SCHOOL OF ADVANCED AIRPOWER

TO WAR ON TUBING AND CANVAS:

A Case Study in the Interrelationships Between Technology, Training, Doctrine and Organization

By

Lieutenant Colonel Jonathan C.

AIR UNIVERSITY

UNITED STATES AIR FORCE

MAXWELL AIR FORCE BASE, ALABAMA

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A CASE STUDY IN THE INTERRELATIONSHIPS BETWEEN TECHNOLOGY, TRAINING, DOCTRINE AND ORGANIZATION

LIEUTENANT COLONEL JONATHAN C. NOETZEL

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Air University

Maxwell Air Force Base, Alabama

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David R. Mets

James S Corum

Gary P. Cox

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Abstract

The combat glider was effectively used by German, British and US forces in World War II (WWII). Each country had unique doctrines of development, pilot training, and force employment. Germany, restricted by the Treaty of Versailles, saw the glider as an effective means of training future Luftwaffe pilots and only in the mid-1930s realized the gilder's combat potential. The British and American military did not embrace gliders until Germany's dramatic early WWII successes in Poland and the European Low Country. British doctrine closely resembled Germany's by using gliders in commando raids of limited size. The US used gliders primarily as "air-trailers" for resupply missions. The study reviews each force's combat glider experience and analyzes it in light of the glider doctrine, or lack thereof, with which each began the war. While military cargo gliders have seen their day, recent technological advances in gliders make them a viable platform for certain missions requiring stealth and silence.

BIOGRAPHY

Lieutenant Colonel Jonathan C. Noetzel (BS, USAF Academy; MS, University of Michigan) is a fighter pilot. A recent graduate of the inaugural class of the School of Advanced Airpower Studies, he was just assigned to Headquarters Space Command, Peterson AFB, Colorado. Also a recent graduate of Air Command and Staff College, his previous assignment was as a USAFE sponsored Research Fellow, Maxwell AFB, Alabama. Previous assignments included F-111 pilot and Assistant Chief, Wing Operations and Training, RAF Lakenheath, England; Assistant Professor of Chemistry, USAF Academy, Colorado; and F-IO6 and T-33 pilot, Langley AFB, Virgina.

TO WAR ON TUBING AND CANVAS:

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INTRODUCTION

The military glider's history represents a spike in the time line of war. Used in combat only during the Second World War (WWII), under current doctrine they are unlikely to be used again during conflict.

Gliders were used extensively by both Germany and the allies. Each side adopted a dramaticaly different doctrine and training philosophy. Germany, who had been building a glider fleet since 1922, had the edge. The "Johnnie-come-latelies" (US and Great Britain) observed the German successes, drew different principles from the German experience, and formed their doctrine while they simultaneously developed their glider forces. The Germans stopped using gliders in large assaults after the Crete invasion. Interestingly, the allies viewed the Crete invasion as a herald for glider assaults and continued to use large numbers of gliders until the end of the war.

After the war, gliders fell from use quickly. Their demise was only delayed by the C-123's slow development due to austere budgets. Today the military uses the glider only as an elementary flight trainer.

Recent glider technology advances warrant taking another look at the glider's viability for specific military operations. Advances in materials, manufacture techniques, and airfoils make today's sport glider a markedly different machine from those in the 1930s.

This study examines military glider's development, use, demise, and limited rebirth since the early 1930s along with the doctrines used to employ the WWII glider. Doctrine, aircraft

development, and aircrew training took dramatically different courses in Germany, England, and the US. In the end, technology made the combat transport glider obsolete, yet the reasons for the dramatic German successes and the rather limited Allied successes are grounded in their doctrines and organizations. Germany and England emphasized smaller, commando raids while the US fully embraced the "air trailer" concept using gliders primarily for resupply missions.

The Germans were the pioneers military glider tactics and developed an effective doctrine over seventeen years prior to their use in combat. Years of training development and, later, wargames confirmed the glider's value. The glider offered a qualitative leap in airborne operations. Germany developed a doctrine to support its use. The Luftwaffe organized to perfect the glider's employment and to analyze its effectiveness.

Great Britain exploited Germany's experience in the Low Country and similarly developed a glider-borne infantry team which was primarily dedicated to combat and secondarily concerned with glider supply operations. Only later in the war did the English use the large, mass glider-borne assaults preferred by the US.

The US Air Corps ignored the sport glider enthusiast's pleas throughout the 1930s and failed to appreciate the glider's potential until confronted with the German successes in Poland and the Low Country. The subsequent production of over 15,000 gliders became a confusing, irregular, excessively expensive, and essentially an ad hoc affair. No coherent glider doctrine existed until nearly the end of the war and its effectiveness was tested in combat.

Coupled with modern technologies, the glider remains the only air vehicle to offer true stealth at relatively low cost for a variety of missions. The last part of the study discusses the recent technological advances and possible missions for a modern military glider.

PRE-WAR DEVELOPMENT

The Early Years in Germany

German development of military glider technology and tactics began almost immediately after World War I. The Treaty of Versailles forbade Germany from building a powered air force, left unpowered flight untouched. In 1922, Hermann Goering outlined the future of German airpower to Captain Eddie Rickenbacker:

> Our whole future is in the air. And it is by air power that we are going to recapture the German empire. To accomplish this we will do three things. First we will teach gliding as a sport to all our young men. Then we will build up commercial aviation. Finally, we will create the skeleton of a military air force. When the time comes, we will put all three together--and the German empire will be reborn.[1]

While the interwar years offered all nations ample opportunity to perfect the tactics and strategy for the military glider, only the Germans, constrained by the Versailles Treaty, had the motivation to capitalize on the opportunity. The World War One (WWI) peace settlement limitations forced creative German minds to find other ways to form an Air Force.

As Goering predicted, the sport flourished throughout Germany in the late 1920s and 1930s. Once Hitler came to power in 1933, his *Jugend* began to dominate the civilian flying organizations. By 1937, the Germans laid claim to the international glider duration, distance, and altitude records and had over 40,000 pilots with 10,000 to 12,000 gliders active throughout the country.[2] Research in sailplane design and construction was second to none. A modern sailplane of the day, the "Minimoa," had a glide ratio of 26:1 and introduced, for the first time, spoilers to control the glidepath on descent.[3] By the time the *Luftwaffe* was disclosed in 1935, glider training was a requisite to acceptance into *Luftwaffe* flight training. Young aspirants were required no less than twenty flights in a two-place glider of not less than one minute each.

The advances in German glider aviation fostered two high ranking advocates within the military. General Ernst Udet was involved with glider research and development from the glider's beginning. It was Udet who first suggested that the 1934 high altitude weather glider (the OBS) be modified to carry troops. Udet's glider vision was to use them to land troops behind enemy lines as part of a special operations force.[4] This concept of landing a special operations force in the enemy's rear area dominated German military glider employment until the Crete invasion.

The *Luftwaffe's* other glider advocate, General Kurt Student, had been a glider enthusiast from the start of his military career. Student was the mastermind of the Crete invasion, Germany's largest and last glider assault.

Early Gliders in the US

By comparison, the US had only 413 gliders and 140 glider pilots in 1936.[5] 182 of the gliders were in four states: Ohio New York, California and Michigan. Many of these gliders were of foreign design, the most popular of which was the "Minimoa" mentioned above. This sailplane was the day's most popular foreign design primarily because of its good cross-country performance. US soaring advocates hoped this airplane would help bring some soaring records to the US. At the time our glider records lagged far behind.[6]

A US Military Glider? For What Purpose?

