

UNITED STATES AIR FORCE
ASSISTANT CHIEF OF STAFF
STUDIES AND ANALYSIS



DECEMBER 1969

THE AIRCRAFT INDUSTRY OF THE PREDICTED RESULTS

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STUDIES AND ANALYSIS (AIRCRAFT)

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*U.S. Dept. of the Air Force, Chief of Staff
of Staff Studies & Analysis*

THE UNCERTAINTY OF PREDICTING RESULTS
OF AN INTERDICTION CAMPAIGN

*Department of the Air Force
Assistant Chief of Staff
Studies & Analysis*

December 1969

SABER MEASURES (ALPHA)

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INTRODUCTION

The purpose of this study is to gain a better understanding of how to evaluate the effectiveness of an air interdiction campaign by analyzing the historical records relating to Operation STRANGLE in Italy, which was conducted from 15 March 1944 to 11 May 1944.

The effectiveness of air interdiction has usually been measured quantitatively, in terms of the reduction in flow or level of supplies, the closure of lines of communication, etc. This study analyzes the relevancy of the conventional quantitative measures (1) before the campaign was implemented, to determine whether it should have been attempted, and (2) after its completion, to determine whether it was successful. Also, the factors which made Operation STRANGLE a success are examined, including the dynamics of the elements of disruption and their complex interactions.

Primary sources of information for this study were drawn from the historical records of the Twelfth, Fifteenth, and Mediterranean Allied Air Forces, as well as German quartermaster reports compiled during World War II. The histories reflecting the Allied effort were obtained from the USAF Archives, Maxwell AFB, Alabama; information as to German efforts was obtained by consulting the German reports at the National Archives, Washington, D.C.

This study is one of a series accomplished under the overall SABER MEASURES study: "Analysis of the Impact of Alternative Force Postures on the Outcomes of Past Wars."

