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DIRECTORATE OF
INTELLIGENCE

Intelligence Memorandum

An Assessment of the Rolling Thunder Program Through December 1967

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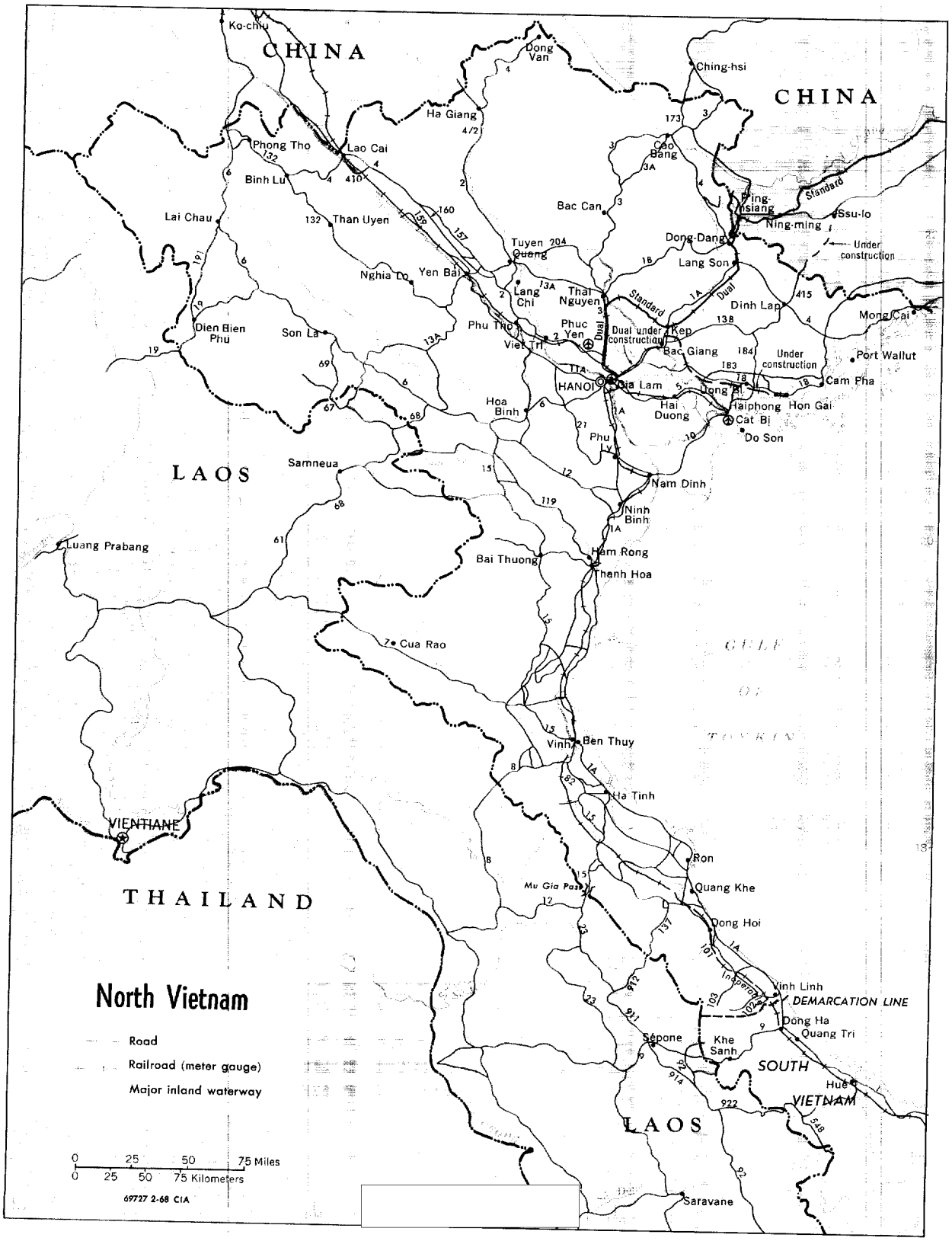

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CENTRAL INTELLIGENCE AGENCY
Directorate of Intelligence
March 1968

INTELLIGENCE MEMORANDUM

An Assessment of the Rolling Thunder Program Through December 1967

Summary

During 1967 a sustained and intensive interdiction campaign was carried out against almost every significant military and economic target in North Vietnam. The activity level was well above that of any previous year of the Rolling Thunder program. The physical damage inflicted on North Vietnam during 1967 exceeded that achieved during 1965 and 1966 combined. Most of modern industry was effectively neutralized; the disruption of agriculture, trade, and transportation reached new heights; and the lot of the average citizen became more trying. None of these results, however, has produced any significant weakening of North Vietnam's military capabilities, the apparent resolution with which the regime carries on the war, or the popular support of the regime.

The cumulative pounding by the Rolling Thunder program for almost three years has caused formidable physical damage to North Vietnam. The cost of damage to military and economic targets through 1967 is valued at nearly $420 million. Economic targets accounted for nearly $290 million of the damage (almost 70 percent of total damage), and military targets accounted for the remaining $130 million (see Figures 1 and 2). The cost of all damage inflicted during 1967 was more than one-half of the total for the three years and was more than double that in 1966.

Note: This memorandum was produced solely by CIA. It was prepared by the Office of Economic Research and was coordinated with the Office of Current Intelligence and the Director's Special Assistant for Vietnamese Affairs.

The estimated number of casualties resulting from the Rolling Thunder program continues to be remarkably low -- less than 76,000 after almost three years of bombing. Indeed, preliminary estimates indicate that the casualties during 1967 were at a much lower rate than in previous years, despite the marked increase in sorties against targets in heavily populated areas.

Air attacks in 1967 increased significantly in terms of number of sorties flown and ordnance dropped. The 191,000 sorties flown over North Vietnam in 1967 were almost as many as the total flown during the two preceding years of the air war, and ordnance dropped during 1967 was half again as much as was dropped in 1965 and 1966 combined (see Figures 3 and 4).

Many key industrial and transport targets in the Northeast were struck for the first time in 1967. Normal traffic movements in the Hanoi area are hindered by damage to the Doumer Bridge over the Red River and in the Haiphong area by the damaged railroad/highway bridge, although large numbers of bypasses have insured a continuous movement of traffic. By the end of 1967, electric power generating capacity was about 35 percent of the pre-bombing national capacity compared with a low of 20 percent during June through October 1967. The major manufacturing plants, including the Thai Nguyen Iron and Steel Complex and the Haiphong Cement Plant, were inoperable at the end of the year, but a few manufacturing facilities had been put back into partial operation as a result of the increase in electric power.

Despite serious disruptions to the transport system in 1967, the bombing has not put a relevant ceiling on the Communist force structure or levels of combat in the South. The flow of materials to support the war in South Vietnam has been stepped up and by the end of the year reached record levels. During the bombing campaign, ~~the truck and railroad~~ rolling stock inventories have increased despite heavy losses. Repairs to highways, railroads, and bridges are being made in record time. The North Vietnamese still have sufficient resources to undertake the construction and repair of railroads and highways that are not directly related to the present movement of supplies to South

Vietnam. These programs have required the diversion of large amounts of North Vietnamese manpower and assistance from Communist China. The overall result, however, is that the transport system presently has more capacity to move supplies than at any time since the bombing began.

The air defense system received most of the damage to military targets in 1967, with heavy losses of fighter aircraft accounting for almost one-half of all costs of military damage. Large amounts of military aid were supplied by Communist China and the USSR, and by the end of 1967 the air defense system was increasingly effective. Attacks on military target systems other than air defense probably have had little impact on the overall effectiveness of North Vietnam's military forces.

Despite the damage inflicted on North Vietnam's air defense system, the air war has taken an increasingly heavy toll of US aircraft. In 1967, 366 planes were lost over North Vietnam, an increase of 16 percent from 1966. Moreover, the ratio of US air losses to the number of sorties, which had declined each year since 1965, increased during the second, third, and fourth quarters of 1967. One reason was the heavy losses incurred in the large number of attacks against heavily defended industrial and military targets in the Hanoi and Haiphong areas. Loss rates in attacks against these targets are as much as nine times the overall average rates. Another reason was the increasingly effective and aggressive North Vietnamese air defense, as reflected by the continued increase in the loss rate during the fourth quarter of 1967, despite a slackening of attacks on targets in Hanoi and Haiphong.

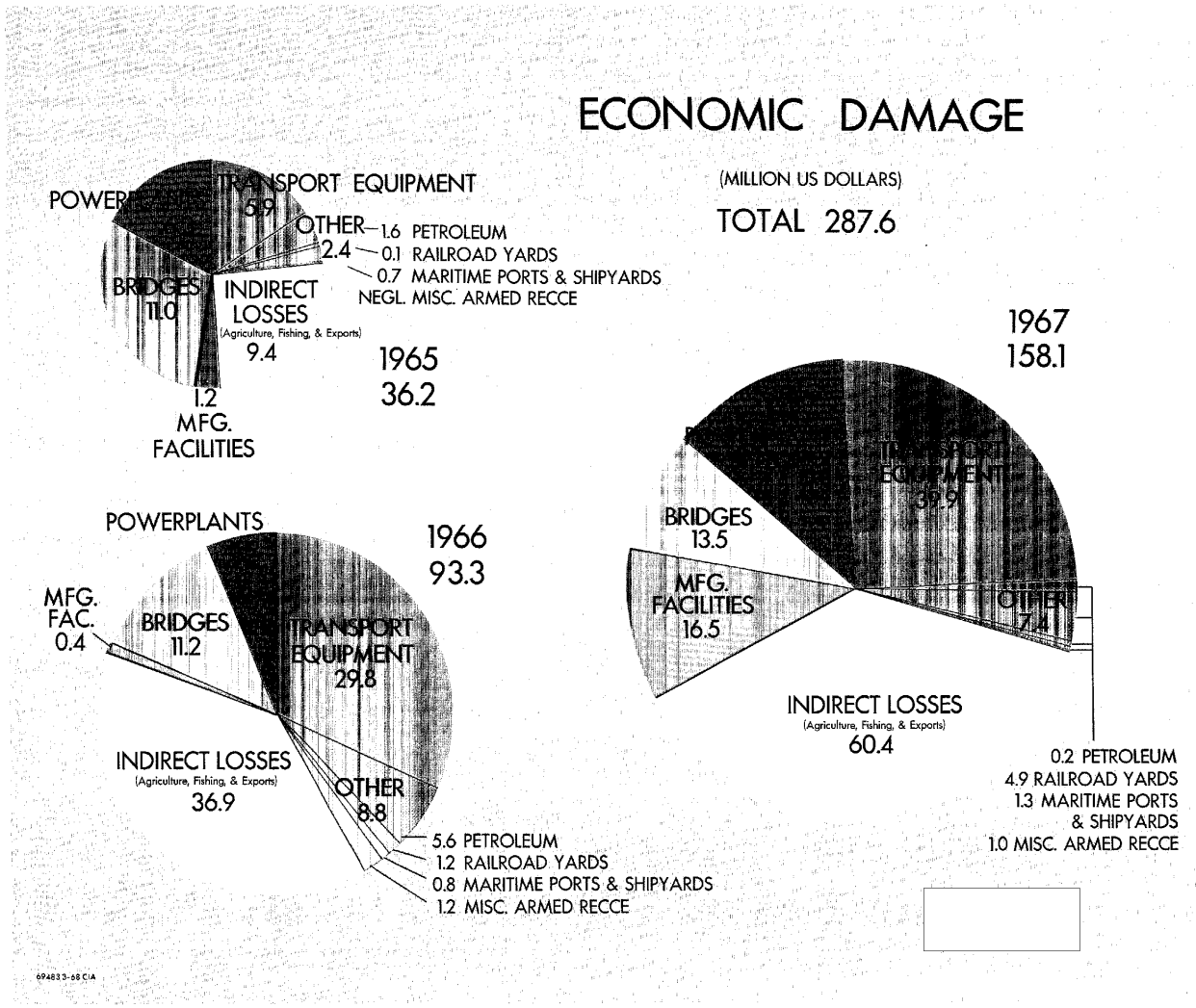

Figure 1. Value of Economic Damage in North Vietnam, by Sector, 1965, 1966, and 1967

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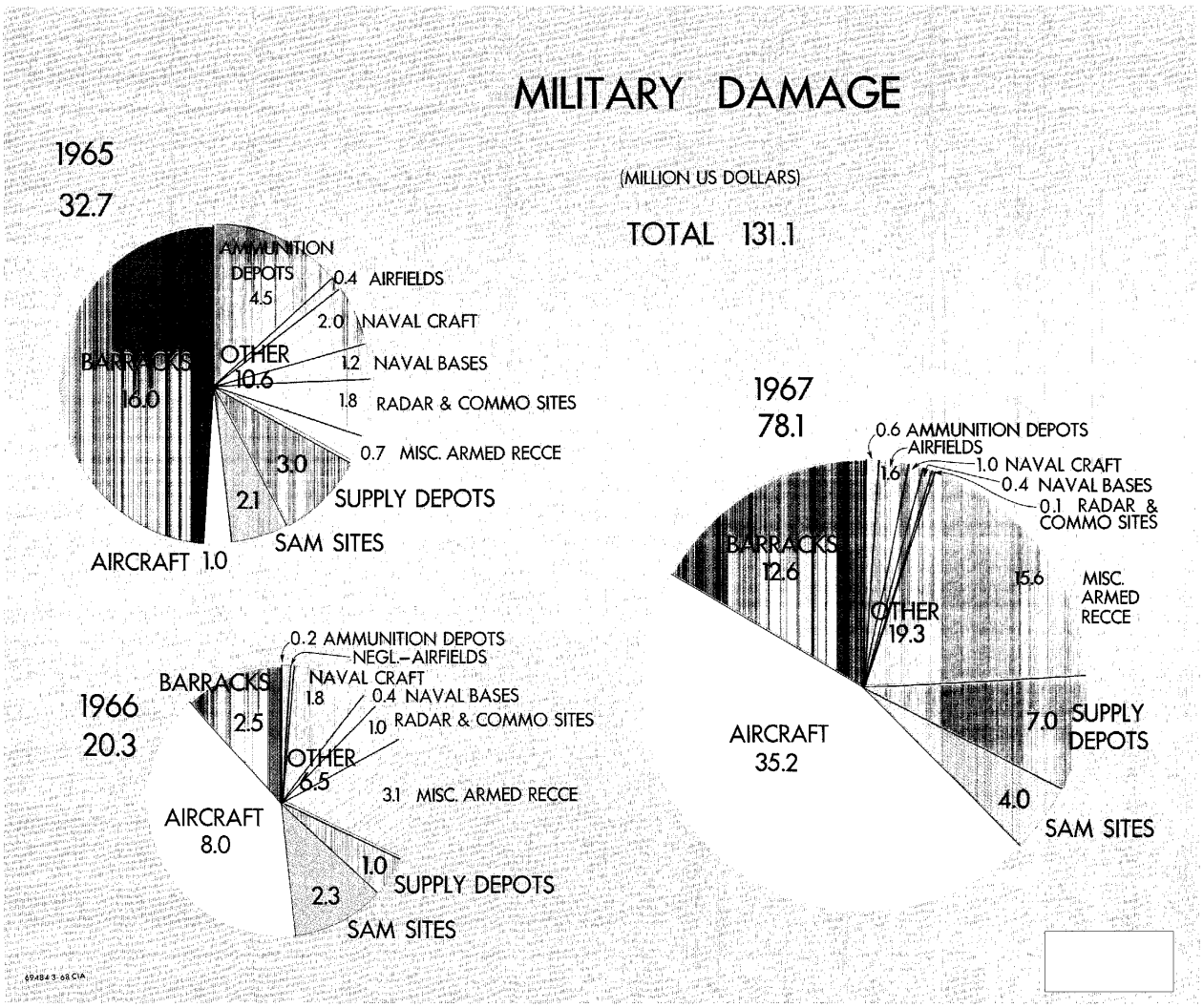

Figure 2. Value of Military Damage in North Vietnam, by Sector, 1965, 1966, and 1967

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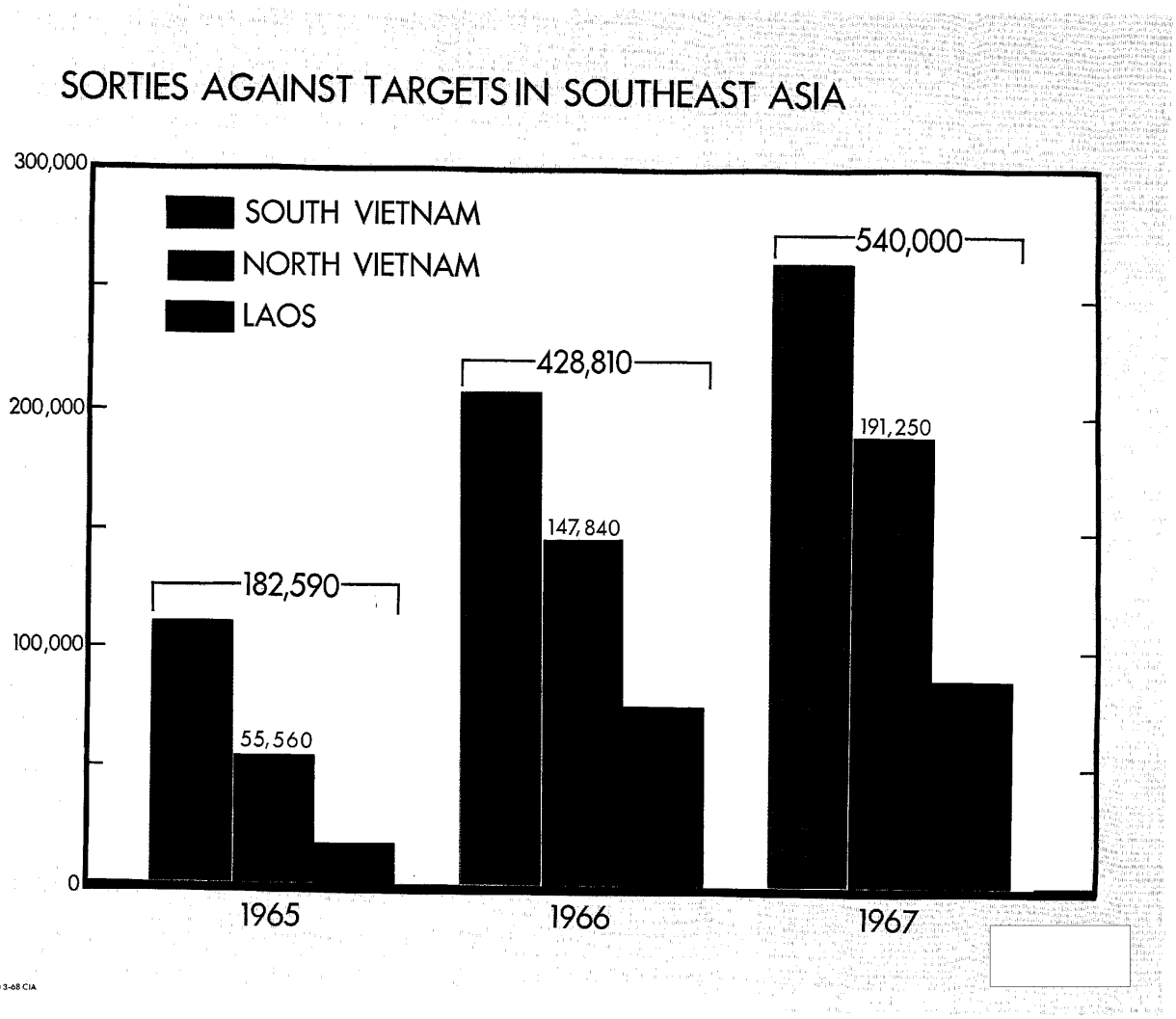