The US military held no interest in a combat glider and only passing interest in a glider for military training. In the US gliders, with their limited range and payload, were only thought of as auxiliaries to training. As early as 1929, the War Department received suggestions to use

gliders as inexpensive training aircraft. The Air Corps solicited opinions from its flight instructors on the utility of glider training. Most instructors could see no practical use for them. The Brooks Army Air Field instructor corps reported that "military airplanes . . . are high powered and no beneficial result would ensue from training our student pilots in gliding." The Advanced School at Kelly Field reported their students could fly any type of aircraft with only a short transitional training course. (emphasis added)[7] Consequently, gliders remained out of the Air Corps. Some officers maintained their glider interest and attempted to maintain civilian flying currency in them. However in 1931, the Air Corps curtailed such activity by mandating specific War Department approval to fly sport gliders.[8] In 1934 the Navy investigated the idea of giving its aviation cadets glider training but never included gliders in its flying training program.[9]

Abroad, airborne and paratroop doctrine was in its infancy in Russia and Germany. The US would not start to develop an airborne force until late in the decade.[10]

Gliders Head Into Combat

Germany struck Poland in 1939 using gliders and again used gliders as part of the 1940 European Low Country campaign. In the US, the glider successes had a major impact on the War Department and Air Corps officials. The Germans had demonstrated a effective combat use for gliders and the US had no program whatsoever to use them. The US finally embraced the glider as a military tool on 25 February 1941 when General Arnold directed a study of glider development.[11] Once the decision to employ gliders was made, development and procurement proceeded rapidly but was fraught with difficulties.

Because the gliders were a new concept, doctrine for their use was virtually non-existent. General Arnold's 25 February 1941 memo sought a glider for "transporting personnel and material and seizing objectives that can not normally be reached by conventional ground units." It further specified the glider would deliver a self-contained combat team.[12] This view was in contrast to that of the newly formed I Troop Carrier Command (TCC) which believed the glider pilots were only "aerial truck drivers" of "air trailers."[13]

I TCC was given responsibility to develop methods, techniques, and equipment for glider operations in conjunction with the appropriate segments of the Army Air Force (AAF). By August 1942, the Commanding General, TCC, recommended developing following concepts:

1. Design and procurement of gliders
2. Communication between the tug and glider
3. Aerial pickup
4. Development of the glider as an extra fuel supply for the transport.
5. Instrument flying in gliders.14

Even the May 1942 manual, Tactics and Technique of Airborne Troops, emphasized the general concept that parachute troops would be only resupplied by glider forces. Noticeably absent was portion of General Arnold's memo calling for a combat team. The doctrine evolving in the US was the exact opposite of both German and British doctrines using gliders in primarily commando/raid operations and as a surprising lead element reinforced with additional glider and paratroop forces.[15]

Used as "air trailers," an invasion force would require a large number of gliders. Initial estimates called for 1,000 gliders (thus 1,000 glider pilots) and 202 transports would be necessary to move a 14,000 man division. The gliders would carry three-fourths of the division

while the other quarter would ride in the tugs. Half of the gliders would be eight-place versions and the other half would carry 15 troops each. 202 tugs for 1,000 gliders meant multiple tows would be the rule: 4 eight-place gliders or 3 15-place gliders for each tug.[16]

Within 20 months of General Arnold's memo, the CG-4A Waco design had been tested, approved, and 999 Wacos had been ordered on the first contract.[17] Over the remaining years of the war, the US received over 13,909 CG-4A Waco gliders. The program to produce this large number of gliders quickly has been criticized on several points. Major aircraft manufacturers were already committed to produce fighters, bombers, and transports and would remain so by Air staff direction. Prior to the war gliders and sailplanes were not cost-effective to produce in large numbers so none of the allies started with a production capacity in place Air Materiel Command (AMC) let production contracts with virtually anyone who could promise rapid delivery of the Waco-design glider. Eventually, twenty-two companies built CG-4As. Ford Motor company built over 4200 Waco-design gliders at an average cost of $15,400. This was at far less cost than the other contractors who charged between $19,367 and over $50,000 per copy.[18]

The single design caused some problems with parts compatibility between different contractor's products. Because of the program's hurried nature, design specifications sent to the various contractors were often illegible copies of Waco's pencil sketches. Common machine jigs were not readily available and this led to individual aircraft which looked like a Waco but had unique differences.[19]

While the various contractors complained of poor blueprints lack of jigs, and frequent design changes, the AAF in turn complained about the aircraft's high cost and delivery delays. Even Ford took over six months re-tooling their Iron Mountain, Michigan production line. With the exception of Cessna, received sizable government subsidies, no manufacturer met their

production schedule on time.

The concurrent development of production, doctrine, training can lead to serious delays should the development of one or more parts not keep pace with the others. To the frustration of thousands of glider pilots and glider pilot aspirants, insufficient airframes at the elementary and advanced schools, the slow delivery of full-sized combat gliders with which to train, and indecision by AAF leaders about the glider pilots after-landing role led to the forming of large pools of half-trained glider pilots with little to do. Having completed some training, their proficiency waned as did morale. Several attempts to give the pooled pilots more time off helped morale but did little to recover lost flight skills.[20]

Come Join the Glider Pilot Corps!

The first military glider training took place in the summer of 1941. The first six officers, including then Major Frank Dent who became the officer-in-charge of AMC's glider production program, trained for three weeks at the Elmira (New York) soaring School with a like number at the Frankfort (Illinois) Soaring School.[21] It wasn't until the following spring that the US Army formed its first glider training school at Twenty-nine Palms.[22] From December 1941 through May 1942, three separate glider pilot training programs were directed. The final plan, approved on 8 May 1942, called for 6,000 pilots by year's end with half completing training by 1 September.[23] While this plan seemed ludicrous, a qualification change requiring the candidate to be a CAA certificate holder or a graduate of the command pilot training school ensured highly experienced candidates. Still there was insufficient response to achieve the 6000 pilot goal. The Air Corps increased the granting of waivers, promised staff Sergeant on enrollment rather than graduation, and offered high pay, rapid advancement along with adventure to anyone physically

and mentally qualified.[24]

The trainee floodgates opened and the material inadequacies aggravated the training shortfall. The glider pilot acquisition program underwent three additional revisions that year reaching, in the 10 August revision, a maximum pilot production rate of 12,000 a year. Sometime in the early fall of 1942, it became apparent that pilot production was exceeding any existing or contemplated tactical need. Glider pilot procurement ended on 16 November 1942.[25]

Glider pilot Training Shortfalls

The real problem remained the limited number of gliders throughout the training system but particularly at the advanced schools. AMC had been directed to procure 1500 CG-4A aircraft by 1 October 1942 and another 1500 by year's end. The first CG-4A was not delivered until the first of September.[26] Tow planes were equally scarce. On 17 Oct 1942, there were 1900 men awaiting elementary training, 2600 waiting for basic glider school, and 1600 ready for the advanced course. The number waiting for advanced training was expected to reach 5000 by June 1943.[27]

The large pools of pilots waiting further training offered an opportunity to train these pilots in ground infantry tactics this was suggested by several officers closest to the morale problems. Yet the training given to those in the pools remained heavy on flight related duties (maintenance courses, signals, etc.) rather than infantry tactics.[28] It is clear that the proper role of the glider pilot after landing had not been completely thought through. He was expected to return via Army routes to his unit. If the glider-borne troop were to be used only as aerial truck drivers, this philosophy might have worked. However, as part of an assault airborne force, their fate was in their own, largely untrained, hands.

The doctrine for the glider and its pilots can best be found in the training curricula. At first each school developed its instructional publications. The first training directive was not issued until the May 1942 program was approved. The May program directive provided a definition, of sorts, of the glider pilot's combat role:

> In training glider pilots, primary attention will be given to their training in the piloting role. The secondary function of these pilots. . . .will consist of ground combat operations with the air-borne units which have been transported on their gliders. . . .
>
> The role of the glider pilot in combat will be primarily to land his glider safely, expedite the rapid debarkation of his passengers, secure his glider on the ground, assure that transport which may land after the glider-borne troops have secured the airdrome or locality to permit reinforcement by transport-borne troops. The glider pilot will participate in ground combat only in exceptional circumstances or after his glider has been wrecked in landing.[29]

Each school's training plan outlined the goals of its program, that is, the desired proficiency of the graduates. The 1942 program of instruction for the Advanced School listed its objective:

> "To become proficient to the degree that the graduate is qualified to operate cargo gliders in various types of towed flight, both night and day, and to be qualified to service gliders in the field."[30]

Combat-oriented training is similarly absent from the Twenty-nine Palms Instructor's Manual.

