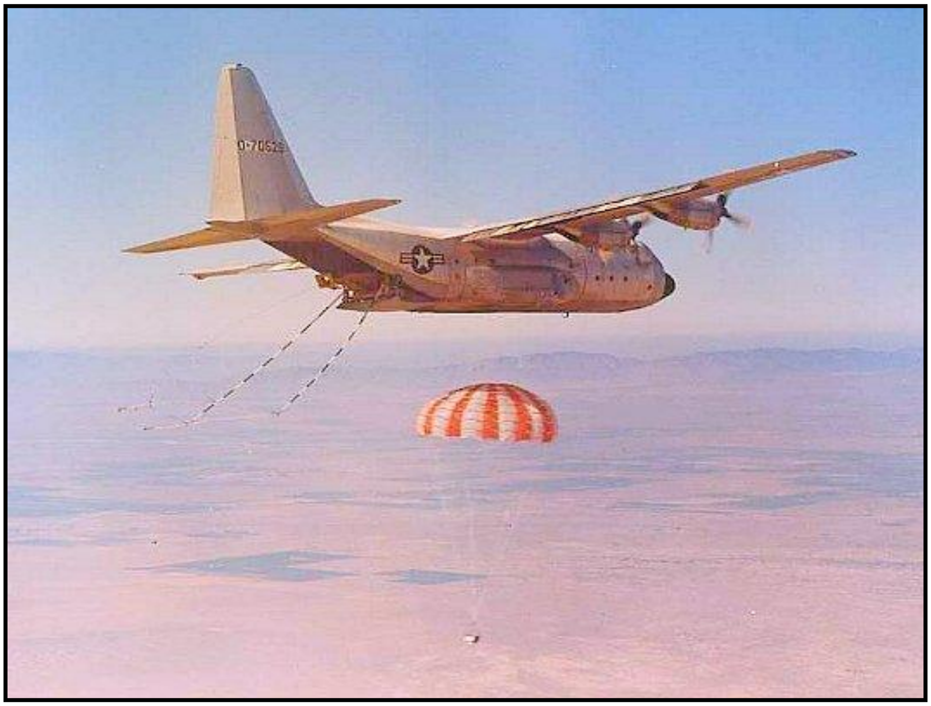
It is uncertain what the future battlespace holds for the warfighter in terms of technological capability and capacity of MUM-T both as a friendly weapon and as an enemy threat. What is certain, however, is through analysis of a historical MUM-T case and future concept and design presented in this paper, current US warfighting functions and Clausewitz' friction elements of danger, physical exertion, and intelligence are enduring in nature. The oldest military doctrine taught in today's US top level military schools is still an effective method to solve future problems. MUM-T is changing the battlespace landscape for tomorrows warfighters, and no matter what technology comes to fruition, the US warfighter will be both prepared and successful with the academic knowledge of how to employ it.

Annex A: Historical and Future Concept Photos of MUM-T Design

1: Historical Case CIA A-12 Project OXCART fleet at an undisclosed location.[29]

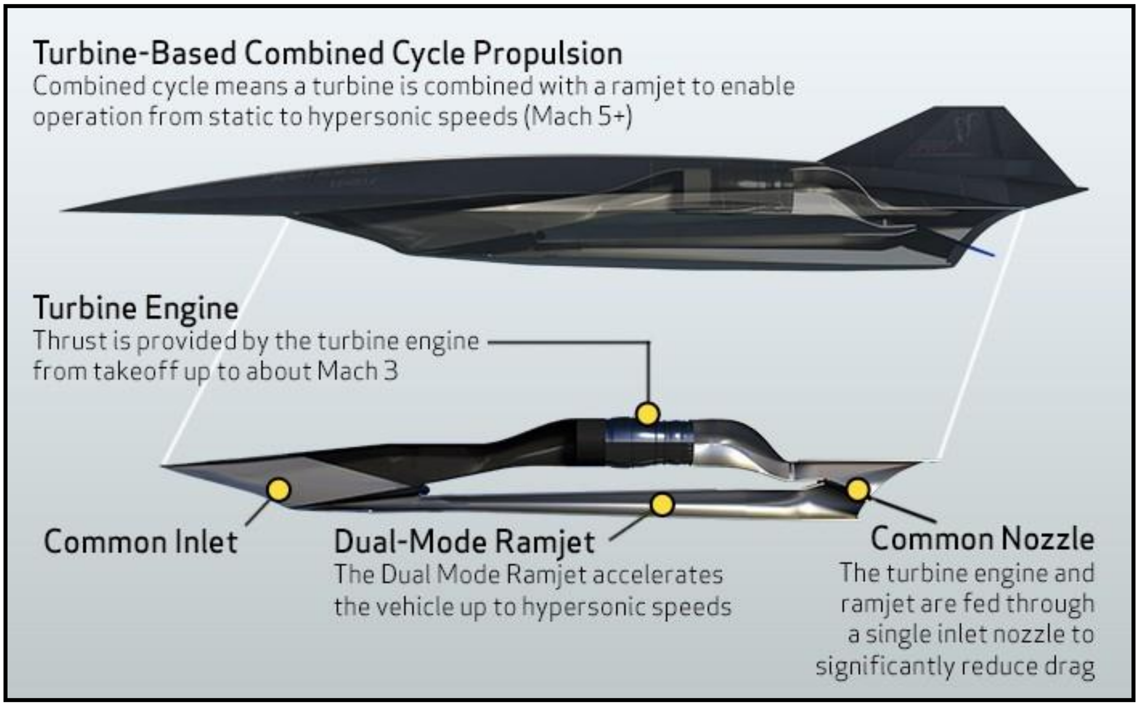
2: Historical Case Project OXCART M-21/D-21 MUM-T pair in-flight.[30]