Figure 3. Sorties Flown Against Targets in Southeast Asia, 1965, 1966, and 1967

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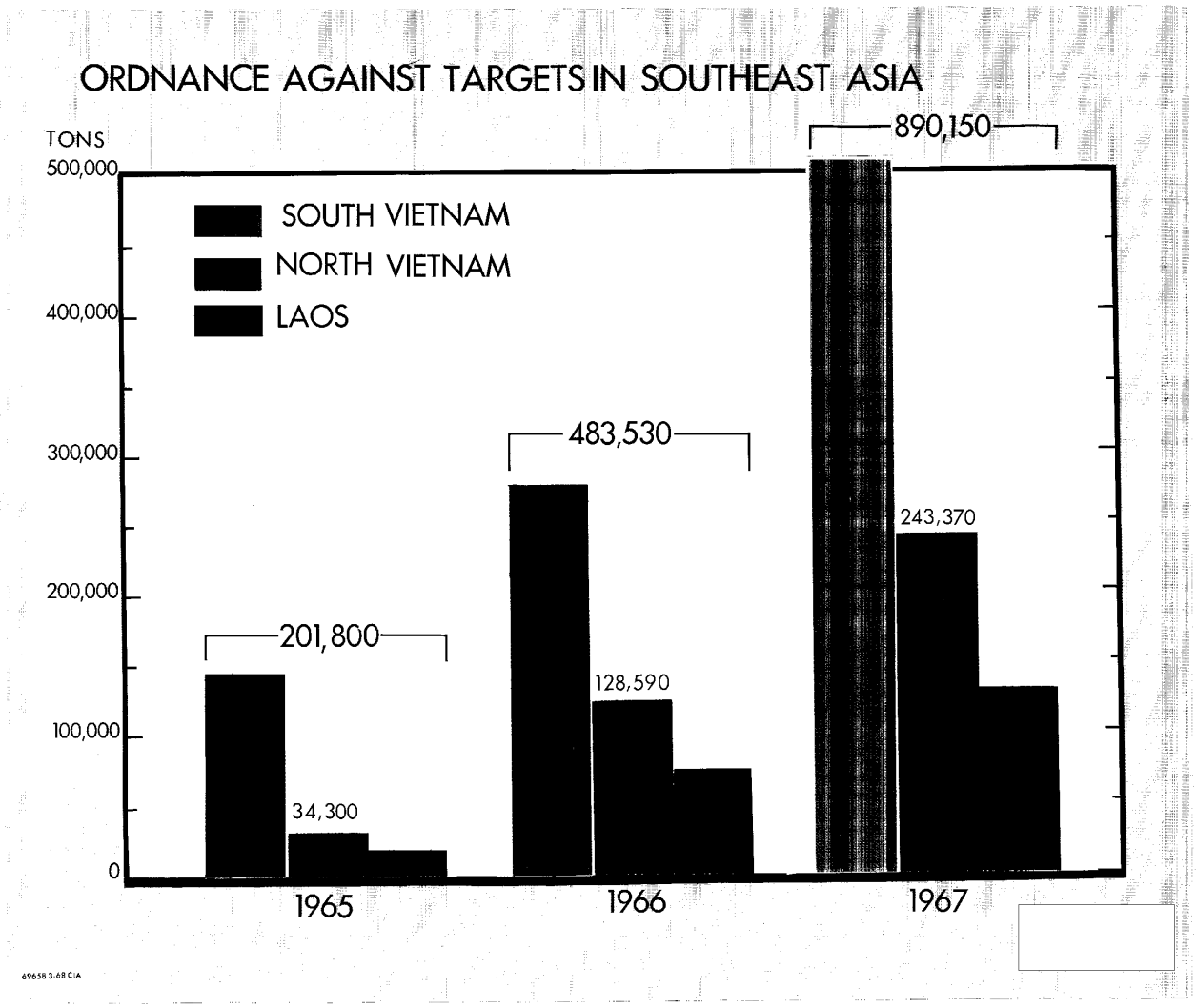

Figure 4. Ordnance Delivered Against Targets in Southeast Asia, 1965, 1966, and 1967

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I. General Trends

After reaching new peaks of intensity in the second and third quarters of 1967 the Rolling Thunder program slackened in the last quarter as flying weather deteriorated in the Northeast and intermittent bombing restrictions were imposed. Attacks against the transport system increased the disruption to transport and took a heavy toll in transport equipment. However, expansion of the bypass system in the Hanoi and Haiphong areas insured a more than adequate capacity for moving vital import goods. There were no significant air-strikes against industrial facilities during the last quarter. Damage to military facilities was limited primarily to aircraft and airfields.

The cumulative value of measurable damage inflicted by the air campaign through 1967 is estimated at about $420 million (see Table 1). Nearly 45 percent resulted from direct damage to economic facilities and equipment, 25 percent from indirect economic losses, and slightly more than 30 percent from damage to military facilities and equipment. A comparison of the cost of damage by year is as follows:

	Million US $		
	1965	1966	1967
Economic	36.2	93.3	158.1
Military	32.7	20.3	78.1
Total	*68.9*	*113.6*	*236.2*

The value of damage inflicted in 1967 was 56 percent of the total. During the first half of the year, damage increased sharply, reaching a peak in the second quarter. Although there was a significant decline in the cost of damage during the last half of the year, it remained well above comparable periods in 1965 and 1966 (see Figure 5). The only significant increase in damage during the final quarter of 1967 resulted from a heavy loss of MIG fighters.

A. Damage to the Economy

The measurable cost of damage to the North Vietnamese economy during the fourth quarter of 1967 dropped to $32 million, the lowest level for the year. Direct losses of transport equipment, rail and highway bridges, and indirect losses of crops and exports accounted for most of the cost. Losses of transport equipment were more than 50 percent below those in the preceding quarter because of the poor flying weather in the Northeast.

More than 60 percent of the direct economic damage during 1967 occurred during the first half of the year, when major industrial plants and transport targets in the Hanoi and Haiphong areas were struck for the first time. By the end of 1967, because of the longer periods free from bombing, some electric power and manufacturing facilities were put back into partial operation.

The cumulative cost of damage to the economy through 1967 is estimated at about $288 million. Direct damage to economic facilities and equipment accounted for more than 60 percent, and the remainder was from indirect losses in output of agriculture, fishing, and export products. Direct damage increased sharply in 1967, as shown in the following tabulation:

Year	Million US $
1965	26.8
1966	56.5
1967	97.6
Total	*180.9*

1. Transportation

The high levels of damage to the transport network and equipment during the second and third quarters of 1967 declined in the final quarter of the year as poor flying weather and other restrictions limited strikes in the Northeast. Although repeated interdiction of key bridges in

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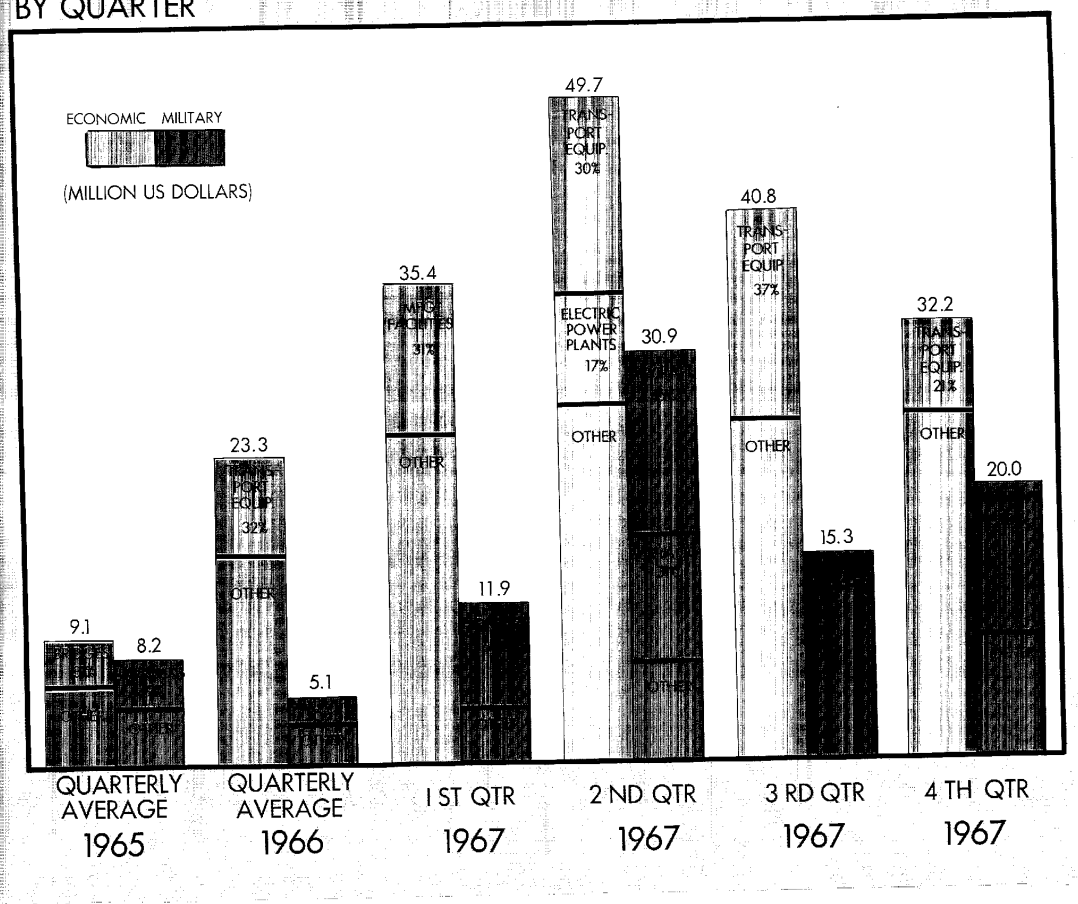

Figure 5. North Vietnam: Value of Economic and Military Damage, by Quarter, 1965-67

the Hanoi and Haiphong areas during the fourth quarter increased the cost of maintaining logistic movements and forced the use of less efficient alternates, supplies and equipment continued to flow into Laos, South Vietnam, and the DMZ at increased rates.

The value of damage to transport equipment and facilities during 1967 reached nearly $60 million, about 38 percent of all economic losses during the year and about half of the total damage to the transport system for the three years of the Rolling Thunder program. Although heavy damage was inflicted on the transport system, it has been able to withstand the bombings because of extensive and rapid repair work, substantial foreign assistance, and the construction of new and improved transport routes and bypasses. Despite numerous interdictions in the last half of 1967, for example, the key Doumer and Canal des Rapides Bridges were open to rail and truck traffic at least half the time. At the end of 1967, North Vietnam probably had more transport capacity and was better able to counter air attacks against transportation than at any previous time.

Requirements for transportation in 1967 decreased substantially below those of previous years because the shutdown of much of modern industry eliminated transport requirements for coal and other raw materials. The gross decline in the tonnage to be transported was partly offset by an increase in the volume of goods imported through Haiphong, but the net decline during 1967 amounted to about 4 million tons, an amount equal to about 20 percent of the tons carried in 1966. Consequently, transport performance dropped off for the first year since the bombing began, falling 13 percent below the 1964 pre-bombing level, as shown in the tabulation below:

	Million Tons Carried			
	1964	1965	1966	1967
Railroad	4.13	3.7	3.3	2.9
Highway	7.18	7.9	7.9	7.6
Inland water	7.01	7.7	8.5	5.3
Coastal water	0.37	0.4	0.5	0.4
Total	*18.69*	*19.7*	*20.2*	*16.2*

a. Railroads

The railroad system of North Vietnam has been under heavy attack throughout the Rolling Thunder program, particularly during the summer of 1967. During 1965 and 1966 the principal emphasis was on the line leading south of Hanoi. In June 1967 the bombing program was enlarged to include intensive attacks against multiple targets on the important railroad lines in the north and against railroad targets in previously restricted areas such as Hanoi, Haiphong, and the Buffer Zone along the Chinese border. During the last quarter of 1967, attacks against rail targets declined from the peak levels of the past summer as poor weather began to hinder air operations, particularly in the northern regions.

Air attacks during 1967 have resulted in formidable disruptions to the North Vietnamese rail network. Direct rail transport into Hanoi has been hampered by airstrikes in the latter half of 1967 on the Hanoi Railroad/Highway (Doumer) Bridge over the Red River, and the Hanoi Railroad/Highway Bridge over the Canal des Rapides (see Figure 6).* Strikes during December destroyed about 800 feet of the Doumer Bridge, and repair activities have not yet been noted. Rail transport to and from the port of Haiphong was cut in late September 1967 by strikes on the Haiphong Railroad/Highway Bridge, and although rail service has been resumed using the bypass, the bridge has yet to be restored. Traffic on the Haiphong and Dong Dang lines has been temporarily disrupted several times. The cumulative effects of the bombings have rendered much of the Hanoi-Vinh line inoperable except for shuttling operations between interdicted points.

North Vietnam's diligent application of countermeasures such as bypasses, efficient repairs, and transshipments to trucks and watercraft continues to permit an extensive use of the rail system. There are more freight cars in North Vietnam now than before the bombings, and photography

* *For a detailed discussion of the current transport situation in Hanoi and Haiphong, see Appendix A.*

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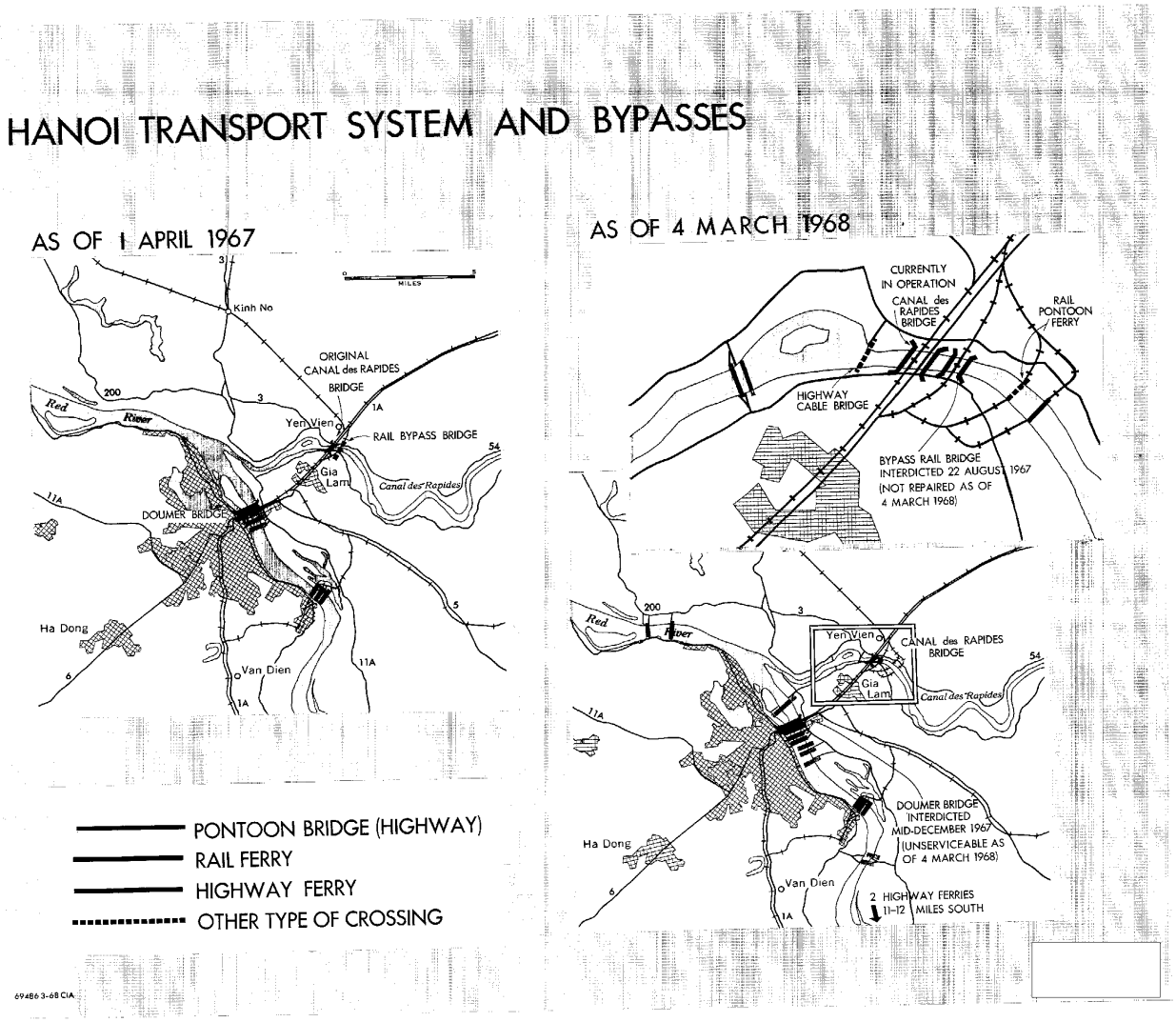

Figure 6. Hanoi Transport System and Bypasses

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provides adequate evidence that they are in use. Throughout the period of intensified attacks in the summer and fall of 1967, most bridges had at least one serviceable bypass available immediately following strikes. Railroad yards usually had at least one through track available for service soon after a strike. The heavily attacked Hanoi-Vinh line has been repeatedly repaired, and most bridges have elaborate bypass systems.

Railroad construction in 1967 further offset the disruptive effects of air attacks. The Hanoi - Dong Dang rail line north of Kep and the Hanoi - Thai Nguyen line were dual gauged.* The Hanoi - Dong Dang line south of Kep is being dual gauged. The new Kep - Thai Nguyen standard-gauge rail line also provides a high-capacity alternate for part of the rail route between China and Hanoi. The work currently under way directed at the construction of a railroad line from Kep to Hon Gai indicates that the North Vietnamese have ample capability to construct and repair rail lines, admittedly with some Chinese help.

b. Highways

The majority of attacks against the North Vietnamese highway system have been concentrated on targets south of Thanh Hoa, with primary Routes 1A and 15 receiving the heaviest damage. Intensive armed reconnaissance has also been maintained against routes which lead into the DMZ and Laotian border areas. As with the rail system, the campaign against the road network has been expanded to include highway targets, principally key bridges, in previously restricted areas near Haiphong, Hanoi, and the Chinese border.

The air attacks have had no sustained effects on truck operations because of effective North Vietnamese countermeasures. In response to the interdiction of the permanent

** The term "dual-gauge" refers to the use of three or four rails on the same roadbed, making possible the use of both meter-gauge and standard-gauge rolling stock. It is not to be confused with "double tracking" -- two separate tracks on two roadbeds with a total of four rails.*

bridges within Hanoi and Haiphong, the North Vietnamese have constructed numerous substitute, and less vulnerable, pontoon and ferry facilities which offer greater total throughput capacity than the original structures. In addition, the North Vietnamese have been able to offset the large losses of vehicles of the three-year bombing campaign by importing large numbers of trucks from Communist countries.*

The North Vietnamese, [redacted] continue to improve and expand the highway system. A new all-weather, high-capacity road linking the Ning-ming area of China with Haiphong and Cam Pha is now in the advanced stages of construction. This route will increase the existing China/North Vietnam transborder highway capacity by almost 1,000 tons per day. The North Vietnamese have even had sufficient resources to build and improve roads that are not strategically significant to the war in the south or the movement of supplies from China; Route 191 from Lai Chau to Dien Bien Phu has recently been improved and many side roads were constructed for probable use as truck parks. Numerous concrete culverts have been constructed in the Northwest across water barriers in lieu of more vulnerable bridges; the culverts consist chiefly of loose earth and concrete poured on top of steel tubes or concrete arches through which water can flow.