So through 1942 and most of 1943, glider pilot training was primarily concerned with "the safe and proficient operation of the CG-4A glider." A revised training program, implemented on 16 August 1943, attempted provide a more combat-oriented training program. Tactical landings, night landings, and multiple tows were newly included in the course.[31]

The Flying Training Command's (FTC) attempt to provide a combat ready glider pilot was still lacking, however. In December 1943 (five months after the Sicily invasion), I TCC highlighted eight continuing problem areas with the pilots FTC was providing:

1. Accuracy landings
2. Down-wind landings
3. Down-wind takeoffs
4. Take-off technique
5. Landings, in general
6. Command of the situation
7. Slack towline releases
8. Insufficient combat team training to function and NOT be a liability.[32]

Not until 1945, did the training directives delineate an offensive and defensive combat mission capability. Small arms and combat team training did not become part and parcel of final glider pilot training until the same year.[33]

It becomes clear that there were more than one plan driving procurement, training, and employment of gliders. Those involved with procuring gliders tended to fall in line with the trainers providing a system that would simply haul men and material to the front and land on unprepared fields. The pilots would make their own way back to friendly lines and after the main force advanced through the old landing site, gliders could be recovered, refurbished, and sent into battle again. Those charged with employing the glider, i.e. the pilots and airborne commanders, were expecting a combat role for the glider pilot.

Unfortunately this evolving concept of "air trailers" neglects the flight crew's role after landings in contested areas, possible defenses against glider landings, mission redundancy should one or more gliders not land where expected, resupply of the glider-borne troops, and the untried practicability of recovering combat gliders for reuse. These weaknesses were also prominent in the allied operational history of combat gliders.

Military Gliders in Britain

The British glider forces developed much quicker than the US forces and resembled the German model more than the evolving US doctrine. Major George Chatterton, the Glider Regiment's first operational commander, fought hard to make the glider pilot part of the combat team and drew glider candidates from the infantry rather than the pilot corps. These men were excellent soldiers first and then were also trained as glider pilots. The US adopted the opposite approach; specially-selected glider pilots were not expected to be part of the army squad he transported.

Major Chatterton's belief in the fighting glider pilot was frustrated by the urgency to get the glider unit into combat. Pitifully insufficient training and ignorance of the glider operation's complex planning requirements set up their first attempt at glider war for disaster.

Sir Winston Churchill committed the British Army to develop an airborne force in June 1940. Major (later Lieutenant Colonel) John F. Rock, Royal Engineers, was ordered to assemble the 5,000 man force desired by the Prime Minister. Initially, the force was to be of parachutists entirely, but the airlift shortage required a more innovative troop carrier technique.[34] Gliders were thought to be a relatively inexpensive way to solve the airlift problem.

Starting with a small demonstration exercise in October 1940, the 1st Airborne Division was formed in January 1942. Major General F. A. M. "Boy" Browning, its commander, chose Lieutenant Colonel Rock and Major Chatterton to develop the Glider Regiment.[35]

Major Chatterton firmly believed the glider pilot should be able to fly the glider, deliver the required cargo in the most demanding combat conditions, and should also be part of the fighting force on landing. Chatterton demanded the highest quality fighting man in his glider regiment.[36] This philosophy was in stark contrast to the American approach to glider pilots.

American glider pilots were sent overseas with little or no combat infantry training to help them fight on the ground, let alone protect themselves and their gliders after landing.

The RAF was responsible for the glider pilot's flight training. The training began with light powered aircraft then moved to Hotspur and Horsa gliders. Although the Hotspur never saw combat, its size and weight (once fully ballasted) made an excellent trainer for Horsas and larger Hamilcars. Here again, the British training was superior the US program.

Continuation training for the British glider pilots was difficult at first. The RAF did not really know what to make of these infantrymen acting like pilots. But by the end of the war and after some clever maneuvering by Major Chatterton, the glider pilots not only trained with the RAF tugs but were actually members of the tug crew and were billeted on the RAF station until needed overseas.[37]

In the early months however, trained glider pilots were sent back to the Salisbury Plain, home of the 1st Airborne Division. Once the 1st Battalion was formed and completed their initial training, the Division was sent to North Africa for the invasion of Sicily. Unfortunately, the glider regiment was not ready for combat. The pilots averaged just over eight hours of glider flying over the preceding six months with virtually no night flying time whatsoever. Despite Chatterton's protests, the battalion was dispatched to North Africa.[38]

OPERATIONAL USE OF GLIDERS

Germany

The Germans had the advantage of being the first to bring combat gliders to the battlefield with a unique and practical doctrine to use them. The primary precept of German combat gliders doctrine was that gliders are most effective in a commando/raider role. The

following paragraphs detail the major German uses of gliders and demonstrate this characteristic.

Early Commando Raids

General Student got his chance to prove the attack glider's value (by no means a forgone conclusion in the paratroop force) in the opening of hostilities against Belgium. The famous attack of Fort Eban Emael was a stroke of military genius by Student. Ten gliders carried the initial attack force of 78 Germans to most modern fortress of the day manned by 780 Belgians. The 10 May 1940 attack began at 0505 hours. By 1300 hours the following the day, fortress had surrendered.[39] Other gliders were used in the same campaign to seize critical bridges for the invasion blitzkrieg forces.

Nothing reinforces an idea like another success. The next German use of gliders came in April, 1941. Greece had surrendered only two days before and, seeing another Dunkirk in making, the Germans believed they could trap a large number of British and Australian forces by capturing the bridge spanning Corinth Canal. It was the main artery toward the southern ports and if the Germans captured the ports north of the bridge before the evacuation was complete, the allied forces would depend on the bridge for their very survival. Lieutenant Wilhelm Fulda led the glider and paratroop attack on the bridge which began with preliminary bombing of the allied forces. Within one hour, the bridge was taken intact. While Fulda ordered the wires and charges removed from the bridge, a lieutenant engineer refused to remove the charges maintaining that his orders were to only cut the wires. The charges stayed put. Shortly thereafter a remaining Bofors gun crew, firing tracer rounds, began to close in on the charges. Lieutenant Franz Phenn was on the bridge when the Bofors hit its target. The bridge and the Lieutenant crashed to the canal floor. Although the bridge was destroyed, the allied forces were cut in two

and the Germans were able to take many prisoners.[40]

Crete

With the capture of mainland Greece, only Crete remained as last stronghold for Greek, British, and other Commonwealth forces. The island became a necessary stepping stone in Hitler's goal to take the Suez Canal. Gliders had worked before on a smaller scale and General student believed the experiment in a larger scale invasion would also succeed.

Seventy-two gliders were used in a combined invasion force to land 14,000 Germans on the island. Sixty-one gliders landed close enough to their objectives to be effective, but only 40 percent of the landed troops accomplished their assigned missions. Unfortunately for the Germans the 42,500 Allied troops exacted a high cost from the ultimately successful invasion force. Of the 6000 airborne troops used, 4000 were killed or wounded Most of the troop deaths were paratroops--nearly 80% were killed. [41]

The German experience on Crete soured Hitler on large airborne forces in future attacks. However, General Student did give up on the attack glider. In early 1941, he was directed to draw up plans to take Gibraltar. After some study however, he determined that it was not feasible. Student had also developed detailed plans to capture Malta in June 1942 but these too were cancelled by Hitler. In October of the same year, Hitler reversed his disdain for airborne operations and ordered Student to disrupt the flow of Russian reinforcements and material coming from the Georgian republic. His plan used 16,000 parachute troops, 400 transports and 250 gliders. The Russian army began moving rapidly just prior to the operation and it was abruptly cancelled. [42]

Although gliders were not used in an large airborne attack force again, the Germans used

the now-surplus gliders to experiment with supply and tactical evacuation missions while maintaining their commando role. Each *Stuka Gruppe* had three DFS-230 gliders assigned to carry supplies or maintenance personnel. The GO-242 and Me-321 were also used as mobile maintenance workshops. Modified internally, these gliders were unit-assigned and accompanied the workshop platoons.[43]

Other Operations

In 1943 German forces were removed from the Kuban peninsula in the first air transport evacuation. Every serviceable transport and glider was used to rescue some 82,000 troops over a five-week period. Gliders were also initially used to reinforce the Crimea offensive and were later used to evacuate the same forces.[44]

The most interesting commando use of gliders was Mussolini's rescue from his Italian captors at the Hotel Campo Imperatore, nearly 6,000 feet up Monte Corno, the highest peak in the Apennines. All approaches had been blocked and the altitude precluded a paratroop assault. Major Otto Skorzeny believed a small glider force could land on a tiny triangular field on the peak, near the hotel. The force would grab Mussolini and a light airplane would fly them to Aquila airfield. A He-111 would meet them there and take Mussolini to Berlin.

