REPORT TO

COMMITTEE OF OPERATIONS ANALYSTS

ECONOMIC EFFECTS OF SUCCESSFUL AREA ATTACKS ON SIX JAPANESE CITIES

4 September 1944

Prepared by a subcommittee
consisting of the following:

Commander Francis Bitter, USNR, Chairman
(OP-16-VA, Navy)

Lt. Colonel De Forest Van Slyck, AC
(A-2)

Dr. Robert L. Stearns
(Twentieth Air Force)

Mr. Paul Kerschbaum
(Foreign Economic Administration)

Mr. Edwin Martin
(Office of Strategic Services)

and a joint working staff under the direction of:

Lt. (jg) Roswell Whitman, USNR (OP-16-VA, Navy)
Lt. Charles J. Hitch (Office of Strategic Services)

NOTE: This report is preliminary in character and deals only with the economic effects of successful urban area attacks. A separate report with respect to estimates of force requirements is in process of preparation and should be available shortly.

TABLE OF CONTENTS

		PAGE
Preface:	Findings and Conclusions	
SUMMARY		
I.	Introduction	1 - 2
	Findings of the Study	1.
	Purpose	1.
	Assumptions	1.
II	The Target Cities	2 - 3
	Population	2.
	Industrial Concentration - Comparison with Germany	2.
	Vulnerability	3.
III	Damage Inflicted and Resulting Production Loss	
	Damage	4 - 5
	Total Production Loss	4.
	Production Loss by Industries	4.
IV	Absenteeism and Direct Damage	5 - 10
	Absenteeism	5.
	Absenteeism from Firefighting	6.
	Absenteeism from Casualties	6.
	Absenteeism from Dehousing	7.
	Absenteeism from Social Disorganization	7.
	Absenteeism Additional Loss by Reason of Unbalanced Labor Force	8.
	Absenteeism Impact on Priority and Non-Priority Industries	8.
	Direct Damage	9.
	Direct Damage to Identified Plants	9.
	Direct Damage to Unidentified Plants - Priority and Non-priority	9.
	Direct Damage: Translation into Economic Loss	10.
	Calculation of Total Loss	10.
V	Cost of Repair and Replacement	10 - 12
	Method of Calculating Repair and Replacement Costs	11.
	Total Cost	11.
	Incidence of the Burden	12.
VI	Conclusion	13 - 15
	Results of the Attacks - Comparison with Germany	13.
	Validity of Statistical Results	13.
	Recommendations	14.
CHART I	- Relative Importance of Various Factors in Causing Total Estimated Loss	16.
CHART II.-	Direct Production Loss by Industry as Percentage of Annual National Output of Japan.	16.
CHART III.	- Allocation of Total Direct Production Loss Among 6 Japanese Cities	17.
CHART IV.	- Relative Importance to War Production of 25 German and 6 Japanese Cities	17.

SECRET

TABLE OF CONTENTS (Continued)

CHAPTER I.-	Introduction	18 - 20
	Purpose of Study	18.
	Organization and Scope	18.
	Major Assumptions	19.
	Selected Japanese Cities (Map)	21.
	Density of Population (Map): Tokyo, Kawasaki Yokohama	22.
	Density of Population (Map): Kobe - Osaka	23.
	Density of Population (Map: Nagoya	24.
CHAPTER II.	Importance of the Target Cities in the Japanese War Economy	25 - 28
	Population and Physical Characterization	25.
	Figures in Study Apply to Japan Proper	
	Japanese Industrial Concentration - Comparison with Germany	26.
	Portion of Priority Industry in Conflagration Zone.	28.
CHAPTER III.	Absenteeism	29 - 36
	Basis for Estimating Absenteeism	29.
	Housing Destruction Assumed	30.
	Industrial Absenteeism Resulting from Fire Fighting Activities	31.
	Manpower Loss from Casualties	31.
	Absenteeism Resulting from Dehousing	32.
	Absenteeism Resulting from Impairment of Transportation	34.
	Absenteeism Resulting from Social Disorganization.	34.
	Distribution of Total Loss Between Priority and Non-priority Industry	35.
CHAPTER IV.	Production Loss from Damage to Industrial Structures.	37 - 49
	General Method	37
	Assessment of Damage	37.
	Duration of Loss	41.
	Addition of Loss from Absenteeism	42.
	Overall Production Loss	44.
	Loss by Individual Industries	45.
CHAPTER V	Cost of Repair and Replacement	50 - 54
	Significance of the Cost of Repair and Replacement	50.
	Assumptions and Methods	50.
	Overall Cost of Repair and Replacement	51.
	Replacement Burden Allocated by Industry	52.
	Total Loss: Production Loss Plus Repair and Replacement	52.
CHAPTER VI.	Conclusion	55 - 63
	Role of Present Report	55.
	Statistical Conclusions of Present Report	55.
	Comparison with Area Attacks on Germany	56.
	Factors Affecting Statistical Conclusions	57.
	Evaluation of the Attacks.	61.

SECRET

SECRET

SECRET

TABLE OF CONTENTS (Continued)

EXHIBIT I. Estimated Population and Labor Force 1944 for Selected Japanese Cities. Assumptions

EXHIBIT II Data on Building Construction and Housing: Major Japanese Cities.

EXHIBIT III Emergency Rehousing - Japanese Urban Industrial Areas.

EXHIBIT IV. Estimates of Casualties Caused by Conflagrations.

EXHIBIT V. Conflagration Damage to Utilities.

EXHIBIT VI. Method of Estimating Absenteeism.

EXHIBIT VII Basis for Estimated Distribution of Manufacturing Employment by Industries and Cities.

EXHIBIT VIII Fire Vulnerability of Identified Industrial Targets.

EXHIBIT IX. Estimated Damage and Production Loss on Identified Plants.

EXHIBIT X. Description of the Six Target Cities.

Tables in Summary

		PAGE
TABLE I.	Relative Importance of 6 Japanese and 25 German Cities to War Production in Their Respective Countries.	3.
TABLE II.	Contribution of Various Factors to Total Absenteeism	6.
TABLE III	Casualties Caused by Attacks	6.

Tables in Body of Report

TABLE I.	Estimated Distribution of Employment in Manufacturing in 6 Selected Japanese Cities, July 1944	27.
TABLE II	Relative Importance of 6 Japanese and 25 German Cities to War Production in Their Respective Countries.	
TABLE III	Housing Destruction in Six Cities	30.
TABLE IV	Casualties and Manpower Loss from Attacks	32.
TABLE V.	Factors Causing Absenteeism	36.
TABLE VI	Estimated Vulnerability of Identified Priority Factories.	39.
TABLE VII	Priority Industry Labor Apportionment to Identified and Unidentified Factories	43.
TABLE VIII	Production Loss Summaries	46.
TABLE IX	Production Loss in Man-months	47.
TABLE X	Percentage of Total National Loss Suffered by Each City.	
TABLE XI	Production Loss of Cities as Percent of Annual City Production.	48.
TABLE XII	Production Loss Per Ton IB in Man-months.	49.

Charts and Maps

CHART I	Relative Importance of Various Factors in Causing Total Estimated Loss	16.
CHART II	Direct Production Loss by Industry as Percentage of Annual National Output of Japan.	
CHART III.	Allocation of Total Direct Production Loss Among 6 Japanese Cities	17.
CHART IV.	Relative Importance to War Production of 25 German and 6 Japanese Cities	17.

SECRET

TABLE OF CONTENTS (Continued)

	PAGE
Map showing SELECTED JAPANESE CITIES	21
Map of TOKYO, KAWASAKI, YOKOHAMA (Density of Population)	22
Map of KOBE, OSAKA (Density of Population)	23.
Map of NAGOYA (Density of Population)	24

PREFACE: FINDINGS AND CONCLUSIONS

1. FINDINGS.

This study attempts to assess the economic effects of incendiary attacks which destroy 70 percent of the housing in six major Japanese cities: Tokyo, Kawasaki, Yokohama, Osaka, Kobe and Nagoya. These attacks, it is estimated, would result in a loss equal to 15 percent of one year's total Japanese manufacturing output. In major war industries (munitions, metals and chemicals), the average loss would be 20 percent of one year's output.

This production loss results from two elements:

(a) direct damage to industrial and housing facilities;

(b) the diversion of Japanese industry from its normal activities to the repair and replacement of this damage.

The direct production loss due to incendiary damage would be distributed among a number of industries, among them certain producers of front line equipment: aircraft components (loss of 20 percent of one year's output), tanks and trucks (13 percent), radio and radar (11 percent), aircraft engines (8 percent), ordnance (7 percent). The apparent existence of considerable stocks of aircraft components and of excess manufacturing capacity in tanks and trucks would probably prevent substantial reduction in final output in these categories. It is doubtful if losses of the magnitude indicated in other categories would appreciably affect front line strength.

The loss imposed by the burden of repair and replacement of incendiary damage would fall most heavily on the construction and machine tool industries. Since these industries lie deep in the productive process, the effect on front line strength would be delayed and diffuse. It has been assumed in this study that these basic industries would be capable of meeting the burden of repair and replacement resulting from the attacks within a six-months period. This assumption will be examined critically in a future study. If it should prove to be incorrect, the loss of production resulting from the attacks would be greater than stated in this paper.

II. CONCLUSIONS

Final judgment on the desirability of incendiary area attacks on Japan cannot be formed until a study of force requirements, now under way, is completed, and studies have been made of alternative target systems. However, one conclusion emerges clearly.

> Area incendiary attacks should be undertaken only when it is possible to conduct them in force and to complete the planned destruction of all six cities within a period of a few weeks. A lack of concentration in the attacks will substantially diminish their effects.

In addition, two tentative conclusions appear warranted.

> Incendiary attacks on congested urban areas will produce very great economic loss, measured in man months of industrial labor -- probably greater loss per ton of bombs despatched than attacks on any other target system. But because of the wide diffusion of this loss over many industries it is unlikely that output in any one important category will be so reduced as substantially to affect front line strength. (Precision attacks, assuming adequate intelligence and operational feasibility, can achieve such effects).
>
> Area attacks might, however, significantly increase and prolong losses affected by precision attacks on war industries. The direct loss they impose on war production is not inconsiderable. Their effect in delaying recuperation of vital factories damaged in precision attacks is of greater importance. Area attacks, for example, will do substantial damage to the machine tool industry and at the same time impose upon this industry an enormous replacement burden. Under such conditions, the task of reorganizing a munitions industry heavily damaged in precision attacks becomes far more difficult.

The findings of this report are preliminary and will be revised as more complete data become available.

SECRET

SUMMARY

I. INTRODUCTION

Findings of the Study

This study attempts to estimate the probable effect on Japanese war production of area incendiary attacks which are assumed to destroy 70 percent of the housing in six important industrial cities. It concludes that such attacks would impose on Japan a direct production loss equal to 7 percent of one year's production. For priority industry (munitions, metals, machinery, and chemicals) the figure rises to 10 percent. And for certain of these priority industries it would rise even higher. Aircraft components, for example, would suffer a 20 percent loss; tanks and trucks would experience a 13 percent loss; machinery, tools and instruments, 12 percent; radio and radar, 11 percent. Other categories of priority industry and all non-priority industry would suffer less. Tentative estimates of the burden of repair and replacement of damaged stocks, machinery and industrial buildings bring the total average loss to approximately 15 percent of one year's production; in priority production, the figure is 20 percent.

Purpose

The study was undertaken to provide data which would be used in relating the results to be expected from area incendiary attack to the effort required, which is being estimated in a separate report. Comparable studies of precision attacks on specific target systems are necessary for a judgment as to the most efficient use of the available striking force.

Assumptions

An analysis of the probable effects of hypothetical attacks against targets about which information is not complete necessarily requires the making of certain assumptions. In addition to the

basic assumption that it is operationally feasible to destroy 70 percent of the housing in the cities studied, the important further assumptions made in this paper are:

a. That the damage is not sufficiently great to overwhelm Japanese repair facilities.

b. That Japanese administrative controls do not suffer a major breakdown, and that the civilian population is not permanently demoralized.

c. That the attacks are made in force, and that all cities are attacked within a period of a few weeks.

d. A series of assumptions (described in Section IV) concerning the location and vulnerability of the large number of unidentified factories, both of priority and non-priority classification.

II THE TARGET CITIES

Population

The six cities included in this study -- Tokyo, Kawasaki, Yokohama, Osaka, Kobe, and Nagoya -- have a combined population (estimated as of July, 1944) of 14,908,000, approximately 20 percent of the total population of Japan Proper. They contain more than one-third of all workers in Japanese manufacturing plants and nearly one-half of all workers in priority industries. (The term priority industries as used in this study includes aircraft, shipbuilding, tanks and trucks, ordnance, radio and radar, machinery, tools an instruments, metals and chemicals -- the industries on which the Japanese war effort most directly depends.)

Industrial Concentration -- Comparison with Germany

No other industrial nation is dependent on so small an area for so substantial a portion of its manufactured products as is Japan. These six cities provide a far more concentrated target than do cities containing a comparable amount of German industry. All 25

of the principal German target cities for the RAF offensive of 1943 do not contain as high a percentage of the country's industry as do these six of Japan. Comparative figures showing the relative importance of the industrial concentration in these two groups of cities in the total war economy of the two countries are presented in the following table:

TABLE I

Relative Importance of 6 Japanese and 25 German Cities

To War Production in Their Respective Countries

	6 Japanese Cities	25 German Cities
% of total population	20	25
% of total industry	35	24
% of priority industry	48	31
% of aircraft	71	30
% of aero-engines	66	48
% of metals	53	28
% of machine tools	64	55
% of shipbuilding	25	20
% of chemicals	27	30

Vulnerability

The construction in these cities is largely of wood (over 90 percent of all buildings in the more congested residential areas of wooden construction), and they are characterized by a very high degree of inflamability. In the central areas of most of the cities, roofs cover 50 to 80 percent of all ground, and the percentage runs as high as 40 to 65 for the whole of Zones I and II, the assumed area of attack.

Although data on the location of plants are far from complete, nearly 60 percent of identified priority targets in the six cities are in the conflagration zones, so that in addition to residential destruction, damage could be expected to a substantion portion of industrial installations.

III. DAMAGE INFLICTED AND RESULTING PRODUCTION LOSS

Damage

The attacks assumed in this study would effect a degree of destruction never before equalled. Hamburg, with 56 percent of its housing destroyed or seriously damaged, suffered the heaviest losses among German cities attacked by the Allied Air Forces; the six Japanese cities, it is assumed, will suffer an average loss by complete destruction of 70 percent of their housing. From the six cities it is estimated that nearly 3,500,000 people will be evacuated; an additional 7,750,000 will be dehoused; more than 500,000 fatal casualties will be suffered; nearly 40 percent of all identified priority plants will be seriously damaged; and non-priority plants located in more inflammable buildings and more concentrated in congested districts, will suffer an even greater degree of damage.

Total Production Loss

The total estimated loss from absenteeism and direct damage to industrial plants (without taking account of replacement costs) amounts to 7,600,000 man-months of labor in the six cities, or an average of ten weeks' loss for each of the 3,200,000 industrial workers located in the six cities. This loss is equivalent to a little over three weeks' production of the whole Japanese economy, or 7 percent of one year's production. Because of the concentration of priority industries within these cities, loss within these categories is greater. Total losses in priority industries amount to 5,900,000 man-months--about five weeks' production in priority industries in Japan as a whole, or 10 percent of one year's production.

Production Loss by Industries

Losses are unevenly distributed among industrial categories; the range is from 2 percent in the case of textiles to 20 percent in aircraft components. The general machinery, tools, and in-

struments group suffers a 12 percent loss. Tanks and trucks also suffer heavy loss (13 percent). Moderate losses are inflicted on radio and radar (11 percent), the general metals category (9 percent), and aircraft engines (8 percent). Losses are relatively minor in the case of ordnance (6.5 percent), chemicals (6 percent), aircraft assembly (4 percent), and shipbuilding (2 percent). (See Chart II).

IV. ABSENTEEISM AND DIRECT DAMAGE

Production loss estimates were arrived at by combining loss caused by absenteeism and loss caused by direct damage to industrial installations. (See Chart I). Absenteeism causes industrial loss when workers fail to report for work in plants which are capable of operating. Industrial damage causes production loss until repairs have been effected. Loss from these two factors is obviously not altogether additive. If a plant is almost completely destroyed, absenteeism will not be a factor of any significance.

Absenteeism

In computing the probable amount of absenteeism which would result from the 70 percent destruction of housing postulated, British experience has been used as a guide, but the method employed has been modified to take account of elements peculiar to Japan.

Upon analysis, the principal factors contributing to absenteeism following an incendiary attack prove to be firefighting, casualties, dehousing (including the relocation of workers, the clearance of debris, and the diversion of labor to new construction), the impairment of transportation, and social disorganization.

The total loss from absenteeism is estimated to be equal to one month's production of all industrial workers in the cities attacked. The relative importance of the various factors in producing these losses is indicated in the following table:

TABLE II

CONTRIBUTION OF VARIOUS FACTORS TO TOTAL ABSENTEEISM

	Percent of Total Loss
Firefighting, etc.	12
Casualties	14
Dehousing (Relocation, debris clearance, new construction)	40
Transport dislocation	17
Social disorganization	17
TOTAL	100

Absenteeism from Firefighting

Firefighting against conflagrations of the dimensions assumed will require the efforts of a large part of the civilian population. On the basis of available information about ARP organization in Japan and the characterization of past conflagrations, it is assumed that firefighting activities will occupy the time of about half the labor force over a four-day period. First aid activities, time spent caring for injured family members, etc., will add to this figure.

Absenteeism from Casualties

The ratio of fatal casualties estimated to total population corresponds closely to that experienced in the Tokyo fire which accompanied the earthquake of 1923. Taking into account the significant characterizations of the various cities, an experienced fire staff estimated the probable casualties (persons killed, missing or seriously injured) to be expected as a result of the attacks. These estimates appear in the following tables:

TABLE III

CASUALTIES CAUSED BY ATTACKS

Cities	Casualties	Worker Casualties*
Tokyo	260,000**	135,000
Yokohama	45,000	22,000
Kawasaki	20,000	10,000
Nagoya	60,000	30,000
Osaka	150,000	80,000
Kobe	25,000	13,000
TOTAL	560,000	290,000

* Worker casualties were estimated by applying the percentage of

workers in each city to the total number of casualties.

** Tokyo casualties are based on the assumption that four attacks will be required to effect the 70 percent level of destruction. All other estimates are based on the assumption that the indicated destruction will be accomplished by one attack.

Some 290,000 casualties among industrial workers would, it is estimated, cause a loss within four months equal to about 4½ days production of the entire labor force.

Absenteeism from Dehousing

Even assuming 25 percent evacuation of the total population of the six cities, the destruction of 70 percent of all houses would leave 7,750,000 dehoused people. Under a system of compulsory billeting, with the allocation of 40 square feet per person, the housing available after the attacks would be able to accommodate approximately 8,60[illegible],000 of the total population of 10,310,000 which would remain in the devastated cities. Relocating these millions would require time and cause considerable absenteeism. New construction would be required for about 1,170,000. Before new construction could be commenced and utilities required, a considerable amount of debris clearance would have to be undertaken, the individuals burned out would no doubt spend some time attempting to salvage possessions from the ruins. It is assumed that about half the persons requiring new housing would be provided for in hutments largely of their own construction, the building of which would contribute to industrial absenteeism. These three factors, it is estimated, would produce a total loss equal to more than 12 working days of the entire labor forces. Relocation alone would be equal to nearly 9 working days of the entire labor force.

Absenteeism from Social Disorganization

The estimate of loss from social disorganization presented in this paper is based on the assumption that the Japanese will be no less efficient than the Germans in their maintenance of order and administration of medical aid, emergency relief, evacuation and emer-

gency housing. The German ARP organization, built up gradually as the weight of the RAF attacks increased, was seldom overwhelmed. When it was, as in the case of Hamburg, chaotic conditions ensued. The destruction assumed in thesix Japanese cities would be on a scale beyond anything the Germans were called on to meet. If a series of saturation attacks against all six targets should be launched without any preliminary period of small-scale area attacks during which the Japanese could develop and improve their organization and techniques, it is possible the defenses might be overwhelmed. The economic effects of such a debacle - without regard to its effects on morale, and its possible immediate military significance - might be of a magnitude beyond anything in European experience. On the basis of European experience, however, which provides the only objective standard available, it is estimated that this factor would cause a loss equal to 5 working days of the entire labor force, over and above losses from all other causes.

Absenteeism: Additional Loss by Reason of Unbalanced labor Force.

In addition to the average loss of time by all workers, estimated to equal one month, there would be a further loss in output - estimated as an additional week - due to the reduced efficiency of these reporting for work. This would be caused partly by the condition of workers reporting, and partly by the unbalanced character of the force available in many plants. The total average loss from absenteeism and reduced efficiency is therefore estimated at five weeks.

Absenteeism: Impact on Priority and Non-Priority Industries

Since the authorities, by providing special facilities for certain categories of workers, and by directing labor from one industry to another, can within limits determine which sectors of the economy will bear the major burden of absenteeism, priority industries are certain to suffer less than the average loss. It seems reasonable to assume that the average loss for workers in priority industries would be of the order of four weeks, and in non-priority industries six weeks.

Direct Damage

A pre-attack assessment of loss from direct damage to industrial installations poses two problems: first, the determination of what damage will be done; second, the translation of that damage into economic loss.

To determine probable damage, it is necessary to locate plants and to estimate their physical vulnerability. Paucity of data has made the task difficult. Information is available, however, concerning the location of many of the important pre-war installations. Some 317 identified priority plants account for an estimated 55 percent of all priority production in the six cities. For purposes of this study, Japanese industrial plants were divided into three groups: (1) identified priority plants; (2) unidentified priority plants; (3) non-priority plants (unidentified).

Direct Damage to Identified Plants

A staff of expert fire engineers estimated the likelihood of damage to all the identified priority plants, taking into consideration their location, their physical vulnerability, and the assumed spread of the conflagration. In making these estimates, the likelihood of direct hits was calculated on the basis of an assumed density of attack averaging 20 tons per square mile.

Direct Damage to Unidentified Plants -- Priority and Non-Priority

The extent of employment in unidentified priority plants of each category in each city was determined by subtracting the number of workers assigned to the identified plants from the total in the category estimated to be employed in the city. In some cases, identified plants accounted for all priority workers. Where they did not, one of two principles was followed in allocating unidentified plants to zones. If the location of identified plants seemed to form a pattern, as in the shipbuilding industry in Osaka, unidentified priority plants were allocated to zones in the same proportion. Where location seemed to be at random, as in machinery, tools and instruments in Tokyo, unidentified priority plants were apportioned to the various zones in proportion to the number of residences in these

zones. It was assumed that nearly all non-priority plants would be old, and located predominantly within the central areas. They were apportioned to Zones I and II on the basis of the percentage of residences in those zones. All unidentified factories apportioned to Zones I and II were assumed to suffer 60 percent destruction from fire. The validity of these assumptions is discussed in the conclusion.

Direct Damage: Translation into Economic Loss

On the basic assumption, derived from British experience and other evidence, that production loss for each damaged factory was equivalent to six months' production of the burned-out area, physical damage was converted into economic loss. Where excess capacity exists, as in the non-priority industries, it was assumed that damage to installations would affect production for only three months.

Calculation of Total Loss

In adding loss caused by absenteeism to loss caused by direct damage, a rule of thumb was used which provided for the addition of production loss from absenteeism to production loss from damage to installations when the latter was of the order of 33 1/3 percent or less; when physical damage was in excess of 33 1/3 percent, no additional loss was assumed to occur because of absenteeism.

V. COST OF REPAIR AND REPLACEMENT

Production loss in Germany was only a minor portion of the total loss imposed by area bombing. The cost of repair and replacement of damaged goods and buildings proved to be the major cost imposed on economy. (In 1943, of the total loss of approximately 7.4 percent of one year's German industrial production, 2.2 was attributed to production loss and 5.2 to repair and replacement.) The burden of repair and replacement of damaged machinery, stocks, and buildings is important because it diverts labor from other work, and because it is concentrated principally on a few industries, such as iron and steel, electrical engineering, and machine tools, which may be unequal to the effort.

Method of Calculating Repair and Replacement Costs

It has not been possible at this stage to undertake detailed estimates of the costs of repair and replacements to Japan, but an attempt has been made to assess their general magnitude, and certain tentative conclusions have been reached. In making these tentative estimates, factors used in assessing damage to industrial buildings, equipment and stocks in Germany have been applied to the estimates of damage to Japanese factories. These factors were worked out mainly from British data, and insofar as Japanese conditions and practices vary from the British, they introduce a margin of error. It is necessary to point out that this margin of error may be great.

Total Cost.

The application of these factors to the estimates of damage to Japanese factories already developed yields the following results:

	Thousands of man-months
Cost of repairing or reconstructing factory buildings	3,200
Cost of replacing destroyed machinery and other equipment	3,600
Cost of replacing destroyed stocks of finished goods and work in process	2,000
TOTAL	8,800

Practically all the burden of replacing equipment and stocks will fall on priority industries. Most of the burden of repairing building damage would fall on the construction industry and on the producers of building materials, which, except for metals and chemicals,* are primarily non-priority. The total loss comprises 5,900,000

* The category chemicals as employed in Japanese official statistics includes glass and cement. Obviously, the repair burden on these portions of the chemical industry would have little direct military significance.

Method of Calculating Repair and Replacement Costs

It has not been possible at this stage to undertake detailed estimates of the costs of repair and replacements to Japan, but an attempt has been made to assess their general magnitude, and certain tentative conclusions have been reached. In making these tentative estimates, factors used in assessing damage to industrial buildings, equipment and stocks in Germany have been applied to the estimates of damage to Japanese factories. These factors were worked out mainly from British data, and insofar as Japanese conditions and practices vary from the British, they introduce a margin of error. It is necessary to point out that this margin of error may be great.

Total Cost.

The application of these factors to the estimates of damage to Japanese factories already developed yields the following results:

	Thousands of man-months
Cost of repairing or reconstructing factory buildings	3,200
Cost of replacing destroyed machinery and other equipment	3,600
Cost of replacing destroyed stocks of finished goods and work in process	2,000
TOTAL	8,800

Practically all the burden of replacing equipment and stocks will fall on priority industries. Most of the burden of repairing building damage would fall on the construction industry and on the producers of building materials, which, except for metals and chemicals,* are primarily non-priority. The total loss comprises 5,900,000

* The category chemicals as employed in Japanese official statistics includes glass and cement. Obviously, the repair burden on these portions of the chemical industry would have little direct military significance.

man-months in priority industries; 1,900,000 man-months in non-priority industries.

These estimates do not include allowance for destruction of factories in non-priority industries, of non-industrial buildings and installations, nor of stocks of goods in warehouses.

When added to the estimates of direct production loss, these figures bring the total loss inflicted by the attacks to approximately 16,500,000 man-months, equivalent to almost two months total Japanese output. Approximately 12,000,000 man-months are in priority industries, equivalent to more than two months of total annual output in this category. (See Chart I)

Incidence of the Burden

The repair and replacement burden is heavily concentrated on the construction and equipment industries. Although the analysis is too tentative to permit any firm conclusions, the possibility seems to exist that the impact of demands on certain of these industries--notably the machine tool industry--may so far exceed their capacity that the effect of the attacks would be prolonged well beyond the six-months period assumed on the basis of British and German experience. The ability of the replacement industries to bear this burden is being made the subject of a special study. Pending the completion of this study, it is tentatively estimated that the construction and equipment industries will have to devote their whole resources to replacing damage for about two months, and that in some sectors of these industries--e.g., machine tools--the burden will be the equivalent of at least eight months' production at pre-attack rates of output. When it is considered that a substantial portion of machine tool capacity will be destroyed in the attacks, and that a large part of the output of the remaining plants will be required to make good the damage in the industry itself, the possibility of producing serious and long-lasting dislocation of a considerable portion of the entire Japanese productive machine appears promising.

man-months in priority industries; 1,900,000 man-months in non-priority industries.

These estimates do not include allowance for destruction of factories in non-priority industries, of non-industrial buildings and installations, nor of stocks of goods in warehouses.