SITUATION MAP OF CENTRAL ITALY AS OF 15 MARCH 1944

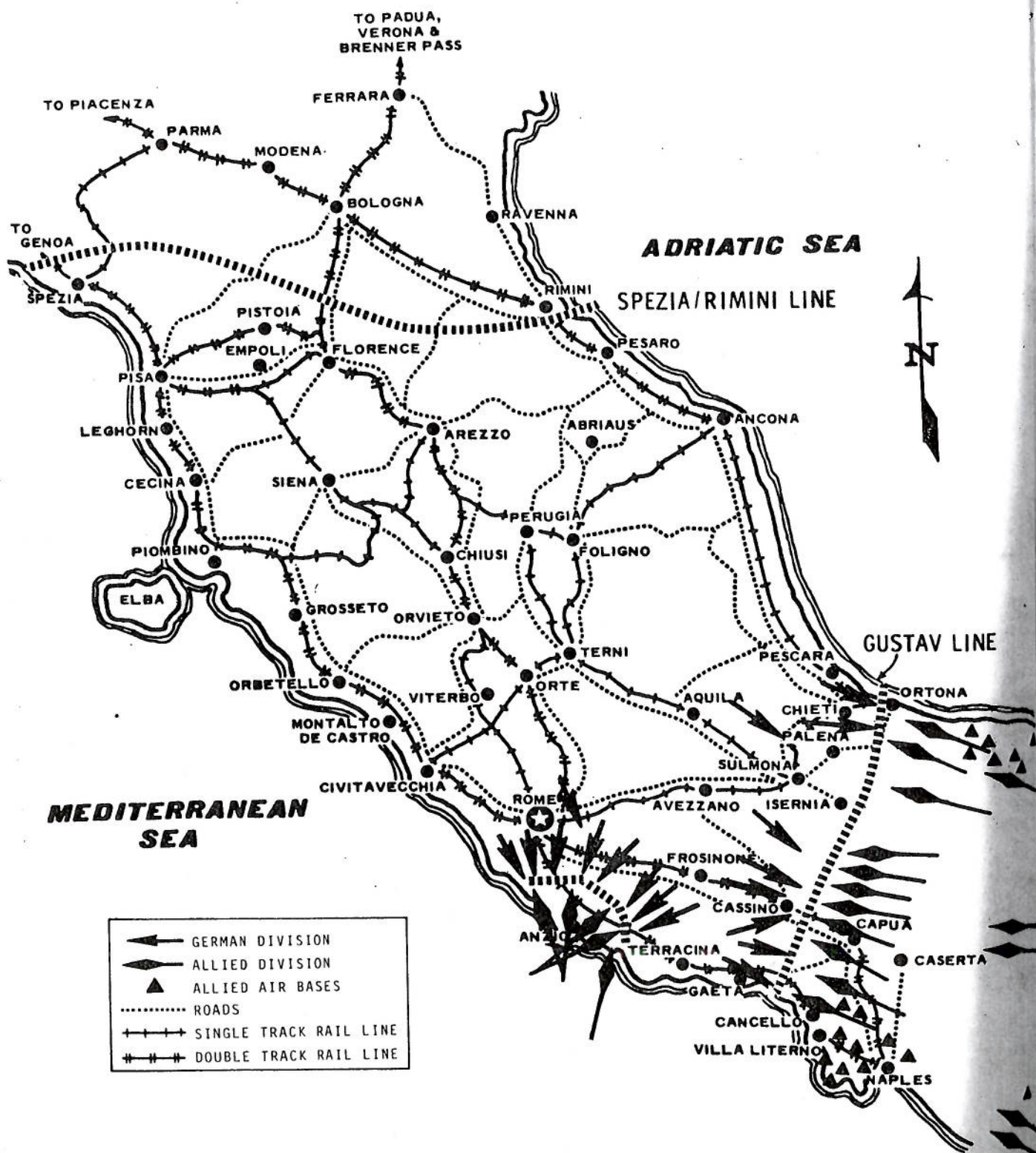


Figure 1

OPERATION STRANGLE

Scenario

Through the winter of 1943-1944 the German forces in Italy were entrenched between the Mediterranean and Adriatic Seas (through Cassino), along what the Italian General Staff had called the strongest defensive line on the Italian Peninsula--the Gustav Line (see Figure 1). Although the Allied armies were numerically superior by several divisions, they had not been able to break the four-month stalemate either with the beachhead established at Anzio or by the intensive attacks at Cassino. All attempts to pry the enemy forces from their positions had failed. As a result of this stalemate on the ground, Allied attention in mid-March was focused on using air-power to "reduce the enemy's flow of supplies to a level which will make it impracticable for him to maintain and operate his forces in central Italy."¹ Thus, in mid-March 1944, a directive was issued to implement an air interdiction program called Operation STRANGLE.

Although the lines of communication (LOC) had been previously attacked, the Mediterranean Allied Air Force (MAAF) estimated that at the start of the campaign the enemy railway system was still capable of delivering 80,000 tons of supplies daily to points near Rome. This capability could be augmented, south of the Spezia/Rimini Line, by motorized transport which could deliver 2,525 tons per day and by coastal shipping which could deliver 900 tons daily.

In their supply system, the Fourteenth German Army had 27 depots, and the Tenth German Army had 23. These included storage sites for fuel, ammunition, and food. All of the depots were served by rail lines and/or adequate highways.

¹ Directive implementing Operation STRANGLE.

MAAF estimated that the German daily requirements were for about 4,000 tons of supplies during an inactive operation, increasing to about 5,500 tons for a defensive operation (such as the one against the Allied offensive the Germans anticipated in mid-May).²

² During the period of STRANGLE, the two German armies (19 divisions) consumed between 2,000 and 3,000 tons of ammunition, fuel, food, and fodder per day.