The North Vietnamese took advantage of the recent holiday truce periods to move large amounts of supplies by highway into North Vietnam's Panhandle region. Unlike similar periods last year, emphasis was placed on trucks rather than watercraft to move supplies. Although poor weather limited aerial reconnaissance efforts during all three truce periods (Christmas, New Year's, and Tet), about an eightfold increase in vehicle traffic above the 1967 daily average was observed on the major coastal routes south of Thanh Hoa.

c. Waterways

The heavy campaign against North Vietnam's waterways throughout the Rolling Thunder program has not appreciably affected inland or

* *For additional information on the North Vietnamese inventory of transport equipment, see Appendix B.*

coastal water transportation. The main attacks against the water transport system have consisted of armed reconnaissance strikes against waterborne logistic craft, and during the last half of 1967, the seeding of 12,000 MK-36 destructors along important water routes and at transshipment areas. Since the bombing began, pilots have reported destroying 8,000 waterborne logistic craft and damaging 14,000. Despite these attacks, both inland and coastal water transport continue to meet requirements. There is no apparent shortage of watercraft, and an inventory estimated to be in excess of 30,000 inland and coastal craft has been maintained through repairs, construction, and imports from other Communist countries.

The performance of the MK-36 is uneven. There is evidence that the MK-36 destructors have in a few instances disrupted waterborne traffic. For example, photographs indicate that the MK-36 denied use of a ferry site at Ben Thuy for a period of almost two months, although over-the-beach transshipment operations were noted in the area. Press reports from Hanoi have implied that the mining of inland waterways has hampered rescue and repair work and disrupted traffic. The MK-36's have been much less effective at Haiphong and at the Quang Khe transshipment facility. Watercraft activity has increased noticeably at Haiphong in recent months despite mines around the port area. More MK-36 devices have been dropped at Quang Khe than at any other single mining target -- a total of 845 between 15 December 1967 and 31 January of this year. Despite the presence of these mines, large concentrations of watercraft were noted operating at the facility during the Christmas and New Year's standdowns and to a lesser degree during Tet. It is becoming increasingly apparent that the use of the MK-36, even at future planned rates of seeding, will not cripple the North Vietnamese transport system.

d. Railroad Yards and Shops

Airstrikes against railroad yards and shops have increased dramatically since 1965. During 1967, 23 major yards were attacked 591 times,

compared with 16 attacks in 1965 against six major yards. The heaviest concentration of strikes in 1967 was against facilities on the Hanoi - Dong Dang and Hanoi-Vinh lines. By the end of 1967, 23 of the 27 targeted major yards had been attacked; the yards at Hanoi, Haiphong, Dong Dang, and Lao Cai have not yet been authorized for attack. In addition to the major yards, at least 30 secondary yards and numerous railroad sidings have been attacked. The estimated total cost of repairs for damage resulting from these attacks from 1965 through 1967 is $6.2 million (see Table 2). Although these attacks have disrupted activity, destroyed large numbers of rolling stock, and temporarily halted rail traffic, most yards have had at least one serviceable track available most of the time, and train operations have continued.

e. Maritime Ports and Shipyards

Four of the six JCS-targeted ports in North Vietnam and four shipyards in Haiphong had been attacked through 1967, inflicting damage estimated at $2.7 million (see Table 3). The facilities at Ham Rong and Ben Thuy, two minor ports, have been heavily damaged; Ben Thuy is unable to berth ships. The coal treatment facilities at Cam Pha were struck in 1966 and the port area was hit in September 1967. Following the September strike, coal exports dropped sharply. The port facilities at Hon Gai, another coal loading port, were attacked in April and May 1967. Four small shipyards in Haiphong -- Haiphong Shipyard No. 2, Thuong, West, and Lach Tray -- were rendered unserviceable between October and November 1967, with damage estimated at $900,000. Haiphong Shipyard No. 4, North Vietnam's largest and best equipped ship repair facility, was accidentally damaged in January 1968 during a strike against the nearby Haiphong Highway Bridge; the damage incurred is estimated at $200,000.

Damage to these ports and shipyards has had little effect on North Vietnam's maritime capabilities. The two major ports of Hanoi and Haiphong remained untouched until late February 1968 when Hanoi port was attacked. Ham Rong and Ben Thuy represented only 1 and 4 percent

of national prestrike capacity, respectively. The damage sustained at Cam Pha and Hon Gai apparently has been repaired because coal shipments have increased. Haiphong Shipyard No. 4 could be returned to pre-strike capacity in about two weeks. Damage to the other Haiphong shipyards did not reduce the North Vietnamese capacity to repair and construct steel barges and other watercraft, because the North Vietnamese can perform these functions at other yards.

f. Transport Equipment

Damage inflicted on transport equipment by airstrikes during 1967 increased significantly compared with 1965 and 1966. Reported destruction and damage of motor vehicles reached record highs in August 1967, and losses of watercraft reached new highs in May 1967. Reported monthly losses of railroad rolling stock in 1967, however, were below the record level set in September 1966. (Damage and destruction of equipment is shown on Table 4.) The total cost of replacing and repairing transport equipment destroyed or damaged through 1967 is about $76 million. The cost of damage inflicted during 1967 was $40 million, compared with about $30 million in 1966 and $6 million in 1965. An all-time monthly high in cost of damage to transport equipment was achieved in June 1967.

North Vietnam had no serious shortages of transport equipment in 1967.* Imports of trucks have been sufficient to maintain the truck inventory at pre-bombing levels.

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[redacted]

Known imports of railroad rolling stock have not equalled reported damage, but problems in rail transportation related to shortages of equipment have not been identified. Counts made from photography indicate that there is more rolling stock in the country now than was estimated to be in the

* *For a discussion of present inventories of transport equipment, see Appendix B.*

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pre-bombing inventory. In addition, Chinese railroad equipment can be made available to compensate for any shortages in the North Vietnamese inventory. More than 22,000 watercraft have been reported destroyed or damaged since the beginning of the bombing, but again there are no apparent shortages.

g. Bridges

Airstrikes against bridges were increased markedly in 1967; 326 attacks were carried out against 52 JCS-targeted bridges, compared with 144 attacks against 44 bridges in 1965 and 186 attacks against 39 bridges in 1966 (see Table 5). The total number of bridges (both JCS-targeted and non-targeted) confirmed by photography to have been damaged or destroyed by the Rolling Thunder program now stands at 507. In this total, which includes both original and bypass bridges, there are 362 highway, 97 railroad, and 48 combination railroad/highway structures. These figures understate somewhat the number of small bridges (primarily highway) that actually have been damaged or destroyed because photography may not be available for some of these bridges.

A survey of the 507 damaged bridges showed that 455 bridges have had one or more "serious damage occurrences" (SDO's).* There have been a total of 759 SDO's since the beginning of the bombings in February 1965 (see Table 6). The number of SDO's by year and the average number of times each of the 455 bridges was interdicted are as follows:

* *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	207	93	2.23

While a specific bridge may be interdicted an increasing number of times, in most cases the crossing is bypassed in a variety of ways. Of the 258 bypass bridges observed in aerial photography, 73 have sustained 110 SDO's.

The estimated cumulative cost of completely restoring the confirmed damaged or destroyed bridges to their original condition through 1967 would be $28.8 million -- an increase of more than 50 percent during 1967 and almost three times the estimate of 1965.* It is estimated that a total of at least $7.0 million has been spent on temporary repairs to bridges through December 1967, of which an estimated $3.7 million was spent during 1967. The estimated cost of temporary repairs to the number of unrepaired bridges at the end of December 1967 is $1.6 million.

The North Vietnamese have effectively countered the bomb damage to JCS-targeted bridges by building a variety of bypasses in the vicinity of each target. The average number of bypasses per bridge increased from 2.2 through May to 3.2 through December 1967, as shown in the following tabulation:

** The estimated costs for restoring bridges to their original condition as of the end of 1965 and 1966 were $10.1 million and $19.0 million, respectively.*

Type of Bypass	Through May 1967	Through September 1967	Through December 1967
Total number of damaged JCS-targeted bridges (confirmed by photography)	46	52	54
Total number of bypasses	99	157	175
Fords (including causeways and culverts)	18	22	22
Alternate bridges	26	36	38
Cable bridges	9	14	15
Ferries and pontoon bridges	46	85	100
Average bypass per bridge	2.2	3.0	3.2

The upward trend in bypass construction for JCS-targeted bridges continued during the last quarter of 1967, but at a slower rate than previously because additional bypasses are no longer needed at most of them. Available photography indicates that at least one bypass is almost always serviceable at a crossing, and instead of building new bypasses the North Vietnamese are concentrating on repairing existing bypasses to use in tandem service. Near such important crossings as the Doumer Bridge, however, the North Vietnamese continue to add bypasses and they now have 16 pontoon/ferry crossings at this location compared with 12 in early October.

2. Other Economic Targets

a. Electric Power

The main electric power network, centered on Hanoi and Haiphong, received the brunt of attacks against electric power facilities in 1967, a shift of emphasis from the 1965-66 campaign against small power systems in the southern part of the country (see Table 7). About 85 percent of attacks against the electric power industry in 1967 were against

facilities in the main network. Air attacks against power stations reached their peak during the second and third quarters; no strikes were carried out from early November 1967 to mid-January 1968. The cumulative cost of damage inflicted on power facilities is about $33 million.

Airstrikes against elecric power facilities during the first half of 1967 and restrikes in the third quarter reduced the availability of electric power to about 20 percent of the pre-strike national generating capacity of 187,000 kilowatts (see Figure 7). The respite from attacks since early November permitted a small improvement in power supply, so that by the end of 1967 an estimated 35 percent (67,000 kilowatts) was operational. Additional diesel-generating capacity of 30,000 kilowatts makes available about 50 percent of the country's pre-bombing capacity.

By the end of the year, six powerplants in the main Hanoi/Haiphong network -- Hanoi, Viet Tri, Bac Giang, Nam Dinh, Uong Bi, and Hon Gai -- were in partial operation, capable of supplying almost 30 percent of the pre-strike capacity of the network, compared with about 10 percent in the third quarter. In addition, repairs were in progress on a seventh plant at Thai Nguyen. Strikes against power facilities during January and February 1968 are believed to have caused little additional damage, but cannot be assessed finally because of a lack of post-strike photography.

The repair of damaged facilities has been accomplished by salvaging equipment that escaped heavy damage. Earlier attempts at extensive reconstruction of power facilities apparently have been abandoned. Damage to central powerplants during 1967 was so severe that complete restoration of most plants would require from one to two years, but restoration to one-half of capacity could be made by mid-1968 if the plants remained unattacked.* During the third quarter of 1967 the North Vietnamese undertook measures to safeguard transformers at network

** For a discussion of restoration attempts and alternative power sources provided by imported diesel-driven generators, see Appendix C.*

substations. Recent photography shows that a number of these transformers have been relocated in deep revetments, away from substations. This program provides an added measure of protection for equipment that will be needed to connect a powerplant into the network when salvaged generating equipment is ready for operation.

Loss of central generating plants has caused major shortages of power and heavy reliance on diesel-driven generating equipment. The cities of Hanoi and Haiphong ration power and experience intermittent power outages. Hanoi currently relies on one local powerplant, a number of diesel stations, and a small amount of power available from the main network. Haiphong is dependent on power from diesels and from the network. The inventory of diesel equipment appears adequate to provide minimal power supplies for high-priority consumers and for essential services, but it falls far short of the capacity necessary to cover total demands of heavy industry and residential-commercial users. The number of diesels available probably could offset only about 25 percent of present losses in the central generating plants at the end of 1967.

b. Manufacturing Facilities

North Vietnam's small modern manufacturing sector was severely damaged by airstrikes during 1967. Most of the larger industrial plants have been put out of operation by either direct bomb damage or a shortage of electric power. The greater part of the damage was inflicted in the first half of 1967; only one strike was carried out against a manufacturing facility -- the Hanoi Concrete Products Plant -- between August and the end of the year. Restoration of damaged industrial facilities has been observed only at the Phu Tho Phosphate Fertilizer Plant and the coal processing plants in Hon Gai and Cam Pha. The total cost of damage to manufacturing facilities is about $18 million, of which over 90 percent occurred during 1967 (see Table 8).

More than 70 percent of the cost of damage is attributed to strikes against the Thai Nguyen Iron and Steel Complex and the Haiphong Cement Plant. Both

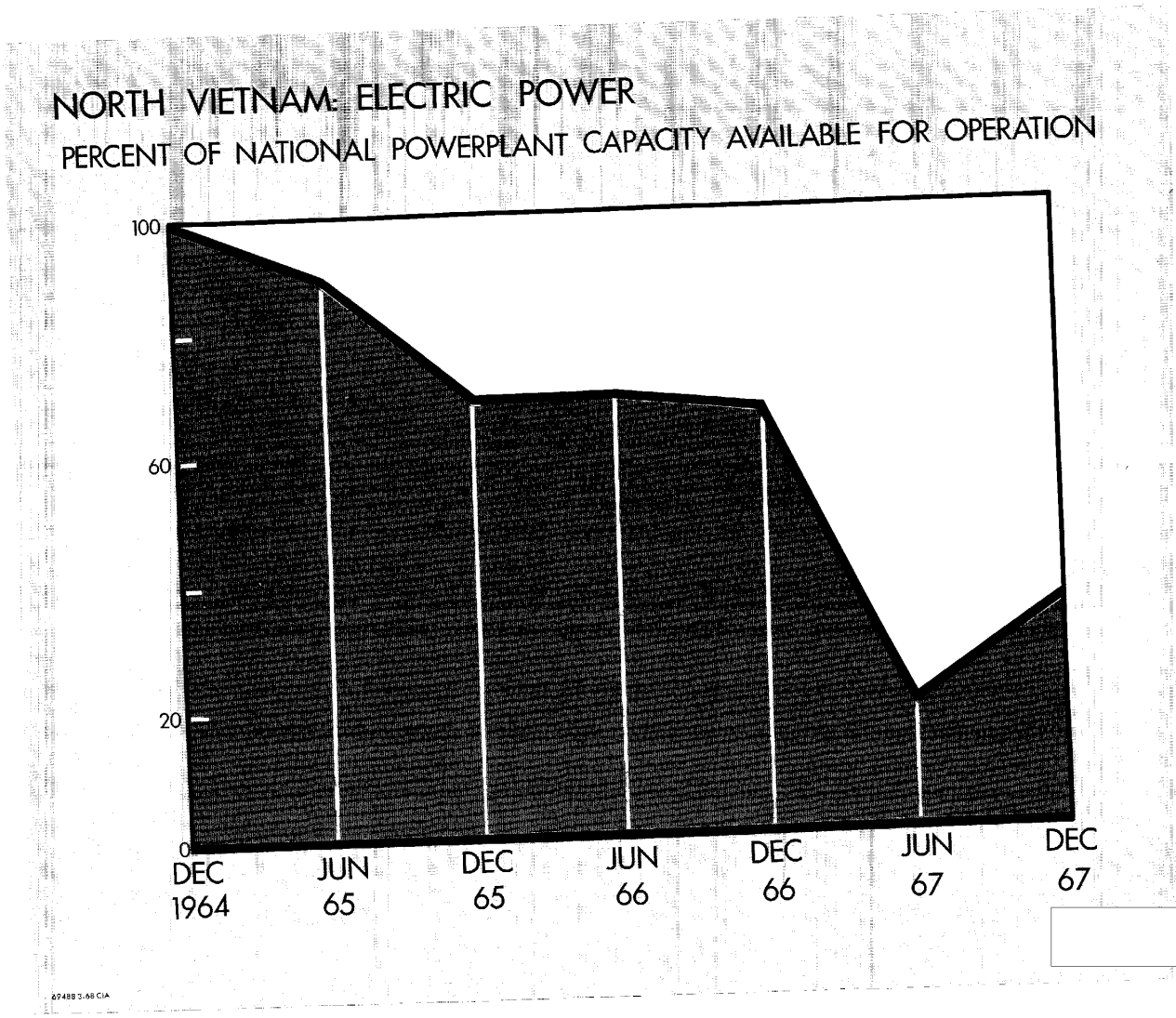

Figure 7. North Vietnam: Electric Power Capacity, 1965-67

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of these industrial installations have been inactive since the spring of 1967, and there is no evidence of reconstruction or production at either plant since that time. Results of a strike against the Thai Nguyen Complex in January 1968 are not yet known.

Production at North Vietnam's major chemicals plants was seriously disrupted in 1967. Bomb damage stopped production at the Bac Giang Chemical Fertilizer Plant, the Phu Tho Phosphate Fertilizer Plant, the Lang Chi Explosives Plant, and the Hon Gai Calcium Carbide Plant. Repair of minor damage to the Phu Tho Fertilizer Plant permitted a resumption of production during the last quarter. The Viet Tri Complex was inoperative for a large part of the year probably as a result of a shortage of power. The sugar refinery and alcohol plant of this complex, however, are believed to have resumed production late in the year. Output of fertilizer at the Haiphong Fertilizer Plant was disrupted in mid-1967, when equipment was dismantled and moved, apparently in anticipation of attacks on important nearby bridges. There is no information on the relocation of this plant.

Partial operation has been restored at other industrial facilities. The high level of activity at the coal processing and port facilities at Hon Gai and Cam Pha observed in recent photography indicates that most of the damage has been repaired. The Nam Dinh Textile Mill received heavy damage in 1967, but some parts of the bleaching, dyeing, and finishing shops are believed to be operating.

The small machine building industry with two major plants in Hanoi and one in Haiphong has remained relatively undamaged by US airstrikes. The capacity for machine building and metal processing probably has been enlarged since the beginning of the air war through substantial imports of machinery and equipment. Most machine tools imported in 1966 were appropriate for repair work and were probably intended for installation in small shops being set up throughout the country. Lathes now being imported were formerly produced domestically, indicating that North Vietnam's machine tool industry, which has not been damaged by bombing and remains in production, has probably been charged with the output of other products. Some machine tools now being imported are

high-output types, suggesting that the three machine building plants are probably engaged in the production of significant quantities of small agricultural pumps, generators, and diesel engines. The models of machine tools being imported do not suggest military output. The major tasks of the machine building shops appear to be maintaining transport equipment and producing simple agricultural equipment.

c. Petroleum Storage Facilities

During 1967, 13 airstrikes were mounted against JCS-targeted petroleum storage facilities. Identified damage was inflicted only at Do Son where about 1 percent of North Vietnam's original storage capacity was destroyed. One of the original sites -- Can Thon -- that had been partly destroyed in attacks at the end of 1966 was abandoned during 1967. The buried tanks that survived the attacks were exhumed and presumably have been relocated at an unidentified dispersed storage site. Airstrikes during 1967 against dispersed storage, including both tanks and 55-gallon drums, resulted in the destruction of an estimated 3,000 tons of petroleum, with a value of about $300,000.

The cumulative value of destruction inflicted on petroleum storage facilities through 1967 was between $7.5 million and $8.2 million. Of this, the total value of the tankage, contents, and related facilities destroyed at the JCS-targeted sites is estimated to be between $6.7 million and $7.4 million. The value of similar destruction at the dispersed storage sites is estimated to have been $0.5 million (5,000 tons) in 1966 and $0.3 million (3,000 tons) in 1967.