A pre-launch raid by Allied bombers prevented two of the five gliders in the initial attack force from taking off. Upon landing, the three remaining glider pilots found the field "studded with rocks ledges and loose boulders."[45] Within three minutes the commandos freed Mussolini. Unable to reach the light aircraft at Aquila by radio, Skorzeny ordered the overhead Storch observation plane to land on the tiny field. He piled himself and Mussolini into the aircraft over the initial refusals of its pilot. Using a dozen troops to hold the plane, the aircraft's engine was

run up to full power before the troops let go. Losing one wheel during the takeoff, the pilot successfully flew to Rome and made a single-gear landing. Mussolini and Skorzeny continued on to Berlin and a delighted Hitler headquarters.[46]

With the single exception of the Crete invasion, Germany held to Udet's vision of combat gliders. They were used in small numbers to land a special operations force behind enemy lines. There is no evidence that the Germans had any plans to recover and reuse their gliders flown into combat. General Student appears to be the strongest advocate for an increasing role for the assault glider but he could not convince the rest of the General Staff. There would be no large German serials of tugs and gliders as part of an invasion force similar to the US employment doctrine.

US and Great Britain

Sicily

US gliders first saw combat during the Sicily invasion. Flown mostly by British pilots during Operations Ladbroke on 9/10 July 1943 and Fustian on 12/13 July, the US glider pilots were not ready for combat in July.[47] Major Chatterton's Glider Regiment had been moved from the Salisbury Plain to North Africa in early 1943 without knowing the plan for their use. He was truly surprised on 1 April 1943 when he was told that the Glider Regiment's mission was to lead the night landings around Syracuse on 9/10 July.

The Regiment's commander had a formidable job to do in the next three months. Chatterton's pilots had not flown in three months, had little or no night experience, and were to use American Waco gliders of which there were only 4 operational in all North Africa.[48]

The rush to get gliders and the airborne forces into combat highlighted further weaknesses in the US doctrine such as transportation of gliders to the battlefield, reassembly

locations and personnel, and adequate in-theater training. Wacos were shipped in five crates from the US. The operation called for 137 primary gliders plus reserves and replacements for those damaged in training. Approximately 500 gliders were sent to the theater.

The first four gliders to arrive were in dismal shape. They required a month to repair the rusted fittings, rotted fabric, and loose gluing. If the remaining shipments suffered the same problems, sufficient gliders would not be ready for the invasion.

Following shipments were, in fact, in almost perfect condition, having been crated and stored only a short while. Every mechanic in theater, both from Service Command and Troop carrier Command, was assigned to the three depots to assemble gliders. Innovative assembly line techniques brought the number of hours for assembly down to 250 hours per airplane. [49]

375 gliders had been ferried forward by 30 June where more problems awaited. Most significant of these were the lack of vehicles to tow the gliders around the airfields and the lack of tow ships. Often glider ferry flights were combined with airborne training flights.[50]

By the time training ceased on June 20, the British pilots averaged only 4.5 hours in the Wacos. Within this 4.5 hours, just over one hour was at night. The crews averaged 16 landings. None of the practice missions include a mass release over water or at night. Once again the rushed planning to employ gliders overlooked the details. The Sicily mission was set for disaster.[51]

The glider portion of the Sicilian operation was, by most measures, successful but at great cost. In the first attack on the evening of 9/10 July 1943, 144 gliders were to be released 3000 yards off shore at 1500 to 1800 feet of altitude. The three landing zones were a maximum of 3000 yards inland. The landings were to commence just after midnight under the dim light of the first quarter of a new moon. Of the 137 gliders sent on Operation Ladbroke, 49 Wacos and five

Horsas landed in Sicily. Only four landed where they were supposed to land. Three in landing zone (LZ) 1 and one in LZ 2. The remaining 46 landed within ten miles of their goal. Chatterton himself along with at least 69 other gliders landed in the sea. About 605 men of the 1690 carried were lost.[52]

The three nights later another airborne assault (Operation Fustian), using only 19 gliders, fared slightly better. Unfortunately, naval fratricide reduced the glider force by one third before they reached shore. The paratroopers had an equally tough time as fewer than one-fifth of the parachute brigade was dropped at the right place and time. Of 105 Dakotas, eleven aircraft were shot down and 27 returned to base. The object, the Primasola bridge, was taken and secured although Chatterton recalls it as a closely contested operation.[53]

That the operations were successful at all were undoubtedly due, in part, to the combat training of the British glider pilots. Because the landed troops of Operation Ladbroke were scattered throughout sea and land, less than 100 troops, including several glider pilots, arrived and captured their objective, a bridge spanning the Primasole river. Despite their valiant efforts, only 4 officers and 15 other ranks were unwounded when they surrendered their position to the German counterattack. Major Chatterton's insistence that the glider pilots be infantry trained proved to be correct. (The British Fifth Division retook the bridge and rescued their comrades later that day.) [54]

As explained above, these glider operations suffered from extremely poor planning. Sicily was a bitter experience for the glider forces, both American and English. While many factors contributed to the disaster, such as the folly of night releases over water, the necessity of close coordination, insufficient training, and the criticality of close attention to the weather, the thirty-five knot off-shore gale on 9 July was key.[55]

British Gliders are First to Normandy

Nearly a year later thirty seven US gliders, manned with members of the British sixth Airborne Division, landed around the towns of Merville and Benouville on the night of 5 June 1944 in advance of the Normandy invasion. Their objectives were to knock out artillery and seize bridges. These missions fared immensely better than Sicily. All gliders landed with relatively few injuries.

Seventy-two gliders took off early on the 6th to deliver elements of the 6th Airborne Division. 49 landed under very difficult circumstances because of the poles ("Rommel's asparagus") erected in the landing fields. While landing strips were cut by the parachute engineers, several pilots missed the strips. Strong cross-winds complicated the landings and consequently there were many crashes, yet virtually all of the passengers with most of their equipment accomplished their missions.[56] Fourteen of 23 which did not make the landing were lost, five landed back in England, three ditched at sea, one was lost in a mid-air collision.[57]

Later that day 250 gliders landed the 6th Air Landing Brigade. This landing went extremely well. Several gliders crash-landed but with extremely few casualties.[58] Gliders had served their purpose although virtually none were recoverable. The next major British operation, at Arnhem, demonstrated the doctrinal weakness of relying on airdrop for large force resupply.

US Glider pilots Join the War in France

Hundreds of US glider missions were flown supporting Operation Neptune, Eisenhower's airborne portion of operation Overlord. Gliders flew in six missions, four on D-day and two on D + 1. These missions, divided among the 82nd and 101st Airborne Divisions, were named

Chicago, Detroit, Elmira, Galveston, Hackensack and Keokuk.