When added to the estimates of direct production loss, these figures bring the total loss inflicted by the attacks to approximately 16,500,000 man-months, equivalent to almost two months total Japanese output. Approximately 12,000,000 man-months are in priority industries, equivalent to more than two months of total annual output in this category. (See Chart I)

Incidence of the Burden

The repair and replacement burden is heavily concentrated on the construction and equipment industries. Although the analysis is too tentative to permit any firm conclusions, the possibility seems to exist that the impact of demands on certain of these industries--notably the machine tool industry--may so far exceed their capacity that the effect of the attacks would be prolonged well beyond the six-months period assumed on the basis of British and German experience. The ability of the replacement industries to bear this burden is being made the subject of a special study. Pending the completion of this study, it is tentatively estimated that the construction and equipment industries will have to devote their whole resources to replacing damage for about two months, and that in some sectors of these industries--e.g., machine tools--the burden will be the equivalent of at least eight months' production at pre-attack rates of output. When it is considered that a substantial portion of machine tool capacity will be destroyed in the attacks, and that a large part of the output of the remaining plants will be required to make good the damage in the industry itself, the possibility of producing serious and long-lasting dislocation of a considerable portion of the entire Japanese productive machine appears promising.

VI. CONCLUSION

Results of the Attacks -- Comparison with Germany.

The great concentration of industry in the six Japanese cities studied in this report, together with their high degree of inflammability, makes them peculiarly suited to area incendiary attacks. Attacks of the degree of effectiveness assumed in t is report would produce economic losses of far greater magnitude than those experienced in the European Theater. A comparison of the results estimated to follow successful attacks on the six Japanese cities with the results of the area bombing of Germany is illuminating.

The RAF in 74 full-scale attacks on 25 German cities in 1943 dropped nearly 100,000 tons of bombs to achieve an average level of 25 percent destruction or serious damage to houses in these cities, and to render 4,500,000 persons homeless. On the basis of the assumptions employed in this report, a fraction of this effort directed at six Japanese cities would destroy 70 percent of their housing, rendering 7,750,000 people homeless. Germany suffered an estimated direct production loss of 2.2 percent of one year's industrial output, a total loss of about 7.5 percent. The corresponding figures for Japan are 7 percent and 15 percent; for priority industry total loss rises to 20 percent. The highest direct production loss imposed on Germany was 7 percent of one year's machine tool output. The Japanese loss in the general category of machinery, tools and instruments is 12 percent, in aircraft components it is 20 percent.

Validity of Statistical Results.

The statistical findings of this report are liable to two principal errors. Estimates of damage to factories are possibly high; the procedure used in assessing factory vulnerability may have assigned too large a portion of unidentified plants to the conflagration zone, and may have taken insufficient account of the possible construction of fire breaks. If unidentified plants, contrary to the

VI. CONCLUSION

Results of the Attacks -- Comparison with Germany.

The great concentration of industry in the six Japanese cities studied in this report, together with their high degree of inflammability, makes them peculiarly suited to area incendiary attacks. Attacks of the degree of effectiveness assumed in t is report would produce economic losses of far greater magnitude than those experienced in the European Theater. A comparison of the results estimated to follow successful attacks on the six Japanese cities with the results of the area bombing of Germany is illuminating.

The RAF in 74 full-scale attacks on 25 German cities in 1943 dropped nearly 100,000 tons of bombs to achieve an average level of 25 percent destruction or serious damage to houses in these cities, and to render 4,500,000 persons homeless. On the basis of the assumptions employed in this report, a fraction of this effort directed at six Japanese cities would destroy 70 percent of their housing, rendering 7,750,000 people homeless. Germany suffered an estimated direct production loss of 2.2 percent of one year's industrial output, a total loss of about 7.5 percent. The corresponding figures for Japan are 7 percent and 15 percent; for priority industry total loss rises to 20 percent. The highest direct production loss imposed on Germany was 7 percent of one year's machine tool output. The Japanese loss in the general category of machinery, tools and instruments is 12 percent, in aircraft components it is 20 percent.

Validity of Statistical Results.

The statistical findings of this report are liable to two principal errors. Estimates of damage to factories are possibly high; the procedure used in assessing factory vulnerability may have assigned too large a portion of unidentified plants to the conflagration zone, and may have taken insufficient account of the possible construction of fire breaks. If unidentified plants, contrary to the

assumptions employed in this report, were to prove no more vulnerable than identified plants, loss from damage to plants would be reduced by 1,440,000 man months -- a loss only in small part compensated for by an increase of 200,000 man months loss from absenteeism. Production loss would be diminished from 7 to 5 percent of one year's output; and total loss (production loss plus repair and replacement costs) would fall from 15 percent to 11 percent.

Estimates of the duration of loss, on the other hand, are quite possibly too low. The preliminary analysis undertaken in this report suggests that the replacement demands on certain industries -- notably the machine tool industry -- may greatly exceed their capacities, extending the period required for recuperation far beyond the six months allowed in this study.

The estimates of this report assume that attacks would be sufficiently concentrated to prevent the dissipation of their effects, but not so concentrated as to overwhelm defences and government administration. If the attacks should be only sporadic and extend over a considerable period of time, loss from absenteeism and factory damage would be reduced and the problem of repair simplified. The estimates made in this study will accordingly be too high. There is reason to believe that a sudden series of saturation attacks against all six targets may overwhelm the untried Japanese ARP organisation and the administration, creating chaotic conditions. If this situation should be produced, economic losses would be more serious than those estimated.

Recommendations

No recommendation concerning the desirability of including incendiary attacks on Japanese cities in a general bombing program is possible until a more satisfactory estimate has been made of force requirements and similar data prepared on other target systems.

One definite conclusion emerges from the present study: area attacks should not be commenced until it is possible to conduct them

assumptions employed in this report, were to prove no more vulnerable than identified plants, loss from damage to plants would be reduced by 1,440,000 man months -- a loss only in small part compensated for by an increase of 200,000 man months loss from absenteeism. Production loss would be diminished from 7 to 5 percent of one year's output; and total loss (production loss plus repair and replacement costs) would fall from 15 percent to 11 percent.

Estimates of the duration of loss, on the other hand, are quite possibly too low. The preliminary analysis undertaken in this report suggests that the replacement demands on certain industries -- notably the machine tool industry -- may greatly exceed their capacities, extending the period required for recuperation far beyond the six months allowed in this study.

The estimates of this report assume that attacks would be sufficiently concentrated to prevent the dissipation of their effects, but not so concentrated as to overwhelm defences and government administration. If the attacks should be only sporadic and extend over a considerable period of time, loss from absenteeism and factory damage would be reduced and the problem of repair simplified. The estimates made in this study will accordingly be too high. There is reason to believe that a sudden series of saturation attacks against all six targets may overwhelm the untried Japanese ARP organisation and the administration, creating chaotic conditions. If this situation should be produced, economic losses would be more serious than those estimated.

Recommendations

No recommendation concerning the desirability of including incendiary attacks on Japanese cities in a general bombing program is possible until a more satisfactory estimate has been made of force requirements and similar data prepared on other target systems.

One definite conclusion emerges from the present study: area attacks should not be commenced until it is possible to conduct them

in force and to complete the entire program within a period of a few weeks.

Some additional conclusions of a tentative nature appear to be warranted by the magnitude and character of the production loss resulting from these attacks.

The amount of loss -- measured in total man months -- is extremely large, probably considerably larger per ton of bombs than could be achieved by attacks on any other type of target. It is, on the other hand, highly diffused, affecting all industries to some extent, and crippling no industry engaged in the production of finished munitions. Much of the loss will not be felt for many months.

It is possible that attacks on precision systems may achieve effective concentration on industries of strategic importance and affect military strength within a brief period.

Area attacks would seriously damage the machine tool and other equipment industries, and would impose a heavy replacement demand on their capacity; if area attacks are made subsequent to attacks on specific target systems, these effects would delay the recuperation of factories damaged in the precision attacks. A more accurate assessment of this possibility will be possible upon the completion of the study of the capacity of the replacement industries now in progress.

The social and administrative disorganization which would be produced by these attacks might prove valuable as an adjunct to invasions

These conclusions all apply to incendiary attacks on congested urban areas. The desirability of attacking specifically industrial urban areas with heavy combined HE-IB loads has not yet been considered.

The findings of this report are preliminary, and will be revised as more complete data become available. The problem of recuperability

will be dealt with in a supplementary report. An estimate of force requirements is also in process of preparation.

in force and to complete the entire program within a period of a few weeks.

Some additional conclusions of a tentative nature appear to be warranted by the magnitude and character of the production loss resulting from these attacks.

The amount of loss -- measured in total man months -- is extremely large, probably considerably larger per ton of bombs than could be achieved by attacks on any other type of target. It is, on the other hand, highly diffused, affecting all industries to some extent, and crippling no industry engaged in the production of finished munitions. Much of the loss will not be felt for many months.

It is possible that attacks on precision systems may achieve effective concentration on industries of strategic importance and affect military strength within a brief period.

Area attacks would seriously damage the machine tool and other equipment industries, and would impose a heavy replacement demand on their capacity; if area attacks are made subsequent to attacks on specific target systems, these effects would delay the recuperation of factories damaged in the precision attacks. A more accurate assessment of this possibility will be possible upon the completion of the study of the capacity of the replacement industries now in progress.

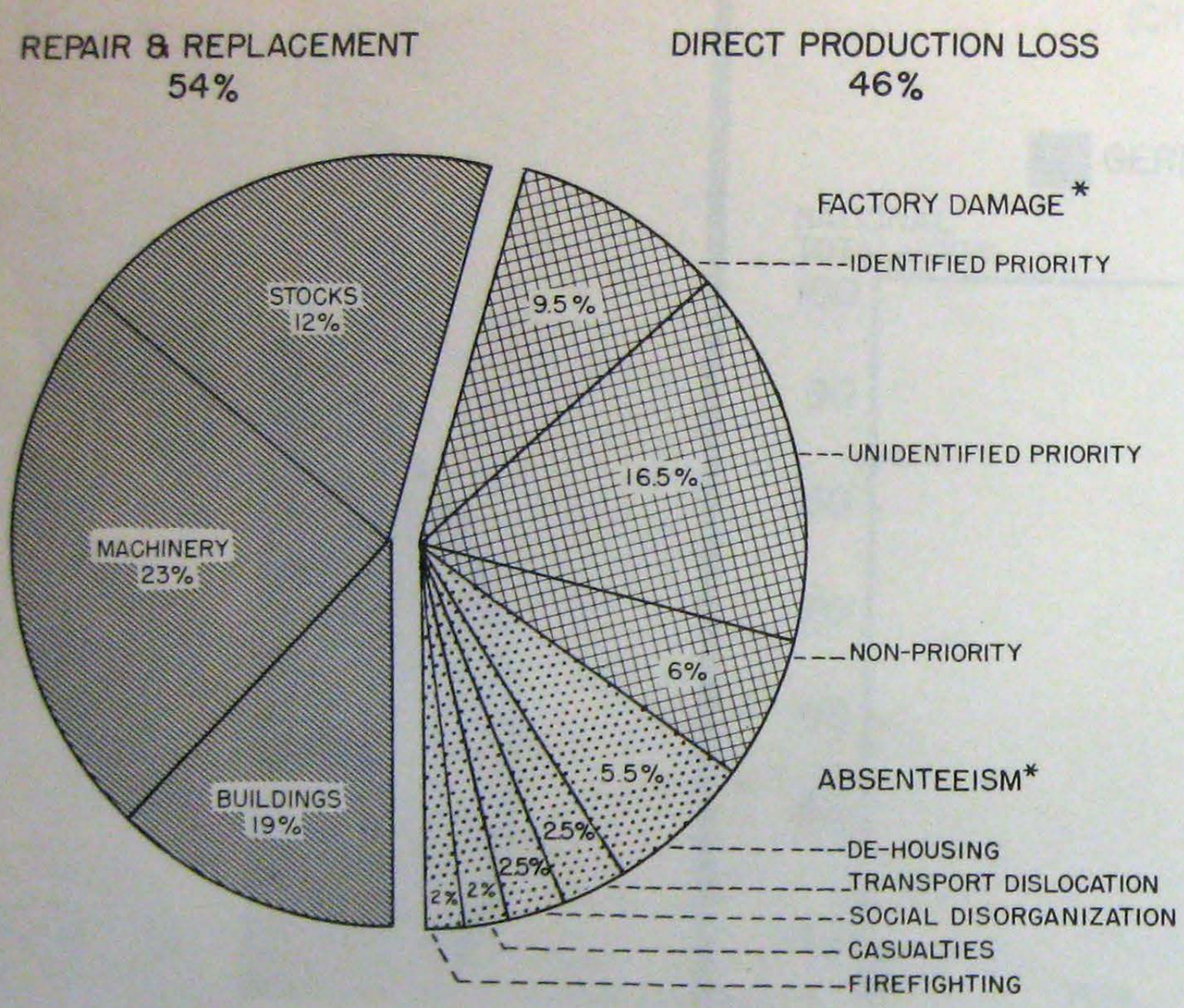
The social and administrative disorganization which would be produced by these attacks might prove valuable as an adjunct to invasions

These conclusions all apply to incendiary attacks on congested urban areas. The desirability of attacking specifically industrial urban areas with heavy combined HE-IB loads has not yet been considered.

The findings of this report are preliminary, and will be revised as more complete data become available. The problem of recuperability

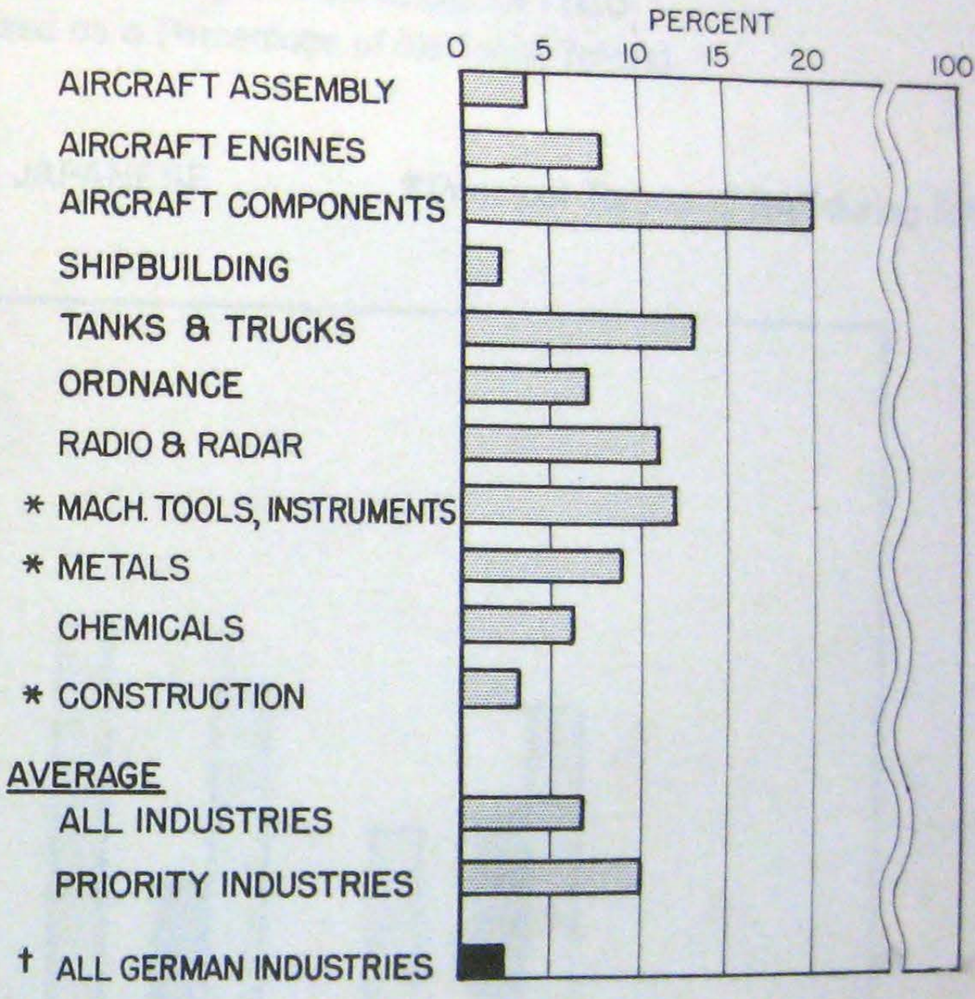
will be dealt with in a supplementary report. An estimate of force requirements is also in process of preparation.

CHART I–RELATIVE IMPORTANCE OF VARIOUS FACTORS IN CAUSING TOTAL ESTIMATED LOSS



* Wherever loss from factory damage and absenteeism overlaps, the entire loss has been allocated to factory damage.

CHART II–DIRECT PRODUCTION LOSS BY INDUSTRY AS PERCENTAGE OF ANNUAL NATIONAL OUTPUT OF JAPAN



* The burden of repair and replacement will fall heavily on these industries, increasing losses considerably beyond those shown.

† Imposed by RAF attacks on 25 cities during 1943.

SECRET

CHART III - ALLOCATION OF TOTAL DIRECT PRODUCTION LOSS AMONG 6 JAPANESE CITIES

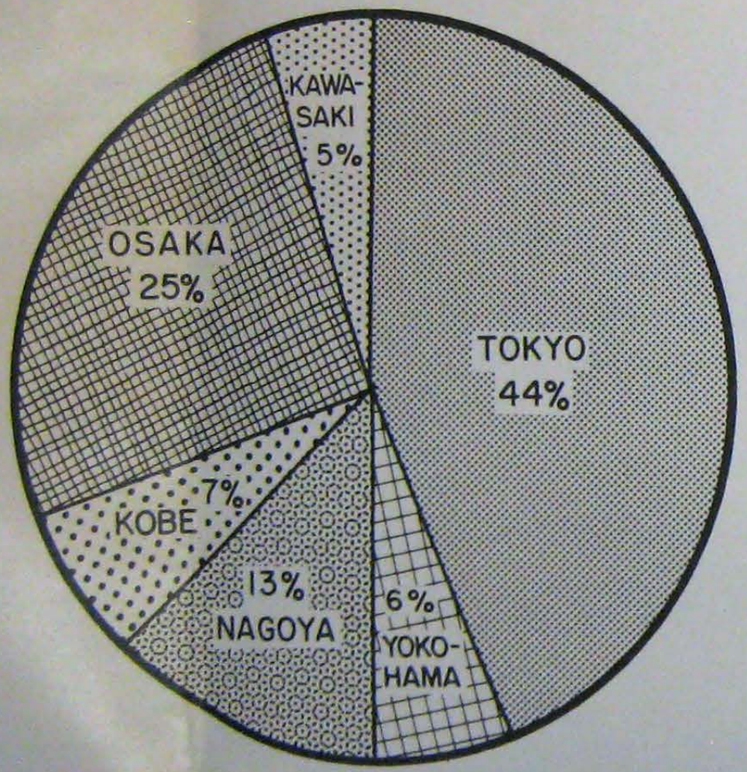
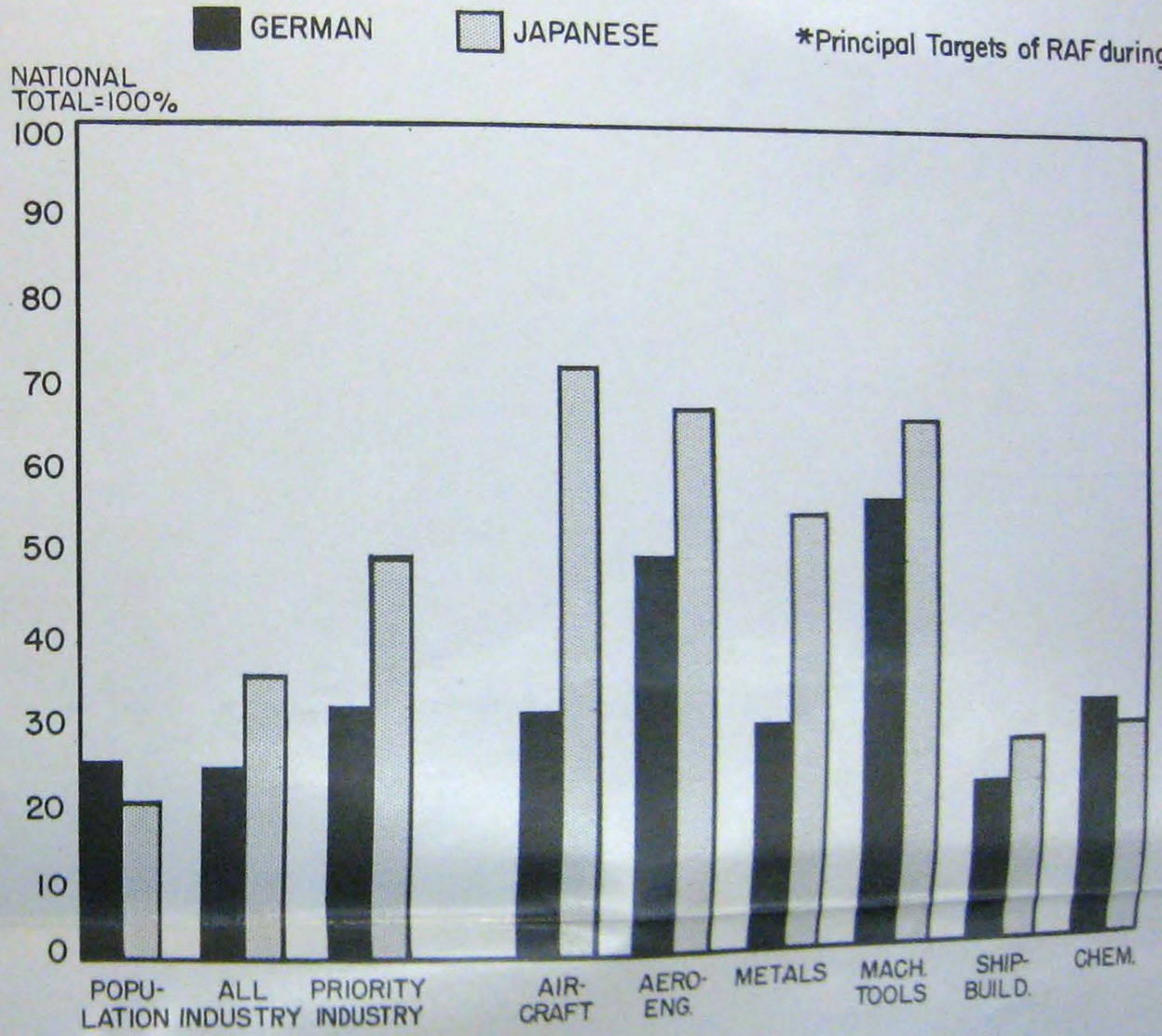


CHART IV - RELATIVE IMPORTANCE TO WAR PRODUCTION OF 25 GERMAN* AND 6 JAPANESE CITIES

(City Totals expressed as a Percentage of National Totals)



SECRET

CHAPTER I

INTRODUCTION

Purpose of Study.

This study is a pre-attack appraisal of the economic ef
to be expected from successful area incendiary attacks upon t
Japanese industrial cities of Tokyo, Yokohama, Kawasaki, Nago
Osaka and Kobe. These cities were selected as constituting t
most profitable urban areas for this type of attack.

The purpose of study is to estimate the production loss
which may be inflicted on industries of military importance b
area incendiary attacks. When compared with the effects whic
be achieved by attacks on precision targets, it should form a
sis for determining the most effective use of a strategic bom
force of a given size.

Organization and Scope.

Chapter II contains a general description of the target
and an analysis of their importance in the Japanese economy.

The following three chapters analyze the major causes o
industrial production which can be expected from successful a
General damage, destruction of houses and transport facilitie
organization, and casualties resulting from the attack, affec
trial production by causing workers to absent themselves fro
places of employment. The extent of such absenteeism is est
Chapter III. Damage to factories and other industrial insta
is directly responsible for the stoppage or interruption of
the damaged factories. The extent of such damage and the ma
the resulting loss of production is assessed in Chapter IV.
the destruction of factory buildings, machinery, equipment,
imposes an indrect loss on the Japanese economy, since labor

resources must be diverted to replace them. This indire
assessed in Chapter V. The results of the analysis are
and evaluated in a concluding chapter.

Attached to the study are exhibits explaining the
analysis used and presenting essential detail which has
nated from the body of the report.

Major Assumptions:

In preparing a pre-attack assessment of this chara
necessary to make various assumptions relating to operat
tors, the vulnerability of the target, and other matters
which the state of our present knowledge is inadequate.
assumptions underlying this study are as follows:

1. That the incendiary attacks on the central are
six Japanese cities succeed in burning out Zones I and I
cities; or that, if these areas are not completely burne
equivalent amount of destruction will occur in Zone III.

2. That, with the exception of Tokyo, each of the
be subject to a single attack, continuous in time, and wi
cation of sufficient force to burn out Zones I and II; i
Tokyo, four separate attacks, within a short period, are
operationally necessary. If attacks are made on a small
over a lengthy period of time, their effects will be les
ficance of attacks of this pattern is discussed in the c

3. That a ground density of approximately 20 tons
per square mile is achieved in Zones I and II of each ci
assumption is used only in estimating the physical damag
structures; elsewhere it is merely assumed that the weig
will be adequate to achieve the objective of burning out

4. That the extent of damage will not be such as
the Japanese construction and equipment industries. A d
relating the burden imposed on these industries with the
is being prepared as a supplement to this report. For t

of this study, a maximum of six months is assumed to be re
restoration of production.

5. That Japanese administrative controls do not suf
major breakdown, and that the civilian population is not p
demoralized.

6. That fire breaks of industrial structures will n
major factor in removing the conflagration hazard.

7. Priority industry factories accounting for more t
of the workers employed in priority industries in the targe
have been identified and individually analyzed; in locating
ing the vulnerability of unidentified factories, both prio
non-priority, a series of assumptions (stated in Chapter IV
been necessary. These factories employ a substantial porti
total industrial labor force; the production loss may be ei
or understated. They will be checked and revised as soon a
intelligence or air cover becomes available.

Assumptions of limited and special application are ex
the relevant sections of the text.

CHAPTER II

IMPORTANCE OF THE TARGET CITIES IN THE JAPANESE WAR ECONOMY

Population and Physical Characteristics.

The six target cities considered in this study have a combined population of 14,908,000, approximately 20 percent of the total population of Japan Proper. They contain nearly 35 percent of all workers employed in Japanese industries, and about 48 percent of all workers in priority industries -- those on which the Japanese war effort most directly depends. The study was confined to the six cities selected because on the basis of present information it appears that the inclusion of other urban area targets of comparable physical vulnerability would not add substantially to the industrial loss inflicted.

All six cities are located on the eastern and southern side of Honshu Island, placing them within feasible operational range. Each contains large areas with high structural densities, and each is built primarily of wood. In the more congested areas of Japanese cities as much as 50 to 80 percent of all ground is built up and the percentage runs as high as 40 to 65 in some cases for the whole of Zones I and II, the assumed area of attack. Population densities in Japanese cities are high, running to as many as 133.5 thousand per square mile in the most congested section of Tokyo. Considering each city as a whole, Osaka is the most densely inhabited, with an average of 45.5 thousand per square mile. The other cities show lesser average densities, down to a minimum of 6.3 thousand per square mile in Kawasaki and Yokohama.

Figures in Study Apply to Japan Proper.

The figures used throughout this study in the effort to assess the economic importance of these cities to Japan's ability to wage war, apply only to Japan Proper, and therefore do not take into account the industrial development which has occurred on the mainland in Korea and Manchuria. Although there has been extensive exploitation of the hydro-electric

resources of these regions, and there is definite information that certain factories for truck, aircraft, aero-engine and machine tool production have been erected, their chief industrial contribution is coal, iron, and steel. Even these bulk items continue to be produced mainly in the islands of Ja an Proper. For example, only 12 percent of total steel furnace capacity, and 10 percent of steel rolling capacity is located outside Japan Proper. In the case of precision products, such as machine tools, radio and radar, bearings, aircraft, etc., the conclusion seems justified that the proportion of productive capacity located outside Japan Proper would be so small as in no case to affect the percentages employed to any significant degree.

Japanese Industrial Concentration - Comparison with Germany.

Table I shows in detail the relative importance of each of the six cities in the Japanese economy. The high proportion of total national production, particularly of priority production, is striking.