AIR OPERATIONS - TOTAL SORTIES PER WEEK

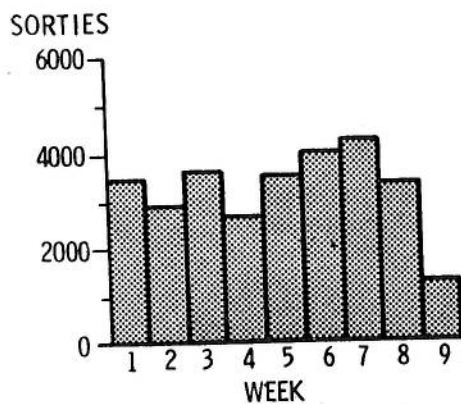


Figure 2

SORTIES PER WEEK BY TARGET CATEGORY

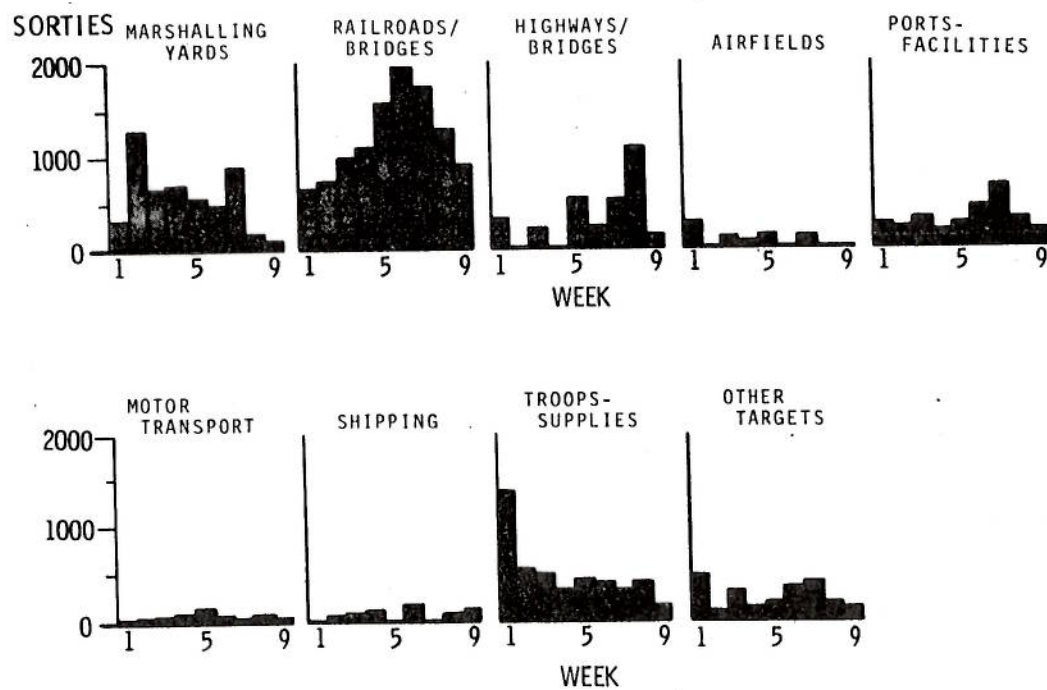


Figure 3

Summary of the Operation

During Operation STRANGLE, 34,000 Allied sorties were flown to deliver 33,000 tons of munitions and to perform the necessary reconnaissance. This equates to approximately 600 sorties per day. Figure 2 presents a summary of the sorties flown per week. The primary effort of the medium bombers and fighter/bombers was against bridges, rail lines, and motor transport in the area between the Spezia/Rimini Line and the Gustav Line. Heavy bombers concentrated on the marshalling yards in northern Italy. These yards became increasingly lucrative targets as supplies accumulated in them as a result of cuts in the rail lines south of the Spezia/Rimini Line. Reconnaissance played an important role; more than 5,000 reconnaissance sorties were flown in STRANGLE (over a period of two months) in an attempt to cover enemy LOC's every 48 hours.

The Allies possessed air superiority in Italy. Anti-aircraft fire was generally light, although occasionally it was moderate to heavy. The Allies' attrition rate was relatively low, five aircraft per thousand sorties. The weather favored Allied air operations, and only a small proportion of the combat sorties was rendered ineffective by bad weather.

Records of operations against rail traffic show that air attacks were applied primarily against bridges and rail lines; only 12 percent of the entire effort was directed against marshalling yards. Figure 3 shows the weekly allocation of effort against each target category.

The Results

After the war, Field Marshall Albert Kesselring, the senior German commander in the Italian Campaign, commented that the main difficulties in supplying the Italian theater were caused by the destruction inflicted on the lines of communication by Allied air raids. From the end of March to the middle of May the number of rail cuts rose steadily from a daily average of 25 to 75. From the very beginning of the operation, rail traffic into Rome (which was the major redistribution point to the operating units), was reduced to a trickle. During STRANGLE, MAAF destroyed: 42 locomotives (damaged 71); 337 railroad cars (damaged 516); 800 motor transport vehicles (damaged 1,000); and 50 coastal craft (damaged 100).

By the end of STRANGLE on 11 May, the stage was set for DIADEM, the combined ground-air attack by which the Allies sought to break the stalemate. The drive for Rome and the Po Valley began with heavy attacks on the German right flank between Cassino and the Mediterranean. The Germans made a precipitate withdrawal of about 200 miles, suffering an estimated 70,000 casualties, about one-third of their forces in Italy. Rome fell on 4 June and Florence on 4 August. STRANGLE had achieved its purpose, inasmuch as the enemy did not have, when the Allied offensive came, sufficient capability to "maintain and operate his forces in central Italy."

The next section of this report will measure the effectiveness of STRANGLE in a more detailed, quantitative manner. The purpose is to see if these measures of "effectiveness" really are relevant, given an interdiction campaign that has been, in retrospect, judged "successful." That is, with these measures of effectiveness, could one have made the case ahead of time that the operation would be a success--or was succeeding.

MEASURING THE EFFECTIVENESS OF STRANGLE

Conventional Quantitative Measures

Over the past decade, studies of interdiction effectiveness have relied upon quantitative measures of merit. In this paper the effectiveness of STRANGLE will be similarly measured, and a determination will be made as to whether the campaign should have been attempted. The following conventional measures were used in this assessment: (1) overall capacity of the logistic system; (2) redundancy of LOC's; (3) repair capability; (4) LOC closure and reduction in the flow of supplies; and (5) level of supply.

The enemy's original railway system had the capability to transport approximately 100,000 tons daily into and within Italy. This capability was down to 80,000 tons daily by the time STRANGLE started. The two German armies required only about 5,500 tons per day when in a defense posture. If one assumed that reducing this extensive rail net to five or six percent of its original capacity would be an impossible task, one could assert that the rail system would always support the two German armies quite adequately.

