THE EFFECTIVENESS OF THE ROLLING THUNDER PROGRAM AND ENEMY COUNTERMEASURES
1 January 1966 - 30 April 1967

Summary

The Rolling Thunder program has made some progress in meeting its current two-fold objective:

(1) To limit, or raise, the cost of sending men and supplies to South Vietnam.

(2) To make North Vietnam pay a price for its aggression against the South.

The recent expansion of the bombing program has had some positive effects relative to these objectives, particularly in the modern sector of the North Vietnamese economy. Increased disruptions to orderly economic activity and sustained pressures on North Vietnam's limited human and material resources are evident. The damage to economic and military target systems has not been sufficient, however, to cause a meaningful degradation of North Vietnam's ability to support the war, at least at current levels of combat. There are no signs that the determination of the regime to persist in its aggression has abated; despite increasing hardships, popular morale has not eroded to the point where widespread apathy and war weariness are threatening the control of the Hanoi regime.

The bombing program has forced North Vietnam to divert from 575,000 to 700,000 individuals, about equally divided between full-time and part-time workers and troops, to air defense activities and to repair, reconstruction, and dispersal programs. The cost of physical and military damage has been growing. Total damage resulting from air attacks through April 1967 is estimated at over $233 million. More than 70 percent of this damage was inflicted on economic target systems.

Despite the increasing costs and burdens resulting from the air attacks, North Vietnam, aided by an increased flow of imports from the USSR and Communist China has managed to maintain, and in many respects to improve, its organized support of the war. The electric power industry has been the most heavily damaged sector of the economy, and its neutralization may paralyze almost all of the modern industrial sector. However, the modern sector makes only a marginal contribution to the war effort since virtually all war-supporting materiel is imported. Other important targets which have been subjected to heavy attack -- particularly transportation and petroleum storage facilities -- have successfully

employed countermeasures so that their overall performance and support capabilities remain as high as, if not higher than, they were when the bombing programs started.

The attacks on military target systems through April 1967 had not significantly reduced the capabilities of the military establishment. These capabilities have, in fact, been greatly expanded through large infusions of military aid from the USSR and Communist China.

The ability of North Vietnam to withstand the pressures of air attacks is explained by several factors. The economy is essentially agrarian and provides little direct input, other than manpower, into the war in the South. The increasing flow of essential economic and military aid into North Vietnam far surpasses the total damage resulting from air attacks. This aid provides North Vietnam the necessary materials to continue the war; it also implies that the USSR and Communist China will underwrite the damage sustained and the eventual reconstruction of the country, as they did in the case of North Korea. Finally, the North Vietnamese have devised and employed an elaborate and highly successful system of countermeasures -- dispersal of industry, mobilization of labor units,

evacuation of population and the like -- which negates most of the desired impact of air attack on the vital flow of men and supplies to the war in the South.

The results to be expected from a further expansion of the bombing program, with the possible exception of a mining program, are limited, ruling out for humanitarian reasons attacks on dikes or population centers. Experience indicates that the remaining land transportation targets will be extremely difficult and costly to interdict. The few lucrative economic targets remaining do not make a significant contribution to the war effort, and their loss can be compensated by additional foreign aid. The neutralization of the remaining military targets, such as airfields, SAM sites, and radars, would reduce losses to US aircraft but would have virtually no effect on the ability of Hanoi to support the war in the South.

There seems, in summary, to be no politically feasible bombing program which would create sufficient pressures or problems to prevent Hanoi from sustaining the flow of essential military materials

and continuing its support of the war in the South. The mining of Haiphong and other ports would, however, give promise of imposing greater hardships on North Vietnam and of raising further the cost of sustaining the insurgency than would other alternatives.

Virtually all of the remaining economic targets are concentrated in densely populated and heavily defended areas of North Vietnam. Their neutralization could be very costly to US air forces. The recent attacks on targets in the Hanoi-Haiphong area indicate, for example, that the combat loss rate for US aircraft could be as much as 10 times greater than that experienced in the air campaigns over other areas of North Vietnam.

I. Physical Effects

A. General

The extension of the Rolling Thunder program during 1967 to include attacks against major industrial facilities in former sanctuary areas, and against important military targets such as airfields, has given new dimensions to the nature of US air operations. However, the program remains preponderantly an interdiction campaign against lines of communication and logistic targets of opportunity in the southern part of the country.

The changed scope of the bombing program has been sufficient to erode significantly North Vietnam's limited industrial and military base. The increased damage inflicted on North Vietnam undoubtedly will have unfavorable repercussions, particularly in the modern industrial sector of the economy. Many of the achievements of a decade of industrial growth have been neutralized, if not lost. Programs for orderly economic development have been forgone. The allocation of limited human and material resources has been a particularly disruptive problem.

The cumulative measurable damage to economic and military target systems through April 1967 is esti-

mated at over $233 million.* Over 70 percent of the cumulative damage has been inflicted on economic targets. A comparison of total measurable damage to economic and military target systems for 1965, 1966, and January-April 1967 is as follows:

	Million US $		
Type of Target	1965	1966	January-April 1967
Economic	36.2	93.3	36.2
Military	32.5	19.1	16.0
Total	68.7	112.4	52.2

The cost of damage to both economic and military target systems has increased as the US air campaign has been directed against the more lucrative targets in the Hanoi-Haiphong area of North Vietnam. Economic damage in the first four months of 1967 has been at an average monthly rate of $9.1 million, compared with rates of $3.6 million during 1965 and $8.5 million during 1966. Military targets have sustained damage at an average monthly rate of $4.0 million during January-April 1967, compared with rates of $3.3 million during 1965 and $1.7 million during 1966.

*These estimates are based on bomb damage assessments using post-strike photography available to this Agency as of 7 May 1967. This photographic coverage, with minor exceptions, includes all major targets as of the end of April 1967.

The estimated value of damage to the economic and military facilities and equipment attached under the Rolling Thunder program through April 1967 is as follows:

Economic Facilities and Equipment		Military Facilities and Equipment	
Direct Losses	Million US $	Direct Losses	Million US $
Transportation equipment	41.4	Barracks	19.9
Railroad/highway bridges	24.8	Aircraft*	19.4
Electric powerplants	20.5	Supply depots	5.0
Manufacturing facilities	11.8	Ammunition depots	4.9
Petroleum	7.4**	Naval craft*	3.8
Railroad yards and shops	3.5	SAM sites	3.4
Maritime ports	1.4	Radar sites	2.6
Miscellaneous armed reconnaissance	1.4	Naval bases	1.6
		Airfields	0.4
		Communications sites	0.2
		Miscellaneous armed reconnaissance	6.4
Subtotal, direct losses	112.2		

*Previous assessments of the value of aircraft and naval craft damaged or destroyed by air attack were calculated on the basis of US production costs for comparable equipment. The assessment in this report is made on the basis of Soviet foreign trade prices (prices charged for similar equipment sold to less developed countries) as those most closely approximating the true value of this equipment.

**Midpoint of the range at $7.1 million to $7.8 million.

Indirect Losses			
Exports	20.2		
Agriculture	25.5		
Fishing	7.8		
Subtotal, indirect losses	53.5		
Total, direct and indirect losses	165.7	Total	67.6

Despite the rising costs inflicted by the Rolling Thunder program, the damage to North Vietnam has apparently been within acceptable limits, and the regime has continued its hard-nosed stand on negotiations. No vital part of Hanoi's military establishment has been neutralized nor has its war-supporting capability been significantly reduced. With the exception of electric power generation, the North Vietnamese have been able to devise and execute adequate countermeasures to keep most essential economic war-supporting activity going. The loss of electric power facilities is having unfavorable repercussions throughout most of the modern industrial sector. But modern industry does not play a vital part in sustaining North Vietnam's ability to continue with the war. The USSR and Communist China are underwriting most of the costs of the war by providing the military the economic aid necessary

for the defense of North Vietnam and its aggression in the South. The North Vietnamese regime shows no apparent weakening in either its determination or its ability to continue with the war. Although reports of food shortages, distribution problems, and increasing hardships being borne by the people are received more frequently, popular morale is judged not to have eroded significantly.

B. Economic Damage

1. Direct Effects

The cost of direct damage inflicted on economic target systems in North Vietnam through April 1967 is estimated at over $112 million. (For a chart showing total damage--direct and indirect--see Figure 1.) More than one-fourth of this damage--$28.9 million--occurred in the first four months of 1967, as shown in the following tabulation:

	Million US $		
	1965	1966	January-April 1967
Damage to economic facilities and equipment	26.8	56.5	28.9

The emphasis on the Rolling Thunder program as an interdiction campaign is reflected in the losses sustained by the several economic target systems. More than one-fourth--$41.4 million--of

the estimated direct damage is accounted for by the destruction or damage of transport equipment. Destruction or damage of railroad and highway bridges amounts to almost $25 million. In terms of value, the greatest amount of damage to industrial target systems was inflicted upon the electric power industry, which lost about 70 percent of its power-generating capacity at an estimated cost of over $20 million. The recent emphasis in attacks on modern industrial facilities such as the Thai Nguyen iron and steel complex and the Haiphong cement plant is reflected in the estimates of damage to manufacturing facilities. Direct damage to manufacturing facilities is estimated at almost $12 million. More than 85 percent of this damage was inflicted during the first four months of 1967.

The most heavily damaged target system in terms of loss of capacity has been the petroleum storage system, which has lost about 85 percent of the major bulk storage facilities existing prior to the Rolling Thunder. This loss amounted to an estimated $7.4 million. The disruptive effects of the loss of storage facilities have been offset by an elaborate system of dispersed storage and distribution of petroleum stocks.

None of the remaining economic target systems has sustained direct bomb damage to any significant extent. The physical effects of the direct bomb damage to each of the major economic target systems are discussed in the following sections.

2. Electric Power

Air strikes against electric power facilities in North Vietnam have put out of operation about 131,000 kilowatts of power-generating capacity, or 70 percent of the national total. The cost of restoration of these facilities is estimated at $20.5 million.

About 55 percent of the reduction of capacity in the main power network, which is centered on Hanoi and Haiphong, has resulted from attacks during 1967. Damage to central generating facilities has reduced the serviceable capacity of this network from 136,000 kw to 32,500 kw, about 24 percent of the pre-strike level. The air strikes during January-April 1967 inflicted severe damage on powerplants at Hon Gai (with an original capacity of 15,000 kw), Thai Nguyen (24,000 kw), and Viet Tri (16,000 kw), Haiphong West (10,000 kw), and Haiphong East (7,000 kw). The time required to restore partial

operation of these plants will be a minimum of four months, with the exception of the Haiphong East plant which will require at least one year. Complete restoration in every instance will take one year or more.

Damage inflicted by two strikes on the Dong Anh transmission substation, the most important in the network, will prevent operation of the installation for at least two to three months. The results of a 4 May strike on the substation are not yet known. An additional powerplant at Bac Giang (12,000 kw), which is outside the main power network, was put out of operation for a minimum of three months.