Chicago and Detroit were early morning releases on D-day. The Chicago lift contained 51 gliders. Despite rough landings and the loss of the only General, Brigadier General Donald Pratt, killed in a glider landing, the mission was a success. Again, however, night operations proved difficult. Several crews lost sight of the landingS "T" marker (which was subsequently found to have been set up in the wrong field) and few could see obstacles in their landing path. Only a few gliders failed to land their cargo and passengers completely intact.[59]

Detroit's 52 gliders all took off within twenty minutes and were ten minutes behind Chicago. Fourteen gliders were prematurely released primarily because of weather. Most of the remaining gliders landed near the landing zone. However misidentification of the LZ led some glider pilots to land in other fields.

Keokuk and Elmira combined to land 210 Wacos and Horsas. The twilight landing had its difficulties, too. Only thirteen of the 84 Horsas and none of the Wacos in the 98-ship Elmira mission survived intact.[60]

Galveston began its takeoffs 30 minutes before sunrise on D+1. The two serials carried 101 Horsas and Wacos. 35 gliders were destroyed on landing and 17 glidermen were killed, 98 injured.[61]

Hackensack followed Galveston by two hours. Of the 100 gliders launched, 28 were destroyed, 48 damaged, 19 men were killed (including 3 glider pilots), and 85 men were injured. The second serial of Hackensack was particularly successful. With almost 90% of its cargo undamaged and few injuries, it set the standard for future glider operations.[62]

Daytime missions successfully landed approximately 90% of the men and equipment ready for battle within two hours of touchdown. Pre-dawn missions landed with about 40-50%

cargo losses. The night missions were successful, but the hazards of landing in small, hedgerow encircled fields proved destructive. The Normandy glider operations showed gliders to be a sturdy and reliable method of delivering troops and cargo within very narrow and critical operational constraints.[63] Air superiority, daylight, and good weather operations were essential.

Disappointment at Arnhem

The September 1944 airborne assault at Arnhem was to be truly a melancholy affair highlighting the airborne force's dependence on reinforcement and the glider pilots reliance on good weather. The glider assault, using 692 airships, was gigantic. The first lift of 359 went well and over 325 gliders landed safely, unloading their cargos within thirty minutes of the last touchdown.[64]

The following days English weather precluded the second wave of gliders and reinforcements from arriving on time. Ultimately the British forces took heavy losses and had to be withdrawn. While there is no single reason for the Arnhem operation's failure, the reinforcement delay caused by the glider's weather limitations contributed significantly to the ultimate Allied defeat.

Operation Market

The US glider contribution to Operation Market (the invasion of Holland) proved to be the war's largest. IX Troop Carrier Command launched 1618 effective glider missions delivering 10,374 troops, 526 trailers, and 830 jeeps. Combined with the British data, operation Market was a truly monumental effort. Of the 34,876 troops delivered by air, 13,781 landed in gliders.[65]

More than 1700 US glider pilots flew into the battle. But once on the ground, their poor

infantry tactics training left them "aimlessly wandering about caus[ing] confusion and generally get[ting] in the way and hav[ing] to be taken care of."[66] The glider pilots constituted about 5% of the landed force, yet had virtually no training in infantry operations. General James Gavin, commander of the 82nd Airborne Division, expressed the Army's frustration with the glider pilots,

> ...One thing in most urgent need of correction, is the method of handling our glider pilots. I do not believe there is anyone in the combat area more eager and anxious to do the correct thing and yet so completely, individually and collectively, incapable of doing it than our glider pilots.[67]

Glider Success Over the Rhine?

While Operation Market was large, the Varsity operation was substantially more difficult. The airborne assault across the Rhine in March, 1945, was the last major glider operation of the war. Within a twenty-five square mile area on the east side of the Rhine river, almost 17,000 men and their associated equipment were landed within 4 hours. Gliders delivered over 8,000 troops, over 1036 tons of cargo, 109 artillery pieces and 1386 vehicles.[68] The landing was contested by the Germans who had massed a portion of their dwindling force (about 12,000 men) in the immediate air assault area.[69] The lightly-contested amphibious crossing, launched eight hours before the air assault, could not, with the exception of the British 15th Division, move fast enough to support the airborne operation.[70] Still by nightfall, all organized opposition had been crushed.

The airborne assault had been a success but it did not come without cost. The Glider pilot Regiment suffered 250 glider pilots killed, missing, or wounded.[71] US glider forces lost 194 glider pilots and 163 glider-borne troops killed, wounded, injured, or missing.[72] This mission was well planned, well executed, and consistent with the US (and by this time British) doctrine

for air assault. And while the operation may not have even been necessary because of the virtually unopposed amphibious crossing, the doctrine was properly tested and found wanting.

Operation Dragoon

The last glider-borne invasion of the continent was in Southern France. Code named Dragoon, the table below summarizes the successes of glider operations in August 1944.

Sorties Intended	857
Sorties Flown	852
Wacos	372
Horsas	36
Paratroops	444
Troops Delivered	9,099
By Glider	2,611
By Parachute	6,488
Gliders on/near LZ	90-95%
Paratroops " "	50%
Drop casualties	2%
Landing casualties	4%

The most interesting part of this glider operation was the difficulty imposed by "Rommel's asparagus." These four to six inch poles were stuck in the ground to eliminate a clear landing path. Although these were not new to this landing, they were not expected. The gliders were a complete loss.[73]

US Commando Operations in Burma

Between the Sicily and Normandy operations several smaller, but very effective, glider operations occurred in the China-Burma-India (CBI) theater. Generally these operations used a different doctrine than that used in Europe.

General Orde Wingate's use of gliders in Burma constitute a real success story. Wingate's mission was to cut the Japanese supply routes in central Burma and force their withdrawal. His plan called for an air landing of troops deep in the Burma jungle. Breaking from the airborne doctrine of using gliders in a reinforcement role, he planned to land glider-borne engineers to clear a jungle strip for the transports.

The sites Wingate chose were only clearings and could not directly support airlanding of troops without improvement. On 5/6 March 1944 forty-nine gliders successfully landed at two of the clearings. Both fields were prepared and receiving C-47s by the morning of 7 March.[74]

Advance units preparing for the assault were the first to use a glider for medical evacuation. On 29 February 1944 the 16th British Infantry Brigade received two resupply gliders on the Chindwin river banks. Once the cargo of boats, motors, gasoline, and two technicians were unloaded, the one serviceable glider was "snatched" by a C-47. On board was a hospital-bound litter.[75]

After Wingate's death on 25 March, Major General Walter D. A. Lentaigne continued to use gliders in numerous small operations with varied success. In all ninety-six glider sorties were flown by Wingate's forces.[76] While these were few in number compared to those launched in Europe, they remain outstanding examples of creative and bold use of a previously unknown tactic. The successes General Wingate's forces had using gliders could go unnoticed. Colonels Philip Cochran and John Alison were responsible for putting the forces together, obtaining the

equipment, and training both ground and air crews. They were so successful that General Eisenhower, through General Arnold requested Colonel Alison's expertise in Europe. He was the first of many from Burma to develop the glider's use for the Normandy invasion.[77]

Summation

Despite the successes of the glider forces, there were several problems with both gliders and the glider pilot that jeopardized their continued use for airborne delivery of troops and equipment. The US gliders could not be flown to the theater were crated and shipped displacing other cargo. Trained mechanics were required for disassembly and re-assembly at the destination. The glider-tug combination was much more vulnerable to enemy fighters than the tug alone. The glider was often hard or impossible to handle while under tow in bad weather or at night. Most gliders used in combat were so badly damaged on landing or so deteriorated that relatively few were ever recovered from the battlefield to fly again. Consequently, dispensable glider became a great expense for the AAF. Lastly, the appearance of a number of gliders near the front compromised the airborne commander's operational security.

Under the current doctrine, glider pilots were a separately trained pilot corps with their own unique training requirements. Certainly in the US, the primary mission of the glider pilot was to land the airplane, not to be part of the combat team. Because of the difficulties in training the glider pilot for his primary mission, the secondary combat training never materialized. How he was expected to land his cargo or troops in a hostile and contested area and NOT participate in combat remains a mystery to the author.