This assumption would be strengthened by examining the complex railway network in central Italy prior to STRANGLE. Its redundancy would be a major drawback in interdicting this zone. (See Figure 1). Unless all lines across the boot of Italy were cut, military supplies could easily be moved around the breaks by using alternate lines.

Experience during STRANGLE showed that there were few targets within the railway system which could not be repaired within 48 hours after a successful bombing attack. For example, the average time to repair a rail cut made by a bomb crater 16 feet in diameter and 5 feet deep, and to re-lay the railway track, was 4 to 6 hours. Repairs were vigorously pursued by the enemy

throughout STRANGLE. While some sectors were allowed to lag temporarily, there was no tendency on the part of the enemy to abandon any stretch of rail line. Usually, minor cuts on long stretches of a line remained untouched until the major cuts were close to serviceability, at which time the enemy rapidly repaired the entire stretch of line. At all times, there appeared to be sufficient personnel, materials, and equipment to repair the railroads.

An analysis of Italian railway records indicates that for a few short periods of time all the rail lines were blocked. When this occurred, motor transport was used for transshipment around rail cuts or for long hauls. Raids against marshalling yards did not stop through traffic for long. It was only necessary for the Germans to construct a "through" track from choke point to choke point in order to restore the traffic pattern. Considerable tonnage of material moved forward by motor transport, horse-drawn vehicles, and along the coast by small craft.

MAAF estimated that the daily logistic capability of the railway system (capability existing at the beginning of the campaign) was reduced from about 80,000 tons per day to 4,000 at the end of Operation STRANGLE. Thus, the railroads alone were providing enough tonnage to sustain 19 divisions in an inactive posture. The additional supplies moving by truck or boat should have been enough to enable the divisions to go on the defensive. Indeed, an analysis of German quartermaster records indicates that while the flow of tonnage was drastically reduced, it never fell below minimum requirements. From this, it could easily be concluded that sufficient tonnage was arriving, and that it had been impossible to close the LOC's to the extent hoped for by the Allied planners.

Supply levels of ammunition and fuel brought forward and distributed months before STRANGLE were sufficient for defensive operations. MAAF estimates show that on 15 March 1944 the German area command held stocks amounting to some 10 to 12 days' supplies, while stocks with the Armies (on the basis of sustained operations) were believed to amount to 30 days' ammunition and 10 days' fuel.