By the end of 1967, an estimated 86 percent of the 128,000 tons of petroleum storage capacity that existed at the beginning of 1965 had been destroyed. About 75 percent of this destruction occurred during the last half of 1966 (see Table 9). Only four of the original 13 targeted sites were in operation at the end of 1967. No attempts have been made to restore any of the damaged sites.

Despite the damage to petroleum facilities, North Vietnam has re-established satisfactory petroleum supply and distribution procedures. At the end

of 1967 there was storage capacity of between 40,000 and 50,000 tons at more than 120 dispersed tank sites. In addition, North Vietnam had accumulated about 300,000 petroleum drums, equivalent to about 50,000 tons of capacity. The remaining JCS-targeted sites, therefore, are of decreasing importance. North Vietnam was able to import about 260,000 tons of petroleum in 1967, the highest level in its history. About 90 percent of this was imported by tankers that discharged their cargoes into barges and other lighters in Haiphong harbor without serious delays in unloading. An apparent accommodation between the USSR, Communist China, and North Vietnam permits the delivery and interim storage of petroleum in Communist China when high inventories and storage limitations would otherwise cause delays in the discharge of the tankers at Haiphong. At the end of 1967, there probably were about 65,000 tons of petroleum on hand in North Vietnam, equal to about 100 days of supply at the rate of consumption estimated for 1967 and representing an increase of about 13,000 tons over the stocks on hand at the end of 1966.

3. Indirect Effects

In addition to the direct costs of restoring damage caused by bombings, North Vietnam has incurred significant indirect losses caused by damage to industrial facilities, the dispersal of industry, diversions of manpower to war-related tasks, disruptions of normal work routines, forced evacuation of cities, separation of families, personal injuries, and loss of property and life. Indirect losses that can be quantified -- decreases in the rice crop, the fish catch, and exports -- are estimated at about $107 million through 1967, or more than one-third of total economic damage. Additional unquantified losses would amount to tens of millions of dollars.

a. Agriculture and Fishing

Agriculture and fishing have been affected by bombing attacks even though they have never been targeted and suffered only minor accidental bomb damage. Output has been adversely affected by management problems, disruption of work routines, interruptions in the supply and distribution of fertilizer, and the threat of air attack against watercraft and the seeding of mines in waterways. The cumulative loss of rice production (which includes substantial

but unknown losses due to adverse weather) and of the fish catch from early 1965 through 1967 is estimated to be about $72 million, as tabulated below:

	Million US $			
	1965	1966	1967	Total
Rice production	3.5	22.0	35.0	60.5
Fishing	1.7	3.3	6.0	11.0
Total	*5.2*	*25.3*	*41.0*	*71.5*

Both rice crops during 1967 are believed to have been below the average, but the shortfalls are not likely to have caused more than localized food shortages. The fifth-month crop, which accounts for one-third of the annual harvest, was estimated to be 200,000 tons of paddy below average. The shortfall in the tenth-month rice crop may have been as high as 300,000 tons of paddy. Some of the reduction in output of rice has been offset by increased production of less palatable subsidiary crops. Moreover, imports of food during 1967 reached a record high level of 450,000 tons, more than offsetting the estimated loss of rice.

b. Export Losses

The cumulative measurable loss in North Vietnam's seaborne exports attributable to the bombing reached about $35 million at the end of 1967, but these losses had little effect on the economy. Export losses for 1967 totaled about $19 million, nearly 70 percent greater than in 1966 and more than four and one-half times the 1965 total. The significant increase in the loss of exports in 1967 resulted from the stepped-up attacks on industrial facilities during the first half of the year. Since May, exports of pig iron and cement have not been observed, and exports of coal were well below normal levels. Only 10,000 tons of apatite has been exported by North Vietnam by ship since the first week of August 1965, although it is possible that apatite has been shipped by rail to China. Coal shipments, which averaged about 78,000 tons per month in 1966, decreased to only

21,000 tons per month in the second half of 1967. The value of losses of identified seaborne exports during 1965, 1966, and 1967 is shown in the following tabulation:

	Million US $				
Year	Apatite	Pig Iron	Cement	Coal	Total [a]
1965	3.3	0	0.9	0	4.2
1966	6.1	0	0.7	4.7	11.6
1967	6.2	1.3	1.7	10.2	19.4
Total	*15.6*	*1.3*	*3.3*	*14.9*	*35.2*

a. Because of rounding, components may not add to the totals shown.

The measurable export losses of $19.4 million in 1967 represent less than 20 percent of North Vietnam's annual exports before the initiation of the bombing program and only a small fraction of the estimated $340 million of economic aid contributed by the Communist countries in 1967.

4. Miscellaneous Economic Damage by Armed Reconnaissance

A number of miscellaneous economic facilities not included in the major target categories -- principally targets associated with lines of communication such as rail lines and sidings and highways -- are reported by pilots as destroyed or damaged under the armed reconnaissance programs. The total cost of damage to these targets through 1967 is estimated to be $2.2 million, of which about $1.0 million was inflicted in 1967.

B. Military Damage

The cost of damage to military facilities and equipment during the fourth quarter of 1967 was about $20 million, almost one-third more than in the previous quarter. The high level was primarily the result of the destruction of fighter aircraft -- 5 MIG-21's and 12 MIG-17's. The cumulative cost of military damage through 1967 was about $131 million, or about 30 percent of the total measurable cost of bomb damage. Nearly 60 percent of the damage resulted from destruction of aircraft and of military barracks. The cost of damage in 1967 was nearly 50 percent greater than the combined total for 1965 and 1966.

The 1967 campaign against military targets has not brought about any serious degradation of North Vietnam's military capabilities. Inventories of military equipment have been maintained or improved through increased imports from the USSR and Communist China. North Vietnamese fighter operations have become increasingly effective. The capability of the radar system has been increased through new infusions of more sophisticated equipment and improved operator proficiency, and the number of SAM sites has been expanded. Dispersed storage sites have largely compensated for the loss of damaged supply depots. Moreover, the military logistics system has been able to support an expansion of military activity in South Vietnam.

1. Air Defense

a. Aircraft

Losses of North Vietnamese fighter aircraft from attacks by US aircraft during the fourth quarter of 1967 were significantly higher than in the third quarter, but below the high level achieved during April through June (see the tabulation below). Total cumulative losses of North Vietnamese fighter aircraft included 29 MIG-21's and 82 MIG-17's,* valued at $44 million. Slightly

* *Including destruction on the ground of an estimated two MIG-21's and eight MIG-17's in US attacks on airfields at Phuc Yen, Kep, and Hoa Lac during 1967.*

more than $35 million of the total damage occurred in 1967.*

			Quarter of 1967				
	1965	1966	1st	2nd	3rd	4th	Total
MIG-21's	0	9	6	7	2	5	29
MIG-17's	5	13	5	42	5	12	82
Total	*5*	*22*	*11*	*49*	*7*	*17*	*111*

Replacements of MIG-21's from the USSR and MIG-17's from China have been sufficient to maintain North Vietnam's MIG inventory at a relatively constant level since 1965. At the end of 1967 the inventory included 25 MIG-21's and 72 MIG-15/17's, most of which are held in reserve in China. A small effective fighter force of 10 to 20 MIG's continues to stage out of North Vietnamese airfields. North Vietnamese fighter defenses have generally improved their capabilities since 1965. Their operations have been expanded from defensive patrols around the Hanoi-Haiphong area to areas as far west as the Laos border and as far south as Vinh, suggesting the possibility of offensive operations in the DMZ. In addition, new types of radar equipment being introduced are improving and expanding the ground-control intercept network.

b. Airfields

Airstrikes against North Vietnam's primary airfields were intensified during the fourth quarter, as strikes were flown for the first time against Phuc Yen and Haiphong/Cat Bi airfields. The Hanoi/Gia Lam airfield, the international commercial airport as well as a military airfield, is the only major airfield not yet struck. The cost of damage during the fourth quarter is estimated to be $0.7 million, and the cumulative cost of damage to airfields through 1967 is $1.9 million (see Table 10).

* *Including five helicopters destroyed on the ground in the fourth quarter of 1967.*

There has been little change in the operational capability of North Vietnam's major airfields since 1965. At the end of 1967, all six primary airfields were capable of sustaining at least limited fighter operations as the North Vietnamese continued to repair damaged airfields in relatively short periods of time. At Phuc Yen, for example, following heavy strikes in October, the runway was sufficiently repaired to allow at least limited MIG operations within three days.

Furthermore, the basic airfield and control system is being expanded. An airfield under construction at Bai Thuong will soon be able to accommodate MIG's, and Chinese engineering troops are constructing another airfield capable of accommodating MIG's at Yen Bai. The airfield at Vinh may also be capable of supporting limited MIG operations, as ground controllers are currently operating in the area and MIG-21's have recently flown near Vinh.

c. SAM Sites

Approximately 1,600 attack sorties have been directed against SAM facilities in North Vietnam from July 1965 through 1967. Assessment of the damage caused by these airstrikes has been severely limited by a lack of post-strike photography. Estimates of the minimum value of damage to sites and support facilities are shown in the following tabulation:

	Thousand US $			
SAM Facilities	1965	1966	1967	Total
Firing sites	500	2,100	3,700	6,300
Support facilities	1,600	200	300	2,100
Total	*2,100*	*2,300*	*4,000*	*8,400*

Attacks on SAM sites apparently have not reduced either the total number of active SAM battalions or the available firing sites, but the attacks may have succeeded in reducing SAM effectiveness. There are now up to 30 active

battalions, the same number estimated for the third quarter of 1967. These battalions can use about 230 prepared or pre-surveyed sites, a net increase of about 10 sites over the number available in September. The airstrikes have necessitated frequent redeployment of equipment, however, which probably has reduced the efficiency of firing units and complicated logistics.

d. Radar*

Airstrikes were conducted against two of the five targeted radar sites in the fourth quarter of 1967. Damage resulting from these strikes, however, is believed to be insignificant. The cumulative cost of damage to JCS-targeted radar facilities through 1967 is estimated at $2.6 million. A sizable amount of additional damage has been reported by pilots flying miscellaneous armed reconnaissance missions.**

Airstrikes have not prevented the North Vietnamese radar net from becoming increasingly formidable and sophisticated. There were 195 operational early-warning and ground-control-intercept radars at 62 sites at the end of 1967, an increase from 149 radars at 50 sites at the end of 1966. Modern equipment for the system has been provided by both the USSR and Communist China in abundant quantities. The proficiency of the personnel operating the system has been improved by experience gained during the air war.

2. Naval

a. Craft

The cost of damage to naval craft during 1967 was about $1.0 million, all of it occurring in the third quarter. Total damage through 1967 is estimated at $4.8 million. Twelve North Vietnamese naval craft*** have been confirmed

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* *Excluding radar associated with SAM sites.*

** *See 4, p. 31, below.*

*** *Excluding the eight to ten naval craft destroyed by the Pierce Arrow attacks in August 1964 following the Gulf of Tonkin incidents.*

destroyed by air attack: four *Swatow*-class gunboats in 1965, three PT boats and one SO-1 subchaser in 1966, and one *Shanghai*-class patrol boat and three PT boats in 1967. The small North Vietnamese navy currently is estimated to include 19 *Swatow*-class gunboats, 13 to 16 PT boats and two SO-1 subchasers. Naval activity to date has been confined largely to the Hanoi and Haiphong areas to bolster the air defense system and to occasional training exercises in the Cat Ba Island area near Haiphong.

b. Bases

Airstrikes against the naval facilities at Port Wallut in August accounted for the only major attack in 1967. The cumulative value of damage inflicted on naval bases is estimated to be $1.9 million (see Table 11). About 30 percent of North Vietnam's naval base support facilities were destroyed or inactive at the end of the year, compared with an estimated 15 percent at the end of 1965. Because of the modest needs of the small North Vietnamese navy and the deployment of naval craft to Hanoi and Haiphong, attacks on fixed facilities have probably had a minimal effect on naval operations.

3. Support Facilities

a. Barracks

The most significant airstrikes against military barracks in the last quarter of 1967 were against the important barracks complex at Haiphong/Cat Bi, not a JCS-numbered target. The total number of airstrikes against JCS-targeted barracks during the year was about equal to the high level in 1965, and more than three times the number in 1966. Thirty targeted barracks were struck during 1967, eleven for the first time. Most of the 1967 damage occurred during the second quarter of the year. By the end of 1967, all but five of the active JCS-targeted barracks had been struck, four in the Hanoi area. The cumulative cost of restoration of damage inflicted since 1965 is $31.2 million; $12.6 million of this total was incurred in 1967, as shown in the following tabulation:

Year	Number of Strikes	Cost of Restoration (Million US $)
1965	166	16.00
1966	52	2.54
1967	173	12.64
Total	*391*	*31.18*

The damage to barracks caused by the airstrikes has been substantial, but it has had little effect on the North Vietnamese war effort. Sixty-five percent of the 65 JCS-targeted barracks have been abandoned. The loss of capacity through destruction and abandonment represents housing for about 119,000 men, or 27 percent of the pre-strike national capacity. This loss is undoubtedly causing some inconvenience outside the urban areas. Two-thirds of the lost capacity had occurred by the end of 1965, however, and there is no evidence that the North Vietnamese have had any serious difficulty in adjusting to the loss.

b. Supply and Ordnance Depots

Only three strikes were flown against JCS-targeted supply and ordnance depots in the fourth quarter of 1967, and each had been hit earlier in the year. In addition, four important storage areas which are not JCS-targeted -- Hanoi/Bac Mai, Hanoi/Gia Thuong, Haiphong Southeast, and the Kinh No Vehicle Repair Depot -- were struck during October-December. About one-half of the 29 JCS-targeted supply depots were attacked during 1967, six for the first time. By the end of the year, all but three of the JCS-targeted depots had been attacked, and one of the three was abandoned. The two active, unstruck depots represent 10 percent of total national capacity and are both within two nautical miles of the center of Hanoi.

The cost of damage during the fourth quarter was slightly more than $1.0 million. The total cost of damage for 1967 is estimated at $7.0 million, compared with $1.0 million in 1966 and $3.0 million in 1965. Most

of the damage in 1967 occurred during the second and third quarters. The attacks have also destroyed a significant amount of valuable supplies and equipment, the value of which cannot be quantified.

Damage to supply areas has disrupted the flow of supplies and increased the requirement to operate from a dispersed logistics base, but it has not seriously limited the storage and distribution of supplies. The loss in capacity of targeted depots, either destroyed or inactive, represents only about 19 percent of the total pre-strike national capacity. Nearly one-half of the targeted depots were inactive at the end of 1967, but most of the larger depots continued to function at more than 50 percent of their pre-strike capacity. In addition, there has been a significant expansion of dispersed storage along the Hanoi - Dong Dang rail line and in the Northwest as well as in the southern part of the country.

c. Ammunition Depots

Relatively little damage was inflicted on ammunition storage depots in the last two quarters of 1967. Ten JCS-targeted depots were attacked during the year, five for the first time. All 18 JCS-targeted depots had been attacked by the end of April 1967. The total cost of restoration of facilities damaged during the year is estimated at about $600,000, compared with $200,000 in 1966 and $4.5 million in 1965.

Damage to the depots has been extensive but probably has not significantly affected the North Vietnamese ability to store ammunition. Eleven of the JCS-targeted depots were abandoned at the end of 1967. More than three-fourths of the total pre-bombing capacity, or about 87,000 tons of storage, had been lost through destruction or abandonment. Continuing airstrikes and the forced dispersal of facilities undoubtedly have caused temporary delays in the distribution of ammunition. Most ammunition, however, apparently has been stored in dispersed storage areas since the end of 1965.

d. Communications

Known physical damage to North Vietnam's telecommunications system since the initiation of the Rolling Thunder program has been relatively modest. Reported damage to radio centers at Xom Trung Hoa, Phuc Yen, and Kim Quan Dong during the last quarter of 1967 raised estimated monetary losses to North Vietnam's telecommunications system to approximately $300,000: $100,000 during 1965, $80,000 during 1966, and $120,000 during 1967.

The communications system remains fully capable of providing essential services to Party, military, and government users. Damage to physical facilities has been confined to two of approximately 50 telephone exchanges, to eight of about 30 of North Vietnam's fixed radio centers, and to segments of the nationwide open wireline network.

4. Miscellaneous Military Damage by Armed Reconnaissance

A variety of miscellaneous military facilities not included in the major target categories are reported by pilots as destroyed or damaged during armed reconnaissance missions. These include movable and temporary targets such as mobile radar units, dispersed storage areas, and defensive weapons positions. Because of the limitations inherent in this type of air operation -- double counting by pilots, impreciseness of targets struck, and inflated damage estimates -- the value of damage can be based only on an assumed level of damage to a typical target in each category.

The total cost of replacement or restoration of the targets reported destroyed or damaged by miscellaneous armed reconnaissance strikes is estimated at about $19.4 million through 1967. A substantial portion of the

increase in the level of reported damage during 1967 is a reflection of increased attacks on non-targeted radar units ($8.2 million) and on dispersed storage areas and supply depots ($5.9 million).

C. Casualties

Preliminary estimates indicate that civilian and military casualties in North Vietnam from US air attacks in 1967 totaled 36,000, one-third greater than in 1966. Civilian casualties accounted for about two-thirds of the total. Total casualties resulting from the Rolling Thunder program are estimated as follows:

	1965	1966	1967 a/	Total
Civilian				
Fixed targets	2,000	900	2,000	4,900
Armed reconnaissance	4,000	18,100	21,000	43,100
Subtotal	6,000	19,000	23,000	48,000
Military				
Fixed targets	4,300	400	6,000	10,700
Armed reconnaissance	2,900	7,300	7,000	17,200
Subtotal	7,200	7,700	13,000	27,900
Total	*13,200*	*26,700*	*36,000*	*75,900*

a. Preliminary.

Despite the intensified bombing in 1967 and the heavier concentration of attacks against the northern, more heavily populated areas, casualties in terms of attack sorties flown and ordnance dropped apparently have been running at a lower rate than that observed in previous years. An analysis of North Vietnamese propaganda statements providing casualty information also shows that there has been a decline in the number killed as a percentage of total casualties from 40 percent in 1966

to about 30 percent in 1967. These developments are due in large part to the increasing effectiveness of North Vietnamese civil defense programs as well as the continued restraint of the US attack. The construction of air raid shelters which has been under way since early 1966 and the evacuation of cities which began in mid-1966 and was intensified in early 1967 have been important factors in reducing hazards to the population during air attacks.

Hanoi's propaganda continues to allege that the US bombing is a ruthless attempt at mass extermination of old people and children. At the same time, however, Hanoi claims that despite the intensity of the bombing, total casualties are minimal because of the efficiency of the government's countermeasures.*

Although estimates of casualties resulting from the bombing are subject to fairly wide margins of error, the available evidence indicates that they are in the right magnitude.

[redacted]

In view of the intensity of the Rolling Thunder program, total casualties have been remarkably low. Although civilians sustain the greater number of casualties, a large proportion of them are actively engaged in air and civil defense, truck driving, transport repair, and other war-related activities.

