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HUMAN POWERED VEHICLES IN SUPPORT OF LIGHT INFANTRY OPERATIONS

A thesis presented to the Faculty of the U.S. Army
Command and General Staff College in partial
fulfillment of the requirements for the
degree

MASTER OF MILITARY ART AND SCIENCE

by

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↙ This study examines the suitability of using bicycles to enhance the mobility of U.S. light infantry units. Initially the study defines mobility problems encountered by U.S. light infantry units as a result of force design. The study presents historical examples of previous military cycling operations at the turn of the century, during both World Wars, and the Vietnam Conflict. The tactical use, mobility, speed, distance, and load carrying capacity of bicycle troops during each of these periods are discussed. The present use of three bicycle regiments in the Swiss Army is examined. The impact of recent technological improvements in the bicycle industry is examined for possible military application. *Key words: mobility, bicycle troops*

The investigation found that previous infantry units equipped with bicycles enjoyed a significant mobility advantage over foot soldiers. The Swiss cycle regiments continue to demonstrate the utility of the bicycle on the modern battlefield. The study determined that recent improvements in bicycle technology serve to further enhance its military use.

The study concludes that equipping U.S. light infantry units with the bicycle would significantly improve their tactical mobility, yet allow them to retain their present force design.

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

HUMAN POWERED VEHICLES IN SUPPORT OF LIGHT INFANTRY
OPERATIONS, by Major Stephen T. Tate, USA, 179 pages.

This study examines the suitability of using bicycles to enhance the mobility of U.S. light infantry units. Initially the study defines mobility problems encountered by U.S. light infantry units as a result of force design. The study presents historical examples of previous military cycling operations at the turn of the century, during both World Wars, and the Vietnam Conflict. The tactical use, mobility, speed, distance, and load carrying capacity of bicycle troops during each of these periods are discussed. The present use of three bicycle regiments in the Swiss Army is examined. The impact of recent technological improvements in the bicycle industry is examined for possible military application.

The investigation found that previous infantry units equipped with bicycles enjoyed a significant mobility advantage over foot soldiers. The Swiss cycle regiments continue to demonstrate the utility of the bicycle on the modern battlefield. The study determined that recent improvements in bicycle technology serve to further enhance its military use.

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CHAPTER 1

THE PROBLEM OF MOBILITY IN LIGHT INFANTRY UNITS

The famous ancient Greek mathematician, Archimedes, once boasted "give me a lever long enough, and a fulcrum strong enough, and single-handed I can move the world."(4:1573) I believe we should equip our light infantry with just such a device in the form of the bicycle.

Present U.S. light infantry battalions are limited in tactical mobility. The majority of their combat assets move about the battlefield on foot. This absence of rapid tactical mobility is a by-product of the force design.

To understand this absence of vehicle assets we need to look at the origins of the present light infantry battalion. In February 1980 the Chief of Staff of the Army, General E.C. Meyer, published a White Paper entitled, "A Framework for Molding the Army of the 1980s into a Disciplined, Well Trained Fighting Force." This document formally outlined the need for light infantry units.(3:1) In the introduction the Chief of Staff provided an overview of strategic requirements: "The most demanding challenge

confronting the US military in the decade of the 1980s is to develop and demonstrate the capability to successfully meet threats to vital US interest outside of Europe, without compromising the decisive theater in Central Europe."(3:1) General Meyer further stated that to meet this challenge would require an improvement in the capability of active forces to rapidly deploy, encounter, and defeat a more sophisticated threat in regions other than Central Europe.(3:2)

In describing the forces for these non-NATO contingencies, General Meyer stated, "the forces committed should be designed to facilitate rapid deployment, exploit technological advantages, and meet the requirement for lean hard-hitting combat forces."(3:5) The key phrase was "rapid strategic deployment." He believed that most potential adversaries in this area have limited logistical capability. This factor would cause them to attempt to gain a decisive victory in the first few weeks of a conflict.(3:5) General Meyer felt that the rapid deployment of light infantry could achieve the early presence necessary to preclude an unopposed threat victory. This deployment in turn would permit US forces to gain the initiative.(3:5) General Meyer, with the publication of this White Paper laid the foundation for the creation of light infantry divisions.

In 1984, General Meyer's replacement as the Army's Chief of Staff, General John A. Wickham, reiterated the Army's commitment to light infantry units. General Wickham dedicated his 1984 White Paper solely to the subject of light infantry divisions. He reaffirmed their purpose by stating, "Army leadership is convinced, based on careful examination of studies which postulate the kind of world in which we will be living and the nature of conflict we can expect to face, that an important need exists for highly trained, rapidly deployable light forces." (5:1) Again, the key phrase that impacts on the tactical mobility of light forces is "rapidly deployable."

In planning for the structure of these "rapidly deployable forces", force developers were faced with a major limitation. The US had, and still has, limited airlift capability. To be effectively used as Generals Meyer and Wickham had envisioned, the units had to deploy by airlift. Once deployed these forces had to be logistically supported. Again, limited airlift assets would initially provide this service.

To meet this airlift demand, force developers had to design units that were physically light and they had to balance this need with other critical requirements. These light units had to retain enough combat power to accomplish a wide range of missions. They would have to have the ability to be rapidly tailored to meet a variety of enemy

forces. The units had to be flexible enough to allow deployment into various types of terrain and climates.

By 1983 force designers set a number of goals in order to meet these requirements. They established a goal that the entire light division require less than 500 C141 aircraft sorties to deploy. This requirement led to a personnel strength ceiling for the division of just over 10,000 men. Since the majority of the division would be "foot mounted", force planners reduced the number of vehicles and other heavy equipment to a bare minimum. This reduction also curtailed the logistics tail, further diminishing airlift requirements.(1:6)

General Wickham endorsed these goals in his 1984 White Paper, "Light Infantry Divisions." While addressing force structure he stated: "This 10,000(+) man force will have a greater tooth-to-tail ratio than any of our other Army divisions and will be deployable worldwide three times faster than existing infantry divisions."(5:1)

Based on the goals, force developers had successfully developed a strategically mobile light infantry divisional organization. By eliminating a large number of motor transport vehicles they solved both the airlift problem and the tooth-to-tail dilemma. They did so, however, at the cost of tactical mobility.

This cost is best illustrated by examining one of the nine light infantry battalions that make up the prime

combat forces of the division. Although they constitute the majority of the combat power in the division, the infantry battalions are also the least mobile. The nature of the light infantry division's other combat, combat support, and combat service support units require that they have vehicle assets. For example, the division's artillery units must have vehicles to tow their howitzers. The support units in a light infantry division have enough vehicles to carry both their assigned personnel and organic equipment. It is the light infantry battalions that need the additional transport capability. By looking at the 1987 Table of Organization and Equipment for a light infantry battalion we can gain an insight into this problem of mobility. There are a total of forty-two vehicles organic to the light infantry battalion. Of these, twenty-seven are High-Mobility, Multipurpose Wheeled Vehicles, (HMMWV) and fifteen are motorcycles. (8:1-16, 6-3)

The High-Mobility, Multipurpose Wheeled Vehicle (HMMWV) is a 5/4-ton, 4x4 wheeled vehicle powered by a diesel engine. It uses a common chassis with various body configurations to serve as a weapons carrier, cargo carrier, command and control vehicle, and ambulance. (9:A-16) All four of these variants are found within the light infantry battalion. (8:1-10) Ten of the HMMWVs in the battalion are used as weapons carriers. The 81mm mortar platoon has four. The antitank (TOW) platoon

has the other six.(8:1-13) Thirteen HMMWVs are used to support the logistical requirements of the battalion. They are found in the support platoon. The transportation section of the platoon has five. One of these five vehicles is dedicated to each of the three rifle companies in the battalion. The other two vehicles support the battalion's command posts. The support platoon's ammunition section has six HMMWVs. They are divided between two squads, each having three vehicles. One vehicle with a trailer belongs to the fuel (POL) and water section of the platoon. The last vehicle is the support platoon leader's command and control vehicle.(8:6-3) The signal platoon of the battalion has two HMMWVs. One carries the radios for the S3 section of the main command post. The other belongs to the wire section.(8:1-5) The medical platoon has two HMMWV ambulances. Without additional augmentation these assets constitute the sole medical evacuation capability for 559 men.(8:1-16) The fifteen motorcycles are not assigned permanent operators. They are used as the battalion commander sees necessary. Their normal uses are for command and control, liaison, and reconnaissance.(8:1-16) Little redundancy exists in the system. The TO&E includes no backup vehicles to replace those lost to combat or to maintenance failure!

This insufficiency of tactical motor vehicles within its organizational design affects light infantry units in

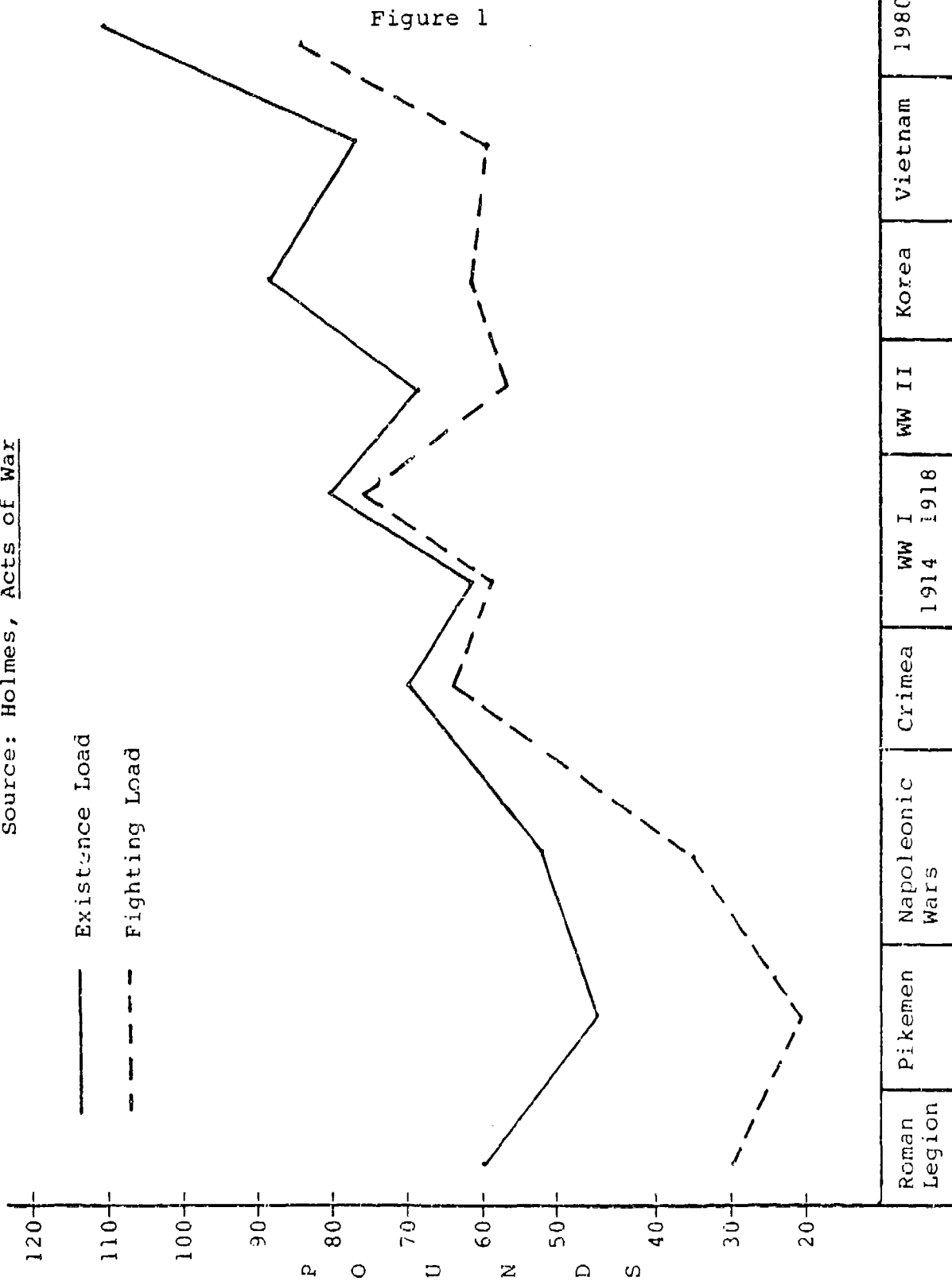
two areas concerning mobility. First, it dictates the deployment speeds of the majority of the unit. Second, it places severe restraints on the ability of light infantry units to logistically support themselves.

The entire resupply effort for a 130 man rifle company is tied to one truck and trailer. This scarcity of transportation means the majority of the logistics effort in the company falls on the shoulders of the individual infantryman. Not only is he responsible for his own sustenance, but he must carry unit equipment as well. Although technical advances in light weight fabrics, metal alloys, and the use of plastics have helped, technology has also produced problems. High technology instruments like night observation devices, thermal sights, and range finders with their accompanying batteries have added weight. The thermal night sight alone for the rifle platoon's antitank weapon (Dragon) weighs 30.4 lbs.(11:27) Depending on the climate, he is required to carry more and heavier equipment than at any other time in history.(Figure 1) For the infantryman in today's light infantry units the term "light" is a misnomer.

The problem of how much weight a soldier can carry is an old one. In 1894 the Fredrick Wilhelm Institute of Germany conducted a study to determine the maximum weight for a soldier's backpack. They determined that the maximum a backpack should weigh was 48 lbs.(Figure 2) The British

HISTORY OF THE INFANTRYMAN'S LOAD

Source: Holmes, Acts of War



HISTORICAL STUDIES ON SOLDIERS LOAD

Source: USAIS Brief to the 1988-89 Command & General Staff College, Aug 88

<u>DATE</u>	<u>STUDY</u>	<u>CONCLUSIONS</u>
1894	Fredrick Wilhelm Institute Study to Determine Maximal Backpack Weight	48 lbs is Max Load
1919	Cathcart & Orr, Her Majesty's Stationery Office, London: "Energy Expenditure Of The Infantry Recurit In Training."	45% of Body WT is Max Load
1923	Cathcart, Richardson & Campbell, Physiology Institute, University of Glasgow: "On The Maximum Load To Be Carried By The Soldier."	40% of Body WT is Max Load
1955	Reid, Renbourne, & Draper, Clothing And Equipment Physiological Research Establishment Great Britian: "A Comparative Physiological Field Trial of Personal Load Carriage Equipment."	40% of Body WT is Max Load
1970	Hughes & Goldman, U.S. Army Research Institute of Environmental Medicine: "Energy Cost Of Hard Work."	66-88 lbs is Max Load

Figure 2

conducted three separate studies in 1919, 1923, and 1955.(Figure 2) They recognized that the man's size had an impact on how much weight he could carry. Their conclusions were based on body weight. The last two studies deduced that a man can carry up to 40% of his body weight. In other words a man that weighs 180 lbs can carry a maximum of 72 lbs. In 1970 the U.S. Army Research Institute of Environmental Medicine conducted a study titled "Energy Cost of Hard Work." The institute, like the British, used the percent of body weight to determine the weight of the load. The study concluded that, depending on the soldier's weight, the majority of U.S. infantrymen would carry between 66-88 lbs.(Figure 2) The U.S. Army Development and Employment Agency (ADEA) at Ft. Lewis, Washington, conducted studies into the same question. ADEA determined that the optimal load is 30% of body weight.(11:9) Their studies concluded that the maximum weight a soldier can carry is 45% of his body weight.(Figure 3)

Based on the weight distribution of men in the Army, ADEA found the following. The majority, or average infantryman weighs around 160 lbs.(11:8) He can carry an optimal load of 48 lbs. and a maximum load of 72 lbs.(Figure 3) These figures represent rough estimates. Other factors, however, such as climate, the terrain, and combat stress must be taken into account in determining

ARMY DEVELOPMENT & EMPLOYMENT AGENCY

STUDY DATA SUMMARY

50 PERCENTILE SOLDIER WEIGHS 160 LBS

OPTIMAL TOTAL LOAD IS 30% OF BODY WEIGHT = 48 LBS

MAXIMUM TOTAL LOAD SHOULD NOT EXCEED 45% OF BODY WEIGHT = 72 LBS

Figure 3

PERCENTILE SOLDIER	BODY WEIGHT	OPTIMAL LOAD 30% BODY WEIGHT	MAXIMUM LOAD 45% BODY WEIGHT
5	126	37.7	56.7
50	160	48	72
95	202	60.6	90.9

what a light infantryman can carry.(10:5-7) The climate affects both what a soldier carries and how much energy he uses to carry it. In colder climates the soldier must carry more food and clothing to keep warm. Both add weight to his load. Hot weather causes soldiers on the march to expend more energy as the body attempts to cool itself. The Fredrick Wilhelm Institute found that a soldier in what they called brisk (cool) weather marching fifteen miles could carry 48lbs. comfortably. In warm weather the same load, and the same distance produced physical impairment lasting one day.(11:7) The terrain over which the soldier is expected to move is another factor in determining what he can effectively carry. The gradient, amount of foliage, and surface composition will affect the amount of energy he will expend.(Figure 4) This in turn will effect how much he can carry and still be combat effective.

The physical drain caused by stress in combat is the one factor generally ignored today. It may be impossible in a peacetime environment to accurately measure its full impact on what a soldier can carry. What is known is that physiologically fear burns glycogen just like physical exertion. Combine fear and physical activity and the soldier will use more than normal amounts of energy. A soldier will not be able to carry the same load as efficiently in battle as he did in training.(10:5)

IMPACT OF TERRAIN AND SOLDIER LOAD
 Energy Expended by Soldiers by Varying Terrain & Weight
 Course Traveled: 1.98 KM at 4 Kph
 Source: Soule and Goldman, 1972

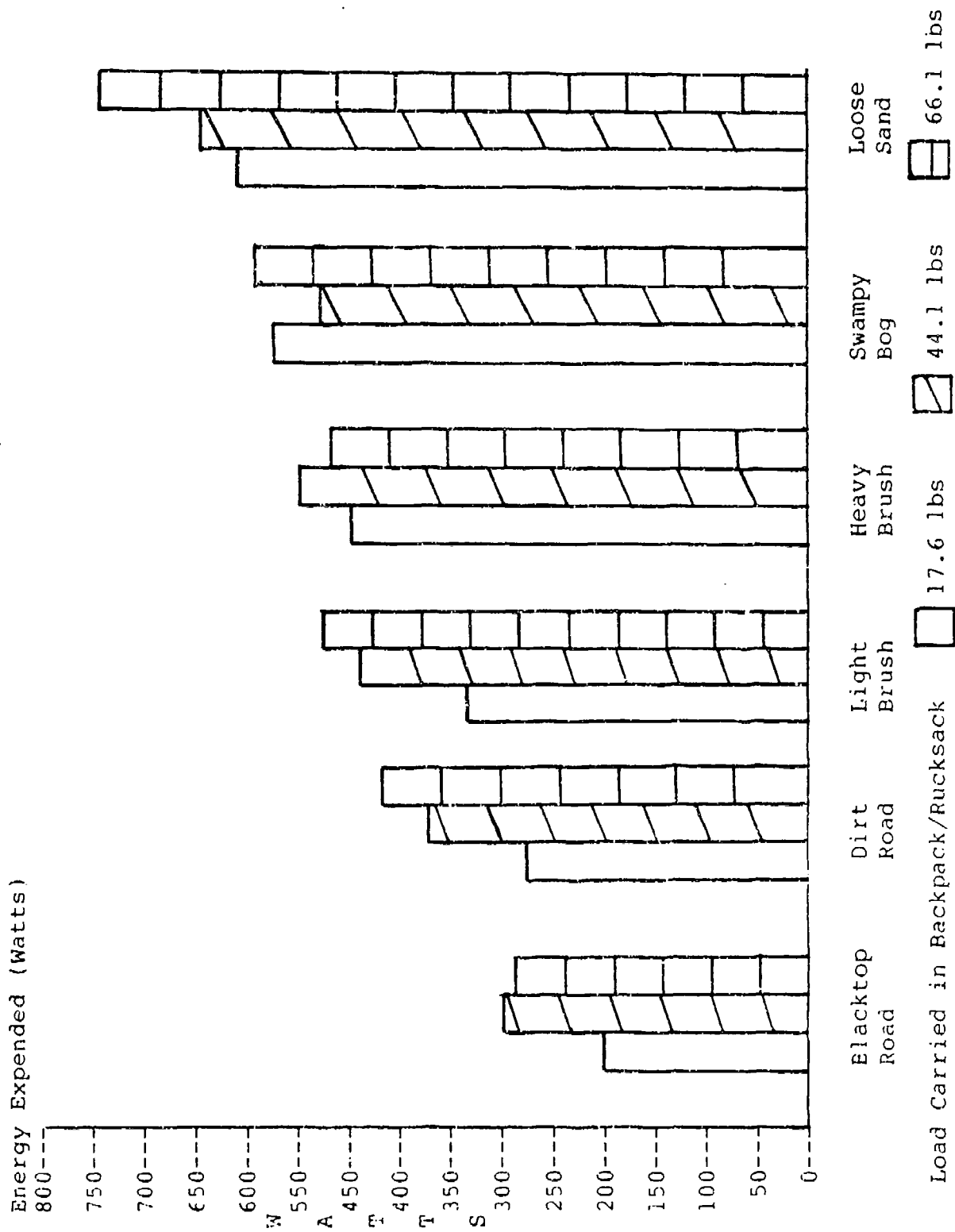


Figure 4

The problem of how much an infantryman can carry determines what he carries. The problem of "what" the soldier should carry has plagued commanders for years. It has been a source of endless debate. FM 7-71 Light Infantry Company divides the soldier's load into three areas. The first area, called combat load, is what the soldier carries that he will immediately need to fight and survive. The next area, known as sustainment load, is what the battalion carries that the soldier may need for imminent future operations. The last area is known as contingency load. The contingency load is stored at division or corps level and contains those items not needed for imminent future operations.(7:76-78)

The items that go into these areas are determined by the commander's estimate of the mission and the threat. If the mission is offensive in nature, entrenching tools may be regulated to the sustainment load. If intelligence has determined that an armor threat does not exist, antitank weapons may even be stored at division level as part of the contingency load.

The combat load is further subdivided into two areas. The first area is called "the fighting load". It consists of the items a soldier will need while in actual contact with the enemy. Weapons, ammunition, and communication equipment make up the primary portion of this load. The target weight is 48 lbs.(7:7-7) The other part

of the combat load is known as the "approach march load". This load is dropped just prior, or upon contact with the enemy. It comprises those items not immediately needed to fight the enemy. It may include rations, extra ammunition, night sights and clothing. Its target weight, combined with the fighting load, is 72 lbs.(7:7-7)

The problem is that the weight of the equipment the soldier needs to accomplish most combat missions will exceed these limits. In calculating the combat load of soldiers, FM 7-71 Light Infantry Company tells company commanders to divide the combat load into three areas: common essential items, duty position load, and variables. FM 7-71 offers an example of the relative weights of a bare bones combat load for a rifleman.(Figure 5) The example does not provide for crew served weapons, night vision devices, communications equipment, or leader oriented equipment. It merely provides a guideline for what a rifleman should carry in a temperate climate zone. It provides the commander with a starting point.