AMMO SUPPLY LEVELS AND CONSUMPTION
FOR 10th GERMAN ARMY - 15 MARCH TO 25 MAY 1944

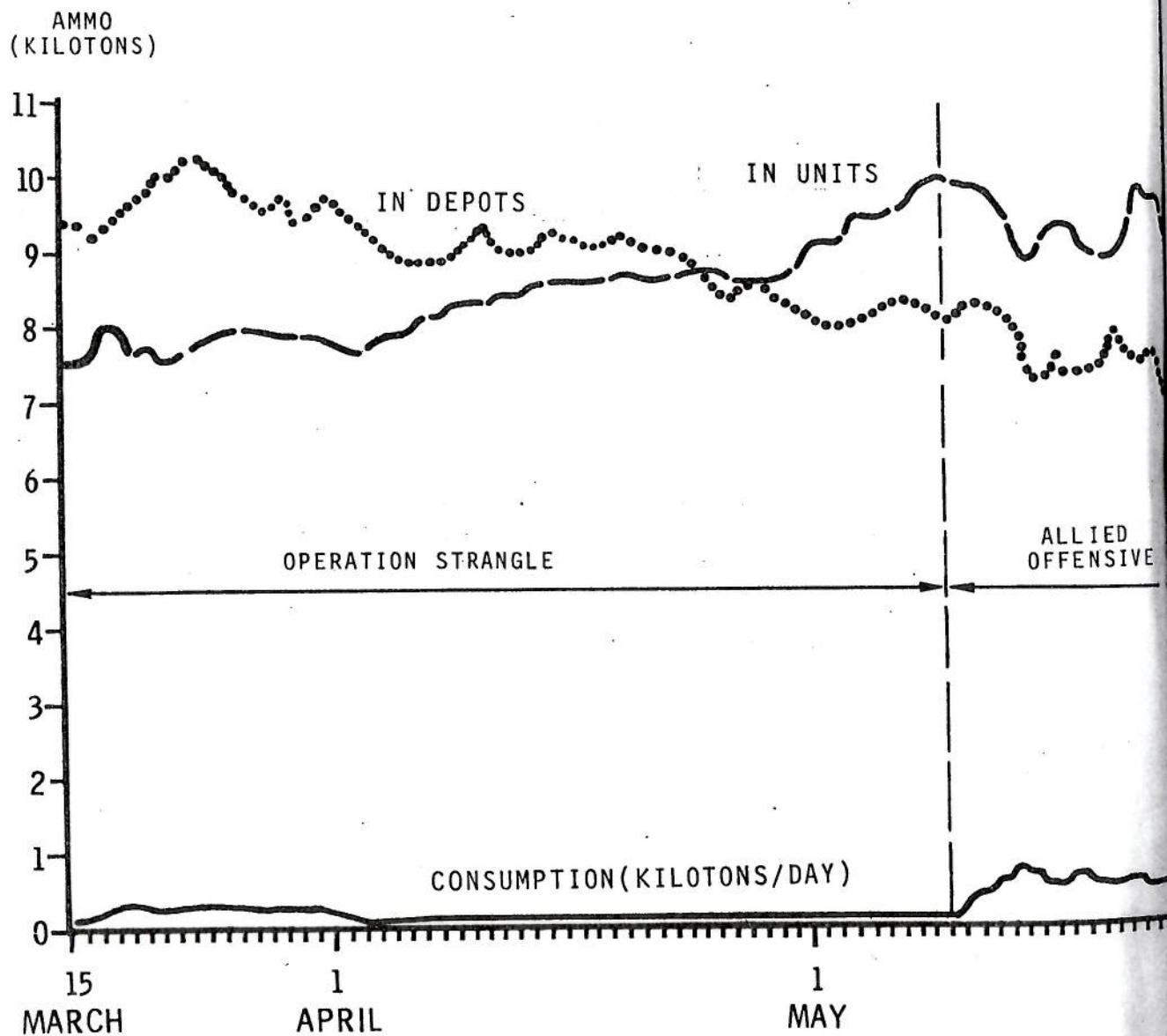


Figure 4

Figure 4, based on German quartermaster reports, shows the daily ammunition supply levels and daily consumption for the Tenth German Army. This figure indicates that the ammunition consumption rate of the German forces was a maximum during the early period of the Allied offensive, and even at this rate the German Tenth Army had 24 days of ammunition in units and depots.

ALLIED
OFFENSIVE

FUEL SUPPLY LEVELS AND CONSUMPTION FOR 10th GERMAN ARMY - 15 MARCH TO 23 MAY 1944

AUTO AND
DIESEL FUEL
(CUBIC METERS
x 1000)