* *Civilian casualties for 1967 as announced by the North Vietnamese and compiled from individual propaganda reports total 4,400.*

[redacted]

[redacted]

Table 1

Value of Economic and Military Damage
Cumulative 1965-67

Economic	Million US $	Military	Million US $
Direct losses a/	180.9	Direct losses a/	131.1
Transportation equipment	75.6	Aircraft	44.2
Railroad and highway bridges	35.8	Barracks	31.2
Electric powerplants	32.9	Supply areas and depots	11.0
Manufacturing facilities	18.1	SAM sites	8.4
Petroleum and facilities	7.5	Ammunition depots	5.3
Railroad yards and shops	6.2	Naval craft	4.8
Maritime ports and shipyards	2.7	Radar sites	2.6
Miscellaneous armed reconnaissance	2.2	Naval bases	1.9
Indirect losses	106.7	Airfields	1.9
Agriculture	60.5	Communications sites	0.3
Fishing	11.0	Miscellaneous armed reconnaissance	19.4
Exports	35.2		
Total, direct and indirect losses	287.6		
		Total economic and military	418.7

a. Because of rounding, components may not add to the totals shown.

Table 2

Major Railroad Yards and Shops Attacked
1965-67

Location	Number of Yards Attacked			Number of Attacks			Cost of Restoration (Thousand US $)			
	1965	1966	1967	1965	1966	1967	1965	1966	1967	Total
Hanoi area		2	2		4	31		820	3,105	3,925
Hanoi - Dong Dang line		3	7		12	218		Negl.	370	370
Hanoi - Haiphong line			2			18			120	120
Hanoi - Thai Nguyen - Kep line		1	2		6	61		400	770	1,170
Hanoi - Lao Cai line	3	4	5	5	11	87	70	N.A.	500	500
Hanoi - Vinh line	3	5	5	11	67	176		N.A.	N.A.	70
Total	6	15	23	16	100	591	70	1,220	4,865	6,155

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25X1

Table 3

Maritime Ports and Shipyards Attacked
1965-67

JCS Target Number	Name	Percent of Total Maritime Cargo Handling or Shipyard Repair Capacity a/	Dates of Attack	Percent of Target Capacity Destroyed	Percent of Total Capacity Destroyed	Cost of Restoration (Thousand US $)
	Ben Thuy	4	5,6,8 Jun 9,10,11,17,19,21 Jul	61	2.4	470
	Ham Rong	1	14,16,18 Jul	15	0.2	190
	Subtotal: 1965					660
	Ben Thuy	4	1 Feb 8 Mar 30,31 Oct 4,9 Nov 6 Dec	85	3.4	590
	Cam Pha b/	16	24 Apr 8 Nov	21	3.4	160
	Subtotal: 1966					750
	Ben Thuy	4	7,9,14,23 Jan	85	3.4	N.A.
	Hon Gai b/	18	24 (initial strike), 25,26 Apr, 24,25,26 May	22	3.9	N.A.
	Cam Pha	16	10 Sep	30	4.8	370
	Haiphong Shipyard No. 2	7	Sep (initial strike), 16 Nov	23	1.6	367

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25X1

Table 3

Maritime Ports and Shipyards Attacked
1965-67
(Continued)

25X1

JCS Target Number	Name	Percent of Total Maritime Cargo Handling or Shipyard Repair Capacity a/	Dates of Attack	Percent of Target Capacity Destroyed	Percent of Total Capacity Destroyed	Cost of Restoration (Thousand US $)
[redacted]	Haiphong Shipyard Thuong	N.A.	12 Oct (initial strike)	80	N.A.	76
	Haiphong Shipyard West	10 d/	14 Oct (initial strike)	N.A.	N.A.	213
	Haiphong Shipyard Lach Tray	3	18 Oct (initial strike)	N.A.	N.A.	244
	Subtotal: 1967					1,270
	Total					2,680

25X5

a. All the shipyards struck to date perform minor repairs and construct or fabricate barges and small watercraft. All are designated Category III shipyards, i.e. dry dock capacity of less than 1,700 short tons and 250 feet in length.
b. Strikes were not conducted against port facilities but against related areas such as support facilities and coal-treatment facilities which affected port operations and resulted in export losses. The estimated cost at Cam Pha in 1966 is the cost of damage to support facilities.
c. Not JCS-targeted.
d. Represents 10 percent of the national barge construction capacity.

Table 4

Destruction and Damage of Transport Equipment
1965-67

Units

	Locomotives	Railroad Cars	Trucks	Ferries	Barges	Other Watercraft
1965						
Destroyed	6	227	318	53	263	144
Damaged	6	592	487	56	487	210
1966						
Destroyed	10	1,101	1,935	67	2,520	867
Damaged	14	935	1,801	131	4,289	1,372
1967						
Destroyed	15	894	2,935	13	3,946	162
Damaged	31	1,527	1,928	13	7,520	320
Total						
Destroyed	31	2,222	5,188	133	6,729	1,173
Damaged	51	3,054	4,216	200	12,296	1,902

Table 5

Strikes Against JCS-Targeted Bridges
1965-67

Units

	1965		1966		1967	
	Strikes	Bridges	Strikes	Bridges	Strikes	Bridges
Railroad and combination railroad and highway	67	14	110	16	170	23
Highway	77	30	76	23	156	29
Total	144	44	186	39	326	52

Table 6

Bomb Damage Assessment of Bridges in North Vietnam a/
Cumulative 1965-67

Units

Type of Bridge	Bridges Damaged			Total Serious Damage Occurrences (Including Initial Hits and Re-hits)		
	Total	Seriously	Moderately	Total	Original Bridge	Bypass Bridge
Highway	362	323	39	496	452	44
Railroad	97	90	7	176	138	38
Combination railroad/ highway	48	42	6	87	59	28
Total	507	455	52	759	649	110

a. Damage to bridges confirmed by available photography.

25X1

25X5

Table 7

Electric Power Facilities Attacked a/
1965-67

25X1

JCS Target Number	Name	Pre-Strike Target Capacity (Kilowatts)	Percent of Total Capacity b/	Dates of Attack	Cost of Restoration (Million US $) c/
	Thanh Hoa	5,000	3	4 Apr 27,29,30,31 Jul 4 Aug	0.2 0.9
	Ben Thuy	8,000	5	4,4 Jun	1.0
	Co Dinh	1,500	1	8,10 Jun	0.4
	Nam Dinh	7,500	4	28,29 Jun 2,3 Aug	0.5 1.5
	Ban Thach	1,000	0.5	21,22,23 Aug	0.3
	Uong Bi	24,000	14	15,20,22,22 Dec	1.5
	Subtotal: 1965				6.3
	Uong Bi	24,000	13	18,28 Apr 11,14,17 Aug	0.1 4.3
	Thai Nguyen	24,000	13	6-8 Jul	0.8
	Viet Tri	16,000	9	Prior to 19 Jul	
	Ben Thuy	8,000	4	13,15 Mar 23,26,26,27,28,29 Oct	 0.2
	Thanh Hoa	5,000	3	22,23,23,23 Sep	0.4
	Trinh Xuyen substation	N.A.	N.A.	1 Nov	

Table 7

Electric Power Facilities Attacked a/
1965-67
(Continued)

25X5

25X1

25X1

JCS Target Number	Name	Pre-Strike Target Capacity (Kilowatts)	Percent of Total Capacity b/	Dates of Attack	Cost of Restoration (Million US $) c/
	Co Dinh	1,500	1	4 Nov	0.4
	Subtotal: 1966				6.2
	Hon Gai	15,000	8	24 (initial strike), 25 Feb	
				2,10 Mar	2.2
				20,22 Apr	
				3 Oct	1.0
	Bac Giang	12,000	6	24 (initial strike), 26 Feb	
				11,16,24 Mar	
				5 Apr	0.5
				10,20,22 May	
				16,19 Jun	0.1
				1 Aug	0.1
	Viet Tri	16,000	9	12,19 Mar	2.8
	Thai Nguyen	24,000	13	19,23,24 Mar	1.5
				28 Jun	0.1
				6,7,13,22 Jul	0.5
				2 Aug	0.7
	Haiphong West	10,000	5	20 (initial strike), 25 Apr	1.1
				10,20,26 May	0.5
	Haiphong East	7,000	4	20 (initial strike), 21 Apr	1.0
				10 May	0.3
	Nam Dinh	7,500	4	22,26 Jun	0.7
				22 Aug	
				9 Sep	
				6 Oct	

Table 7

Electric Power Facilities Attacked a/
1965-67
(Continued)

25X1

25X1

JCS Target Number	Name	Pre-Strike Target Capacity (Kilowatts)	Percent of Total Capacity b/	Dates of Attack	Cost of Restoration (Million US $) c/
	Ben Thuy	8,000	4	29,30 Jun 2,23,24,25,31 Jul 5,15,18,19 Aug	 0.4 0.1
	Dong Anh Substation	N.A.	N.A.	25 (initial strike), 26,30 Apr 4,22 May 6 Nov	0.2 0.1 0.4
	Hanoi 25X5	32,500	17	19 (initial strike), 21 May 10 Jun 21 Aug 26 Oct	0.8 0.6 0.5
	Uong Bi	24,000	13	26 May 8,11,11 Jun 21,25 Aug 2,9,13,30 Sep 5,8,9,12,26,27,30 Oct 11 Nov	 2.3 0.4 0.8
	Thanh Hoa	5,000	3	12 Jun	0.7
	Subtotal: 1967				20.4
	Total				32.9

a. Electric generating capacity out of operation in North Vietnam was 27 percent in 1965, 32 percent in 1966, and about 65 percent at the end of 1967.
b. Based on national installed capacity of 175,000 kw in 1965 and on 187,000 kw in 1966 and 1967.
c. Lack of an entry indicates either no damage or no information available on which to make an estimate.

Table 8

Manufacturing Facilities Attacked
1965-67

25X1 25X1

JCS Target Number	Name	Percent of Total Capacity	Date of Attack	Percent of Target Capacity Destroyed	Percent of Total Capacity Destroyed or Inactive	Cost of Restoration (Thousand US $)
1965						
	Lang Chi Explosives Plant	100	24 Jul			
a/	Nam Dinh Textile Mill	Cotton spinning: 70 to 75	7, 8 Aug	71 (inactive)	100 Spinning inactive: 60	370
		Cotton weaving: 50	28 Jul	5	Weaving inactive: 40	800
	Subtotal: 1965					1,170
1966						
a/	Cam Pha Coal Treatment Plant	N.A.	24 Apr 8 Nov	N.A.	N.A.	75
a/	Viet Tri Paper Mill	80	Mid-Jul	N.A.	N.A.	100
a/	Nam Dinh Textile Mill	N.A.	Oct-Dec b/	N.A. c/	N.A. c/	250
	Subtotal: 1966					425
1967						
	Thai Nguyen Iron and Steel Complex	95 d/	10, 11, 18, 21, 25, 26, 30 Mar 7, 10, 18, 23 Apr 1, 4, 10, 27 May 21, 27 Jun	N.A. (inactive)	95 d/	10,000
	Haiphong Cement Plant	95	20, 25 Apr 7, 27 May	70 (inactive)	95	3,050
	Lang Chi Explosives Plant	100	16, 23, 29 Jun 6, 8, 18, 20 Jul 1, 3, 18, 19, 20 Aug	80 (inactive)	100	45
a/	Nam Dinh Textile Mill	N.A.	Mar, Jun, Jul	N.A. c/	N.A. c/	1,330
a/	Cam Pha Coal Treatment Plant	N.A.	Feb	N.A.	N.A.	Negl.

25X5

Table 8

Manufacturing Facilities Attacked
1965-67
(Continued)

25X5

25X1

25X1

JCS Target Number	Name	Percent of Total Capacity	Date of Attack	Percent of Target Capacity Destroyed	Percent of Total Capacity Destroyed or Inactive	Cost of Restoration (Thousand US $)
	Phu Tho Phosphate Fertilizer Plant	56 e/	Jul	3	N.A.	200
a/	Hon Gai Calcium Carbide Plant	N.A.	9, 12, 13 Mar 16, 17 Apr	75	N.A.	200
a/	Haiphong Enamelware Plant	N.A.	Apr	35	N.A.	360
	Bac Giang Chemical Fertilizer Plant	37 e/	24, 25 Feb 11, 16 Mar 10, 20, 22 May 16, 19 Jun	3 (inactive)	37	395
a/	Viet Tri Paper Mill	80	Mar	20 (inactive)	80	675
a/	Hanoi Concrete Products Plant	N.A.	19 Nov	N.A.	N.A.	210
	Subtotal: 1967					16,465
	Total					18,060

a. Not JCS-targeted.
b. Two strikes within the period.
c. Relocation of much of the mill's equipment is believed to have permitted restoration of perhaps a significant share of national capacity.
d. Pig iron only. It is not possible to determine the plant's relative share of fabrication work.
e. Percent of chemical fertilizer capacity (excluding apatite and phosphate rock).

Table 9

Petroleum Storage Facilities Attacked
1965-67

25X5

25X1

JCS Target Number	Name	Percent of Total Targeted Capacity	Dates of Attack	Percent of Target Capacity Destroyed	Percent of Total Targeted Capacity Destroyed	Cost of Restoration (Thousand US $)	Value of Petroleum Destroyed (Thousand US $)
	Phu Van	Negl.	6 May	100	Negl.	40	20
	Vinh a/	6	24, 26 May	34	2	120	70
			11, 15 Sep	34	2	120	70
			6 Oct	17	1	60	30
	Nam Dinh	9	2, 4 Jul	100	9	500	270
	Phu Qui	6	18 May	100	6	340	0
	Subtotal: 1965				20	1,180	460
	Haiphong	32	29 Jun	46	14	840	300 to 460
			7 Jul	32	10	600	190 to 310
			2 Aug	21	7	380	80 to 150
	Hanoi	24	29 Jun	100	24	1,380	490 to 760
	Vinh a/	6	30 Jul				
			7, 8 Aug				
			6 Sep				
			8, 11, 13, 27, 28, 29 Oct				
	Nguyen Khe	6	30 Jun	10	2	112	39 to 60
			19 Jul				
			17, 18, 22 Aug	22			
			4 Sep				
			8 Oct				

25X1

Table 9

Petroleum Storage Facilities Attacked
1965-67
(Continued)

JCS Target Number	Name	Percent of Total Targeted Capacity	Dates of Attack	Percent of Target Capacity Destroyed	Percent of Total Targeted Capacity Destroyed	Cost of Restoration (Thousand US $)	Value of Petroleum Destroyed (Thousand US $)
1966							
	Bac Giang	2	30 Jun 31 Jul 11 Aug 14 Sep	31	1	32	11 to 17
	Do Son	2	29 Jun 3 Jul 5, 8, 10, 14, 15, 17, 22 Aug 12, 22 Oct 1 Nov	50	1	64	16 to 35
	Viet Tri	1	30 Jun 19 Jul 14 Aug 5 Sep	97	1	0 2 0 0	0 1 to 2 0 0
	Duong Nham	3	1, 12, 23 Jul 17, 22 Aug 12 Sep	100	3	185	16 to 25 24 to 30
	Ha Gia	8	22 Nov 2, 3, 4, 5, 19, 30 Dec	22	2	99	0
	Can Thor b/	1	23 Nov 2 Dec 3 Dec	33	Negl.	37	20
	Phu Qui c/	6	8 Aug 11 Oct				
	Subtotal: 1966				65	3,731	1,187 to 1,889

25X1

25X5

25X1

Table 9

Petroleum Storage Facilities Attacked
1965-67
(Continued)

25X5

25X1

25X1

JCS Target Number	Name	Percent of Total Targeted Capacity	Dates of Attack	Percent Target Capacity Destroyed	Percent of Total Targeted Capacity Destroyed	Cost of Restoration (Thousand US $)	Value of Petroleum Destroyed (Thousand US $)
1967							
	Vinh a/	6	7 Feb 13, 14, 15, 16 Apr				
	Ha Gia d/	8	15 Feb				
	Do Son e/	2	5 Mar	50	1	64	35
	Haiphong f/	32	26 Apr, 2 May				
	Phu Qui c/	6	20 May, 12 Jun				
	Nam Dinh c/	9	22 Aug, 9 Sep				
	Subtotal: 1967				1	64	35
	Total				86	4,975	1,682 to 2,384

a. The facility at Vinh was attacked in August 1964, prior to the Rolling Thunder program. Vinh was attacked ten times in 1966 and five times in 1967, but no destruction of storage capacity has been identified since 1965.
b. Undamaged tanks have been exhumed and removed and the site is considered to have been abandoned as of 31 December 1967.
c. This facility was 100 percent destroyed in 1965 and apparently has been abandoned.
d. Ha Gia had been attacked in 1966; available photography indicates that the destroyed tankage did not contain petroleum at the time of the 1966 attack.
e. Do Son had been attacked in 1966; the facility is now 100 percent destroyed.
f. The facility at Haiphong had not been attacked since 2 August 1966. Photography of early 1967 revealed that storage tanks previously considered to be serviceable were being dismantled. For purposes of this table, the dismantled tanks and their contents are considered to have been destroyed in the attack of 2 August 1966. No damage to storage was observed after the attacks in 1966.

25X5

Table 10

Airfields Attacked
1965-67

25X1

25X1

JCS Target Number	Name	Target as a Percent of National Targeted Capacity	Dates of Attack	Percent of Target Utility Destroyed	Cumulative Percent of National Targeted Capacity Destroyed or Inactive	Cost of Restoration (Thousand US $)
	Na San	4	25 Jun; 23 Sep; 24 Oct	45 (inactive)	4	144
	Dien Bien Phu	3	2, 8 Jul	94 (inactive)	3	143
	Dong Hoi	6	30 Mar; 6 Jun; 1 Jul; 17, 22, 23 Sep	53 (inactive)	6	50
	Vinh	6	8 May; 30 Jun; 1 Jul	10 (inactive)	6	43
	Subtotal: 1965				19	380
	Dien Bien Phu	3	6, 11 Feb	94 (inactive)	3	2
	Dong Hoi	6	19 Nov	53 (inactive)	6	Negl.
	Subtotal: 1966				19 a/	2
	Dong Hoi	6	29 Mar	67 (inactive)	6	13
	Subtotal: Jan-Mar 1967				19 a/	13

Table 10
Airfields Attacked
1965-67
(Continued)

25X5

JCS Target Number	Name	Target as a Percent of National Targeted Capacity	Dates of Attack	Percent of Target Utility Destroyed	Cumulative Percent of National Targeted Capacity Destroyed or Inactive	Cost of Restoration (Thousand US $)
Apr-Jun 1967						
b/	Hoa Lac	b/	24 Apr (initial strike); 28 Apr; 1, 3, 8, 19, 21, 26, 30 May; 29 Jun	N.A.	b/	306
	Dong Hoi	6	16 May	67 (inactive)	6	Negl.
	Haiphong/Kien An	7	10 May (initial strike); 14, 25 May	N.A.	N.A.	4
	Kep	10	24 Apr (initial strike); 1, 7, 21, 26, 31 May; 29 Jun	40	4	248
	Subtotal: Apr-Jun 1967				23 a/	558
Jul-Sep 1967						
b/	Hoa Lac	b/	12 Jul; 30 Aug	N.A.	b/	229
	Na San	4	22 Jul	45 (inactive)	4	Negl.
	Vinh	6	31 Aug; 1 Sep	10 (inactive)	6	Negl.
	Haiphong/Kien An	7	12 Aug	N.A.	N.A.	N.A.
	Kep	10	4, 7 Jul; 3, 9, 30 Sep	45	4	17
	Kep Ha	3	21 Aug (initial strike); 24 Aug	17 (inactive)	3	33
	Subtotal: Jul-Sep 1967				26 a/	279

25X1

25X1

25X5

25X5

Table 10

Airfields Attacked
1965-67
(Continued)

25X1

25X1

JCS Target Number	Name	Target as a Percent of National Targeted Capacity	Dates of Attack	Percent of Target Utility Destroyed	Cumulative Percent of National Targeted Capacity Destroyed or Inactive	Cost of Restoration (Thousand US $)
Oct-Dec 1967						
	Phuc Yen	25	24 Oct (initial strike); 25, 26 Oct; 5 Nov; 17 Dec	3	1	163
	Hanoi/Bac Mai	2	17 Nov (initial strike)	N.A.	N.A.	355
	Haiphong/Cat Bi	17	8 Oct (initial strike); 10, 12, 29 Oct; 20, 28 Nov	38	7	152
	Haiphong/Kien An	7	1, 4, 8, 14, 17, 30 Oct; 16, 19, 21, 27 Nov; 4, 10, 16 Dec	18	1	N.A.
	Kep	10	1, 2, 13, 14, 24, 30 Oct; 6, 15 Nov; 17, 22, 31 Dec	45	4	40
	Kep Ha	3	30 Oct; 27 Nov	17 (inactive)	3	N.A.
	Subtotal: Oct-Dec 1967				35 a/	710
	Total				35	1,942

a. Including that capacity destroyed or inactive at airfields not attacked during the time period.
b. Not JCS-targeted.