The FM 7-71 example has drawbacks. For example, the commander must have deduced several critical conclusions from his estimate of the situation. The climate, for instance, is obviously very mild because long underwear is not listed. The enemy does not possess an offensive chemical capability (no NBC suits), or artillery (no entrenching tool). Nevertheless (even with these

Figure 5

Rifleman's Combat Load Example
Source: FM 7-71 Light Infantry Company

1. Common Items		Weight
Battle dress uniform (BDU), boots		8.20 pounds
Pistol belt, straps, & first aid kit		1.60 pounds
Canteen, cup & cover with water		3.30 pounds
Poncho		1.70 pounds
Gloves		0.30 pounds
Socks		0.30 pounds
Meals ready to eat (MRE) (1)		0.25 pounds
Bayonet with scabbard		<u>1.30 pounds</u>
Total:		16.95 pounds
2. Duty Load		
M16A1 (A2) with 30-round magazine		
Two ammunition pouches		
Six magazines/180 rounds		
Two grenades		
Total:		17.00 pounds
3. Variables		Environment
Field jacket		3.00 pounds
Pile cap		0.26 pounds
2-quart canteen, cover, water		4.80 pounds
Poncho liner		<u>1.60 pounds</u>
Total:		9.66 pounds
		Threat
Protective mask		3.00 pounds
Helmet		<u>3.10 pounds</u>
Total:		6.10 pounds
		Mission
ALICE pack with frame		6.30 pounds
Round, 60-mm mortar (1)		3.50 pounds
Grenade, smoke, HC (1)		2.56 pounds
LAW (1)		4.70 pounds
Compass		<u>0.25 pound</u>
Total:		17.31 pounds
4. Total Combat Load		
Common items		16.95 pounds
Duty load		17.00 pounds
Variables		
Environment		9.66 pounds
Threat		6.10 pounds
Mission		<u>17.31 pounds</u>
Grand Total:		67.02 pounds

considerations), the total combat load listed in the example comes to 67.02 lbs. This load leaves a little less than 5 lbs. for extra equipment before the list reaches the ADEA target weight of 72 lbs.(10:31) The manual seems to recognize the problem when it admits that in most cases it will be difficult to meet the suggested weights. It further states that there may be times when the approach march weights will be up to 120 lbs. When this factor is mentioned, however, the manual warns about the reduction in efficiency of troops forced to carry these loads.(7:7-8)

Most light infantry units follow a standard operating procedure (SOP) in deciding what to carry. Most SOPs are locally produced based on the unit's mission. 1st Battalion 9th Infantry Regiment of the 7th Light Infantry Division stationed at Ft. Ord produced a SOP for soldier's load in 1987.(6:8-1) The 1-9's SOP divides the soldier's load by his position in the unit and the season of the year.(Figure 6) The ammunition weights listed in the SOP are the units basic load by weapon. A limit of two rations, meal-ready-to-eat (MRE), are carried per man. The NBC chemical protective suits are not listed. They are carried in the battalion trains.(6:B-4)

The lightest combat load carried by anyone in the company is that of the 1st Sgt. In basic conditions he carries a combat load of 63.1 lbs. The heaviest load carried by anyone in the company is that of the Company RTO

Figure 6

1-9 INF SOP: Load Weights By Duty Position
Source: 1-9 Standard Operating Procedures, Oct 87

Equipment Common to All

Worn and LCE = 27.3 lbs

Winter Rucksack = 34.0 lbs

Spring Rucksack = 23.4 lbs

Basic Rucksack = 22.3 lbs

UNIT CO HQS	MIS Equip WPN/AMMO	TOTAL SOLDIER LOAD		
		BASIC	WINTER	SPRING
CO CDR	18.6	68.2	79.9	69.3
XO	15.4	65.0	76.7	66.1
1SG	13.5	63.1	74.8	64.2
SNIPER	17.3	66.9	78.6	68.0
CO RTO	46.7	96.3	108.0	97.4
COMMO CHF	22.9	72.5	84.2	73.6
FO	47.2	96.8	108.5	97.9
<u>RIFLE PLT</u>				
PLT LDR	24.8	74.4	86.1	75.5
PSG	25.6	75.2	86.9	76.3
SQD LDR	21.6	71.2	82.9	72.3
TM LDR	14.1	63.7	75.4	64.8
M203	19.5	69.1	80.8	70.2
SAW	22.4	72.0	83.7	73.1
M60	33.8	83.4	95.1	84.5
M60 AG	30.6	80.2	91.9	81.3
RIFLEMAN	22.2	71.8	83.5	72.9
PLT RTO	33.5	83.1	94.8	84.2
<u>60mm MORTAR</u>				
SEC LDR	24.5	74.1	85.8	75.2
SQD LDR	34.0	83.6	95.3	84.7
GUNNER	22.7	72.3	84.0	73.4
AG	23.5	73.1	84.8	74.2
<u>AT SECTION</u>				
SQD LDR	16.9	66.5	78.2	67.6
TM LDR	15.0	64.6	76.3	65.7
GUNNER	10.2	59.6	71.5	60.9
AG	10.2	59.6	71.5	60.9

and Forward Observer. Under winter conditions their combat load is 108.5 lbs. The basic rifleman, devoid of any unit equipment, carries a spring load of 72.9 lbs and a winter load of 83.5 lbs.(6:B-12) The 1-9 SOP represents a realistic approach to the problem. To make, or at least come near the target weight the units are taking risks in certain areas.

The chemical protective garments, alarms, radiation detectors, and marking kits for the rifle companies are carried by the battalion's vehicles. All of the wire communications equipment in the company is carried on its one assigned HMMWV. The same vehicle carries twelve night vision devices for each platoon as well as all the machine gun tripods and spare barrels in the company. Any other special equipment is also loaded on the same vehicle.(6:B-14) Therefore the loss of this vehicle to enemy fire or mechanical breakdown represents a severe reduction in the company's fighting capability.

Present light infantry battalions do not have enough transportation to carry the equipment they need. Both FM 7-71 Light Infantry Company and the February 1987 Army Development & Employment Agency's report on Soldier's Load recognize this deficiency. The Field Manual proposes augmenting the company with transport from the host nation. One of the suggested vehicles is the BICYCLE.(7:7-11) The ADEA report recommends equipping light infantry companies

with additional small motor vehicles known under the name of Combat Load Handling Equipment (CLOTHE).(10:25) The addition of transportation assets to carry equipment will answer only half the mobility problem. Even if the infantryman's load is reduced below 48 lbs. he is still footmobile. This fact limits his deployment in terms of speed and distance.

In the best of circumstances the infantryman will be able to maintain a march speed of 4 Kilometers an hour. The best of circumstances means a good flat surfaced road, traversed during daylight in a moderate climate. This speed is reduced to 3.2 Kilometers per hour at night. If the march is conducted cross-country the speed will fall to 2.4 kilometers per hour. If conducted at night the cross-country speed will fall to 1.6 kilometers per hour.(8:C-4) Any of a number of other factors will, however, further reduce the soldier's march speed. The temperature, gradient, vegetation and condition of the troops can all work to the detriment of speed. The length of the march, hence distance of deployment, is also subject to a wide range of external factors. The same ones that affect speed generally affect distance.

A unit conducting a march under ideal conditions at a speed of 4 Kilometers per hour for eight hours will cover

a distance of 32 Kilometers. By doctrine any march over 32 kilometers in a 24 hour period is considered a forced march.(8:C-4)

History is replete with examples of successful forced marches, but there may be a price to pay. As far back as Hastings in 1066 A.D. exhausted troops lost battles after forced marches. As S.L.A. Marshall pointed out: "Tired men take fright more easily, frightened men swiftly tire."(11:9)

What is clearly needed is a vehicle that can transport not only the infantryman's load but the infantryman. The problem is finding a vehicle that can do this yet meet certain requirements. The vehicle must not be an "end unto itself." The challenge is to find a vehicle that will improve the capabilities of light infantry units, but not change their characteristics. Based upon personal experience and the gist of light infantry doctrine a vehicle suitable for light infantry units must meet the following requirements:

1. It should be able to traverse most types of terrain.
2. It must be able to operate in most weather conditions.
3. It must have a low battlefield signature,
(noise, silhouette).
4. It must require a minimum of logistical support.
(fuel, maintenance)
5. The vehicle itself must be transportable.
6. It should be relatively inexpensive to obtain.
7. Operator training should be simple and timely.
8. It must be able to carry the soldier's load.
9. It must be reliable.
10. It must give the soldier a speed advantage over
4 kmph.
11. It must be rugged and durable.

In its final report titled "The ADEA Soldier's Load Initiative", ADEA identified the specifications for a vehicle to support light infantry operations.(Figure 7) While many of these specifications are concerned with the mechanics of the internal combustion engine, most fit into the categories listed above. Of the twenty specifications that are applicable, bicycles would meet or exceed 18. The vehicle identified in the ADEA report is a small motor powered all-terrain-vehicle (ATV). A limited number would be used at platoon level to only lessen the soldier's load.(10:25)

There is a viable alternative to the ADEA suggested vehicle: mount the entire unit on bicycles. Soldiers on bicycles can carry greater weights than those on foot while expending less energy in doing it. The bike answers part of the problem concerning the soldier's load. It will also answer part of the problem of the limited tactical mobility found in light infantry battalions.

To examine the feasibility of using bicycles in light infantry units this study will look into several areas. An examination of past and present military use will be coupled with a study of new bicycle technology to determine future application. Military forces in the past

Figure 7

COMBAT LOAD HANDLING EQUIPMENT (CLOTHE) SPECIFICATIONS

Source: Final Report of the ADEA Soldier Load Initiative,
12 March 1987

- E 1. Low cost - Disposable in battle.
- F 2. Payload: 600 to 1000 lbs (excludes driver, kits, fuel issue items).
- E 3. Noise level: 65 decibel maximum desirable, 70 decibel essential, at 50 meters at full engine RPM.
- M 4. Travel speed: 0 to 12 mph minimum.
- M 5. Lifts and tiedown/lashing rings suitable also for towing and recovery.
- F 6. All terrain mobility fully laden. six inch vertical step capability (twelve inch desirable). Can ascend/decend 25 degree slopes. Can cross 15 degree side slope. Six inch ground clearance.
- M 7. Ground clearance: 5 inch minimum.
- E 8. Fuel range: 100 miles minimum fully laden over trails
- E 9. Safety and ease of driver handling and operation. 30 minute orientation on operation and maintenance.
- M 10. Water fordability: 2 1/2 feet.
- F 11. Equipment must float unloaded (desirable float with 600 lbs load).
- E 12. Reliability, availability, and maintainability (RAM)
- E 13. Durable and rugged construction.
- E 14. Air transportable via helicopter and cargo aircraft to include "piggy-backing" of one vehicle on another. Must include a sling loading capability.
- E 15. Air droppable, LAPES capability loaded without damage.
- E 16. Ground transportable in standard or modified service trailer.
- M 17. Crew seating capacity: 1 person essential
- M 18. Overall height: 50 inches maximum.

M= bicycle meets requirement E= bicycle exceeds requirement
F= bicycle fails requirement

have used bicycles on various occasions with some degree of success. A historical study in this area may shed light on possible uses today. Several foreign armies still employ bicycle units. A study of their organization and doctrine would be useful in determining those areas that may be applicable for U.S. use.

The bicycle in its present form has been around since the invention of the Rover Safety Bicycle in 1885.(12:81) The fitness craze of the last decade has been a boom to the bicycle industry. This renewed interest has sparked advances in bicycle technology. Yet, the bicycle remains a relatively simple machine. The bicycle's simplicity may be the reason it has been constantly overlooked by the American military. Some of this new technology will be examined for possible use in military cycling. This simple, yet efficient machine may be the answer to the mobility problems of present light infantry units.

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CHAPTER 2

PAST MILITARY USE OF BICYCLES

The use of bicycles for military operations is not a new idea. In that soldiers have always looked for ways to improve their mobility, it was natural that early bicycles attracted the attention of military men. In fact, the bicycle has quite a military heritage. A study of this 100 year military heritage will give insights into possible future use by U.S. light infantry units.

In 1885, J.K. Starley of England introduced the Rover Safety Bicycle.(18:87) It's introduction marked the bicycle's inauguration as a practical means of transportation. It also started a bicycle craze in England that rapidly spread throughout the world.

Earlier models, like the familiar high wheeler of the 1870s, had been around for sometime. For propulsion previous bicycles used a set of pedals attached directly to the axle like a child's tricycle. Others used complicated

lever systems. Both modes required either great strength, or an awkward design like the high wheeler.(1:38) The Rover required neither.

The Rover was the first bicycle to incorporate most of the features of the bicycle as we know it today. It had a tubular-steel diamond shaped frame mounted on two wire spoked wheels of equal diameter. The rider sat on a seat (saddle), controlling the direction of the front wheel with a set of handle bars. What made the Rover unique was its drive system. It was the first bicycle to use a rear-wheel chain-and-sprocket drive with a "geared up" transmission.(18:87)

Overnight the Rover's design changed the cycle industry. Bicycles were inexpensive enough for the middle classes to purchase. The Rover offered cheap, reliable transportation to the average man.(18:87) The Rover also made the military use of bicycles practical.

Starting with the French in 1870, most of the major military powers in Europe had experimented with previous bicycle designs.(1:39) The majority of European Armies, however, had rejected these earlier bicycles for the same reasons as the civilian population. Early bicycles were too awkward to handle or required too much strength to propel.

The Rover had changed this, and almost immediately widespread military experimentation with bicycles began.

Germany, for example, begin experiments in January 1886.(6:219) Both the British and French quickly followed suit. Experiments in the American Army did not begin until 1891. In October of that year the Commander of the Department of Missouri, General Nelson Miles attended a six day bicycle race at Madison Square Garden in New York. While there, Miles publicly stated his interest in the bicycle for Army use. He noted that the bicycle was quiet and reliable. He also noted that it did not require maintenance and feeding like the horse.(3:7) As a result of the Garden races, on November 25, 1891 General Miles ordered the Fifteenth Infantry to conduct experiments with bicycles. The bicycles were provided by the Pope Bicycle Company at no expense to the government.(3:7) Thus the U.S. Army entered the bicycle age.

These experiments were short-lived. Less than two months later, in January of 1892, the Department of the Army ordered Miles to stop the experiments. Miles was told that only the Secretary of War could approve the testing of new military equipment. Therefore Miles requested permission from the Secretary of War and a month later his request was approved. Nevertheless, for some undetermined reason the testing never started again.(3:8)

Despite this initial setback, Miles continued to advocate military use of the bicycle. With his appointment as Major General Commanding the Army in 1895, Miles was now

in a position to put advocacy into action. In his first annual report to the Secretary of War in 1896, Miles recommended equipping a regiment with bicycles. Although the Secretary of War did not follow this suggestion, he did authorize Miles to conduct limited bicycle tests.(3:10)

In 1896 Miles officially formed the Twenty-fifth Infantry Bicycle Corps at Fort Missoula, Montana.(1:10) The 25th Bicycle Corps was actually formed from an ad hoc bicycle drill team already in existence in the 25th Infantry Regiment.(3:10) The commander of this twenty man drill team was a 1894 West Point graduate, Lieutenant James A Moss.(6:221)

Upon assignment to the all-black enlisted men's unit in 1894 Moss had become a cycle enthusiast. Shortly after his arrival he received permission to organize a bicycle club among the soldiers at the fort. The highlight of this activity was a demonstration in cycle drill by twenty soldiers during the Post's 1895 Fourth of July program.(3:10) When Miles officially recognized the 25th, Moss was given command of the new unit.

In spite of its impressive title, the 25th Bicycle Corps never had more than a hundred soldiers. At this point it consisted of one white officer, and eight black enlisted men.(6:222) During the summer months of 1896 Moss conducted numerous cycle experiments with the unit. He worked out commands and steps for mounting, dismounting,

and a host of other drills.(6:222) For instance, on the order, "Prepare to Mount," the soldier put his left foot six inches in front of the right, preparing on the command of, "Mount" to swing his left leg over the frame.(6:222) While commands of this nature would seem archaic today, they were still very much a part of the Army in 1896.

The unit also developed more practical cycle drills to cross obstacles. Before the summer was over the unit standard for crossing a nine-foot fence with their bicycles was twenty seconds. At the command of "Jump Fence" one soldier would lean his bicycle against the fence and use it to climb over. Another soldier would pass both bicycles over the fence then climb over. Both soldiers would then move to their assigned location and assume the position "Stand to Bicycle." In crossing a shallow stream the bicycles were dismounted and forded across. For deeper streams two men would hang a bicycle on a pole and carry it across on their shoulders.(6:224)

The soldiers experimented with load plans. Moss tried to determine what to carry and where to place it on the bicycle. He also tried to determine what spare bicycle parts he would need to carry. From photographs of the period, it appears he decided to tie most of the equipment onto the front handlebars.(6:223)

In August the unit took a 126 mile round trip to Lake McDonald and back. The shake down trip took about 24 hours of actual traveling time. It proved valuable in that the unit was exposed to a full range of adverse conditions. They suffered the bane of all cyclists: high winds, rough roads, and steep grades.(3:10) Their bicycles suffered as well with flat tires, broken pedals, and lost chains. The men learned a great deal. On the basis of this experience Moss made modifications in both training and equipment upon returning to Ft. Missoula on August 9.(6:224)

Less than a week later the unit undertook a more ambitious trip. Moss planned an 800 mile route to Yellowstone National Park and back. Each cyclist would carry full gear. Moss planned for rations to be picked up along the route every 150 miles. This plan meant each cyclist would have to carry a four day supply of rations. The soldiers tied their knapsacks filled with rations, clothing, and shelter tent halves to the front handlebars. They strapped their Krag-Jorgensen rifles horizontally to the left side of their bicycles and each soldier carried forty rounds of ammunition in his cartridge belt. The total weight of bicycle and equipment was 77 lbs.(3:11)

During the Lake McDonald trip, the unit experience a large number of tire punctures. Moss decided to use the Yellowstone trip to test various types of tires. The Advanced Tire Company provided Moss with nine

puncture-proof tires.(3:11) On 15 August 1896 the 25th left Fort Missoula for Yellowstone Park. Again, strong winds and poor roads slowed the unit's progress. Despite having to pedal along a railroad track they covered 42 miles in eight hours.(3:11) This trek is twice the distance today's FM 7-72 prescribes as a forced march for dismounted infantry.

It took the unit ten days to reach Yellowstone Park.(3:11) Poor roads, bad weather and bike repairs were the major causes for delays. For example, on the second day out the unit started on the road at 6:18 A.M. They did not close on their objective 44 miles away until 7:30 P.M. Still this was much better than foot infantry. They spent an estimated two hours on bicycle repairs. Of the two hours, 70 minutes was spent on repairing a total of six tire punctures.(3:11)

Tires continued to be a problem. The puncture-proof tires of the Advanced Tire Company must have failed. Moss records that on one particular day, burst tires and punctures delayed the unit seven hours.(3:11)

After arriving on the 25th, the unit spent five days sightseeing at the Park. On September 1st they left Yellowstone retracing their original route back to Ft. Missoula. The return trip, being a little more downhill, took only eight days to complete.(3:11) The unit had traveled 790 miles in 126 hours of actual riding time.

The troops averaged a speed of 6.25 m.p.h.(6:226) With the exception of tire problems, they experienced only one major equipment failure. On the return trip the wooden rim of one soldier's bicycle splintered. This mishap caused a one day delay as Moss bought a replacement rim from a local civilian.(6:225)

Three days after their September 8 return to Fort Missoula the soldiers were again in the field.(3:12) They took part in a joint exercise between the 25th Infantry and the 10th Cavalry. During the exercise the bicycle corps set up a fifteen mile courier system between the supply wagon train and the head of the infantry march column. This system proved valuable when the wagon train became stuck in mud, requiring the Regimental Commander to send infantry troops to extract it. The Corps also conducted route reconnaissance missions for Colonel Burt, the regimental commander. They reported on road conditions, availability of water, and possible camp sites. The famous frontier artist, Frederic Remington watched the exercise, noting: "It is heavy wheeling and pretty bumpy on the grass, where they are compelled to ride, but they manage far better than one would anticipate."(6:226)

During the winter Moss was placed on temporary duty in Washington. While back east he obtained literature on bicycles from the Bureau of Information. He also toured several bicycle manufacturers and tire factories.(3:12)

Following an earlier suggestion from General Miles, Moss proposed the following test for the upcoming year: first, expand the present bicycle corps from eight to twenty enlisted men and one surgeon under his command; second, select the soldiers from the 25th Infantry; third, secure improved bicycles from a manufacturer at no expense to the government; finally, undertake a trip from Fort Missoula, Montana to Saint Louis, Missouri carrying arms, ammunition, and full equipment.(:12)

Based on tentative approval from General Miles, Moss went to the Spalding Bicycle Company of Massachusetts to arrange for bicycles. Spalding had provided the bicycles used during the 1896 testing. The company had provided the bicycles for free, receiving in return an endorsement with accompanying photographs from Moss for their 1896 advertisement campaign.(3:21)

Moss requested several modifications for the bicycles that were to be used for the Saint Louis trip. Steel rims replaced the wooden ones used earlier. He added chain guards to keep the chains free from mud and prevent accidental loss. The side forks and crowns were reinforced. Luggage carriers and comfortable Christy saddles were added. Hard leather cases that fit into the frame diamonds were provided to carry rations and equipment. Three of the cases were made of metal and

designed to be used as cooking utensils.(3:13) With these modifications the bicycle's riderless weight came to thirty-two pounds.(1:45)

On May the 4th the Secretary of War formally approved the project. One month later, Moss took delivery of twenty-two new Spalding bicycles at Fort Missoula.(3:13) By the time the bicycles arrived, Moss had already selected the twenty enlisted men for the trip. Moss had personally chosen each man from a group of forty volunteers. Of the twenty, five were from the original Bicycle Corps.(3:13)

Sergeant Mingo Sanders was the chief enlisted man and acted as the unit Noncommissioned-Officer-In-Charge (NCOIC).(1:45) He was assisted by two lance corporals. With the exception of one musician the rest of the men were infantry privates. One private, John Findley was a bicycle mechanic.(6:222) The oldest man was Sanders at thirty-nine; the youngest was twenty-four. The heaviest man weighed 177 pounds; the lightest 125 pounds, with the unit average being 148.5 pounds.(1:146) Moss chose the men based on physical conditioning rather than cycling experience. In fact, one man learned to ride a bicycle only one week before the unit left for Saint Louis.(3:13)

Dr. James M. Kennedy, the assistant post surgeon at Fort Missoula, was ordered to accompany the group. Reports of his enthusiasm for the expedition vary according to different sources. Some state that he was a cycle

enthusiast.(3:13) Most point out that he was less than thrilled about riding 1,900 miles to St. Louis.(1:45) Whatever his attitude he completed the trip, at one point even taking temporary command from a sick Moss.

Each soldier slung the standard Krag-Jorgenson rifle across his back. For some reason one soldier carried a shotgun.(1:46) Each man wore a cartridge belt containing fifty rounds and a bayonet.(6:228) Blanket rolls containing shelter half tents, poles, blankets, and toiletries were tied to the luggage carrier on the handlebars. The leather cases attached to the frame diamond contained the individual's mess kit, two days rations, extra clothes, cycle tools and spare parts. The average weight loaded on a bicycle was fifty-nine pounds.(1:45)

The route Moss selected traversed the state of Montana then cut across the Northeast corner of Wyoming. It continued in a Southeast direction touching the Southwest corner of South Dakota, then traversed the Northwest/Southeast axis of Nebraska. Crossing into the state of Missouri at St. Joseph, the route continued due East finishing up at St. Louis.(6:229) It is unclear why Moss picked St.Louis as the objective for the trip. It may have been suggested by Miles. It did provide for a variety of conditions in terms of gradient, road surface and climate. There were rocky mountain roads in Montana, dirt

roads through the rolling hills of Wyoming, sand roads through much of Nebraska, and clay roads through Missouri. Temperature and weather would range from sleet in the mountains of Montana to 110 degree temperatures in the sands of Nebraska. All totaled the unit would travel 1,900.2 miles.(3:22)

Moss coordinated with various quartermaster units to set up ration depots along the route. These depots were in reality food and water caches located in towns. The depots were set up about every 100 miles. The soldiers were carrying a two day supply of rations.(3:14) This schedule required the unit to cover at least fifty miles a day.

At 0530, 14 June 1897 the 25th Bicycle Corps left Fort Missoula to begin its 1,900 mile trek to St. Louis.(3:16) Moss's daily plan was to break camp prior to daybreak and ride through the morning until midday lunch. After lunch the men would rest during the hottest part of the day. Around five in the afternoon they would resume traveling, then stop at dark.(6:228)

Poor roads and weather interrupted this schedule from the very beginning. On the first day the unit ran into a thunderstorm.(1:47) At the turn of the century, western roads were still little more than wagon trails, after almost any rain they generally turned to mud.

At some points the mud forced the riders to dismount and push their bicycles along. Despite the storm and the road the unit was able to cover fifty-four miles on the first day out.(1:47)

Neither the weather nor the roads improved during the next week. The unit crossed the Continental Divide in two inches of snow.(6:228) Coming down the other side they ran into sleet. At times, poor roads forced Moss to order the men to ride on the railroad tracks that paralleled the route. While this route offered some relief, the vibrations caused by the crossties made for rough riding.(3:16)

Nine days after it left Ft. Missoula, on the 23rd of June, the Corps pedaled through Billings, Montana. While passing through the town the troops were subjected to verbal abuse from the local population. To add insult to injury, they suffered the same type bantering while fighting a stiff headwind passing through the Crow Indian Reservation. Two days later on the 25th the Corps rode into Fort Custer, Montana.(1:51) At Fort Custer, Moss rested his men for one day. They were issued clean uniforms, performed maintenance on their equipment, and even toured the nearby Little Big Horn Battlefield. The next day they pushed on into Wyoming.(6:228)

Shortly after entering Wyoming the unit was forced to cross the Little Big Horn river a total of six times.