Mass troop transport was not the glider's strength. The Germans experimented with this concept during the Crete invasion and abandoned it in favor of the more successful

commando/raider role. Likewise, the British used gliders primarily as commando deliverers until the Arnhem operation. Only the US remained resolute in its use of gliders as mass troop transports and aerial resupply trucks in Europe. While some very successful experiments were used by General Wingate's Chindits in the CBI theater, they were relatively small operations and had minimal impact on overall US glider doctrine.

The mass troop transport doctrine required large numbers of gliders and glider pilots. The wild variations in the glider pilot training program and the inadequacies of the training are a direct result of the paucity of doctrine to implement the "new" technology. The costs of this poor training, doctrine and low morale was in soldier's lives.

POST-WAR GLIDER POLICY

The CG-4A had always been too small. It was able to carry 15 soldiers, or a jeep, or a 75 mm howitzer, but could not carry any combination of the three. The Waco design was improved, enlarged somewhat, and redesignated the CG-15 but only 427 of these gliders were ever delivered. Its chief drawback: too small as well.

All existing gliders were declared obsolete by the Deputy Chief of Air Staff in March 1945. During the next month, ground and air force representatives met to develop the requirements for the next generation of gliders. These gliders were to be all- metal, rear-loading, and adaptable to engines. Two sizes were required, the lighter assault glider required an 8,000 pound load and a cargo space of 24' X 7.5' X 6'. The heavier assault glider was to have twice the payload and a larger cargo compartment. A five-year glider development program was approved to make these two gliders operational. [78]

The four ton payload glider was developed by Chase Aircraft during 1946/1947. The first YCG-18 was first flown in December 1947 but wasn't tested and declared operationally suitable

until the fall of 1949. No contractor wanted to build the aircraft however because of the consumer demand for post-war goods. Chase, itself, finally accepted the contract to build thirteen of gliders, but delivered only four as of June 1950.[79]

Chase had also won the competition for development of the eight-ton capacity heavy assault glider. Its development was much slower than that of the smaller glider and the XCG-20 not ready for its initial flight tests until April 1950. It was never placed into production.

Thus at the turn of the decade, the US glider forces consisted of one XCG-20, four CG-18s, 115 CG-15s (only 34 of which were in active use) and 34 Wacos (six of which were used for demonstrations). Only 18 gliders were rated combat-ready in Fourteenth Air Force, the primary keeper of the US combat gliders.[80]

While Chase was developing the CG-18, the AMC included in its contract to produced a powered version of the glider. The transformation was relatively simple and the powered version, designated the YC-122, was delivered in November 1947, one month before the unpowered glider. A similar effort was made with the XCG-20. Designated the XC-123, its first successful flight was on 12 October 1949, six months before the unpowered glider version was ready.[81]

By the beginning of 1950 it was clear to ground and air force commanders alike that the assault aircraft would be viable. By September both Army and Air Force personnel agreed that requirement for gliders in troop carrier operations no longer existed. The Joint Airborne Troop Board, Fort Bragg, wrote the glider's epitaph in April, 1952, with a memorandum stating "gliders, as an airborne capability, are obsolete, and should no longer be included in airborne techniques, concepts, and doctrine, or in reference thereto."[82] The glider's only mission to survive the war, to deliver troops and supplies as part of the airborne force, had finally fallen to

technology. The commando raid and medical evacuation roles would be handled by the coming helicopter.

TECHNOLOGICAL ADVANCES IN GLIDERS

The advent of the jet engines, helicopters, and nuclear weapons swept gliders from the military planner's mindset. US conventional forces took a back seat to nuclear force development. Yet while the USAF looked to an all jet, high-speed, nuclear force, the sport glider continued to improve in performance and materials.

Glide ratios began a steady climb. The standard, medium performance, US-produced sport glider in the late 1960s and early 1970s had a glide ratio of about 23:1. Glide ratios of high performance gliders were nearly twice that figure. By the early eighties, performance of the best contest ships took a dramatic leap. Glide ratios of the highest performance sailplanes approached 60:1. Gross weights of these ships were very light and design improvements made assembly and disassembly simple. Improvements were made in three areas. First, the introduction of airfoils specifically designed for low speed, soaring flight became available during the mid-1960s. Extensive investigations into low-speed airfoil improvements were done by a German aerodynamicist, Dr. F. X. Wortmann, in 1962-1964. His contributions were significant because his designs greatly increased low-speed lift without increased drag over the then commonly-used sailplane airfoils. His detailed examinations also determined how laminar airflow could be maintained over the entire wing surface to very low airspeeds. The introduction of positive flap settings delayed low-speed airflow separation even further and helped reduce drag at higher cruising speeds.[83]

Construction techniques and materials were the other important areas which saw major improvement. WWII glider fuselages were constructed primarily of fabric-covered steel tubing

or wood. Wing sub-structures were almost exclusively wooden. While some sport gliders of the 1950s and 1960s retained fabric coverings throughout, manufacturers of higher performance sailplanes used either all metal wings with fabric-covered steel tubing for fuselages or wood for both wing and fuselage sub- structures.

The introduction of fiberglass allowed large improvements in the aerodynamics of both wings and fuselages. Foreign manufacturers readily embraced these new techniques while the dominant US producer, Schweizer Aircraft, preferred all metal skins for the wings and either conventional fabric-covered tubular or all metal fuselages. Fiberglass wings were constructed in molds from the outside inward. The resin was strong, light-weight and could be smoothed to a much higher degree than wood. The wing and fuselage substructures, however, remained of primarily wood or metal construction. These two improvements contributed to about a twofold increase in sport glider performance through 1970.[84]

The "superships" of today owe their performance to high strength composite, specifically carbon fiber, materials. The wood or metal wing spar could be replaced by a much lighter and stronger carbon fiber spar. This lighter and stronger spar enabled the wings to begin grow to today's twenty-four meter spans.[85] Previously fifteen meters was the practical limit to high performance sailplane's wingspan.

Aircraft made of these composites boasted a 20% increase in performance over sailplanes made just a few years before and about a 300% increase over WWII standards. Common descent rates for a 1930s sport glider was approximately 2.5 - 3.0 ft./sec. Thus for a release of 1500-1800 feet above the ground, a glider could stay aloft for about 10 minutes. Military gliders descended about 30% faster with the associated decrease in flight time.

The today's superships not only travel a long way (with up to a 60:1 glide ratio) but can

stay aloft for very long periods. Minimum sinking speeds have been halved and approach the 1 ft./sec. mark. A modern glider released from 1800 ft. above the ground could take up to 30 minutes to land.

The strength of composites also increased the payload capacity of modern gliders. The Nimbus 3, for example, weighs only 853 lbs. empty yet has a maximum gross weight of 1656 lbs. The CG-4A weighed approximately 6000 lbs. empty and had a maximum gross weight of 9000 lbs. Thus the CG-4A could carry about 1/3 of its maximum weight in cargo and crew while in modern gliders nearly half the maximum gross weight is available for cargo/crew.[86] While this increased payload performance would likely not be realized in a modern military cargo glider, it is reasonable to assume its cargo-to-gross weight ratio would be greatly improved over that of WWII aircraft.

American and British military gliders used in WWII had glide ratios of approximately 10:1. Most sport gliders of the day had glide ratios of about two to two and a half times those of military gliders. Using a similar correlation today, industry should be able to produce a military glider of similar capacity to those of WWII with glide ratios three times greater than the 1940s models. Setting aside the possibilities of other missions the military glider warrants another look on this basis alone. However, current doctrine, while emphasizing stealth, continues to emphasize speed, range, and flexibility. While a modern military glider may have excellent stealth characteristics, it would still be slow, have short range, and be a one-time use item. Such an aircraft does not fit well with today's USAF doctrine.