Table 11

Naval Bases Attacked
1965-67

JCS Target Number	Name	Target as a Percent of National Naval Base Support Capacity	Dates of Attack a/	Percent of Base Utility Destroyed	Cumulative Percent of National Naval Base Support Capacity Destroyed or Inactive	Cost of Restoration b/ (Thousand US $)
1965						
[redacted]	Phuc Loi	10	20 May 12 Sep	78	8	815
	Quang Khe, Cuu Dinh	15	2 Mar; 28 May; 21, 24, 27, 28 Sep	47	7	400
	Subtotal: 1965				15	1,215
1966						
[redacted]	Hon Gai/Bai Chay Port Naval Complex	17	6 Aug; 28 Oct; 4 Nov	14	2	28
	Phuc Loi	10	4, 5 Apr	78 (inactive)	10	230
	Quang Khe, Cuu Dinh	15	26 Apr; 25 Nov	47	7	100
	Subtotal: 1966				19	358
1967						
[redacted]	Phuc Loi	10	15 May; 8 Jun; 7 Sep	78 (inactive)	10	2
	Port Wallut	15	21 Aug (initial strike); 25 Aug	30	4	250
	Quang Khe, Cuu Dinh	15	17, 28 Mar; 3 Apr; 22 Jun; 19 Aug	90	14	101
	Subtotal: 1967				30 c/	352
	Total				30	1,925

a. Dates of attack indicated only assigned strikes; in certain instances more attacks have been made against a specific target than is indicated.
b. Because of rounding, components may not add to the totals shown.
c. Including that capacity destroyed or inactive at naval base support facilities not attacked during the time period.

II. Air Operations

A. Scale of Attack

More than 191,000 sorties were flown over North Vietnam during 1967, almost one-half of all the sorties flown over North Vietnam since the air war began. Sorties flown against targets in North Vietnam accounted for more than one-third of all sorties over Southeast Asia, a ratio that prevailed in 1966 and 1967, as shown in the tabulation below. More than 55 percent of all sorties over North Vietnam in 1967 were attack sorties,* the same as in 1966.

Area of Operation	Sorties				Percent of Total
	1965	1966	1967	Total	
North Vietnam	55,560	147,840	191,250	394,650	34
Laos	16,050	77,370	88,570	181,990	16
South Vietnam	110,980	203,600	260,180	574,760	50
Total Southeast Asia	*182,590*	*428,810*	*540,000*	*1,151,400*	*100*

The usual unfavorable weather restricted the air war against North Vietnam during the last quarter of the year, when an average of 7,540 attack sorties were flown per month, compared with monthly averages in excess of 10,000 during the second and third quarters. The following tabulation shows the average number of attack sorties per month over North Vietnam by quarters for the years 1965-67:

* *Attack sorties carry out strike and flak suppression missions. Support sorties make up the remainder, which conduct photo and electronic reconnaissance, combat air patrol, search and rescue, electronic countermeasure, refueling, and forward air control missions.*

Quarter	Average Number of Attack Sorties per Month 1965	1966	1967
First	280	2,480	6,850
Second	1,870	5,900	10,590
Third	3,560	11,450	10,700
Fourth	2,930	7,560	7,540
Average	2,160	6,850	8,920

The air war in North Vietnam, as in all of Southeast Asia, continues to be almost totally a US operation. During 1967, South Vietnamese Air Force sorties over North Vietnam averaged only about ten per month. During the three years of the air war the South Vietnamese Air Force has flown less than 1 percent of the sorties over North Vietnam. Table 12 shows sorties over North Vietnam by mission and nationality.

The share of sorties flown over North Vietnam by each US military service has remained relatively constant over the past two years of the air war. The US Air Force has carried out about one-half of all sorties, the US Navy about 45 percent, and the Marines about 5 percent. Table 13 shows the number of sorties flown by each service against targets in North Vietnam.

B. Ordnance

Ordnance delivered by US and South Vietnamese Air Forces against North Vietnam during 1967 increased to about 243,000 tons, about 60 percent of all the ordnance delivered against North Vietnam since 1965. The amounts of ordnance delivered throughout Southeast Asia increased substantially during the three years of the bombing, but the largest percentage increase occurred in North Vietnam. The amounts and shares of ordnance delivered against each country in Southeast Asia are shown in the following tabulation:

Area of Operation	Tons 1965	1966	1967 a/	Total	Percent of Total
North Vietnam	34,300	128,590	243,370	406,260	26
Laos	18,500 a/	73,690	130,000	222,190	14
South Vietnam	149,000 a/	281,250	516,780	947,030	60
Total Southeast Asia	*201,800*	*483,530*	*890,150*	*1,575,480*	*100*

a. Ordnance delivered in South Vietnam and Laos during 1965, and in all three countries during December 1967, are estimated.

The increased tonnages delivered in North Vietnam and the rest of Southeast Asia resulted from increases in both the number of attack sorties flown and substantial increases in the tons delivered per attack sortie, as shown in the following tabulation:

Area of Operation	Tons per Attack Sortie 1965	1966	1967
North Vietnam	1.3	1.6	2.3
Laos	1.7	1.5	2.8
South Vietnam	1.5	1.8	2.5
Average Southeast Asia	1.5	1.7	2.4

The improved performance in ordnance delivered over North Vietnam and the rest of Southeast Asia during 1967 resulted primarily from large increases in the number of sorties by B-52 aircraft. During 1967, B-52's flew 9,670 sorties over Southeast Asia, compared with 5,250 during 1966. These aircraft delivered an average of about 24 tons per sortie, ten times the overall average for 1967. As a share of total attack sorties in Southeast Asia, sorties by B-52's have only increased from less than 1 percent in 1965 to 3 percent in 1967, yet these

strikes delivered 16 percent of all ordnance in 1965 and 30 percent in 1967. B-52's delivered about 16 percent of all ordnance over North Vietnam during 1967, primarily near the DMZ.

During the last quarter of 1967 the average ordnance delivered per month against targets in North Vietnam declined as poor weather limited the scale of attack. However, the average remained well above that for the same period of 1966, primarily because of the sharp increase in the use of B-52 aircraft against targets in the Panhandle of North Vietnam. The following tabulation shows the average number of tons delivered per month against targets in North Vietnam by quarter during 1965-67.

	Average Tons of Ordnance Delivered per Month		
Quarter	1965	1966	1967
First	1,130 a/	4,260	12,600
Second	2,460	9,180	21,180
Third	4,550	17,140	26,010
Fourth	4,040	12,270	21,330
Average	3,430 b/	10,720	20,280

a. Ordnance delivered only in March 1965.
b. Averaged over the ten months, March-December.

C. Distribution of Attacks Against North Vietnam

Armed reconnaissance sorties against logistics and military targets continued to dominate the Rolling Thunder program, despite intensified attacks during 1967 against JCS-numbered targets.* The number of sorties against

** In the last half of 1967, previously unstruck fixed targets have been attacked which are not JCS-numbered but are treated operationally as JCS-numbered targets. These include such targets as railroad and highway* [footnote continued on p. 57]

JCS targets in 1967 was two and one-half times that in 1966, whereas ordnance delivered was more than three times the 1966 level. However, only about 3.5 percent of all sorties in North Vietnam in 1967 were flown against JCS targets, and less than 5 percent of all ordnance was dropped on JCS targets. Tables 13 and 14 show number of sorties and ordnance against JCS and armed reconnaissance targets during 1965-67.

The number and nature of JCS targets attacked for the first time increased significantly during 1967. Forty-four JCS targets were attacked for the first time in 1967, compared with 27 in 1966. Most of these targets were struck during the second and third quarters. The new targets were primarily industrial, communications, and fixed military targets in former sanctuary areas in the Northeast. Of the 44 initial strikes, 12 were against targets in the Hanoi and Haiphong areas. The number of initial strikes on JCS targets, by quarter in 1967, the number of attack sorties, and the ordnance delivered on these targets are shown in the following tabulation:

Quarter of 1967	Number of Initial Strikes: Total	Number of Initial Strikes: Hanoi-Haiphong Area	Attack Sorties	Ordnance (Tons)
First	7	0	158	680
Second	17	11	381	1,170
Third	12	1	173	580
Fourth	8	0	197	400
Total	*44*	*12*	*909*	*2,830*

bridges, railroad yards and sidings, shipyards, and supply and storage areas in the Hanoi and Haiphong areas and the Chinese Buffer Zone. The inclusion of attacks against such targets with attacks against JCS-numbered targets would increase only slightly the proportion of JCS targets as a percent of total targets.

The share of attack sorties flown in Route Packages I and VI was increased substantially during 1967 as a result of intensified attacks against industrial and LOC targets in the Northeast and against military concentrations and infiltration movements near the DMZ. In 1967, 47 percent of all attack sorties were flown in Route Package I and 19 percent in Route Package VI; during 1966 the corresponding shares were about 37 percent and 7 percent. Table 15 shows the distribution of attack sorties by Route Package for 1966 and 1967.

D. Cost of Air Operations Against North Vietnam

The direct cost* to the United States of air operations against North Vietnam during 1967 is estimated at about $1,665 million -- an increase of one-third above that of 1966, as shown in the following tabulation:

	Million US $	
	1966	1967
Aircraft losses	605.6	739.0
Operational cost of sorties flown	330.4	451.2
Ordnance	311.5	475.0 a/
Total	*1,247.5*	*1,665.2*

a. Cost of ordnance is estimated for December 1967.

The measurable costs to North Vietnam for reconstruction and repair of bomb-damaged facilities and for indirect losses attributed during 1967 are estimated to be $236.2 million.

** Costs in this calculation include only production costs of aircraft lost, ordnance costs, and those items which vary in proportion to number of hours flown, such as POL and replacement parts.*

The trend of the cost of inflicting one dollar's worth of damage on North Vietnam is as follows:

	Million US $		Operational Cost per Dollar of Damage
Year	Cost of Damage	Operational Cost	
1965	68.9	460.0	6.68
1966	113.6	1,247.5	10.98
1967	236.2	1,665.2	7.05

The increase in cost per dollar of damage in 1966 was attributable primarily to the increasing costs of the accelerated air interdiction program that concentrated on low-yield target systems. The improved ratio in 1967 reflects the increased number of attacks against significant economic targets in industry. Prospects for further improvement in cost effectiveness are dim, however, as the number of these significant targets is decreasing, a fact pointed up by the decline in cost of damage from $127.9 million during the first half of 1967 to $108.2 million in the second half.

Table 12

Sorties Against North Vietnam, by Mission and Nationality a/
1965-67

25X1 25X1

	By US Services			By the South Vietnamese Air Force			Total		
Year	Attack Sorties	Support Sorties	Total Sorties	Attack Sorties	Support Sorties	Total Sorties	Attack Sorties	Support Sorties	Total Sorties
1965	25,270	29,570	54,840	610	110	720	25,880	29,680	55,560
1966	81,360	65,660	147,020	810	10	820	82,170	65,670	147,840
1967	106,940	84,180	191,120	130	0	130	107,070	84,180	191,250
Total	213,570	179,410	392,980	1,550	120	1,670	215,120	179,530	394,650

a. Rounded to the nearest 10 sorties.

Table 13

Sorties Against North Vietnam, by Program and by Service a/
1965-67

Year	On JCS Fixed Targets: Total on Fixed Targets	On JCS Fixed Targets: By JCS Fixed Target Strikes	On Armed Reconnaissance: By Armed Reconnaissance Strikes	On Armed Reconnaissance: Armed Reconnaissance Not on JCS Fixed Targets	On Armed Reconnaissance: Total on Armed Reconnaissance	Total by JCS Fixed Target Strikes and Armed Reconnaissance	Services: United States: Air Force	Services: United States: Navy	Services: United States: Marine	Services: South Vietnamese Air Force
1965	13,890	11,060	2,830	41,670	44,500	55,560	24,620	29,220	1,000	720
1966	2,620	420	2,200	145,220	147,420	147,840	78,580	62,550	5,890	820
1967	6,770	1,200	5,570	184,480	190,050	191,250	101,130	77,520	12,470	130
Total	23,280	12,680	10,600	371,370	381,970	394,650	204,330	169,290	19,360	1,670

a. Rounded to the nearest 10 sorties.

Table 14

Ordnance Delivered by Air on North Vietnam, by Program a/
1965-67

Year	On JCS Fixed Targets: Total on Fixed Targets	On JCS Fixed Targets: By JCS Fixed Target Strikes	On Armed Reconnaissance: By Armed Reconnaissance Strikes	On Armed Reconnaissance: Armed Reconnaissance Not on JCS Fixed Targets	On Armed Reconnaissance: Total on Armed Reconnaissance	Total by JCS Fixed Target Strikes and Armed Reconnaissance
1965	12,800	11,960	840	21,500	22,340	34,300
1966	3,560	440	3,120	125,030	128,150	128,590
1967	11,710	2,030	9,680	231,660	241,340	243,370
Total	28,070	14,430	13,640	378,190	391,830	406,260

a. Rounded to the nearest 10 tons.

Table 15

Distribution of Attack Sorties over North Vietnam, by Route Package 1966 and 1967 a/

Percent

Year and Month	I	II	III	IV	V	VI	Buffer Zone
1966 b/	37	15	13	9	4	7	0
1967							
January	44	6	15	21	4	10	0
February	63	7	9	12	3	6	0
March	59	9	12	8	4	8	0
April	49	11	14	7	5	14	0
May	39	13	18	11	3	16	0
June	36	13	17	11	4	19	0
July	38	9	7	9	4	33	0
August	48	7	10	8	2	22	3
September	58	8	6	8	3	16	1
October	43	4	6	10	3	32	2
November	52	5	7	11	5	20	Negl.
December	58	8	7	9	4	14	0
Average 1967	47	9	11	10	3	19	1

a. North Vietnam is divided, for operation, into six geographic areas, known as Route Packages. Percentage data shown are approximate because of the effects of multiple route package sorties and coastal sorties.
b. Route Package destinations are unknown for 15 percent of the attack sorties flown in 1966.

III. Air Losses

A. Introduction

Aircraft losses over North Vietnam, as over all of Southeast Asia, have mounted each year with intensification of the air war. The ratio of US air losses to the number of sorties, however, has declined each year since 1965. Although the annual loss rates for aircraft in the Rolling Thunder program have declined, loss rates by quarter increased during each of the last three quarters in 1967. Increases in the second and third quarter could be explained by the greater number of sorties against heavily defended targets. During the fourth quarter, however, air operations in the Northeast were curtailed, and an improvement in the loss rates might have been expected. The increasing loss rate, therefore, appears to be attributable to improved effectiveness of the North Vietnamese air defenses.

B. Air Losses in Southeast Asia

About 2,880 helicopters and fixed wing aircraft have been lost over Southeast Asia by the US and South Vietnamese Air Forces during the three years of the Rolling Thunder program. Total losses in 1967 were almost 50 percent greater than in 1966, primarily as a result of a near doubling in the number of helicopters downed over South Vietnam. About 90 losses were South Vietnamese Air Force aircraft, and 282 of the 2,790 US losses were aircraft flying training and other non-combat-associated missions. Of the remaining 2,508 aircraft lost in combat operations, about 60 percent of all losses of fixed wing aircraft occurred over North Vietnam, about 30 percent over South Vietnam, and about 10 percent over Laos. The following tabulation shows US losses of helicopters and fixed wing aircraft, by year.

Year	Fixed Wing Aircraft	Helicopters	Total
1965	311	170	481
1966	495	319	814
1967	583	630	1,213
Total	*1,389*	*1,119*	*2,508*

C. Rolling Thunder Losses

1. Loss Trends

Combat and operational losses* over North Vietnam totaled 867 fixed wing aircraft from 1965 through 1967. About 90 percent were combat losses caused by antiaircraft artillery and small arms fire, surface-to-air missiles, and MIG aircraft. Almost three-fourths were by antiaircraft artillery and small arms fire. In 1967 the number of combat losses of fixed wing aircraft over North Vietnam increased by 16 percent above those of 1966. The increase in 1967 resulted from a higher toll exacted by surface-to-air missiles and MIG aircraft. The number of fixed wing aircraft downed by antiaircraft artillery and small arms fire in 1967 was only one greater than in 1966. The following tabulation gives the numbers of US fixed wing aircraft downed over North Vietnam, by cause, during 1965, 1966, and 1967:

* *Causes of aircraft losses fall into two categories: operational losses caused by equipment failure and combat losses resulting from damage inflicted by the enemy's defenses. Aircraft downed by either of these causes may be flying one of two basic types of sorties -- attack sorties, which carry out strike and flak-suppression missions, and support sorties, which conduct photo and electronic reconnaissance, combat air patrol, search and rescue, electronic countermeasure, refueling, and forward air control missions.*

Cause	1965	1966	1967	Total	Percent of Total
Combat	168	283	328	779	90
Antiaircraft/ small arms	153	240	241	634	73
SAM	11	31	61	103	12
MIG	4	12	26	42	5
Operational	17	33	38	88	10
Total	*185*	*316*	*366*	*867*	*100*

The overall annual loss rate of US aircraft has decreased each year since the Rolling Thunder program began in 1965. During 1965, 185 US attack and support fixed wing aircraft were lost because of both operational failure and combat causes while flying 54,840 Rolling Thunder sorties -- an overall loss rate of 3.4 aircraft per 1,000 sorties. During 1966 and 1967 these rates decreased to 2.1 and 1.9, respectively. Similarly, combat losses of attack aircraft alone, which comprised 70 percent of the total number of losses during the three-year period, were sustained at a rate of 5.1 per 1,000 attack sorties during 1965, and subsequently decreased to 2.8 in 1966 and 2.4 in 1967. Table 16 shows the trends of the Rolling Thunder loss rates for the past three years.