Each time they waded through chest high water carrying their bicycles across on long poles.(1:53) Despite this they were only slightly behind schedule when they passed through Sheridan. On the 29th they broke for lunch in Gillette, Wyoming. Moss wanted to make Moorcroft, thirty miles away, by nightfall. Shortly after leaving Gillette, the unit experienced the only structural failure of a bicycle during the trip. The front axle on Private Foreman's bicycle broke.(1:54) This mishap meant that Foreman would have to walk to Moorcroft. Moss left Sgt Sanders in charge of the unit with orders to proceed to Moorcroft as fast as Foreman could walk. Moss, the cook, and one other man proceeded on to Moorcroft to set up camp and wait for the unit to catch up. Sanders and the main party did not arrive until morning.(1:56)

Because of the night march the unit did not push off for South Dakota until 2 P.M. the next day.(1:56) For the next five days the soldiers made steady progress through South Dakota into Nebraska. The only problem they experienced was a shortage of good drinking water. In parts of South Dakota and in virtually all of Nebraska, the only water they found was alkali.(3:16) About half the Corps became sick from the combined effects of alkali water and the daily 100 degree heat. Shortly after passing through Alliance, Nebraska, Moss became so ill that Surgeon

Kennedy declared him unfit to continue. Moss was taken back to Alliance to recover while the unit pedaled on with Kennedy in command.(1:56)

Whatever Kennedy's previous attitude, he guided the Corps through what was probably the worst part of the trip. For the next 170 miles the Corps rode or pushed their bicycles through the sand hills of Nebraska. The unit still had problems with the water supply. The only good water in the area came from water tanks along the rail line. Kennedy decided to again try riding on the rail line. Although solving the water problem, the wider spacing of rail ties in Nebraska prevented the men from riding their cycles. When using the rail line the men dismounted and pushed their bicycles.(1:57) Many times even this route was better than attempting to negotiate the sand roads. Even when it could be done , pedaling in the deep sand required more energy than walking.

Adding to their discomfort were the extremely high temperatures during the afternoons. On July the 7th the midday temperature was 110 degrees. Two soldiers suffered blistered feet from walking in the hot sand.(3:16) It took the Corps four and a half days to cover the 170 mile stretch, averaging 37.7 miles a day.(6:229)

Four days after dropping out at Alliance, a partially recovered Jim Moss linked up with the unit by train.(1:57) From the end of the sand hills at Broken Bow, Nebraska, the unit made good progress. On July 17 the bicycle troops crossed into Missouri.(1:57)

With the exception of the local population's generally hostile attitude towards the black soldiers, the ride through Missouri was uneventful.(3:19) Although Moss described the roads through Missouri as being poor, the Corps made excellent time. Averaging 62 miles a day, the Corps covered the 433 miles through Missouri in seven days. The troops entered St. Louis on July 24th.(1:58)

The city of Saint Louis welcomed them with open arms. A large number of civilian cyclists escorted them into the city.(1:58) After a weeks celebration in Saint Louis the Corps boarded the train back to Fort Missoula. The men arrived at Ft. Missoula only to find that the news of their success had been overshadowed by the discovery of gold in Alaska.(3:20)

The 25th Infantry Bicycle Corps crossed 1,900.2 miles of rough terrain in forty days. Of the forty days, thirty-five had been spent in actual travel.(6:229) The trip averaged fifty-two miles a day at 6.3 miles an hour. Of the twenty-two men who started the trip only one failed to finish. With less than a week to go, Private Eugene Jones was too sick to continue.(1:59) The rest of the men

finished in excellent condition. In fact, fourteen actually gained weight.(9:36) The bicycles held up well. With the exception of one broken axle, not a single bicycle suffered structural damage. Tire punctures were still a frequent problem. None of the eight different brands of tires Moss took on the trip proved to be completely satisfactory.(6:229) It appears however, based on Moss's after-action report, that tire problems were less troublesome on the Saint Louis trip. Perhaps with experience the soldiers became more adept at fixing punctures. Based on the trip, one change to the bicycle Moss wanted concerned the carrying of the rifle. The Krag Jorgensen rifle the soldiers carried was 49.9 inches long and weighed 9.38 pounds. The troopers had carried these rifles slung across their backs. This arrangement proved very uncomfortable. Upon returning to Ft. Missoula, Moss had sets of clips made enabling the soldiers to carry their rifles attached to the bicycle frame.(9:22)

On 7 February 1898 Moss wrote to the adjutant general proposing a trip in the spring from Ft. Missoula to San Francisco.(6:230) Less than a week later the U.S.S. Maine blew up in Havana harbor. With a possible war with Spain imminent the Army did not want to spend funds to send troops cycling all over the country.(6:231) Moss's proposal was rejected. Moss and the 25th Infantry Regiment sat out the three month war at Fort Missoula.(1:62)

Although the 25th Bicycle Corps never went to war, the unit did eventually get to Cuba. Shortly after the war ended a yellow fever epidemic broke out in Havana. Riots erupted in Havana as a result of American medical countermeasures. General Miles ordered the Bicycle Corps expanded to 100 men and dispatched the unit to Cuba.(1:62) Moss was placed in command and with 100 handpicked men took the train for Tampa. Almost immediately upon arrival in Cuba the unit went on riot control duty. Moss's technique for controlling riots was to rapidly approach the dissatisfied elements simultaneously from different directions. If the unruly gathering started to get violent the bicycle troops would erect a barricade using their bicycles. The technique must have worked. The riots subsided with Moss's men never having to fire a shot. Moss credited the enhanced mobility of the unit as being key to the operation.(1:64) It allowed him to rapidly concentrate almost anywhere in the city where small groups of dissidents started to gather. This rapid show of force enabled authorities to control the crowds.

After Cuba the Corps returned to Fort Missoula. There they disbanded.(1:64) It appears that the Army's interest in bicycles died along with the civilian bicycling fad. The 25th Infantry Bicycle Corps experiments are important to any study of military cycling. They were the first to demonstrate the ability of the bicycle to carry

troops and equipment great distances. They proved the bicycles ability to traverse different types of terrain under varied weather conditions. In the non-mechanized Army of the 1890s it is puzzling why they were not adopted.

In studying the possibility of bicycle use in today's Army, two additional factors need to be remembered. The road system of the United States at the turn of the century would rival those of the poorer third world countries today. The second factor is that the bicycles the 25th used were single gear systems and very crude by today's standards.

The 25th Infantry Bicycle Corps proved that the bicycle is capable of meeting the vehicular criteria for light infantry units. While taking place 92 years ago, the results of the experiments are still valid today. The unit successfully negotiated 1,900 miles of mountains, rivers, fences, and sand deserts. The soldiers proved that the bicycle is able to traverse most types of terrain. Moss's men rode their bicycles in rain, snow and sleet. They rode in temperature extremes from 110 degree heat to freezing conditions. They proved the bicycle is able to operate in most weather conditions. The fact that only one bicycle suffered a structural failure during the 1,900 mile trip proves the bicycle is both durable and reliable. Moss's men carried what was at that time considered the soldier's

load. At times this burden weighed to 77 lbs., (well within what the modern light infantryman carries). While Moss initiated a cycle training program, one man still learned to ride a bicycle only one week prior to the 1,900 mile trip. The fact that he completed the trip is proof that operator training is simple and timely. On their best days Moss's men rode up to 62 miles a day. This mileage is over three times the distance of a modern light infantry unit's forced march range. Even their shortest daily advance of 37.7 miles is greater than the forced march distance of the modern light infantry unit. Moss's bicycles gave his soldiers a speed advantage of over 4 kmph.

The strategic mobility of U.S. light infantry units earmarks them for use in security missions overseas. Units deployed in this fashion could find themselves in a position similar to that of Moss's troops in Cuba. Moss's skillful use of bicycles in a riot control situation has application for today's light infantryman.

While American generals wrote off the bicycle for military use, their European counterparts formed bicycle units. Less than a year after the introduction of Starley's Rover Safety Bicycle the Kaiser's Army formed it's first cycle unit.(6:219) Two years later, in 1888, the Swiss formed the nucleus of bicycle units they still use today.(5:52) France quickly started testing again, this time using the improved drive system. Italian Bersaglieri units which had persisted in trying to make the old lever system work, quickly adopted the new design.(1:13)

European armies not only formed cycling companies, they experimented with changes to the bicycle itself. By 1899 both the French and British had developed lightweight folding bicycles strictly for military use. In 1901 the British even invented a tandem tricycle capable of hauling a machine gun or lightweight cannon.(9:24)

The British were the first to use the modern bicycle in an actual conflict. During the Boer War, from 1899 to 1902, the British employed several thousand bicycles.(1:66) Although bicycles were issued to infantry units, the British Army did not form organized bicycle units per se. The British were pleased by the performance of the bicycle in Africa. Its success in actual combat insured it a place in the British military system. To Britain's European neighbors, their own expenditures in bicycle testing seemed justified by the British experience in South Africa.

In a few rare cases infantry troops used the lightweight, folding, Dursley Pedersen bicycle in pursuit operations. The Dursley Pedersen offered the advantage of enabling the infantry to fold it down and carry it on their backs.(9:24) This capability allowed a continuance of the pursuit in rough terrain. Once out of rough terrain the troops unfolded their bicycles and continued mounted operations.

The majority of the bicycles issued, however, were primarily used as a supplement for the critical shortage of horses. Their main use was in scouting, liaison, and limited supply operations. For instance, some of the tandems were converted to supply vehicles by replacing the back seat with a cargo box.(1:44)

On the eve of World War I, the following countries fielded bicycle units: England, Sweden, Norway, Austria-Hungary, Germany, France, Belgium, Switzerland, Italy, Spain, Bulgaria, Holland, Russia, Serbia, Denmark, and Rumania.(9:13) On the Western Front the British employed an estimated 100,000 bicycles. The French and Belgium armies combined used over 150,000 bicycles. The Germans put in service over a quarter of a million bicycle troops on both fronts.(9:9) Even the late coming American Expeditionary Force utilized 29,000 bicycles for administrative, signal and liaison purposes.(9:9)

Bicycle troops were put to use for many types of missions. At the beginning of the war, during the period

of initial movement, cycle troops performed missions similar to cavalry. In fact, the bicycle battalions of both the French and German Armies were generally attached to cavalry divisions.(9:B-1) During this period cycle units provided their respective armies with mobile reserves, screening forces and supply train escorts.(9:B-1,B-6) They also conducted reconnaissance missions, provided advance guard elements, and in the case of the allies rear guard detachments.(9:B-1) In short, any mission that required rapid movement was apt to fall to cycle troops.

The nature of World War I makes it impossible to describe every operation in which cycle troops were involved. A good example of an operation involving the use of purely cycle troops was the German raid on the Mt. St. Pere Bridge. Early in the war the 1st Bicycle Company, Rifleman Battalion of Guards, 5th Cavalry Division of the German Army, conducted a 1914 version of "the deep attack."

The objective of their attack was the vital bridge over the Marne river at Mt.St. Pere. French forces were using the bridge to bring reinforcements North for a counterattack into the advancing Germans.(1:73) The bridge was twenty miles behind French lines, but was known to be well guarded.(1:73) Because of the vital nature of the bridge, the French positioned an infantry company on the far bank. On the near bank another infantry company was positioned in support.(1:13) Security was lax among the

guard force. The Germans were thought to be more than a night's march away. Any approach by cavalry would be heard in time to give the alarm.

On the night of 2 September 1914 the 1st Bicycle Company infiltrated through a gap in the French lines.(1:73) Throughout the night the Company silently pedaled 35 Kilometers to the bridge.(9,B-2) Travelling with the riflemen was a special detachment of engineers whose mission was to destroy the bridge. In the predawn hours the Company moved into position. Part of the unit dismounted and took up firing positions to provide support for the attack. The rest of the unit plus the engineers remained mounted on the main road.(1:75)

Around first light the signal was given to begin the attack. The attack caught the French guard force totally by surprise. The majority of Frenchmen were still asleep in their tents. Many of the soldiers on the French far bank (nearest to the Germans) were annihilated in the initial fusillade by the support element. As the survivors staggered out of their tents they were cut down by the assault force rapidly pedaling for the bridge. Some of the Germans were even reported to have fired at the fleeing Frenchmen while still riding their bicycles!(1:76)

Once the assault force reached the bridge, the support force shifted its fire across the river. Concentrating on the French support company across the river, the cyclists' accurate rifle fire threw that

unit into confusion. The engineers accompanied by a security element from the assault force raced across the bridge. They set the charges, lit the fuses and pedaled back to their positions. As the bridge blew up the company remounted their bicycles and rapidly retreated to friendly lines. They had destroyed a vital bridge, annihilated one enemy company, and inflicted heavy casualties on another. In return their own casualties had been very light.(9:B-2)(1:79)

The raid demonstrated the ability of cycle troops to rapidly and quietly strike a target deep in the enemy's rear. Today, a U.S. light infantry company could not accomplish the same mission. A modern light infantry company on foot cannot physically cover 35 km in less than six hours of darkness and be in position to attack at dawn.

German cyclists were not the only cycle units to enjoy successes during the war of movement in the fall of 1914. Less than a week after the Mt.St. Pere debacle, on September 8 and 9, 1914, French cyclists obtained some measure of revenge. The 5th Bicycle Group,(probably a battalion size unit) operated in the forest area of Villers-Cotterets. There they surprised and destroyed a enemy ammunition carrier column under the escort of a German cycle unit. Eleven days later the same unit successfully ambushed another German logistical column on the Cambrai-St. Quentin highway.(9:B-8)

Belgian cycle units seemed to specialize in cutting German lines of communication. From September 25th to October 9th, 1914, Belgian cycle units, including a bicycle engineer company, wreaked havoc on German rail lines. Seven cycle companies operated behind the lines for a two week period in German occupied Belgium. These units cut the tracks at sixteen different places.(1:22)

During this period, cycle units were on the forefront of almost any action involving the collision of opposing armies. Their use in reconnaissance, pursuit, advance and rear guard missions naturally meant they usually made initial contact with the enemy. Many times this initial engagement turned out to be with their cycling colleagues on the opposing side. For instance, on the 8th of September German cyclist encountered a British cycle unit on a bridge over the Small Morin River near Boiton. One month later an advance guard made up of German cycle units ran into a Belgian cycle company near Edemolen.(9:B-1) The 10th of October alone saw action between German and French cycle units at Rouge Croix, Doulieu, and Morslede.(9:B-1)

Once the stalemate of trench warfare set in, bicycles still saw use in a variety of ways. Cycle units were generally kept out of the front trenches. They were placed in positions behind the lines where they could rapidly reinforce a number of frontline units. Once the enemy's main effort was identified cycle reserves would be

rushed to the threatened sector. Cycle messenger orderlies were attached to both artillery and infantry battalions. Wartime photos show German cyclists not only delivering messages, but repairing their cycles under artillery barrages.(1:photo 49)

The ability to maintain a mobile reserve is a feature not present in today's U.S. light infantry battalions. Because they were equipped with bicycles, World War I units were able to maintain this critical capability at a fraction of cost.

By midwar the Germans had come to appreciate the mobility of cycle units to the point they began using them as a strategic reserve. In July 1916, the German General Staff began organizing cycle battalions from the cycle companies found in Jager battalions and infantry divisions. They were able to organize five bicycle battalions. Each bicycle battalion had four bicycle companies and one machine gun company. Three battalions were organized on the Eastern Front, two on the Western Front.(9:10)

In the Fall of 1916 the 4th and 5th cycle battalions saw action at the battle of Somme. Their compatriots on the Eastern Front were engaged in operations in the Carpathians. In October all five battalions were sent to Transylvania. There they were formed into a cycle brigade and attached to the Ninth German Army under General von Falkenhayn. General Falkenhayn used them as a screening force during his drive into Rumania.(9:10)

In January of 1917 the Cyclist Brigade was transferred from Rumania to the Western Front. While there they assisted the 2nd and 7th Cavalry Divisions acting as the rear guard for the German retirement to the Hindenburg line in March.(9:10) In October the Brigade, minus the 3rd Battalion, was sent to the Eastern Front. The 3rd Battalion went to the Italian Front, taking part in the subsequent Austro-German offensive on Piave. After this operation it joined the rest of the Brigade on the Eastern Front.(9:10)

Initially the Brigade was stationed at Libau, Russia. In October the Brigade took part in the capture of the Moon and Oesel Islands in the Gulf of Riga. Four months later, in February of 1918 the Brigade led the German drive against the Red Guards at Reval. Once the fighting ended at Revel the Brigade was employed on police duties.(9:11) From April until July the 5th Battalion was detached for duty in Finland. While there, it fought a vicious battle with the Red Guards in April. After the Red Guards were defeated, it returned to the Brigade.(9:11)

In the early part of September the Brigade left the Eastern Front for the last time. By the 5th of October they went into the line in the Cambrai-St.Quentin Sector of the Western Front. There they remained until the armistice in November.(9:12) In the course of the war the Cycle Brigade or its battalions had been transferred six times to different fronts.

On today's battlefield transportation assets are a rare commodity. A U.S. light infantry unit in Europe would find itself in competition with other priorities for scarce transportation assets. The Germans through the use of bicycles found the solution to this problem 70 years ago.

As befitting a World War the bicycle saw action worldwide. The British used them in Palestine. The famous commander of German forces in East Africa, General von Lettow Vorbeck mounted his entire staff on bicycles. Perhaps a more telling measure of their use was the casualties they suffered. By the end of the war more than six thousand cycle troops lay dead on the various battlefields. Eight thousand cyclists were among the warring nations' wounded.(1:85)

The end of the war did not bring about an end to military cycling. Unlike their wartime partners, the horse cavalry, bicycles continued to be used in European armies after the war. Even von Seeckt's German Army, suffering under the Versailles restrictions, opted to keep its cycle units.(1:94)

In fact, despite constrained peacetime budgets, military experiments with bicycles actually increased between the two World Wars. For instance, the German Army experimented with bicycle mounted chemical detection equipment.(1:96) In one of the more bizarre experiments, the Russian Army came up with a man-dog-bicycle combination.(1:93) The man was supposed to rapidly scout

ahead on the bicycle with his trusty four legged companion trotting beside him. The dog provided early warning and security while moving through wooded areas or when the scout slept at night. It does not mention when the dog slept.

The outbreak of World War II again saw the extensive use of bicycle troops. Given Europe's military cycling heritage, it is ironic that the most successful use of bicycle troops was by a Asian country. In what many historians consider its most brilliant campaign, the Imperial Japanese Army employed 50,000 bicycle troops for the conquest of Malaya.(1:97)

The real target for the Japanese was not so much Malaya itself, but the port of Singapore. Singapore, with its excellent harbor and great naval base enabled the British to control access to the resource rich East Indies. The British had installed a formidable coastal defense system to defend the harbor against attack from the sea. For defense against an attack from inland, they had placed their faith on the inhospitable terrain of the Malaya Peninsula.(13:26)

At first glance, Malaya would not appear to be a suitable place to use bicycles. The 500 mile long peninsula is covered by thick jungle. Numerous streams and small rivers criss-cross the landscape. Malaya was connected North to South by a British built road. Although an excellent asphalt road, it represented the only road

network on the peninsula. Any force attempting to take Singapore from the land side would be forced to operate over this one road. British intelligence analysts felt the only military use the jungle trail networks would support was dismounted infantry. That being the case, it would take any army attempting an overland drive several months just to get to Singapore.(4:43) The difficult terrain and limited road system suited delaying operations. The British, falling back to Singapore, would be operating on progressively shorter lines of communication. Their adversary proceeding down the peninsula would be forced to stretch his logistical lines. Considering these advantages the British felt relatively secure in their "Fortress in the Sun."(13:28)

In January of 1941, the Japanese Army set up a research group to find a way to set the sun on the British Empire in Malaya. Based on the Island of Formosa, the group was composed of ten staff officers under the command of Colonel Masanobu Tsuyi. For one year this group, called "The Taiwan Army Research Section" studied the Malaya problem. They questioned jungle experts, former attaches and a host of other specialists.(13:18)

The section assumed that most of the 250 bridges connecting the main road South would be destroyed by the retreating British Army. This destruction precluded the use of motorized forces. At the same time the research group estimated that to rely on the walking pace of

dismounted infantry and the repair of bridges would take them over a year to reach Singapore. The bicycle seemed to offer a possible solution to their dilemma.(13:18)

On November 2,1941, Lieutenant-General Tomoyuki Yamashita was appointed to command the invasion force assigned to conquer Singapore. By this time the four divisions assigned to his newly formed 25th Army had been identified. Two of the divisions, the 5th and 13th, were assigned to spearhead the assault.(13:19) Both divisions had been fighting in mainland China. Following the advice of the Taiwan Army Research Section, General Yamashita ordered the divisions to turn in their horses for bicycles and trucks. Each division was issued about five hundred motor vehicles and six thousand bicycles. The units had a little over a month to train with their new found transport.(8:16) Nevertheless by 8 December they were ready to carry out their assigned missions.