No other industrial nation is dependent on so small an area for so substantial a portion of its manufactured products as is Japan. German industry, for example, is far more widely diffused. All 25 of the principal German target citis for the RAF offensive of 1943 do not contain so high a percentage of the industry of the country as do these six of Japan. The six Japanese cities contain approximately 25 percent of the country's total manufacturing employment. The comparable figure for Germany's 25 cities is 24 percent. The six Japanese cities contain approximately 48 percent of all workers employed in priority industry; the 25 German cities, 31 percent. In some of the most vital war industries the disparity is ever more pronounced. In aircraft production, for example, the figures are 7? percent for the six Japanese cities, as compared with 30 percent for t' 25 German cities. Comparative figures showing the proportion of wo by categories in the two groups of cities as compared with the to' the countries as a whole are presented in the following table.

ESTIMATED DISTRIBUTION OF EMPLOYMENT IN MANUFACTURING IN 6 SELECTED JAPANESE CITIES, JULY, 1944
(IN THOUSANDS)

Item	Total Japan Proper	Total 6 Cities Number	% of Total	Tokyo Number	% of Total	Yokohama Number	% of Total	Kawasaki Number	% of Total	Nagoya Number	% of Total	Osaka Number	% of Total	Kobe Number	% of Total
otal Population	74,250	14,908	20.1	7,387	9.9	1,191	1.6	472	.6	1,523	2.1	3,350	4.5	985	1.3
ivilian Population	69,308	13,675	19.8	6,779	9.8	1,102	1.6	426	.6	1,401	2.0	3,061	4.4	906	1.3
otal Labor Force	36,992	7,209	19.5	3,541	9.6	556	1.5	263	.7	728	2.0	1,640	4.4	481	1.3
fg. Employment Total	9,300	3,212	34.5	1,375	14.8	296.7	3.2	176.3	1.9	380	4.1	751	8.1	223	2.5
riority Industry	5,100	2,422	47.5	1,032	20.2	268	5.3	160	3.1	285	5.6	484	9.5	193	3.8
on-priority industry	4,200	790	18.8	343	8.2	28.7	.7	16.3	.4	95	2.3	267	6.4	40	1.0
riority Industries															
ircraft - Total	700	499	71.3	300	42.9	30	4.3	20	2.9	100	14.3	29	4.1	20	2.9
Final Assembly	70	16	22.9	6	8.6	—	—	—	---	9	12.9	1	1.4	—	---
Engine Mfg.	250	165	66.0	105	42.0	--	--	--	---	60	24.0	--	---	--	---
Components	380	318	83.7	189	49.7	30	7.9	20	5.3	31	8.2	28	7.4	20	5.3
emicals	700	190	27.1	110	15.7	20	2.9	5	.7	15	2.1	25	3.6	15	2.1
chinery, Tools, Inst.	1,700	815	47.9	325	19.1	80	4.7	40	2.4	100	5.9	200	11.8	70	4.1
tals	750	400	53.3	150	20.0	20	2.7	30	4.0	25	3.3	150	20.0	25	3.3
dnance	500	205	41.0	60	12.0	50	10.0	5	1.0	30	6.0	40	8.0	20	4.0
dio and Radar	100	76	76.0	25	25.0	3	3.0	40	40.0	—	---	5	5.0	3	3.0
ipbuilding	400	102	25.5	12	3.0	30	7.5	15	3.8	—	---	15	3.8	30	7.5
nks and Trucks	250	135	54.0	50	20.0	35	14.0	5	2.0	15	6.0	20	8.0	10	4.0
n-Priority															
ramics	200	67	33.5	20	10.0	3	1.5	2	1.0	15	7.5	25	12.5	2	1.0
othing	400	70	17.5	30	7.5	3	.8	2	.5	5	1.3	25	6.3	5	1.3
nstruction	900	165	18.3	75	8.3	7	.8	3	.3	15	1.7	60	6.7	5	.6
od Products	600	95	15.8	40	6.7	3	.5	2	.3	10	1.7	35	5.9	5	.8
s & Electricity	200	48	24.0	15	7.5	3	1.5	2	1.0	4	2.0	20	10.0	4	2.0
mber, Wooden Ware	700	130	18.6	50	7.1	2	.3	1	.1	20	2.9	55	7.9	2	.3
inting	200	98	49.5	70	35.0	.7	.4	.3	.2	7	3.5	15	7.5	5	2.5
xtiles	700	75	10.7	20	2.9	3	.4	2	.3	15	211	25	3.6	10	1.4
her Manufacturing	300	42	14.0	23	7.7	4	1.3	2	.7	4	1.3	7	2.3	2	.7

SECRET

TABLE II

RELATIVE IMPORTANCE OF 6 JAPANESE AND 25 GERMAN * CITIES

TO WAR PRODUCTION IN THEIR RESPECTIVE COUNTRIES

	6 Japanese Cities	25 German Cities*
% of total population	20	25
% of total industry	35	24
% of priority industry	48	31
% of aircraft	71	30
% of aero-engines	66	48
% of metals	53	28
% of machine tools	64	55
% of shipbuilding	25	20
% of chemicals	27	30

*These cities were the principal targets of the RAF during 1943.

To complete this comparison, it may be pointed out that RAF attacks on the 25 German cities during 1943 destroyed 25 percent of all housing in these cities; it is assumed that the attacks against six Japanese cities will destroy 70 percent of all houses.

Portion of Priority Industry in Conflagration Zone.

Available data indicate that more than 50 percent of priority industries would be within the conflagration zones, but precise estimates are not possible. It is known that the Japanese Government has made considerable effort to locate critical war plant outside congested urban areas, and that in some instances facilities have been moved from old plants to new or converted factories in outlying areas. In an economy as stretched as that of Japan, however, the possibility of shifting facilities is severely limited by the necessity of maintaining current production.

Individual cities are described in more detail in Exhibit X, Description of the Six Target Cities.

CHAPTER III

ABSENTEEISM

Basis for Estimating Absenteeism.

The principal product of an incendiary area attack is housing destruction. This destruction, with attendant casualties, and the disruption of municipal services and administration, has military significance only insofar as-- directly or indirectly -- it reduces the output of military equipment or impairs the enemy's will to fight. The ratio of reduced output to the sum total of housing destruction effected in the cities of the United Kingdom proved to be relatively constant and predictable. Housing destruction, casualties, and administrative breakdown cause absenteeism, and absenteeism reduces production.

The estimates presented of the amount of absenteeism resulting from the housing destruction assumed in this study have been checked against British experience, for which exact figures are available. No data are available fo casualties and social disorganization caused by incendiary attacks of the scale here assumed, but the Tokyo and Yokohama fires, which accompanied the earthquake of 1923, and incomplete information on the effect of the Hamburg attacks of July-August 1943, provide a rough standard. The methods used in estimating absenteeism for this report are discussed in Exhibit VI.

British experience indicated that, as a result of large scale attack, absenteeism is widely diffused throughout a city-- affecting all categories of workers. The incidence of absenteeism, however, is less than average among workers in priority industries. Special efforts are made to get such workers back to work. Billets are more quickly found for them. Those injured or killed are replaced by other workers from non-industrial occupations. In addition, there is probably a tendency for the newer war plants, at least in some industries, to be located away from more congested areas, and for their workers to live nearby. To the extent that this is the case, deaths and he destruction of houses among such workers are reduced, and the incidence

of absenteeism among them correspondingly diminished.

In both Britain and Germany civil defense organization and measures developed as the weight of attack with which the defenders had to cope gradually increased. If area attacks on Japan are withheld until it is possible suddenly to produce a degree of disorganization beyond the power of authorities to control, the effects on production may substantially exceed those estimated.

Housing Destruction Assumed.

For purposes of this study it is assumed that 70 percent of all houses in six Japanese cities will be destroyed. This destruction will be largely concentrated in the central districts of the cities, where density is greatest and the attack concentrated. Because of the high density of buildings and the extreme inflamability of construction, it is assumed that whole sections will be burned clean, except for isolated larger buildings of fire-proof construction. Since dwellings in the city centers have a greater density of population per unit than those in outlying districts, it is estimated that destruction of 70 per cent of the dwellings in these six cities will dehouse 75 percent of their population. At least 25 percent of the total population of each of the selected cities will probably be evacuated - either before or immediately after the attacks. The working population has been distributed on the same basis as the rest of the population. On these assumptions, the destruction populated would effect dehousing as follows:

TABLE III

HOUSING DESTRUCTION IN SIX CITIES

City	Estimated Population 7/1/44	Population After 25% Evacuation	Dehoused After 25% Evacuation	Estimated Total Workers	Workers Dehoused
Tokyo	6,780,000	5,090,000	3,820,000	3,540,000	2,660,000
Yokohama	1,100,000	830,000	620,000	560,000	420,000
Kawasaki	430,000	320,000	240,000	260,000	200,000
Nagoya	1,400,000	1,050,000	790,000	730,000	550,000
Oseka	3,060,000	2,300,000	1,730,000	1,640,000	1,230,000
Kobe	910,000	680,000	510,000	480,000	360,000
Totals	13,680,000	10,270,000	7,710,000	7,210,000	5,420,000

Industrial Absenteeism Resulting from Fire Fighting Activities.

Fires of the size assumed would, judged by the experience of the Tokyo fire of 1923, burn strongly for at least three days, and smoulder for a longer period. On the basis of available information concerning the organization of ARP in Japan, it is assumed that approximately half of the labor force would be engaged in fire fighting for a period of four days. First-aid activity, timesspent in caring for injured family members, making funeral arragements, etc. would increase this figure somewhat. Aggregate absenteeism from the causes enumerated would, it is estimated, amount to 26,550,000 days.

Manpower Loss from Casualties.

The attacks of July-August 1943 on Hamburg resulted in destruction or serious damage to 56 percent of all the city's housing, including 77 per ent in the central zones. This amount of destuction, it has been officially announced by the Police Commissioner of Hamburg, caused nearly 40,000 fatal casualties. Although about half the total bomb load of more than 8000 tons was composed of HE, the statement of the German authorities attributed the large number of deaths principally to the gigantic area fires produced by the attack. A more reliable standard is provided by the casualties resulting from the earthquake and attendant fires in Japan in 1923, since almost all of the casualties suffered were attributed to the fires. Over 1,350,000 (about 60 percent) of Tokyo's population were rendered homeless on this occasion, and there were more than 76,000 casualties (killed, missing or seriously injured). In Yokohama, with a population of 442,000 nearly three-fourths of the population was rendered homeless and there were more than 25,000 casualties.

An experienced fire staff, considering the population of the fire areas, location and size of the fire breaks, types of structures, probable speed of the development of the conflagration, etc., has estimated that there would probably be more than 500,000 civilian casualties resulting from the incendiary attacks postulated in this study, and these together with the consequent loss of industrial manpower are presented

in the table below:

(See Exhibit No. IV, Estimates of Casualties Caused by Conflagration).

TABLE IV

CASUALTIES AND MANPOWER LOSS FROM ATTACKS

Cities	Casualties	Worker Casualties*	Days Lost in 4 months**
Tokyo	260,000 ***	135,000	14,060,000
Yokohama	45,000	22,000	2,340,000
Kawasaki	20,000	10,000	1,080,000
Nagoya	60,000	30,000	3,240,000
Osaka	150,000	80,000	8,420,000
Kobe	25,000	13,000	1,380,000
Total	560,000	290,000	30,500,000

* Worker casualties were estimated by applying to the figure of total casualties for each city the estimated percentage of workers.

** Although fatal casualties are permenently lost to the labor force, it is assumed that industrial replacements will be recruited from non-industrial occupations within four months, and that industrial production will not be affected beyond the period indicated.

*** Tokyo casualties are based on the assumption that four attacks will be required to effect the 70 percent level of destruction. All other estimates are based on theassumption that the indicated destruction will be accomplished by one attack.

Absenteeism Resulting from Behousing.

Housing destruction of the extent envisaged will require the government to assume the administration of the remaining dwelling facilities. It is estimated that in Tokyo, Yokohama and Kawasaki, there were in 1944 about 84 square feet of floor space per person. Since the outlying areas of the cities comprising better class homes with more spacious quarters (about 20 percent greater floor space per occupant than the average) will largely escape destruction, a utilizable margin of accommodation is here provided. For a discussion of urban housing in Japan, see Exhibit No. II, Data on Building Construction and Housing: Major Japanese Cities.

During the period of greatest emergency, it is assumed that drastic measures will be taken by the authorities to utilize remaining housing to the utmost limits. Probably not more than 30 square feet will be allotted per person. This expedient, together with the full utilization

of remaining school buildings, office buildings, etc., would just provide emergency accommodations for the number dehoused, provided that 25 percent of the population have been evacuated before and immediately after the attack. Crowding to this degree will only be feasible under efficient administration of a military pattern, and at best must produce lessened efficiency among workers and constitute a threat to health. Accordingly, it is assumed that the Japanese Government will make every effort to alleviate conditions as rapidly as possible, and will undertake an emergency housing program calculated to reduce crowding to about one person per forty square feet of housing. If this standard is applied, about 8,600,000 people could be accommodated in the houses remaining after the attack. New construction to provide for approximately 1,700,000 would thus be required. See Exhibit No. III, Emergency Rehousing, for a discussion of the rehousing problem.

A program of relocation of shelterless workers on the scale contemplated will require time. Workers in war industry will no doubt be provided for first; others later. It is estimated that the average worker will, within three weeks after the attack, lose six days' working time in the process of relocation. This corresponds closely to British experience. Further moves within the ensuing period up to four months after the attack are estimated to cause the loss of three additional days, bringing the total absenteeism from this cause in the six cities to 64,800,000 days.

As a preliminary to the construction of new housing and the reestablishment of utilities, particularly transport, a considerable amount of debris clearance will be required. In addition, it is to be expected that workers will spend some time in an effort to salvage what personal effects they can from the ruins. Debris clearance, it is estimated, will occasion three days absenteeism on the part of about half the labor force. Salvage attempts will cause the loss of two working days on the part of 75 percent of the labor force. The total loss from these causes amount to 21,600,000 days.

of remaining school buildings, office buildings, etc., would just provide emergency accommodations for the number dehoused, provided that 25 percent of the population have been evacuated before and immediately after the attack. Crowding to this degree will only be feasible under efficient administration of a military pattern, and at best must produce lessened efficiency among workers and constitute a threat to health. Accordingly, it is assumed that the Japanese Government will make every effort to alleviate conditions as rapidly as possible, and will undertake an emergency housing program calculated to reduce crowding to about one person per forty square feet of housing. If this standard is applied, about 8,600,000 people could be accommodated in the houses remaining after the attack. New construction to provide for approximately 1,700,000 would thus be required. See Exhibit No. III, Emergency Rehousing, for a discussion of the rehousing problem.

A program of relocation of shelterless workers on the scale contemplated will require time. Workers in war industry will no doubt be provided for first; others later. It is estimated that the average worker will, within three weeks after the attack, lose six days' working time in the process of relocation. This corresponds closely to British experience. Further moves within the ensuing period up to four months after the attack are estimated to cause the loss of three additional days, bringing the total absenteeism from this cause in the six cities to 64,800,000 days.

As a preliminary to the construction of new housing and the reestablishment of utilities, particularly transport, a considerable amount of debris clearance will be required. In addition, it is to be expected that workers will spend some time in an effort to salvage what personal effects they can from the ruins. Debris clearance, it is estimated, will occasion three days absenteeism on the part of about half the labor force. Salvage attempts will cause the loss of two working days on the part of 75 percent of the labor force. The total loss from these causes amount to 21,600,000 days.

Indications are that supplies of lumber for an emergency housing program will be adequate (See Exhibit III). Of the approximately 1,700,000 persons requiring housing beyond those billeted in unburned dwellings, it is assumed that about half will be provided for in barracks constructed by professional workers in the building trade. The remainder will be housed in hutments constructed largely by their own efforts of the types described in Exhibit III. Workers employed in erecting such houses will absent themselves from work, and a further loss of production will ensue. Total loss from this cause is estimated at 2,600,000 days.

The relocation of shelterless workers, personal salvage operations, debris clearance, and private construction of new housing -- all direct results of housing destruction -- would thus cause, in the aggregate, the loss of 89,000,000 working days.

Absenteeism Resulting from Impairment of Transportation.

It is estimated that the fires assumed would destroy 50 percent of existing street railway rolling stock, overhead trolley circuits and supports in the six cities attacked, and that there would be considerable heavy damage to trackage. Repair will not be quickly possible, and in the case of the destroyed rolling stock, replacement will present an extremely difficult problem.

A large portion of the working population of Japan is dependent on the street railway system for transport. In the case of Tokyo, for example, it is estimated that approximately 25 percent of the population -- probably half the workers in the city -- are daily roundtrip riders. Distuption of transport facilities, extending over a several months' period, is expected to produce the loss of approximately 37,500,000 working days in the cities attacked. (See Exhibit V).

Absenteeism Resulting from Social Disorganization.

Destruction on the scale here considered must be attended by substantial dislocation and possibly by temporary chaos. The wider the divergence between the dimensions of the emergency and the capacity of

authorities to deal with it, the more chaotic the situation will become. In neither Great Britain nor Germany did this gap often appear. The German attacks on Britain were seldom of the necessary weight and concentration: British attacks on Germany built up so gradually in weight that German defense measures were able to keep pace fairly effectively. Even so, occasionally, as in the case of Hamburg in July-August 1943, the defense organization was overwhelmed. Nearly the whole population poured out of Hamburg during the period of the attack and the authorities lost all control of the movement. Only several days after the attacks were over did advertisements appear in the newspapers of the surrounding area requiring the return of essential transport workers and furniture movers.

If this could happen in Germany after two years experience with area incendiary attacks, during which a large and skilled organization had been developed, there is a parent justification for considering the possibility of overwhelming the untried Japanese organization. A series of saturation attacks directed at all six objectives within a brief time period would, of course, be most likely to achieve this end. The economic effects of such a debacle -- without regard to its effects on morale, and its possible immediate military significance -- might be of a magnitude beyond anything in European experience.

Since European experience provides the only available standard of measurement, however, it will be assumed for the purposes of this study that disorganization in Japan will not be proportionately greater than that experienced in Hamburg. On this assumption, it is estimated that the entire working population of the six cities will lose 37,500,000 days from this cause, over and above losses from all other causes.

Distrubution of Total Loss Between Priority and Non-Priority Industry.

The estimated loss from the various factors discussed is summarized in the following table:

SECRET

TABLE V

FACTORS CAUSING ABSENTEEISM

	Loss (in working days)	Percent of Total Loss
Firefighting, etc.	26,550,000	12
Casualties	30,500,000	14
Dehousing (Relocation, debris clearance, new construction)	89,000,000	40
Transport dislocation	37,500,000	17
Social disorganization	37,500,000	17
Total	220,000,000	100

The loss of 220,000,000 days is equal to four weeks' total output in the cities attacked. A further loss of one week's production is expected to result from fatigue, lateness to work, and the existence in many plants of an unbalanced labor force -- with some sections understaffed and producing below normal, thereby affecting the output of other sections engaged in the same process. A total loss of five weeks' output is thus expected, amounting to about 30 percent of total output in these cities, over the four month period. In terms of the total productive activity of Japan, this constitutes about 10 percent loss of four months' output or approximately 3.3 percent of one year's output.

This total loss will not be distributed evenly over all industry. Within limits the authorities can determine where the major incidence of absenteeism will occur. Preferential treatment for priority workers ihsthe provision of housing, supplies, and transportation reduces absenteeism. Labor is, in many cases, interchangeable, and drafts on less important industries may be resorted to in order to supplement the supply in priority plants. (The burden of casualties, for example, probably will be shifted through Government controls from priority to non-priority industry). Since an average loss of five weeks is estimated for all industry within the attacked cities, it is probably a reasonable hypothesis that priority industry would suffer about a four weeks' loss. while non-priority industry would lose about six weeks' output.

CHAPTER IV

PRODUCTION LOSS FROM DAMAGE TO INDUSTRIAL STRUCTURES

Successful incendiary attacks on congested Japanese urban areas will damage or destroy numerous factories and other industrial installations. The purpose of this chapter is to assess the amount of production which will be lost in factories so damaged. This loss will be added to the loss from absenteeism assessed in Chapter III in order to arrive at an estimate of the effect of the attacks in each Japanese industry. A major difficulty in making this overall estimate is the fact that losses from the two causes cannot simply be added; to a considerable extent one will duplicate the other.

No account is taken in this chapter of the cost to the Japanese economy of replacing the industrial buildings, machinery, equipment, and stocks, which are destoyed in the attacks. This chapter is concerned only with the production time which is lost in the damaged factories; the cost of repairing or replacing the damage is the subject of Chapter V. Similarly, no account is taken of any losses in undamaged factories due to the interruption of the flow of materials or other supplies from damaged factories.

General Method.

In the case of all factories, the estimate of production loss involved two stages:

(1) An assessment of the probable extent of damage to factory buildings and their contents from the assumed density of attack and from exposure to conflagrations.

(2) An estimate of the loss which can be expected to result from the damage so assessed.

Assessment of Damage.

For purposes of assessing damage, factories and other industrial establishments were divided into three groups:

(a) Identified priority factories.
(b) Unidentified priority factories.
(c) Non-priority factories.

Priority factories are defined as those in the following industries: aircraft, shipbuilding, tanks and trucks, ordnance, radio and radar, machinery, tools, instruments, metals, and chemicals. The non-priority industries include construction, textiles, clothing, ceramics, lumber, woodworking, printing, food products, gas and electricity, and miscellaneous manufacturing. No estimate of loss is made in commerce and service occupations.

In the case of the priority industries, an effort was made to identify from available intelligence material as many as possible of the operating factories, and to determine their location, size, products, layout, and construction. The factories so identified are listed by industry in Exhibit IX attached; they are principally the larger, comparatively well-known, pre-war establishments.

The extent of probable damage to identified priority factories was assessed individually for each factory by a staff of fire engineers, who considered the vulnerability of the factory both to conflagrations in Zones I and II, and to direct hits by incendiary bombs of the ground density postulated. The probable damage was estimated separately for the factory buildings and their contents. The methods used by the fire engineers in making these estimates are explained in Exhibit VIII, and the assessments of damage to individual identified factories are presented in Exhibit IX.

Table VI summarizes the physical vulnerability of the identified priority factories by industry and by city. The vulnerability of each target is indicated by ratings of high (expected damage greater than 44 percent), moderate (25 to 44 percent), low (10 percent to 24 percent), and negligible (less than 10 percent). Of the 317 identified targets in the six cities for which

TABLE VI

ESTIMATED VULNERABILITY OF IDENTIFIED PRIORITY FACTORIES

Industry	Tokyo				Yokohama				Kawasaki				Nagoya				Osaka				Kobe				Total 6 cities			
	High	Mod.	Low	Negl.	High	Mod.	Low	Negl.	High	Mod.	Low	Negl.	High	Mod.	Low	Negl.	High	Mod.	Low	Negl.	High	Mod.	Low	Negl.	High	Mod.	Low	Negl.
raft	-	2	-	1	-	-	-	-	-	-	-	-	-	-	2	-	1	-	1	-	-	-	-	-	1	2	3	1
embly	1	1	-	5	-	-	-	-	-	-	-	-	1	1	2	-	-	-	-	-	-	-	-	-	2	2	2	5
rines	7	6	-	12	-	-	-	3	3	1	-	1	2	2	-	-	-	2	-	1	-	-	-	-	12	13	-	17
mponents	-	-	1	2	-	-	1	3	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	2	-	-	2	12
uilding	3	-	-	2	-	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-	4	2	-	5
& Trucks	2	2	4	10	-	-	-	2	-	-	-	1	-	-	3	-	-	-	1	-	-	-	-	-	2	2	8	13
nce	-	1	1	1	-	-	-	1	-	-	1	2	-	-	-	-	-	-	-	-	-	-	1	-	-	1	3	4
& Radar	17	9	5	16	1	1	1	3	2	3	2	1	8	1	4	2	2	12	7	1	-	1	-	1	30	27	19	24
,Tools,Inst.	-	-	5	4	-	-	1	-	-	-	-	7	-	-	-	7	1	1	1	11	-	-	-	6	1	1	7	35
s	6	3	1	7	4	1	-	10	-	-	1	8	1	3	-	1	3	1	2	1	-	-	1	1	14	8	5	28
cals	36	26	17	60	5	2	3	25	5	6	4	20	12	7	11	10	7	16	12	19	1	1	2	10	66	58	49	144
s																												

Estimated Percent Physical Damage

"High" vulnerability	45 - 100%
"Moderate" vulnerability	25 - 44%
"Low" vulnerability	10 - 24%
"Negligible" vulnerability	0 - 9%

Production Loss

3 to 6 months
1 to 3 months
1 week to 1 month
None

SECRET

individual vulnerability assessments were made, 21 percent were found to be of high, 18 percent of moderate, 16 percent of low, and 45 percent of negligible vulnerability. Thus, on the basis of this assessment, 39 percent of the identified targets appear susceptible to a substantial order of destruction from successful area incendiary attacks.

Employment in unidentified factories in each priority industry, in each city, was determined by subtracting estimated employment in identified factories from total employment in the industry (see Table VII). It was then necessary to make assumptions regarding the location of these unidentified factories and their vulnerability. In the absence of adequate intelligence and of air cover, this had to be done on the basis of general knowledge of the cities. The procedure was to determine, for each priority industry in each city, the probable proportion of employment in unidentified factories in Zones I and II; and then unless it appeared justifiable to assume a degree of vulnerability equal to that of the identified plants, to assume that 60 percent of these factories would be destroyed by the conflagrations. In view of the fact that factories are generally in less vulnerable locations than residences, and of more fire-resistant construction, this assumption appeared to be reasonable.

The apportionment of unidentified factory employment between the central and other zones was complicated by the fact that unidentified factories fall into two distinct categories:

(a) Small and medium sized old factories, the bulk of which are probably located in the older and more congested central areas.

(b) Large factories constructed during the last few years for war production, on which intelligence is still inadequate. These are presumably located outside the vulnerable areas. While employment in factories of this second category is small in relation to the total, it is undoubtedly important in some of the highest priority industries engaged in munitions.

In making the apportionment in the highest priority industries no general formula was employed; judgment had to exercised for each industry in each city. In some cases, the unidentified plants were assumed to be distributed in the same way as the identified plants in the same industry and city; this was the method employed for ordnance in Tokyo and for machinery, tools, and instruments in Nagoya. In many other cases it was possible to assign the whole urban labor force to identified plants; this was done, for example, for aircraft assembly, aircraft engines, shipbuilding, and radio and radar in Tokyo, for aircraft assembly and aircraft engines in Nagoya, and for shipbuilding, tanks and trucks, and radio and radar in Yokohama.

Where it was believed that the bulk of the unidentified priority factories in an industry were of category (a), the apportionment to Zones I and II was made on the basis of the ratio of residential structures in these zones to total residences in the city (64 percent in Tokyo, 71 percent in Kawasaki, 71 percent in Yokohama, 69 percent in Nagoya, 83 percent in Osaka, and 86 percent in Kobe). The effect of possible error in these assumptions on the statistical results is pointed out in the Conclusion.

No detailed study was made of the probable location of factories in non-priority industries. It was assumed that nearly all would be old, and they were, therefore, apportioned to Zones I and II on the basis of the percentage of residences in those zones.

Duration of Loss.

For both identified and unidentified priority factories, production loss was based on a maximum recuperability period of six months. In most cases it was assumed (on the basis of British experience and other evidence) that the production loss for each damaged factory was equivalent to six months production of the burned-out area (for example, if 20 percent of the structure and

contents were destroyed, it is assumed that the production loss would be 20 percent x 6 months or 1.2 months for the plant as a whole). This assumption was modified if the character of the building or contents indicated the desirability of specific treatment. For example, in some types of installations destruction may be widespread but easy to repair. For factories estimated to have sustained 45 percent or more damage, loss was estimated in amounts ranging from three to six months' production for the entire installation.

Non-priority industry was assigned a recuperability period of three months on the ground that the decline in production in non-priority industries has resulted in a substantial amount of excess capacity which would facilitate rapid recuperation.

The adoption of these assumptions as to the recuperability of Japanese industry is subject to gross error if the equipment and construction industries are overwhelmed by extensive and concentrated air attack. This possibility is discussed in Chapters V and VI.

Addition of Loss from Absenteeism.