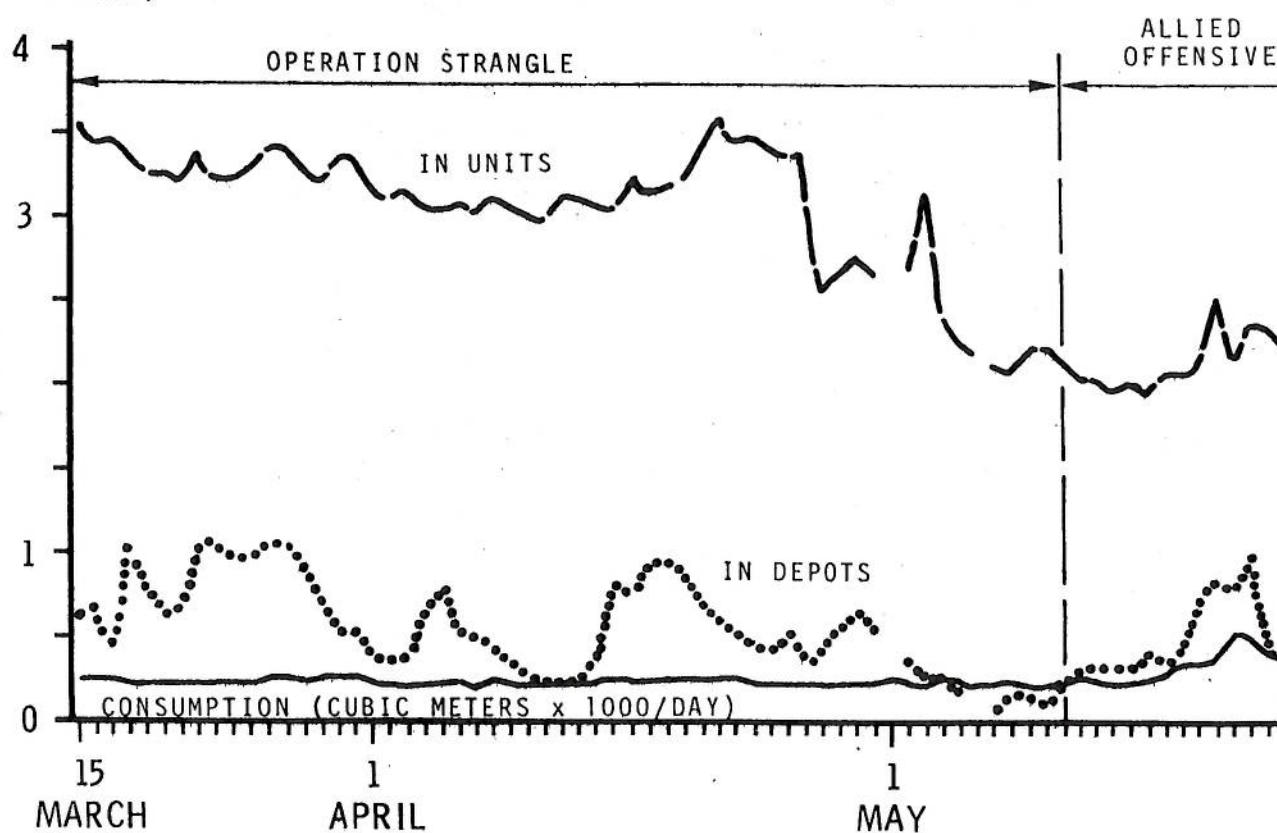


Figure 5

ALLIED
OFFENSIVE

Similarly, Figure 5 shows the daily fuel supply levels and consumption; this figure indicates that the Tenth Army had 9 days of fuel in units and depots. Other German records show that there were 5 days of fuel in transit, and more than a day's supply of fuel arriving at the depots per day. With this quantitative picture, it could be concluded that, although supplies could be in more abundance, they did not appear to be at a critically low level.

Upon examining the quantitative measures applied to Operation STRANGLE, one might conclude that it should not have been attempted or was not a success for the following reasons:

(1) The redundancy of the complex railway network in central Italy apparently provided the enemy with more alternative routings than the Allies could hope to close and keep closed.

(2) There was sufficient labor, material, and equipment to repair rail cuts rapidly at all times.

(3) The rail lines were never closed completely, and considerable tonnage of supplies flowed by other means.

(4) The supply/logistic system retained more than sufficient capacity to support the German army's relatively small requirements.

(5) Although the ammunition and fuel supply levels were lowered significantly prior to the Allied offensive, they did not appear to be critical.

Factors which Made STRANGLE a Success

On the hypothesis that the traditional statistical measures of merit did not adequately show the full impact of STRANGLE, an investigation was made of other factors which are not as amenable to quantification. These factors present an insight into the disruptive

effects of interdiction. In analyzing these effects, the German logistics and resupply system must be considered as an entity in the area from the Gustav Line to the northern Italian border.

According to MAAF intelligence reports, there was abundant evidence long before the start of Operation DIADEM (the combined ground-air offensive) that enemy troops were short of food and clothing. Both motor fuel and certain types of ammunition were rationed. Nevertheless, as long as the front remained static and quiet, the enemy's supply situation did not appear to be critical.

Based on German quartermaster records, the average arrivals of fuel supplies at major depots were greater than the average consumption each day. Therefore, it would appear that there was no real shortage in fuel. Yet this is at variance with statements in German war diaries indicating that the fuel supply was critical. The daily quartermaster records also indicate that fuel levels at the depot and in the units did decline during STRANGLE. This net decline, however, must be attributed to an inadequate fuel distribution system as well as to the losses sustained from Allied air interdiction.

The denial of railroad routes required the enemy to divert his limited motor transport from tactical support to logistical support in order to assist in the distribution of supplies. When the Allied ground offensive was launched, its speed and intensity made it impossible for the German armies to redistribute their motor transport in time to take care of the pressing needs in the combat zones. As early as 4 April 1944, the German quartermaster war diary states:

The enemy's air superiority has led to cessation of railroad traffic south of Florence. Army Group, although having sufficient supplies available, can cover only 2/3 of Field Army's daily requirements and therefore directs that all tactical vehicles be used for hauling supplies . . .

The impact of losses and the diversion of vehicles seriously reduced the tactical mobility of German combat units. Such mobility was particularly needed when

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the Allied ground offensive began. Lack of motor transport was thus regarded by the Germans as the largest single factor in the breakdown of local distribution immediately behind the front.

Rail cuts also imposed difficulties in transporting troops to the front. After the start of STRANGLE, ground troops en route to the battle area could travel by rail only as far as Florence; then they had to proceed to Rome and the front by motor transport, the latter used in relays.

After many of the rail lines had been cut, the intermediate supply depots and the motor transport convoys were selected as principal targets. The operation against highways during this period denied their use to the Germans during daylight hours. Attacks were usually made as late in the day as possible in order to create traffic blocks and cause rerouting problems for convoys at night.

Although direct military requirements constituted only a small percentage of rail capacity, the reduction in the overall traffic volume affected the flow of military supplies long before the rail capacity was reduced to this minimum level. The general railway system became disorganized, resulting in the user's inability to sort out highest priority traffic. This disorientation caused a reduction in vital military traffic. Because of the disorganization and non-availability of critical rail lines, his capability to select priority-type traffic was hampered, and a real transport crisis resulted. Generally speaking, once a decline in rail capacity had been initiated, disorganization became the major obstacle to an adequate flow of military traffic.