Loss of the generating capacity at Hon Gai, Viet Tri, and Thai Nguyen has eliminated the supplementary supply of power formerly received by Hanoi and Haiphong from the main transmission network. The neutralization of the main power network means that Hanoi now is dependent on one local powerplant with a capacity of 32,500 kw, which is believed capable of serving about one-half of its normal needs. Haiphong is without a central power supply and must rely on whatever mobile or stationary diesel-generating equipment that is available in addition to a small amount that can be supplied from Hanoi for high-priority needs.

The degree of curtailment of electric power supply is difficult to quantify. The loss of generating facilities undoubtedly has created a severe shortage of power and disrupted activities that normally depend on a reliable central power supply in addition to the small amount that can be supplied from Hanoi for high-priority needs.

It appears almost certain that nonessential consumption by residences, commercial establishments, and street lighting has been eliminated. Curtailment of the industrial power supply probably has caused fragmentation of industrial processes in some cases, and in other cases has caused complete shutdown. The few heavy or continuous-process industries, such as the Viet Tri chemical and paper complex or the Haiphong cement plant,* will probably be forced to stop operations unless some provision for power supply has been made by the installation of diesel-generating units larger than those currently estimated to be available. In several instances there is no ready substitute for the industrial process steam formerly furnished by the central powerplants. Industrial or manufacturing processes that can be divided into small segments

*This plant also sustained bomb damage in April 1967.

(such as machine shops, truck repair facilities, coal mining, or port loading operations) can probably be furnished sufficient power by small diesel-generating units, but not without some loss of efficiency.

There are some signs of strain and bottlenecks in North Vietnamese attempts to rebuild damaged power facilities. Progress in reconstruction during 1966 was largely thwarted by restrikes that took place during the year. Repair of the Thai Nguyen powerplant was rapidly accomplished in the latter part of 1966 after damage was inflicted in July. The Uong Bi plant, damaged in August 1966, showed little sign of reconstruction in January 1967. The Thanh Hoa and Ben Thuy plants were apparently still unserviceable in April 1967. Work on the Nam Dinh plant progressed steadily until late 1966, and then apparently halted. Although some of the boilers at Nam Dinh currently are serviceable, it is estimated that the plant still cannot generate electricity. Reconstruction of small plants at Co Dinh and at Ban Thach apparently has been abandoned. The North Vietnamese seem willing to restore damaged powerplants to partial operation where limited damage permits equipment to be readily salvaged. Some evidence indicates that they are

willing to abandon plants for which a major reconstruction effort would be required.

3. Petroleum Storage Facilities

On 1 January 1965, North Vietnam had a combined petroleum storage capacity of about 128,000 tons* at 13 fixed facilities that were JCS-targeted. By the end of 1966 about 85 percent of this capacity was destroyed. There were eight air strikes against JCS-targeted facilities during the first four months of 1967. The only identified damage was inflicted on Do Son, where all of the residual capacity was destroyed -- an additional one percent of the original capacity. Damage to the Haiphong terminal as a result of an attack in April 1967 was restricted to rail facilities and buildings in the terminal. No damage to tankage was observed. At the end of April 1967, therefore, a combined capacity of only about 18,000 tons, or 14 percent of the original capacity, remained at seven JCS-targeted facilities.

The total value of the tankage, contents, and related facilities destroyed at JCS-targeted sites is estimated at about $6.7 million to $7.4 million. In addition, an estimated 5,000 tons of

*Tonnages are given in metric tons throughout unless otherwise indicated.

storage capacity -- including contents -- at dispersed tank sites were destroyed during 1966 with a value of about $0.4 million. Although the 55 gallon drum inventory also has been attacked since 1965, no adequate assessment of the damage inflicted can be made. Thus the measurable damage to all petroleum facilities and contents through April 1967 is estimated at about $7.1 million to $7.8 million.

Air strikes against JCS-targeted petroleum facilities undoubtedly have been effective when measured in terms of the storage capacity and petroleum destroyed. Although the cost and difficulty of importing and distributing petroleum have been increased, the bombing has not effectively reduced North Vietnam's capability to maintain petroleum supplies. This capability stems principally from the development of dispersed bulk oil storage capacity before extensive attacks against JCS-targeted facilities began.

By the end of April 1967, there probably were more than 100 dispersed petroleum storage tank sites in North Vietnam with a total estimated capacity of between 30,000 and 40,000 tons. The accumulation of 55 gallon drums also has given North

Vietnam increased flexibility in petroleum storage and distribution. The storage capacity represented by the drum inventory at the end of April 1967 probably was between 35,000 and 40,000 tons. In addition, there is an indeterminate amount of "floating storage capacity" represented by oil barges, rail tank cars, tank trucks, and a newly assigned small tanker for use in North Vietnamese waters. Soviet willingness to modify petroleum delivery procedures by shifting from supply sources in the Black Sea -- almost 30 days' sailing time from North Vietnam -- to sources of supply in the Soviet Far East -- only 5 days' sailing -- also has eased the burden on available petroleum storage capacity in North Vietnam. The relative invulnerability of the dispersed tank sites and drums makes it improbable that bombing will adversely affect the North Vietnamese capability to import and distribute petroleum.

There is no evidence that the bombing of petroleum targets has seriously weakened the economy, produced significant shortages of petroleum, or diminished North Vietnam's capability to support military activities or the infiltration of men and supplies into Laos and South Vietnam.

4. Manufacturing

The small manufacturing sector of North Vietnam has suffered important setbacks as a result of US air strikes during the first four months of 1967. Not only is North Vietnam's industry now faced by a general electric power shortage, but the Thai Nguyen Iron and Steel Combine and the Haiphong Cement Plant -- North Vietnam's largest industrial facilities -- have been damaged by bombing. The value of direct bomb damage to North Vietnamese manufacturing facilities through April 1967 is estimated to total $11.8 million, of which $9.5 million is accounted for by damage to the Thai Nguyen Plant in 1967 as shown in the following tabulation:

	Million US $			
	1965	1966	Jan-Apr 1967	Total
Thai Nguyen Iron and Steel Combine	--	--	9.5	9.5
Haiphong Cement Plant	--	--	0.3	0.3
Nam Dinh Textile Mill	0.8	0.2	0.4	1.4
Cam Pha Coal Treatment Plant	--	0.1	--	0.1
Viet Tri Paper Mill	--	0.1	--	0.1
Lang Chi Explosives Plant	0.4	--	--	0.4
Total	1.2	0.4	10.2	11.8

The indirect costs of the bombing to the manufacturing sector are also substantial. These costs, in terms of lost production and the resulting loss of foreign exchange earnings, probably will amount to tens of millions of dollars annually. Most of North Vietnam's major chemical facilities have probably been forced to curtail operations because of the damage to electric powerplants. The more intensive use of capital equipment and the inclusion of additional women in the labor force have mitigated some of the losses to production. Nevertheless, apparently the best that North Vietnam could claim for the chemical and coal industries -- even in 1966 -- was that they "continued operating" and for light industry that it "increased the production of necessities and turned out new varieties of goods."

The effect of the air strikes on North Vietnam's manufacturing facilities has been uneven. It is not possible at this time, for example, to make a firm estimate of the effects on production of the 12 attacks against the Thai Nguyen Iron and Steel Combine. This plant is primarily a producer of pig iron and coke. It has also engaged in the fabrication of barges, small watercraft, pontoons, petroleum storage tanks, and construction materials

from imported steel. Most of these products are inputs to North Vietnam's transportation and logistics system. Much of this fabrication work undoubtedly has been disrupted by the bombing. Available photography covering strikes through 23 April shows no direct damage to the blast furnaces. Therefore, the production of pig iron may be possible unless it has been affected by damage to associated facilities such as the steam plant.

The Haiphong cement plant is estimated to be inoperative both because of the air strikes on 20 and 25 April 1967 and because of the loss of electric power from the damaged Haiphong Thermal Power Plant West. Partial operation of the plant at about 85 percent of its original capacity (600,000 tons a year) could probably be achieved in 90 days. It is highly unlikely that the plant would be restored to full capacity until after the cessation of the bombings. The loss of cement output will deprive North Vietnam of one of its few earners of foreign exchange. If the bomb damage is not restored quickly, North Vietnam will also be forced to import cement, probably from Communist China.

It is not possible to quantify the effect on production at most of the remaining manufacturing

facilities. No effort has been made to repair the Nam Dinh textile mill, which accounted for half of North Vietnam's weaving capacity in 1965. Much of the equipment from this mill was dispersed after the first inadvertent strike in July 1965. The Cam Pha coal treatment plant has been inadvertently struck three times. Although damage to this plant has been minor, this damage in combination with a shortage of power normally supplied from Hon Cai apparently was the reason for a sharp drop in coal exports during April. The Viet Tri paper mill, the largest producer of paper in North Vietnam, was inadvertently struck in July 1966 and the damage was repaired by the end of 1966. Production may again have been disrupted by the damage to the Viet Tri powerplant in March 1967. The Lang Chi explosives plant remains inoperable from the heavy damage inflicted by air strikes in July and August 1965.

The damage already inflicted to North Vietnamese industry by the bombing undoubtedly has crushed North Vietnam's once promising hopes for a high rate of economic growth, and has added to the heavy burden on economic management. Still, North Vietnam has always been a predominantly agricultural

nation with an important local industry and handicraft sector providing for a large degree of self-sufficiency. Moreover, industry has played only a small role in support of the military effort, with a great part of military and military-associated materiel being imported from North Vietnam's Communist allies. Thus the destruction of the remainder of North Vietnam's major industrial facilities -- mainly the large chemical, fertilizer, and engineering plants and the large undamaged part of the cement plant -- would not add significantly to the problems of the civil population or detract significantly from the military effort. Added imports would be required, but not at a level beyond North Vietnam's present import and distribution capability.

5. Transportation

Air strikes against the transport system of North Vietnam during the past two years have not significantly affected North Vietnam's transport capability or its ability to move supplies in support of the economy or the war effort. There have been no indications of serious supply shortages or bottlenecks. Interdictions have been effectively repaired, and the use of rail ferries, pontoon bridges, by-

passes, and shuttling facilities has been effective in reducing time lost due to damage caused by air strikes.

The capacity of nearly all major transport routes continues to be greater than the volume of traffic to be moved on the routes -- thus traffic delayed due to bombing is moved after repairs are made. A comparison of performance estimates for the entire transport system indicates that, while total ton-kilometer performance has declined slightly, the total amount of tons carried has increased from year to year (see Table 1). Performance on the rail lines has decreased from the high in 1964, when tons carried were 4.13 million and ton-kilometers equaled 927 million. In 1966, it is estimated that 3.3 million tons were carried and ton-kilometers reached 620 million. The decline in rail performance is attributable for the most part to the loss of apatite exports normally carried by rail to Haiphong and to the ending of Chinese rail transit traffic through North Vietnam.

Performance on the highways has increased slightly, and waterway and coastal transport have shown the largest increases. The increased use of these modes of transport reflects North Vietnam's

increasing reliance on means of transport which are less vulnerable to air attack.