Absenteeism as a factor in production loss has been regarded as additive where the physical damage to structures and equipment is nil or relatively small, and non-additive where physical damage is extensive. Absenteeism causes production loss when workers absent themselves from factories in which work is available. If a factory suffers slight damage, e.g., 5 percent of structure and equipment, additional production loss is occasioned by absenteeism. On the other hand, if a factory is largely destroyed, e.g., 90 percent of structure and equipment, with six months required for reconstruction, absenteeism of a month or six weeks, which has its principal impact in the immediate post-attack period, would merely duplicate the loss from damage to the factory, and hence should be ignored.

TABLE VII

PRIORITY INDUSTRY LABOR APPORTIONMENT TO IDENTIFIED AND UNIDENTIFIED FACTORIES

Industry	Tokyo		Yokohama		Kawasaki		Nagoya		Osaka		Kobe		Total	
	Iden.	Uniden.	Iden.	Uniden.	Iden.	Uniden.	Iden.	Uniden.	Iden.	Uniden.	Iden.	Uniden.	Iden.	Uniden.
Aircraft Assembly	6,000	--	--	--	--	--	9,000	--	1,000	--	--	--	16,000	--
Engines	105,000	--	--	--	--	--	60,000	--	--	--	--	--	165,000	--
Components	40,000	149,000	15,000	15,000	2,000	18,000	20,000	11,000	15,000	13,000	--	20,000	92,000	226,000
Shipbuilding	12,000	--	30,000	--	15,000	--	--	--	15,000	--	30,000	--	102,000	--
Tanks & Trucks	25,000	25,000	35,000	--	5,000	--	--	15,000	--	20,000	500	9,500	65,500	69,500
Ordnance	50,000	10,000	40,000	10,000	5,000	--	25,000	5,000	25,000	15,000	10,000	10,000	155,000	50,000
Radio & Radar	25,000	--	3,000	--	40,000	--	--	--	--	5,000	3,000	--	71,000	5,000
Mach., Tools & Inst.	50,000	275,000	50,000	30,000	30,000	10,000	75,000	25,000	100,000	100,000	40,000	30,000	345,000	470,000
Metals	60,000	90,000	15,000	5,000	25,000	5,000	20,000	5,000	100,000	50,000	20,000	5,000	240,000	160,000
Chemicals	30,000	80,000	17,000	3,000	5,000	--	12,000	3,000	15,000	10,000	12,000	3,000	91,000	99,000
Total	403,000	629,000	205,000	63,000	127,000	33,000	221,000	64,000	271,000	213,000	115,500	77,500	1,342,500	1,079,500

Summary - Priority Industry Labor Apportionment to Identified and Unidentified Factories

Identified factories - 1,342,500 Percent of Total - 55%

Unidentified factories - 1,079,500 Percent of Total - 45%

SECRET

SECRET

SECRET

In order to make the translation of (1) physical damage to industrial installations and (2) absenteeism to production loss, and avoid duplication, a rule of thumb was used which provided for the addition of production loss from absenteeism to production loss from damage to installations when the latter was of the order of 33 1/3 percent or less; when physical damage was in excess of 33 1/3 percent, no additional loss was assumed to occur because of absenteeism.

Production loss from absenteeism was assumed to be four weeks in the case of priority industries, and six weeks in the case of non-priority industries; the basis of these estimates and the reasons for the lower estimate in priority industries have been discussed in Chapter III.

Overall Production Loss.

Table VIII summarizes the estimated production loss in priority and non-priority industry by cities; losses from damage to installations and from absenteeism are shown separately. The total estimated loss is 7,600,000 man months, or an average of about ten weeks' production for each of the 3,200,000 industrial workers in the six cities. Since one-third of all industrial workers in Japan are in these six cities, this loss would be the equivalent of a little over three weeks' production in the Japanese economy, or 7 percent of one year's production.

The loss in priority industries is somewhat greater because of the much greater concentration of these industries in the six cities. Total losses in priority industries amount to 5,900,000 man-months for the 2,400,000 workers in the cities employed in priority industries--again the equivalent of ten weeks' priority production in these cities. Since the cities employ 48 percent of all priority workers in Japan, this loss is the equivalent of five weeks' production in priority industries in Japan as a whole, or 10 percent of one year's production.

Since only 19 percent of non-priority industrial workers are located in the six cities, the loss inflicted on this sector of the Japanese economy is considerably smaller--only about two weeks, or 4 percent of one year's production.

Table VIII suggests that the loss from direct damage to installations accounts for about 70 percent of the total loss, and absenteeism for only 30 percent. This is to some extent an arbitrary result, since whenever the two factors overlapped, the resulting loss was credited to direct damage to installations. If the alternative policy had been followed of crediting the overlap to absenteeism, each factor would have been responsible for about one-half the total loss.

Loss by Individual Industries.

The overall loss to the Japanese economy, expressed in terms of man-months, would be significant in a war of attrition; it represents a loss in the total output of the economy which will be reflected in the output of some product or products at some subsequent time. But in order to evaluate its military significance for operations in the near future, it is essential to know the extent to which individual industries have been affected. A loss in steel production, for example, may have no effect on military production, and may not affect essential civilian production for eighteen months, whereas a loss in aircraft assembly may have a specific impact on front line strength within a few weeks.

To estimate loss by industries, it has been necessary to determine the number of employees in each industry for Japan as a whole and in each of the cities considered for attack. The basis of these estimates are explained in Exhibit VII and the results are summarized in Table I. (See Chapter II) While the intelligence information on which many of the figures are based is inadequate, it is believed that errors in the figures for individual cities will be compensating in character and that the totals for the six cities are reasonably accurate.

TABLE VIII

PRODUCTION LOSS SUMMARIES

Identified Priority Factories

City	Man-months Production Loss From Destruction of Bldgs. & Equip.	Man-months Production Loss from Absenteeism	Total Man-months Production Loss
Tokyo	609,000	199,000	808,000
Yokohama	33,000	202,000	235,000
Kawasaki	104,000	110,000	214,000
Nagoya	419,000	161,000	580,000
Osaka	353,000	214,000	567,000
Kobe	45,000	115,000	160,000
Total	1,563,000	1,001,000	2,564,000

Unidentified Priority Factories

Tokyo	1,439,000	391,000	1,830,000
Yokohama	161,000	36,000	197,000
Kawasaki	84,000	19,000	103,000
Nagoya	159,000	37,000	196,000
Osaka	636,000	107,000	743,000
Kobe	240,000	38,000	278,000
Total	2,719,000	628,000	3,347,000

Non-Priority Factories

Tokyo	395,000	317,000	712,000
Yokohama	39,000	27,000	66,000
Kawasaki	18,000	12,000	30,000
Nagoya	118,000	84,000	202,000
Osaka	399,000	201,000	600,000
Kobe	62,000	29,000	91,000
Total	1,031,000	670,000	1,701,000
Grand Total	5,313,000	2,299,000	7,612,000

TABLE IX

PRODUCTION LOSS IN MAN-MONTHS

Industry	Tokyo	Yokohama	Kawasaki	Nagoya	Osaka	Kobe	Total	Production Loss -- % of Annual Production: Six Cities	Production Loss -- % of Annual Production: In Japan
Aircraft				18,000	3,000		35,000	18	4
Assembly	14,000			156,000			239,000	12	8
Engines	83,000								
Components	551,000	62,000	63,000	104,000	74,000	72,000	926,000	24	20
Shipbuilding	15,000	30,000	15,000		15,000	30,000	105,000	9	2
Tanks & Trucks	201,000	35,000	15,000	46,000	70,000	36,000	403,000	25	13
Ordnance	120,000	71,000	5,000	59,000	90,000	46,000	391,000	16	7
Radio & Radar	50,000	3,000	54,000		17,000	6,000	130,000	14	11
Mach., Tools & Inst.	950,000	156,000	120,000	324,000	633,000	187,000	2,370,000	24	12
Metals	346,000	34,000	41,000	35,000	327,000	38,000	821,000	17	9
Chemicals	309,000	40,000	6,000	34,000	81,000	23,000	493,000	22	6
Construction	155,000	15,000	7,000	32,000	135,000	11,000	355,000	18	3
Textiles	42,000	7,000	3,000	32,000	56,000	23,000	163,000	18	2
Clothing	63,000	7,000	3,000	11,000	56,000	11,000	151,000	18	3
Ceramics	42,000	7,000	3,000	32,000	56,000	5,000	145,000	18	6
Lumber & Woodenware	104,000	4,000	2,000	42,000	124,000	5,000	281,000	18	3
Printing	145,000	1,000	1,000	15,000	34,000	11,000	207,000	18	9
Food Products	84,000	7,000	3,000	21,000	79,000	11,000	205,000	18	3
Gas & Elec.	32,000	7,000	3,000	8,000	45,000	9,000	104,000	18	4
Miscellaneous	47,000	9,000	4,000	8,000	16,000	5,000	89,000	18	3
TOTAL	3,353,000	495,000	348,000	977,000	1,911,000	529,000	7,613,000	20	7
						Priority Industry	5,913,000	20	10

SECRET

The case of aircraft components, much depends upon the stock position in the industry. In the case of machinery, the major effect will be on the recuperability of other industries--which would be important in a long war, but would not necessarily affect frontline strength for many months. An attempt is made to evaluate these losses in the concluding chapter.

Table X shows the contribution of attacks on each of the six cities to the overall loss. Of the total loss of 10 percent in the case of priority industries, the attacks on Tokyo account for over 4 percent. Attacks on no other single city contribute more than 2.1 percent.

TABLE X

PERCENTAGE OF TOTAL NATIONAL LOSS SUFFERED BY EACH CITY

Industry	Tokyo	Yokohama	Kawasaki	Nagoya	Osaka	Kobe
Priority	4.3%	.7 %	.5 %	1.3%	2.1%	.7%
Non-Priority	1.4%	.13%	.06%	.4%	1.2%	.2%
Total	3.0%	.4 %	.3 %	.9%	1.7%	.5%

Table XI indicates the loss inflicted by attacks on each city as a percentage of that city's annual production. It therefore provides for each city an index of the effectiveness of an area incendiary attack which destroys the congested central areas. There are significant differences due to the configuration of the cities and the extent to which their industries are located in the fire-vulnerable areas; Nagoya and Osaka are notably above the average in vulnerability to this type of attack, and Yokohama and Kawasaki below average.

TABLE XI

PRODUCTION LOSS OF CITIES AS PERCENT OF ANNUAL CITY PRODUCTION

Industry	Tokyo	Yokohama	Kawasaki	Nagoya	Osaka	Kobe
Priority	21%	13%	17%	23%	23%	19%
Non-priority	17%	18%	14%	18%	19%	19%
Total	20%	14%	16%	22%	21%	19%

Table XII relates the production loss inflicted on each city to the assumed tonnage of IB required to burn out Zones I and II. It shows that Yokohama and Kawasaki are, ton for ton, the most profitable targets. The

concentration of priority industries in these cities is so great that it more than offsets the fact that their industry is, on the average, less affected than most other cities by area attack on the central zones. It should be emphasized that these conclusions assume the same densities of IB required in each city, and that they take no account of the operational factors involved in achieving the assumed ground densities.

TABLE XII

PRODUCTION LOSS PER TON IB IN MAN MONTHS

Industry	Tokyo	Yokohama	Kawasaki	Nagoya	Osaka	Kobe
Priority	1,955	2,912	3,467	1,865	1,662	2,121
Non-Priority	529	432	315	483	763	442
Total	2,484	3,344	3,782	2,348	2,425	2,563

CHAPTER V

COST OF REPAIR AND REPLACEMENT

It has not been possible to make an independent investigation of the cost to the Japanese economy of repairing and replacing the industrial damage which would be caused by these attacks. Such a study requires a determination both of the extent of destruction to industrial buildings, equipment, and stocks and of the capacities of the construction, equipment, and other supplying industries. It is possible, however, to obtain a general idea of the probable magnitude of this burden by making a number of broad assumptions based on an analysis of damage and repair costs in Germany and Britain. It must be emphasized that the assumptions are subject to a large margin of error and at best establish a general order of magnitude.

Significance of the Cost of Repair and Replacement.

The burden imposed on the Japanese economy of making good the damage in these attacks is significant from two points of view:

1. Labor and other industrial resources in the construction and equipment industries must be diverted from other work to repairing or replacing damage. This chapter attempts to measure the extent of this diversion in terms of man months of labor in the industries affected.

2. Beyond a certain point damage becomes so extensive in relation to the capacity of the industries required to replace it that it cannot be repaired at all, or only after long delay. Until a special study has been made of the capacity of the Japanese industries concerned, only the most tentative conclusions can be reached regarding the effect of the replacement burden on the recuperability of the damaged factories.

Assumptions and Methods.

The basic method involves the application of the factors used in assessing damage to industrial buildings, equipment and stocks

in Germany to the estimates of factory damage made for Japan in Chapter IV. These factors are based largely on British damage and repair experience. Their application to Japan required the following assumptions:

1. That the amount of equipment and stocks per employee in different industries is the same for Japan and Britain.

2. That the ratio of equipment loss to building loss is the same in Japanese factories as in British.

3. That all equipment, and stocks of finished goods or work in process destroyed in priority industries must be replaced; also that 75 percent of the factory building destroyed in such industries must be replaced. No allowance is made for damage to buildings, equipment, or stocks in non-priority industries; nor for damage to stocks in warehouses, stores, or in transit.. Destruction of raw material stocks in factories is also ignored, since it may be expected that the replacement of such stokks will be made without difficulty by supplying industries by the time the damaged factories are ready to resume production.

4. That the man month cost of replacing destroyed buildings, equipment, and stocks is the same in Japan as in Britain. This amount s to assuming the same efficiency of labor in the two countries.

The allocation of the repair and replacement burden among industries is made by use of the factors referred to above, but the results are necessarily less reliable for any single industry than in total. The distribution of loss among industries is particularly difficult because the Japanese industrial classification differs from the British and German, and is less detailed.

Overall Cost of Repair and Replacement.

In accordance with the produdure outlined above the following estimates have been made of the cost of repairing and replacing destroyed industrial property:

	Thousands of man months
Cost of repairing or reconstructing factory buildings.....	3,200
Cost of replacing destroyed machinery and other equipment.....	3,600
Cost of replacing destroyed stocks of finished goods and work in process.....	2,000
Total.....	8,800

Practically all the burden of replacing equipment and stocks will fall on priority industries. In the case of building damage, on the other hand, most of the burden will fall on the construction industry and on producers of building materials which (except for metals and chemicals) are classified as non-priority. The share of the burden which will have to be borne by pribrity industry is therefore estimated as 5,900,000 man months.

Since no allowance has been made for destruction of factories in non-priority industry, of stocks in warehouses, and of non-industrial buildings and installations, the estimates cannot be regarded as a complete appraisal of the burden which would be imposed on the Japanese economy. It is believed, however, that damage left out of account is not of7great significance, particularly as affecting priority industries.

The estimates of repair and replacement cost are of the same order as the estimates of direct production loss from damage to installations and from absenteeism. In assessments of damage in Germany repair and replacement costs were estimated as being considerably greater than direct production loss. The proportion of direct production loss is higher in Japan because of the greater relative incidence of absenteeism and because no allowance was made for the repair and replacement of residences and household goods.

Replacement Burden Allocated by Industry.

One feature of the burden of repairing and replacing damage is the degree to which it is concentrated on a few industries. Although

these industries are located deep in the productive process, the concentration of replacement demand is such that some may be overwhelmed by the burden, with the result that repair of damage and restoration of production would be long delayed.

The analysis is too tentative to justify any definite conclusions regarding this possibility. This is to be the subject of a special study. The burden on the equipment, machinery and metal working industries as a whole will certainly be substantial, and may represent about two months' average production of these industries. In particular sectors of these industries the burden will undoubtedly be much more severe, and in some it is likely to be extremely serious.

The most critical appears to be machine tools, where replacement demand is estimated to equal at least eight months' production of the industry at pre-attack levels of output. Since the machine tool industry will itself suffer severe damage in the attacks, and must repair its own equipment before it can replace tools damaged in other industries, it is possible that it will be overwhelmed by the damage and that the output of Japanese machine tool using industries will not fully recover from the attacks for a year, or even much longer. The burden on some sectors of the electrical equipment industry, e.g. small electric motors, is likely to be of similar magnitude.

The estimated burden on the construction industry is heavy -- about 1,300,000 man months. This may represent about two months' work of all Japanese construction workers not engaged on routine repair and maintenance. There will also be a heavy burden on industries supplying construction materials such as lumber, cement, glass, and structural steel.

Total Loss: Production Loss Plus Repair and Replacement.

The cost of repairing and replacing essential equipment, stocks, and industrial buildings damaged in successful area attacks on the six cities is estimated as 8,800,000 man months, of which 5,900,000 must be borne by priority industries. This is the equivalent of approximately one month's output of Japanese industry.

When repair and replacement loss is added to the estimtes for direct production loss the total loss inflicted by the attacks is approximately 16,500,000 man months, equivalent to almost two months' of total Japanese industrial output. Approximately 12,000,000 man-months are lost in priority industries, equivalent to more than two months of total annual priority output.

It must be remembered that, while the addition of direct losses and replacement costs is legitimate, replacement costs are in general less significant because their indidence on final output is at a later date.

CHAPTER VI

CONCLUSION

Role of Present Report.

This report estimated the loss of production which can be expected from incendiary area attacks on six Japanese cities and the cost to the Japanese economy of repairing and replacing the damage to industrial installations which will be inflicted.

It has been assumed in preparing this report that the damage to industrial installations can be repaired and production restored within a period of time comparable to that required to repair similar damage in Britain and Germany. There is, however, some evidence that an insufferable burden will be imposed on the Japanese construction and equipment industries, particularly the machine tool industry. This possibility will be examined in a supplementary report which it is hoped to complete in about one month.

Before the desirability of area incendiary attacks on congested areas can be evaluated in relation to other targets, it is necessary to estimate the force which will be required to destroy the areas. A report on force requirements is now in preparation.

Statistical Conclusions of Present Report.

Assuming that the attacks on these six cities succeed in burning out the central congested areas (Zones I and II), and destroy only 70 percent of the housing, it is estimated that they will force the evacuation of nearly 3,500,000 persons, dehouse an additional 7,750,000, cause more than 500,000 casualties, and destroy or seriously damage 123 important identified factories as well as a very large number of small unidentified factories.

Damage on this unparalleled scale will, it is estimated, impose a direct production loss equal to 7 percent of one year's output of Japanese industry; 10 percent in prbrity industries. In certain

significant industrial categories the loss is even higher, amounting to 20 percent in aircraft component manufactures, 12 percen t in machinery, tools, and instruments, 13 percent in tanks and trucks, and 11 percent in radio and radar. Losses in other industries producing munitions are somewhat lower - 8 percent in aircraft engines, 4 percent in aircraft a assembly, 7 percent in ordnance, and 2 percent in shipbuilding.

The cost of repairing and replacing the damage to industrial installations will impose a further heavy burden on the Japanese economy, equivalent to an additional 8 percent of the annual capacity of Japanese Industry. In the case of priority industry the burden will be even heavier (10 percent of annual capacity), and the machine tool industry may be occupied for eight months or longer in repairing and replacing damaged tools.

The total loss inflicted by the attacks is therefore equivalent to 15 percent of annual Japanese output.

Comparison with Area Attacks on Germany.

Comparable estimates have been made of the effects of area attacks on Germany by the RAF. They indicate that both the scale of damage and the resulting loss of production would be considerably greater in the attacks on Japan.

In 74 attacks in force on 25 German cities in 1943 the RAF dropped nearly 100,000 tons of bombs. The direct production loss inflicted was estimated at 2.2 percent of annual industrial production (as compared with 7 percent in the case of Japan). A direct production loss of 7 percent was inflicted on the machine tool industry (as compared with 20 percent on machines, tools, and instruments in Japan); losses in all other industries were less than 5 percent. Addition of the cost of the repair and replacement in Germany raised the overall loss to about 7.5 percent of one year's output (as compared with 15 percent in Japan).

The much greater effectiveness of the attacks on Japan is accounted for by two factors -- the great congestion and high inflammability of the central zones, and the extent to which industrial production is concentrated in the six cities. In no other important and industrial nation does so small an area account for so large a proportion of manufactured products. The 25 German cities attacked by the RAF in 1943 contained only 24 percent of German industry and 31 percent of priority industry; for the six Japanese cities the figures are 35 percent and 48 percent. The 100,000 tons of bombs dropped on the 25 German cities destroyed or seriously damaged 25 percent of their housing; it is assumed that a much smaller tonnage of bombs dropped on the six Japanese cities will destroy 70 percent of their housing. In the German cities it is estimated that some 4,500,000 people were dehoused; in the six Japanese cities destruction of the dimensions assumed is expected to dehouse 7,750,000.

Factors Affecting Statistical Conclusions.

Given the validity of the basic assumption that it is operationally feasible to burn out the central zones of these cities, the conclusions are subject to two principal errors. One error involves the estimate of direct production loss; the other, the factor of recuperation.

The estimate of direct production loss may be too high because of an overstatement of the amount of industrial plant which would be directly damaged by the attacks. Only a minor portion of the industrial plants in the six cities were actually identified; for the others it was assumed that unidentified factories are located in the congested areas either (1) to the same degree as identified factories, or (2) to the same degree as residences. It is probable that the older and smaller factories are distributed roughly according to these patterns, but the unidentified group probably includes some newly constructed factories in relatively invulnerable locations. It was further assumed that 60 percent of the unidentified factories located in the conflagration zone would be destroyed -- an assumption which may not be warranted if there has been significant fire breaking.

If these assumptions are substancially wrong, the effect on the statistical conclusions will be considerable. About 65 percent of production loss from direct damage was attributed to unidentified plants, which were accredited with only 45 percent of total production. If on the average unidentified plants should prove no more vulnerable to area incendiary attack than identified plants, the total production loss from plant damage would be reduced by more than 1,400,000 man months -- a reduction only in small part compensated for by an additional 200,000 man months' loss from absenteeism. Repair and replacement costs would be correspondingly reduced, falling by more than 2,500,000 man hours. Total loss (production loss plus repair and replacement costs) would thus be reduced from 15 percent to 11 percent of one year's total national production.

The tentative analysis presented in Chapter V indicates that the estimate of recuperation time may be too low. The burden of repair and replacement falls very heavily on the machine tool, electrical equipment, and construction industries. The machine tool industry in particular appears likely to be subjected to a severe replacement burden superimposed on an industry which itself has suffered extensive damage. There is some evidence that the demands on this industry may far exceed its capacity, and that general recovery may considerably exceed the six-months limit assumed in this study. The supplementary study referred to above will examine this possibility.

These possible errors are not directly compensating except in a statistical sense. The effect of overestimating direct damage is to exaggerate the immediate results of the attacks on finished munitions and other products. The effect of underestimating the problem of recuperation is to shorten unduly the time period over which the results are extended.

The estimates presented in this study assume that the attacks will be of sufficient weight and concentration to effect the postu-

lated damage in a relatively short time-period (a few weeks); but that they will not be of such weight and intensity as to overwhelm the defense organization and the state administration. If either of these assumptions is proved wrong, the validity of the estimates will be affected.

If the attacks are not heavily concentrated -- at least, against the indivhual cities or city-groups -- the effects will be considerably dissipated. Firefighting activities will probably be more successful in preventing damage to important industrial installations. The estimated absenteeism may be reduced by 30-40 percent; since there will be fewer casualties, the problem of relocation will be more readily handled over an extended period, the rehousing program will be facilitated, damage to transportation will be less in the aggregate, and social disorganization will be less pronounced.

Losses will be reduced by the possibility of using up supplies of materials and components in pipe lines during the period of repair. In priority industries, losses in sections of one plant producing a standardized product might be made up by working an extra shift in another plant. No general rule can be developed as to the stage of destruction which must be reached before this possibility can be eliminated. It is obvious that the more wide-spread the destruction the less does this possibility exist.

The difficulty of recuperation, of course, increases with the concentration of the attacks. Destruction of a million square feet of factory space in one month places a far greater strain on the replacements industries than the same amount of damage extended over six months. If the destruction is sufficiently concentrated, an enormous administrative problem is created in the setting of priorities and, even assuming the system works efficiently, repairs for installations of lower than top priority are long-delayed. This delay in recovery may have important effects in creating unbalance in the economy.

Finally, the more diffuse the attacks and the longer the period over which they are spread, the more effective will be the Japanese counter-measures which can be expected. The efficiency of an organization depends largely on the experience it has had and the time in which to adapt forms and tenhniques to the problems with which it is called upon to deal. Given experience and time, the Germans, in general, were able to develop an organization which proved able to deal with the most severe attacks which the Allied Air Forces were able to make. Not only will Japanese organization and techniques become more efficient with practice, but once a pattern of incendiary attacks becomes obvious, they will be able to take some precautionary measures to reduce their effects. They may, for example, construct an extensive system of fire-breaks, evacuate non-workers, and move certain installations.

There is the further important consideration that small-scale incendiary attackw will have the effect of creating firebreaks, and thereby make the starting of conflagrations increasingly difficult.

On the other hand, a sufficient concentration of attack may actually succeed in overwhelming the defense forces and achieving results beyond all the estimates (largely based on European experience) presented in t is study.

The maximum effects in achieving damage probably can be secured by concentrating attacks on all the cities within a particular geographical group (e.g., Tokyo, Yokohama, Kawasaki). This concentration will present the maximum possibility of overwhelming the fire-fighting services, since it will prevent the diversion of equipment from one area to another.

The maximum possibility of overcoming the cushion of stocks in pipe lines and of maximizing the difficulties of repair and replacement lies in a concentration of attacks on all cities within the shortest possible time.

The best chance of creating social chaos and administrative failure also lies in a concentration of attacks against all targets in

the shor test possible period. The tasks involved in evacuating some 3,000,000 people; providi g food, clothing and shelter for an additional 7,500,000 who will have lost all their possessions; and in supplying medical aid for hundreds of thousands will be enormous. The more concentrated in time these results are, the more likely is the Japanese administrative organization to be overwhelmed.

Evaluation of the Attacks

The advisability of including area attacks on Japanese cities in a general bombing program against Japan cannot be decided until a satisfactory estimate has been made of force requirements for such attacks and analysis made of the force requirements and economic effects of attacks on other target systems.

One positive conclusion emerges, however, from the present study. Area incendiary attacks on Japanese cities should not be undertaken until it is possible to conduct them in force and complete the program against all six cities within a period of a few weeks.

In addition, some tentative conclusions appear warranted from the magnitude and character of the estimated loss resulting from these attacks.

a. The advantage of these attacks is that they inflict a very heavy general loss on the Japanese economy - probably a much heavier loss per ton of bombs deppatched than could be achieved by attacking any alternative target system, and a far heavier loss per ton than was achieved by area attacks on Germany.

b. The limitation of these attacks is that the loss inflicted is diffused among many industries and spread over a lengthy period of time. The highest direct production loss (20 percent of annual production) is in aircraft components where there is evidence of substantial stocks to cushion the loss and prevent a proportionate effect on finished plant production. In tanks and trucks, which suffer 13 percent loss, there is evidence of excess capacity, machinery, tools, and instruments are deep in the economic process and the 12 per ent loss suffered by this group cannot affect finished output for many months.

Other of the direct productin losses are either also deep in the productive process (e.g., iron and steel) or affect industries producing civilian goods. The chief importance of the burden of repair and replacement -- more than half the total loss -- is in the delay it imposes on the reconstruction of damaged factories. Precision attacks, on the other hand, assuming adequate intelligenceand operational feasibility, can be concentrated on a particular type of vital military production; the loss inflicted, while less in man months per ton of bombs despatched, is likely to be of much greater military significance, particularly in theshort run.

c. Once the central zones of the six selected cities have been burnt out, it is unlikely that further substantial losses can be imposed by additional area attacks. The devastated cties will certainly not be reconstructed in such a way as to make them vulnerable to re-attack by this method. Nor does it seem likely on the basis of present information that total losses can be much increased by similar attacks on other cities. The degree of industrial concentration is elsewhere so much less that further losses would, it appear, be disproportionatlye expensive to inflict. This problem will be studied and it is hoped to produce definite estimtes shortly.

d. Area attacks might significantly increase andprolong losses effected by precision attacks on munitions industries. The estimated loss inflicted on high priority industry, while a small proportion of the total loss caused by area incendiary attacks, is not inconsiderable. Even more important would be theeffect of the area attacks in delaying recuperation of vital factories damaged in predsion attacks. The vulnerability to area attacks of the machine tool and other industries making industrial equipment, and the extremely heavy burden of replacement which area attacks would impose on these same industries, make this type of attack peculiarly effective as a means of hampering the reorganization of high priority industries (such as aircraft engines) which are large users of such equipment.

e. The social and administrative disorganization which would be produced by these attacks might prove valuable as an adjunct to invasion.