Once the Allied offensive began, the enemy was pressed to evacuate troops, to withdraw certain items from particular sectors, and to supply and reinforce in others. To accomplish this task he had to use his motor transport on the highways in daylight, with full exposure to Allied fighters. The resulting destruction

AN EXAMPLE OF DISRUPTION

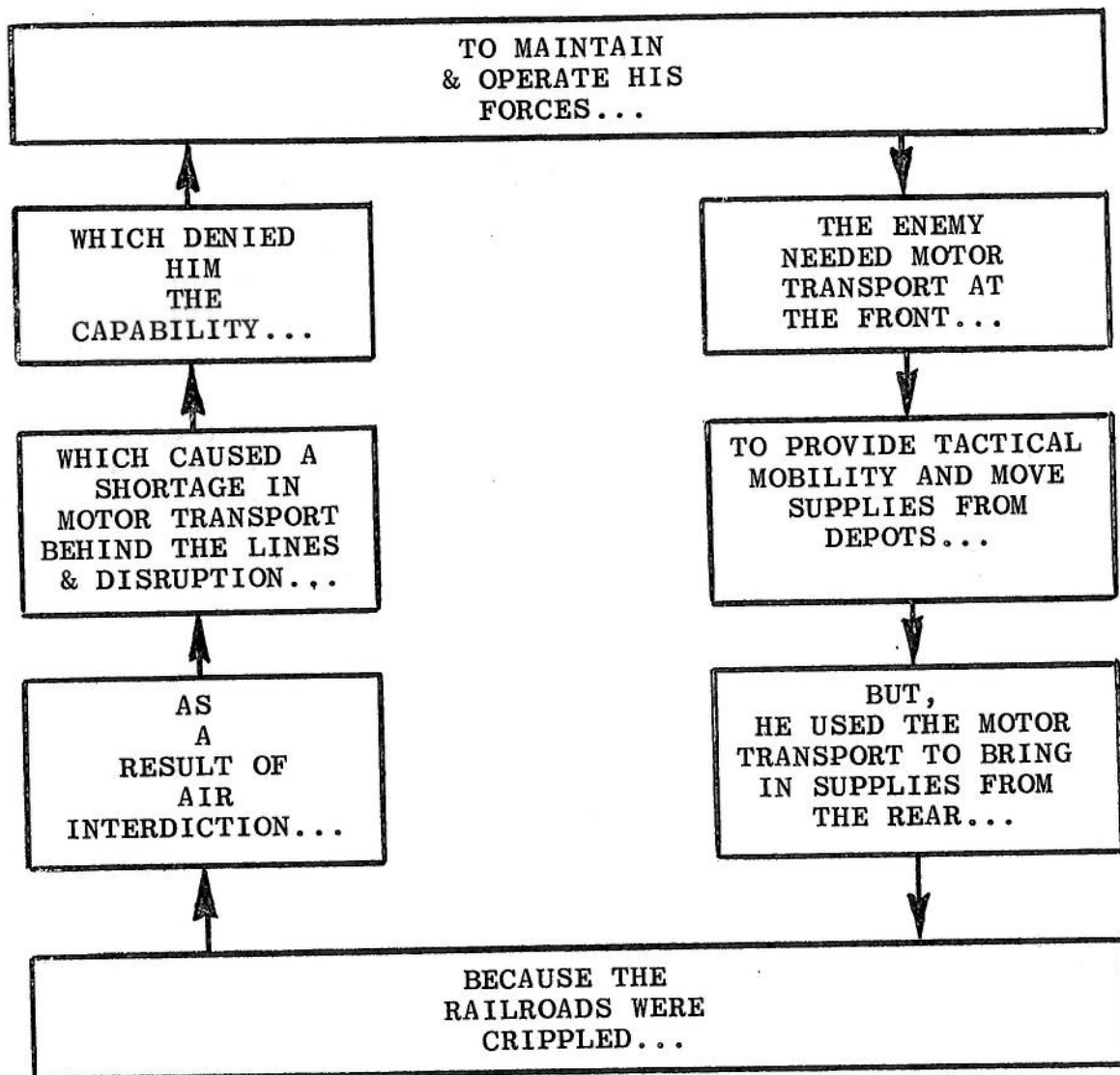


Figure 6

of his trucks by Allied air further added to the disorganization. The War Diary of the (German) Fourteenth Army Command Quartermaster, 19 April 1944, illustrates the confusion by stating that rail transportation had been completely eliminated and wave after wave of Allied air attacks on the Army rear deteriorated the supply situation. It further states that German motor transport units were rerouted from point to point not knowing where they were headed, never knowing the location of the transshipment point; that many transport vehicles were disabled; and that the mobility of German Army units was eliminated.