Table 1

North Vietnam's Transport Performance, 1963-1966

	Million Ton-Kilometers			
	1963	1964	1965	1966
Railroad	847	927	770	620
Highway	164	179	200	200
Inland waterway	448	490	540	590
Coastal waterway	142	156	170	190
Total	1,601	1,752	1,700	1,600

	Million Tons Carried			
	1963	1964	1965	1966
Railroad	3.86	4.13	3.7	3.3
Highway	6.71	7.18	7.9	7.9
Inland waterway	6.56	7.01	7.7	8.5
Coastal waterway	0.35	0.37	0.4	0.5
Total	17.48	18.69	19.7	20.2

The data on performance make it clear that the transport network is still providing adequate service to meet the country's economic and military needs.

a. Railroads

The Rolling Thunder program has had some adverse effects on the railroad system of North Vietnam during the past year, but in general the network is still capable of fulfilling the country's requirements. The destruction of the rail bridge at Viet Tri in the summer of 1966, the most significant result of the program against lines of communication during the year, reduced the capacity of the Hanoi-Lao Cai line from 3,000 to 600 tons each way per day. The line south of Hanoi has been repeatedly attacked -- reducing capacity from 1,800 to 500 tons each way per day and heavily damaging the rail yard facilities at Vinh, Thanh Hoa, and Nam Dinh -- but this line accounted for less than five percent of the total rail performance in North Vietnam prior to the initiation of the Rolling Thunder program. Infrequent attacks against the Hanoi-Thai Nguyen and Kep-Thai Nguyen lines have disrupted through traffic for only a day or two at a time. However, attacks against the Thai Nguyen rail yard in the first quarter of 1967 have created more severe problems for the movement of traffic on the Kep-Thai Nguyen and Hanoi-Thai Nguyen lines.

During April 1967 the Hanoi Railway/ Highway Bridge over the Canal des Rapides was struck. A photo mission of 30 April indicated that two spans are destroyed and that the rail line north of the bridge is interdicted. This destruction cuts Hanoi's connection with the Lao Cai and Dong Dang lines and should effectively limit operations until the bridge is reconstructed or bypasses are built. The important line between Hanoi and Haiphong, on which most of North Vietnam's import and export materials enter and leave the country, has been open for through traffic most of the time during the Rolling Thunder program. The Hanoi-Dong Dang line, the other major import-export rail line in North Vietnam, has been only intermittently attacked during much of the Rolling Thunder program. However, during the last two weeks of April 1967 the level of air strikes against the line increased, probably disrupting traffic for a few days. The key rail yards at Vu Chua, Kep, Bac De, and Cao Nung were attacked, as were the bridges at Bac Giang and Dap Cau.

Despite two years of bombing, there have been no significant, adverse effects on the

North Vietnamese rail system as a whole. Indeed the system has been extended and improved. The network is still able to move adequate supplies to meet the country's requirements, although hindered at times by interdictions, shuttling, and damaged yard facilities. In terms of total capacity on all lines, the system has improved slightly during the past year as the Kep-Thai Nguyen line has been completed and dual-gauging is in progress.

b. Highways

Air strikes against the highway system of North Vietnam have had no sustained effects on motor truck operations. The road system serves primarily as a short-haul feeder service for the railroads and connects areas not served by other transport facilities. The majority of the air strikes have been concentrated in the region south of Thanh Hoa, with Routes 1A, 15, and 7 receiving the heaviest damage. Although traffic has been interrupted and slowed by frequent interdictions and the need for shuttling operations, North Vietnamese repair efforts have been effective and sufficient to maintain traffic at required levels. Route 15, near the Mu Gia Pass, however, has been

repeatedly attacked and seeded with delayed action bombs, and maintenance of traffic on this route has probably been difficult.

Nevertheless, average truck traffic, as reported by ground observers, has increased significantly during the first quarter of 1967 compared with past years. It is estimated that the tonnage delivered daily by truck into Laos along Routes 7 and 15 during the current dry season is considerably higher than that delivered during the 1964-65 and 1965-66 dry seasons.

c. Waterways

Attacks against the waterway system in North Vietnam have not appreciably affected operations on the inland waterways or along the coast. While important transshipment areas such as Quang Khe, Dong Hoi, and Vinh have been repeatedly attacked, causing supplies to be off-loaded "over-the-beach" in many instances, the system remains very flexible and capable of meeting the country's requirements because of the ability of the North Vietnamese to restore, improvise, or relocate their transfer operations.

The mining of the Kien Giang, Song Ca, Song Giang, and Song Ma rivers, all key waterways in the southern portion of the country, has probably impaired operations in these areas. Sightings of watercraft in the mined areas declined, but did not cease, after the mining. Through the use of counter-measures, operations are now being maintained at fairly normal levels. Total sightings of watercraft by pilots and naval observers have remained at fairly constant levels -- with some minor fluctuations -- throughout the bombing.

d. Railroad Yards and Shops

Eight comparatively important railroad yards have been attacked since the beginning of the Rolling Thunder program, four of which are JCS targets. Two of these yards, at Gia Lam and Thai Nguyen, also have railroad repair facilities in the complex. In addition, many small yards and sidings have been attacked under miscellaneous armed reconnaissance.

The key rail yard and repair facility at Gia Lam was attacked in April 1967 and is one of the most significant air strikes against rail yards thus far in 1967. An initial readout indicates that

numerous buildings and some rolling stock were destroyed. Sixteen percent of the rail car repair shop floor plan is estimated to be destroyed, as well as 27 percent of the floor plan area of support buildings. In general, more than 5 percent of the national capacity of North Vietnam's railroad repair shops and over 20 percent of its rail yard capacity had been neutralized as of 8 May 1967. The cost of restoration of the damage inflicted on railroad yards and shops from January to April 1967 is estimated at $2.2 million, bringing the total of such damage by the Rolling Thunder program to about $3.5 million. Most of this estimate stems from the cost of repairing or reconstructing warehouses and other buildings rather than yard track. Air strikes have resulted in only temporary disruption to through service, and damage has usually been restored in about 24 hours after each attack.

3. Maritime Ports

Six North Vietnamese ports, representing 88 percent of the country's total maritime cargo-handling capacity, have been selected as JCS targets. Ben Thuy -- which represents 4 percent of the total capacity -- and Ham Rong -- which accounts

for only 1 percent -- were struck in 1965. During 1966, Ben Thuy was restruck and Cam Pha -- which represents 16 percent of the total capacity -- was attacked for the first time. Ben Thuy was the only port struck during the first four months of 1967. Damage to port facilities through 1966 is estimated at $1.4 million. Information is not available to assess the damage done in 1967.

The direct impact of this damage on North Vietnam's economy is not significant, although significant indirect export losses have resulted, particularly from the attacks against the port of Cam Pha. Twenty-one percent of the cargo-handling capacity at Cam Pha has been destroyed, representing a nominal cost of only $160,000. During the attacks, however, Cam Pha's coal-washing machinery and rail facilities were also hit, reducing the port's capacity for producing washed and graded coal. The damage to these facilities resulted in coal export losses of more than $6.8 million through April 1967.

f. Transport Equipment

Destruction and damage of all types of transport equipment by air strikes increased during the first quarter of 1967, compared with the same

period in 1966. However, the extent of destruction and damage was significantly lower than the quarterly average in 1966. Destruction and damage of trucks and watercraft increased significantly in the month of April and reached the peak levels obtained during the summer of 1966. Table 2, which is based primarily on pilot reports and includes some duplication,* provides a general indication of the damage inflicted, by type of equipment.

The estimated cost to the North Vietnamese of replacing or repairing transport equipment damaged from the initiation of air strikes through the first four months of 1967 is estimated at $41.4 million.

While the level of damage inflicted during 1966 and 1967 was significantly higher than in 1965, there has been no evidence of serious transport problems resulting from equipment shortages. Imports of trucks have been sufficient to maintain the inventory at previous levels. Imports of railroad rolling stock have not equaled the reported attrition

*Data have been adjusted downward to eliminate duplication whenever possible.

rate,* but there is no indication of any problems associated with rail equipment shortages. In addition, Chinese rail equipment is available in sufficient numbers to compensate for any shortages. Destruction and damage of watercraft have not been significant in relation to the North Vietnamese watercraft inventory.

*Reported losses of railroad rolling stock have included many small, makeshift cars used on the rail line south of Hanoi which are not included in the inventory estimate of mainline freight cars.

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Table 2

North Vietnam: Destruction and Damage of Transport Equipment
1965-66 and First Quarter 1967

Units

Type of Equipment	1965 - 10 Months		1966 - 12 Months		Quarterly Average 1966		First Quarter 1967	
	Destroyed	Damaged	Destroyed	Damaged	Destroyed	Damaged	Destroyed	Damaged
Locomotives	6	6	10	14	2.5	3.5	0	0
Rail freight cars	227	592	1,101	935	275	234	61	84
Trucks	318	487	1,935	1,801	484	450	178	172
Ferries	53	56	67	131	17	33	0	1
Barges	263	487	2,520	4,289	630	1,072	453	1,313
Other watercraft	144	210	867	1,372	217	343	79	234
Total	1,011	1,838	6,500	8,542	1,625	2,135	771	1,804

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g. Bridges

The number of attacks against JCS-targeted bridges increased slightly in 1966 compared with 1965, but the number of such bridges attacked was slightly less than the total in 1965, as shown in the following tabulation:

	1965		1966		January-April 1967	
	Strikes	Bridges	Strikes	Bridges*	Strikes	Bridges*
Rail and rail/highway	67	14	110	16	34	10
Highway	77	30	76	23	42	13
Total	144	44	186	39	76	23

*Including bridges struck initially before the time period.

In the first four months of 1967, 76 strikes were conducted against 23 bridges, all but two of which had been previously attacked. The number of strikes against highway bridges decreased slightly during 1966, while strikes against rail and rail-highway combination bridges increased. During the first four months of 1967, this trend was reversed.

The total number of bridges, (both JCS-targeted and non-targeted) confirmed by available photography to have been damaged or destroyed by the Rolling Thunder program now stands at 410. In this total, which includes both original and bypass bridges,

there are 303 highway, 77 railroad, and 30 combination railroad/highway structures. These figures understate somewhat the number of smaller bridges (primarily highway) that actually have been damaged or destroyed because photography may not be available for some of these bridges. The estimated cumulative cost of completely restoring the confirmed damaged or destroyed bridges to their original condition through March 1967 would be $20.7 million -- an increase of 9 percent since 31 December 1966 and double the estimate of 1965.* It is estimated that at least $4.1 million have been spent already on temporary repairs to bridges through March 1967, of which an estimated $0.8 million were spent during the first quarter of 1967. Estimated cost for temporary repairs to the number of unrepaired bridges at the end of March 1967 is $1.25 million.