3: Historical Case C-130 recovery plane in-flight recovery of MUM-T ISR data.[31]



4: Future Concept- SR-72 Air Vehicle (Lockheed Martin Website).[32]

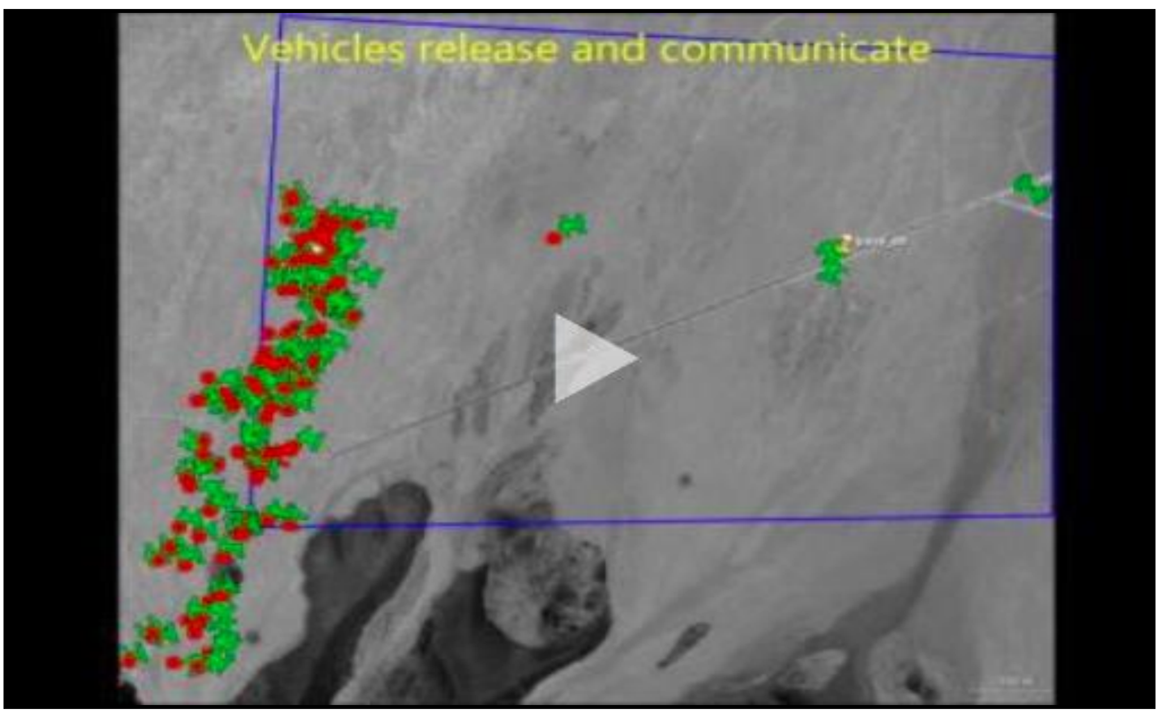
5: Future Concept- SR-72 Air Vehicle Hypersonic Technology (Lockheed Martin Website).[33]



6: Future Concept- DARPA HTV-2 "Falcon" Air Vehicle Illustration.[34]

7: Future Concept-Micro Drone Swarm Technology (Launched by US Fighter Jets).[35]

8: Future Concept- Micro Drone Swarm in-flight (engaging a target).[36]