Japanese cycle mounted infantry set both the tempo and pattern for the Malayan Campaign. Dismounting short of established British defense lines they would assault as normal infantry. Once a penetration or flanking movement had succeeded in forcing the British to retreat, infantry cyclists would pursue in one of three ways. A cycle mounted reserve, sometimes in conjunction with tanks, would pass through the dismounted elements to continue the pursuit.(19:122) If a reserve was not available, the dismounted infantry would either return to their bicycles,

or have the bicycles brought forward. The bicycles were brought forward either in trucks, or if trucks were not available, by impressed native labor.(8:17)

The British were caught off guard by the speed of the Japanese advance. Their planning had been based on the estimate that the Japanese would be bound to the single decent road network leading South. They believed that road blocks, blown bridges, and rear guard actions would delay the Japanese a significant amount of time. This delaying action would allow retreating forces to gain a measure of rest, and time to establish deliberate defensive lines. The British also felt that they enjoyed superior mobility over their less mechanized foes. The majority of British forces had motorized transport.(13:69)

The Japanese cycle mounted infantry were not deterred by any of these measures. When facing a road block, they bypassed it either using jungle trails or by pushing their heavy laden machines through the jungle underbrush. When they came upon a blown bridge they would hoist their bicycles on their shoulders and wade across. Once on the other side they would remount and continue the pursuit.(8:16) British rear guard units constantly found Japanese cyclists in their rear areas, attacking their supporting artillery, wreaking havoc among service troops and seizing bridges. Many times the seizure of a bridge meant the loss of the rear guard's motor transport.(13:69) When this happened, the foot bound British units would be

driven off the road by pursuing cycle detachments. Once in the thick underbrush units became separated and many times lost. Small groups and individuals would then be forced to surrender. Said the Chief of the Operations and Planning Staff for the 25th Japanese Army, Colonel Tsuyi: "Even the long-legged Englishman could not escape our troops on bicycles." (8:18)

The constant pressure exerted by the pursuing Japanese severely damaged the morale of British troops. The rapid tempo of the retreat exhausted frontline units. For the British Army the retreat turned into a nightmare. On the other hand the morale of the pursuing Japanese was high. As Private Yamashita of the 3/41st Infantry noted in his diary, "Without giving the pedals a rest we are advancing to Singapore." (4:169)

The bicycles issued to the infantry were single gear, relatively simple machines of Japanese manufacture. They were the same type of cheap bicycle that Japan had been exporting to Malaya for years. This fact has given rise to a number of false impressions. First is the belief that the Japanese planned to use native bicycles. In fact they merely commandeered them from the local inhabitants. With these confiscated bicycles they are supposed to have formed ad hoc bicycle units. The other rumor is purported by no less an authority than Winston Churchill. In his memoirs, he surmised that fifth column organizations supplied the Japanese with bicycles from hidden prewar

stocks. (2:535) Neither of these stories is correct. What may have given rise to these rumors is that the Japanese did find a ready supply of repair parts from native models. The two man bicycle repair squads assigned to each company routinely confiscated native bicycles for replacement parts.(8:17)

Even though they acquired their mounts only a month before, Japanese soldiers were expected to ride up to twenty hours a day.(8:18) Allied intelligence reports, based on first hand observations, indicate that they traveled at speeds of between eight to ten miles an hour.(14:15) Japanese sources state that soldiers were expected to carry loads on their bicycles of between sixty-six and eighty-two pounds.(8:18) Allied intelligence confirms these reports with an estimate of seventy-five to one hundred pounds per load.(14:17)

The Japanese did encounter two problems while using bicycles. One could be identified as a technical shortcoming, the other a training problem. The technical problem dealt with the familiar problem of tire punctures. Colonel Tsuyi estimates that company repair teams fixed an average of twenty punctures a day. He also notes that when conditions prevented immediate repair, the troops would take the tires off and ride on the rims. He believes that the noise this created at night led some British units to think that tanks were in the area.(8:17) Allied sources do not confirm Colonel Tsuyi's theory. They do point out,

however, that their reconnaissance patrols could not hear passing cycle troops further than 150 yards from the road when regular tires were used.(14:14)

The other problem the Japanese experienced could have been corrected with training and discipline. The success and high morale may have caused some units to become reckless. Intelligence reports from the period constantly refer to the apparent lax security of Japanese troops when riding their bicycles.(14:14) Even Japanese sources refer to the bad habit some units developed of tying their weapons directly to the bicycle. This apparent disregard for security caught up with the 3rd Battalion, 41st Infantry Regiment on the 14th of January, 1942. As two companies were approaching a small bridge riding in a column of six abreast, they were ambushed. A company from the Australian 2nd Battalion, 30th Infantry Regiment had mined the bridge. They waited until the majority of the column was crossing, then blew the bridge and opened fire. The cyclists were slaughtered, many being unable to get to their weapons. As one Japanese soldier recorded in his diary, "The enemy, realizing that we were unable to use our weapons, attacked with pistols, our lives now depended only on swords."(4:167)

Allied reports described groups of about seventy soldiers travelling two or three abreast with no apparent formation. The general observation of one British patrol of cycle units moving into action was; "Japanese cyclist

groups, although outwardly lighthearted, had a resolute expression that reminded one of a touring club out for an arduous competition tour."(14:14) Whatever their problems, from their first engagement to the British surrender seventy-three days later, Japanese cycle troops won every competition. The contribution the bicycle made to the Japanese success in Malaya is best summed up by the man who planned the campaign. Colonel Tsuyi in his book Singapore-The Japanese Version, boasted, "Thanks to Britain's dear money spent on the excellent paved roads, and to the cheap Japanese bicycles, the assault on Malaya was easy."(8:18)

The Japanese use of bicycles in the conquest of Malaya provides the best illustration of why U.S. light infantry battalions need bicycles. Japanese bicycle mounted infantry accompanied by tanks set a tempo for battle that the motorized British could not match. Through the use of bicycles they gained and maintained the initiative. Their rapid pursuit of British forces kept the their enemies off-balance in the best Airland battle tradition. The bicycle's mobility enabled the Japanese infantrymen to keep up with tanks. In this way the Japanese solved their problem of integrating light and heavy forces. Once again, the bicycle showed its capability to haul the soldier's load, traverse difficult terrain and cross obstacles. Its durability, ease of maintenance, and low cost were also demonstrated. The fact

that Japanese soldiers had only one month with their bicycles highlights the ease of operator training.

Current U.S. light infantry battalions do not have the mobility to keep up with tanks or conduct pursuit operations against mobile forces. By being foot mobile U.S. light infantry units are tied to moving at 4 kmph. At first glance Malaya would appear and actually is "light infantry country." Yet the Japanese, through the use of bicycles turned it into a fluid battle zone.

On the other side of the globe, cycle troops continued to maintain a place in the order of battle of most European armies. As Europe plunged into another world war cycle troops were again on the leading edge of the initial engagements. One of the first photographs of the war shows German troops ceremoniously removing a customs barrier on the Polish border. In the background of the photo is a German soldier on a bicycle.(16:31) German bicycle units followed in the van of the Panzer Divisions.(1:100) Their primary mission was to assist the following infantry divisions in mopping up bypassed Polish units. When Poland surrendered three weeks later, the bicycle units took their place in the victory review held before Hitler.(1:101)

The speed of the German advance through Poland negated the use of the cycle units in other than support roles. This experience was not the case in Norway. Here, the mountainous nature of the terrain prevented a rapid

advance by mechanized forces. The mission of rooting out Norwegian mountain troops holed up in narrow valleys and passes fell to cycle troops.(1:102) Unlike their motorized cousins, cycle troops did not have to worry about their transport causing congestion on narrow mountain roads. This time it was the Panzer units that were in a supporting role. The tanks were used to initially spearhead the advance. Bicycle mounted infantry followed close behind the tanks. Once the tanks ran into trouble the cycle troops would dismount and assault the position.(1:102) The tanks would provide fire support to the assaulting cyclists. Sometimes the cyclist would proceed the tanks. When the cycle troops became pinned down, they would call forward the tanks to provide supporting fires. Once they overcame the resistance, the cycle troops would remount and continue the pursuit. German cyclists pursued the harried Norwegian mountain troops up steep mountain roads covered with ice and snow.(1:103) Like the British experience two years later in Malaya, Norwegian mountain troops were never able to gain enough time to establish a solid defense.(10:1) Although they suffered heavy casualties, the use of bicycle troops enabled Hitler to end his Norwegian campaign in time to launch the Western Offensive in May.

The Germans, like the Japanese, found that bicycles enabled infantry, other than Panzergrenadiers to be used in conjunction with tanks. The enhanced mobility of German cycle units allowed them to be used in follow-on operations

behind the fast moving panzer columns. On the modern battlefield U.S. light infantry units may also be called upon to reduce bypassed pockets of enemy resistance behind mechanized forces. Presently they would be unable to perform this mission without being augmented with additional transportation assets.

During the rapid conquest of France, German cycle units were used much the same way as they had been in Poland. Their colleagues on the other side were not as fortunate. Allied cycle units performed much the same way as their parent armies. Wartime photographs depict hundreds of bicycles piled by the roadside apparently abandoned by fleeing cycle troops.(1:71) Why these troops threw away their one hope of escape can only be guessed. It may be attributed to the general state of panic found in both the French and Belgian Armies.

By the beginning of 1944 German resources in both manpower and material were nearly exhausted. Petroleum was especially in short supply. Hitler attempted to alleviate the manpower problem in the German Army by ordering the formation of twenty-five new divisions.(7:22) The new units were called Volks (people's) Grenadier Divisions. The new divisions were smaller than normal infantry divisions. Regular infantry divisions had a personnel strength of 17,000. Similar to a modern U.S. light infantry division, the Volks Grenadier Division's

personnel strength was 10,072.(15:C-2) Like a U.S. light division, the Germans made the personnel cuts in the combat service support area.

There was a certain militia quality about these new units. To get the personnel for the new divisions, Hitler stripped the other services and rear area service troops of all non-essential able-bodied men. Luftwaffe ground crews without planes and sailors without ships were sent to the Army. To offset their small numbers, Volks Grenadier divisions were equipped with more automatic weapons than normal. For protection against enemy tanks a large number of troops carried the Panzerfaust in addition to their assigned weapon.(7:22)

As part of the effort to reserve petroleum supplies, the divisions were assigned very few motor vehicles. Each division's full complement of motor transport came to 568 assorted vehicles. Of these 119 were motorcycles. The rest were divided among the units as shown in figure 8. Horse drawn vehicles provided the majority of logistical transportation in the divisions.(15:C-2) To give the combat units the required mobility to operate in a European environment, the Germans turned to the bicycle.

Each division received 1,522 bicycles. Seventy percent of the bicycles issued went to the infantry units in the division. A large portion of the Division's

engineer battalion were also mounted on bicycles.(15:C-14)
The rest of the bicycles were distributed throughout the division as shown in figure 8.

Figure 8

TRANSPORTATION ASSETS OF A VOLKS GRENADIER DIVISION

UNIT	# PERSONNEL	MOTOR VEHICLES*	HORSE CARTS	BICYCLES
Division HQ	227	53	0	5
Fusilier Co	200	1	19	166
Signal BN	305	54	12	4
Inf Regt +	1911	20	223	698
Inf Regt	1852	19	219	100
Inf Regt	1852	19	219	100
Art Regt	1744	112	285	49
Antitank Bn	460	150	0	0
Engineer Bn	442	26	35	297
eSupply Regt	1075	121	130	103
TOTAL	10072	577	1142	1522

* includes motorcycles and self-propelled AT guns

+ assigned the bicycle battalion

Bicycle pure infantry units were found at several levels throughout the divisions. Each of the three infantry regiments in a division were composed of two infantry battalions. One of these battalions in one regiment was entirely mounted on bicycles.(14:C-9) This

force, because of its mobility, was usually the division's counterattack force. Each of the other two regiments in a division contained an infantry bicycle platoon in the regimental headquarters company. The bicycle platoon generally constituted the regimental mobile reserve. A division had an additional bicycle reserve in the Fusilier company. This unit was under direct division control and represented the division commander's "ace in the hole." It differed from a normal infantry company by having a larger number of automatic weapons and a 75mm Howitzer section. Although not an infantry unit, it should be noted that 2/3rds of the divisional engineer battalion was mounted on bicycles.(14:C-14)

The combat performance of the Volksgrenadier Divisions varied depending on the individual unit, and the general fortunes of war. At this stage in the war fortune did not shine on the German Army in many places. One place it did shine briefly was the initial phase of the Ardennes Offensive. On 16 December 1944 the 18th and 62nd Volksgrenadier Divisions attacked the American 106th Division.(7:92) The 106th was surrounded and cut to pieces, suffering one of the worst defeats ever inflicted on a U.S. Division. At one point, early in the attack, the 106th's right flank regiment, the 424th, appeared to be holding its own. All morning they had beat off the attacks of the 62nd Volksgrenadier Division. Then the Division Commander committed his mobile reserve of bicycle troops.

They were able to break through the 424th and seize the key town of Winterspelt. From there the way was open for Panzer units to continue towards the vital road junctions at Saint-Vith.(7:93)

In an effort to maintain some degree of tactical flexibility the Germans turned to the bicycle. The bicycle mounted regiment constituted the mobile reserve allowing Volksgrenadier divisions some degree of flexibility. Present U.S. light infantry units, without augmentation, do not have this flexibility.

Axis forces were not the only ones to successfully use the bicycle during World War II. Early in the war, after the Dunkirk debacle, the British found a novel way to employ bicycles. In January of 1942 British Commandos were planning for a series of raids along the coast of occupied France. One of their targets was a powerful German radar station near Bruneval. The radar was sited on a plateau atop 300-foot cliffs that dropped off into the ocean. Expecting a possible attack from shore, the Germans had installed fortified positions facing the beach. Any force coming from that direction would face certain annihilation.(12:32)

The commandos decided to try a parachute landing inland and attack the installation from the rear. Once they gathered the technical intelligence and destroyed the radar they planned to be picked up by the Royal Navy on the beach.(12:34) The radar site had a guard force of about a

100 men. Two miles away a German infantry regiment was garrisoned. The close location of these forces ruled out a parachute drop on the site. The best drop zone was located eight miles away. The problem was make the night drop, then cover the eight miles to the target, destroy the radar, and be picked up before morning.(1:113) To make the drop without attracting attention, the commandos used deception. To rapidly cover the eight miles to the target, they used bicycles. For several nights preceding the raid, British bombers followed a route to a target inland that took them over the drop zone.(12:32) Shortly after midnight on 17 February 1942 ten planes followed this standard route. This time, however, instead of bombs, they carried a company of commandos. Along with the rest of his equipment each commando carried a folding bicycle.(1:113)

The drop proceeded a smoothly as a night parachute drop can. Despite the fact that two planes missed the drop zone, the commandos quickly assembled. Under a full moon the commandos hastily unfolded the bikes and erected the seats and handlebars. When all were ready, they set off for the site pedaling down the moonlit path.(1:113)

They noiselessly pedaled to within a hundred yards of their target. There they broke down into smaller groups, some pedaling off to fire support positions, others to set up security posts. When all was ready, the assault began. The commandos quickly overran the surprised Germans. In the process they not only gathered the

technical intelligence, but captured several radar technicians. The charges were set as the supporting troops held off the German relief force from the nearby garrison. As the radar blew up the commandos abandoned their bicycles and made their way to the beach.(1:121)

Once on the beach the commandos signaled the Navy to come in and pick them up. Naval shell fire held the pursuing Germans at bay until the last of the commandos came off the beach. Casualties had been fairly light, one man killed, five wounded, and seven missing.(12:35) In return they had destroyed the site, made off with the radar, and the technicians who knew how to use it. All this activity was accomplished in 2 1/2 hours through the use of bicycles.

The British used the bicycle to solve the problem of dropzone security vs tactical surprise. Modern U.S. light infantry units face the same dilemma in choosing landing zones for heliborne assaults. Equipping them with bicycles will allow them to land far enough from their target for security, yet close enough to limit the time spent travelling.

Resource constraints probably forced the AXIS to make more use of the bicycle than their foes. However, as we have seen, the British still found military uses for the bicycle. Even the resource rich and mechanically minded American Forces went overseas with 60,000 bicycles.(1:106)

With the Americans, however, it was a repeat of World War I. The majority of the bicycles were used for administrative purposes. In this light, it is interesting to note that G.I. infantrymen prized captured German bicycles as valuable booty. In fact, some American units, like the 84th Infantry Division, formed unauthorized, ad hoc bicycle units with captured machines.(1:109)

The U.S. Army's interest in the bicycle had not always been so lackadaisical. Prior to America's involvement in World War II, the Chief of Infantry in Washington queried the President of the Infantry Board at Fort Benning about the possible military uses for bicycles. In a letter dated 28 December 1940, the Chief of Infantry noted the recent success of German cycle troops in Norway. He went on to explain further that he was taking steps to procure several types of bicycles for testing.(10:1) He then suggested several ways in which he envisioned cycle troops being used. He closed the letter with a request that the Infantry Board along with the Infantry School make a preliminary study to determine the parameters of the test.

On January 31, 1941, the Infantry Board sent a reply. In their letter, the board members suggested that bicycles would be of value only to marching infantry columns, in patrolling areas subject to airborne attack, and to motorized troops once they left their vehicles. They went on to explain that bicycles had been successful

in Europe only because of an excellent road system, a lack of sufficient motor vehicles, and the general use of bicycles by the civilian population. The letter went on to list seven advantages and six disadvantages to bicycle use. In closing their letter they explained the real reason for their rejection of the bicycle. It appears that the commander of the designated test unit, the 4th Infantry Division, did not want to test bicycles. He was more anxious to test the new Bantam car, later known as the Jeep.(11:5) His personal prejudice appears to have ended the matter. It is ironic that less than four years later the 4th Infantry Division would be fighting in Europe.(17:196)

The bicycle had survived one of the most violent half-centuries in history. As a participant in both World Wars, it had seen action worldwide. Of the seven continents, the bicycle saw action on four. In a fifty year period, bicycles participated in military operations in North America, Europe, Africa, and Asia. Soldiers rode them across North American deserts, African savanna grasslands, Eastern European steppes, and Asian jungles. From Moss's expedition in the 110 degree heat of Nebraska to the 62nd Volks Grenadier's attack in the snow of Saint-Vith, bicycles successfully transported troops. They had been successfully used in conjunction with horse cavalry as well as its successor, the tank. Bicycles accompanied parachutists as they plummeted out of

airplanes during airborne assaults. In short, any place soldiers needed additional mobility the bicycle saw use. In fact, almost any time motor vehicles were not available, or their use undesirable, the bicycle has successfully served as a viable alternate means of transport.

Let, the U.S. Army has always looked upon bicycles with chagrin and skepticism. From the verbal abuse Moss's soldiers suffered outside of Billings, Montana, to the comments of the 4th Infantry Division's commander, Americans have constantly ignored the bicycle as a tool of war. Now, as we look for ways to improve the mobility of light infantry units we might once again look at this combat tested vehicle.

With the end of War II the question of whether or not U.S. Forces should use bicycles was academic. The world had entered the Atomic Age with some people questioning the need for an army. Military cycling was viewed by most modern armies as something relegated to the past along with horse cavalry. Yet, during the Atomic Age, the simple bicycle will enable a primitive army to defeat two modern world powers.

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CHAPTER 3

RECENT USE OF BICYCLE TROOPS: THE VIETNAM EXPERIENCE

World War II ended with the dropping of the atomic bomb on Japan. This act appeared to some to render most forms of land warfare obsolete. At a very minimum it appeared, and with some justification still appears, that the nation with the most advanced technology would win any future conflict. To most modern nations the bicycle did not have a place in the new age of high technology warfare. Besides, the defeated Axis nations had been the ones to make the most use of the bicycle. To the military professionals in victorious armies the bicycle seemed to represent an interesting piece of military trivia. Its use by Axis forces in World War II was seen as an act of desperation. To most people it would have seemed ridiculous to suggest that a backward nation using bicycles would defeat one modern army and fight another to a standstill. Yet, for a period of twenty-five years that is exactly what happened.

In October of 1967 there was laughter on the floor of the U.S. Senate. Senator William Fulbright of Arkansas

had just suggested what appeared to be a ludicrous idea on how to cut the Ho Chi Minh Trail. Fulbright's Senate Foreign Relations Committee had just finished hearing testimony from a New York Times correspondent that had recently returned from North Vietnam. Correspondent Harrison Salisbury had described how the North Vietnamese were using bicycles to transport supplies to their forces in the South. Salisbury had concluded his testimony with the comment, "I literally believe, that without their bicycles they would have to get out of the war."(1:146)

Upon hearing this, Fulbright's seemingly comical reply was, "Why don't we concentrate on bombing their bicycles instead of their bridges? Does the Pentagon know about this?"(1:146) If the Senators had studied the role of the lowly bicycle in the defeat of French Forces in Indochina thirteen years before, they might not have laughed.

The story of the bicycle in Vietnam begins with Ho Chi Minh's declaration of the establishment of the Democratic Republic of Vietnam on September 2, 1945.(4:169)

It soon became apparent to Ho Chi Minh that the French Government was not going to recognize an independent Vietnam.(4:172) The French were returning to Vietnam in strength. French units with modern American supplied tanks, planes, and artillery were being rapidly shipped into the country. Against this overwhelming force Ho's

supporters, the Vietminh, were forced back into the jungle. There, they reverted to guerrilla warfare.(4:176)

Ho's chief military aide, General Vo Nguyen Giap, knew that as long as the Vietminh remained in small guerrilla groups they could live off the countryside. Giap also knew that as these cadre groups grew into larger units he faced a logistical problem. The surrounding countryside would not be able to support these larger units. As the war progressed the problem would be compounded as he massed larger units for decisive large scale operations. The main problem was one of transportation. That is, how to transport the supplies needed to feed and equip division sized units? For his answer Giap turned to the bicycle.(1:128)

While trucks were scarce, limited in mobility, and attracted enemy aircraft, there were plenty of bicycles around. Like most Asians, the Vietnamese appreciated the cheap form of transportation offered by the bicycle. Because of their popularity, there were thousands of bicycles available. Ironically most had been made in France.(1:136)

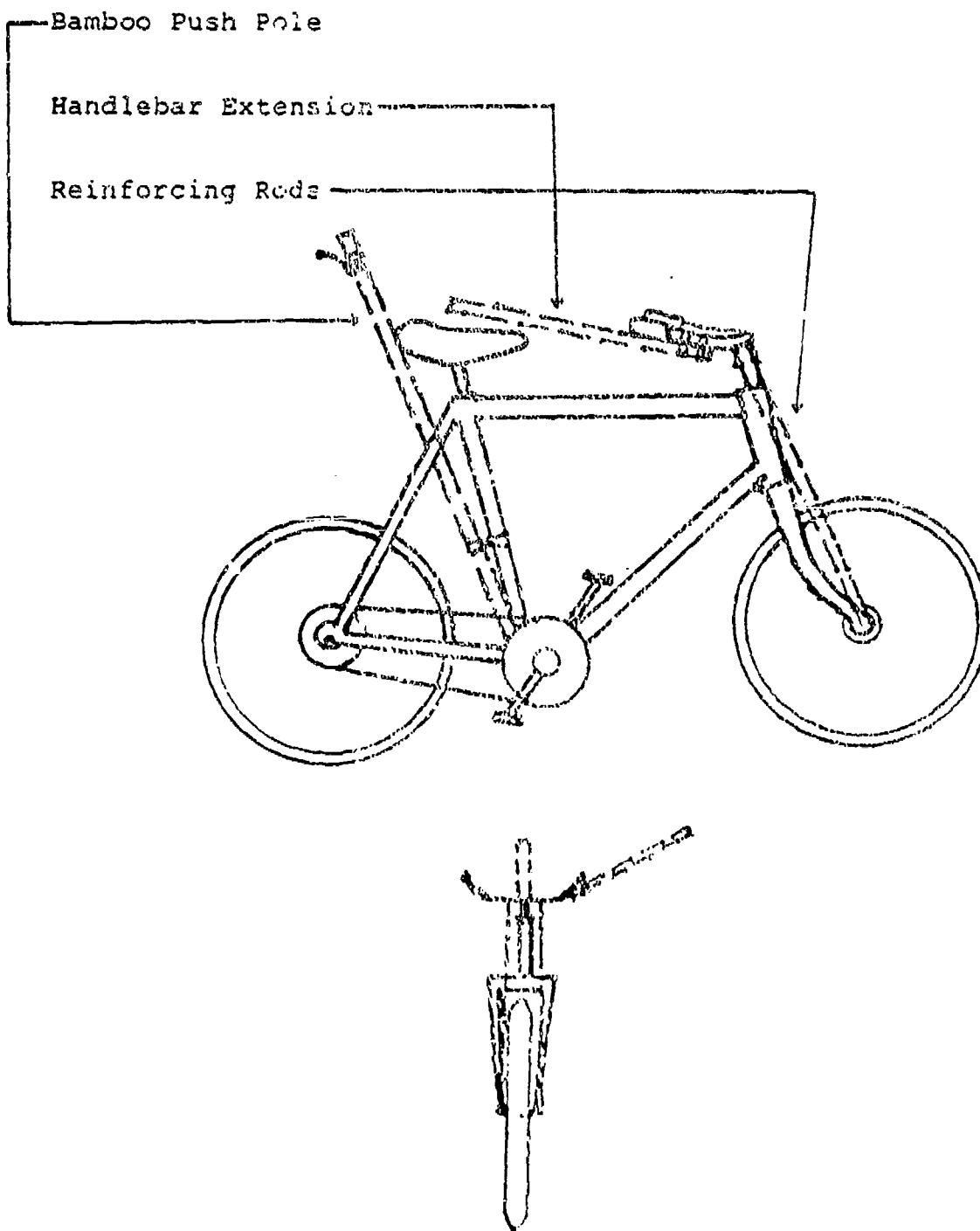
The Vietminh did not form combat cycle units in the same sense as the Japanese or Germans. Because Giap used the bicycle primarily as a logistical support vehicle, Vietminh cycle units were organized and used as supply porters. The bicycle itself was seen as a form of pack

mule. They were loaded down with as much weight as the bicycle could possibly support. The operator did not actually ride the loaded bicycle, but pushed it along.(1:128)

Modifications were made to the bicycles to enable them to carry the extra weight.(see Figure 9) To begin with, the bicycle most often used for porter work was the robust French Peugeot. This single gear, thirty to forty pound bicycle was then modified with two wooden poles and metal reinforcing rods. One or two reinforcing rods were bolted or welded to each side of the front yoke from the front axle to the handlebars. This modification strengthened the front part of the bicycle against the shock of heavy loads over rough terrain. The wood poles were used to aid the porter in both pushing and controlling the heavy machine. One pole, about four feet long, was tied along the length of the seat post. It was attached in a way that allowed a two foot section to protrude above and behind the seat. The lever for the rear brake was attached to the top part of the pole. This configuration aided the porter in both pushing and controlling the speed of the bicycle. The other pole was used to steer the bicycle. It was also about four feet long and was attached to the left handlebar. It served as an extension of the handlebar.(5:29)(1:photos,p9 115-117)

Figure 9

Vietminh Modified Bicycle



Loads were tied to the frame, the majority of the weight being placed on the center of the frame. Sometimes baskets were attached on both sides of the central frame to facilitate carrying loose objects. Bags of rice and crates of ammunition were tied to both sides of the horizontal bar in a way that facilitated balance.(1:photo pg 115)

A modified bicycle pushed by a coolie could transport up to 500 pounds.(5:29) This load is seven times the amount present U.S. Light Infantry doctrine states a soldier should carry on his back. It is even more remarkable when we consider that the average Vietnamese weighed around 100 pounds.(1:134) Taking into account the 45% body weight rule, a bicycle porter transported eleven times more weight than a walking coolie.