Although estimates of what it would cost the North Vietnamese to restore bridges to their original condition or how much they have spent on temporary repairs are of value, they do not give any qualitative answer to the effects of bomb damage on bridges. Thus a survey of the 410 bridges confirmed by available photography to have been damaged

or destroyed showed that 377 bridges have had one or more "serious damage occurrences" (SDO's)** There have been a total of 598 SDO's since the beginning of the bombings in February 1965 through March 1967. The number of SDO's by year and the average number of times each of the 377 bridges were interdicted are as follows:

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*The estimated costs for restoring bridges to their original condition as of the end of 1965 and 1966 were $10.1 million and $19 million, respectively.

**A "serious damage occurrence" consists of initial hits and re-hits and is defined as damage sufficiently severe that a crossing is denied to users until a significant amount of repairs has been performed -- requiring considerable time, materials, and labor. For example, serious damage would include a dropped span(s), a destroyed pier(s), or a destroyed abutment(s). Holes in a deck, cratered approaches, twisted superstructure, or a slight shifting of spans is not considered serious damage.

Year	SDO's	Number of Bridges with SDO's	Average Number of Interdictions Per Damaged Bridge
1965	218	177	1.23
1966	334	185	1.81
1967 (first quarter)	46	15	3.07 a/

a. The high figure for the first quarter of 1967 is not comparable to the earlier two periods because the time span is too short for a meaningful comparison.

While a specific bridge may be interdicted an increasing number of times, in most cases the crossing is bypassed in a variety of ways. Bypass bridges, moreover, have not been damaged as extensively as the original bridges. Of the 129 bypass bridges observed in aerial photography, only 30 have sustained 46 SDO's.

B. 2. Indirect Effects

The air campaign has also resulted in sizable losses to the economy of North Vietnam, which are indirect results of the bombing. The principal indirect losses result from shortfalls in production, disruptions of normal economic activity, and the impairment of foreign exchange earnings through decreases in the quantities of goods available for export. Many of these losses cannot be quantified.

The few that can -- reductions in agricultural output and the fish catch, and the loss of export earnings -- totaled $53.5 million through April 1967, or almost one-third of total economic damage. The unquantifiable losses -- production inefficiencies, the costs of dispersing industry, civil defense measures, production losses due to lack of power, the reallocation of manpower, and the like -- undoubtedly total in the tens of millions of dollars.

a. Agriculture and Fishing

Although agriculture and commercial fishing have not been direct targets of the air strikes against North Vietnam, the bombing campaign has had significant indirect effects on production. These indirect effects have resulted from the disruption of normal farming and fishing schedules, the loss of some managerial cadres and labor due to transfer to war-related activities which has intensified manpower problems during peak loads in the crop cycle, and disruptions in the manufacture and distribution of fertilizers. Since it is not possible to separate the effects of the bombing campaign from the effects of adverse weather on agriculture, the estimates of losses in agricultural output also include those resulting from adverse weather.

The cumulative losses in agriculture and fishing through the first four months of 1967 are estimated at about $33.3 million as shown in the following tabulation:

	Million US $			
Losses from	1965	1966	January-April 1967	Total
Rice Production	3.5	22.0	N.A.	25.5
Fishing	1.7	3.3	2.8	7.8
Total	5.2	25.3	2.8	33.3

The shortfall in rice production is estimated to be about 300,000 tons below the normal average of about 4.5 million tons. Although all of this loss occurred in 1966, $3.5 million is attributed to the effects of bombing in 1965 because the spring rice crop was planted in that year. The final outcome of the 1967 spring rice crop -- normally about one-third of the annual harvest -- cannot yet be evaluated. However, the acreage planted was less than usual and transplanting of the crop was delayed, so that the harvest probably will be below normal. The loss in the salt-water fish catch resulted primarily from the interruption of normal fishing activities because of the threat of air attack.

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Recent information indicates that agricultural and fish shortages have contributed to a deteriorating food situation in North Vietnam. Salt-water fish, fish sauce, sugar, and meat are reported to be in short supply. Prices of many food items have risen, and known seaborne imports of bulk foods during the first four months of 1967 -- about 100,000 tons -- are nearly nine times the volume known to have been imported by sea during the same period in 1966. However, these imports amount to about two percent of the normal annual production of rice, and has become critical. Fresh-water fish and vegetables are adequate in many areas, and the rice ration -- albeit frequently mixed with corn and other subsidiary crops -- has been maintained.

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b. Export Losses

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The cumulative measurable value of reductions in seaborne exports attributable to the bombing through April 1967 was about

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$20.2 million,* as shown in the following tabulation:

	Thousand US $			
	Apatite	Cement	Coal	Total
1965				
2nd quarter	665	192	0	857
3rd quarter	1,043	324	0	1,367
4th quarter	1,554	395	0	1,949
Subtotal	3,262	911	0	4,173
1966				
1st quarter	1,554	205	0	1,759
2nd quarter	1,554	40	1,476	3,071
3rd quarter	1,457	244	2,192	3,893
4th quarter	1,554	243	1,060	2,857
Subtotal	6,118	733	4,729	11,580
1967				
1st quarter	1,554	199	1,273	3,026
April	518	113	835	1,466
Total	11,452	1,956	6,837	20,245

*Estimated dollar equivalents at f.o.b. prices.

Seaborne exports of apatite ceased abruptly after the interdiction of the Hanoi-Lao Cai rail line in July 1965 and when stockpiles at Haiphong became exhausted early in August. It is possible, however, that some apatite has been exported by rail from the mines near Lao Cai to China. Although known seaborne exports of cement declined after the initiation of the Rolling Thunder program, no direct connection between the program and the decline can be determined. It is possible that cement has been exported to China without being detected. Coal shipments decreased rapidly after the coal-processing facilities at Cam Pha, North Vietnam's major coal port, were damaged in April 1966, and huge stockpiles were drawn down. After a slow recovery to over half the pre-strike level, exports declined sharply again in March and April 1967. This decline apparently resulted from the combined effects of damage to the Hon Gai powerplant, which supplies power for both the Hon Gai and Cam Pha port areas, and direct damage to coal-processing facilities. Seaborne coal shipments in April were the lowest recorded in the last 16 months.

C. Military Damage

The damage to military target systems through April 1967 is estimated at $67.6 million (see

the chart, Figure 2). Losses of aircraft and damage to barrack complexes comprised most of the damage, each accounting for 29 percent of the total. The damage inflicted on military targets has had no significant impact on North Vietnam's military capabilities. The ammunition depots are the only military target system to have been attacked in depth. Yet the loss of about 70 percent of ammunition storage capacity has had no measurable impact on the availability of ammunition. No other military target system has lost as much as 25 percent of its pre-strike capacity. Although 24 percent of the capacity of barrack facilities has been destroyed, most of the barracks attacked had been inactive by the end of 1965, the years when they were first attacked. Despite the air attacks the North Vietnamese have been able to strengthen and improve the capability of most military target systems since the bombings started. Fighter aircraft facilities in North Vietnam are still sufficient to meet requirements. The inventory of SAM sites and radar and communications facilities has increased markedly since the bombings started. Although fighter aircraft losses have increased in recent months, the fighter inventory has been maintained at about its level at the end of 1966.

1. Barracks

North Vietnam had a total barracks capacity for about 443,000 men at the beginning of the bombing, of which JCS-targeted barracks had a capacity for 182,000 men. About 75 percent of the JCS-targeted barracks had been attacked by the end of April 1967, with a loss of capacity -- either destroyed or inactive -- for about 107,000 men. This loss represents about 24 percent of the total barracks capacity in North Vietnam, compared with nearly 23 percent at the end of 1966 and about 18 percent at the end of 1965. In addition, non-targeted barracks also have been struck under the miscellaneous armed reconnaissance program, but the loss of capacity resulting from this program cannot be estimated.

Air strikes against JCS-targeted barrack complexes during the first four months of 1967 exceeded the total flown during all of 1966. The return from these strikes has been disappointing, yielding damage of only $1.3 million compared with $2.5 million in 1966 and about $16.0 million in 1965. The decreasing returns reflect the fact that most of the

strikes are against already damaged or inactive complexes.

The loss of both targeted and non-targeted barracks capacity in the outlying areas -- primarily in the southern part of the country, along the border of Laos, and in the northwestern provinces -- undoubtedly is causing much inconvenience. Damage to barrack complexes in these areas has not been repaired and the remaining barracks have usually been vacated. The troops apparently are being quartered with civilians in nearby villages, in tents, or in other makeshift shelters in the surrounding area. The North Vietnamese have had sufficient time to adjust to the loss of barracks in these areas, however, and the housing problem probably is less inconvenient now than it was at the end of 1965.

2. Airfields

No significant change in the capability of targeted airfields in North Vietnam has occurred since 1965, when as a result of air strikes, about 19 percent of airfield capacity was judged to be destroyed or inactive. This estimate does not include the results of the April strikes against the airfields at Kep and Hoa Lac, because of the lack of photography with which to make a reliable damage estimate. The confirmed

damage to date is estimated at only $0.4 million. The attacks on airfields have probably had only a limited military or economic impact. Although the airfields at Kep and Hao Lac both had jet handling capabilities, their complete loss would not seriously impede North Vietnam's capability to mount air operations.

In fact, fighter aircraft facilities in North Vietnam, which were inadequate at the beginning of the bombing, have been expanded significantly -- even outpacing the MIG inventory. The gradual expansion of the basic airfield and control apparatus apparently has been tailored to specific air defense needs to counter the Rolling Thunder program. At least four airfields -- Hanoi/Gia Lam, Phuc Yen, Haiphong/Cat Bi/Kien An -- could support MIG operations at the end of April 1967, and an additional airfield under construction at Bai Thuong will be able to accommodate jets when it is completed. The airfields at Kep and Hao Lac also had jet capabilities at the end of March but their present status is unknown. North Vietnam now has the capacity for expanding the MIG inventory and preparing for more aggressive air operations. In the event of attacks on the major airfield at Phuc Yen, the North Vietnamese can still sustain a fighter force, although less effectively, in the Hanoi area.

3. SAM Sites

From July 1965 through April 1967, approximately 450 air strikes were directed against SAM installations in North Vietnam. The assessment of the effects of these strikes has been severely limited by the lack of post-strike photography.

The following tabulation reflects the minimum damage estimated to have been inflicted on SAM facilities:

	Thousand US $			
	1965	1966	Jan-7 May 1967	Total
SAM Facilities				
Firing sites	310	900	130	1,340
Support facilities	1,600	170	300	2,070
Total	1,910	1,070	430	3,410

The attacks on the SAM sites have not significantly affected the total number of active SAM battalions, which have increased steadily and by spring 1967 totaled from 28 to 32 units. In addition, the number of prepared or pre-surveyed sites now totals at least 162.

By 7 May 1967, over 2,250 SA-2 missiles had been fired at Allied aircraft, resulting in the destruction of 55 airplanes (43 confirmed and 12 probable) and 29 reconnaissance drones.

4. Naval Bases

By the end of April 1967, nearly 20 percent of North Vietnam's naval base support facilities were destroyed or inactive, compared with about 15 percent at the end of 1965. The cumulative cost of repair for the damage inflicted is estimated at nearly $1.6 million. It is doubtful that the damage to the naval bases has seriously affected the operations of the small North Vietnamese navy. Restoration of the damaged facilities can be accomplished quickly and without foreign assistance.