These conclusions apply to incendiary attacks primarily directed at congested residential areas. Other types of area attacks have not yet been considered. There are in Japanese cities a number of compact industrial districts containing high priority targets which, while not vulnerable to a light incendiary attack, might prove to be profitable targets for heavy combined HE-IB area attack.

EXHIBIT NO. I

ESTIMATED POPULATION AND LABOR FORCE 1944

FOR SELECTED JAPANESE CITIES

SECRET

EXHIBIT NO. I

ESTIMATED POPULATION AND LABOR FORCE 1944

FOR SELECTED JAPANESE CITIES

SECRET

EXHIBIT No. I

ESTIMATED POPULATION AND LABOR FORCE 1944
FOR SELECTED JAPANESE CITIES

ASSUMPTIONS

1. Sex ratios for 1930 and 1935 city areas are applied to population of each city within 1940 limits (Toshi Mundai, 1941 series) to give population by sex in constant area, 1930, 1935, 1940.

2. Quinquennial rates of increase, 1930-35, 1935-40, are extrapolated to July 1, 1944. Exception: Absolute increases are used for Tokyo Fu and part of Fu outside Tokyo Shi, with remainder taken as estimate for Tokyo Shi.

3. The latest available proportional age-distribution for females of each city is applied to estimated total number of females, July 1, 1944, to give distribution by age (using data for 1935, except in case of cities in Kanagawa Ken, where 1930 data are the latest available.) Sex ratios for persons 0-4 years and 5-9 years at same latest date are used to give males at these ages. The remainder of male population is distributed in proportion to distribution of males at same latest date, to complete the distribution by sex and age of the 1944 population of each city, including persons inducted into military service from this area.

4. The number in the armed forces of Japan, July 1, 1944, is estimated as 4,450,000. It is assumed that these men were reported in the 1940 census as members of families resident in Japan---ignoring men inducted as residents of other areas. The number of permanent casualties to July 1, 1944, among persons living on October 1, 1940 is estimated as 495,000. The sum of these figures gives 4,945,000 "inducted men" previously counted in the 1940 census. A small sample of prisoners of war (52) shows the following percentage distribution by age: 15-19 years, 4 per cent; 20-24 years, 45 per cent; 25-29 years, 29 percent; 30-34 years, 18 per cent; 35-39 years, 4 per cent. The 1944 reduction in the age of inducted men made available those age 18

years, 1 month, on January 1, 1944 (ages reckoned on basis of dates of birth). A constant flow of inductees, giving a proportional utilization equal to that in the age class 20-24 years would draw from men under 20 on July 1, 1944, a number equal to 6.2 percent of the total figure above, 4,945,000---with unknown overlap between this number and the number of volunteers already enlisted. In view of this circumstance the percentages reported above (based on prisoners of war information) are reduced by 4 percent at ages 20 and over, and the percentage for the age class 15-19 years is raised from 4 percent to 7.84 percent (giving 100 percent as the required sum). These percentages are applied to the total number of inducted men (4,945,000) and related to U.S. Census Bureau A-B estimates of population by age and sex, Japan Proper, October 1, 1944, show the following percentages of utilization of men through induction:

AGE CLASS	PERCENT INDUCTED TO JULY 1, 1944 (including permanent casualties since October 1, 1940)
15-19	9.42
20-24	59.42
25-29	48.36
30-34	30.29
35-39	7.87

These ratios are obviously rough, tentative figures, but errors in relative values for particular classes will not greatly effect the total number of inducted men estimated as drawn from each area.

5. Prior to deduction of "inducted men", the following arbitrary proportions are applied to the various age and sex classes to give estimated number in labor force plus inducted men.

SEX AND AGE CLASS		LABOR FORCE PLUS INDUCTED
Children	0-9	--
"	10-14	50 percent
Males	15+	
	15-49	95 percent
	50-60	90 percent
	65+	70 percent
Females		
	15-49	
	Mothers1/	20 percent
	Others	80 percent
	50-65	50 percent
	65+	20 percent

1/ Children under ten times .4.

These assumptions are high, and the estimate of labor force or military personnel obtained by their application to estimated population classes probably gives a maximum figure for the potential labor or military force available in each area.

The estimated number of inducted men is then subtracted from the figure thus obtained for males 15-49 years.

POPULATION ESTIMATES, SELECTED CITIES, 1930-44

	10/1/1935	10/1/1940 Including Mobilized (absent) Personnel	7/1/1944 Including Mobilized (absent) Personnel	7/1/1944 Civilian
Shi	5,895,882	6,778,804	7,387,102	6,779,000
les	3,086,801	3,494,890	3,765,734	3,158,000
males	2,809,081	3,283,914	3,621,368	3,621,000
aki	191,700	300,777	471,910	426,000
les	100,186	165,673	254,831	208,740
males	91,514	135,104	217,079	217,260
ama	796,581	968,091	1,190,558	1,102,000
les	407,534	503,199	618,834	530,000
males	389,047	464,892	571,724	572,000
a	1,110,314	1,328,084	1,522,739	1,401,000
les	569,025	687,852	794,066	672,000
males	541,289	640,232	728,673	729,000
	2,989,874	3,252,340	3,350,349	3,061,000
les	1,594,176	1,691,176	1,712,268	1,423,000
males	1,395,698	1,561,164	1,638,081	1,638,000
	912,179	967,234	984,931	906,000
les	467,945	491,443	497,794	419,000
males	444,234	475,791	487,137	487,000

Sources:

1940 values from Horei Zensho (Naikaku Kokuji No. 6).

1935 values, by sex, from official census, with adjustments of population to 1940 area, as given in Toshi Mundai, Vol. 32, 1941, pp. 1148-1167. These figures were checked as regards area (and population in 1935) by comparison of Sawada list in Nihon Chisei Daijiten, 1937-38, and area figures in Nippon Toshi Nenkan, 1941.

SECRET

TOKYO, ESTIMATED POPULATION, JULY 1, 1944

	Population	Military Status	Labor Force
Total	7,387,102		
Inducted		607,781	
Civilian		6,779,321	
Children			
0-9	1,712,138		---
10-14	687,081		343,541
Males, Aged 15+			
15-49	2,193,837		1,506,753
50-64	269,074		242,167
65+	66,989		46,892
Females, Aged 15+			
15-49			
Mothers	684,855		136,971
Others	1,368,678		1,094,942
50-64	294,971		147,486
65+	109,479		21,896

Total Labor Force: 3,540,648

Relative to Civilian Population 52 Percent

SECRET

KAWASAKI, ESTIMATED POPULATION, JULY 1, 1944

	Population	Military Status	Labor Force
Total	557,540		
Inducted		54,728	
Civilian		502,812	
Children			
0-9	130,539		---
10-14	53,199		26,600
Males, Aged 15+			
15-49	191,275		131,384
50-64	19,752		17,776
65+	5,160		3,612
Females, Aged 15+			
15-49			
Mothers	56,279		11,256
Others	79,309		63,447
50-64	115,956		7,977
65+	6,071		1,245

Total Labor Force: 263,297

Relative to Civilian Population 52 **percent**

SECRET

YOKOHAMA, ESTIMATED POPULATION, JULY 1, 1944

	Population	Military Status	Labor Force
Total	1,190,558		
Inducted		88,864	
Civilian		1,101,694	
Children			------
0-9	297,538		------
10-14	108,587		54,294
Males, Aged 15+			
15-49	348,107		246,281
50-64	50,747		45,672
65+	13,533		9,473
Females, Aged 15+			
15-49			
Mothers	119,015		23,803
Others	185,828		148,662
50-64	48,631		24,315
65+	18,572		3,714

Total Labor Force: 556,214

Relative to Civilian Population 50 **Percent**

SECRET

OSAKA, ESTIMATED POPULATION, JULY 1, 1944

	Population	Military Status	Labor Force
Total	3,350,349		
Inducted		289,125	
Civilian		3,061,224	
Children			
0-9	741,407		-------
10-14	288,272		144,136
Males, Aged 15+			
15-49	1,039,965		713,298
50-64	124,543		112,089
65+	28,849		20,194
Females, Aged 15+			
15-49			
Mothers	296,563		59,313
Others	636,987		509,590
50-64	140,965		70,483
65+	52,798		10,560

Total Labor Force: 1,639,663

Relative to Civilian Population: 54 Percent

SECRET

NAGOYA, ESTIMATED POPULATION, JULY 1, 1944

	Population	Military Status	Labor Force
Total	1,522,739		
Inducted		122,185	
Civilian		1,400,554	
Children			
0-9	353,469		-------
10-14	154,312		77,156
Males, Aged 15+			
15-49	458,946		319,923
50-64	65,970		59,373
65+	18,797		13,158
Females, Aged 15+			
15-49			
Mothers	141,388		28,278
Others	242,033		193,626
50-64	61,989		30,995
65+	25,835		5,167

Total Labor Force: 727,676

Relative to Civilian Population 52 Percent

SECRET

KOBE, ESTIMATED POPULATION, JULY 1, 1944

	Population	Military Status	Labor Force
Total	984,931		
Inducted		78,884	
Civilian		906,047	
Children			
0-9	220,329		-------
10-14	87,009		43,505
Males, Aged 15+			
15-49	292,248		202,696
50-64	40,330		36,297
65+	10,073		7,051
Females, Aged 15+			
15-49			
Mothers	88,132		17,626
Others	186,481		149,185
50-64	43,248		21,624
65+	17,051		3,416

Total Labor Force: 481,400

Relative to Civilian Population: 53 Percent

EXHIBIT NO: II

DATA ON BUILDING CONSTRUCTION AND HOUSING:

MAJOR JAPANESE CITIES

Statistics of building construction, covering the 82 largest cities of Japan, show that between 1937 and 1940 construction of all types dropped more than 30 percent.

Table I

BUILDING CONSTRUCTION OF ALL TYPES, 1937-1940

Japan's 82 Largest Cities and Their Suburbs

Year	Number of Buildings	Floor Area (1000 sq. meters)
1937	132,169	15,991
1938	119,331	14,695
1939	122,713	15,055
1940*	87,624	10,843
1939		
Nov.	3,[illegible]	830
Dec.	[illegible]	848
1940		
Jan.	4,362	661
Feb.	[illegible]	899
Mar.	7,734	951
Apr.	7,073	871
May	6,397	959
June	7,545	985
July	7,457	970
Aug.	7,412	904
Sept.	7,328	853
Oct.	8,582	1,075
Nov.	7,676	907

*Estimates made from average monthly production of first eleven months, 1940.

Data for 1938 and 1939 for the eight largest cities -- Tokyo, Yokohama, Kawasaki, Nagoya, Osaka, Kobe, Sasebo, and Yokosuka -- indicate that preference was being given to industrial construction, with residential construction being sacrificed as little as possible, the greatest loss being sustained in commercial and miscellaneous types of building.

1/ Oriental Economist, April, 1941, p. 219. Statistics compiled by Domei and Japanese Finance.

EXHIBIT NO. II

DATA ON BUILDING CONSTRUCTION AND HOUSING:

MAJOR JAPANESE CITIES

Statistics of building construction, covering the 21 largest cities of Japan, show that between 1937 and 1940 construction of all types dropped more than 30 percent.

Table I

BUILDING CONSTRUCTION OF ALL TYPES, 1937-1940 1/

Japan: 21 Largest Cities and Their Suburbs.

Year	Number of Buildings	Floor Area ('000 sq. meters)
1937	132,165	15,991
1938	119,331	14,095
1939	122,713	15,055
1940*	87,624	10,848
1939		
Nov.	6,510	830
Dec.	5,766	848
1940		
Jan.	4,562	661
Feb.	6,360	899
Mar.	7,751	951
Apr.	7,073	871
May	8,397	959
June	7,545	925
July	7,487	970
Aug.	7,442	904
Sept.	7,328	825
Oct.	8,612	1,074
Nov.	7,676	907

*Estimates made from average monthly production of first eleven months, 1940.

Data for 1938 and 1939 for the eight largest cities — Tokyo, Yokohama, Kawasaki, Nagoya, Osaka, Kobe, Amagasaki, and Yokosuka — indicate that preference was being given to industrial construction, but that residential construction was being sacrificed as little as possible, the greatest loss being sustained by commerical and miscellaneous types of building.

1/ Oriental Economist, April, 1941, p. 219. Statistics compiled by Commerce and Industry Ministry.

Table II

AREA COVERED BY NEW CONSTRUCTION*

JAPAN: EIGHT LARGEST CITIES, 1938-1939 1/

Type	1938 Area Sq. meters	1938 Percent	1939 Area Sq. meters	1939 Percent	Percent Change 1938-1939
Residential	3,573,825	39.0	3,293,446	38.4	-7.9
Commercial	1,324,248	14.5	877,623	10.2	-33.7
Industrial	3,386,409	37.0	3,746,944	43.7	+10.7
Other	873,521	9.5	660,436	7.7	-24.5
Total	9,158,003	100.0	8,578,449	100.0	-6.3

*New building, extensions, and reconstructions are covered.

It is probable that building construction of all types has declined sharply since 1940, accentuating the trend already apparent at that time, and that housing construction has suffered with the general decline. This conclusion is suggested, on the one hand, by apparent manpower and lumber supply limitations, and consequent Governmental efforts to conserve both inventories and flow, and, on the other hand, by evidences of inability on the part of the Government to carry out a minimal housing program in the large cities at least over the period 1939-1942.

Housing Space and Distribution

Certain statistics pertinent to Japanese housing space and distribution are shown below. The data on size of land plot and buildings are for the year 1939, and cover the six largest cities — Tokyo, Osaka, Nagoya, Kyoto, Yokohama, and Kobe. It is believed that these statistics are reasonably representative of current conditions in these cities.

1/ Toshi Kenkyu (Japan Municipal Yearbook), 1940, 1941.

Table III

SIZE OF LAND PLOT AND RESIDENTIAL BUILDING FLOOR SPACE

SIX LARGEST CITIES, JAPAN PROPER, 1939 1/

	Tsubo	Sq. Ft.
Size of land plot	18.1	644.0
Size of extended floor space*	15.1	537.3
Size of enclosed floor space #	11.5	409.2

*Extended floor space includes porches and verandas.
#Enclosed floor space excludes porches and verandas.

The size of lots for home construction, on the average, is extremely small by American standards; e.g., a lot of 644 sq. ft. is an area approximately 20 ft. x 32 ft. or 25 ft. x 26 ft. With the average size house utilizing 83.4% of the land upon which it is situated, very little land in the average house plot remains without roof coverage.

Information on the number of houses and their occupants is somewhat inadequate for the six cities covered by this report. However, the data on three cities -- Tokyo, Yokohama and Kawasaki -- present a reasonable picture, when compared with past conditions and other information available. These three cities are estimated to have had 4.82 persons per house in 1940. 2/ Since, according to the preceding table, the average house in 1939 had 409.2 square feet of enclosed floor space, the average per capita space allotment was 84.9 square feet per person. No real estimate of 1944 space allotments can be made since construction data are unavailable. A rough calculation based on a 10 percent differential between the net increase in houses and population growth gives a 1944 space allotment of 84.2 square feet per person for these same cities.

In estimating the size of the average Japanese room the figure of 84.9 square feet per person has been divided by .651, the number of persons per room in Tokyo Prefecture as computed from the 1930 Census figures. This gives an estimate of 130.4 square feet on the average per room. This method of calculation is somewhat arbitrary, but falls within

---

1/ Toshi Nenkan (Japan Municipal Yearbook), 1941, p. 2325.

the range of other estimates, less accurate than the 1940 per capita space estimate, which indicate that the average room might be somewhere between 111 and 135 square feet.

The table below gives an estimate of the distribution of living space in Tokyo prefecture for 1930. The original data gave the population according to the number of rooms occupied. The data on rooms have been converted to square feet on the basis of the 130.4 square feet per room estimated above. The population distribution figures are as given in the Census.

Table IV

ESTIMATED DISTRIBUTION OF HOUSING SPACE 1/

TOKYO PREFECTURE, 1930

Rooms per household	Persons per room	Sq. feet per person	Population so housed	
			Percent	Cumulative percent
1	2.868	45.5	8.1	8.1
2	2.027	64.3	27.0	35.1
3	1.596	81.8	26.5	61.6
4	1.382	94.4	17.5	79.1
5	1.229	106.1	8.7	87.8
6	1.133	115.1	4.6	92.4
7	1.035	126.0	2.7	95.1
8	.975	133.8	1.6	96.7
9	.903	144.4	1.0	97.7
10	.860	151.7	.7	98.4
11 and over	.698	186.9	1.6	100.0
Average	1.53	84.9	100.0	--

Housing Cushion

The ability of Japanese cities, on the average, to absorb dehoused population following a bombing raid may be determined by comparing the per capita space that would be available to rehouse a given proportion of the population with a minimum per capita space allotment. The difference between the average space allotment and the pre-determined absolute minimum gives the surplus space per person available for absorbing dehoused persons.

1/ Japanese Census, 1930.

The reduction of the population to an average space allotment of either 20 or 30 sq. feet per person would affect every individual in the area, since no one in Japan lives at that level (see Table IV). Reduction to 40 sq. feet per person might leave about 4 or 5 percent of the population unaffected, while reduction to 50 square feet would leave about 20 percent of the population unaffected. A reduction to these low standards of living which would affect so many persons probably could not be achieved voluntarily, but the administrative labor costs might be less than those required in rehousing through building new dwellings, and of course no material would be required.

EXHIBIT NO. [illegible]

EMERGENCY REHOUSING

EXHIBIT NO. III

EMERGENCY REHOUSING

EXHIBIT NO. III

Emergency Rehousing - Japanese Urban Industrial Areas

This study of lumber and plywood inventories and flows in Japan Proper and of probable housing types with material and labor costs is made for the purpose of indicating probable recuperability in minimum rehousing as to character and extent subsequent to area incendiary attacks. Housing destruction is an important factor in causing worker absenteeism through residence relocation and construction of new housing; hence, production loss. With destruction of homes workers must be relocated in living quarters which involves absorption of workers in existing dwellings or converted structures, and/or new construction, depending on the extent of housing loss and the post-raid housing cushion.

Estimates of the 1940 as well as the current lumber supply position of the Japanese Empire and in particular Japan Proper, indicate no serious shortage for the present rate of dwelling construction under circumstances of the present restricted demand. Dwelling construction and major repair activities may proceed only under license.

Efforts have been made to increase lumber production - particularly since 1942 as follows:

(1) Encouraging the cutting of timber in shrines, on farms, and in government preserves; also from private residences;

(2) Special efforts to make labor available in adquate quantity (use of registered laborers and their freezing in the industry);

(3) Reduction of the strain on transport by the rafting of logs to points of processing including, apparently rafting from the Asiatic mainland (China, Korea, Taiwan, etc.);

(4) Increases in the prices of lumber products;

(5) The provision of adquate supplies for those engaged in lumbering;

(6) Special attention has been directed to the increased production of plywood to be used in aircraft manufacture by the Imperial Government.

It is estimated that production for Japan Proper in 1940 approximated 11,523,000,000 bd. ft., with consumption of 11,023,000,000 bd. ft. Lumber stocks at the end of 1940 were estimated at 3,007,000,000 bd. ft. (Estimate of Department of Agriculture and Forestry submitted to lumber control bill committee, House of Representatives, Feb. 18, 1941.)

Although the rate of cutting of timber as indicated above has been attended with serious difficulties there seems little reason to expect that there has been any appreciable decline in production, 1944 as compared with 1940; in fact, some increase in output may well have been achieved because of extraordinary measures undertaken. Lumber production, consumption, and inventories, for 1944 are therefore assumed to approximate the 1940 output (Japan Proper).

Supply and Demand for Lumber in Japanese Empire During 1940
in 000,000 bd. ft.

	Japan Proper	Karafuto	Chosen	Taiwan	Total
Lumber production	11,523	1,230	1,245	226	14,224
Received from other parts of Empire	334	-	387	256	977
Imports-3rd countries	387	-	37	2	427
Stocks end 1939	3,497	502	484	103	4,586
Total supply 1940	15,741	1,732	2,153	588	20,214
Shipments-Empire	669	255	27	27	977
Exports to foreign industries	1,042	36	61	8	1,146
Total demand 1940	11,023	939	1,607	450	14,019
Stock end 1940	3,007	502	459	103	4,071

Source: Statement submitted by Dept. of Agriculture and Forestry to the House of Representatives on Feb. 18, 1941, in connection with the lumber Control Bill, and reported in local newspapers and in U.S. Consular Report, Revies of Developments in the Japanese Lumber Market, by Carl H. Boehringer, completed Aug. 25, 1941.

Japan, 1940 Consumption of Lumber

(Japan Ministry of Agriculture, quoted in paper on lumber by Mr. Butts, FEA, April, 1943.)

Use	1000 bd. ft.	Percent of Total
Construction and Furniture Making	2,030,640	18.4
Box shooks, packing, etc.	1,160,880	10.5
Mining timbers, etc.	1,387,920	12.6
Pulp manufacture	968,640	8.8
Ship construction	438,720	4.0
Manufacture of vehicles, etc.	352,320	3.2
Road construction	299,640	2.7
Railway sleepers	401,520	3.6
Telephone and other poles	157,440	1.4
Miscellaneous	3,825,000	34.8
Total Consumption Japan Proper	11,022,720	100.0

It is estimated that the 1944 consumption pattern in major outline has not altered appreciably. There is likelihood that mining timbers and ship construction will show some relative increase but such greater absolute needs probably will be met out of increased production and diversion from miscellaneous uses. Furniture manufacture doubtless has tended to decrease somewhat to bare minimum requirements.

Carl Boehringer has estimated that lumber stocks of the five largest cities will approximate 40% of total lumber stocks or 1,202,800,000 bd. ft.

During the period 1931 to 1940 a very rapid development occurred in Japanese plywood manufacturing capacity and plywood production. This capacity is now being used in part, for plywood production for airplane manufacture. Total Japanese production of plywood in 1938 closely approximated U. S. production of Douglas fir plywood. In view of past production rates of increase it is believed that plywood production in 1944 may well exceed one billion sq. ft. The special emphasis attached to plywood in airplane manufacture would appear to make the estimate of one billion sq. ft. for 1944 reasonably conservative.

Japanese Plywood Production (M sq. ft.)

(Table XXIX, Appendix to "The Economic Vulnerability of Japan in Forest Products and Manufactures.")

Year	No. of Plants	Domestic Consumption	Export Markets	Chests	Total Production
1931	15	55,000	12,500	30,000	97,500
1932	25	93,500	22,500	42,500	148,500
1933	38	110,000	45,000	60,000	215,000
1934	80	172,200	62,270	83,150	317,620
1935	125	251,310	72,210	96,300	419,820
1936	173	410,330	107,660	96,600	614,590
1937	187	517,850	155,300	115,500	788,650
1938	167	356,400	109,440	74,520	540,360
1939	Estimates indicate considerable increase over 1938; by at least 25 percent-probably reach 800 milion sq. feet.				

Japan Proper - Lumber and Plywood Supplies

Estimated 1944 Lumber production 11,523,000,000 bd. ft.

" " Lumber Inventory (Stocks on hand) 3,007,000,000 bd. ft.

" " Plywood Production 1,000,000,000 sq. ft.

" " " Inventory(Stocks on hand - 20% Prod) 200,000,000 sq. ft.

(Assumed that 40% of (a) lumber and plywood inventory)and (b) lumber and plywood flows are found in Tokyo, (Osaka, Nagoya, Yokohama, and Kobe.

Lumber Inventory 1,202,800,000 bd. ft.

Lumber Flow per month 384,100,000 bd. ft.

Plywood Inventory 80,000,000 sq. ft.

Plywood Flow per month 33,333,000 sq. ft.

Assumed that 40% of lumber and plywood inventories and flow are available for housing; 60% of lumber and plywood inventories and flows for industrial and commercial structures.

Available for Housing

Lumber Inventory 481,120,000 bd. ft.

Lumber Flow per month 153,640,000 bd. ft.

Plywood Inventory 32,000,000 sq. ft.

Plywood Flow per month 13,333,000 sq. ft.

Japan Proper - Lumber and Plywood Supplies (Cont'd)

Assumed that 50% of lumber and plywood inventories are destroyed in IB area attack:

Remaining Lumber Inventory	240,560,000 bd. ft.
Remaining Plywood Inventory	16,000,000 sq. ft.

Assumed that lumber and plywood inventories and flows are distributed as follows:

		Lumber - Inv.	Plywood - Inv.
Tokyo	52%	125,091,200 bd. ft.	8,320,000 sq. ft.
Osaka	25%	60,140,000 bd. ft.	4,000,000 sq. ft.
Nagoya	10%	24,056,000 bd. ft.	1,600,000 sq. ft.
Yokohama	7%	16,839,200 bd. ft.	1,120,000 sq. ft.
Kobe	6%	14,433,600 bd. ft.	960,000 sq. ft.
	100%		

	Monthly Flows	
	Lumber	Plywood
Tokyo	79,892,800 bd. ft.	6,933,160 sq. ft.
Osaka	38,410,000 bd. ft.	3,333,333 sq. ft.
Nagoya	15,364,000 bd. ft.	1,333,300 sq. ft.
Yokohama	10,754,800 bd. ft.	933,310 sq. ft.
Kobe	9,218,400 bd. ft.	799,980 sq. ft.

Dwelling Reconstruction Chungking, China

(Reported by Lowdermilk, Dept. of Agriculture)

Dwelling construction in Chungking following air raids and housing loss primarily took the following form:

Rectangular shaped mud-surfaced huts;
Frame composed of rough timbers or poles hand hewn and noched to fit;
Walls of bamboo lattice mats plastered with clay-lime mud to a thickness of 1½" to 2". (Single wall construction);
Roof of bamboo mats to several thicknesses to turn water;
Floor - dirt (primarily) pounded to firm;
Construction was with a very minimum use of rough hardware, virtually no nails used in construction.

Labor Cost of Construction (8' x 10' structure - 80 sq. ft. floor area)

Frame	-	8 man days
Walls	-	12 " "
Roof	-	8 " "
Total	-	28 man days (Labor applied in groups of four)

Types of Japanese Emergency House Construction (Post-raid)

1. Types sponsored by government:

a. Rough board construction (clapboard); single wall construction with rough timber frame and with tile, sheet iron, thin shingle, or board roofs. (This is the basic type of pre-war construction.)

TYPE A

b. Prefabricated plywood construction with plywood or bamboo mat roofs (without timber frame). (This type is new and represents a minimum use of lumber for wooden structures and minimum labor cost of construction.)

TYPE B

c. Clay-lime, bamboo mat construction with rough timber frames and bamboo mat, tile, or thatch roofs. (This type of construction has been in common use in Japan.)

TYPE C

d. Barracks; rough board construction (clapboard); single wall construction with rough timber frame and with tile, sheet iron, thin shingle, or board roof; rough wood floors; no partitions.

TYPE D

*The relative employment of these types of dwelling construction will depend primarily upon the availability of materials. Labor supply and the time requirements in post-raid housing of dehoused workers are other considerations; also immediate place availability of materials to dehoused populations.

2. Types of Privately developed housing:

a. Clay-lime bamboo mat construction;

b. Hastily erected shacks construction from packing cases, scraps of sheet iron, bamboo mats, etc.

*It is assumed that government housing to meet needs of essential labor will absorb 40% of all available lumber and plywood supplies either in stock-pile or flow. The balance of lumber and plywood supplies both in inventory and flow will be required for factory repair and reconstruction, docks and wharves, etc., (industrial needs) and for commercial structures.

Estimates of Lumber and Plywood Requirements re: Dwelling Types

TYPE A. (9' x 9'; 7' ceiling)

Rough board construction; rough timber frame; rough board floor; tile roof; single wal:

(450 bd. ft. for walls, roof, floor; 300 bd. ft. for framing)

Assumed small roof overhang and loss of 10 per cent in cutting and fitting.