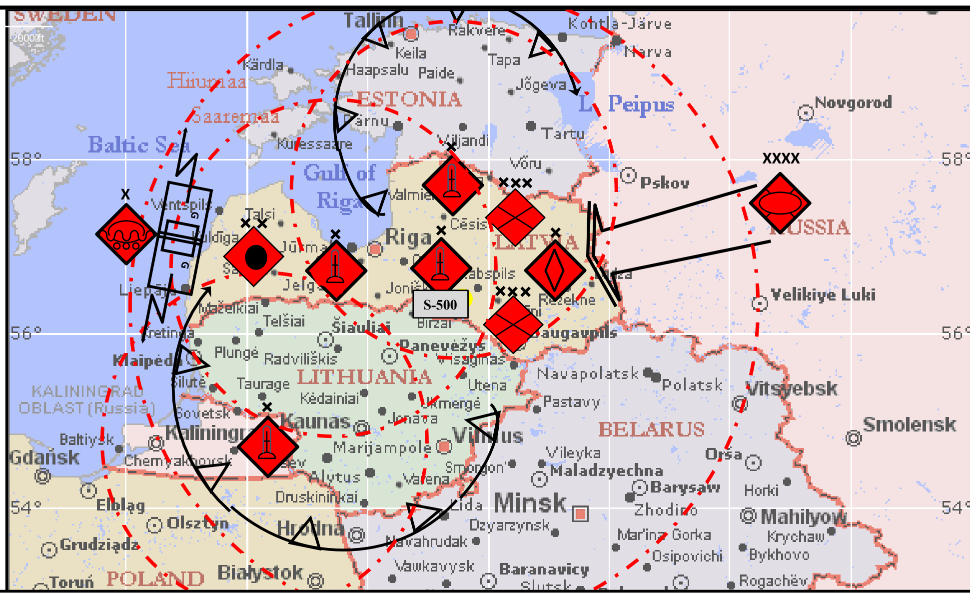
Annex B: Operational Decision Game (ODG) Presented to Subject Matter Experts

Situation 2027: *Fait Accompli- Europe*

- **(U) Snapshot**: (Hour + 18:00)
  - You are the EUCOM J3/5 Chief stationed at Stuttgart, Germany, and have been tasked to provide response options to a Russia *Fait Accompli* (surprise annexation) of Latvia.
  - After 5 years of annual large Russian military exercises consisting of troop build-ups greater than 60,000 supported by Russia's latest A2-AD S-500 system/ 5th Gen Fighters, the U.S. and NATO assumed that a current large force exercise taking place along the Latvian border was merely "routine"- It wasn't.
  - The following day after completion of the month long exercise, NATO assumed military draw down would occur. Russia initiated a full-scale surprise invasion of Latvia, additionally establishing a no-fly zone over Estonia and Lithuania IOT contain both with augmented support of its IADs stationed in Kaliningrad.
  - 8x Latvian aircraft, 4x NATO response aircraft, & 6x Satellites have been shot down in the last 18 hours, confirming the S-500, S-350, and PAK-FA in Latvia. No-fly zone has been established over Latvia, Lithuania & Estonia.
- EUCOM Guidance
  - "Give me options…need to know where Russia's vulnerabilities are for response- I currently have zero ISR- avoid WWIII."
  - "What do I target, how do I target it, and what do I target it with given the S-500/PAK-FA capes and 60,000 troops/equipment in theatre."

Russian Military Forces

- **Land:** Western Military District: (est 60,000+ total troops)
  - 6th Guards Army: 2 x Troop Divisions (Odintsovo, Moscow Region)
  - 6th Tank Brigade
  - 20th Guards Army (Nizhny Novgorod region) Reserve Unit on Border
  - 288th Artillery Brigade
  - 112th Missile Brigades
    - 1 x Battalions of S-500 SAMs (Ability to simultaneously engage 80+ targets)
      - Advertised capability to engage current stealth fighters and satellites w/in 400nm
    - 2 x Batallions of S-350 SAMs (Ability to simultaneously engage 60+ targets)
      - Augmentation to S-500 A2-AD
- **Air:**
  - 5 x Squadrons PAK-FA 5th Gen Stealth Fighter (60 total)
  - 7 x Squadrons Su-35 Multi-Role Strike (84 total)
- **Maritime:** (Baltic Fleet)
  - 2 x Submarines
  - 4 x Destroyers
  - 1 x Aircraft Carrier = 6 x PAK-FA // 12 x Su-35
  - 1 x Shore Defense Complex (shore based) = 6 x advanced ASCMs



The most likely ECOA is complete annexation of Latvia while isolating both Estonia & Lithuania by A2-AD for follow-on annexation.

1. **A2-AD:** S-500 systems augmented with S-350's provide blanket air/near orbit denial = no satellites/no GPS/no aircraft except approved airline traffic. Satellite trajectories have been re-programmed to adhere to 60NM lateral overflight restriction.
2. **Air:** Fixed Wing 5th Gen and 4th Gen fly continuous CAPs in support of Latvia annexation and establishment of air superiority. Aircraft can be launched out of several different bases from Russia's border, and can recover to alternative locations if bases are struck. Assume multi-role capability and good GCI capability.
3. **Sea:** Maritime forces establish sea superiority w/in 100nm of coasts from Kaliningrad to north of Tallinn- will mine and retrograde if cannot maintain superiority. Assume both submarines have been dispatched to unknown locations near the border of Latvia to support the main effort. Carrier is operational.
4. **Land:** Both divisions have been given explicit guidance to seize initiative through maneuver and surprise, and to branch off along main avenues of approach to distribute personnel and equipment throughout Latvia. Expect large populated areas to be occupied by Russian troops, with sparsely populated areas less affected.