5. Radar*

North Vietnam expanded its radar system considerably during the first four months of 1967. At the end of April the country had over 160 known early warning and ground control intercept radars at 60 sites, compared with 149 known radars at 50 sites at the end of 1966. Five of these sites are JCS-targeted because of their strategic locations along the coast.

* Excluding radar associated with SAM sites.

During 1965-66 the targeted sites at Hon Matt and Hon Nieu were totally destroyed, those at Vinh Son and Bach Long were damaged, and there was no significant damage to the site at My Duc. The cumulative cost of damage to these sites is estimated at $2.6 million. The destroyed site at Hon Nieu was reactivated during the first quarter of 1967, and the sites at Vinh Son and My Duc were strengthened appreciably by the deployment of additional early warning, searchlight control, height-finding, and fire control radars. There were no known attacks against these radar sites during January-April 1967.

6. Communications

North Vietnam's telecommunications system remains operationally intact not only because relatively few facilities have been targeted and attacked, but also because of large-scale imports of equipment. In fact, the overall capabilities of the system may have been improved since the beginning of the Rolling Thunder program. Radio facilities have been expanded and the message-handling capacity of the wireline system has been increased. In addition, the North Vietnamese have taken steps to reduce the potential effects of air strikes on the telecommunications system. Newly constructed open wirelines are

being placed from 150 to 600 yards away from railroads and highways, telephone poles are being pre-positioned along wireline routes, and a blast wall has been constructed around the radio broadcasting complex at Me Tri.

By the end of April 1967, the cumulative cost of the damage inflicted by air strikes amounted to only about $185,000, of which about $105,000 occurred during 1965 and about $80,000 during 1966. No confirmed damage was inflicted on the system during the first four months of 1967.

7. Supply and Ordnance Depots

Four of North Vietnam's JCS-targeted military supply and ordnance depots were attacked during January-April 1967, two for the first time. The most significant strike during the period was against the Thai Nguyen Army Supply Depot North which serves the area north of Hanoi and represents nearly 4 percent of the total national capacity.

Only about 17 percent of North Vietnam's supply and ordnance storage capacity was destroyed or inactive as a result of air strikes through April 1967. The damage inflicted is estimated at about $5.0 million. Except for the depot at Thai Nguyen

and those at Vinh and Yen Bai (which were struck prior to 1967), the depots attacked are of relatively minor importance to the North Vietnamese Army. However, the functions that were performed by these depots are essential to maintain the infiltration system in support of activities in South Vietnam and Laos. The requirement to operate from a dispersed logistics base has probably resulted in increased management problems and reduced efficiency.

8. Ammunition Depots

During January-April 1967, five JCS-targeted ammunition depots -- Hon Gai, Vinh Yen, Haiphong, Bac Giang, and Cam Ly -- were attacked for the first time, and the ammunition depot at Phu Qui was restruck. The cost of restoration of the depots at Hon Gai and Haiphong is estimated at $100,000 each. There was no loss of capacity at the Phu Qui and Bac Giang depots, and there is no information available on which to base an assessment of damage inflicted on the Vinh Yen and Cam Ly depots. By the end of April 1967, at least 70 percent of the capacity of North Vietnam's JCS-targeted ammunition storage facilities had been destroyed or was inactive. The cumulative cost of the damage inflicted through April is estimated at about $4.9 million.

The loss of ammunition depots has been inconvenient to the North Vietnamese and probably has resulted in temporary delays in distribution. The loss apparently has not, however, caused prolonged shortages of ammunition in the areas where the depots are located. More than 60 percent of the targeted depots (all of which have been attacked) are inactive, and airstrikes during the past year apparently have not significantly affected the overall storage of ammunition in North Vietnam.

9. Naval Craft

The destruction of eight North Vietnamese naval craft* has been confirmed as of April 1967: four Swatow-class gunboats in 1965 and three PT boats and one SO-1 subchaser in 1966. The cost of these losses is estimated at $3.8 million. The small North Vietnamese navy currently is estimated to include 12 Swatow-class gunboats, 13 PT boats, 3 SO-1 subchasers, and 4 unidentified naval craft.

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*Excluding the 8 and 10 naval craft destroyed by the Pierce Arrow attacks in August 1964 following the Gulf of Tonkin incidents.

10. Aircraft

The North Vietnamese lost 17 MIG-21's and 29 MIG-17's through April 1967 from attacks by US aircraft. Eleven MIG-21's and 8 MIG-17's were destroyed during the first four months of 1967. The cost of all aircraft losses is estimated at $19.4 million, of which $10.4 million is attributed to losses during January-April 1967. The MIG inventory of 30 April 1967 included 16 MIG-21's and 87 MIG-15/17's. Thirty-two MIG-15/17's were still being held in China. The North Vietnamese have replaced all but those aircraft lost during the latter part of March and April. North Vietnam's air force has taken an increasingly aggressive role in air defense systems when vital targets are attacked, and it apparently plans to keep the jet fighter inventory at least at the present level or increase it in the future.

D. Miscellaneous Targets of Armed Reconnaissance

Most of the damage resulting from the armed reconnaissance program has been discussed in earlier sections of this memorandum under the major categories of targets. Pilot reports, however, have indicated a variety of miscellaneous targets -- principally transport and military facilities -- as destroyed or damaged and which cannot be included in the major target categories.

Because of the nature of air operations, it is difficult to provide a definitive evaluation of the results of air strikes based on pilot reports. There is some double-counting in the reports and a tendency for pilots to overestimate the amount of destruction or damage inflicted. In addition, the description of the targets is usually imprecise. The cost of damage can thus be based only on an assumed level of damage to a typical target in each category. With these limitations in mind, the total cost of replacement or restoration of the miscellaneous targets destroyed or damaged by armed reconnaissance strikes is estimated at about $7.8 million, as shown in the following tabulation:

Million US $

	1965	1966	January-April 1967	Total
Economic facilities and equipment	N.A.	1.2	0.2	1.4
Military facilities	0.7	3.1	2.6	6.4
Total	0.7	4.3	2.8	7.8

E. Manpower Effects

The effects of the Rolling Thunder program on North Vietnam's manpower resources are twofold -- the loss of manpower as casualties to air strikes, and the diversion of substantial amounts of manpower to tasks associated with air defense and civil defense programs and to repair, reconstruction, dispersal, and transport programs.

1. Casualties

Preliminary estimates of casualties for the first quarter of 1967 demonstrate the stepped-up rate of the Rolling Thunder program. The monthly casualty rate increased from an average of 2,200 during 1966 to 2,800 in early 1967 (see Table 3). Markedly greater armed reconnaissance strikes in heavily populated Route Package IV were chiefly responsible for the increase in the casualty/sortie ratio from 0.32 in 1966 to 0.40 in January-March 1967. In addition, fixed targets selected for initial strikes in early 1967 were situated in heavily defended areas of greater civilian population density.

TABLE 3

North Vietnam: Estimated Casualties 1965 - March 1967

	1965	1966	First Quarter 1967*	Total
Civilians				
Fixed targets	2,000	900	300	3,200
Armed reconnaissance	4,000	18,100	6,000	28,100
Subtotal	6,000	19,000	6,300	31,300
Military				
Fixed targets	4,300	400	700	5,400
Armed reconnaissance	2,900	7,300	1,300	11,500
Subtotal	7,200	7,700	2,000	16,900
Total	13,200	26,700	8,300	48,200

*Based on preliminary data.

The estimates of casualties resulting from the bombing of North Vietnam are subject to unknown and conceivably large margins of error. Information from Hanoi has generally been of little value in estimating casualties. Two recent reports, however, make us reasonably confident that our estimates are of the right order of magnitude. The first report, a detailed statement from Hanoi, "Report of US War Crimes in Nam Dinh City," released a number of statistics and allegations concerning the US bombing of Nam Dinh during 1965-66. The information presented in this report seemed to be

accurate when measured against detailed studies made on the basis of post-strike photography. The casualties claimed by the North Vietnamese were also consistent with independent casualty estimates made by this Agency, using Nam Dinh as a pilot study. A second report in late April 1967 indicated

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that only 20,000 North Vietnamese had been killed by the US bombing from August 1964 to date. This statement closely corresponds to our own estimate. We have previously estimated on the basis of COMINT and other sources that about 40 percent of the total casualties are killed and the remainder wounded. On this basis we would estimate that slightly more than 19,000 of the total casualties through March 1967 were killed,

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Although the monthly rate of casualties continues to increase and to be heavily weighted with civilians, the total casualties are small in relation to total population. Civilian casualties continue to be primarily those involved in war-supporting activities such as the repair of bomb damage and the operation in maintenance of logistic supply lines.

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2. Diversion of Manpower

Air strikes against North Vietnam have required the services of 575,000 to 700,000 individuals -- about equally divided between full-time and part-time workers.

	Thousand Persons	
Task	Full-Time	Part-Time
Loc repair and reconstruction	72	100 to 200
Transport and dispersal	100 to 120	25
Civil defense	--	150
Air defense	83	25 to 30
Coast defense	20 to 25	--
Total	275 to 300	300 to 405

Most of the full-time workers repairing LOC's are deployed in the four Route Packages south of Hanoi which have borne the brunt of the Rolling Thunder program. In addition to these Vietnamese workers, up to 34,000 Chinese engineering troops are employed north of Hanoi to repair and reconstruct the two rail lines to China. Additional 19,000 North Vietnamese workers are estimated to be in the Laotian Panhandle expanding and repairing the infiltration corridors to South Vietnam.

Although the total manpower requirements stemming from the air war may have limited somewhat North Vietnam's capability for sustained large-scale operations in South Vietnam, and to some degree contributed to a shortfall in agriculture, the diversions have not placed a relevant ceiling on North Vietnam's ability to infiltrate troops into South Vietnam. For example, the full-time requirement for 172,000 to 192,000 civilians for LOC repair and transportation-dispersal operations is only about 4 percent of the estimated 4.3 million males in the 15 to 49 age group. Only in relatively lightly populated but heavily attacked Route Package I does the labor force required to counter the bomb damage account for a significant -- up to one-fourth -- share of the labor force. In this area substantial numbers of laborers have probably been imported from other areas of North Vietnam to repair roads and speed the transport of goods.

Most of the workers perform only manual labor requiring no special skills, and they can easily be recruited from city evacuees, farms, and fishing villages with a minimum of dislocation to the economy. Other tasks such as the operation of construction machinery, bridge repair, bypass construction, and rail repair do require higher skill levels. Permanent

crews to perform these types of functions impose a burden on the economy in two important ways. Because personnel possessing modern skills such as heavy equipment operation are in short supply in North Vietnam, a step-up in the bombing spreads a thin resource even thinner. Second, the logistical needs of the full-time construction personnel place an additional requirement on North Vietnam's economy for food, housing, medical services, and the like.