Lumber requirement - 750 bd. ft.

Labor cost of erection - 8 man days

TYPE B. (9' x 9'; 7' ceiling)

Prefabricated plywood construction; no framing timbers; plywood roof; plywood cut to dimensions for construction; plywood or rough board floor; rough timber sills:

(walls and roof, 342 sq. ft.; 81 sq. ft. for floor; 80 bd. ft. rough timber sills and floor joists)

Plywood requirement - 423 sq. ft.

Lumber requirement - 80 bd. ft.

Labor cost of erection - 2 man days

TYPE C. (9' x 9'; 7' ceiling)

Type C-1

Clay-lime walls, bamboo mat construction; rough timber frames; tile or thatch roof; dirt floor: (framing 250 bd. ft; false roof 90 bd. ft.)

Lumber requirement - 340 bd. ft.

Labor cost of erection - 9 man days

(Erection of frame - 3 man days; Bamboo walls and plastering - 4 man days; tile or thatch roof - 2 man days).

Type C-2

Use of bamboo mats for roof - saving of 1 man day; also saving of 90 bd. ft. of lumber.

Lumber requirement - 250 bd. ft.

Labor cost of erection - 8 man days

Estimates of Lumber and Plywood Requirements re:Dwelling Types (Cont'd)

TYPE D. (16' wide x 60' long; 7' ceiling)

Barracks; rough timber frame; single wall construction; rough board walls (clapboard); rough wood floors; tile, sheet iron, or thin shingle, or board roof; no partitions.

Lumber requirement - 4600 bd. ft.

Labor cost of erection - 48 man days

Lumber Available - (Cumulative Totals)

(Board Feet)

City	Post-raid (Immediately)	First 30 days	60 days	90 days	120 days
Tokyo	125,091,200	204,984,000	284,876,800	364,769,600	444,662,400
Osaka	60,140,000	98,550,000	136,960,000	175,370,000	213,780,000
Nagoya	24,056,000	39,420,000	54,784,000	70,148,000	85,512,000
Yokohama	16,839,200	27,594,000	38,348,800	49,103,600	59,858,400
Kobe	14,433,600	23,652,000	32,870,400	42,088,800	51,307,200

Plywood Available - (Cumulative Totals)

(Squrre Feet)

City	Post-raid (Immediately)	First 30 days	60 days	90 days	120 days
Tokyo	8,320,000	15,253,160	22,186,320	29,119,480	36,052,640
Osaka	4,000,000	7,333,333	10,666,666	13,999,999	17,333,332
Nagoya	1,600,000	2,933,300	4,266,600	5,599,900	6,933,200
Yokohama	1,120,000	2,053,310	2,986,620	3,919,930	4,853,240
Kobe	960,000	1,759,980	2,559,960	3,359,940	4,159,920

Type B (Plywood) may be regarded as non-competitive with respect to supply as it is assumed that logs which qualify as "peeler" logs will be diverted to plywood mills in preference to lumber conversion to the extent of mill capacity. This would be dictated by (1) economy in log conversion, (2) labor economy in house construction through use of plywood, and (3) need of plywood in airplane manufacture. Plywood of inferior quality (grade by-products) would be available for house construction.

Types A, C (C-1 and C-2), and D are competitive for the existing lumber supply (stockpiles and flow). Both types may be built concurrently, however, in which event the total of structures resulting would depend upon the relative proportions of types A, C-1, C-2, and D structures. Type B structures are competitive with Types A, C-1, C-2, and D but only to a very limited extent. The lumber requirements for floor supports, sills, and joists are only 80 bd. ft. per B structure.

Types C-1 and C-2 structures (in comparison with Types A and D) are most economical in use of lumber. However, Type C-1 is the most costly in terms of labor. Type D structures (barracks) can be provided with the lowest man-power cost but is somewhat more exhaustive of the limited lumber supply - hence a longer time interval is required. On the other hand, it is a better type of housing than Type C-1.

It may be expected that Type D, Type C-1, Type A, and Type B structures will be built concurrently although with rather wide variation in the relative number of these different types of structures. It is likely that the Japanese Government will be primarily concerned with the rehousing of its labor supply employed in priority industries in the immediate post-raid period. Type D structures are particularly well suited for this purpose and, consequently, the construction of wooden barracks will be initially emphasized. The quantity of this type of construction probably will be largely determined by the number of essential factory laborers to be rehoused. Type B structures, subject only to the limitation of plywood supply, probably will be constructed because of their economy in the use of wood, the

rapidity with which they may be set up, and their economy in the use of man-power. Types C-1, C-2, and A may be regarded as residual in their claims on the limited supply of lumber with Types A, C-1 and C-2 built in roughly similar proportions. Type C-2 dwellings, in general, will be located in suburban areas and used by those in the low income groups. Type C-1 probably will make its appearance in theworking class districts. Types C-1 and C-2 probably will depend to a large extent for their construction on family labor. Type A structures, on the other hand, will depend largely on the employment of building mechanics, will establish an urban location, and will house those who are relatively well circumstanced as toincome.

To achieve the rehousing program, which it is assumed the Japanese government will undertake, all types described in this exhibit will probably be constructed. Because the barracks type of construction economizes material and labor and is particularly adaptable to emergency housing of workers under conditions which facilitate communal feeding and largely eliminate transport problems, it is assumed that extensive resort will be had to t is type. The assumed program,on which the estimates employed in the text are based, assigns 50 percent of new construction to barracks, dividing the remainder equally among "A", "B", "C-1", and "C-2" types. Material and manpower requirements of this program are summarized in the table below:

NEW CONSTRUCTION -- HOUSING

City	Type	No. Units	Lumber Required	Man-Month Cost	Number of People Housed
Tokyo	D	17,653	81,203,800 Bd. ft.	28,244	423,688
Yokohama	D	2,870	13,202,000 " "	4,592	68,875
Kawasaki	D	1,310	6,026,000 " "	2,096	31,438
Nagoya	D	3,648	16,780,800 " "	5,837	87,563
Osaka	D	8,000	36,800,000 " "	12,800	191,313
Kobe	D	2,360	10,856,000 " "	3,776	56,625

(Cont'd.)

City	Type	No. Units	Plywood	Lumber	Man-month Cost	Number of People Housed
Tokyo	B	53,000	22,419,000 Sq.ft.	4,240,000 Bd.ft.	3,533	106,000
Yokohama	B	8,610	3,642,000 " "	688,800 " "	574	17,220
Kawasaki	B	3,930	1,662,390 " "	314,400 " "	262	7,860
Nagoya	B	10,946	4,630,158 " "	875,680 " "	730	21,891
Osaka	B	23,914	10,115,622 " "	1,913,120 " "	1,600	47,828
Kobe	B	7,078	2,993,994 " "	566,240 " "	472	14,156
Tokyo	C-1	53,000		18,020,000 Bd.ft.	16,060	106,000
Yokohama	C-1	8,610		2,927,400 " "	2,610	17,220
Kawasaki	C-1	3,930		1,336,200 " "	1,191	7,860
Nagoya	C-1	10,946		3,731,640 " "	3,320	21,891
Osaka	C-1	23,914		8,330,760 " "	7,247	47,828
Kobe	C-1	7,078		2,406,520 " "	2,145	14,156
Tokyo	C-2	53,000		13,250,000 Bd.ft.	14,427	106,000
Yokohama	C-2	8,610		2,152,500 " "	2,300	17,220
Kawasaki	C-2	3,930		982,500 " "	2,980	21,891
Nagoya	C-2	10,946		2,736,500 " "	6,378	47,828
Osaka	C-2	23,914		5,978,500 " "	1,887	14,156
Kobe	C-2	7,078		1,769,500 " "		
Tokyo	A	53,000		39,750,000 Bd.ft.	14,427	106,000
Yokohama	A	8,610		6,457,500 " "	2,300	17,220
Kawasaki	A	3,930		2,947,500 " "	1,050	7,860
Nagoya	A	10,946		8,209,500 " "	2,920	21,891
Osaka	A	23,914		17,935,500 " "	6,378	47,828
Kobe	A	7,078		5,308,500 " "	1,887	14,156

SUMMARY OF LUMBER REQUIREMENT AND LABOR COST

City	Total No. Housed	Total Lumber Requirements	Total Plywood Requirements	Total Man-Month Cost
Tokyo	847,688	156,463,800 Bd.ft.	22,419,000 Sq.ft.	76,691
Yokohama	137,755	25,428,200 " "	3,642,000 " "	12,367
Kawasaki	62,878	11,606,600 " "	1,662,390 " "	5,649
Nagoya	175,127	32,334,120 " "	4,630,158 " "	15,727
Osaka	382,625	70,957,880 " "	10,115,622 " "	34,403
Kobe	113,249	20,906,760 " "	2,993,994 " "	10,167
Total	1,719,322	317,697,360	45,463,164	155,013

It is estimated that lumber and plywood supplies will be sufficient to undertake and complete this very limited building program within a period of approximately 60 days. Total lumber supplies available for housing within 60 days for the seven cities are in the estimated amount of 547,840,000 Bd. ft. with requirements of 317,697,000 Bd.ft.; plywood supplies 42,666,000 Sq. ft. with requirements of 45,463,164 Sq. ft.. The small apparent deficit in plywood supply during the first 60 days is not significant.

SECRET

EXHIBIT NO. IV

ESTIMATES OF CASUALTIES CAUSED BY CONFLAGRATIONS

SECRET

EXHIBIT NO. IV

ESTIMATES OF CASUALTIES CAUSED BY CONFLAGRATIONS

The assumptions upon which the estimates of casualties by cities were reached are as follows:

1. Area of attack: Zones I & II as defined and outlined in the report entitled "Japan, Incendiary Attack Data", October, 1943.

2. Weight of attack: 20 tons IB per square mile.

3. Results of attack: 168 appliance fires per square mile. 93 residual or uncontrollable appliance fires per square mile. Fires will reach conflagration proportions in 30 - 60 minutes.

4. Number of attacks on individual cities: Tokyo - 4 separate attacks; also 1 attack. Other cities - 1 attack.

Casualties are defined as "persons killed, missing, or seriously injured."

A successful incendiary attack of the magnitude assumed will certainly result in a large number of casualties. Precautionary air raid protection measures, which have been adopted by the Japanese Government, probably require civilian fire watchers to assist organized fire fighting forces. The development of numerous fires should prevent many of these fire watchers from escaping from fire areas. In addition, avenues of escape for some of the persons not fighting fires will probably be blocked, and death and injury on a large scale should result from suffocation, incineration, and heat.

These general conclusions are, of course, supported by an examination of the results of the Tokyo and Yokohama fire and earthquake of 1923. With a population of 2,265,000 prior to the disaster, Tokyo suffered a loss of 58,104 killed, 10,556 missing, and 7,876 seriously injured. The largest loss of life in one incident occurred at the Military Clothing Depot in Honyo ward where many people had taken refuge and where about 40,000 died as a result of incineration and suffocation. Yokohama, with a population of

442,600, suffered a loss of 21,382 killed, 1,951 missing, and 3,114 seriously injured. Assuming that approximately two-thirds of the population of Tokyo and Yokohama lived in the burned-out areas, the ratio of casualties to affected population in the 1923 disaster was approximately 6 percent.

In seeking to apply the 1923 experience to a forecast of the consequences of the assumed attack, consideration must be given to the different circumstances which will probably surround that attack. The Japanese Government, in all likelihood, is anticipating incendiary attack on Japan's principal cities. Past experience with numerous fires has demonstrated the high vulnerability of Japanese urban areas. The Japanese Government has probably prepared measures to deal with incendiary attack, and such attack will probably not find the people and the authorities in the state of unpreparedness which existed at the time of the fire of 1923. Fire watchers have probably been organized, trained and equipped. Scattered throughout the cities are large parks and buildings of fire-resistive construction, such as schools and shrines protected by fire breaks. In each district, certain of these points of comparative safety may have been designated as places of shelter, and individuals may have been assigned to particular shelters. This should, of course, reduce the danger of overcrowding both exits to places of refuge and the places themselves. It is recognized, however, that even these points of comparative safety may be destroyed by a general conflagration or that the people within them may die of suffocation or heat generated by surrounding fires.

The number of casualties will tend to be reduced not only by pre-raid precautions but also by the probable absence of conditions which increased the casualties caused by the fire of 1923. Thus, neither the quakes, which ruptured water mains, thereby hampering fire fighting in 1923 and which caused many fires; nor the high winds, which spread the fire, can be expected. Moreover the straightening and widening of certain streets, the provision of fire-breaks, the construction of fire-proof buildings and similar measures which the Japanese have taken since 1923, will operate to reduce the number of casualties.

The foregoing factors are offset by the fact that the saturation of Zones I and II should produce many times the number of uncontrollable fires and a more widespread distribution of such fires than occurred in 1923. Moreover, population density in Tokyo has increased since 1923. In view of these considerations, it is reasonable to expect that four separate attacks on Tokyo will produce at least as high a ratio of casualties to the number of people in Zones I and II as was caused by the fire of 1923.

Individual estimates of casualties for each of the selected cities are set forth below. In making these estimates consideration has been given to the density and combustibility of structures, and to fire breaks in the form of canals, wide streets, parks and open areas in each of the cities. Consideration has also been given to the shape of the fire area as it affects probabilities of escape. Thus the casualty rate for Kobe is relatively low because the area of attack is long and narrow, with the result that egress is relatively easy.

ESTIMATES OF CASUALTIES BY CITIES

City	Zones I & II Population	Area	Est. Min. No. of Casualties
Tokyo	4,356,000	67.5 sq. mi.	260,000 (four separate attacks)
Yokohama		7.4 " "	45,000 (single attack)
Kawasaki		4.6 " "	20,000 " "
Nagoya	972,000	20.8 " "	60,000 " "
Osaka	2,534,000	39.4 " "	150,000 " "
Kobe	776,000	10.3 " "	25,000 " "

The ratio of estimated casualties to total population in Zones I and II in each of the cities is approximately equal to the ratio of casualties to population in the burnt-out areas in the Tokyo-Yokohama fire of 1923, except for Kobe where the comparative ease of escape has resulted in a much lower ratio. It is believed that the proportion of those killed to total casualties will be very high - of a magnitude of not less than 75%.

The foregoing estimates are statements of probable loss on the assumption that conditions unusually favorable to conflagration will not exist. Should the attack have the favorable circumstances of high winds conducive to the

SECRET

rapid and effective spread of the flames, should a regular bombing pattern occur with full saturation of the attack area, should exit arterials be quickly blocked by conflagrations, should mass entrapment of people occur, the resulting casualties will probably be substantially higher.

In the case of Tokyo it is not expected that enough force can be applied to secure simultaneous saturation of Zones I and II by incendiaries since the area involved is 67.5 square miles. It is assumed, therefore, that Tokyo would be subject to four separate attacks. The number of casualties resulting from several attacks on only a part of Zones I and II will be relatively less than if the entire area is saturated in one attack. In other words, casualties are expected to increase at more than a proportionate rate with increases in the size of attacked areas (assuming the same weight of attack per square mile) because (1) the difficulty of escape from the area attacked increases geometrically as the area becomes larger, and (2) with a larger area of attack, more fires will be started and the amount of fire-fighting equipment and trained man-power available to combat each individual conflagration will be less. In the event of a single mass attack on Tokyo, instead of four separate attacks, the estimate of casualties is 700,000.

SECRET

EXHIBIT NO. V

CONFLAGRATION DAMAGE TO UTILITIES

SECRET

EXHIBIT NO. V

CONFLAGRATION DAMAGE TO UTILITIES

1. Transportation Facilities.

The facilities for public transportation in the selected cities consist of electric surface street railway systems, buses, subways, and taxicabs. The most important loss will result from destruction of substantial numbers of street cars, buses and taxicabs. In addition, overhead electric circuits for street cars with their supports and exposed trackage (ties and rails) will suffer serious damage. No significant damage to subway facilities is expected.

At the time of the raid and ensuing fires, cars, buses, etc., would be operating on the streets or would be in car barns, garages, or other places of storage or repair. Cars on the street which were caught within the conflagration area probably could not escape because their power would be cut off, as a result of the destruction of overhead wires and supporting poles. These cars would probably be destroyed. Buses and taxies, because they are self-propelled and are not restricted to fixed routes, would be able to escape from the conflagrati n areas more easily than street cars.

It is not clear whether cars in car barns would be subjected to greater risks than cars on the street. This would, of course, depend on the incendiary potentialities of car barns, i.e., their structure and location--- factors concerning which adequate data can be secured only from air cover. Similarly on the basis of available data, it is difficult to assess the comparative risks of buses and taxies in use as opposed to those in garages. However, it appears that those in use at the time of attack may more easily be driven beyond the range of the fires.

The time of the attack may,therefore, affect the amount of damage to cars, buses, etc. During the peak load periods

substantially all of the facilities not being repaired are probably in use on the streets. On the other hand, during the off-peak periods, most of the cars, buses, etc. are off the streets and in car barns, garages, etc. If car barns have a low fire vulnerability because of structure and location, an area attack during off-peak hours would have a diminished effect in the destruction of rolling stock. However, in view of the inadequacy of information concerning the vulnerability of car barns and garages, it does not appear feasible to base varying estimates of damage with reference to different times of attack.

4. In the Tokyo fire and earthquake of 1923, 900 cars were destroyed. These represented 60% of the number on hand. As a result of increased population, there are more surface cars in Tokyo than were there in 1923. Moreover, the saturation of Zones I and II in all of the cities should produce many times the number of uncontrollable fires per square mile than occured in 1923.

It is believed that these factors should largely offset whatever decrease in destruction may be expected to result from Japanese preparations against incendiary attack. Accordingly, it appears reasonable to estimate destruction of the order of 50 percent of the street cars in the selected cities and destruction of a somewhat smaller proportion of buses and taxicabs.

2. Electric Power.

Electric power generating stations located in the selected cities, because of their heavy construction and non-combustible character, are not susceptible to serious damage by direct hits of incendiaries alone. Transformer sub-stations, likewise, offer poor incendiary possibilities. However, both sub-stations and generating stations in the path of the conflagration would probably be destroyed or seriously damaged. Overhead distribution lines and their supporting poles would probably suffer serious damage. These overhead circuits could be quickly repaired--- assuming adequate replacement supplies

of wire and poles. Underground circuits would, of course, be relatively invulnerable.

3. Gas.

Gas mains would not be damaged as they would be underground and would not be ruptured. However, service extension lines to individual consumers would probably be destroyed, and burning gas would feed the fires until the isolation valves in the pipes supplying the installations involved could be closed. Moreover, gas plants, gas holders and gas meters, if in the path of conflagration, would be destroyed or seriously damaged.

4. Water.

The water systems,as a whole, would probably not be seriously damaged by a conflagration. However, filter plants or pumping stations in the path of the conflagration would be seriously damaged or destroyed. Moreover, service connections to the burned buildings probably would be destroyed or rendered unusable. In the aggregate, the destruction of these connections might cause a significant waste of water, a lowering of pressure in the mains and a consequent decrease of water available for fire fighting.

SECRET

EXHIBIT NO. VI

METHOD OF ESTIMATING ABSENTEEISM

SECRET

EXHIBIT NO. VI

METHOD OF ESTIMATING ABSENTEEISM

The basic factors employed in estimating the amount of absenteeism expected in Japan after a destruction of 70 percent of the housing in six cities have been influenced by those which the Ministry of Home Security developed on the basis of British experience. There are, however, several respects in which conditions in Japan differ substantially from those in Great Britain, and it was, therefore, not considered justifiable to extrapolate the British factors directly.

The most important of these differentiating elements is the scale of destruction anticipated in Japanese cities. British factors were worked out on the experience with absenteeism in some seven cities in most of which housing destruction was less than 20 percent; in only one case did it run as high as 30 percent, and here the figures were probably affected by the existence of available housing in an adjacent city. In Japan, destruction amounting to 70 percent of all housing is anticipated. It is possible that, somewhere beyond the limits included in British data, there is a threshold of destruction which, once passed, results in a sharply increased incidence of absenteeism. Available ground intelligence, for example, seemed on the whole to confirm the applicability of British factors to Germany, but, in the case of Hamburg, where about 56 percent of all housing was destroyed, there is evidence that they produced an underestimate of absenteeism. It should be noted that the Ministry of Home Security formula makes an implicit allowance for increasing returns from absenteeism as the scale of damage increases, since it relates absenteeism to housing destruction. In England, the ratio of total houses damaged to houses destroyed fell sharply, as the extent of damage increased. It is questionable, however, whether this implicit allowance adequately reflects the increasing returns

from absenteeism to be expected when destruction is on the scale assumed in Japanese cities.

The actual nature of the anticipated damage in Japan also constitutes a differentiating element. The British absenteeism factors were worked out on the basis of housing destruction (A plus B damage), but included the effects of other damage (C plus D damage), which accompanied it in a fairly systematic manner as well. The factors, in other words, although based on figures of destruction damage, assume the existence of a substantial sum of other damage. Because of the extreme inflammability of construction, it is expected that whole areas of Japanese cities will be burned clean, and that there will be very little other damage. The application of the British factors, therefore, might cause an overestimate of resulting absenteeism. Other differentiating elements include: the probable method of rehousing, the incidence of casualties, the type and severity of government controls imposed.

Under the circumstances, it was thought better to use British factors as a guide, rather than to apply them directly. The subject was accordingly approached with great caution. Absenteeism was first broken down into its component causal factors, and an effort was then made to estimate the probable magnitude of each of these factors in Japan. In the case of some of these component factors, British experience seemed to afford a useful standard; in others, it did not. The number of working days assumed to be lost by each Japanese worker whose house is completely destroyed, for example, corresponds almost exactly with British experience. The estimates of the number of casualties, however, have been more influenced by the records of the Tokyo-Yokohama fire which accompanied the earthquake of 1923.

The estimate of four weeks total absenteeism (five weeks including an allowance for reduced efficiency) for the entire working population of the cities attacked was arrived at by adding the sums

of the indivudual items considered in the analysis, taking care to add only those elements which are properly additive. Absenteeism resulting from social disorganization, for example, is not altogether distinct from absenteeism resulting from necessary relocation of dehoused workers and from transport difficulties; adjustments were, therefore, made in the estimate of the effects of social disorganization in order to avoid double counting. It is interesting, though probably no more than coincidental, that the total computed by this method agrees closely with the figure which would be derived from the straight application of the Ministry of Home Security formula.

SECRET

EXHIBIT NO. VII

BASIS FOR ESTIMATED DISTRIBUTION OF MANUFACTURING EMPLOYMENT BY INDUSTRIES AND CITIES

Population figures for Japan were derived by extending the estimates of casualties from the Census Bureau estimates of population for 1944. Populations of cities for 1944 are from the JTA study entitled "Estimated Population and Labor Force, 1944, for Selected Japanese Cities."

Estimates of manufacturing employment are based on the statistics of factories with five or more workers. Kojo Tokei-hyo, 1930-1940; the Bank of Japan Employment Index 1932-1941, for factories of fifty or more; investigations of the Labor Bureau of the Welfare Ministry, published in Rodosho Keisai Shuho, July 5, 1941; and current intelligence. Estimates of employment in detailed manufacturing industries were also used in building up the total for all manufacturing.

EXHIBIT NO. VII

Aircraft: The estimate of total aircraft employment is based on the joint JTA-CAB study of aircraft production and is consistent with production in the United States aircraft industry, allowing for differences in technology and productivity rates. The breakdown of employment between assembly, engine manufacture and the manufacture of components was based on comparative U.S. experience. The distribution of aircraft employment among cities was estimated on the basis of the reports on airplane production by individual plants.

Shipbuilding: Estimates of shipbuilding employment and its distribution among cities was based on the CWI report on merchant and naval shipbuilding, tonnage launched in 1943 and the estimated output of each yard. It was assumed that 4.5 man years were required for each ton of merchant shipbuilding and that the ratio of labor requirements in naval shipbuilding to merchant shipbuilding is three to one.

Estimates of employment in tank and truck production were based on pre-war locations of the automobile and truck manufacturing plants and on current intelligence.

SECRET

EXHIBIT NO. VII

BASIS FOR ESTIMATED DISTRIBUTION OF MANUFACTURING EMPLOYMENT BY INDUSTRIES AND CITIES

Population figures for Japan were derived by deducting MID estimates of casualties from the Census Bureau estimates of population for 1944. Populations of cities for 1944 are from the FEA study entitled, "Estimated Population and Labor Force, 1944, for Selected Japanese cities."

Estimates of manufacturing employment are based on the statistics of factories with five or more workers Kojo Tokei-hyo, 1930-1938; the Bank of Japan Employment Index 1932-1943, for factories of fifty or more; investigations of the Labor Bureau of the Welfare Ministry, published in Kokusei Keizai Shuho, July 5, 1941; and current intelligence. Estimates of employment in detailed manufacturing industries were also used in building up the total for all manufacturing.

Aircraft: The estimate of total aircraft employment is based on the joint FEA-OSS study of aircraft production and on a comparison with production in the United States aircraft industry, allowing for differences in technology and productivity rates. The breakdown of employment between assembly, engine manufacture and the manufacture of components was based on comparative U.S. experience. The distribution of aircraft employment among cities was estimated on the basis of the reports on airplane production by individual plants.

Shipbuilding: Estimates of shipbuilding employment and its distribution among cities was based on the ONI report on merchant and naval shipbuilding, tonnage launched in 1943 and the estimated output of each yard. It was assumed that 4.5 man years were required for each ton of merchant shipbuilding and that the ratio of labor requirements in naval shipbuilding to merchant shipbuilding is three to one.

Estimates of employment in tank and truck production were based on pre-war locations of the automobile and truck manufacturing plants and on current intelligence.

The estimated distribution of ordnance employment was based on the directory of Japanese arsenals and the type of equipment produced in these arsenals.

The estimated distribution of employment in radio and radar was based on reports of production in individual plants.

Distribution of employment in the metals and machinery and tools industries was based on the proportion of employment in these industries by city, as reported in the 1941 Japanese Municipal Year Book, with adjustments for establishments of less than five workers and for the decentralization program put into effect in 1938.

EXHIBIT NO. VIII

FIRE VULNERABILITY OF

IDENTIFIED INDUSTRIAL TARGETS

SECRET

EXHIBIT NO. VIII

FIRE VULNERABILITY OF

IDENTIFIED INDUSTRIAL TARGETS

SECRET

EXHIBIT NO. VIII

FIRE VULNERABILITY OF IDENTIFIED INDUSTRIAL TARGETS

Introduction

A Fire Vulnerability analysis by fire engineers has been prepared as a part of this study of the economic effects to be expected from successful incendiary attacks on Japanese urban areas. The industrial works and installations analyzed included identified plants located in Tokyo, Yokohama, Kawasaki, Nagoya, Osaka, Kobe, and Amagasaki. It is known that in the area incendiary attacks on Japan, damage to industrial installations may occur through either or both of two factors: (a) exposure to conflagration, (b) fire started by a direct hit. The study and report have therefore considered:

(1) Probable fire damage to industrial works located in urban areas by exposure to conflagration in the urban area.

(2) Probable fire damage to industrial works located in urban areas resulting from direct hits by incendiary bombs during an attack on Zones I and II of a density assumed to be sufficient to achieve 100% destruction of residential property in the Zones. The density assumption was provided to the fire engineers from other sources.

This Exhibit should be regarded as an exposition of the method whereby expected fire damage to identified industrial installations in the urban centers studied has been estimated.

This methodology is not intended to eliminate possible future requirements for detailed target analysis, combining ground intelligence and photographic cover. Data sheets provided for each industrial works have been written to provide interim conclusions, which will be modified as soon as photo intelligence and assessment of actual bomb damage in the Far East permit more accurate analyses.

Assumptions

Assumptions under which this analysis proceeded were as follows:

(1) Area of attack: Zones I and II as defined and outlined in the report entitled "Japan, Incendiary Attack Data", October 1943.

(2) Density of attack: 20 tons IB per square mile.

(3) Type Weapon: 6 lb., gel type, tail ejection IB bomb.

(4) In the absence of more accurate information it was assumed that Japanese industrial plants are similar to American industrial plants in construction and manufacturing hazards.

(5) All buildings were assumed to be single story unless definite information to the contrary was available.