Bicycle porters usually travelled in ten man groups.(1:photo pg 116) When French aircraft were not active, the porters travelled on roads. The noiseless operation of the bicycle allowed the porters to hear the approach of enemy airplanes. When aircraft were heard the porters silently ducked into the underbrush. A camouflaged bicycle in the underbrush was difficult to spot from a moving aircraft. If French aircraft were too active during the day, the porters travelled at night. When roads were not available, or too dangerous to use, the porters travelled along the thousands of trails throughout Vietnam. Here, they were aided by the small width of the bicycle.

Small trails, wide enough for two people to pass, were able to support the bicycle convoys.(1:128)

In 1951 Giap started waging long term battles with the French using division size units. In January of that year he fought the French in a battle lasting five days and nights.(1:133) The French were surprised to find that the Vietminh were able to sustain the battle for that long. What they did not know was that Giap had used 180,000 transport workers (most of them bicycle porters) to bring in a thousand tons of supplies a day.(1:133) When the French did learn about the bicycle porters, they underestimated their capability. The Commander of French Forces in Indochina, General Henri-Eugene Navaire, estimated that a bicycle porter would be able to transport about two and a half times his own weight on a bicycle.(1:134) This faulty estimate meant that French staff officers used a planning factor of between 200-250 pounds per cycle coolie. They underestimated the bicycle porter's limitations by 50%.

Although the French underestimated its carrying capacity, they did realize the bicycle was key to the Vietminh supply system. As already noted, looking for the porters themselves was like searching for a needle in a haystack. Rarely were French pilots successful in locating cycle convoys. Instead, French aircraft routinely bombed the roads. While the bombing delayed some supply units,

the bicycle porters were able to bypass the bombed out roads using small trails. Once Vietminh road crews repaired the roads, the porters would again start using them at night. The French then began dropping time-delayed bombs to delay road repair. The problem was even when a road was cut the porters could use a nearby trail. It was impossible for the French to bomb all the numerous trails crisscrossing the countryside. Despite their technical advantage, the French were unsuccessful in stopping the primitive bicycle porters.(1:135)

In 1954 the bicycle porters faced their greatest test. Late in 1953, General Navarre decided to build and fortify an airstrip near the small village of Dien Bien Phu.(3:1296) The village was deep in Vietminh territory near the Laotian border 220 miles from Hanoi.(3:1296) Navarre wanted to goad the Vietminh into attacking the fortress. He felt that the Vietminh would not be able to mass enough forces to overrun the base. Instead they would be forced into making smaller attacks which could be destroyed by superior French firepower. He felt that even if Giap massed enough troops, the Vietminh would not be able to logistically support them for a siege. With this idea in mind, Navarre sent Brigadier General Christian de la Croix de Castries and 15,000 troops into Dien Bien Phu.(3:1296) Along with his mixed bag of Foreign Legionaries, French regulars, and indigenous troops,

Castries had twenty-five 105 mm and four 155mm howitzers.(3:1296) If surrounded, Castries reasoned that French aircraft could provide the necessary supplies as long as the airfield was secure.(1:133)

To oppose the French, Giap massed four divisions. Two divisions surrounded and lay siege to Dien Bien Phu. The other divisions sealed off the area from reinforcement. To reduce the base the Vietminh massed over 200 guns and rockets of various calibers.(3:1296) Ammunition, food and medical supplies were transported into the area by over 200,000 bicycle porters.(1:30) By 8 March 1954, the siege began in earnest. Every day for the next two months the bicycle porters brought in over seventy tons of food to feed the besieging forces. Two tons of medical supplies were brought in daily to treat Vietminh wounded.(1:134) French aircraft, hampered by bad weather, poor target identification, and antiaircraft fire sought in vain to disrupt the bicycle convoys. On March 27, the French lost control of the airfield.(3:1296) Their own supply line cut, it was now the French who experienced a shortage of ammunition, rations and medical supplies. On 7 May 1954, the final assault overran the starving defenders.(3:1296) Of Castries' 15,000 troops only seventy-three escaped.(3:1296) Some 10,000 surrendered to Giap's victorious forces.(3:1296) Vietminh losses were estimated to be 25,000 casualties.(3:1296)

Giap's ability to mass the required numbers of troops and artillery into the area was the key to the Vietminh success. The bicycle porters' ability to supply these forces is what enabled Giap to mass them.

The Vietminh used the bicycle in a unconventional way to fight an unconventional war. Instead of employing bicycles as transport for infantry, the Vietminh used them as logistical vehicles. The bicycle's unique construction, strong frame, and narrow width allowed its use on routes too narrow for handcarts or trucks. In the bicycle, the Vietminh found a logistical vehicle that could keep up with and support their units in "light infantry" terrain. The premise of this study concentrates on the bicycle as transport for the individual infantryman. However, the Vietminh use of bicycles in a logistical role could easily apply to present U.S. light infantry doctrine. For instance, there will be times when operational or terrain constraints will prohibit the movement of supplies by the HMMWVs of U.S. light infantry units. Weather, the threat, or availability may preclude the use of helicopters. Under these conditions the 1987 FM 7-71 suggests using some soldiers as porters. It cautions that soldiers used as porters are capable of loads of 150 lbs. only at the risk of injury.(7:7-8) A light infantry unit equipped with bicycles would have the capability of copying the method of transporting supplies used by the Vietminh. By doing so,

they reduce the possibility of injury to the porters while tripling the weight each can carry. Using bicycles reduces the overall number of porters required.

Dien Bien Phu spelled the end of French domination in Indochina. Six months after the battle on December 29, 1954, France signed treaties giving Vietnam, Cambodia, and Laos their independence.(3:1297, As the French withdrew, they left a divided Vietnam. The northern part of the country came under the domination of the Communist Vietminh led by Ho Chi Minh. The southern portion of the country became a pro-western republic supported by the United States.(3:1297)

From the very outset the Communist North attempted to unite the South by force. From 1956 to 1964 South Vietnam was in a constant state of insurgency.(3:1297) The insurgents were Communist Viet Cong supplied and trained by the North. The bicycle again came into use as a means of transporting supplies from North Vietnam to the Viet Cong in the South. Viet Cong forces also used bicycle mounted couriers and scouts. Sometimes the Viet Cong would use the bicycle as a means to rapidly gather for ambushes or raids. After the mission the guerrillas would use the bicycle to quickly disperse back to their hamlets.(1:142)

As the war continued, direct involvement of both U.S. and North Vietnamese forces increased. Despite technical aid from both Communist China and the Soviet

Union the North Vietnamese continued to rely on the bicycle to ferry supplies to the South. As during the war with France, convoys of bicycle porters made their way south. Their main route was along the numerous small paths that made up the Ho Chi Minh trail.(1:142)

Long before Fulbright's 1967 comment, the Pentagon was well aware of the bicycle's importance to the North Vietnamese supply system. In 1964 they had assigned Colonel B.F. Hardaway of the United States Advanced Research Projects Agency to find ways to interdict the bicycle convoys.(1:144) Hardaway, it appears, was no more successful than the French in finding a clear cut way to defeat the bicycle porters. You simply cannot bomb what you cannot see. The bicycle convoys that were destroyed were usually those caught in the general interdiction campaign waged against the Ho Chi Minh Trail.

While failing to find a solution to stop the bicycle porters, Hardaway's research did produce an interesting sideline. Hardaway reasoned that if the enemy could use the bicycle to improve operations, why couldn't the South Vietnamese as well?(1:144) As part of his research project, Hardaway began investigating possible uses for the bicycle by South Vietnamese Forces.(5:1) One place he felt they might be of benefit was in internal defense operations by South Vietnamese militia units.(6:1)

By 1964 the South Vietnamese had established a number of home defense units. These militia units were designed to provide villages and hamlets with a measure of self-defense against the Viet Cong. Platoon sized elements, called Popular Forces (PF), were usually assigned to specific villages. Regional Forces (RF) usually operated as companies and were assigned at the district level. U.S. advisor teams were provided at the district level.(6:1)

When the Viet Cong attacked a hamlet the local Popular Force platoon was supposed to defend the inhabitants until reinforcements arrived. Regional Force units usually served as the reinforcements, although sometimes nearby Popular Force platoons were used. Popular Forces also conducted local reconnaissance and ambush patrols.(6:1)

Both types of forces were lightly armed. Individual weapons consisted of M-1 carbines, M-1 rifles, pistols, and Browning automatic rifles. Crew served weapons found in the units consisted of 60mm mortars and .30 caliber machineguns. Communications were limited to hamlet radios. Transportation was either nonexistent, or occasionally civilian trucks or buses commandeered from local sources.(6:2)

The lack of transportation eroded the effectiveness of both RF and PF forces. The rural nature of the area

meant that PF forces were spread out among the numerous villages and hamlets. This dispersion allowed the Viet Cong to attack isolated hamlets defended by poorly trained PF platoons. Often by the time the RF arrived to assist the PF unit the hamlet had already been overrun. At other times the Viet Cong would attack a hamlet in order to draw the RF into an ambush. The Viet Cong knew they would have time to establish an ambush by the time the RF reached the hamlet. Even when RF and PF units acquired motor vehicles they were delayed by blown bridges or difficult terrain. In motor vehicles they were also much more subject to ambush.(6:4) What RF and PF units needed was a vehicle that would enable them to move rapidly to the endangered hamlets. The vehicle needed to be able to travel along small trails as well as cross streams and negotiate rice paddy dykes. This same vehicle had to be cheap, simple, and easy to maintain. In short, PF and RF forces needed bicycles.

As part of Hardaway's study, the Military Assistance Command, Vietnam (MACV), directed the Army Concept Team in Vietnam (ACTV), to evaluate the employment of bicycles by RF and PF units. In December 1964 and January 1965, 792 bicycles were issued through the Army of the Republic of Vietnam (ARVN), supply channels to selected RF and PF units. The bicycles were issued to two RF companies and fourteen PF and RF platoons.(6:4) The units receiving the

bicycles were spread throughout three of the four corps areas that divided South Vietnam.(2:14) The three corps receiving bicycles were I, II, and IV Corps as well as the Capital Military District.(6:2) Issuing the bicycles among the corps allowed the test to be conducted over a wide area with different types of terrain and tactical situations.

The French-made bicycles issued to the units were the type common to Vietnam. The only distinguishing characteristic marking them as government bicycles was olive green painted frames. Each bicycle was equipped with chrome fenders, a head and tail light, and a back fender rack. The machines were simple one gear systems with narrow tires. Oddly enough they came without tools or pumps.(6:2)

The units that received the bicycles used them in whatever way they desired. Some Popular Force commanders did not form bicycle units but used them as transportation for key personnel and couriers. Others used them for intelligence and reconnaissance (I&R) missions. Units in areas with well developed road and trail networks used them extensively. One RF company went so far as to rent motorcycle-drawn two-wheeled trailers to haul their 60mm mortars and .30 caliber machineguns. Another used bicycles for infiltration missions. The platoon, dressed in

civilian clothes, would split up taking different routes to a specific location. There they would set up an ambush, using weapons concealed underneath their disguises.(6:3)

The amount and way the bicycles were used by the unit seems to have been driven by terrain and the unit commander's aggressiveness. Units in the inundated regions of the delta used them less than units along the dryer coastal plain. PF and RF units that conducted aggressive patrolling used them more than less active units. Twice during the six month evaluation period RF companies used them to respond to Viet Cong attacks on hamlets. Although in neither case contact was made with the enemy, both threatened hamlets survived the attack without being overrun. In one of the two reaction missions, the reaction force had to ford a chest deep stream as a result of a destroyed bridge. Like the Japanese, and Moss before them, the RF platoon forded the stream holding their bicycles above their heads. Despite this delay, the unit reached the threatened hamlet twelve kilometers away in half the time it would have taken on foot. Most units reported that they could maintain a rate of march of six to ten kilometers per hour. Units that used their bicycles for patrols reported that they could cover a much greater area with less people because of the improved mobility.(6:3)

Units that used the bicycles for unit transport reported carrying their weapons slung across either their chest or backs. The soldiers carried whatever they needed to fight with on their person instead of strapped to the bicycle. Unit commanders stated that they did not want to strap large amounts of equipment on the luggage carriers. Most felt that the extra equipment would make too much noise in the underbrush. Except for the RF company that rented the motorcycle-drawn trailers, no unit reported carrying their crew-served weapons on the bicycles. Other than slight changes in operational techniques the bicycles did not change the unit's organization.(6:3)

At no time during the six month evaluation was a cycle mounted force ambushed. Some unit commanders felt that cycle units were more apt to be taken by surprise when mounted. Others felt that the speed and the apparent natural dispersion of cycle mounted troops made them less vulnerable than formations on foot. All the unit commanders and their advisors agreed that cycle troops were much less vulnerable to ambush and mines than vehicle mounted soldiers.(6:4)

At the end of the six month evaluation period the U.S. advisors and Vietnamese commanders of five units were requested to fill out a questionnaire. The first question on the form was; "In your opinion has the bicycle measurably increased the mobility of this unit? In what

way?" The responses of both the advisors and commanders of all five units was yes.(6:Incl 1) The reasons they gave are listed verbatim from the report:

1."The company can move faster as a unit and it has led to carrying the light machinegun and 60mm mortar on motorcycle trailers."(6:Incl 1)

2."Bicycles have given the unit continuous mobility and the ability to react faster to a given situation."(6:Incl 1)

3."Bicycles were used by intelligence agents and PF hamlet officials to travel between hamlets and district headquarters, and to PF locations."(6:Incl 1)

4."Made liaison fast and in safe condition. Unit moved fast; however, they can't be used in searching and attacking enemy."(6:Incl 1)

5."Enables PF platoons to made better use of a good network of trails and small roads. Increases speed of movement and permits unit to operate clandestinely."(6:Incl 1)

In the final letter report from the Army Concept Team In Vietnam (ACTIV) dated 11 August 1965, the chief of the evaluation, Colonel Hugh E. Quigley made the following recommendation: "Additional bicycles be procured to equip select PF platoons and RF companies having missions requiring improved mobility means in the coastal plain and delta areas."(6:6) This recommendation was endorsed by ACTIV's parent organization, the Joint Research and Test Activity.(6:1st Ind) Unfortunately Colonel Quigley's recommendation was not accepted, or at least not acted upon.(1:144) Perhaps it was thought that with the introduction of American combat troops the role of PF and

RF units would diminish. The massive and sometimes wasteful influx of American military assistance may have eliminated the simple bicycle in favor of more exotic forms of transport. After all, Americans are not the only ones susceptible to the belief that, "the more technical the better." For whatever reason the idea of widespread usage of the bicycle by the South Vietnamese died shortly after the report was submitted. Hardaway made the mistake of suggesting that American troops might find some use for the bicycle. He was told by his superiors to stick to the problem at hand; that is, how to eliminate the North Vietnamese bicycle porters.(1:144)

Interestingly enough, about the same time General Giap was embroiled in a dispute with the North Vietnamese Army Chief of Staff, General Van Tien Dung, over a very similar issue. General Dung wanted to fight a more conventional war with the modern weapons coming in from the Soviet Union and Communist China. Dung wanted to do away with archaic ideas like the bicycle porters. Giap stuck by the bicycle porters and his unconventional methods for waging war. In the end, Giap won both the argument, and the war. When the victorious North Vietnamese marched into Saigon the bicycle porters were with them.(1:143)

It is unfortunate that the ACTIV bicycle experiment fell victim to the technology argument that Giap was able to defeat. Although relatively short-lived, the experiment

nevertheless successfully demonstrated the bicycle's utility in security operations. Bicycles gave the poorly trained and equipped PF and RF security forces a mobility that present U.S. light infantry forces do not have. U.S. light infantry units assigned security missions involving a dispersion of forces have to rely on augmented transportation or move on foot. Without additional transportation, present light infantry forces are limited to movement at 4 kmph. RF and PF forces equipped with bicycles routinely moved at speeds from 6 to 10 kmph.

The ACTIV experiment indicates that the use of bicycles does not significantly alter the organization or operational techniques of a unit. This factor enables the rapid introduction of bicycles to present U.S. light infantry units as their need becomes apparent. If after initial lodgement U.S. light infantry forces find the situation requires greater mobility, bicycles can be brought in without significant changes in operations. The strategic mobility, training, and general nature of U.S. light infantry forces insures their place in the forefront of low intensity conflicts. In these conflicts the enemy relies heavily on maintaining a mobility advantage over conventional forces. The bicycle gave British forces the mobility to hunt down elusive Boers in 1901. In future low

intensity conflicts the bicycle would aid U.S. light infantry forces in maintaining a greater degree of mobility than they presently possess.

With a shrinking foreign aid budget the State Department needs to look at the bicycle once again. Many third world countries we support could find much better use for it than the motor vehicles we send them. In 1982 the author was on a mobile training team to the Democratic Republic of Somalia. While there he witnessed the off-loading of fifty new U.S. 5-ton trucks bound for the Somali Army. After viewing the tons of Soviet equipment sitting idle due to maintenance problems one had to wonder at the future of the new U.S. equipment. The Somalis might have been better off with bicycles.

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CHAPTER 4

CURRENT USE OF BICYCLE TROOPS: THE SWISS REGIMENTS

Despite the bicycle's excellent war record, few modern armies employ bicycle troops. The one exception is the Swiss Army. For over a century the Swiss have maintained a steadfast loyalty to the use of bicycle troops. The Swiss believe that cycle troops play a critical part in the overall defense of their country. Sceptics and critics are quick to point out that Switzerland has not fought a war this century. Yet, this circumstance alone points to the effectiveness of their armed forces. In fact, this 100 year period has witnessed a continual growth in the number of Swiss bicycle units. For example, in 1949, as other armies were disbanding their cycle units, the Swiss increased the number in their army. That year they added three battalions of cyclists to the Army. The additional battalions enabled them to form three bicycle regiments.(1:52)

The Swiss have over one hundred years of military cycling experience. Using this experience, the Swiss have successfully integrated the bicycle onto the modern

battlefield. By examining their organization, tactics, and training we gain insights into ways that the bicycles will enhance U.S. light infantry operations.

The three regiments formed in 1949 are still active today. Each Regiment is assigned to one of the three corps that make up the Swiss Army. Unlike much of the Army, which is made up of conscripts, the men belonging to cycle regiments are all volunteers. In a way similar to our Ranger Battalions, cycle regiments are looked upon as elite units by the rest of the Army. Oddly enough, their branch color is not the green of standard Swiss infantry. It is the branch color for mechanized units, yellow.(1:52)

In their organization, the cycle units bear a marked similarity to our light infantry brigades. The basic units are triangular in nature. As with any infantry organization the lowest unit is the squad. Each rifle squad consists of eight privates commanded by a corporal. All are armed with assault rifles. The platoon consists of three rifle squads and a headquarters section. The headquarters section contains a lieutenant who is the platoon leader, a platoon sergeant, the platoon radio operator and a sniper. All the members of the platoon are mounted on bicycles. The cycle companies are made up of three cycle platoons, a machinegun platoon, and a headquarters platoon. The machine gun platoon is also mounted on bicycles. It contains four machineguns, each with a five-man crew. At company level you find the first

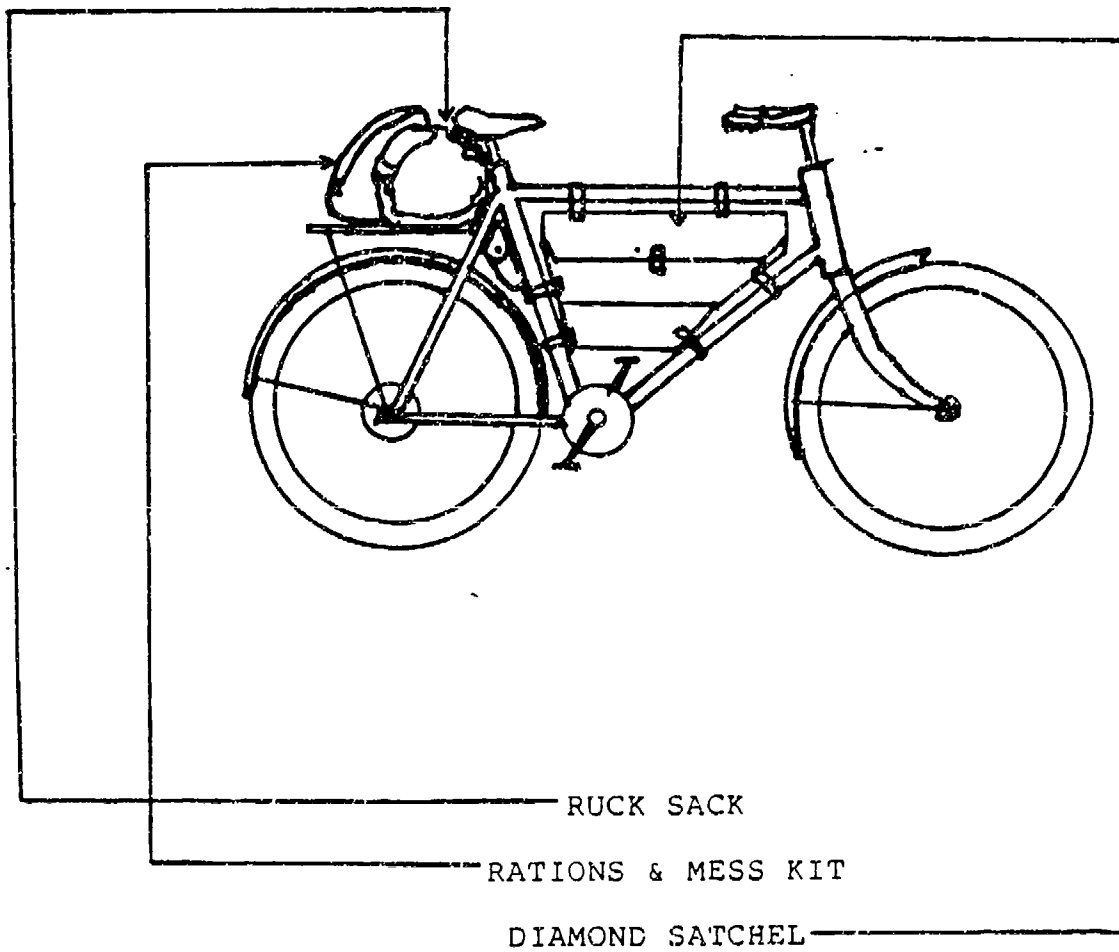
motor vehicles. Each company has five small all-terrain vehicles, similar to the old U.S. motorized mule. One of these vehicles is assigned to each rifle platoon to carry reserve ammunition and night sights. The machinegun platoon has two of these motor vehicles assigned. The company commander operates his mobile command post from a jeep. The rest of the headquarters platoon, consisting mainly of the mess team, rides in a truck.(2)

The battalion structure consist of three cycle companies, a antitank company, mortar company, and headquarters company. All of the specialty companies at battalion level are motorized. The antitank company uses the U.S. medium antitank weapon known as the Dragon. The 8.1 cm mortar is used in the mortar company. Like the battalion, all the specialty units at the regimental level are motorized. Each regiment is made up of three cycle battalions. Additional asset consist of a heavy antitank company using the U.S. TOW, a medical company, and the regimental headquarters company.(2)