The most difficult factor in comprehending the disruption of a system is assessing the interaction between the system's elements. The disruption of one of the basic elements in a supply system affects other elements in the system to an extent often difficult to measure. For example, the disruption of a major rail line should not be examined in isolation of other factors. In STRANGLE, the disruption in rail capacity necessitated withdrawal of some motor vehicles in combat areas for long-haul convoy outside the combat area. If each one of the factors which causes disruption is examined in isolation, it might be considered insignificant. However, the interaction of all factors produced a synergetic effect, which can be summed up in a statement by a POW--he "didn't have the right thing at the right place at the right time" (see Figure 6 for an example of disruption).

In essence, there is no single quantitative value that can measure the overall disruptive effect of interdiction. Tables can be constructed to help understand the cause and effect relationship (see Table #1). The important thing to note, however, is that there is a far greater detrimental effect on the enemy's military potential (especially on ground force operations) than is readily apparent in examining the direct effect of attacks in terms such as, trains destroyed, bridges cut, supplies delayed, etc.

The following are the factors of disruption which made STRANGLE a success:

- (1) Creation of supply shortages in fuel and certain types of ammunition at the front prior to the Allied ground offensive.

TABLE 1

SOME INTERACTING ELEMENTS OF DISRUPTION DURING STRANGLE
WHICH PREVENTED THE ENEMY
TO MAINTAIN AND OPERATE
HIS FORCES IN AN EFFECTIVE MANNER

<u>Cause</u>	<u>Effect</u>
1. Destruction of railroads.	Removal of motor transport from Army units to haul supplies on LOC: disorganization; inadequate flow of military traffic near the front.
2. Use motor transport for hauling supplies on LOC's; lack of motor transport.	Reduction of tactical mobility of combat elements; breakdown of local distribution of supplies behind front.
3. Attacks on motor transport late in day; attacks on highways/bridges.	Creation of traffic blocks at night and difficulty of re-routing for convoys; reduction of carrying capacity on highways during daylight hours.
4. Destruction of supplies at front and enroute.	Creation of shortages in fuel, food, clothing, and certain types of ammo; reduce military potential.
5. Attacks on Army rear; breakdown of local distribution immediately behind front.	Paralysis in the tactical mobility of Army units; motor transport misrouted; disorganization and delay in maneuver movements.

(2) Re-allocation of motor transport to long-haul and resultant reduction in tactical mobility near the front.

(3) Reduction and disorganization of rail traffic.

(4) Interaction between the various elements of disruption and the resulting synergetic effect.

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SUMMARY

The air interdiction campaign, Operation STRANGLE, was a success inasmuch as the enemy could not maintain and operate his forces in central Italy when the Allied offensive came. Prior to STRANGLE the Allied armies had been unable to break a four-month stalemate on the ground, but when the Allied offensive came after STRANGLE, German resistance collapsed, and Rome fell within 30 days.

Questions have been raised in some quarters whether tactical air attacks can limit the forces which an enemy can sustain at the front, in view of the large capacity, redundancy of LOC's, and the speed with which roads, rail lines, and bridges can be repaired. It was demonstrated in this study that if one resorted to the classic "quantitative" measures commonly used to measure the effectiveness of interdiction, i.e. reduction of total capacity, redundancy of LOC's, fast repairs, and complete closure of LOC, one could prove that the STRANGLE interdiction campaign was of little value and should never have been attempted. On the other hand, one could also prove that it was a success by using a different set of "quantitative" measures. (It is recognized that any variation in the basic parameters, such as air superiority, terrain, weather, allocation of effort, etc., will affect the outcome.)

Measuring the value of interdiction with the above "static" measures did not take into consideration the "dynamic" nature of events which take place during an air interdiction campaign. The two examples following will illustrate this. First of all, that the Allies could not completely destroy the railroads and stop the flow of supplies did not mean that the campaign failed. When transport by rail was being denied in Operation STRANGLE, the Germans were forced to divert motor transport from combat units to LOC; this created shortages in motor transport, reduced tactical mobility, and caused disruption in the rear. Thus, the enemy's military potential was reduced when the Allied ground offensive began.

Secondly, to doubt the value of interdiction on the basis that the enemy requires only a small percentage of his logistic system to sustain operations can be misleading. The logistic system in Italy had a capacity for hauling approximately 100,000 tons per day; the German armies needed only 5,500 tons per day during a defensive operation, according to MAAF estimates; and that much was getting through. According to German quartermaster records, furthermore, supply stocks and daily arrivals were sufficient. Still a POW stated that the units were not getting the right thing in the right place at the right time.

Why should there be shortages? How can these differences be reconciled? The fallacy is in assuming that the needed aggregate of supplies that got through were distributed at the right times and to the right places. They were not.

The insights that can be gained from this study in evaluating the value of air interdiction are as follows:

(1) "Static" measures alone do not adequately treat the "dynamics" of air interdiction.

(2) Aggregated numbers can be misleading. Total supplies must be broken down into their components and traced to their destinations on a time scale; and

(3) The elements of disruption and their synergetic effects must be recognized as indispensable factors in evaluating the effectiveness of an air interdiction campaign.