(6) All structures and contents on a factory site had the same degree of combustibility, unless intelligence information indicated otherwise.

(7) The effectiveness of automatic sprinklers, fire doors, and wire glass windows in preventing fire spread is 100 percent discounted.

Probability of Exposure of Industrial Installations to Conflagration and Damage Therefrom

A clearly defined procedure for the study of exposure of individual industrial installations to conflagration was established, based on location, plant identification and damage probability. In each case, general data from American experience was modified in the light of intelligence evidence on the specific installation.

The areas of each city within Zones I and II were classified as to their general vulnerability to conflagration. This survey concerned itself with area concentrations of structures, general building construction and possible limit of conflagration.

Within the areas studied, intelligence was assessed as to the identification and location of individual plants by occupancy. In some

instances sufficient data was available to provide complete identification and details as to construction, contents, and exposure. In others, little data was available on one or more of these factors.

On the basis of available data for each installation, damage probability was evaluated in the following steps:

(1) From American experience, a general classification of buildings by type of construction and vulnerability to fire damage was set up. The categories are as follows:

(a) Frame (wood walls and roof).
(b) Brick and concrete walls, wood roof.
(c) Iron-clad walls and iron-clad roof (steel frame).
(d) Brick and concrete walls, iron roof (steel frame).
(e) Fire - resistant.

(2) American experience was utilized to establish possible maximum loss to be expected from civil fire by industry and by construction type. The table of percentage damage used is the result of the combined experience and judgment of the fire engineers (see Table A). A civil fire is defined as fire originating from whatever cause within the site limits of an industrial installation.

(3) A factor for susceptibility of each industrial works to conflagration was next derived, both from fire risk data and the above-mentioned intelligence on location of the installation within an area of possible conflagration. Exposure to conflagration was defined on the basis of width of fire-breaks (streets, canals, rivers, parks) which serve as space intervening between industrial works and conflagration, and the following distances agreed upon as indicators of the degree of exposure:

(a) High Exposure - less than 200 feet.
(b) Medium Exposure - 200 to 500 feet.
(c) Low Exposure - 500 to 1000 feet.

It was assumed that a conflagration was under way and that ignition of industrial plants would occur as a result of one or a combination of three factors:

(a) Close proximity
(b) Heat radiation
(c) Fire-brands

TABLE A

ESTIMATED MAXIMUM PERCENTAGE BUILDING AND CONTENTS DAMAGE TO BE EXPECTED IN CIVIL FIRES

Occupancy / Construction	Airplane Assembly (Sub & Final Assembly)		Aircraft Engines		Light Metal Works. Tools, dies, Instruments etc.		Heavy Metal Works. Heavy Machine products etc.		Electrical Mfg. (Power Equipment Motors, Generators, Transformers Cable, etc.)		Light Elec. Mfg. (Electronics, Radio, Radar Telephone etc.)		Iron & Steel Mfg.		Petroleum (Refineries & Storage Tanks.		Rubber Mfg.		Munitions & Explosives (Loading & Storage)	
	Bldg.	Conts	Bldg.	Conts.	Bldg.	Conts.	Bldg.	Conts.	Bldg.	Conts.	Bldg.	Conts.	Bldg.	Conts.	Bldg.	Conts.	Bldg.	Conts.	Bldg.	Conts.
rame (Wood alls & Roof)	95	75	95	70	95	75	95	25	95	75	95	90	Not Applicable		95	15	95	80	100	100
rick & Conc. Walls, ood, Roof.	60	70	60	50	50	60	30	20	65	60	60	75	50	10	60	10	60	65	75	95
ron-clad Walls and ron-clad Roof (Steel rame)	25	40	25	30	20	25	20	15	25	45	25	60	10	5	75	10	40	55	95	95
rick & Conc. Walls, ron Roof (Steel Frame)	20	40	20	30	15	25	15	15	15	35	20	55	10	5	55	10	30	50	70	95
ire Resistive	10	40	5	30	5	25	5	10	5	30	5	35	5	5	10	10	10	45	50	95

SECRET

A table, used as a guide in evaluation, was prepared listing factors for high, medium and low exposure by industry and construction type (1, a,b,c,d,e, above).

(4) The percentages expressing maximum expected fire damage by civil fire (2) were then corrected to allow for greater fire damage to be expected during conflagration. Industrial works ignited by and exposed to mass conflagration in which fire guards and fire service have been overwhelmed, increases the probability of certain types of heat damage, both to structures and equipment. A guide table by industry, construction and occupancy vulnerability was prepared by the fire engineers and used to calculate average expectancy of damage.

(5) It will be noted that subsection (3) discusses the susceptibility of industrial works to damage by conflagration. Subsection (4) deals with the maximum fire damage to be expected in various industrial works, once fire by conflagration has begun. In claculating the average expectancy of damage to a specific installation by conflagration, it was necessary to multiply the factor of susceptibility to conflagration loss by the factor of maximum expected loss by conflagration to obtain a percentage probability of expected building loss and contents loss separately. It should be noted that the estimate is an average expectancy for all buildings and contents on a factory site or in an industry.

An example will illustrate the technique:

An aircraft plant of wooden construction was so situated as to be moderately exposed to a conflagration. By reference to the table for susceptibility, the plant was found to have an 80 percent degree of susceptibility to conflagration. By reference to the table for maximum expected loss by conflagration, it was found that a maximum building loss of 100 percent can be expected. Thus, average expectancy of damage by conflagration was found:

100% x 80% = 80% Expected Building Loss.
90% x 80% = 72% Expected Contents Loss.

This is a rule of thumb technique and has been corrected for conditions peculiar to each industrial works or installation.

(6) Finally an estimate was made by the fire engineers of the time required for recovery, derived from American data on repair and replacement rates. Such an estimate is necessary to a final calculation of production loss.

Expectancy of Fire Damage by Direct Hits

In addition to the evaluation of probable expected damage by industry, construction and occupancy when exposed to conflagration, it was necessary for this study that the fire engineers evaluate the probable expected damage resulting from direct hits by incendiary bombs dropped during an area attack of the density assumed to be sufficient to achieve 100% destruction of residential property in Zones I and II in the various cities.

The estimate for expected fire damage to building and contents by direct hits recorded on the data sheets by the fire engineers was the result of their analysis using the methodology described below:

(1) Each industrial works or installation was evaluated for direct hit damage probability following the evaluation of the probable expected damage by exposure to conflagration.

(2) A table for use in this analysis was prepared by the fire engineers to provide a basis for estimating the effectiveness of the IB weapon against industrial targets of varied vulnerability of construction and occupancy. The table prepared used the following assumptions in addition to those applicable and stated in the Section titled "Assumptions" above.

a) One active incendiary bomb will land in approximately every 6000 square feet of ground floor area. The density of active incendiary bombs inside the factory buildings is based upon a weight of attack of 20 tons per square mile less a 30% factor for dud bombs and a 15% factor for non-penetrating bombs.

b) It was assumed that for each active incendiary bomb that hit a plant the effect would be one of the following:

1. The IB would burn itself out.....30%*
2. Fire watchers would extinguish.....60%*
3. The IB will actually start a fire...10%*

*These percentages are approximate, and would vary with construction and occupancy.

c) The estimate obtained in the table by industry, construction and occupancy was for the entire plant and not for individual building or occupancy on the plant site.

d) In the absence of data as to performance of the IB weapon in operational use against Japanese industrial targets its effectiveness has been assumed from available test data obtained from various sources.

(3) Each industrial works or installation was evaluated using the prepared table as a guide. Where intelligence information on a specific plant in regard to construction, height, and arrangement was available proper deviations were made from the table. The estimates, stated in percentage expectancy in the recorded data sheets, are considered to be average expectancy. In the economic study, using the data sheets for each industrial works prepared by the fire engineers, allowance has been made for the probability that a works or installation may be damaged by exposure to conflagration or that fire within the plant site may be started by a direct hit. The higher expectancy of damage as calculated by the fire engineers has been taken from production loss estimates, whatever the cause.

Effectiveness of Methodology in Computing Expectancy of Damage

Following the completion of the study as outlined above the results of the computations and judgment of the fire engineers employed in this work were checked against a schedule of the same industrial plants and areas, which had been studied in England by fire insurance engineers, two of whom had 16 and 20 years experience in Japan.

In a very few instances discrepancies did occur between the two independent estimates. This was the result of a more accurate knowledge of location and structural vulnerability than could have been possible for the fire engineers engaged in this study. The principal factors of difference in the probability of damage from exposure to area conflagration were (1) the decision to discount 100% the effectiveness of automatic sprinklers, wire glass windows, etc., and (2) the need to use oblique photographs for rule of thumb estimates of width of streets, and other air-gaps. On the whole, the studies may be considered to be in remarkable agreement, considering the fact that the intelligence information on which the fire engineers had to rely was in many cases meager.

EXHIBIT NO. IX

IDENTIFIED FACTORIES: ESTIMATED DAMAGE AND PRODUCTION LOSS

SECRET

EXHIBIT NO. IX

IDENTIFIED FACTORIES: ESTIMATED DAMAGE AND PRODUCTION LOSS

SECRET

EXHIBIT NO. IX

ESTIMATED DAMAGE AND PRODUCTION LOSS ON IDENTIFIED PLANTS

The purpose of Exhibit IX is to show for each identified priority plant (1) its fire zone, (2) the probable damage to its buildings and contents which would result from exposure to surrounding fires, and (3) from direct hits, (4) the general damage category into which each plant falls (negligible, 0-9% physical damage; low, 10-24%; moderate, 25-44%; high, 45-100%), and (5) the production loss in months estimated for each plant.

Key: Target numbers with prefix "A" refer to targets not included in Air Objective Folders.

Target numbers without prefix refer to same numbered targets as in Air Objective Folders.

For definition of the fire zones, see "Japan Incendiary Attack Data", Oct. 1943, prepared in Office of the Assistant Chief of Air Staff, Intelligence.

SECRET

EXHIBIT NO.

SECRET

VULNERABILITY A FRAISAL OF IDENTIFIED INDUSTRIAL TARGETS

Industry	Target No.	Name of Plant	Principal Product	TOKYO Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Conts.	% Direct Hit Loss Bldgs.	% Direct Hit Loss Conts.	Vulnerability Appraisal High	Mod.	Low	Negl.	Prod. Loss Mo.
Aircraft Assembly	1393	Aeronautical Experimental Lab.	Assembled aircraft	3	0	0	1	1				x	0
	332	Nakajima Sea-plane Works	Assembled aircraft	2	34	37	6	8		x			3
	331	Tokyo Gas Elec. Engineering	Assembled aircraft	2	41	33	4	3		x			3
Engines	799	Mitsubishi Aircraft (Oimachi Plant)	Engines	2	62	64	4	4	x				6
	327	Mitsubishi Aircraft (Shibaura Plant)	Engines	2	30	30	4	4		x			2.5.
	356	Nakajima Hikoki KK(Ogikubo Plant)	Engines	3	0	0	0	0				x	0
	357	Nakajima Hikoki KK (Musashino Plant)	Engines	3	0	0	0	0				x	0
		Shoda Aircraft Co.	Engines	3	0	0	0	0				x	0
	791	Showa Aircraft	Engines	3	0	0	0	0				x	0
	792	Tachikawa aircraft	Engines	3	0	0	0	0				x	0

Key: Target numbers with prefix "A" refer to targets not included in Air Objective Folders.
Target numbers without prefix refer to same numbered targets as in Air Objective Folders.

For definition of the fire zones, see "Japan Incendiary Attack Data", Oct. 1943, prepared in Office of the Assistant Chief of Air Staff, Intelligence.

SECRET

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Conts.	% Direct Hit Loss Bldgs.	% Direct Hit Loss Conts.	Vulnerability Appraisal High	Vulnerability Appraisal Mod.	Vulnerability Appraisal Low	Vulnerability Appraisal Negl.	Prod. Loss No.
Aircraft Components	368	Aeronautical Instrument Co.	Components	3	0	0	3	4				x	0
	A32	Asahina Tekkosho	Components	2	61	52	3	3	x				6
	A59	Dai Nippon Koku Kogyo	Components	1	62	58	3	3	x				6
	A37	Dai Nippon Kikai Kogyo Plant #5	Components	3	0	0	0	0		x		x	0
	A37a	Dai Nippon Kikai Kogyo	Components	3	0	0	0	0				x	0
	A61	Fuji Koku Kogyo KK	Components	2	16	32	1	3		x			2
	A62	Fujikura Koku Keiki KK	Components	3	0	0	0	0				x	0
	A64	Hitachi Kokuki KK	Components	2	28	30	2	3		x			1.5
	A63	Hitachi Kokuki KK	Components	3	0	0	0	0				x	0
	1394	Kanegafuchi Spinning Mill Co.	Components	2	37	37	6	5		x			3
	A60	Kajaba Seisakusho KK	Components	2	56	60	2	3	x				4
	A65	Meiji Gomu KK	Components	2	18	42	1	5		x			2
	A66	Metro Denki Kogyo	Components	2	56	60	2	3	x				4

SECRET

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Conts.	% Direct Hit Loss Bldgs.	% Direct Hit Loss Conts.	Vulnerability Appraisal High	Vulnerability Appraisal Mod.	Vulnerability Appraisal Low	Vulnerability Appraisal Negl.	Prod. Loss Mo.
Aircraft Components	A43	Mikuni Shoko KK	Components	3	0	0	0	0				x	0
	534	Nakajima Aircraft	Components	3	0	0	0	0				x	0
	A68	Nippon Kikoki	Components	2	58	54	3	3	x				4
	A67	Nippon Keiki Seizo KK	Components	3	0	0	0	0			x		0
	A70	Nippon Musen Denshin Denwa KK	Components	2	28	30	2	3		x			1.5
	A17	Nippon Musen Denshin Denwa KK	Components	2	56	60	2	3	x				4
	A71	Sakura Gomu KK	Components	3	0	0	0	0				x	0
	A67 a	Shibaura Plant	Components	2	28	30	2	3		x			1.5
	A72	Shinagawa Seisakusho	Components	2	38	48	3	5		x			3
	A58	Tanaka Keiki Seisakusho Omori Plant	Components	2	37	48	6	9	x				4
	A73	Tanaka Kuki Seisakusho	Components	2	15	30	1	3		x			1.5
	A74	Tokyo KC Kogyo KK	Components	3	4	4	2	3				x	0
	A68 c	Tokyo Machine Shop	Components	3	0	0	0	0				x	0

TOKYO (Cont'd.)

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Conts.	% Direct Hit Loss Bldgs.	% Direct Hit Loss Conts.	Vulnerability Appraisal High	Vulnerability Appraisal Mod.	Vulnerability Appraisal Low	Vulnerability Appraisal Negl.	Prod. Loss Mo.
Aircraft Components	919	Tokyo Measuring Instrument Works	Components	3	2	4	1	3				x	0
Shipbuilding	330	Ishikawajima Dockyard	Ships	2	20	15	1	1			x		1/2
	1462	Shinagawa Shipyard	Ships	3	0	0	0	0				x	0
	1459	Susaki Dockyard Ishikawajima Shipbuilding Co.	Ships	3	0	0	0	0				x	0
Tanks & Trucks	1340	Harley Davidson Motorcycle Co.	Motorcycles	2	62	66	4	5	x				6
	883	Ikegai Motor Plant	Engines	2	62	62	4	4	x				6
	1344	Japan Auto Co.	Autos and Parts	3	0	0	0	0			x		0
	1342	Japan Machine Industry	Parts	1	62	64	4	5	x				6
	573	Miyato Engineering Works	Motorcycles	3	0	0	0	0			x		0
Ordnance	352	Army Arsenal Engineering Shhool	Ordnance	2	15	15	2	3		x			.5
	214	Armory	Ordnance	2	15	15	2	3		x			.5
	A32	Asahina Iron Works	Ordnance	2	52	33	1	1			x		3

TOKYO (Cont'd.)

Industry	Target No.	Name of plant	Principal Product	Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Conts.	% Direct Hit Loss Bldgs.	% Direct Hit Loss Conts.	Vulnerability Appraisal High	Mod.	Low	Negl.	Prod. Loss Mo.
Ordnance	A33	Daido Seiko	Forged Parts	2	58	33	1	1	x				3
	A35	Jakasago Iron Works (Jekkosho)	Ordnance	3	0	0	0	0			x		0
	A36	Katsura Seisakusho	Ordnance	3	0	0	0	0				x	0
	1331	Kayaba Engineering Co.	Ordnance	2	8	7	4	4				x	0
	A13	Koito Seisakusho	Ordnance	2	3	3	3	3				x	0
	209	Military Works	Ordnance	2	10	10	2	3		x			.5
	1333	Nippon Type-writer Co.	Ordnance	3	0	0	0	0				x	0
	541	Oriental Otis Elevator Co.	Ordnance	3	0	0	1	3				x	0
	1332	Rolling Stock Co.	Ordnance	3	0	0	2	1				x	0
	366	Steam Engin ering & Rolling Stock Manu. Co.	Ordnance	2	4	3	2	1				x	0
	A35	Takasago Iron Works	Ordnance	3	0	0	0	0				x	0
	A34	Takasago Tanko	Forged Parts	2	58	33	0	0	x				4
	206	Tokyo First Army Arsenal	Ordnance	2	10	10	2	3		x			.5
	205	Tokyo Second Army Arsenal	Ordnance	2	3	3	2	3				x	0

TOKYO (Cont'd.)

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	Exposure Loss % Bldgs.	Exposure Loss % Conts.	Direct Hit Loss % Bldgs.	Direct Hit Loss % Conts.	Vulnerability Appraisal High	Mod.	Low	Negl.	Prod. Loss Mo.
Ordnance	A24	Taraka Seiki Kogyo	Ordnance	2	56	60	2	3	x				4
Radio & Radar	A11	Kato Electric Lamps	Radio Tubes	2	15	36	1	4		x			2
	326	Nippon Electric Co.	Radar equip.	2	11	27	.5	1			x		1
	885	Oki Electric Co. Plant #1	Communications equip.	2	1	3	.5	1				x	0
Machinery Tools & Instruments	A21	Chiyoda Electric Wire Co.	Electric equip.	2	56	56	2	3	x				4
	A7	Chuo Electric	Electric equip.	2	62	65	4	5	x				5
	A7a	Chuo Kogyo KK Plant #1	Electric equip.	2	68	72	5	6	x				6
	A6	Dengyosha	Electric equip.	3	0	0	0	0				x	0
	826	Fujikura Densen	Electric wires.	2	26	25.	4	5		x			1.5
	A30	Furukawa	Electric equip.	1	56	56	2	3	x				4
	913	Hatton Co.	Precision Inst.	1	11	22	1	3			x		.75
	916	Hitachi Engineering (Kamado Plant)	Electric equip.	2	3	4	1	2				x	0
	A3	Hokushin Elec. Manu. Co.	Electric equip.	3	0	0	0	0				x	0

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Conts.	% Direct Hit Loss Bldgs.	% Direct Hit Loss Conts.	Vulnerability Appraisal High	Vulnerability Appraisal Mod.	Vulnerability Appraisal Low	Vulnerability Appraisal Negl.	Prod. Loss Mo.
Machinery Tools & Instruments	882	Ikegai Machine Foundry	Machine tools	2	61	56	3	3	x				6
	A12	Imperial Elec.	Electric equip.	2	28	28	2	3		x			2
	1355	Japan Steel Bearing	Anti-friction bearings	2	30	28	3	3		x			2
	A28	Japan Telephone Wire(Main Plant)	Electric equip.	2	56	56	2	3	x				4
	1362	Kitashin Elec. Engineering Co.	Electric Instruments.	2	0	0.	0	0				x	0
	A31	Kokusan Elec.	Electric equip.	2	62	65	4	5.	x				6
	1361	Kokusan Seiki KK	Machine tools	2	73	63	6	6	x				6
	880	Konishi Photo Wks.	Photo equip.	3	0	0	8	10			x		0
	A1	Kurita Steel Co.	Machine tools	3	0	0	0	0			x		0
	A9	Kuwano Elec. Manu. Co.	Elec. Instruments	2	15	36	1	4		x			2
	A22	Metro Lamp Co.	Electric equip.	2	15	36	1	4		x			2
	A23	Mitsubishi Elec.	Electric equip.	2	10	10	2	3			x		.5
	551	Midensha Elec. Equip. Co.	Aircraft Detection equip.	2	80	72	10	10	x				6

SECRET

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Conts.	% Direct Hit Loss Bldgs.	% Direct Hit Loss Conts.	Vulnerability Appraisal High	Mod.	Low	Negl.	Prod. Loss No.
Machinery Tools & Instruments	1421	Nidensha Electrical Equip.	Electric equip.	3	0	0	0	0				x	0
	A2	Nihon Seiko KK	Anti-friction bearings	3	0	0	0.	0				x	0
	1353	Niigata Iron Wks.	Machine tools	3	0	0	0	0			x	x	0
	918	Niigata Iron Wks.	Compressors and machine tools	2	7	6	2	2				x	0
	889	Nippon Elec. Co. Factory #3	Electric equip.	2	8	15	1	3			x		.5
	A25	Nippon Elec. Inst. Co.	Electric equip.	2	56	56	2	3	x				4
	1430	Nippon Elec. Wire & Cable Co.	Wire and cable	2	37	35	4	5		x			3
	A69	Nippon Kogaku Kogyo KK	Machine tools	2	68	72	5	6	x				6
	1354	Nippon Piston Ring Co.	Piston rings	3	0	0	0	0				x	0
	A17	Nippon Wireless Telephone and Telegraph	Electric equip.	2	56	56	2	3	x				4
	A26	Oana Electric	Machine tools	1	15	36	1	3		x			2
	A18	Oriental Elec. Meter Manu. Co.	Electric equip.	3	4	4	2	3				x	0

TOKYO (Cont'd.)

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Conts.	% Direct Hit Loss Bldgs.	% Direct Hit Loss Conts.	Vulnerability Appraisal High	Vulnerability Appraisal Mod.	Vulnerability Appraisal Low	Vulnerability Appraisal Negl.	Prod. Loss Mod.
Machinery Tools & Instruments	1364	Physico-Chemical Industry Ltd.	Precision machinery	2	17	20	4	5		x			1
	A5	Seidensha	Electric Equip.	3	0	0	0	0			x	x	0
	354	Shibaura Machine Tool Co.	Machine tools	2	25	19	2	2		x			1
	A29	Shikishira Elec. Manu. Co.	Electric Equip.	2	56	56	2	3	x				6
	A8	Shinagawa Manu. Co.	Electric Equip.	2	56	56	2	3	x				4
	A15	Showa	Electric Equip.	2	56	56	2	3	x				6
	A14	Tareka Instrument Co.	Electric Equip.	2	56	56	2	3	x				4
	A20	Toden Electric Plant #1	Electric Equip.	2	56	56	2	3	x				4
	A19	Toden Electric Plant #2	Electric Equip.	3	0	0	0	0				x	0
	A10	Toda Electric Lamps	Electric Equip.	2	15	36	1	4		x			2
	A4	Tokyo Electric Bulb	Electric Equip.	3	0	0	0	0				x	0
	1357	Tokyo Special Machine Manu. Co. Japan Physico-Chemical Co.	Machine tools	3	0	0	0	0				x	0

TOKYO (Cont'd.)

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Contn.	% Direct Hit Loss Bldgs.	% Direct Hit Loss Contn.	Vulnerability Appraisal High	Mod.	Low	Negl.	Prod. Loss No.
Machinery Tools & Instruments	350	Toukishima Machinery Co.	Machine tools	2	34	31	3	4	x				2
Metals	212	Asahi Denka Kogyo KK	Magnesium	2	8	18	1	4			x		.75
	336	Japan Special Steel Co.	Alloy steels	3	14	4	0	0			x		.5
	1349	Japan Special Steel Works	Steel	3	0	0	0	0				x	0
	334	Nisso Steel Manu. Co.	Steel, Steel prod.	2	36	10	0	0			x		.75
	904	Sakurada Engine ring Works	Steel prod.	2	14	4	0	0			x		.5
	1352	Steel Plants in N.E. Joto ku (4)	Steel prod.	2	4	1	0	0				x	0
	1348	Toho Steel Foundry Co.	Iron and steel	3	0	0	0	0				x	0
	1350	Tokyo Kozai Co.	Steel	3	36	10	0	0			x		.75
	328	Watanabe Steel Works	Steel prod.	3	0	0	0	0				x	0
Chemicals	208	Army Branch Powder Factory		2	60	73	18	25	x				6
	360	Edogawa Petroleum Refinery	Oil	3	0	0	0	0				x	0

TOKYO (Cont'd.)

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	Exposure Loss Bldgs.	Exposure Loss Conts.	Direct Hit Loss Bldgs.	Direct Hit Loss Conts.	Vulnerability Appraisal High	Mod.	Low	Negl.	Prod. Loss Mo.
Chemicals	1400	Hodogaya Soda	Caustic soda	3	0	0	0	0				x	0
	204	Japan Artificial Fertilizer Co.	Chemicals	2	0	0	3	2				x	0
	1365	Japan Bakelite Co.	Plastics	2	29	26	3	3	x				2
	1397	Japan Refining Co.	Chemicals	3	7	8	2	3			x		0
	A65	Meiji Gomu Seizo KK	Rubber	2	9	21	1	5		x			.5
	1335	Naval Gunpowder Plt.	Explosives	2	60	73	18	25	x				6
	A27	Nippon Kayaku Seizo	Explosives	2	60	72	18	25	x				6
	A41	Nippon Kayaku Seizo	Explosives	3	0	0	0	0				x	0
	911	Ogura Oil Co.	Oils, gasoline	1	68	68	1	1	x				6
	207	Oji Army Explosives Arsenal	Explosives	2	60	72	18	25	x				6
	217	Powder Factory	Explosives	3	0	0	0	0				x	0
	1398	Tokyo Gas Co. (Omoti Branch)	Chemicals	2	45	30	1	1		x			1.5
	907	Tokyo Gas Co. (Sura Machi Wks.)	Coke	1	72	48	1	1	x				3
	A38	Tokyo Kayaku Kogyo	Explosives	3	0	0	0	0				x	0
	359	Uibara Oil Co.	Oil	2	37	45	0	0		x			2

SECRET

EXHIBIT NO. IX

VULNERABILITY APPRAISAL OF IDENTIFIED INDUSTRIAL TARGETS.

YOKOHAMA

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Conts.	% Direct Hit Loss Bldgs.	% Direct Hit Loss Conts.	Vulnerability Appraisal High	Mod.	Low	Negl.	Prod. Loss No.
Aircraft Components	1390	Hitachi - Solex Aircraft	Components	3	0	0	0	0			x		0
	1391	Ishikawajima Eng. Plant (Tomioka)	Components	3	0	0	0	0			x		0
	446	Nippon Hikoki, KK	Components	3	0	0	0	0			x		0
Shipbuilding	70	Asano Dockyard	Ships	2	0	0	0	0			x		0
	69	Mitsubishi Heavy Industry, Yoko-Hama Dockyard	Ships	2	14	9	1	1			x		0
	122	Tsurumi Steel & Shipbuilding Co.	Ships	3	0	0	0	0			x		0
	71	Uraga Dock Co. - Dockyard #3	Ships	2	20	15	1	1		x			0
Tanks & Trucks	72	Ford Motor Co.	Trucks, tanks	3	10	7	2	2			x		0
	1343	Ishikawajima Motor Co.	Ordnance Automobiles and wheels	3	6	6	0	0			x		0
	522	Nissan Jidosha KK	Trucks, cars	3	7	6	3	3			x		0
Ordnance	899	Japan Military Goods Co.											

YOKOHAMA (Cont'd.)