TODAY'S LIMITED MILITARY ROLE FOR GLIDERS

The USAF maintains some limited interest in gliders. The Air Force still operates two

glider sites for cadet and test pilot training. The USAF Academy's (USAFA) soaring program, the largest glider operation in the world, is currently training over 1000 cadets annually through their first solo flight. While there have been no studies to date on this program's impact on the USAFA graduate's Undergraduate Pilot Training performance, this initial glider training, focused on the basics of aircraft control and precision landing, must enhance the young officer's aviation experience base at comparatively little cost. Through this program the USAF is building a pilot corps with at least some glider experience similar to that of pre-WWII Germany.

The other glider operation is tied to the USAF Test Pilot School (TPS) at Edwards Air Force Base (AFB). The glider training familiarize the students with slow speed flight characteristics rather than soaring techniques or precise glider control. The scope of the TPS program is dwarfed by the USAF Academy operation.

Gliders were also used with success as decoys in operation Desert storm. Primarily carried by naval A-6s, the medium-speed gliders were launched to force the Iraqis to turn their radars on thus revealing their positions for attack.[87] Additionally, gliders could be used to suppress a modern defense network by either offering low cost electronic warfare platforms or by overwhelming the defense network with decoys.

CONCLUSIONS

The day of the military cargo glider has probably passed Gliders offered the WWII armies unique capabilities which could be filled by no other means. Their marginal successes, inadequate doctrine, and the overwhelming costs of the US's glider program were not primarily due to mismanagement, but rather were caused by a quickly developed program, low priority for materials, multiple producers, poor cost control, lack of military experience with gliders, and

tooling difficulties.[88]

The US Army, embracing the combat glider only months before war, was not organized to exploit this "new" technology. The lack of a centralized decision-making or doctrinal-development process led to several theories on the glider's utility. The airborne leaders and some airmen advanced the combat glider-borne team in concert with Germany's doctrine. Others, mostly within the AMC, could only envision the glider as an air trailer to haul men and supplies. Because our experience with gliders was lacking and an over-zealous desire to get the glider into combat, the doctrinal issue was further clouded by initially using undertrained British pilots in us gliders for the Sicily invasion.

Our WWII glider exerience appears to confirm Dr. I. B. Holley's theory that "the failure to emphasize better weapons rather than more weapons and the failure to attach sufficient importance to the formulation of doctrine issue[s] directly from inadequate organization."[89] We failed to have an adequate information gathering mechanism to capture the German's more effective use of gliders in a combat, rather than a resupply, role. We further failed to objectivly analyze if we could efficiently build a combat glider given the production demands already in place and, once produced, its combat effectiveness. The US thus embarked on an ambitious program to build a glider fleet without a clear industrial capacity to do so and without either employment or training doctrine to guide aircraft and tactics development.

A wide variety of missions were given to gliders searching for its "best-suited" mission. The Allies had success with several airborne assault missions after Sicily. The US also success with the airfield preparation, casualty evacuation, and limited glider recovery missions in the CBI theater. Germans were the experts in commando raids, small airborne operations, and large-glider operations.

However, the characteristics which made gliders attractive to the German and Allied forces in WWII remain enticing today. Additionally, the radar signature of a modern aircraft made wholly of composites should be negligible. While a large glider would likely not be made exclusively of composite materials, much of it could be and coupled with low observable technologies would be nearly invisible to radar, infrared and acoustic receivers.

Gliders remain virtually silent in flight which is their advantage over helicopters. The theory of a night, unobserved, silent, glider-borne, ready-to-fight combat squad was and remains a sound concept. Despite rough landings and "Rommel's asparagus," injuries to glider-borne troops and equipment were generally comparable to parachute deliveries. Future clandestine operations requiring only a few men could be safely landed from long distances and the light-weight aircraft parts could easily be camouflaged or otherwise destroyed.

Gliders, along with helicopters, remain the only aircraft types which are designed to land on unprepared terrain with very short landing rolls. There is no doubt that the WWII glider could land men and equipment in tight spaces. But the glider's operational limitations and the cost of using large numbers of cargo gliders only once caused their demise.[90] Ultimately, C-123 and helicopters replaced them.

Although gliders were discarded shortly after the war, US uses gliders today as a viable decoy force and in initial, informal pilot flight indoctrination. The unique characteristics of gliders and its improvements in recent years have made the glider a possibility for other missions. The military glider is not a relic of the past. While it may not enjoy production runs in the thousands again, the glider remains a viable platform for limited, specific missions requiring true stealth and silence.

Still, current USAF doctrine has no place for a glider. The USAF Academy's Soar-for-

All program is certainly a lot of fun and gives each cadet an indoctrination to flight without all of the encumbrances of monitoring engine performance and Instrument Flight Rules (IFR) procedures. It is not, however, a required part of aviation training and exists only as an enrichment program.

Today's situation with manned gliders is not unlike that of the 1920s and 1930s. The technology is fundamentally different than that of the early decades of glider development and continues largely ignored by the military for combat uses, certainly within the USAF.

More importantly, are we in the USAF of the twenty-first century resting in our technological superiority while some future foe develops an innovative idea? I think perhaps not, but during times of drawdown and cutback the small and relatively insignificant innovations can be easily missed.

NOTES

1 Quoted in James E. Mrazek, *The Glider War* (New York: St Martin's Press, 1975), 27. Clearly the restrictions placed on Germany by the Versailles Treaty impacted the direction Germany's airpower would proceed. Germany's engine technology fell behind world standards and probably channeled their efforts into smaller dive bombers rather than strategic bombers. Their blitzkrieg tactics required guaranteed bridges and other lines of communications to remain intact. This, among other factors, encouraged development of the glider-borne commandos.

2 Germany's record for flight duration (with return to point of departure) was established on August 3-4, 1933 by Kurt Schmidt in a D-Loerzes Glider. He flew for 36 hrs. 35 min. The straightline distance record was held by Rudolph Oeltzochener in a D-Leuna glider. He flew 313.293 miles on July 29, 1935. Heinrich Dittmar climbed 14,189.590 feet above his starting point on February 17, 1934 to capture the altitude record. The Russians however laid claim to the duration (8 hrs. 18 min.), distance (405.29 miles) and absolute altitude (39,946 ft.) records in 1937. Lewin B. Barringer, ed., "International Soaring Records," *Soaring* 1, no. 6, (June 1937): inside cover. Victor Rastogoueff, "Three World Distance Records," Soaring 2, no. 1, (January 1938): 11.
Alexis Dawydoff, "Russian Record Flights," *Soaring* 2, no. 2, (February 1938): 10.

3 Lewin B. Barringer, ed., "Three Modern Sailplanes", *Soaring* 1, no. 1, (January 1937): 4.

4 James E. Mrazek, *Fighting Gliders of World War II* (New York: St. Martin's Press, 1977), 24-25.

5 US Department of Commerce, Air Commerce Bulletin 8, No.1, (15 July 1936): 98-99. Of the 413 gliders in the country, only 39 were licensed. Two of the 140 glider pilots were women.

6 The US record for duration was held by Lt. William A. Cooke, Jr. in a Night Hawk glider. He flew for 21 hrs. 34 min. over Honolulu, HI on December 17-18, 1931. Richard DuPont flew 158.299 miles in a Bowlus-DuPont sailplane on June 25, 1934 to capture the distance record. Dupont set the American altitude record five days later flying to an altitude of 6,233.734 feet. Lewin B. Barringer, ed., "International Soaring Records," *Soaring* 1, no. 6, (June 1937): inside cover.

7 History, AAF Flying Training Command, 1 March 1945, 7:1896. Copy on file at the USAF Historical Agency, Maxwell AFB, Alabama.

8 FTC History, 7:1897.

9 Floyd J. Sweet, ed., *Soaring* 5, no. 5-6, 1.

10 John R. Galvin, Air Assault: the development of airmobile warfare (New York: Hawthorn Books, Inc., 1969), 5-6.

11 Memorandum, Maj. Gen. H. H. Arnold, Deputy Chief of Staff for Air to Maj. Gen. G. H. Brett, Acting Chief of Air Corps, Subject: Gliders, 25 February 1941. Copy on file at the USAF Historical Agency, Maxwell AFB, Alabama.