In addition to skilled and unskilled full-time workers, part-time personnel are used on a stand-by basis to repair LOC's, transport supplies, and serve as civil defense workers. Typically these jobs -- such as repair of craters or transloading a boxcar -- require a low-skill worker and are essentially of a "one shot" nature. The temporary absence of such laborers from their primary jobs for several hours or days causes small losses to the economy.

Although the total number of and the skill requirements for full- and part-time workers are well within tolerable limits, the shortage of experienced cadre to plan, coordinate, and direct the ambitious and imaginative system of countermeasures which North Vietnam has devised is a more serious problem. The need for experienced and aggressive

cadre in the North competes directly with the need for military cadre in the South. The neutralization of North Vietnam's modern industrial facilities will probably free some of this scarce talent, but accelerating needs for technologically skilled personnel for operating repair services, transportation crews, and civil defense programs will probably intensify the shortage. On the other hand, after more than two years of bombing, the North Vietnamese are much more experienced at countermeasures than formerly, and as long as morale remains high and imports of necessary equipment continues, North Vietnam will not be faced with a crippling shortage of labor, either skilled or unskilled, unless losses in the South increase sharply.

II. Effectiveness of Countermeasures

The major effect of the air attacks against North Vietnam has been to force Hanoi to cope with extensive disruption to normal economic activity. The greatest effort has been required in the fields of transportation and distribution, in order to keep supply lines open to the South and to maintain the distribution of essential economic and military supplies. A considerable effort has also been required to maintain the essential level of output from North Vietnam's limited industrial capacity in order to counter the effects of air attack and to sustain a capability to support the war in the South. These programs have forced significant reallocations of manpower and rapid increases in the flow of military and economic aid from other Communist countries.

Through the skillful and sometimes ingenious use of a number of countermeasures the North Vietnamese have met with considerable success in withstanding the pressures of US air power. These countermeasures are discussed in the following sections.

A. Civil Defense

The North Vietnamese have developed an extensive civil defense system characterized by increased precautions to minimize casualties, an ex-

tensive shelter system, the dispersal of large parts of the urban population, and radical adjustments in school, work, and marketing hours to avoid large concentrations of people during daylight hours.

During the third quarter of 1966 there was an intensified program to refurbish and to expand the shelter system. According to the North Vietnamese press, some 55,000 shelters were built in Haiphong during one 10-day period. In the city of Vinh it is claimed that every family has its own shelter. Almost every area of the country reports the construction of thousands of shelters and many kilometers of trenches. Although the number of shelters and protective facilities cannot be quantified, a new intensification of the program during the first quarter of 1967,

make it obvious that the program is extensive.

In addition to the shelter program, North Vietnam has vigorously pursued a program of urban evacuation and industrial dispersal.* Urban evacuation was accelerated after the air strikes on petroleum storage facilities near Hanoi and Haiphong in

*Industrial dispersal is discussed in C.

mid-1966 and has acquired a new momentum after the strikes in these areas during the past months. Most cities appear to have evacuated a substantial portion of their population. [redacted]

the North Vietnamese press agree that Hanoi and Haiphong have probably evacuated half their population. Ninety percent of the population of Hai Duong city is reported to have been evacuated, and only 2,000 of Thai Binh's 19,000 residents are reported to remain. Nam Dinh reportedly has reduced its population of 95,000 to 20,000 or 30,000.

The urban evacuation that has been achieved probably approximates the desired level. In fact, recent North Vietnamese newspaper accounts of evacuation appear to be more concerned with the problems encountered in resettling than with encouraging further evacuation. Unsanitary conditions, separations among families, and a cool reception by residents in resettlement areas continue to have an adverse effect on evacuees. Moving people out of cities, the mayor of Hanoi has conceded, is less a problem than providing them with supplies, housing, schools, and means for earning a livelihood. Despite the difficulties of the program, the reduction of urban

populations is regarded by the regime as a prudent measure and has been credited with limiting the number of casualties.

The North Vietnamese population is apparently well disciplined and responsive to civil defense measures. The intensification of US air attacks has meant, however, that routine activities have become increasingly disrupted. In an attempt to minimize the disruptive effect of air raid alerts--reported to number as many as 18 a day--North Vietnam has modified alert procedures for port workers in Haiphong and Hon Gay.

Similar steps have been taken in Hanoi to reduce the harassing effect of air raids. Reportedly, no alarm is sounded in the capital city until hostile aircraft have entered within a 20- to 30-km. radius of the city. In some instances air raid alerts have coincided with the first bursts of AAA or the sound of exploding bombs.

B. Air Defense Countermeasures

During the past three years the Hanoi regime has developed North Vietnam's air defenses from a relatively rudimentary state into a complex, sophisticated system. The system now includes an integrated network of radar sites, interconnected by filter centers and communications facilities, and a widespread deployment of SAM missiles, MIG aircraft, and conventional antiaircraft guns. The number of AAA guns of all calibers increased from about 1,200 in February 1965 to about 6,000 two years later.

Since the introduction of the Soviet-supplied surface-to-air missile system into North Vietnam in mid-1965, at least 162 SAM sites have been constructed. SA-2 missile battalions currently are deployed in from 28 to 32 of these sites, with the remainder of the sites adding to the over-all flexibility of the system. North Vietnam's radar order of battle has increased in size from 24 pieces of equipment in 1962 to 434 pieces in February 1967. Electronic equipment of higher quality and sophistication has added further to the coverage provided. North Vietnam's current inventory of about 100 MIG

aircraft* apparently is not substantially higher than a year ago. Stepped-up employment of MIGs in their air defensive role, however, has been noted in recent periods in the Hanoi/Haiphong area. Although enemy aircraft have not yet inflicted major losses on US air forces, their presence has posed a threat which has sometimes caused US pilots to jettison ordnance short of the assigned targets.

The growing threat presented by North Vietnam's air defense system is illustrated by defensive activities encountered by US forces while carrying out attacks against the Hanoi Transformer Station during a nine-day period in April and May of this year. Enemy air defense operations over this target, which is about seven miles north of Hanoi, included multiple surface-to-air missile firings, harassing flights of MIGs, and heavy antiaircraft fire. US forces, made up of a minimum of 56 strike aircraft, suffered damage amounting to five aircraft lost; one mission was forced to abort short of the target; and several aircraft had to jettison their ordnance in order to react to MIG attacks.

*Including approximately 30 MIGs believed to be filling a reserve role at bases in Communist China.

As shown in Table 4, the primary cause of US losses over North Vietnam is conventional ground fire. However, the threat imposed by SAM missiles presumably accounts indirectly for an unknown percentage of these losses because it forces US aircraft to fly at lower altitudes lying within the range of the AAA guns.

Table 4

Combat Losses of US Aircraft over North Vietnam, by Cause
1965-April 1967

Cause	Number	Percent
Ground fire/other	453 a/	86
SAM	54 b/	10
MIG	20 b/	4
Total	527	100

a. An additional nine GVN aircraft were lost to ground fire in 1965.
b. Including possible/probable downings from these causes.

In view of the buildup in the enemy's air defense system, US losses over North Vietnam have remained surprisingly low, and the over-all ratio actually has declined as the hostilities have progressed. The lower trend in US losses has been especially apparent since the spring of 1966. A

comparison of US loss ratios by year for operations over North Vietnam is given below.

Year	Total Attack Sorties	Combat Losses a/	Losses as a Percent of Total Attack Sorties
1965	25,940	173	0.67
1966	82,170	284	0.35
1967 b/	20,550	52	0.25

a. Excluding operational losses due to equipment failure.
b. January-March.

There are some indications, however, that the favorable decline in the loss ratio may be reversed if there is a major escalation in the number of US attacks against the northern areas of North Vietnam. The loss rate for the recent attacks on targets in the Hanoi-Haiphong area is 3.7 percent compared with the 1967 average for all areas of about 0.25 percent. About 40 percent of US combat losses during 1967 to date were over Route Packages V and VI, although only about 9 percent of total attack sorties were flown over these areas. These route packages are defended by almost 67 percent of the enemy's inventory of 37 to 57-mm. guns and more than 90 percent of the inventory of 85 to 100-mm. guns. Furthermore, an increasing threat from SAM defenses is apparent from the following tabulation, which gives SAM missiles fired by North Viet-

nam per 100 attack sorties flown over Route Packages V and VI.

Year and Month	Attack Sorties a/	Missiles Fired	Missiles Fired Per 100 Sorties
1966			
March-April	900	64	7.1
May-June	770	65	8.4
July-August	2,900	389	13.4
September-October	2,350	144	6.1
November-December	2,030	384	18.9
1967			
January-February	1,130	394	34.9

a. Rounded to the nearest 10.

As shown above, in the first two months of this year, almost 35 SAM missiles were launched by the North Vietnamese for every 100 attack sorties flown over the northern route packages by US air forces. The effectiveness of the SAM response to US attacks should be increased by the recent indications that Soviet personnel have assumed more control over SAM operations.

C. Decentralization of Industry

Although North Vietnam asserted the importance of local industry and called for its continued growth long before the country was subjected to US bombing, the country's main industrial objective before 1965 was to establish a heavy industrial base consisting

of large capital-intensive plants. The advent of US air strikes in 1965 forced an admitted reversal of these priorities and resulted in a renewed and sharply increased emphasis on local industry, which was to be expanded through the dispersal of industry from potential urban target areas as well as through the construction of small facilities supplied with new equipment.

Dispersal of existing facilities reportedly began early in 1965, just before the start of the Rolling Thunder program. It is estimated that most dispersal has involved those facilities--small factories and cooperatives--with easily moved machines and easily divisible production processes. Dispersal has been applied both to facilities in urban areas and to those near probable targets in the rural provinces.

The extent of dispersal of even small facilities in 1965 and 1966, however, is unclear. Several conflicting reports have been received on dispersal of industry in Hanoi and Haiphong, some suggesting almost total economic dispersal of industry, others emphasizing the large numbers of facilities still operating. The mayor of Hanoi, in an interview with a Czechoslovak reporter in January 1967, said that,

although several enterprises were evacuated from the city, there were still more than 200 industrial enterprises of various sizes remaining. The North Vietnamese press also has periodically criticized the slow pace of dispersal. On the other hand, there is little doubt that many small facilities have been dispersed, and the movement probably has been stepped up since the heavy raids in the vicinity of Hanoi and Haiphong in the spring of 1967.

Only two large industrial facilities--both textile plants which accounted for about 75 percent of the national weaving capacity--are known to have been extensively dispersed. Evacuation of the Nam Dinh Textile Mill probably began even before it was unintentionally damaged by an air strike in July 1965, and all spinning and weaving equipment probably was dispersed by the spring of 1966. Photography confirms the absence of equipment in a sizable area of the plant. North Vietnamese films show that the 8 March Textile Mill in Hanoi also had a large part of its capacity removed by early

1966. The Hanoi Engineering Plant is the only large plant reported to have dispersed some equipment, but this plant also has had new equipment installed at the original site.