NATO/Friendly Forces

- **EUCOM/NATO Ground** (can be mobilized in 72hrs):
  - Atlantic Resolve Package
  - NATO Very High Readiness Task Force
  - Latvian Military* (See notes)
  - 3 x Patriot Battalions
  - = Total troops est 40,000 // 100 Tanks // 60 Artillery
- **Maritime** (positioned 200nm off Baltic Coast Inbound):
  - Strike Group
    - 1 x Destroyer (DDG)
    - 1 x SSGN (154 cruise missile complement)
  - 1 x ARG/MEU (standard loadout)
    - Additional elements in Cyprus
      - 1 x DET (4) F-35B
      - 1 x DET (2) KC-130 (with Harvest Hawk kits)
      - 1 x DET (4) MV-22
      - 1 x DET (4) CH-53
      - 1 x INF BN
      - 1 x Radio Company
- **Air** (Joint/Coalition- Can be on station <24hrs):
  - **USAF** = 12x F-22,12x F-35A,12x, 8x KC-135, 8x C-130, 8x C-17, 8x HH-60
  - **Coalition**= 12x Rafale,12x Gripen,12x F-35,12x F-16C, 3x KC-135, 2x C-130, 8x C-17, 8x HH-60
  - ISR = 3x MQ-1, 2x MQ-9
- **Other**
  - 2 x Cyber Support Teams
  - Role 3 Medical Facilities in Landstuhl, DE

Historical Case- Would You Use It?

- Project Oxcart // D-21 & M-21
  - CIA's A-12 Supersonic Vehicle (think SR-71's older brother)
  - Altitude- 90,000 // Speed- Mach 3.0+
  - Manned/Unmanned (CIA actually attempted this)
  - Role: you decide…
    - <u>Reconnaissance</u> (Original Purpose)
    - Strike (Nuclear/Non-Nuclear)
    - C2 Hub
    - EW
    - Other?

Future Concept 1

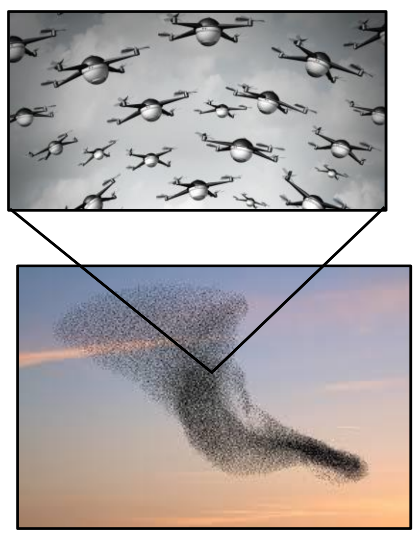
- Hypersonic Vehicle
  - Hypersonic (Mach 6+)
  - Altitude (Outer Atmosphere)
  - Manned/Unmanned (you decide)
  - Role: (you decide…)
    - Reconnaissance
    - Strike (Nuclear/Non-Nuclear)
    - C2 Hub
    - EW
    - Other?

http://www.lockheedmartin.com/us/news/features/2015/sr-72.html (SR-72 Concept)

http://www.darpa.mil/program/falcon-htv-2
(DARPA Hypersonic Concept)

Future Concept 2

- Swarm Concept
  - Saturation
  - Integrated
  - MUM-T (Manned/Unmanned Teaming)
  - Role: (you decide…)
    - Reconnaissance
    - Strike
    - Battlefield Awareness
    - EW
    - Other?



https://www.youtube.com/watch?v=3XKiUtruQiY Click on link to watch actual video

Solution Set

Please fill in the problem framing, COA Graphic/narrative, and theory of victory slides

References on key terms are provided

Problem Framing

Problem Statement (incl. list of key facts and assumptions):
Tensions Between Current Conditions and Desired Conditions:
Elements that Must Change to Achieve the Desired Conditions:
Opportunities and Threats to Achieving the Desired Conditions:
Limitations:

JP 5-0, Figure III-6

COA Graphic and Narrative

	MISSION:
	INTENT (purpose, method, desired condition)
	CONCEPT (incl. key tasks by phase)

Use Deep, close, security & be sure combine offense-defense-stability (ULO)

Theory of Victory

Synopsis of your Central Idea	Necessary Capabilities
Application & Integration of Military Functions	**Spatial & Temporal Dimensions**

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