12 Quoted in FTC History, 7:1900.

13 I Troop Carrier Command, "Glider Program," February 1945, 1:3. Copy on file at the USAF Historical Research Agency, Maxwell AFB, Alabama.

14 I TCC, "Glider Program," 1:4-5

15 Mrazek, Glider War, 104.

16 Assistant Chief of Air Staff, Intelligence, *"The Glider pilot Training Program,* 1941 to 1943," USAF Historical Study 1 (Maxwell AFB, AL: USAF Historical Division, Air University, 1943), 11.

17 Paul M. Davis, 1 Lt. and Amy C. Fenwick, "Development and procurement of Gliders in the Army Air Forces, 1941-1945," AAF Historical study 47 (Washington D. C.: HQ AAF Historical Office, March 1946) 91. Copy on file at the USAF Historical Agency, Maxwell AFB, Alabama.

18 Davis and Fenwick, 187.

19 Davis and Fenwick, 140 -193. These paragraphs are a summation of a very complex program whose evaluation is presented here.

20 Assistant Chief of Air Staff, Intelligence, *"The Glider pilot Training Program,* 1941 to 1943," USAF Historical Study 1 (Maxwell AFB, AL: USAF Historical Division, Air University, 1943), 52-53

21 Alexis Dawydoff, Editor, "The Air Corps Investigates soaring," *Soaring* 5, no. 5-6 (May-June 1941): 1.

22 Floyd Sweet, letter to the editor, "News from Twenty-nine Palms," *Soaring* 6, no. 15-16 (March-April 1942): 13.

23 Mrazek, Glider War, 134.

24 FTC History, 7:1916.

25 FTC History, 7:1927-1928.

26 FTC History, 7:1922.

27 Letter from Maj. Gen. Barton K. Yount, Commander, Flying Training Command, to CG, AAF, 17 Oct 1942. Copy on file at the USAF Historical Agency, Maxwell AFB, Alabama.

28 Mrazek, Glider War, 135

29 FTC History, 7:1914.

30 Advanced Glider Schools Program of Instruction, 21 Sep 1942, 1.

31 FTC History, 7:1937.

32 Letter from Brig. Gen. F.S. Borum, Commander I TCC, to CC, Flying Training Command, 27 December 1943.

33 Training Directive, *Glider Training,* Combat Crew Training Station, I Troop Carrier Command, 5 January 1945, 1-5.

34 Mrazek, *Glider War,* 41. At the time, there was only enough airlift to carry 800 parachutists.

35 George Chatterton, Brigadier, *The Wings of Pegasus,* (London: Macdonald & Co., Ltd., 1962): 36-370.

36 Chatterton, 20-21.

37 Ibid., 116.

38 Ibid., 38.

39 Galvin, 27.

40 Mrazek, *Glider War,* 68-69.

41 Air Intelligence Summary No.9, Report No. W-5294, AC, cited in Memorandum, 1st Lieutenant, G. N. Robinson, Jr., Subject: "Parachute and Glider Troops," Maxwell AFB, Air Corps Tactical School, 7 October 1941, 2. Copy on file at the USAF Historical Agency, Maxwell AFB, Alabama.

42 Mrazek, *Glider War,* 262-263.

43 Ibid., 263-264.

44 Ibid., 264.

45 Galvin, 122.

46 Ibid., 122-123.

47 Mrazek, *Glider War,* 89.

48 Ibid., 82. Chatterton, 41-43.

49 "Report on Operations and Activities," Troop Carrier Command, 18 May 1943 to 31 July 1943, 8. Copy on file at the USAF Historical Agency, Maxwell AFB, Alabama.

50 Ibid.

51 Mrazek, *Glider War,* 88-89.

52 "Report on Operations," 12. Lee Bowen et al., "USAF Airborne Operations: World War II and Korean War," USAF Historical Division Liaison Office, March 1962, 13-16, 22. Copy on file at the USAF Historical Agency, Maxwell AFB, Alabama.

53 Chatterton, 96-100.

54 Lee Bowen et al., 15.

55 One lesson was the impact of the thirty-five knot gale. The tactical glide speed for a CG-4A was approximately 60 mph calibrated airspeed. A thirty-five knot head wind reduces its forward speed to about 23.5 mph. Chatterton increased release altitude by only by 200 feet and the tug pilots refused to come any closer than 3000 yards to shore because of the antiaircraft guns. Assuming the standard descent rate of 400 feet per minute, the 1200 to 1500 foot release height gave between 3 and 3.75 minutes of flight. The glide distance at 23.5 mph is only 1.175 miles (2100 yards) to 1.5 miles (2640 yards) down range! Even if the tugs released at the right range, the gliders could not have made the shore. The landing zones were out of reach. With no head wind at all the glider's range increases to the minimum 6000 yards. CG-4A performance figures are from AAF Manual 50-17, *Pilot Training Manual for the CG-4A Glider,* March 1945, 14 (Reprinted by George A. Peterson, Springfield, Virgina: National Captial Historical Sales, n.d.).

56 Chatterton, 140-141.

57 Mrazek, *Glider War,* 177, 180.

58 Chatterton, 152-155.

59 Mrazek, *Glider War,* 142.

60 Ibid., 146-153.

61 Ibid., 154-157.

62 Ibid., 157-158.

63 Ibid., 158-159.

64 Ibid., 209.

65 Ibid., 216.

66 Letter from General James M. Gavin, Commander 82nd Airborne Division to Major General P.L. Williams, Commander, IX Troop Carrier Command, 25 September 1944, 4. Copy on file at the USAF Historical Agency, Maxwell AFB, Alabama.

67 Ibid.

68 Lee Bowen et al., 92.

69 Ibid., 81.

70 Ibid., 83.

71 Ibid., 93.

72 Ibid., 93.

73 Mrazek, *Glider War,* 197-8.

74 Ibid., 114-122.

75 Ibid., 115.

76 Ibid 127.

77 Ibid., 128.

78 John C. Warren, *Airborne Missions in the Medeterranean:* 1942- 1945, USAF Historical Study 74 (Maxwell AFB, AL: USAF Historical Division, Air University, 1955), 27.

79 Ibid., 27-28.

80 Ibid., 29.

81 Ibid., 31-32.

82 Galvin, 264.

83 See the following three articles by Dr. Wortmann: F. X. Wortmann, "Summary of the influence of the airfoil polar on the performance of sailplanes," *Soaring* 28, no. 1, (January

1964): 6-7 & 14-18; "Drag Reduction in Sailplanes, Part I," *Soaring* 30, no. 6, (June 1966): 10-13; "Drag Reduction in Sailplanes, Part II," *Soaring* 30, no. 7, (July 1966): 20-24.

84 Typical glide ratios of popular high-performance gliders were about 40:1. Minimum sinking speeds were about 125 feet per minute. The reader is referred to a series of sailplane flight test evaluations conducted by Richard H. Johnson throughout the late 1970s and 1980s. These are reported in *Soaring* magazine throughout the period.

85 Richard H. Johnson, "A Flight Test Evaluation of the Nimbus 3," *Soaring* 46, no. 12, (December 1982): 18-24.

86 In modern sport gliders the "cargo" is added water for increased wing loadings in competition.

87 David A. Fulghum, "Navy, Marine Decoy Gliders Forced Iraqi Radars to Reveal Their Locations," *Aviation Week and Space Technology,* 19 August 1991, 64-65.

88 Davis and Fenwick, 141.

89 Irving B. Holley, *Ideas and Weapons* (New Haven, Yale University Press, 1953; repr., Washington D.C.: Government Printing Office, 1983), 176.

90 Raymond J. Snodgrass, "The AAF Glider Program November 1944-January 1947," (Dayton, Ohio: Air Material Command, Intelligence Department, History Office, 1947) 138. Copy on file at the USAF Historical Agency, Maxwell AFB, Alabama.

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