As with U.S. light infantry units, Swiss cycle units contain relatively few motor vehicles. Like U.S. light infantrymen, Swiss cycle troops are expected to carry the majority of their sustenance with them. In this area Swiss cycle troops hold a distinct advantage over their American colleagues. Whereas the American light infantryman is expected to carry a doctrinal weight of 72 lbs., his Swiss counterpart normally carries 110 lbs.(1:52) The Swiss

soldier not only carries more weight, but does so with less expenditure of energy. He carries it on the bicycle. The cycle soldier's load is distributed on the bicycle in several areas.(Figure 10) On the carrying rack behind the seat the soldier straps on his ruck sack. The ruck sack contains his chemical protection overgarments, sleeping bag, and heavy jacket. Strapped onto the ruck sack, riding slightly to the rear is a smaller green plastic pack. It contains the soldier's rations, mess kit, and a small stove. Attached to the diamond of the frame is a plastic satchel about the size of a large brief case. In it the soldier carries extra ammunition, rations, and spare clothing. On his person the soldier wears those items needed immediately upon dismounting. Attached to his combat harness are ammunition pouches, canteen, and entrenching tool, or for some soldiers a hatchet. He wears his protective mask in a pouch slung over his left shoulder. When mounted, his rifle is slung across his back. The machinegun squads carry their equipment in a slightly different configuration. Their bicycles are fitted with special racks on the back for the machinegun, tripod and ammunition. Their ruck sacks are carried on the front attached to the handlebars.(2)

Figure 10



To maintain his bicycle each soldier carries a repair kit in a small pouch attached underneath the seat. It contains wrenches, a tube patch kit, and a small can of oil. Each bicycle also comes with a tire pump that is carried attached to the frame. For repairs beyond the capacity of the soldier there is a maintenance team at company level. Two cycle mechanics are assigned to each company. They carry a special tool kit that enables them to completely disassemble a bicycle. They also carry a complete stock of replacement parts. They are generally able to repair or replace any item on the bicycle. The tool kit and repair parts are carried on one of the company's small all-terrain vehicles.(2)

The training of a Swiss military cyclist begins in his nine week recruit school. There he learns the basic skills required of any infantryman. The second week of training he starts on a series of cycle marches. His first march is only twenty kilometers long. Each succeeding march covers a greater distance. By the ninth week he ends his training with a 200 kilometer march.(1:53) Cycle marches during unit training are conducted much the same way as road marches are practiced in American light infantry units. Various march distances are practiced during the training cycle with a 200 kilometer march being conducted monthly. Other types of bicycle specific training consist of cycle immediate action drills. Most of these drills generally orient on the rapid dismounting and

placing of weapons into operation. The training emphasis the majority of time is on infantry skills, not the bicycle.(2)

In the Swiss view, the cycle battalions will conduct combat the same way as a normal infantry battalion. The difference is in their speed of deployment. In broad tactical concepts, the Swiss feel that cycle units bridge the gap between motorized and light infantry units. For distances under 50 Km, they feel that cycle troops are as mobile as motorized infantry. Yet, they maintain some of the same cross-country capability of light infantry. Like light infantry, they are better suited than motorized forces for deployment in built-up and wooded areas.(2)

The rate of march for Swiss bicycle units will vary according to the situation. The rates, in concept, are similar to those used for types of marches found in U.S. light infantry manuals. Like light infantry, cycle units conduct speed, forced, and normal marches. A cycle unit's normal rate of march is between 12-15 kilometers an hour. The three kilometer variance shown is due to terrain. If the area of operations is mountainous this rate will be on the lower end of the variance. If a forced march is required, the unit will still use the normal march rate, but will extend the time of march. Using this formula, Swiss cycle units are expected to cover up to 200 kilometers in a 24 hour period. Speed marches are limited to a distance of twenty-five kilometers. This limitation

is due to the inability of a soldier to maintain the required 25-30 Kmph speed march rate for more than a hour. As with U.S. doctrine, speed marches are judiciously conducted due to the soldier's exhaustion upon entering into combat.(2)

The Swiss feel that this additional mobility earmarks cycle units as particularly suited for certain missions. One of these missions is the establishment of what the Swiss call a "Quick Barrage." In U.S. terminology this mission is similar to the hasty defense. The Swiss envision the Quick Barrage being used to close off a mobility corridor (avenue of approach) during a meeting engagement. In this scenario, a cycle unit, the size depending on the corridor, will rush forward to seize key terrain. Upon securing this terrain the cyclist will establish a hasty defense. In Switzerland, key terrain generally means a village or wooded hillside controlling the entrance to a valley or pass. In the attack, the Swiss will employ cycle troops to erect a quick barrage to secure an open flank.(2)

Because of their mobility, cycle troops are often placed in reserve. As in the later stages World War I, cycle troops can then be rushed forward to block enemy penetrations. Sometimes cycle units are placed in reserve to guard the rear area from airborne, or heliborne attack. Again, because of their mobility, the Swiss feel that they are especially suited for this type of mission. Their

ability to quickly move and mass from dispersed assembly areas allows them to meet the threat with appropriate forces.(2)

The type of combat drills practiced reflect the type of missions cycle units will be assigned. They practice four basic types of unit drill. First is movement into and out of assembly areas. Second is the establishment of the quick barrage. This practice is followed by extensive training in military operations in urban terrain (MOUT). The final area of emphasis is on combat drills in support of rear area security operations.(2)

Bicycle units normally fight as company teams. They are not piece-mealed out to other units. Battalions may on occasion be cross-attached to another type of unit. However, because of mobility differences the Swiss do not normally cross-attach. When deployed in a deliberate defense, cycle units are treated as regular infantry.(2)

When on the move, cycle units will use a formation geared to the tactical situation. If enemy contact is not expected they may move as a battalion. If the situation is not clear they will move in platoon formations with a security element (advance guard) in the lead. They also mix their formations at the company team and battalion level depending on the expected threat. If an armor threat is expected the Dragon and TOW teams will be well forward in the formation. The motorized elements of the company and battalion will follow in a leap-frog fashion. However,

the Swiss emphasize that for security, a cycle mounted unit always leads the formation.(2) Movement at night is conducted in platoon formations. The lead bicycle will have its head and tail light on. The rest of the unit will follow without lights relying on luminous tape markings worn by each cyclist to maintain formation. The formations themselves, are usually loose columns in single or double file.(3)

The bicycle in present use by the Swiss is simple and robust. It's design and technology level is a throwback to World War II. For simplicity and maintenance ease the cycles are single gear. There is a total absence of modern innovations generally found on modern trail and touring bicycles. Instead of using the knobby balloon tires found on modern trail bicycles, the Swiss still use narrow gauge tires. Swiss military bicycle frames are made of tubular steel rather than the lightweight alloy materials found in most modern bicycles. As a result, the military bicycle alone weighs 61.6 lbs.(2)

In 1988 the Swiss announced that they were going to modernize their bicycle fleet. Reluctance to do so up to this point can be attributed to a number of factors. As with most military budgets, the Swiss simply did not wish to spend the money required to purchase new equipment. They were generally satisfied with the present bicycle's performance. However, much of their present fleet is over forty years old. They have decided to start replacing them

with a slightly more modern bicycle. The replacement process was supposed to start in 1989. Unfortunately, in a tale all too familiar, it was discovered that the new Minister of Defense owns one of the Swiss bicycle companies. At the time of this writing the possible conflict of interest question is still being debated. Although the specific model is still under test, some of the specifications are known. The new cycle is to be robust and of the same general design as the present bicycle. A new type of tire is under study. Unconfirmed reports indicate they are testing the knobby balloon tires used on trail bikes. In a departure from their previous philosophy of a single gear, the new bicycle will have two gear settings.(3)

Regardless of which model they eventually choose, the Swiss will remain dedicated to use of bicycle troops for some time to come. The Commander of the Swiss Recruit School for Light and Mechanized Forces, Colonel Christian Schlapbach, summarized the Swiss Army's position with the following statement: "As long as we think it is intelligent to have infantry troops on the battlefield, cycle troops are justified."(2) Colonel Schlapbach, who has commanded bicycle units at both the company and battalion level, explained; "Their advantage over normal infantry is first in their high mobility. Secondly, they don't demand much logistically, they are very simple. Third, they are very fast."(3)

A Swiss officer attending the U.S. Army Command and General Staff College noted that Swiss bicycle units are known for their esprit de corps. Lieutenant Colonel George Erlach delivered this explanation: "The high physical performance required by cycle troops insures good unit cohesion. Because of this, plus their uniqueness, cycle troops in the Swiss Army are noted for their high morale."(3)

Unique or not, the Bicycle Regiments play a critical part in the overall defense strategy of Switzerland. Unlike much of the Swiss Army, bicycle units are not reserve units, but Federal, active duty units. This front line status demonstrates the faith the Swiss Defense Ministry has in their ability. Their elite status is further demonstrated by the high proportion of brigade and division commanders that have come from these troops.(1:53)

Throughout its first century of existence the bicycle has been employed for military purposes. Granted, with the exception of the Swiss, the use has been somewhat sporadic. The utilization of bicycle units by European armies reached a zenith during World War I. The bicycle's conduct during this war did not invalidate its use as a viable method of military transport. In fact, the opposite occurred: bicycle units generally offered an excellent account of themselves.

However, another form of transportation also started making its appearance about the same time as the bicycle.

The internal combustion engine's performance was even more remarkable than that of the bicycle. Petroleum engine vehicles subverted much of the interest in military cycling. Its unlimited uses made the bicycle seem unnecessary. Yet, when motor transport was unavailable due to logistical, manufacturing, or operational constraints, nations suffering these limitations always turned to the bicycle. Sometimes, as was the case with the Japanese in Malaya and the Swiss today, it was a conscious decision. However, limited logistical and manufacturing capability forced both the Germans in 1944, and later the North Vietnamese, to use bicycles. In both circumstances the bicycle supplied its users with a cheap and efficient form of military transport.

The bicycle has maintained a record of success under a wide variety of conditions. Military cyclists have traversed difficult terrain from the jungles of Malaya to the mountains of Norway. They have successfully performed their missions under a variety of weather conditions. From the Russian winter to the monsoon season in Vietnam, soldiers have used the bicycle. At times nations have bested technologically superior foes with the help of this simple machine.

These accomplishments are even more remarkable when you consider most of these forces used bicycles that were little changed from the 1888 Rover. Military bicycles have always been and, as we have seen with the Swiss, continue

to be, simple machines. They have generally been single geared bicycles with heavy frames and narrow, easily punctured, tires. The types of bicycles used by the various military forces have never seemed to be on the leading edge of bicycle technology.

In the 1970s, concern with the environment, and the rising price of oil brought a renewed interest in bicycles among the developed nations.(4:91) This interest was further enhanced by the increased concern about physical fitness in the 1980s. As a result, bicycle technology has made quantum leaps in the past two decades. Some of this technology may have applications in military cycling.

The past, recent, and present successful use of bicycles in military operations clearly demonstrates their utility. The advances in bicycle technology of the 1970s and 1980s may further increase the capabilities of cycleborne soldiers. If so, future military cyclists may reestablish the place their predecessors once held in various armies around the world. The U.S. Army might once again pioneer this effort by utilizing them in light infantry battalions.

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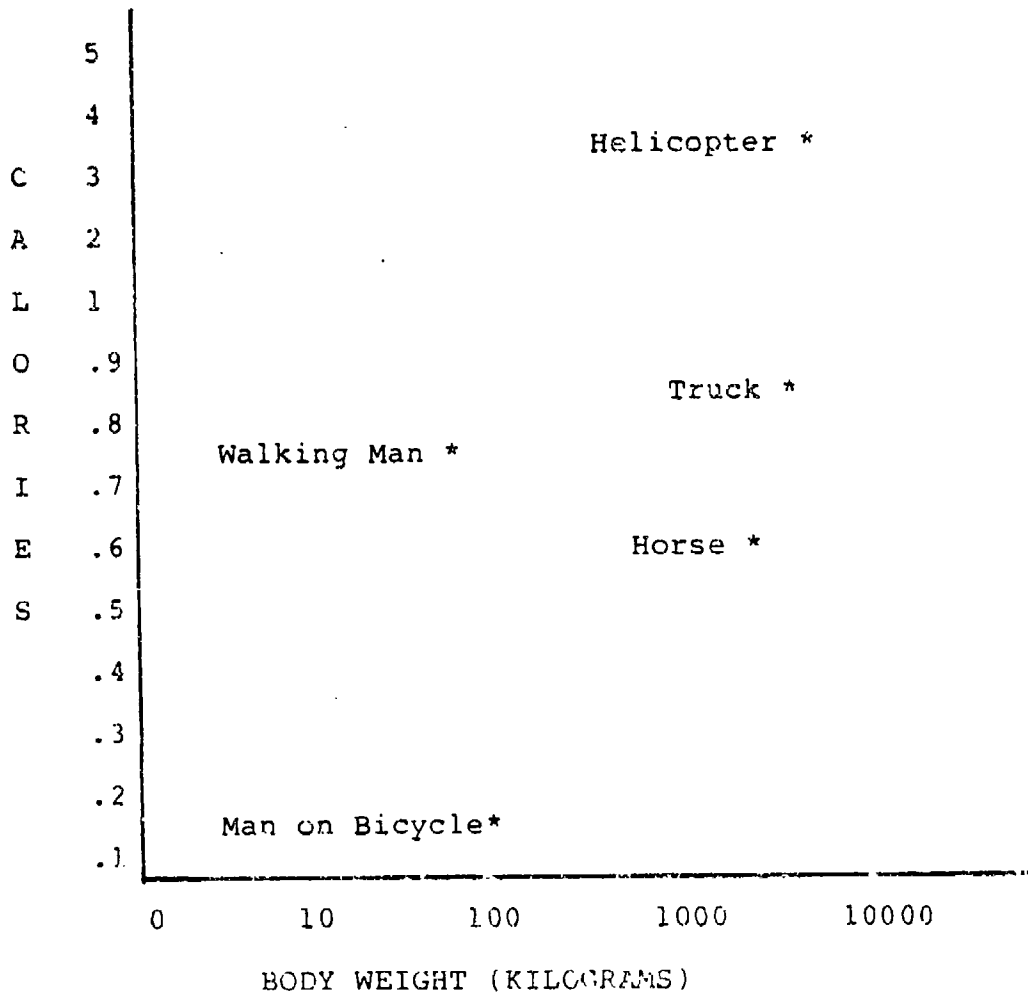
CHAPTER 5

CURRENT BICYCLE TECHNOLOGY

In a 1973 article for Scientific American, S.S. Wilson wrote: "Man on a bicycle ranks first in efficiency among traveling animals and machines in terms of energy consumed in moving a certain distance as a function of body weight." (8:90) Using data compiled by Vance A. Tucker of Duke University, Wilson compared the amount of energy expended by a man on a bicycle with other forms of transportation. The data revealed that a man walking one kilometer will expend .75 calories per gram of his body weight, while the same man riding a bicycle will only use .15 calories to cover the same distance. (8:90) In more practical terms, this data means that a 160 lb. man will burn 54.5 calories walking one kilometer. The same man riding a 40 lb. bicycle will expend only 6.8 calories travelling the same distance. The data does not take into consideration that the man on the bicycle will travel the one kilometer three to four times faster than his walking counterpart.

Figure 11

Source: Scientific American March 1973



Using Wilson's data we can compare the energy expenditure of a bicycle to a horse, truck, and helicopter. A 1,500 lb. horse will use approximately 40.8 calories to traverse one kilometer, compared to the 6.8 calories used by the cyclist.(8:90) The ratios are even greater when we compare fossil fueled vehicles. For instance, a one ton

truck will burn 72.5 calories of fuel per kilometer, over ten times the caloric expenditure of the cyclist. The most inefficient expenditure of energy per body weight goes to the helicopter. For every kilometer a 2,000 pound helicopter flies, it expends 344.7 calories.(8:90) This rate is fifty times the amount of energy the cyclist requires!

A number of factors cause the bicycle's efficient use of energy. First, it is engineered to use the strongest muscles in the human body, namely those of the thighs. Because the cyclist is sitting, the frame relieves the leg muscles of supporting the body's upright position. Unlike walking where the feet meet the resistance and friction of the ground, the cyclist smoothly transmits energy through the rotary action of the legs.(8:83) This energy in turn is transmitted and increased through a system of mechanical advantages. The cranks (levers), sprockets (pulleys), and wheels that make up a bicycle all transmit this energy into forward motion. Rolling resistance is reduced due to the small area of the bicycle tire that actually comes into contact with the ground.(8:84) Weight is reduced by the nature of the bicycle's design and the materials from which it is made.

For the last 100 years virtually all bicycles have possessed these advantages. To improve the performance of a bicycle you have to alter or improve one of the

mechanical advantages, or reduce the weight of the bicycle. Over the years bicycle designers have constantly tried to improve the performance of their machines. Many of these improvements concentrated on improving the mechanical advantage through the use of different gear ratios. Other designers concentrated on reducing the weight through the use of new materials or different frame designs. Improvements were made in both areas. Unfortunately most of these improvements escaped the notice of military cyclist. The military cycles used during the various wars of the 20th Century were technological dinosaurs. In fact, the bicycle currently in use by Swiss cycle regiments is based on a 1905 design.(9:24) Yet, these archaic designs were still able to give their riders a mobility advantage over foot soldiers.

One reason for the military's reluctance to accept some of the new innovations was the nature of the improvement. Most developments had to do with increasing the speed of the bicycle. In an effort to reduce weight for racing, bicycle designers produced lightweight frames with thin tires. In fact, bicycles designed for use on indoor cycle racing tracks, velodromes, weighed only 16 lbs.(1:24) They also had very thin tires, fragile frames, no brakes, and only a single fixed gear.(1:24) Bicycle makers also produced bicycles for long range road races like the "Tour de France." Again, because speed was the

objective, these bicycles used thin tires with lightweight frames and finely tuned gear systems. While excellent for road racing, these bicycles would not stand up to the abuse required of military bicycles. The frames would not stand up to the load of a soldier's equipment, or the thin tires to the rough roads and trails bicycle troops were required at times to use.

With the explosion of bicycle technology in the past two decades much of this has changed. Improvements in metallurgy, gearing systems, frame and wheel design, all have possible military implications. In fact, one entirely new class of bicycle has emerged that may represent the epitome of a military bicycle.

Recent improvements in bicycles are found throughout the separate components. The major parts of any bicycle are the frame, wheels, and transmission. Of the three, most bicycle experts consider the frame first in importance.(1:31) The frame translates pedal effort into forward motion, guides the direction of the wheels, and absorbs the road shock.(1:32) In the past most bicycles, including ones for military use, were made from mild tubular steel. This material was relatively strong, but heavy. Most of the joints were welded, then if a quality machine, lugged. Lugs were used to hold the tubes together during welding. The tubes used in the construction were plain gauged; in other words the same thickness throughout the tube. In recent years a number of improvements have

been made in both the construction and types of materials used in frames. Improved welding techniques have eliminated the requirement for the extra weight of lugs. In quality bicycles, stronger and lighter alloy steels are used. The tubes themselves tend to be butted; that is, the tubes are thicker on the ends where the welding takes place. This design produces a tube that is stronger at the point of greatest stress, yet lighter than a plain gauge tube. Using butted tubes in turn produces a lighter overall frame. Techniques in welding aluminum have also recently improved. Aluminum produces a frame that is not only lighter than steel, but also absorbs road shock better. The problem with aluminum is that it is hard to repair. If it bends, it cannot be straightened back out.(1:35) For military use this problem could be a limiting factor. Aluminum frames also tend to wear out faster than ones made of alloy steel. The past decade has witnessed the introduction frames made of carbon fiber and Kevlar. They represent the height of technology in terms of weight and strength. Unfortunately they also represent the height in price. The cost of some go into the thousands of dollars.(1:36) For this reason alone their military use is limited. Of the three types of materials discussed, frames made of high quality alloy steel appear best suited to meet the requirements of military cycling. They are strong, yet light enough for military cycling. Remember, these are not racing machines. Military bicycles

will be loaded down with the soldiers equipment. Of the three types listed, metal alloy frames are the easiest to repair. Unlike carbon fiber frames, their cost is not prohibitive.

The transmission of a bicycle converts the energy of the revolving pedals into the power that turns the rear wheel. The transmission is the heart of the bicycle's mechanical advantage. Gear ratios determine both the speed (cadence) and power a cyclist will use to propel the machine forward.(1:50) In a low gear ratio the cyclist must rotate the pedals more times for each turn of the rear wheel. It allows the cyclist to apply more power for each turn of the wheel. Low gears are good for climbing hills, however; on level ground it becomes difficult for the cyclist to rotate the pedals fast enough to increase the revolutions of the rear wheel, hence speed of the bicycle. A high gear ratio has the opposite effect. It requires fewer turns of the pedals to turn the rear wheel. High gears work well on level ground where the cyclist applies a constant level of power to the pedals. The high gear ratio enables the cyclist to maintain a high rate of speed as long as there is not much resistance to his forward momentum. On the other hand, when resistance is encountered in the forms of gradient, surface condition, or even wind, it becomes very difficult for the cyclist to turn the pedals.(1:50)

solution was to find a way to change gears on the move as the rider came up against different types of conditions and terrain. In 1900, two Englishmen, Sturmey and Archer, invented a three speed internal gear system, known as the Sturmey-Archer Hub Gear. It established the pattern for hub gears. In fact, most hub gears regardless of manufacture are commonly known as Sturmey-Archers. As the name implies, the gears are contained in an enclosed hub encasing the rear axle. The gearing consists of one large gear ring and several small pinion gears. The large annular gear ring fits snugly into the hub casing with the teeth facing inward. A caged set of four small gears, known as planet pinions, rotate around a central gear known as the sun pinion. The sun pinion is attached directly to the axle. The gear ring and the planet pinions revolve around the sun gear in much the same way as planets in a solar system. A sliding clutch connected to a toggle chain which is connected to a toggle switch on the handlebars controls gear selection. The clutch is connected to the rear sprocket. In high gear the cage is driven by the rear sprocket which in turn drives the large ring gear connected to the wheel. In the middle gear the clutch is connected directly to the ring gear bypassing the cage and sun gear. In low gear the clutch is still connected to the ring gear, but this time the ring gear drives the cage which in turn drives the sun gear turning the wheel at a reduced speed. Fortunately, this whole process is hidden from the rider.