However, a reversal of the declining loss rates that started in mid-1966 has occurred since the first quarter in 1967. After declining for three successive quarters, both the combat loss rate by attack missions and the overall loss rate by all missions rose in each of the last three quarters of 1967, and by the end of the year had reached levels about equal to those of the third quarter of 1966. The following tabulation gives the US combat loss rate and the combined combat and operational loss rate during each quarter of 1966 and 1967:

Table 16

Sorties, Losses, and Loss Rates of US Fixed Wing Aircraft over North Vietnam
1965-67

		Sorties	Losses	Combat Losses per 1,000 Sorties
Combat losses				
Attack missions	1965	25,270	129	5.1
	1966	81,360	226	2.8
	1967	106,940	252	2.4
Total		213,570	607	2.8
Support missions	1965	29,570	39	1.3
	1966	65,660	57	0.9
	1967	84,180	76	0.9
Total		179,410	172	1.0
All missions	1965	54,840	168	3.1
	1966	147,020	283	1.9
	1967	191,120	328	1.7
Total		392,980	779	2.0
Combat and operational losses				
All missions	1965	54,840	185	3.4
	1966	147,020	316	2.1
	1967	191,120	366	1.9
Total		392,980	867	2.2

Quarter	Combat Losses per 1,000 Sorties by Attack Missions 1966	1967	Combat and Operational Losses per 1,000 Sorties by All Missions 1966	1967
First	3.2	1.8	2.0	1.6
Second	3.4	2.3	2.6	1.8
Third	2.9	2.4	2.4	1.9
Fourth	2.0	3.0	1.6	2.3
Average	2.8	2.4	2.1	1.9

2. Aircraft Losses

a. By Geographic Area

Attacks against the industrial and transport targets in Route Package VI clearly entail a higher risk than attacks against targets in other Route Packages. During the last six months of 1967, attack and support missions targeted against Route Package VI carried out only one-fourth of all Rolling Thunder sorties but sustained more than one-half of the combat losses. During this period the combat loss rate of attack and support aircraft over Route Package VI was 4.5 per 1,000 attack and support sorties, almost three and one-half times the average for all other Route Packages. Figure 8 shows loss rates, by Route Package, during attack and support missions.

The disproportionately high loss rate in Route Package VI is attributable in large measure to losses sustained while attacking heavily defended targets within ten nautical miles of Hanoi or Haiphong. During the last nine months of 1967, 16 percent of all Rolling Thunder combat losses of attack aircraft were sustained by the 2 percent of all Rolling Thunder attack sorties targeted against the Hanoi and Haiphong areas -- a rate of 17.9 combat losses of attack aircraft per 1,000 attack sorties. The following tabulation gives sorties, losses, and loss rates recorded by US aircraft during attacks within ten nautical miles of Hanoi and Haiphong during the last three quarters of 1967:

Quarter of 1967	Attack Sorties	Combat Losses	Rate a/
Second	800	21	26.2
Third	685	8	11.7
Fourth	810	12	14.8
Total	*2,295*	*41*	*17.9*

a. Combat losses of attack aircraft per 1,000 attack sorties.

b. By Type of Target

The combat loss rate varies significantly with the type of target taken under attack. Attacks against industrial facilities in the heavily defended Hanoi-Haiphong area have sustained the highest loss rates. During 1967, for example, attacks against North Vietnam's petroleum and electric power facilities and the Thai Nguyen Iron and Steel Complex accounted for only about 1 percent of the Rolling Thunder attack sorties, but the combat loss rate during these attacks averaged 21.4 attack aircraft per 1,000 attack sorties -- almost nine times the overall average. Figure 9 shows loss rates, by target category, on attack sorties. By contrast, more than half of the total Rolling Thunder attack sorties were flown against nine of North Vietnam's primary roads on the infiltration routes to South Vietnam, but the loss rate during these attacks was 0.6 attack aircraft per 1,000 attack sorties, one-fourth of the overall average. Strikes against railroads accounted for one-eighth of the attack sorties and almost one-fourth of the combat losses -- a rate of 4.6 aircraft downed per 1,000 attack sorties. The following tabulation shows the variations in combat loss rates sustained by US attack aircraft against representative target systems during 1967:

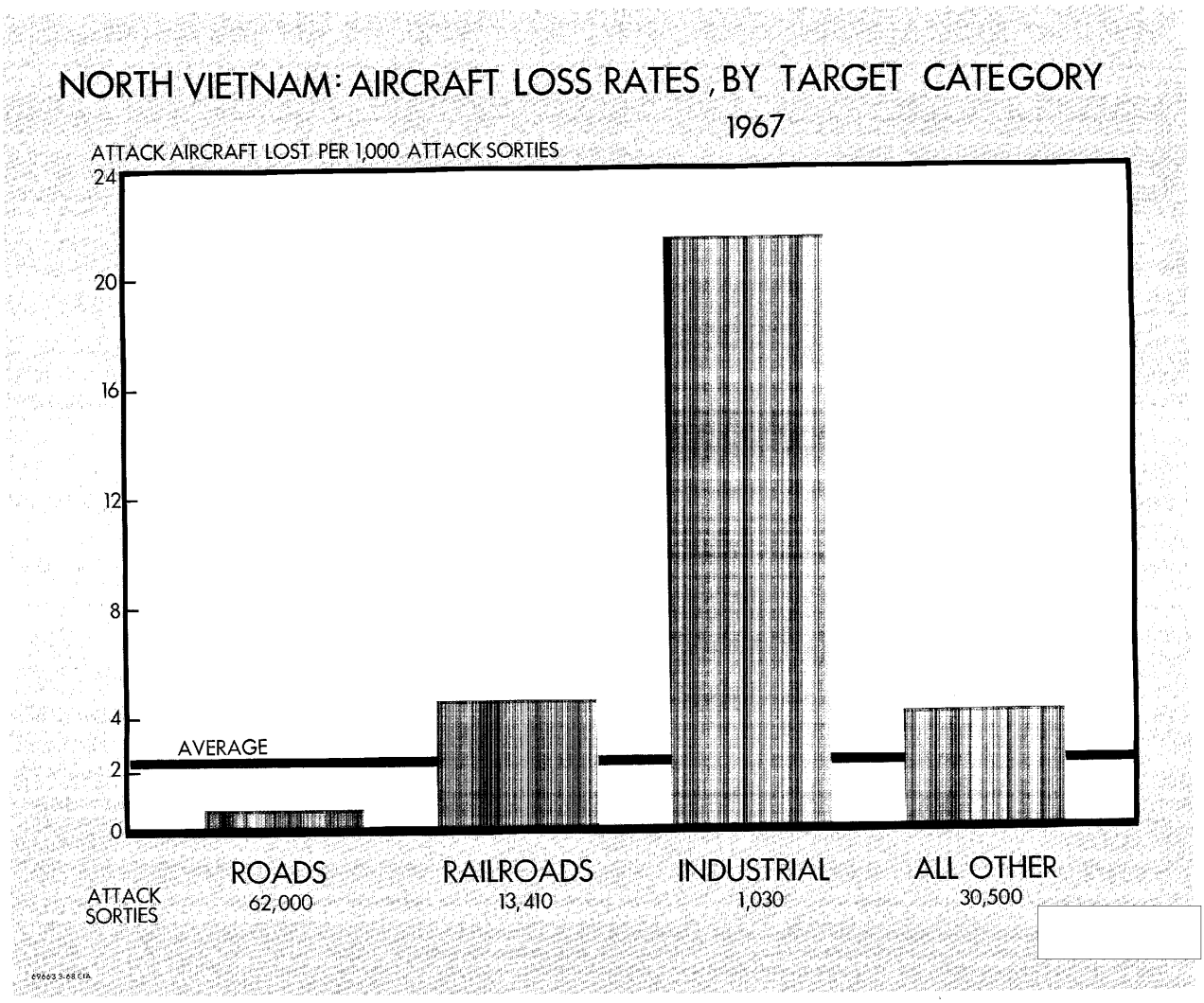

Figure 8. US Aircraft Loss Rates in North Vietnam, by Target Category, 1967

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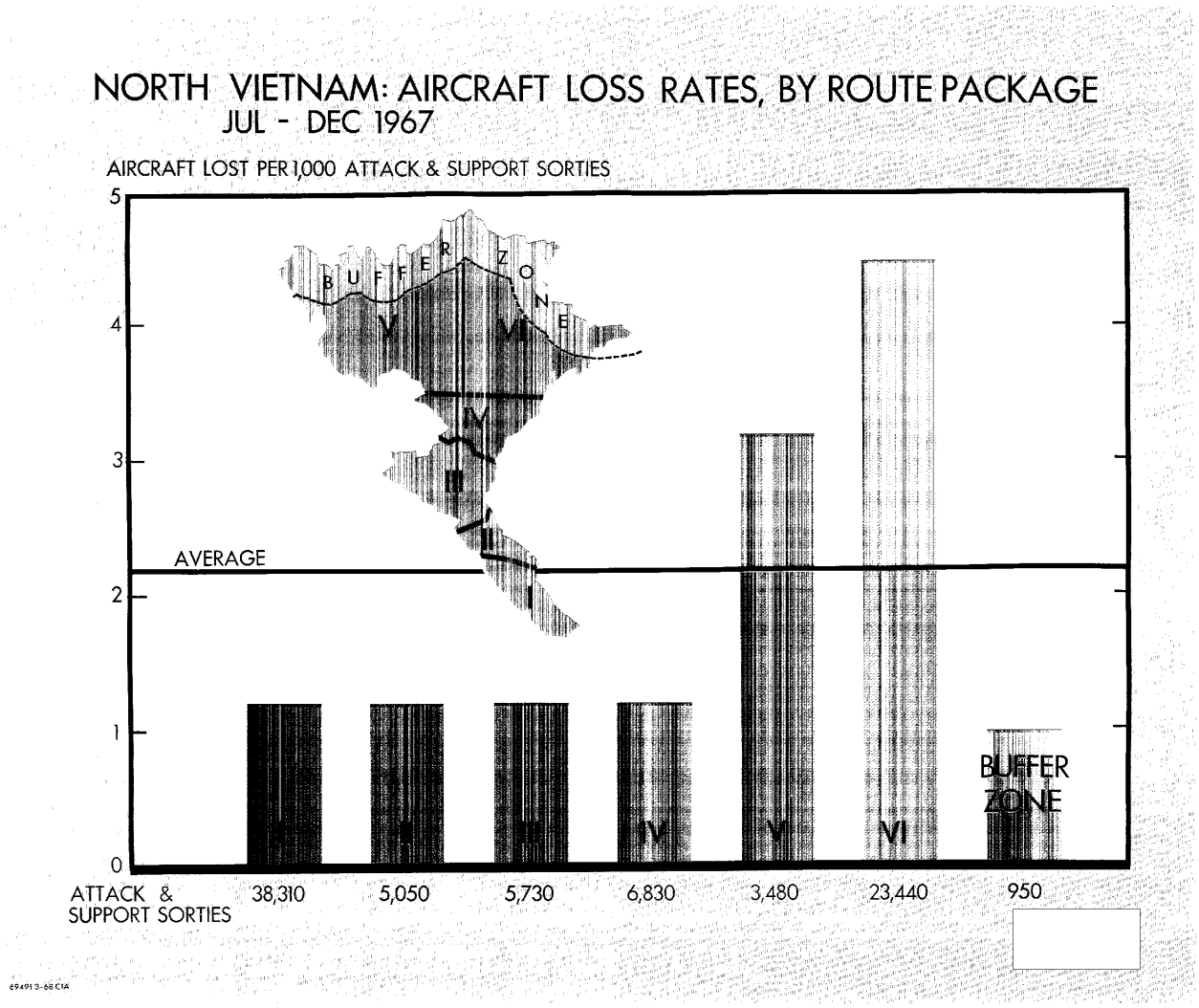

Figure 9. US Aircraft Loss Rates in North Vietnam, by Route Package, July-December 1967

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Target Category	Attack Sorties		Combat Losses		
	Number	Percent	Number	Percent	Rate
Industry	1,030	1.0	22	8.7	21.4
Electric power	630	0.6	12	4.7	19.0
Thai Nguyen Iron and Steel Complex	280	0.3	8	3.2	28.6
POL	120	0.1	2	0.8	16.7
Land transport routes	75,410	70.5	102	40.5	1.4
Highways	62,000	58.0	40	15.9	0.6
Railroads	13,410	12.5	62	24.6	4.6
All other	30,500	28.5	128	50.8	4.2
Total	*106,940*	*100*	*252*	*100*	*2.4*

a. Combat losses of attack aircraft per 1,000 attack sorties.

3. Personnel Losses

During the period August 1964 through 1967, more than 1,100 US Air Force, Navy, and Marine Corps personnel went down with aircraft disabled by hostile action over North Vietnam. About one-third of the downed personnel -- 360 men -- were rescued by US search and rescue forces.

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at least 20 percent of the downed personnel have been captured and 10 percent killed. More than one-third are carried as missing, a large share of the missing have been captured. The following tabulation shows the known status of personnel in each service downed by hostile action during August 1964 through 1967:

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	Downed	Rescued	Captured	Killed	Missing
Air Force	655	205	107	21	322
Navy	432	145	113	89	85
Marine Corps	28	12	5	0	11
Total	*1,115*	*362*	*225*	*110*	*418*

Heavy defenses around Hanoi and Haiphong in Route Package VI severely limit search and rescue efforts in these areas. Only 17 percent of the 192 personnel downed by enemy action in Route Package VI during 1967 were rescued, compared with the overall share of 32 percent for the past three years. Because of hostile surroundings, no search and rescue efforts were initiated for more than one-fourth of the 192 personnel downed by defenses in Route Package VI.

APPENDIX A

Transportation in the Hanoi and Haiphong Areas

Despite the interdiction of the most important railroad/highway bridges on the lines of communication (LOC's) serving the Hanoi and Haiphong areas, the North Vietnamese, at the cost of large expenditures of time and labor, have maintained the capacity of these LOC's at levels far greater than estimated traffic demands. The judgment that traffic continues to move in these areas at high levels is supported by several factors. Imports continue to flow into the port of Haiphong at high levels, the large accumulations of stocks in open storage areas in Haiphong continue to be turned over, and high levels of truck traffic continue to be observed moving south from Hanoi. Moreover, the reduced intensity of the bombing in the Hanoi and Haiphong areas between mid-December and mid-February has given North Vietnam even greater opportunities to further improve the capability and flexibility of its transport network.

Airstrikes against the transportation system in the Hanoi and Haiphong areas in 1967 have been characterized by periodic surges in intensity. The heaviest attacks in the Hanoi area were carried out in August, October, and December. In the Haiphong area, strikes were heaviest and most frequent in late September and early October. With the exception of these periods, land transportation in the immediate Hanoi and Haiphong areas has not been subjected to sustained air attack. There have, on the other hand, been sustained attacks against transportation targets in the important Hai Duong area between Hanoi and Haiphong throughout the last half of 1967. In addition, an extensive mining program has been carried out against water transport in the Hanoi, Haiphong, and Hai Duong areas, particularly in the last quarter of 1967.

1. Hanoi Area

Traffic into and out of Hanoi apparently continues at high levels despite damage to the key Doumer Bridge. Route 1A, the major north-south road in North Vietnam, remains serviceable. A high level of trucking activity and extensive use of highway bypasses was reported in mid-February. Recent comparative photography of the area also indicates that rail ferries and rail-to-water transshipment facilities are operational. In the last half of 1967, the Hanoi Railroad/Highway Bridge (Doumer), the longest and strategically most important bridge in North Vietnam, was open to truck traffic more than 60 percent of the time and to train traffic almost 50 percent of this time. It has been closed since mid-December. The Canal des Rapides Bridgeawas was open to through truck and train traffic about 60 percent of the time in the last half of 1967. This bridge is now open to through rail and highway traffic.

The most important damage inflicted against the Hanoi LOC's in recent months was against the Doumer Bridge. Strikes on 14 and 18 December destroyed 800 feet of the 5,500 foot bridge. The extent of the damage indicates that it will probably take more than the past average of one month to restore truck traffic and more than two months to restore limited rail service. As of 4 March 1968, repair activity apparently had not begun. This bridge previously was interdicted in August and October 1967. The interdictions and the times required for reopening the bridge to traffic are shown in Table 17.

The capacity of the bypasses over the Red River -- a rail ferry, seven highway ferries, four highway pontoon bridges, and two highway/pontoon causeways -- within 20 kilometers of the Doumer Bridge is more than adequate for North Vietnam's needs in the area. Many of these bypasses were installed in late 1967. In addition, there are at least 34 high-way ferries between Hanoi and Phu Tho, about 100 kilometers northwest of Hanoi, which could be used as alternates to the Doumer Bridge.

The Canal des Rapides Bridge also has been effectively backed up by a system of bypasses. In October a new highway cable bridge was added to the bypass system which already included a rail ferry, a highway pontoon bridge, and a highway ferry. A concrete and steel rail bypass bridge was also constructed in 1967 but has not been open to through traffic since it was interdicted in August 1967. The Canal des Rapides Bridge itself was serviceable for both rail and truck traffic by early January, despite the destruction of one span on 15 December 1967. The time required to repair this bridge has decreased progressively after each of four interdictions, the first of which occurred in April 1967. Strikes on 14 February apparently did not succeed in stopping traffic on the line. Earlier interdictions of the bridge and the time required for repair are shown in Table 17.

2. Haiphong Area

Traffic out of Haiphong apparently continues at high levels.

supplies may have been moved out of the port area in quantities roughly equivalent to the record volume of imports received in that month. The flow of seaborne imports into Haiphong did not abate even during the height of the bombing. Photographic analysis shows a continued turnover of the goods in the open storage areas of the port. The buildup in cargo seen in open storage

seems to be related more to the very high level of imports during these months than it is to any basic difficulty in moving the goods out of the port. Moreover, the rate of accumulation of cargo in storage areas has been much slower than the rate of increase of seaborne imports.

Although direct rail transport to and from Haiphong has been disrupted since the interdiction of the Haiphong Railroad/Highway Bridge in late September, rail shipments apparently are again originating from the port.

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rail shipments may be moving via a rail pontoon bypass bridge completed by at least late December 1967 or by the periodic emplacement of a removable span in the original bridge. In addition, there are at least six highway ferries and five highway pontoon bridges. These bypasses have a combined capacity about three times the uninterdicted capacity of the Hanoi-Haiphong railroad line and about two and one-half times the average daily volume of imports into Haiphong during the peak that was reached in January 1968. The damage resulting from strikes against the Haiphong rail line west of the interdicted Haiphong Railroad/Highway Bridge -- particularly against the railroad/highway bridges at Hai Duong -- has also been alleviated by the use of bypasses, and photography indicates that rail and truck traffic is continuing.

The most important roads serving the Haiphong area -- Route 5, which parallels the rail line connecting Hanoi and Haiphong, and Route 10, which serves the areas north and south of Haiphong -- remain operational. The destruction of three key highway bridges on Routes 5 and 10 in Haiphong in September 1967 was effectively circumvented by the extensive system of bypasses mentioned above. In addition, one of the three original bridges has been reconstructed as a cable bridge capable of handling truck traffic, and another has been adapted as a cable bridge for pedestrian traffic. A new highway -- Route 415 -- which will connect the Ning-ming area of China with Haiphong is in an advanced state of construction. This road will add an additional 1,000 tons to the daily capacity of North Vietnam's highway connections with Communist China.

Watercraft were used during the last half of 1967 to supplement the road and rail traffic out of Haiphong and in lightering operations at the main dock area and in the anchorages outside the port.