North Vietnam's heavy industrial plants generally are not easily dispersed because of technological considerations and/or because of the size of equipment involved. Photography has even shown recent construction activity at the 8 March Textile Mill in Hanoi, at the Hanoi Chemical Fertilizer Plant, and adjacent to the Hanoi Engineering Plant. This activity remains unexplained and conceivably is not associated with industrial expansion. The psychological effects of the recent strikes near urban areas cannot be discounted, however, and a determined effort may be under way or in planning to disperse parts of heavy industrial plants--perhaps machine shops from the large engineering plants and batch operations at the large chemical plants--which may not have been affected heretofore. Nevertheless, such industrial processes as the blast furnace operations at Thai Nguyen, chlorine production at Viet Tri, and the kiln operations at the Haiphong Cement Plant still would not lend themselves to dispersal.

Little is known about the locations to which the evacuated equipment is taken. Most North Vietnamese commentary refers to movement to the "countryside." The return to Hanoi at night of many evacuees from the city suggests that the facilities dispersed from the city may not have been moved very far. Some facilities, however, have been moved to the mountainous northwest, reportedly to take advantage of the power potential presented by the presence of numerous small streams. This movement also fits in with North Vietnam's longstanding interest in settling and cultivating the land in the northwest. Several locations have been reported as sites for dispersed equipment from the Nam Dinh Textile Mill, ranging from near Nam Dinh to 50 to 100 miles distant. Caves, jungle, and other natural protection or camouflage are utilized whenever possible in order to provide maximum protection against air attack.

On balance the decentralization program probably has been successful from North Vietnam's standpoint. Efficiency of production and some production *per se* certainly has been lost in the evacuation process as well as in the installation of equipment in less than ideal circumstances. Prob-

ably more important, though, has been the accelerated establishment of new machinery and repair shops, new food-processing facilities, new irrigation facilities, and new handicrafts which have added to the economy of the rural areas without detracting from the economy elsewhere.

D. Countermeasures on Lines of Communication (LOC's)

1. Construction and Repair Activity

The main effect of the Rolling Thunder program against lines of communication in North Vietnam has been a strenuous and successful effort by the North Vietnamese to keep all important transportation routes open to traffic. Besides diversifying the means of transport to include greater use of inland waterways and porter trails, the North Vietnamese have constructed multiple bypasses at road and railroad bridges on all important stream crossings, built alternate roads, and upgraded the rural road system to provide alternatives to heavily bombed routes. The program of countermeasures has had equal priority on LOC's in North Vietnam and the Laos Panhandle and has been accomplished at relatively low cost because of a willingness and ability to use primitive methods and materials. The net effect in

terms of logistic supply capability has been to make North Vietnamese transport more flexible than before the bombing by offering more choices of possible crossings and routes by which to supply the Communist war effort in South Vietnam. Added routes, moreover, further reduce a rather low average daily tonnage requirement per LOC.

The success of the North Vietnamese in outpacing the damage inflicted on LOC's by air strikes can be measured by the change in the number of bypasses built over stream crossings.* A comparison of the period from the start of the bombing through September 1966 with the period from October 1966 through April 1967 shows that the average number of separate bypasses for damaged bridges increased from 0.98 to 1.15 per highway bridge and from 0.51 to 0.86 per railroad and combination railroad/highway bridge. In addition, the Communists are in a less vulnerable position because they have had time to put in alternative crossings even at points not yet struck. In addition to the construction of bypasses, the North Vietnamese often repair the original bridge if the damage is not too extensive.

*Bypasses include temporary bridges, fords/culverts, ferries, and pontoon and cable bridges.

Greater speed in repairs during 1966-67 can be directly attributed to an extensive development of bypasses and to a variety of deception techniques. To augment traditional bypasses such as fords, ferries, and timber bridges, more use was observed in 1966 of prefabricated movable spans, steel cable bridges, and camouflage. The use of a variety of multiple stream crossings suggests that the only effective way for air strikes to render a crossing unserviceable is to destroy the original bridge and all bypasses simultaneously--a very difficult and costly tactic.

A slightly different but equally effective pattern of countermeasures emerges in the Laos Panhandle where an interdicted bridge or ford is usually bypassed by a construction of a short road around the entire chokepoint. Crossings that have been repeatedly bombed take on a cobweb pattern of bypass roads, of which one is serviceable most of the time.

New road construction and the upgrading of rural roads and trails also provides the North Vietnamese with additional supply routes to counteract the effects of the bombings and reduce the

tonnage per road. In North Vietnam during 1966, a system of alternative roads was built to bypass the main coastal route 1A between Thanh Hoa and Quang Khe, while a new border crossing road into Laos was built as a supplement to route 15 through Mu Gia Pass. The pattern of road construction in the Laos Panhandle during the 1967 dry season has emphasized many short bypasses around heavily interdicted points on the existing road system that was so greatly expanded during 1966. The extension of route 922 east into the A Shau Valley of South Vietnam has been the most strategically important new road built thus far in 1967 and the first time a part of the Ho Chi Minh Trail has been made into a motorable road across the border into South Vietnam.

2. The Manpower Involved in Countermeasures

The most important resources employed by the North Vietnamese in their countermeasures on lines of communication have been mass labor and local materials. Although the air attacks have forced the diversion of many North Vietnamese workers to repair LOC's, their ability to simultaneously continue production in the limited industrial sector and de-

velop alternate LOC's indicates that the diversion has not caused serious dislocations in the economy. It is estimated that up to 125,000 workers and Chinese engineering troops, the latter north of Hanoi, are currently engaged in the full-time repair of LOC's in North Vietnam and in the Laos Panhandle (72,000 North Vietnamese, up to 34,000 Chinese engineering troops north of Hanoi, and 19,000 NVA/PL in the Laos Panhandle). The use of part-time workers primarily from the agricultural sector has added at least 100,000 to 200,000 additional day laborers for road, rail, and bridge repair work as needed.

3. The Effectiveness of Bombing Bridges

The bombing of bridges in North Vietnam has been unsuccessful in reducing the flow of men and material toward South Vietnam. Moreover, bridge targets have been very costly in terms of planes lost and have been effectively and quickly bypassed when they were destroyed.

A sample of 48 JCS-numbered bridges has been analyzed in detail to determine the effectiveness of bombing bridges in North Vietnam as a tactic to interdict traffic. Since the start of the Rolling Thunder program in February 1965, the US and the South Vietnamese have bombed 48 out of a total of

61 JCS bridges in North Vietnam. During the numerous strikes and restrikes against these bridges, at least 35 planes were lost.

The North Vietnamese have been able to offset the effects of bomb damage to bridges by constructing multiple bypasses for every chokepoint bridge in the country. They have been able to build 96 separate bypasses for 45 JCS bridges within the immediate vicinity of the 45 JCS-targeted bridges or an average of slightly more than two bypasses per bridge. A single bridge is a very difficult target to destroy by aerial bombardment, and construction of multiple bypasses at a crossing site further reduces the probability of effectively interdicting a LOC. The following tabulation shows a breakdown of the North Vietnamese countermeasures used to bypass 45 JCS bridges:

Type of Bypass	Number
Alternative bridges	24
Pontoon bridges	15
Cable bridges	9
Ferries	30
Fords	18
Total	96

The construction of multiple bypasses, in addition to ensuring a flow of traffic for the North Vietnamese, greatly increases the cost of the bombing program to the US. In general it takes as many sorties and as much ordnance to interdict bypasses as to interdict the original bridge.* The cost to the US of bombing, therefore, increases at a much more rapid rate than the cost to the North Vietnamese because the majority of the bypasses are low-cost expedients which can be repaired rapidly.

E. Contingency Planning

Along with reacting to existing bomb damage, the North Vietnamese have, since the inception of the bombing, developed contingency plans -- countermeasures taken before bombing occurs -- to cope with escalation and shifts in emphasis of the Rolling Thunder program.

*If it is assumed, for example, that 10 tons of supplies each day are moving over a LOC containing one bridge, past performance suggests that one hit on the bridge will be scored and traffic interdicted if 47 bombs are dropped. The average ordnance load carried by aircraft over North Vietnam is just under two tons. If the load consists of 500-pound bombs, it takes approximately six sorties to interdict a bridge. To interrupt the same 10 tons of traffic which can be handled by three possible crossings--the original bridge or each of two separate bypasses--141 bombs in the 500-pound class must be expended and 18 sorties flown.

These contingency plans are difficult to separate from other reactions to existing bomb damage, and thus often not easily recognizable. In addition, contingency plans and countermeasures to existing bomb damage must compete for the same scarce resources.

The nearly complete civil defense evacuation system in Hanoi and Haiphong and the elaborate system of bridge bypasses are examples of ambitious contingency planning. A civil defense shelter program is nearly complete in Hanoi, despite the capital's relative immunity from air attack. In addition, a full half of the populations of Hanoi and Haiphong are believed to have been evacuated. A number of unstruck North Vietnamese bridges have highway and rail bypasses already in place in anticipation of future possible strikes. Before the Hanoi Highway and Rail Bridge over the Canal des Rapides [redacted] was struck in late April, piers for a bypass span had been in place for a number of months, and bridge decking was stored on the river bank. A 7.3-mile rail bypass and rail ferry skirts the unstruck Hanoi "Doumer" Bridge [redacted]

Despite an ability to transport an adequate level of supplies to the South with its existing although constantly attacked transportation network, North Vietnam has continued to expand the capacity

of the network. For example, the Dong Dang Rail Line has been dual gauged and extended from Kep to Thai Nguyen. An alternative road network to Route 1 A is nearing completion south from Thanh Hoa. Presumably Hanoi is preparing for the contingency that the US will greatly escalate the LOC campaign or mine Haiphong harbor, necessitating the use of this extra capacity.

In other areas, Hanoi's contingency plans have been less ambitious because of the strain placed on resource availability by countermeasures to existing bomb damage. Although small portable diesel electric power generators were received from the USSR in small numbers during 1964 (22 in 1964), purchases did not pick up to their present high rate until the US had begun attacking thermal powerplants in the southern route packages in mid-1965. Although partial dispersal of several textile mills and some handicraft industry took place in 1965, other major, unstruck plants appear to be in full operation despite their vulnerability.

Some dike and road interdiction contingency plans appear to have been put into operation. Steel mesh for repairing breaches has been reported in storage along dikes. Piles of stone and earth have

been observed along roadsides; local village "volunteer" crews are ready to fill crater holes.

F. Imports and Foreign Aid as Countermeasures

1. Economic Aid

The sharp and continuing rise in economic aid to North Vietnam in the form of imports from the other Communist countries has been an important countermeasure to the bombing effort in North Vietnam. This aid has risen from an annual average of $50 million to $75 million for 1955-64 to an estimated $150 million in 1965 and $275 million in 1966, and it seems to be increasing again in 1967. Most of the aid extended through 1964 was for North Vietnam's economic development program. The more recent aid agreements make it clear that the Communist countries have implicitly guaranteed to finance the economic losses incurred by North Vietnam in its war effort.

Pact countries had pledged $1 billion to support Hanoi's war effort seems an indication of the effort that the Communist countries seem willing to make.