With the exception of the rear sprocket, the system is enclosed in the rear hub.(8:89) Despite its complicated nature, the system works well. Hub gears are easy to shift. All the rider does is select the gear he wants by moving the toggle switch on the handlebars. By being enclosed in the hub the gears are protected from damage by the elements or rough handling. Despite all the moving parts, hub gears rarely malfunction or need adjustment. They are virtually maintenance free. The operator merely needs to add a few drops of oil monthly through a spout in the hub.(1:29)

One drawback to hub gear systems is the limited number of gear ratios that can fit into the hub. Most hub gears are three speed (three gear ratios). Depending on the front sprocket, high gear is normally in the low 70s, middle gear the mid 50s and low gear in the mid 30s.(1:103)

The original Sturmey-Archer Company recently introduced a five speed hub gear, slightly increasing the range of gears. Because of the limited number of gears, there is a greater interval between speeds making it difficult to maintain a steady cadence. For this reason sport and professional cyclists rarely use hub gears. Another problem is part of the riders output of energy is consumed through the internal friction of the system. Although the amount is still open to debate, as much as 18 percent is often cited.(1:51) While these drawbacks may influence cycle racers, the hub multi-gear system's simplicity of

operation and ease of maintenance make it attractive for possible military use. Although complicated to repair those rare times it breaks, it is small enough that replacement hubs could be carried by maintenance units. It already has a history of military use. During both World Wars, some British military bicycles were equipped with Sturmey-Archer hub gears.(4:28) The Swiss appear to be going towards the same system for their new military bicycle.(2)

In 1933 Tullio Campagnolo invented the derailleur gear system.(1:53) It is the most popular transmission used today. The system consists of several sprockets located on the back axle and one or two large front sprockets. Derailleurs are located on the front and back. The derailleurs move the chain from sprocket to sprocket as the rider shifts gears. The rear derailleur also keeps the chain taut by wrapping it through a spring arm. The derailleurs are controlled by cable connected levers located on the frame or handlebars. The bicycle must be moving to shift gears. The rider moves the lever causing the derailleur to derail the chain from one sprocket, jumping up or down to the next sprocket. Since the sprockets are close together, and the size difference small, the transition is smooth. A large number of gears can be used in derailleur systems. Up to seven sprockets can be mounted on the rear wheel. As many as three sprockets can be used on the crankset (pedal wheel). This

type of setup gives the rider twenty-one gear ratios. However, normally only five sprockets are used on the rear wheel with two being used on the crankset. This arrangement gives the cyclist ten gear ratios. Bicycles setup in this manner are commonly called "ten speeds."(1:103)

The rider with a derailleur system has a wide range of gear ratios to choose from in meeting changing situations. A common ten speed setup would have several gear ratios in the high, medium, and low speed ranges. A typical touring bicycle with a ten speed derailleur would have two front sprockets with 40 and 50 teeth. The back wheel would have five sprockets of 28, 24, 20, 17 , and 14 teeth.(1:105)

This would give the rider the following options:

LOW RANGE	MEDIUM RANGE	HIGH RANGE
(Hills)	(Level Cruising)	(High Speeds)
34	67	96
45	63	79
48	56	77
	54	

The close interval between gear ratios allow cyclists to maintain cadence (pedaling the same number of

revolutions per minute). Being able to maintain cadence reduces fatigue while still being able to traverse difficult terrain. Unlike multi-gear hub systems they are 99 percent efficient in delivering power to the rear wheel.(1:51)

While their performance is superior to multi-gear hub systems, derailleur systems also have drawbacks. The system is completely out in the open exposed to the weather, dirt, and external damage. It requires more maintenance than hub systems. The derailleurs need periodic adjustments to insure the smooth transition from sprocket to sprocket. They also need constant cleaning and lubrication. It takes some practice to learn how to shift through the various ratios. In fact, with the exception of expert riders, the average cyclist rarely uses all ten gear ratios.(1:51)

A decision on which system, (hub or derailleur), best meets the requirements for military cycling would boil down to maintainability versus performance. Simply put, hub gears are simple, reliable, and a bit slow, while derailleur gears are complex, need more frequent servicing, and are faster. Derailleur systems, being the more popular of the two, are constantly being improved on. One expert on cycling, Mr. Fred Zahradnik, feels that recent improvements in derailleurs would enable them to cope with the unique requirements of military cycling. Mr. Zahradnik is the Technical Editor for the worlds largest bicycle

magazine, Bicycling. He claims that improved, quality derailleurs require less tuning (adjustment), and are easier to shift. He also states that new derailleurs are more ruggedly constructed than in the past and would be able to withstand the abuse military bicycles suffer.(7) At the same time it should be noted that the people with 100 years of military cycling experience have rejected derailleur systems. The Swiss believe that derailleur systems are still too fragile for military use. Their new bicycle will use a hub multi-gear system.(2)

Next to the frame, the most important item on a bicycle are the wheels.(1:41) Like bicycles themselves, wheels are designed based on their intended use. Lightweight, thin, fragile wheels are used for racing, while thick, wide, heavy wheels with solid rubber tires are used by industrial tricycles. What can generally be said for wheel design is: lighter is quicker, stiffer riding, and more fragile; heavier is slower, softer riding, and more durable.(1:42) Because of the nature of military cycling, this study will concentrate on the heavier designs.

A bicycle wheel is made up of four major components; hub, spokes, rim and tire. There are two types of hubs: steel three piece, and steel alloy single piece. Steel three piece hubs have a tendency to malfunction and are generally found only on cheaper bicycles.(1:48) They would not be suitable for military use. Because of the intended

load, a quality alloy steel hub is required. Spokes are made from either galvanized steel, chrome or nickel-plated steel, and stainless steel. While stainless steel spokes are strongest they are the hardest to work with.(1:48) For military purposes galvanized steel would be suitable. Galvanized steel spokes have a dull finish and would more readily accept camouflage paint. While some spokes come double butted to save weight, for military purposes, plain 14 gauge spokes would produce a strong durable wheel. Rims are made in steel or alloy. While steel rims are durable, they are also very heavy. Quality alloy rims are just as strong and have the advantage of being lighter. Rims come in different sizes to fit different tires. Most bicycles use rims with a diameter of 26 or 27 inches.(1:44) The difference in rim size is in the width of the rim. Various rims are used to fit different size tires. Simply put, a wide rim is used to match a wide tire. There are two types of rim and tire combinations.(1:43) The first uses tubular tires on sprint rims and are mainly used for racing. They are definitely not suitable for military purposes. They use extremely narrow width tires that are prone to punctures. The tires are glued to the rims. The more common type of tire and rim combination uses a clincher or wire on tire with a U shaped rim.(1:43) The tire is inflated through the use of a pneumatic tube. These tires come in different widths for different purposes. Narrow tires result in reduced surface resistance, hence greater

speed. They are also more prone to injury and punctures, give a harder ride, and reduced traction on poor surfaces.(1:45) They would not be suitable for military use. In the past military bicycles were generally equipped with the type of tire used on touring bicycles. The tire width ranged from 1 to 1.375 inches. Tires of this size perform well on asphalt and gravel road surfaces. However, in mud or sand they tend to lose traction. The tire is not designed for off-road use and is easily damaged by rocks and potholes.(1:45)

In the mid 1970s some bicycle enthusiasts in California started racing old heavy bicycles over rough terrain.(1:165) The sport grew in popularity throughout the late 1970s and has continued into the 1980s. In response, bicycle tire manufacturers started producing knobby tires for bicycles similar to those used on motorcycle dirt bikes. The tires are wider than conventional tires creating a larger surface area for better traction. The tread is serrated providing a surer grip to the surface. Sometimes referred to as "All-Terrain Tires", they are larger than conventional tires. Tread widths range from 1.375 to 2.125 inches.(1:47) The tire is thicker to withstand abuse. For instance, a lightweight racing tire is constructed with a 106 tpi (threads per square inch). Most All-Terrain tires are constructed at 35 tpi.(1:46) A low tpi number indicates a stout, rigid tire with a higher rolling resistance, but better able to resist

damage. The use of new synthetic materials (even Kevlar) has strengthen tire construction.(1:46) Unfortunately the more exotic the material, the greater the cost. Still, the advantages offered by all-terrain tires in terms of trafficability and reliability make them a must for any military bicycle.

Punctured tubes have plagued cyclists since the introduction of the pneumatic tire. Moss constantly encountered the problem to the point of declaring in exasperation that until the problem was solved military cycling was doomed. Some Japanese cyclists were forced to pedal on the rims during the invasion of Singapore. Moss would have been pleased with the recent improvements in tube technology. The thicker and better construction of tires lessens the chance of some punctures. However, the introduction of airless tubes eliminates the problem completely. Airless tubes are made of space age materials.(3:180) As with any new technology, there are several different designs. Two of the most common designs use vastly different approaches to the problem. One type uses a thick walled inner tube made of rubber with a hollow core. It is not pressurized, but uses the thick wall to maintain shape. The hollow core gives the tire its flexibility to absorb the road shock.(3:180) The other type is made of a aerospace elastomer (hard plastic) with a hollow core. It is serrated every half-inch for additional shock absorption and has an inner plastic web to help it

maintain shape.(3:182) While both types solve the puncture problem, they have drawbacks when compared with tubed tires. First, they do not provide as much shock absorption as air-tubed tires. Because they increase the weight of the wheel, they increase rolling resistance. A standard 27 x 1 1/4 inch pneumatic tire has a rolling distance 63 feet. The same tire fitted with plastic serrated tube has a rolling distance of 72 feet. While this difference may appear great, it must be taken in perspective. A cyclist must overcome two primary factors: rolling resistance and wind resistance. A rider will expend about 53% of his effort in overcoming wind resistance. As speed increases, so does wind resistance; however, rolling resistance remains constant. While rolling resistance may affect a racer's performance, its effects on a military cyclist would be less significant. In this light the advantages of airless tubes warrant further study.(3:180)

The mid 1970s California cross-country cycling trend was not just responsible for the all-terrain tire. It led to the creation of a new and unique type of bicycle. Known as all-terrain bicycles (ATB), or sometimes referred to as Mountain Bikes, their design is totally an American creation. To create a bicycle that could be used in difficult terrain, cycle enthusiasts borrowed parts and

technology from throughout the cycling industry. Individual cyclists mixed and matched these parts until they came up with a hybrid bicycle that could traverse difficult trails. Derailleur gearing was taken from lightweight racing bicycles and combined with tires patterned after those used in motocross racing. The frames initially were those found on old heavy cruiser style bicycles of the 1950s. Shift levers were placed on upright handlebars enabling the rider to shift gears without taking his hands off the handlebars. As the popularity of these home-built bicycles grew, bicycle manufacturers recognizing a possible market started producing their own versions of all-terrain bicycles. Their popularity has witnessed a continual growth. In 1987, one in every three bicycles sold was an ATB.(1:170)

Because of their popularity and the ensuing competition among bicycle manufacturers, the ATB's performance is continually being improved. Quality, manufactured models already represent a vast improvement over the original home-built cycles. Strong, lightweight frames are being designed specifically for ATBs. Improved, rugged derailleur gears are in use that simplify shifting. Some have eighteen gears with a substantial number in the lower ranges to aid in traversing hills and rough terrain. The improved models weigh less than 30 pounds, yet are

strong enough to carry equipment loads in excess of 100 pounds.(6) Improved ATB tires are designed to give excellent traction off-road but still light enough for cruising on hard surfaces at 15-20 miles per hour.(6) It is not unusual for recreational cyclists to cover up to 100 miles in 8 hours or less. While not cheap, the price of a quality, "Off-the -shelf" ATB will range from \$500-\$800.(6)

ATBs or Mountain Bikes seem ready-made for military use. While extensive testing of various models would be required, the basic concept behind the mountain bike is full of military implications. It is light, but strong, can traverse small trails and steep hills and still carry more than the soldier's present required load. Their widespread popularity is a mark of successful human engineering (civilians will not buy uncomfortable leisure equipment). They are reasonably priced. Their continued growth in popularity would seem to indicate a degree of reliability and maintenance ease. The only questionable feature is the transmission. Despite the improvements made in derailleur systems, they may not survive soldier abuse. While civilians generally own their machines, soldiers receive theirs through issue. A civilian is not likely to cram his expensive bicycle with its vulnerable derailleur system into the back of a truck or airplane. Nor will a civilian be forced to dive off his bicycle in response to

enemy fire. Although hopefully neither will a soldier, this maneuver is something the Swiss practice.(2) These may be reasons the Swiss rejected the derailleur system. After describing these conditions, the author queried the technical editor of Bicycling magazine for his opinion on derailleur survivability. Mr. Zahradnik was of the opinion that quality derailleur systems would continue to function even after being subjected to this possible abuse.(7) If after testing it is determined that derailleur systems at this stage in their development will not withstand military use, there is an alternative. The alternative is to combine a mountain bike with a five speed Sturmey-Archer hub transmission. The Sturmey-Archer system has already withstood the rigors of two World Wars.

One problem with any standard size bicycle is the space it requires for storage. While weight is rarely a problem, bicycles take up storage space. Sometimes this problem is remedied by removing the front wheel, but even then a bicycle is a large object to store. The rectangular volume for a standard size bicycle is 5' 10" long X 3' high X 8" wide. Simply put, bicycles are bulky. Bicycle storage has always been a problem. Almost from the beginning part of the solution was sought by inventing a folding bicycle. The 1899 Dursley Pedersen was a early folding bicycle used by the British in the Boer War. That

same year the French military also introduced a folding bicycle.(4:24) The designs of these two bicycles represent the two basic types of design theory concerning folding bicycles. The Dursley Pedersen was a folding bicycle that when assembled was the same size as a normal bicycle. The French design invented by a Captain Gerard used wheels of a smaller diameter, mounted on a smaller frame.(4:25) Both systems have pros and cons.

The full size folding bicycles are more efficient but tend to vibrate and are not as structurally sound. The small wheeled bicycles are not as efficient, give a rougher ride, but are more structurally sound. They also tend to fold down into a smaller storage package. Both types of design have seen combat. As already noted, the Dursley Pedersen saw action in Africa. The bicycles used in the commando raid on the Bruneval Radar site were the small wheeled type.

Both types of design are still found on the market today. One example of the folding full size bicycle that definitely has military possibilities is the Montague Folding Mountain Bike. This folding bicycle uses standard mountain bicycle components with the exception of the frame and seat post. The frame breaks down at the seat post which is actually two concentric seat tubes. The inner tube is part of the main frame diamond. The outer tube

connects the seat and rear wheel. The seat tubes act as a large hinge with the frame folded back onto itself. The front wheel is then removed. The whole bicycle slips into a storage bag with a carrying strap. When folded down the package measures 3'x3'x 1'.(5:22) To reassemble the bicycle the rider replaces the front wheel and unfolds the frame, locking it in place with two quick-releases. The bicycle weighs 29.8 pounds. Recent tests conducted by the technical staff of Bicycling magazine found that its overall performance was similar to regular frame ATBs. The one drawback they noticed was a lack of climbing capability on very steep terrain. They attributed this to the upright riding posture required by the short handlebar frame. They also felt that the frame was less rugged than that of a conventional ATB. Overall they gave it a high rating, feeling that it was well worth its \$450 price.(5:22) The folding feature makes it very attractive for possible military use. Tests would have to be conducted to determine if the folding feature outweighs the performance degradation.

One of the more popular small wheel folding designs is the DaHon. The DaHon uses 16 inch diameter wheels and folds down into an 8 x 18 x 28 inch package. It uses a 3 or 5 speed Strumev-Archer transmission. The frame is sturdy although it tends to creak while underway. Despite

its small frame and wheels it is stable. Although a great bicycle for asphalt, it does not have to possess good traction or climbing ability off-road. The small wheels tend to insure the rider feels any bumps in the road. Its military uses are very limited.

The transportability issue will play an important part in any decision concerning which type of bicycle to adopt for military use. The standard pallet the U.S. Air Force uses for cargo storage on C-141 and C-130 aircraft is known as a 463L pallet. Each C-141 aircraft is capable of transporting thirteen 463L pallets.(9:33) Based on the usable area of a 463L pallet and the dimensions of a generic Mountain bike, each pallet is capable of holding thirty bicycles.(9:4) Removing the front wheels of the bicycles increases the load to fifty bicycles per each 463L pallet. Because of its folding frame, the Montague Mountain bike would double the number of bicycles to one hundred per 463L pallet. This fact alone places the Montague to the forefront of models to be considered for military use.

The purpose of this study is not to recommend a particular brand of bicycle. However, certain features found on recent models lend themselves to military application. Any bicycle considered for military use should follow the basic Mountain bike (ATB) design. Field

tests would have to be conducted to answer several critical questions. The tests would determine whether the mountain bike should be equipped with a hub transmission or derailleur gears. The question of the utility and suitability of folding frame models can only be answered through field testing.

After the initial period of experimentation prior to World War I, military forces seemed to lose interest in new developments in cycling. For instance, although invented in 1933 (1:53), sources fail to indicate that derailleur systems have ever been tested or used on military bicycles. Then again, until the last two decades, there was not a tremendous number of bicycling experiments taking place. Cycle technology had seemed to have reached its limits.

In the 1970s and 80s lightweight alloys, spaceage plastics and computer enhanced designs have all entered the bicycle industry. Sparked by energy, environmental, and health concerns there has been a recent flurry of interest in the bicycle. Not since the 1890s has so much research and experimentation gone into bicycle technology. The results have been impressive. Stronger, lighter, and faster bicycles have been the end result. The All-Terrain Bike is a direct result of this technology. This type of bicycle is the anthesis of a military cycle. The feats of

earlier cycle troops are enough in themselves to justify the present existence of bicycles in light infantry units. Imagine what they might have accomplished on modern ATBs. Many of the obstacles and limitations they encountered would be greatly reduced or eliminated all together with modern bicycles. One has to wonder what Lt. Moss would have thought about a modern ATB as his command struggled through the sand hills of Nebraska ninety-two years ago.

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Chapter 6

FACTORS INFLUENCING THE USE OF

BICYCLE TROOPS

The advantages bicycles offer to U.S. light infantry units is bounded by several conditions. These conditions, or factors, determine under what circumstances the use of bicycles offer a mobility advantage to light infantry units. An understanding of these factors is critical in determining how and when to deploy bicycle equipped light infantry.

As with any moving object, the bicycle is affected by a number of external factors. In the case of the bicycle these factors are: surface conditions, gradient, and wind. The impact of these factors on the forward movement of a bicycle is measured in terms of resistance.(11:84) Surface condition relates directly to the amount of rolling resistance the rider must overcome. For instance, a smooth asphalt road offers much less ground resistance than a sand covered trail.(7:41) The gradient

relates to the amount of resistance to the rider caused by gravity. In other words, a rider going up a steep hill faces more resistance from gravity than the rider moving on level ground and on a downhill gradient. All moving objects face varying degrees of resistance simply by moving through air. Traveling at speeds less than 20 mph., the velocity of a moving bicycle is so low that air resistance is generally not significant. However, increased air velocity in the form of wind can increase air resistance. Therefore, a cyclist pedaling into a 15 mph. headwind faces much more resistance than one pedaling on a calm day.(11:84) Since these external factors are always present in the form of wind, surface condition, and gradient we will call them the resistance environment.

The ability of the cyclist to overcome the external factors in the resistance environment is dependent on another set of factors. The type and mechanical condition of the bicycle, physical condition of the cyclist, and the weight carried, contribute or detract from the rider's ability to overcome the resistance environment. These factors are commonly the mechanical advantage. By comparing the interaction of the resistance environment and the mechanical advantage we gain insight into the cyclist's efficiency. An Olympic class cyclist pedaling a 16 lb. racing bicycle on a smooth level track inside a building

operates at peak efficiency. The fact that he is operating in draft-free building, on a smooth, level, track reduces the impact of the resistance environment. His excellent physical condition, the type of bicycle, and the small weight he is carrying all enhance the mechanical advantage. A cyclist efficiency can be measured in terms of energy expended, speed, or distance traversed. Conversely, an overweight individual pedalling a 50 lb. single-speed bicycle up a steep, sandy hill in a 15 mph. headwind is at a disadvantage. He is working in a high resistance environment with a reduced mechanical advantage.

The interaction of mechanical advantage versus resistance environment is the heart of the bicycle question. It will determine if the bicycle has any utility in light infantry units.

Two of the three factors that make up the resistance environment correlate to the nature of the terrain in which a light infantry unit operates. Surface condition and gradient are dictated by the lay of the land. A number of conditions dictate the surface over which a bicycle can travel. Bicycles cannot, for instance, break trail through thick underbrush. They must operate over some sort of trail or pathway.(7:49) As the historical examples clearly demonstrate, cycle troops have always operated over some sort of trail network. Moss used the existing roads of the

period in his trek across the western United States. When these trails became impassible he attempted to use local railroad tracks.(2:48) In Europe during both World Wars, cycle troops used the existing, generally well developed, road or trail networks. The Japanese cyclists in Malaya used the main British built asphalt road or existing trunk trails and logging paths through the jungle.(4:18) Even the British airborne commandos used a small moonlit path to pedal to their objective.(2:113) Therefore a U.S. light infantry battalion using bicycles will have to rely on some sort of trail network in its area.

One of the main tenets of light infantry operations is that foot soldiers are able to operate over terrain that is impassible to vehicular transport. Yet, any area of the world that has a human population will have some sort of trail network. The majority of contingency missions that require the rapid deployment of light infantry divisions take place in regions of the world where an indigenous population exist, hence some sort of road or trail network will exist.

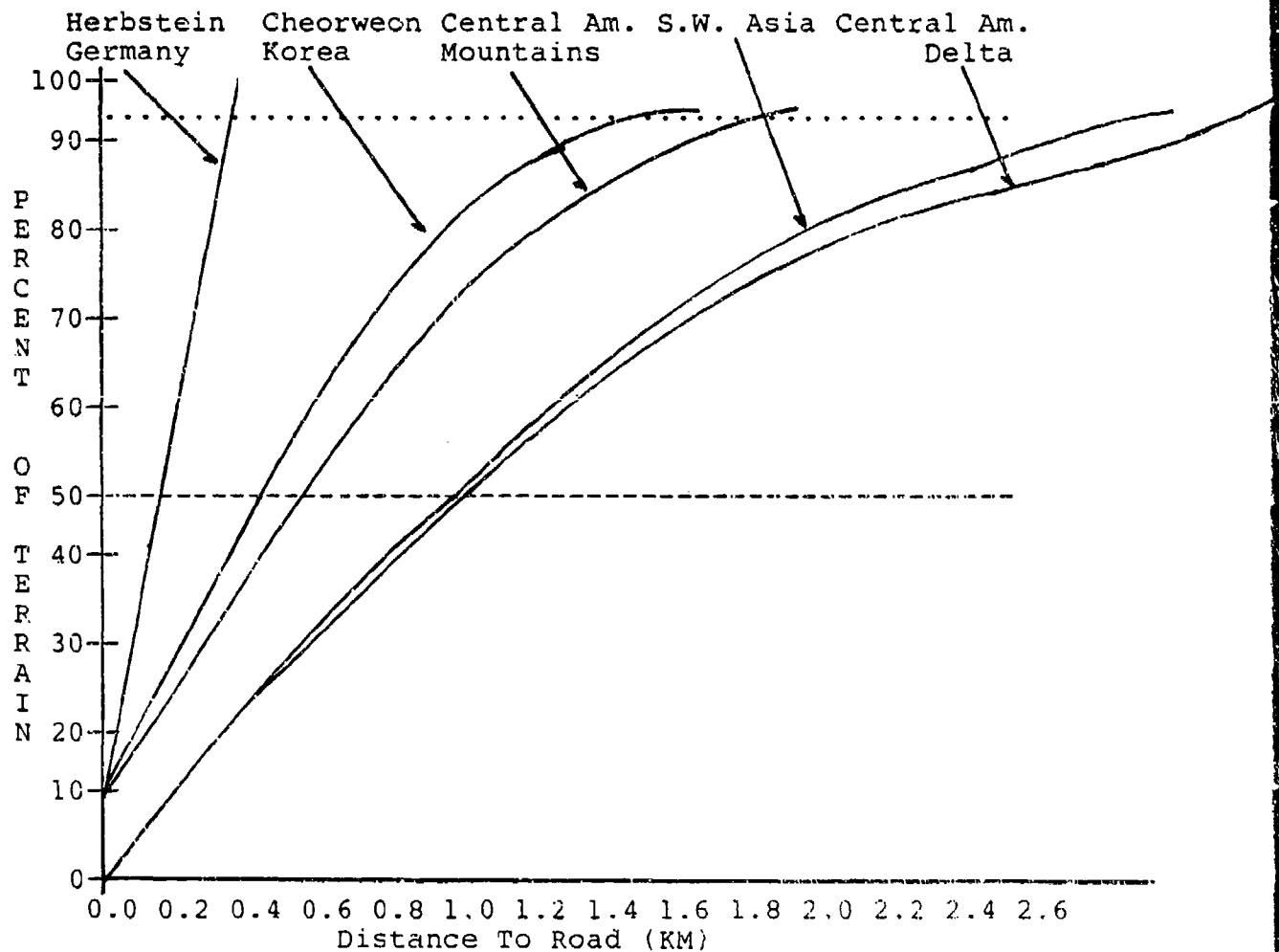
The February 1987 report of the Army Development and Employment Agency's Soldier's Load Initiative confirms that most of the time light infantry battalions will be operating in areas near roads or trails. The test considered five areas of operation as, "light infantry

country" and randomly chose thirty points on each of the five map sheets. From these points they measured the distance in a 180 degree arch to the nearest road capable of supporting FOUR-WHEEL DRIVE VEHICLES. The report states: "Foot paths were not considered, although these were extensive in Korea, Latin America and South West Asia." (9:9) The results are shown in Figure 12. (9:8) The median distance to a road or trail is indicated by a dashed line and the farthest point in 95% of the cases by a dotted line.

As stated, the study shows the distance to the nearest road suitable for a four-wheeled vehicle. The distances to trails and footpaths would be much less. The advantage of bicycles is that they do not require much of a path over which to operate. With the improved mechanical advantage offered by the mountain bike this capability is even greater than in the past. The Malaya and Vietnam experience prove that a bicycle can successfully operate over narrow primitive trail networks. The ADEA study shows that the majority of places where U.S. light infantry forces might deploy will have at least a trail network.

Figure 12

CUMULATIVE DISTRIBUTION OF DISTANCE TO NEAREST ROAD OR
TRAIL (within 180 degree arch)
OF RANDOMLY CHOSEN MAP LOCATIONS



The existence of a route, whether a simple footpath or a road, does not necessarily mean it is suitable for bicycle use. The surface condition represents a

significant measure of the resistance environment encountered by the cyclist. There are some routes that a bicycle cannot follow. A boulder strewn dry creek bed may prove a suitable route for foot infantry, but perhaps not a bicycle.