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Table 17

Interdiction of Major Railroad/Highway Bridges
in Hanoi and Haiphong Areas
1967 - February 1968

Bridge	Date of Interdiction	Approximate Date of Restoration		Number of Days Closed	
		Truck Traffic	Rail Traffic	Truck Traffic	Rail Traffic
Hanoi Railroad/Highway (Doumer) Bridge Over the Red River	11 Aug 67	9 Sep 67	4 Oct 67	29	54
	25 Oct 67	17 Nov 67	20 Nov 67	23	26
	14, 18 Dec 67	No repair activity as of 4 Mar 68		About 80	
Hanoi Railroad/Highway Bridge Over the Canal des Rapides	26 Apr 67	10 Jun 67	10 Jun 67	45	45
	12 Aug 67	17 Sep 67	17 Sep 67	36	36
	26 Oct 67	17 Nov 67	17 Nov 67	22	22
	15 Dec 67	4 Jan 68	4 Jan 68	20	20
	14 Feb 68	17 Feb 68	17 Feb 68	3	3
Haiphong Railroad/Highway Bridge	28 Sep 67	No repair activity as of 19 Feb 68		N.A. A movable span may have been periodically emplaced since interdiction	

APPENDIX B

Inventories of Transport Equipment

Inventories of transport equipment at present are at satisfactory levels, and shortages have apparently never been serious despite the increasing levels of destruction and damage during the three years of the Rolling Thunder program. Pilots have reported the destruction and damage of large numbers of railroad rolling stock, motor vehicles, and watercraft in North Vietnam and have reported heavy losses of trucks in Laos. However, a continuous supply of transport equipment provided by other Communist countries has compensated for these heavy losses. Inventories of railroad rolling stock and trucks have actually increased above the pre-bombing levels. Domestic construction of boats and imports of prefabricated barges have probably replaced most of the heavy watercraft losses, although the exact watercraft inventory is not known.

1. Railroad Rolling Stock Inventory

In 1964, North Vietnam's inventory of railroad rolling stock was estimated as 120 locomotives and 1,800 railroad freight cars. During the three-year bombing campaign, about 2,200 rail cars and 30 locomotives have been reported destroyed and about 3,100 rail cars and 50 locomotives damaged.* Imports, repairs of damaged equipment, and the use of Chinese meter-gauge and standard-gauge rail equipment have helped to increase the rolling stock inventory above pre-bombing levels. Photography [redacted] revealed an estimated 2,000 to 2,300 freight cars in North Vietnam. Several Black Shield missions since that date indicate that the freight car inventory has remained at about this level. Moreover, the capacity of the rail inventory has been increased significantly because at least a portion of the

25X1

* *Including a large number of small makeshift cars used on the Vinh line, mostly south of Thanh Hoa. These are not included in the inventory estimates.*

present inventory is standard-gauge cars with double the carrying capacity of meter-gauge cars.

Most of North Vietnam's rail equipment is used in the northern areas, and patterns of dispersal revealed by photography indicate that North Vietnam makes use of areas that have been relatively free from bombing. Most rail cars sighted were along the Dong Dang route, the principal rail connection with Communist China and the route that handles most of overland imports by rail. The average of nearly 500 cars sighted per photographic mission is more than twice that observed on other northern rail lines (see Table 18). Major concentrations of equipment on the Dong Dang line were in the Hanoi - Yen Vien area and in yards near the Chinese border, especially at Dong Dang which has never been attacked.

On the Haiphong line, major concentrations were noted at the main Haiphong rail yard until late September, when the Haiphong Railroad/Highway Bridge was interdicted and rail traffic serving the port was stopped. rail traffic continued on the remainder of the line, with the Haiphong Rail Yard West serving as a transshipment area for goods moving by rail to and from Haiphong.

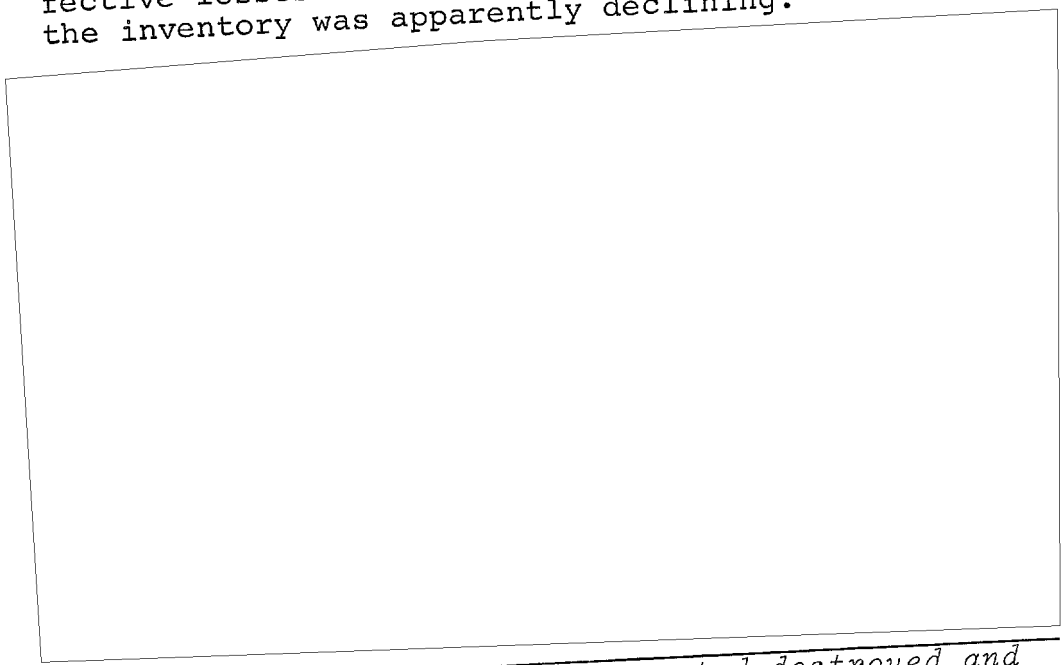
2. Motor Vehicle Inventory

Inventories of motor vehicles are currently above the pre-bombing level. At the beginning of 1965, North Vietnam had an inventory of 9,000 motor vehicles, including 3,000 military trucks. Effective losses* have been estimated at about 8,200

* *To arrive at an estimate of effective truck losses in both North Vietnam and Laos, pilot reports are first adjusted to eliminate double counting. Then a deflation factor is applied to adjust for inaccuracies in the data and for the fact that the North Vietnamese have the ability to repair and rebuild trucks. Inaccuracies are caused by various operational restrictions, such as the high speed of the aircraft, poor visibility due to weather, smoke and dust after the attack, night operations, and intense AAA fire. The formula for computing effective losses as agreed to by CIA and DIA is as follows:* [footnote continued on p. 79]

motor vehicles. Since 1965, however, North Vietnam has imported about 13,000 trucks from its Communist allies. Table 19 shows the estimated vehicle inventory in North Vietnam during the past three years.

A variety of trucks have been supplied by the USSR, Communist China, and Eastern European Communist countries in relatively equal shares, as shown in Table 20. The majority of the trucks imported are general cargo trucks such as the Russian GAZ 63, capable of carrying about two tons, and Chinese "Liberation" model with a payload of about three and one-half tons. Other imported equipment includes dump trucks, construction equipment, jeeps, and specialized items such as POL trucks, crane trucks, ambulances, and motor vehicle repair shops. An unusually high number of vehicles, almost 1,300, were sent from the USSR or Eastern Europe during the two months of December 1967 and January 1968. These vehicles arrived after a period in which effective losses were greater than known imports and the inventory was apparently declining.



75 percent of those trucks reported destroyed and 25 percent of those reported damaged are considered to be effective losses and are deducted from the inventory. For 1966, however, the extremely high numbers of trucks reported destroyed and damaged in Laos were further deflated by a factor of 20 percent.

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An increasing number of motor vehicles are being used to supplement rail transport in the Hanoi and Haiphong areas since the 1967 interdictions of the Hanoi and Haiphong Railroad/Highway Bridges. At Haiphong, the use of large numbers of trucks is common but fluctuates according to the intensity of the bombing. The average number of trucks sighted in the Haiphong area after the interdiction of the rail/highway bridge could have moved slightly more than 6,400 tons per day, the record high daily volume of imports during January 1968.

3. Watercraft Inventory

The number of watercraft in the North Vietnamese inventory -- estimated to be in excess of 30,000 inland and coastal craft -- is apparently adequate for North Vietnam's needs. The watercraft fleet is made up of barges with capacities from 50 to 800 tons, sma;; coasters, junks of from 70 to 300 ton capacity, sampans having capacities of from 4 to 10 tons, and tugs and small river steamers. Although reported losses of watercraft have been heavy since the bombing began -- 8,000 de-stroyed and 14,000 damaged -- there is no indica-tion of serious shortages. Domestic production and imports of watercraft have apparently been sufficient to maintain the operational capability of water transport.

Watercraft are used most extensively in the Red River Delta. Navigable waterways connect the urban centers of the Delta with two principal water routes and a number of minor routes between Haiphong and Hanoi. Besides moving goods through the heavily populated Delta, watercraft have played an important role in clearing imported cargoes from the port of Haiphong. The use of barges and

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other lightering craft for off-loading vessels at the main docks and in the anchorage outside the Haiphong port has increased markedly during 1967. In the Panhandle, watercraft are used to supplement rail and road transport. When required, large numbers of watercraft can be mustered to carry military as well as economic goods.

Table 18

North Vietnam: Rolling Stock, by Rail Line Observed on Photographic Missions a/

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Units

Date of Mission	Hanoi-Dong Dang b/	Hanoi-Haiphong	Hanoi-Thai Nguyen	Kep-Thai Nguyen	Hanoi-Lao Cai	Hanoi-Thanh Hoa	Total Serviceable	Total Damaged
1967								
25X1								
Cars	408	264	31	77	397	213	1,390	39
Locomotives	10	8	0	0	15	1	34	
25X1								
Cars	331	47	128	16	280	186	1,088	54
Locomotives	10	2	0	0	10	1	23	
25X1								
Cars	743		265	34	47		1,089	44
Locomotives	16		1	0	0		17	
25X1								
Cars		82					82	0
Locomotives		1					1	
25X1								
Cars	750	205			315		1,270	35
Locomotives	33	1			14		48	
25X1								
Cars	233		184				417	74
Locomotives	1		0				1	
25X1								
Cars	837	368	325		163		1,693	297
Locomotives	33	18	11		3		65	

Table 18

North Vietnam: Rolling Stock, by Rail Line Observed in Photographic Missions a/ [redacted]
(Continued)

Units

Date of Mission	Hanoi-Dong Dang b/	Hanoi-Haiphong	Hanoi-Thai Nguyen	Kep-Thai Nguyen	Hanoi-Lao Cai	Hanoi-Thanh Hoa	Total Serviceable	Total Damaged
1967 (Continued)								
[redacted]								
Cars	796	454	346		255		1,851	271
Locomotives	24	18	7		9		58	
[redacted]								
Cars	435	162	132	8	26		763	287
Locomotives	20	3	4	0	0		27	
1968								
[redacted]								
Cars	31			9	133		173	83
Locomotives	2			0	2		4	
[redacted]								
Cars	333	13	113	8	100	447	1,014	462
Locomotives	11	1	4	0	1	6	23	
Average Sighted								
Cars	490	199	203	25	191	282		
Locomotives	16	6	4	0	6	3		

[redacted]

b. Including the rail yards at Yen Vien and Hanoi.

Table 19

North Vietnam: Estimated Truck Inventories, Imports, and Effective Losses
1965-67

Units

	Inventory a/ as of 1 January	Imports b/	Effective Losses c/
1965	9,000	3,500	400
1966	11,000 to 12,000	4,700	3,000
1967	11,000 to 13,000	4,700	4,800
1968	11,000 to 13,000		
Total		*13,000*	*8,200*

a. Computed by adding imports and deducting effective losses from airstrikes and retirements (6 percent annually).
b. Estimated minimum imports.
c. Including truck losses in Laos.

Table 20

North Vietnam: Estimated Motor Vehicle Imports a/
1965-67

Units

	China	USSR	Eastern Europe	Total
1965	1,300	1,000	1,200	3,500
1966	1,300	1,800	1,700	4,700
1967	1,200	1,800	1,700	4,700
Total	*3,800*	*4,600*	*4,500*	*13,000*

a. Estimated minimum imports. Because of rounding, components may not add to the totals shown.

APPENDIX C

Restoration of the Electric Power Industry and Alternative Power Supply

North Vietnam's electric power industry has been one of the major targets in the US bombing attacks against modern industry. The North Vietnamese have demonstrated a high degree of resourcefulness and persistence in restoring a significant part of damaged capacity. The present policy emphasizes dispersal and revetment of power equipment, salvage and repair of equipment that can be made readily serviceable, and the use of diesel-driven generating equipment sufficient to cover the demands of essential services. There is no apparent intent to undertake major reconstruction of heavily damaged plants or to build new plants while the bombings continue.

I. Restoration of the Electric Power Industry

During the past three years, 125 strike missions have been flown against 14 JCS-targeted electric power installations. Each installation has been struck at least three times, and the heavily attacked Ben Thuy and Uong Bi Powerplants were struck 21 and 27 times, respectively. Measurable damage was inflicted by only 45 of the 125 missions. About 30 of 35 radar system bombings produced no discernible damage.

During June-October 1967, about 20 percent of the pre-strike national capacity of 187,000 kilowatts was operating. Serviceable capacity by the end of the year was increased to around 35 percent and, given a further respite from bombing, probably could be increased to 50 percent within a few months. Severe damage to about one-half of the generating capacity will require major reconstruction efforts over at least one to two years. Damage at three, and possibly four, plants has been so severe that repair attempts have been abandoned. It appears likely that severely damaged sections of four additional plants will not be repaired and that these sections may be dismantled for salvageable components (see Table 21).

The effect of air attacks has been blunted by the difficulty in accurately delivering ordnance in the presence of formidable air defenses and by North Vietnamese resourcefulness in countermeasures. After the initial strikes on power facilities in 1965, North Vietnam rapidly began to safeguard equipment. Transformers and some switching gear in substations were revetted. Transformers at main powerplants were relocated away from the powerplants in deep revetments. As cumulative losses of generating capacity reduced the capability of the transmission networks, transformers were removed from network substations for safekeeping or for use as spares. Turbogenerators were individually protected from blast effects by steel plates and sand bags.

Powerplants are inherently difficult to destroy because of the massive independent foundations that support generating equipment, and because design features incorporating multiple boilers and turbogenerators permit a high degree of flexibility in operating generating units either singly or in parallel. Little short of a direct hit on boilers or turbogenerators will produce lasting damage. Although near misses have a considerable effect on building structures and auxiliary components, this type of damage can be readily repaired. As the incidence of direct hits is comparatively low, long-term losses of generating capacity have developed by slow attrition.

North Vietnam has made a considerable effort to restore severely damaged powerplants to partial operation. Ten of the plants have been put back into service a total of 21 times after suffering severe damage. The Hanoi Thermal Powerplant was in operation within a few days after airstrikes on three separate occasions during 1967. The Nam Dinh Powerplant required almost two years for restoration to partial service after initial strikes in 1965, but damage inflicted in the fall of 1967 was repaired within one month. The Uong Bi Powerplant has been restored to service after severe damage on four separate occasions. The effort at recovery has in many cases been nullified by restrikes designed to thwart reconstruction programs.

Restoration of existing power facilities apparently has been accomplished by repair and innovation, rather than by new replacement. Foreign technical assistance has been substantial, but foreign material assistance has been minimal. There are no known imports of heavy power components such as steam-driven turbogenerators or auxiliary equipment, although some of the latter must have been received [redacted] 25X1 Hungary's reluctance to ship a replacement steam turbine for the Thanh Hoa Powerplant probably is typical of the attitude of foreign suppliers, who evidently regard new installations as both futile and expensive in a wartime environment. No attempt to install heavy equipment components has been observed in photography.

II. Alternative Power Supply

The North Vietnamese are relying heavily on diesel-driven generators as substitutes for central power facilities. Large orders for diesels placed during 1965 indicate that contingency planning was then well under way for an alternate power supply even though attempts to perform major reconstruction were made during the first year of airstrikes. A policy to forgo new construction of central power facilities apparently had evolved by mid-1966, when construction was halted on the large Thac Ba Hydroelectric Powerplant and most of the Russian technicians on that project returned to the USSR.

North Vietnam has a total inventory of some 3,000 diesel sets with a nominal generating capacity of 50,000 kilowatts. Technical limitations and dispersal practices, however, reduce effectiveness to around 30,000 kilowatts of usable capacity. During 1965-67, North Vietnam imported an estimated 2,500 diesel generating sets that make up 44,000 kilowatts of capacity. About 11 percent of this capacity was imported in 1965, 52 percent in 1966, and 37 percent in 1967. Additional unobserved imports and stocks existing before airstrikes on the power industry are estimated to make up the remainder.

North Vietnamese employment of the diesels varies with the size of the sets. Most of the diesels are small capacity sets used primarily to support transportation and agriculture. In industry these sets

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are also well-suited for supplying power to production activities that can be broken up into small power-consuming units. Undoubtedly a number of diesels are used for essential services such as hospitals and communications centers. Thirty-six identified large diesels with capacities ranging from 200 to 480 kilowatts each are large enough to use in the main power network, particularly when operating in parallel with larger steam-driven generators. Most of the large sets probably are located near Hanoi and Haiphong. Generating sets of 50 to 125 kilowatts capacity most likely have been allocated to small industry, machine building, fragmented manufacturing operations, or small urban localities such as Ben Thuy, where the central powerplant is out of operation. Some of the sets are likely to be held strictly as standby for emergencies. Groupings of diesel units by size are shown in the following tabulation*:

Range of Capacity (Kilowatts)	Number of Sets	Total Capacity (Kilowatts)	Estimated Usable Capacity (Kilowatts)
200-480	36	12,000	10,000
100-125	33	3,400	2,500
50-75	154	10,200	7,500
20-48	286	8,100	5,000
0.6-19	1,979	10,400	5,000

The importance of the diesel inventory depends on how much of the central generating capacity is out of operation. At the end of 1967, diesels were capable of offsetting about 25 percent of the 120,000 kilowatts out of operation. It is estimated that the diesels can effectively produce about 100 million to 120 million kilowatt-hours of electricity per year, some 20 percent of pre-strike production. Fuel consumption requirements for this level of production would be around 45,000 tons of diesel fuel.

Efforts to keep central powerplants in operation clearly demonstrate that sustained reliance on diesel generators is unsatisfactory. The benefits of mobility and easy concealment afforded by diesels

* *Including only those generating sets observed in import data.*

are outweighed by problems of efficient distribution of so many generating units. Difficulty in maintaining former standards of reliability and voltage stability and occasional logistics problems are certain to arise. The need to satisfy demands that exceed available capacity undoubtedly causes chronic problems in determining priorities and allocating power resources.

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Table 21

Status of North Vietnamese Power Facilities at the End of 1967

Name of Facility	Times Struck	Times Put Back in Partial Operation	Installed Capacity (Kilowatts)	In Operation or Lightly Damaged a/ (Kilowatts)	Severely Damaged and Abandoned b/ (Kilowatts)
Thermal powerplant					
Uong Bi	27	4	24,000	12,000	12,000
Hanoi	5	3	32,500	32,500	
Viet Tri	3	1	16,000	8,000	8,000
Thai Nguyen	10	2	24,000	12,000	12,000
Bac Giang	12	1	12,000	12,000	
Haiphong West	5	0	10,000		10,000
Haiphong East	3	0	7,000		7,000
Hon Gai	7	2	15,000	3,000	12,000
Nam Dinh	9	2	7,500	2,500	5,000
Thanh Hoa	11	3	5,000	2,500	2,500
Co Dinh	3	0	1,500		1,500
Ben Thuy	21	2	8,000		8,000
Hydroelectric powerplant					
Ban Thach	3	1	1,000	1,000	
Dong Anh substation	6	0	N.A.	N.A.	N.A.
Total	125	21	163,500 c/	85,500	78,000

a. Capacity that either is currently in operation or that probably could be put back into operation by mid-1968.
b. Capacity so severely damaged that restoration will require a period of one to two years. Abandonment appears to be a likely prospect for all capacity listed with the exception of Uong Bi and Thai Nguyen.
c. Total installed capacity including unstruck power facilities is 187,000 kilowatts.

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