The value of this aid can be seem principally in the rise in imports in 1965 and 1966,

particularly the rise in imports of those goods supporting the war effort.

The Communist countries have provided substantial quantities of equipment for transportation, construction, power, communications, and maintenance programs. Furthermore, machinery and equipment apparently have been made available for both new and continuing aid projects which are not military associated, although this category of aid goods seemed to decline in 1966, and seems likely to decline even further in 1967.

There have been sharp increases in imports of machinery and equipment -- machine building shops, repair shops, small manufacturing enterprises, vehicles (road, rail, and water), heavy transport and roadbuilding equipment, machine tools, small diesel generators, and volumes of spare parts -- all related to the repair and replacement of parts in the transportation and power sectors of the economy and to repair and reconstruction programs. The power sector is particularly dependent on diesel generators because the regular electric power industry has been so heavily damaged by the bombing and because of the decentralization of industry. Telecommunications imports are another valuable but

small-volume category, with most military communications equipment supplied by Communist China, probably by rail.

Petroleum products are an extremely large volume import -- imports by sea increased to 200,000 tons in 1966 compared with 170,000 tons in 1965. Early 1967 reports show another large increase. Petroleum imports are essential to the transportation, construction, and power sectors of the economy, particularly to the power sector since it has become so dependent on diesel generators.

Almost all iron and steel products must be imported because North Vietnam makes no steel, although it does produce pig iron at the Thai Nguyen iron and steel complex. Products related to the war effort, such as barges, POL storage tanks, pontoons, building members, possibly bridge trusses, and other structured shapes, are fabricated at Thai Nguyen and possibly at other locations. Most of these metal products come from the USSR and Japan by ship, although Communist China probably ships some steel products by rail. Imports of these metals by sea during 1966 were double the volume in 1965.

Bulk foodstuffs imported by sea have increased sharply in late 1966 and early 1967. This

increase parallels the reports of losses of rice production in North Vietnam in 1966, and it may also reflect internal distribution problems. Food imports could become important if the seeming food shortage worsens. Another factor in the food supply has been the large and increasing imports of fertilizers. Maintenance of the food supply may be more difficult if the fertilizers are not received and distributed properly.

The relative backwardness of North Vietnam's economy, however, makes it less vulnerable than its dependence on imports might suggest. The economy of North Vietnam is still basically one of subsistence agriculture, with an essential self-sufficiency in food, although continuation of the shortages reported in late 1966 could bring about a critical situation if imports are cut off. Denial of imports to North Vietnam otherwise would have minimal effect on the nonindustrial economic organization generally. Even the loss of transport equipment could be compensated for in the domestic economy by the extensive use of manpower for the transportation of necessary goods.

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2. Military Aid

In addition to increasing their deliveries of economic goods, the USSR and Communist China responded to the Rolling Thunder program by increasing sharply the levels of military assistance,

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Deliveries of military equipment, which previously had been on a very small scale, reached an estimated

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Deliveries in the first quarter of 1967 have been at a slightly higher rate than that observed during 1966, and may increase even more during the remainder of 1967.

Chinese military aid programs follow well-established lines which reflect the capabilities

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of the donors. The USSR has provided heavier and more advanced equipment such as antiaircraft guns, radar, tanks, artillery, SAM systems, and most of the advanced fighter aircraft. The Chinese have been the major suppliers of trucks, small arms ammunition, and equipment for ground forces.

25X1

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In addition to deliveries of military equipment, the USSR and Communist China have provided military advisers and technicians to North Vietnam. The Chinese contribution in this area is far greater than that of the USSR. At the end of 1966 an estimated 25,000 to 45,000 Chinese support troops were in North Vietnam working on the construction, repair, and defense of transportation facilities. In contrast, the number of Soviet military technicians was between 2,500 and 3,000 during 1965 and currently is estimated at from 1,000 to 1,500.

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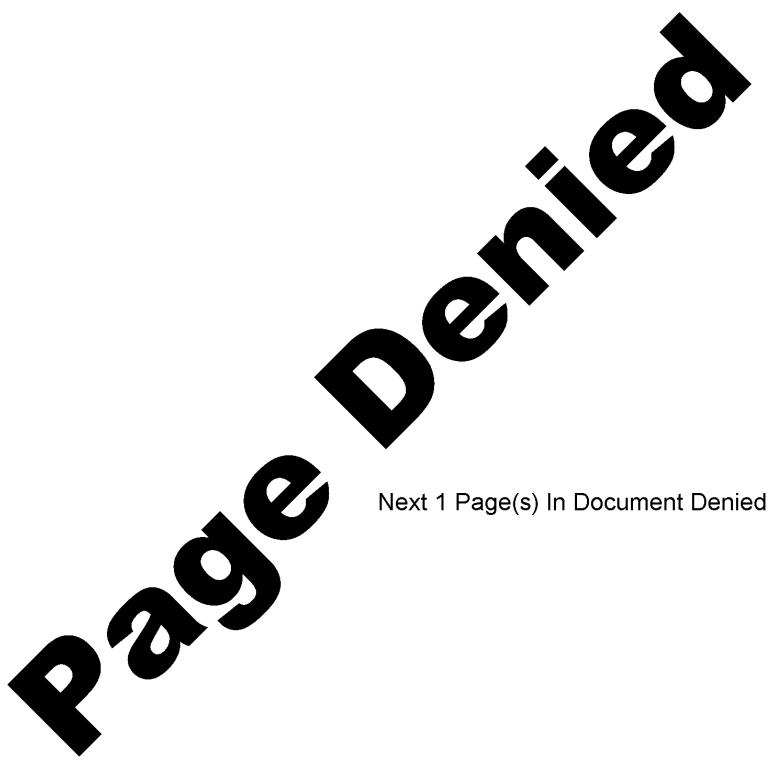

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III. Prospects of an Effective Bombing Program

A. The Success to Date

The objectives of the bombing program are stated currently to be two-fold:

1. To limit or raise the cost of sending men and supplies to South Vietnam.
2. To make North Vietnam pay a price for its aggression against the South.

To the extent that any degradation of enemy capabilities or any penalties imposed on his aggressive conduct in South Vietnam are indicative of successful achievement of US objectives, the US bombing program must be judged to be meeting with some success. But the degree of success is limited. The bombing program has undoubtedly raised the cost and increased the burdens of maintaining the aggression in South Vietnam. These exactions appear to be within acceptable limits to the Hanoi regime. Given a continuing flow of economic and military aid from Communist China and the USSR, North Vietnam remains capable of maintaining and supplying its forces in South Vietnam at both present and higher levels of combat. The price of its aggression, with the exception of manpower losses, is being assumed by its Communist allies.

Despite the increased weight and broadening of the air attack, North Vietnam has increased its support of the insurgency in South Vietnam. There was a three-fold increase in the level of personnel infiltration in 1966 and additional thousands of troops have been positioned in and around the DMZ. The flow of material supplies to the VC/NVA forces in South Vietnam during the current dry season is at least equal to and may well exceed the volume made available last year.

The North Vietnamese economy has suffered increasing damage, but this has had no decisive effect on the attitude of the regime toward the war, nor has it caused a deterioration of popular morale to the point where the regime has lost the support of its people. The performance of the domestic transportation system exceeds that achieved before the Rolling Thunder program; imports both by sea and by rail have moved to increasingly high levels. Deficiencies in domestic food supply are being met by the USSR and Communist China and food shortages have not attained serious proportions. The vital petroleum storage system, as currently dispersed, has survived the destruction of more than 85 percent of its major bulk storage capacities, and

petroleum stocks have been maintained at essentially early 1966 levels. The neutralization of 70 percent of the country's electric power generating capacity has created severe shortages of power and disrupted much of North Vietnam's modern industrial economy. It is unlikely, however, that the loss of electric power can have a significant impact on military operations.

B. Outlook

The outlook for marked success in achieving the current objectives of US bombing programs is not bright. The US bombing program had by the end of April attacked 173 targets or more than 70 percent of the targets on the JCS list. About 20 of these targets received only minor damage, so that their pre-strike capacity is relatively intact. These targets and the 69 unstruck targets are grouped, by category, as follows:

Target System	Number
Bridges	28
Airfields	7
Military barracks headquarters and storage depots	17
Powerplants	9
Locks	7
Industry	6
Mineable areas	4
Miscellaneous	11
Total	89

In addition, there are seven non-targeted industrial facilities that are significant to the North Vietnamese economy and its war-supporting activities.

The returns that can be realistically expected from the neutralization of the remaining economic, military, and land transport JCS targets is small. The two most promising target systems -- locks and mineable areas -- have been unacceptable to date on humane grounds or because of the political problems their neutralization would create. The enemy's success in countering attacks on bridges and in sustaining traffic movement is too well catalogued to warrant further discussion. Attacks on military installations would have only limited effects. Many of these facilities are inactive, and

contingency plans to counter their loss are undoubtedly well developed. Even if North Vietnam were denied complete access to its airfields, this alone would be unlikely to significantly alter the regime's attitude toward the war since it would have only a marginal effect, through increasing costs, on the flow of men and supplies to the South.

The neutralization of North Vietnam's remaining industry would extract a high price in terms of the elimination of the results of years of economic development, loss of foreign exchange earnings, and the displacement of the urban labor force, and would add to the burden of aid from other Communist countries. There is no apparent reason why such losses would force Hanoi to the negotiating table. The loss of its modern industrial sector is apparently a tolerable burden in a country that has an overwhelmingly agrarian economy. The contribution of North Vietnam's modern economy to the war effort is small and its loss can be countered as long as essential economic and military supplies can be obtained from the USSR and China.

The greatest possible impact on Hanoi would result from a US strike program which would include

mining the major ports and inland waterways, to which the remaining JCS transport targets, other than the locks, would make a useful addition. It has previously been estimated that such a program would be a matter of serious concern to the Hanoi leadership. Some import programs would have to be forgone and problems of supply and distribution would be acute. However, even this program's successful execution would be unlikely to dampen down the continued movement of men and supplies from North Vietnam to the South.

C. Costs to the US

The US would probably pay increasing costs -- both political and military -- in choosing any of the available options for escalation of the air war. The political costs in terms of both domestic US and international reactions would vary with the options chosen. US aircraft losses on the recent strikes in the Hanoi-Haiphong area have been at a rate of more than ten times those experienced during the 1966 campaign and in attacks on more isolated targets during 1967. The preponderance of the targets yet unstruck or warranting restrike are in the more heavily defended areas of North Vietnam. Almost 90 percent -- 86 targets -- are in Route Packages 4, 5, and 6. Of

these, eight are in Route Package 5, 69 are in Route Package 6, which includes Hanoi and Haiphong, and nine targets are in the buffer zone along the Chinese-North Vietnamese border.

MEMORANDUM FOR: RECORD

THIS MEMORANDUM WAS DELIVERED TO ME MCO BY THE OFFICE OF THE D/OCI IN NOVEMBER 1968. THE CIRCUMSTANCES SURROUNDING THE MEMO ARE UNKNOWN.

MCO/ [redacted] 24 NOV 68
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