The route's surface composition determines the efficiency of bicycle troops just as it does foot infantry (figure 4, page 12). Like foot infantry, bicycle troops are more efficient on a blacktop road than on loose sand. The surface composition determines the amount of rolling resistance the bicycle wheel must overcome. Asphalt and hard packed dirt roads offer little rolling resistance to a bicycle. They are very suitable routes for bicycle troops. Leaf and pine nettle covered logging trails, like those found in western Europe, also represent good routes for bicycle troops. The suitability of gravel roads depends on the depth of gravel. A road with a deep level of gravel would result in creating more rolling resistance than one with a shallow covering. The same can be said for sand covered roads. During Moss's expedition, he complained about the sand roads of Nebraska. The bicycle tires in deep sand met so much resistance that the soldiers were required to dismount and walk.(2:57) Modern technology, including the Mountain or ATB's wide, serrated tires

and low gearing would help overcome some of this problem if the bicycle troops were equipped with a modern ATB.

Mud also produced problems for Moss. While traversing both Montana and Missouri, Moss's soldiers ran into what he described as "gumbo mud." (2:51) From his descriptions the mud appeared to be a form of clay. It stuck to wheels and clogged chains forcing his men to dismount and scrape it off with bayonets. The type of mud determines how much of a problem it becomes. World War I period photos show British cycle troops pedalling with apparent ease through watery mud about two inches deep. (2:43) All-Terrain Bicycles will solve part of the problem. Unlike the Swiss military bicycle, ATBs do not have fenders that tend to trap the mud, increasing the rolling resistance. Once again the low gearing and wide tires of the Mountain or ATBs provide both a mechanical advantage and good traction through most muddy surfaces. (1:170) Mud will definitely slow cycle troops, but depending on the depth, should not stop them.

Both German and Swiss cycle troops have successfully operated in snow. German manuals state that cycle operations can successfully be conducted in up to four inches of snow. (7:43) During the Norway invasion

German cycle troops successfully operated in snow. A hard packed snow covered trail may actually offer advantages to the modern ATB with its serrated tires.

The surface condition of a route will vary in places along the way depending on surrounding terrain and possible wartime damage. Areas that present the cycleborne soldier with increased levels of rolling resistance may be bypassed. At the very worst, the soldier may be forced to dismount and walk his bicycle until passing through the difficult section. Even while walking through the area the soldier retains mechanical advantage of his load being on wheels.

Another major factor in the resistance environment is the gradient or slope of the terrain. Moss estimated that a cyclist could not traverse a grade steeper than 4.5 degrees.(7:45) A cycling expert in the Austrian Bicycle Corps, Major Theiss, estimated that a three percent slope required twice as much energy to maintain the same cycling speed as on a flat road.(7:45) However, it must be remembered that both these gentlemen were using single-gear bicycles. While not totally eliminating the problem, multi-gear systems operating in low gear ranges will greatly reduce it. Cyclists on Mountain Bikes routinely ride up slopes of 35%.(8) A soldier on a heavily loaded ATB could negotiate a 15% slope without undue

difficulty.(8) Still, there are certain areas where the terrain is so steep that bicycles would not be advantageous. While a cycleborne soldier cannot ride up the side of a mountain in Korea, he could push his loaded bicycle up the slope. He may also be able to ride down the other side.

The final factor of the resistance environment that effects cycle operations occurs regardless of terrain. Wind will affect the amount of energy a bicyclist will expend in maintaining speed. Major Theiss maintained that high winds could suspend cycling operations altogether.(7:46) In commenting on the obstacles he faced crossing the western U.S., Lieutenant Moss stated; "The wind is one of the worst and most discouraging things to contend against."(7:46) One cycling expert, Du Bois Raymond, estimated that a cyclist will expend 57% more energy maintaining the same speed in a 6 mph headwind.(7:46) Again, multi-gear transmissions will reduce this effect. Although the cyclist will move at a reduced speed, the mechanical advantage of a low gear ratio will allow him to continue forward momentum with the same expenditure of energy.

As stated, the ability of the cycleborne soldier to overcome the resistance environment is dependent on the factors that make up the mechanical advantage. The bicycle

itself has already been discussed. It goes without saying that the U.S. light infantryman should be mounted on a multi-gear ATB. The other two factors of the mechanical advantage equation are the weight carried, and the cyclist's physical condition.

Part of the advantage of mounting light infantry units on bicycles is their ability to carry more weight. As early as 1897 the U.S. Twenty-Fifth Bicycle Corps was carrying five pounds more weight than the 72 lbs. prescribed in the 1987 FM 7-71. The Japanese in Malaya carried an average of 82 lbs. on their bicycles.(4:18) Presently the 108 lbs. carried by the company RTO is the heaviest weight routinely carried by a light infantryman.(9:6) Every Swiss cycle soldier routinely carries 110 lbs. on his bicycle.(5) The Swiss load represents a 38 lbs. gain over the doctrinal weight in the 1987 FM 7-71.(10:7-8) To the U.S. light infantryman this equates to the difference of carrying his entrenching tool (2.5 lbs.) and chemical protective garments (6.2 lbs).(9:C1-4) As it is today, both items are not carried in standard packing list. Considering the recent emerging chemical threat from certain third world countries and the ever present danger of artillery this may not be a wise policy. The 110 pound Swiss load does not represent the maximum load carrying capacity of the bicycle. When

required, Swiss soldiers have carried up to 132 lbs. per bicycle.(7:22) If transporting equipment is purely the objective we have the Vietminh example of 500 lbs. per bicycle.(7:22) However, it must be recognized that the more weight a bicycle carries, the less the mechanical advantage.

How much the mechanical advantage is reduced depends on the situation. On a hard surface, level, road the reduction would not be much. In snow the extra weight might even help. It would become a factor on steep grades, but just how much of one is difficult to predict. What does make a difference is how the weight is loaded on the bicycle. Moss started out placing a large measure of the weight on the handlebars.(2:46) Placing the weight here makes it difficult to control the bicycle. It also tends to retard the ability to negotiate obstacles in the pathway. The majority of cycle troops in the past have placed most of the weight over the rear wheel. In that this is the drive wheel, the extra weight tends to aid in traction. As demonstrated, the Swiss tend to spread the weight more evenly over the frame through the use of a center pouch in the frame diamond.(5) Adoption of the Swiss example would best suit U.S. interest with one possible exception. A U.S. military bicycle would benefit from the addition of an extra rack to carry night vision

devices in their protective cases. This rack might be attached to the handlebars as long as it does not affect the roadworthiness or efficiency.

The weight factor is not limited to the bicycle itself. A trade-off must be made in deciding what the cycleborne soldier wears while pedaling his machine. Historically this trade-off has been the source of debate. Moss stated that for ease of movement everything, including the weapon, should be tied to the bicycle. Moss went so far as to attach spring-loaded clips to the bicycle for his soldier's rifles.(7:22) The problem with this line of thought is that it tends to forget the true mission of a cycleborne soldier. He is an infantryman who happens to be using a bicycle merely for transportation. With the dubious exception of the Mt.St. Pere Bridge Raid, bicycle troops have always fought on foot in the same manner as conventional infantry. This fact implies that the cycleborne soldier carries on his person what he will immediately need upon dismounting. The Swiss follow this line of reasoning. Each Swiss soldier rides wearing his combat harness with its ammunition pouches, canteen, and bayonet. He also carries his chemical mask on his person.(5) Most bicycle soldiers have traditionally carried their rifles strapped across the back or chest. This method allows quick access to the weapon upon

dismounting. As the ambush of Japanese soldiers at the bridge in Malaya demonstrated, the carrying of weapons strapped to the bicycle can be disastrous.

U.S. light infantry soldiers using bicycles should wear their load carrying equipment (LCE) at all times. However, what goes on the harness should be restricted to those items needed immediately for dismounted combat. These items will vary somewhat depending on the individual's duty position and the threat. It will basically boil down to ammunition, chemical mask, and possibly a canteen. The lightweight and compact nature of the M-16 rifle makes it relatively easy to carry across the back or chest. Therefore, when the soldier is mounted it should be carried in this manner.

The third leg of the mechanical advantage is the cyclist's physical condition. Most U.S. light infantrymen are already in good if not excellent physical condition. The train-up period for using bicycles is relatively short. The Japanese had a little over a month to train for the Malaya invasion.(4:16) One of Moss's men learned to ride a bicycle only one week before the 1,900 mile trip to St.Louis. However, because slightly different muscle groups are used for cycling, mainly gluetex and lower leg extensors, some cycle training is required. Theiss used a three phased program to train Austrian cycle troops. In

the first phase, entitled "cycle school," the soldier learned how to simply ride and maintain the bicycle. In the next phase, called "terrain cycling," the soldier learned different riding techniques for operating in various types of terrain. The last phase was known as "endurance training." Here the soldier started out making limited marches of between 12 to 15 kilometers at 4 kmph. This distance was gradually increased to 20 and 30 kilometers at 12 to 15 kmph. The final exercise was a 80 kilometer march using speeds of up to 20 kmph.(7:38) The Swiss bicycle regiments of today train in a similar manner. Unit proficiency is maintained through weekly cycle marches.(5) U.S. light infantry units would gain several physical fitness benefits through the use of bicycles. Weekly bicycle marches would improve fitness levels in battalions. They would offer a variety over the standard company and battalion morning runs. Riding a bicycle is excellent aerobic exercise, eliminating the pounding stress on the knees and ankles caused by running.(6:26) Cycling also eliminates the ever present problems of blisters caused by road marching. In fact, weekly cycle training marches may actually save the Army medical expenses, yet still provide physical training.

Obviously, the bicycle's mechanical advantage generally overcomes the resistance environment. Otherwise

it would not be a popular form of transportation around the world. The extent of its efficiency for U.S. light infantry will depend on the type of bicycle chosen, the physical conditioning of the soldiers, and the loads they are expected to carry.

A knowledge of the impact of the resistance environment on cycle operations helps in determining how best to utilize this asset. Although very dependent on the tactical situation, a number of other tenets and planning factors must be taken into consideration when employing cycleborne light infantry. First, is the fact that cycleborne light infantrymen are just that, light infantrymen. The bicycle merely transports them to the battle, not in the battle. Just as air assault soldiers do not fight from helicopters, cycleborne soldiers do not fight on bicycles; they fight on foot. The current tactics and techniques that U.S. light infantry units use to fight battles will not change because they are equipped with bicycles. What will change is the speed and distance capability of the light infantry battalion's approach march. Standard rates of march for bicycle troops are subject to the same situational variables as march rates for foot infantry. However, past historical examples as well as present Swiss cycle doctrine offer credible examples. (see figure 13)

Figure 13

DOCTINAL RATES OF ADVANCE FOR BICYCLE TROOPS
Source: Battelle Memorial Institute

ARMY	DATE	RATES OF ADVANCE			MARCH DISTANCES	
		Slow	Normal	Speed	Forced	Normal
U.S.	1898	4mph	6mph	10mph	75mi	50mi
Italian	1904	5mph	7mph	12mph	uk*	50mi
British	1917	uk*	8mph	10mph	60mi	50mi
Austrian	1925	5mph	7mph	12mph	72mi	48mi
German	1941	5mph	7mph	uk*	72mi	42mi
Swiss	1989	7mph	9mph	14mph	120mi	72mi

uk*-unknown

U.S. light infantry units equipped with multi-gear All-Terrain Bicycles will perform at Swiss levels, if not better. The Swiss march rates are based on single-gear bicycles. From the figures above we gain an insight into just how much of an advantage the bicycle offers light infantry battalions. The light infantryman more than triples his road march speed from 4 kmph to 15 kmph (9mph). What is now considered a eight hour forced march of 32 km. becomes a routine march of less than three hours. If an eight hour march is required, the bicycle equipped light

infantry battalion will travel 120 km as opposed to the 32 km of today. Given 12 hours of daylight, the cycleborne light infantry battalion can cover 130 km. Of equal importance is the fact that they will march these distances carrying 52% more weight than present light infantry. Although these distances and weights are subject to the tactical situation and resistance environment, the increased mobility is nevertheless substantial.

The tactical situation dictates at what point cycleborne light infantry dismount and enter into combat on foot. It also determines how far they leave their bicycles behind. While the World War I manuals from both sides discuss the issue, they do not offer any real solutions. Both sides generally state that it depends on the situation and the commander's intent.(7:App D) The further from the battle the bicycles are left behind, the longer it will take the unit to retrieve them. In some cases the tactical situation may not allow the unit to recover them at all. In these cases support elements or follow-on forces may have to transport the bicycles up to their parent unit. As in the case of the Japanese, a form of host nation support may render this service.(4:17) In many tactical situations the present guidance used to determine when to drop the approach march load would determine the dumping of bicycles. U.S. light infantry battalions would have to

develope standard operating procedures (SOPs) for dropping off and recovering bicycles. These SOPs would be similar to those used presently for the recovery of approach march loads.

The tactical considerations for the employment of cycleborne light infantry are no different than the decisions made for the employment of any other type unit. Those decisions will be based on a careful study of the mission, enemy situation, terrain, troops and time available. For the past 89 years commanders have sought ways to successfully employ cycleborne infantrymen. The result has been the cycleborne infantryman's historical record of success. The problems of resistance environment and mechanical advantage have been successfully dealt with by previous infantry commanders. There is no apparent reason why this success cannot continue.

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CHAPTER 7

CONCLUSIONS

At the U.S. Army's Command and General Staff College officers destined for future assignments on division and corps staffs conduct numerous map exercises. Most of the time the notional troop list for these exercises is made up of heavy forces (mechanized infantry, armor). However, in virtually every exercise course designers have inserted a light infantry brigade or division into the troop list. This addition is made to challenge the students to find ways of integrating the use of light forces with heavy units. In every case, students quickly discover the limited mobility of light forces. The biggest challenge for students is finding the additional transportation assets to move light infantry units around the battlefield. Present light infantry units simply do not have sufficient mobility.

In most cases, equipping light infantry battalions with bicycles will solve this problem. Bicycles will increase the mobility of light infantry units, allow them to carry more equipment, and still allow them to retain the

unique advantages of being "light." The bicycle meets or exceeds every requirement identified for a vehicle to improve the mobility of light forces.

Its 100 year history of successful military use proves the bicycle is capable of meeting the light infantry's requirement for deploying worldwide on almost any type of terrain. Starting with the 1897 march across the western half of the United States by the U.S. Twenty-Fifth Infantry Bicycle Corps, bicycles have proved their ability to traverse great distances in various types of terrain. The 1,900 mile trip on roads similar to those of today's emerging third world nations prove the bicycle's capability of worldwide deployment. The bicycle's first taste of combat was in Africa, not in Europe with its developed road network. In Africa, the British Empire, with its worldwide interest, chose the bicycle to solve a mobility problem in a primitive environment. Then, of course, the bicycle participated in two World Wars. During World War I bicycles were successfully used in combat operations in various types of terrain in Europe, the Middle East, and East Africa. They provided mobility for soldiers in the mountains of northern Italy, on the steppes of Russia, the trenches of France, and even the savanna of East Africa. World War II brought about even greater worldwide deployment on different types of terrain for bicycle mounted infantry. In Europe it was virtually a repeat performance with bicycles seeing action from the

mountains of Norway to the deserts of North Africa. However, during the Second World War the military use of bicycles expanded to the other side of the world. In Asia, the Japanese used them to achieve their greatest military triumph, the conquest of Singapore. Here, thousands of cycleborne Japanese soldiers met and conquered the jungle terrain of Malaya. The use of bicycles in difficult terrain was once again demonstrated during the twenty-five year Vietnam conflict. In this conflict first the French and then American military staffs repeatedly underestimated the capability of the bicycle to traverse difficult terrain.

Its historical record of worldwide military use in various types of terrain fully establishes the bicycle as an all-terrain vehicle. This record is remarkable considering that these past military accomplishments were made on single-gear bicycles manufactured for use on smooth level roads. The introduction of the technologically advanced All-Terrain Bicycle greatly improves the ability of cycleborne infantry to conquer different types of terrain worldwide. The All-Terrain Bicycle's strong frame, robust tires, and multi-gear ratios are to bicycles what the jeep is to motor vehicles. For the first time in history, soldiers have what is truly a military bicycle capable of operating in virtually all types of terrain.

Bicycles fully meet the all-weather requirement for light infantry use. Again, it is an established historical fact that past bicycle troops have operated in all types of weather. Moss's expedition from Montana to Missouri alone proved the ability of the bicycle to operate in climate extremes. During the forty-day march Moss's soldiers pedaled in weather conditions from snow and sleet in the Rocky Mountains to 110 degree heat in the Nebraska sand hills. During both World Wars the bicycle saw action in some of the harshest weather on earth. German soldiers routinely used bicycles in the snow during both wars. During World War I German cycle troops fought and defeated the Red Army on the snow covered steppes outside Revel in Russia. They repeated this performance during the World War II on the snow covered roads of Norway. When Allied forces were having mobility problems due to snow at the Battle of the Bulge, German cycle troops were making the breakthrough attack towards Saint-Vith. On the other side of the world, in another weather extreme, Japanese soldiers successfully pedaled through the hot steamy jungles of Malaya. The Vietminh and later the North Vietnamese viewed the monsoon as a prime time to move supplies by bicycle when enemy aircraft were grounded. New technology has improved this all-weather capability. The wide tires and low gear ratios of All-Terrain Bicycles enhances their

ability to maintain traction in the snow and mud of difficult weather. The bicycle is a proven all-weather vehicle.

History is replete with examples of the bicycle's low battlefield signature. In 1914, the bicycle allowed the Germans to infiltrate silently French lines, quietly move 35 km. through their rear area, then noiselessly approach and destroy the bridge at Mt. St. Pere. Twenty-eight years later, in 1942, these same silent characteristics enabled British Commandos to do the same thing to the Germans at the Radar site in Bruneval, France. At the same time, on the other side of the world, the British were suffering the same fate as groups of Japanese cyclists were silently bypassing British defense positions down the Malayan Peninsula. The bicycle's low battlefield signature allowed North Vietnamese bicycle porters to escape the wrath of the most powerful and sophisticated air force in the world. It's low battlefield signature makes the bicycle the perfect vehicle in keeping with the stealthy nature of light infantry operations.

When compared to other vehicles the bicycle does not have a logistics tail. As long as the soldier is fed the machine is fueled. In fact, scientific data clearly establishes that a soldier on a bicycle burns fewer calories than one on foot moving the same distance.

Due to the bicycle's simple nature, cycle units in the past have required only small teams of part-time mechanics. Even today, the Swiss only assign two part-time mechanics per cycle company. With a small set of tools and a limited supply of parts they are able to repair or replace virtually every part of the bicycle. This capability eliminates the requirement for a maintenance support unit for bicycle repair. When a bicycle unit is equipped with a standard brand of bicycle, parts are readily available from damaged machines or the bicycles of casualties. Necessary spare parts are small, easily carried, and do not create a storage problem. There is no need for technical testing equipment. The tools for bicycle repair are like the bicycle itself: simple. The technically minded Germans, when faced with resource constraints, chose the bicycle to enhance the mobility of Volks Grenadier units. Although the resource constraints of U.S. light infantry battalions are self-imposed, they are nevertheless real. The bicycle is the only vehicle available that gives the light infantry the mobility it needs within the confines of these self-imposed constraints.

The bicycle itself is extremely transportable. Its compact nature allows it to be readily loaded on to trucks, helicopters, boats, or airplanes. During the invasion of Malaya, the Japanese transported hundreds of bicycles on

trucks to infantrymen who had left them behind to assault on foot. When trucks were unavailable local civilians were used to walk the bicycles forward. In the context of rapid deployment by airlift, the transport of bicycles requires very few sorties. Six sorties of C-141 aircraft can bring in enough All-Terrain Bicycles to mount every man in all twenty-seven rifle companies in a light infantry division. If a folding ATB (like the Montague) is used the number of C-141 sorties drops to three. In fact, if a folding ATB is used the soldiers can carry the bicycle with them on the aircraft. There is no other vehicle capable of this degree of transportability.

There is also no other type of vehicle as inexpensive to obtain as a bicycle. First, the technology is already established; hence no research and development cost. Second, the bicycle is relatively inexpensive, especially when compared with other forms of transportation. An excellent ATB can be obtained for \$600. At \$600 a copy, it would cost only \$2.1 million to equip all the rifle companies in a light infantry division with bicycles. The same \$2.1 million might buy enough Bradley Fighting Vehicles to equip one rifle platoon in a mechanized infantry division.

Infantrymen who are going to use bicycles do need some training in specific cycling skills. However, past

experience has proven that trainup period for soldiers who are going to use bicycles is relatively short. The Japanese who conquered Malaya trained with their bicycles for little over a month prior to the invasion. A modified program similar to the Swiss approach for the cycle training of their basic trainees could be used initially in introducing U.S. light infantry units to their bicycles. After this initial trainup of six to nine weeks, cycle training in the form of marches during physical training and field exercises could be used to maintain cycling proficiency. U.S. light infantry units would need to take the same attitude towards cycle training that is presently taken towards road march training. That is, the training is not so much a separate event as it is part of an overall operation. After all, the Swiss bicycle regiments spend the majority of their training time on honing their infantry skills, not cycling.

The history of military cycling proves that the bicycle is a durable and reliable form of transportation for the infantryman. Even the early models were able to withstand the general abuse of military cycling. Of the twenty-one Spalding bicycles that Moss started with on his 1,900 mile trip, only one suffered a structural failure, and even that was quickly repaired. That was with 1897 technology. With modern technology structural frame

failure is not a concern. Perhaps the best endorsement of the bicycle's durability is the fact that many of the Swiss military bicycles presently in use are over forty years old. These models are based on a design first introduced in 1905! The modern ATB is stronger than its predecessors in every way. It's heavy duty frame and balloon tires are specially designed for the shock and abuse of off-road use. It is the tank of bicycles.

Mathematics is an exact science based on a set of known and proven laws. For instance, twelve is always greater than four. In fact it is three times greater than four. Therefore an object that moves at 12 kmph will travel at a greater velocity than an object moving at 4 kmph, in fact three times faster. Not only is the object moving at 12 kmph travelling at a faster velocity, but in a one hour period it will cover more distance than the object moving at 4 kmph. In fact it will travel three times the distance of the slower object. While this rudimentary explanation of mathematics may appear gratuitous, it explains the greatest advantage the light infantry will gain by adopting bicycles. Light infantry units on bicycles will march three times faster and three times further than light infantry units on foot. These figures are simply a mathematical fact. It cannot be disputed. Every military bicycle unit for the last 100 years has

been able to outmarch the best infantry units in terms of both speed and distance. It is not that the cycle units were physically stronger, smarter, or tougher; they just had bicycles. The average or doctrinal road march speed for today's light infantry under the best conditions is 4 kmph. An average of the doctrinal normal road march speed of six different army's, spanning a period of 100 years, is 12 kmph. Again, this figure is just the average normal speed. For rapid mobility, Swiss units can move at speeds of 20 kmph for a period of one hour. This rate is five times faster than the doctrinal road march speed of light infantry. A light infantry unit on foot conducting a eight hour road march at doctrinal pace of 4 kmph will travel 32 kms. A infantry unit mounted on bicycles conducting a eight hour road march at 12 kmph will cover 96 kms. It is

important to remember that these past doctrinal speeds are on single-gear, slow, heavy bicycles. New Technology and lightweight space age materials insure that the present generation of bicycles are both lighter and better geared. New technology means that they will set an even faster pace than military bicycles of the past. They will allow the light infantryman to set the tempo of battle.

Not only does the bicycle allow the soldier to march faster, it allows him to carry more. Again, in virtually every historical example, cycle troops were able to

carrying more than the present light infantry doctrinal weight of 72 lbs. Today's modern Swiss infantryman routinely carries 110 lbs. on his bicycle. This load represents 52% more weight than the U.S. infantryman is suppose to carry. The bicycle is the light infantryman's pack horse.

The bicycle meets or exceeds every requirement for a vehicle suitable for the needs of the light infantryman. Yet, after initially taking the lead in this area, the American military since 1898 has virtually ignored the military possibilities of the bicycle. Whether out of arrogance in the belief that it was not technical enough, or simply because we were used to dealing with unlimited resources, we have historically failed to take advantage of the unique capabilities of the bicycle. With the design of the present light infantry division we are in a mission imposed resource constrained environment. Yet, light infantry forces need additional mobility. The bicycle can provide that additional mobility.

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