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	$ Exposure Loss Bldgs.	Exposure Loss Conts.	$ Direct Hit Loss Bldgs.	Direct Hit Loss Conts.	Vulnerability Appraisal High	Mod.	Low	Negl.	Prod. Loss No.
Ordnance	78	Nirada Fire-cracker Factory	Ordnance	3	0	0	0	0				x	0
Radio & Radar		Japan Radio and Phonograph Co.	Radio and radar	3	8	10	4	6				x	0
Mach., Tools & Instruments	A45	Arai Iron	Electric equip.	1	56	56	2	3	x				6
	A46	Kotaki Ship-building	Electric equip.	2	10	10	2	3			x		.25
	1354	Oriental Babcock Co.	Heavy machinery	3	0	0	1	1				x	0
	133	Shibaura Kosaku, Kikai KK (Shibaura Eng. Works Ltd.)	Machine tools	3	3	5	1	2				x	0
	1363	Showa Engineering Co., Ltd.	Machine tools	3	0	0	0	0				x	0
	A44	Yokohama Elec. Wire Co.	Electric equip.	2	28	28	2	3		x			1.5
Metals	498	Kurada Iron Works	Steel bodies	2	14	10	2	1			x		.5
Chemicals		Asahi Glass Co.	Optical glass, chemicals	2	8	8	3	4				x	0
	1334	Asano Kavite Co. Ltd.	Explosives	3	0	0	0	0				x	0
	1431	Bridgestone Tire	Rubber products	3	0	0	0	0				x	0

YOKOHAMA (Cont'd.)

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	Exposure Loss Bldgs.	Exposure Loss Conts.	Direct Hit Loss Bldgs.	Direct Hit Loss Conts.	Vulnerability Appraisal High	Vulnerability Appraisal Mod.	Vulnerability Appraisal Low Negl.	Prod. Loss Mod
Chemicals	1399	Hodogaya Soda	Caustic soda & other chemicals	2	65	62	5	5	x			6
	88	Japan American Oil Co.	Oils and gasoline	2	51	64	0	0	x			3
	A47	Keihin Gartan	Coke	2	2	2	0	0			x	0
	117	Mitsubishi Oil Co. - Chivoda Oil Tanks	Crude oil, octane gas	3	9	11	0	0			x	0
	80	Niigata Sulphuric Acid Co.	Sulphuric acid	3	3	3	4	4			x	0
	499	Nippon Carbon Co.	Carbon electrodes	2	64	40	1	1	x			4
	129	Nippon Super Fuel Co.	Gasoline	3	51	64	0	0	x			3
	87	Ogufa Oil Co.	Oil	3	6	8	0	0			x	0
	89	Toho Sekiyu (East Pet. Ref.)	Oil	3	6	8	0	0			x	0
	90	Toyo Shuko	Oil	3	6	8	0	0			x	0
	1396	Tsurumi Soda Co.	Caustic soda	3	6	7	3	4			x	0
	141	Yokohama Rubber Co.	Rubber tires, trucks	2	18	42	1	5		x		1.5

EXHIBIT No. IX

SECRET

VULNERABILITY APPRAISAL OF IDENTIFIED INDUSTRIAL TARGETS

KAWASAKI

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Conts.	% Direct Hit Loss Bldgs.	% Direct Hit Loss Conts.	Vulnerability Appraisal High	Mod.	Low	Negl.	Prod. Loss No.
Aircraft Components	A54	Tokyo Denki KK	Components	1	56	60	2	3	x				4
	A53	Tokyo Kiki Kogyo	Components	1	56	60	2	3	x				4
	A56	Tokyo Koku Keiki KK	Components	3	0	0	0	0				x	0
	A55	Tokyo Musen Denki KK	Components	1	56	60	2	3	x				4
	A57	Tokyo Nakajima Denki KK	Components	2	33	35	4	5		x			3
Tanks & Trucks	135	Cooperative Auto Works	Trucks and parts	2	28	34	3	3		x			2
	A48	Diesel Jidosha Kogyo	Engines	1	38	47	3	3		x			3
Ordnance	142	Unidentified Arms Plant	Ordnance	2	none	0	0	0				x	0
Radio & Radar	497	Nippon Elec. Co.	Radar equip.	1	0	0	0	0				x	0
	496	Tokyo Factory #1 Shibaura Elec.Co.	Radio vacumn tubes	1	4	9	.5	2				x	0
			Radar equip.	1	10	24	.5	1			x		1
	488	Tokyo Shibaura Elec. Co. Factory #2											

EXHIBIT No. IX

SECRET

VULNERABILITY APPRAISAL OF IDENTIFIED INDUSTRIAL TARGETS

KAWASAKI

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Conts.	% Direct Hit Loss Bldgs.	% Direct Hit Loss Conts.	Vulnerability Appraisal High	Mod.	Low	Negl.	Prod. Loss No.
Machinery, Tools & Instruments	136	Fuji Elec. Works	Electric supplies	3	40	40	5	6	x				3
	489	Nippon Electric Wire & Cable Co.	Electric supplies	2	40	38	5	5	x				3
	109	Oki Elec. Co. Ltd. #2	Electric equip.	3	3	4	4	6			x		0
	A51	Shibaura	Electric equip.	1	56	56	2	3	x				6
	484	Showa Wire Cable	Electric equip.	1	18	17	5	6			x		.75
	494	Tokyo Elec. Wire & Manu. Co.	Electric supplies	1	70	66	5	6	x				6
	A50	Tokyo Radio	Electric equip.	2	28	28	2	3		x			2
	A49	Tokyo Wire & Cable	Electric equip.	2	15	16	4	5			x		.175
Metals	51	Asano Iron Works	Iron and steel	3	3	1	0	0				x	0
	56	Fuji Steel Wks.	Iron and steel	1	0	0	0	0				x	0
	1347	Japan Service Co.	Stainless steel forgings	2	0	0	0	0				x	0
	52	Japan Steel Tube Co.	Steel and steel products.	3	15	4	0	0				x	0

KAWASAKI (Cont'd.)

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Conts.	% Direct Hit Loss Bldgs.	% Direct Hit Loss Conts.	Vulnerability Appraisal High	Mod.	Low	Negl.	Prod. Loss No.
			NAGOYA										
Metals	57	Oriental Steel Products Co.	Steel	3	9	3	0	0			x		0
	1351	Tokyo Nakayama Iron Works	Steel plates	3	0	0	0	0				x	0
	58	Tokyo Special Steel & Chrome Works	High speed steels	1	30	8	0	0				x	0
Chemicals	147	Aikoku Oil Co.	Oil	3	6	8	0	0				x	0
	130	Asaishi Petroleum Co.	Oil, gasoline	3	6	8	0	0				x	0
	127	Hayama Oil Co.	Oils, gasoline	3	6	8	0	0				x	0
	479	Japan Artificial Fertilizer Co.	Chemicals	3	20	26	4	5			x		1
	116	Mitsubishi Oil Co.	Oils, gasoline	3	6	8	0	0				x	0
	452	Nippon Kokan	Coke	3	0	0	0	0				x	0
	128	Petroleum center	Oils, gasoline	3	6	8	0	0				x	0
	137	Showa Fertilizer	Chemicals	3	7	7	5	5				x	0
	481	Tokyo Gas Co. (Tsurumi Branch)	Artificial gas.	3	9	7	0	0				x	0

EXHIBIT NO.

SECRET

VULNERABILITY APPRAISAL OF IDENTIFIED INDUSTRIAL TARGETS

NAGOYA

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Conts.	% Direct Hit Loss Bldgs.	% Direct Hit Loss Conts.	Vulnerability Appraisal High	Mod.	Low	Negl.	Prod. Loss Mo.
Aircraft Assembly	199	Aichi Aircraft Works	Assembled aircraft	2	20	20	7	8		x			.75
	1129	Okamota Aircraft Works	Assembled aircraft	3	20	20	9	11		x			1
Engines	1828	Aichi Tokei Denki Plant #5	Engines	3	20	20	10	10		x			1
	198	Aichi Tokei Denki - Chitose Fuhogata Plant	Engines	1	50	55	10	10	x				6
	193	Mitsubishi Aircraft Engine Wks.	Engines	2	20	20	6	5			x		1
	194	Mitsubishi Aircraft Works	Engines	3	20	25	3	5		x			1.5
Components	1729	Aichi Aircraft Works	Components	3	40	35	4	7		x			3
	242	Okamota Aircraft Works	Components	2	35	35	5	5		x			2
	430	Toyada Machine Manu. Co.	Components	1	40	45	9	11	x				4
	1735	Toyowa Heavy Industry Co.	Components	1	40	45	9	11	x				4

NAGOYA (Cont'd.)

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Contes.	% Direct Hit Loss Bldgs.	% Direct Hit Loss Contes.	Vulnerability Appraisal High	Mod.	Low	Negl.	Prod. Loss No.
Ordnance	252	Nagoya Army Arsenal	Ordnance	3	20	15	3	2			x		.75
	196	Nagoya Arsenal	Ordnance	2	20	15	3	2			x		.75
	241	Nippon Vehicle Manu. Co.	Ordnance	1	20	15	3	2			x		.75
Machine, Tools and Instruments	1800	Daido Machinery Plant	Machine tools	3	15	20	5	6			x		.50
	1831	Hirano Loom Works (Nakagawa Plant)	Machine tools	3	65	70	5	6			x		6
	1809	Hokiku Machine Co. (Atsuta Plant)	Machine tools	3	65	70	5	6	x				6
	1799	Hokoku Machine Co.	Machine tools	3	65	70	5	6	x				6
	1153	Japan Porcelain Co.	Electric Instruments	1	10	5	1	0				x	0
	254	Mitsubishi Kikai KK	Machine tools	2	10	15	1	3			x		.5
	1171	Nippon Insulator Co.	Electric equip.	2	30	10	2	1			x		.5
	461	Okuma Iron Works (Ozone Plant)	Machine tools	2	35	40	5	6		x			3
	1797	Okuma Iron Works	Machine tools	2	65	70	5	6	x				6

NAGOYA (Cont'd.)

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Conts.	% Direct Hit Loss Bldgs.	% Direct Hit Loss Conts.	Vulnerability Appraisal High	Mod.	Low	Negl.	Prod. Loss No.
Machinery, Tools & Instruments	1146	Okuma Iron Works (Nagino Plant)	Machine tools	2	15	20	5	6	-	x			.5
	1147	Okuma Iron Works (Kunoike Plant)	Machine tools	1	70	65	4	4	x				6
	1795	Osaka Machinery Works	Machine tools	2	65	70	5	6	x				6
	1823	Tokai Electrode Co. (Nagoya #1 Plant)	Electric equip.	2	45	55	9	11	x				6
	1824	Tokai Electrode Plant (Nagoya #2 Plant)	Electric equip.	3	15	5	2	0			x		0
	1825	Tokai Electrode Co. (Nagoya #3 Plant)	Electric equip.	3	40	45	6	8	x				4
Metals	247B	Daido Electric Steel Co. (Atsuta Plant)	Steel Products	2	10	2	0	0			x		0
	247D	Daido Electric Steel Co. (Minami Plant)	Steel products	3	10	2	0	0			x		0
	247A	Daido Electric Steel Co. Oe Plant	Steel products	3	10	2	0	0			x		0
	247C	Daido Electric Steel Co. Tsukiji Plant	Steel products	3	10	2	0	0			x		0

SECRET

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Conts.	% Direct Hit Loss Bldgs.	% Direct Hit Loss Conts.	Vulnerability Appraisal High	Mod.	Low	Negl.	Prod. Loss No.
Metals	1753	Kobe Steel Work (Nagoya Plant)	Non-ferrous metals	3	10	5	19	0			x		0
	1821	Riken Alunite Plant	Non-ferrous metals	3	10	5	1	0			x		0
	1829	Yakagi Steel Plant	Steel products	3	5	1	0	0			x		0
Chemicals	1827	Dai Nippon Cellaphane Plant	Plastics	3	45	55	9	11	x				6
	253	Nissan Chemical Plant	Chemicals	3	3	5	2	3			x		0
	467	Showa Soda	Caustic Soda	3	35	35	5	6		x			2
	456	Toko Gas Works	Oil	2	15	40	0	0		x			.5
	255	Yakagi Electro Chemical Plant	Chemicals	3	35	35	5	6		x			2

SECRET

EXHIBIT C.

VULNERABILITY APPRAISAL OF IDENTIFIED INDUSTRIAL TARGETS

OSAKA

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Conts.	% Direct Hit Loss Bldgs.	% Direct Hit Loss Conts.	Vulnerability Appraisal High	Mod.	Low	Negl.	Prod. Loss Mo.
Aircraft Assembly	793	Fukuda Light Airplane Co.	Assembled aircraft	3	20	25	8	10		x			1
	1706	Mizuno Sporting Good Co.	Assembled aircraft	2	40	50	10	12	x				4
Components	686	Osaka Kinzoku Kogyo - Nakahina Plant	Components	1	40	45	9	11		x			3
	1705	Strong Engr. Works Co.	Components	3	35	40	5	6		x			2
	263A	Sujitomo Kinzoku Kogyo KK - Puropira Plant	Components	3	20	5	1	0			x		0
Shipbuilding	273A	Fujinagata Shipbuilding Co.	Ships	3	2	1	0	0			x		0
	273B	Funinagata Shipbuilding Co.	Ships	3	2	1	0	0			x		0
	272	Osaka Iron Works -Unit 1	Ships	3	5	2	0	0			x		0
	699	Osaka Iron Works -Unit 2	Ships	3	5	2	0	0			x		0
	1711	Osaka Ship-building Works	Ships	3	5	2	2	1			x		0
Ordnance	382	Osaka Arsenal	Ordnance	2	22	15	12	3	2		x		.5

OSAKA (Cont'd.)

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Conts.	% Direct Mfg Loss Bldgs.	% Direct Mfg Loss Conts.	Vulnerability Appraisal High	Mod.	Low	Negl.	Prod. Loss No.
Machinery Tools & Instruments	661	Amatsuji Steel Ball Manu. Co.	Machine tools, bearings	2	15	20	5	6			x		.5
	1740	Funukawa Elec. Co.	Electric equip.	1	35	40	5	6		x			3
		Hadsudcki Engine Works	Machine tools	3	35	35	5	5		x			2
	688	Kubota Iron & Machinery Works	Machine tools	1	35	35	5	5		x			2
	701	Kubota Iron & Machinery Works	Machine tools	1	15	15	5	5			x		.5
	1775	Kubota Iron & Machinery Works	Machine tools	1	35	40	5	6		x			3
	1715	Kwoyo Precision Works Co.	Machine tools	2	40	25	4	3		x			1.75
	1718	Kwyyo Precision Works Co.	Machine tools	2	40	25	4	3		x			1.75
	1720	Kwoyo Precision Works Co.	Ball bearings	2	40	25	4	3		x			1.75
	1751	Matsushita Dry Battery Co.	Electric equip.	2	35	40	5	6		x			3

OSAKA (Cont'd.)

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Conts.	% Direct Hit Loss Bldgs.	% Direct Hit Loss Conts.	Vulnerability Appraisal High	Mod.	Low	Negl.	Prod. Loss No.
Machinery Tools & Instruments	1634	Nisaguchi Gear Wks.	Machine tools	3	15	15	5	5			x		.5
	1755	Nakayama Steel Manu. Co.	Electric equip.	1	15	20	5	6			x		1
	1746	Oki Electric Co.	Electric equip.	2	35	40	5	6		x			3
	1752	Osaka Electric Machinery Co.	Electric equip.	2	35	40	5	6		x			3
	1781	Osaka Machine Co.	Machine tools	3	15	15	5	5			x		.5
	388	Osaka Machine Co.	Machine tools	2	70	55	3	3	x				6
	1783	Osaka Wakayama Iron - Tsuda Wks.	Machine tools	3	35	40	5	6		x			3
	687	Osaka Wakayama Iron Workd	Machine tools	2	35	35	5	5		x			2
	548	Rolling Stock Manu. Co	Heavy equip.	3	10	5	1	0				x	0
	262	Sumitomo Electric Industry Co.	Electric equip.	2	15	20	5	6			x		1
	1721	Tanaka Piston Ring Co.	Machine, tools, piston rings	1	70	75	5	6	x				6
	1703	Toyowa Heavy Industry Co.	Machine Tools	1	15	15	5	5			x		.5
Metals	1765	Japan Iron Works	Steel products	2	10	3	0	0				x	0

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Conts.	% Direct Hit Loss Bldgs.	% Direct Hit Loss Conts.	Vulnerability Appraisal High	Mod.	Low	Negl.	Prod. Loss No.
Metals	685	Kurimoto Iron Works	Steel products	2	10	3	0	0				x	0
Chemicals	1763	Kurimoto Iron Works	Steel products	2	10	3	0	0				x	0
	697	Mitsubishi Kogyo KK	Copper	1	10	5	0	0				x	0
	713	Nakayama Steel Manu.Co.	Steel products	3	10	3	0	0				x	0
		Nippon Aruminiumu Seisakusho	Aluminum products	3	10	2	0	0				x	0
	1786	Oriental Can Manu. Co.	Cans	2	25	25	3	3		x			2
	1787	Oriental Can Manu. Co.	Cans	1	55	60	3	3	x				6
	1785	Oriental Can Manu. Co.	Cans	2	15	10	3	3			x		.5
		Osaka Ceramic Industry Cement Co.	Aluminum	3	10	2	0	0				x	0
	268	Osaka Steel Manu. Co.	Steel products	3	10	3	0	0				x	0
		Sumitomo Kinzoku	Aluminum products	3	10	2	0	0				x	0
	264	Sumitomo Metal Industry	Steel products	3	10	3	0	0				x	0

SECRET

Industry	Target No.	Name of plant	Principal Product	Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Conts.	% Direct Hit Loss Bldgs.	% Direct Hit Loss Conts.	Vulnerability Appraisal High	Mod.	Low	Negl.	Prod. Loss No.
Metals	1774	Yamato Steel Works	Steel products	2	10	3	0	0				x	0
Chemicals	363	Dai Nippon Celluloid	Explosives	3	75	75	25	25	x				6
	1733	Japan Dyestuff Manu. Co. (Dye Plant)	Chemicals	2	20	25	8	10		x			1.5
	1734	Japan Dyestuff Manu. Co. (Druge Plant)	Chemicals	3	10	15	6	8			x		.5
	257	Maruzen Oil Refining & Tokyo Oil Ref.	Oil	2	50	45	1			x			4
	1732	Rasa Industry Co.	Chemicals	2	20	20	8				x		1
	1741	Sankyo Co.	Chemicals	1	65	70	6	8	x				6
	1628	Takeda Drug Co.	Chemicals	2	3	5	2	6				x	0

SECRET

EXHIBIT N°

VULNERABILITY APPRAISAL OF IDENTIFIED INDUSTRIAL TARGETS

KOBE

Industry	Target No.	Name of Plant	Principal Product	Fire Zone	% Exposure Loss Bldgs.	% Exposure Loss Conts.	% Direct Hit Loss Bldgs.	% Direct Hit Loss Conts.	Vulnerability Appraisal High	Mod.	Low	Negl.	Prod. Loss No.
Shipbuilding	171	Kawasaki Heavy Industry Co.	Ships	2	5	2	0	0				x	0
	169	Mitsubishi Heavy Industry	Ships	2	10	4	1	1				x	0
Tanks & Trucks	11	Kawasaki Shaiyo	Tanks	2	55	45	2	1	x			x	3.6
Radio & Radar	1745	Kawanichi Machine Shop	Radar equip.	1	15	20	6	8			x		1
Machinery, Tools & Instruments	1719	Nippon Airbrake Co.	Machinery, tools, airbrakes	1	3	5	1	3				x	0
	1749	Oki Electric Co.	Electric equip.	2	40	45	6	8	x				2
Metals	7	Kawasaki Heavy Industry	Steel Products	3	10	3	0	0				x	0
	1762	Kawasaki Heavy Industry	Steel products	1	10	3	0	0				x	0
	1775	Kawasaki Heavy Industry.	Steel products	3	10	3	0	0				x	0
	5	Kobe Steel Works	Steel products	3	10	3	0	0				x	0
	6	Kobe Steel Works.	Steel products	1	10	3	0	0				x	0
	1768	Kobe Steel Works	Steel products	3	10	3	0	0				x	0

SECRET

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

EXHIBIT X

DESCRIPTION OF THE SIX TARGET CITIES

Tokyo

The population of Tokyo is estimated at 7,387,000 as of July 1944. (with allowances for military conscripts, this figure is reduced to 6,779,000) of whom some 3,540,000 are estimated to be workers. The city, therefore, contains almost 10 percent of the total population of Japan proper. It covers an area of 221 square miles, of which 67.5 square miles are in Zones I and II. The average density of population is 30.7 thousand per square mile, but in the central areas the average increases to above 95 thousand per square mile, reaching 133.5 thousand per square mile in Asakusa Ku.

A minimum of 90 percent of the buildings in the city are estimated to be of wood construction, but vulnerability to fire should not be overestimated. Tokyo, to a greater degree than any other Japanese city, is marked by extensive parks and waterways. A program for the construction of firebreaks, instituted after the disastrous fire of 1923, has been partially carried out, and, according to current intelligence is being extended.

Tokyo's industrial importance is commensurate with its size. Nearly 15 percent of all workers employed in manufacturing industry in Japan Proper are estimated to be employed in the city. About 20 percent of workers in priority industry are employed here. Nearly 43 percent of all workers in the Japanese aircraft industry are estimated to be employed in the city, or the immediate outlying area to the north and west. An estimated 20 to 40 percent of all engines used in combat planes are made in two plants located in the outskirts of Tokyo. The only known manufacturer of starters for certain types of combat planes is located in the city; about half of the oleo shock struts for navy planes and more than half of all aircraft instruments are thought to be produced here.

Other items of importance of which Tokyo produces a substantial

portion are optical glass, pharmaceuticals, machine tools, bearings, and ordnance.

Kawasaki

Kawasaki is in effect a highly industrialized suburb of Tokyo, and had in 1944 an estimated population of 472,000. Priority industries in Kawasaki employ 160,000 workers. About 40,000 workers are engaged in the manufacture of radio and radar, producing about 40 percent of the total output of Japan Proper. Another 40,000 engaged in the production of machinery, tools, and instruments, account for 2.4 percent of output in these categories. Between 60 and 75 percent of the vacuum tubes used in radio and radar equipment are manufactured in three plants in this city. Perhaps 10 percent of Japan's production of electrical indicating instruments and 12 to 15 percent of wire and cable production are located here.

No final assembly of airplanes, or airplane engine manufacture takes place in Kawasaki, but 5 percent of all workers in Japan Proper employed in aircraft component manufacturing and sub-assembly are found here. There is substantial ingot capacity (nearly 10 percent of the total for the empire), a small amount of chemicals production, and some machine tool output.

Yokohama

Yokohama, also in the Tokyo industrial area, had an estimated population of 1,191,000 in July 1944. Population density in 1940 was 6.3 thousand per square mile. Yokohama is a highly developed industrial area; though its population is only 1.6 percent of Japan Proper, it employs 3.2 percent of all workers engaged in manufacturing and 5.3 percent of those engaged in priority industry.

Industry engaged in direct war production is heavily represented here. The city contains about 8 percent of all workers employed in manufacturing aircraft components; 10 percent of the total engaged in ordnance production; 14 percent in tanks and trucks; 7.5 percent in shipbuilding.

In 1941, about 30 percent of all Japanese heavy electrical equipment was produced in one Yokohama plant, the Tokyo Shibaura Denki. The city accounts for about 25 percent of all wire and cable production; is an important center for machinery and machine tool production; and it has at least one important bearing plant, and one of the three leading plants in Japan producing rubber goods.

Nagoya

Nagoya is the third largest city in Japan. Its estimated population in July 1944 was 1,523,000; its population density, on the basis of 1940 figures, was 22 thousand persons per square mile. Many of the large industries are located along the water front and in the southern section of the city, but the official policy of decentralization has resulted in the location of many factories in the outlying districts. With 2 percent of the population of Japan Proper, the city provides employment to an estimated 4 percent of all workers employed in manufacturing in Japan Proper, and to more than 5 percent of those employed in priority industries.

The city's great industry is aircraft production, which accounts for more than 25 percent of its total manufacturing employment. Nagoya employs approximately 14 percent of all workers in the Japanese aircraft industry; for those engaged in the final assembly of combat airplanes, the number rises to 30 percent; for aircraft engine production of combat type, to 35 percent. One of the two Mitsubishi plants located here is the largest integrated aircraft production unit in Japan.

Tank and truck production are also heavily represented, about 6 percent of all workers in this industry being employed in the Nagoya region.

Nagoya's contribution to machine tool production is, proportionately, great. About 18 percent of all workers in this industry are estimated to be employed here. The largest machine tool plant in Japan is located here.

Bearing production is also important. Two of the three plants of the Toyo Bearing Seiso, which is estimated to produce about 55 percent of total Japanese bearing output, are located here, as well as six other small plants.

A large Sumitomo aluminum plant contains about 20 percent of total Japanese aluminum fabricating capacity, and there is a heavy concentration of production of certain types of electrical equipment, such as small motors and generators.

Osaka

Osaka, Japan's second largest city, has the nation's highest population density. Its estimated population in July, 1944, was 3,350,000 persons, some 4.5 percent of the total for Japan Proper; density was 45.5 thousand persons per square mile. The city is compactly built, and has few parks or open spaces, though it is intersected by many canals which might provide fairly effective fire breaks. Principal industrial plants, together with many large warehouses, are located along the waterfront.

About 8 percent of the total workers in Japan Proper engaged in manufacturing are employed here. Osaka provides about 10 percent of the Japanese total of those engaged in priority manufacturing.

About half of its entire manufacturing employment is in the general fields of machinery, tools, instruments, and metals. About 44 percent of aluminum production is located here (most of it several miles outside the city limits to the east), about 22 percent of machine tool production (some of these plants are also in the outlying areas), and approximately 9 percent of rolled steel capacity. There are estimated to be no less than 50 plants producing bearings in the city, and Osaka ranks next to Tokyo and Nagoya in output of this product.

The city is an important center of chemicals production in certain lines. About 25 percent of Japan's dyes, and 45 percent of dye intermediates are manufactured here.

There are more than 100 small plants in Osaka producing a wide range of electrical apparatus--telecommunication equipment, batteries, radios, etc. About 25 percent of Japanese total output of wire and cable is produced in the main plant of Sumitomo Denki Kogyo.

Osaka accounts for approximately 4 percent of Japan's shipbuilding

industry, and, together with Kobe, it provides an estimated 35-45 percent of the ship repair facilities.

The contribution of the city to direct war production is less impressive than its general output in metals and chemicals. It employs, however, about 4 percent of the total number of aircraft workers in Japan proper, and produces almost the entire output of propeller governors used in army planes. It also employs about 8 percent of the total number of Japanese workers engaged in ordnance, and in tank and truck production.

Kobe

Kobe, a principal port of Japan, had in July 1944 an estimated population of 985,000 and a population density in 1940 of 30.5 thousand per square mile. Constricted by the surrounding hills, industrial plants have been pushed close to the highly congested residetial areas of the city, and to the waterfront. Kobe employs about 2.5 percent of the total workers in manufacturing in Japan proper, and nearly 4 percent of those in priority industry.

Its most important single industry is shipbuilding, which accounts for 7.5 percent of Japan's total. It is engaged in submarine production and is a large producer of major ships' components. About 25 percent of the total marine engine manufacture of the Japanese empire is thought to be concentrated here, and there is substantial production of steering gears, ship machinery, accessories and fittings. It is also an important repair center.

Other war production appears in less significant degree. About 4 percent of tank and truck production is located here, and about 4 percent, also of ordnance production. There is some aircraft component production, but most of this consists of heavy non-precision items, such as fuel and oil tanks, oil cylinders, and pumps.

Among other priority industries, heavy electrical equipment is well represented, producing about 10 percent of Japan's total.

PROVISIONAL EDITION

SECRET

SELECTED JAPANESE CITIES

FOREIGN ECONOMIC ADMINISTRATION
FAR EAST ENEMY DIVISION

■ 1,000,000 and over
▲ 500,000 – 1,000,000
● 190,000 – 500,000

KARAFUTO

HOKKAIDO

Sapporo

Hakodate

S E A

O F

J A P A N

KOREA

HONSHU

Sendai

TOKYO

KAWASAKI

YOKOHAMA

Yokosuka

Shizuoka

NAGOYA

Kyoto

OSAKA

KOBE

Wakayama

Hiroshima

Kure

Shimonoseki

Yawata

Fukuoka

Sasebo

Nagasaki

Kumamoto

SHIKOKU

KYUSHU

Kagoshima

TAIWAN (FORMOSA)

INTERNATIONAL BOUNDARIES
PREFECTURAL BOUNDARIES

MILES

KILOMETERS

SECRET

NO. 1629-M AUGUST 18, 1944

DRAWN IN THE CARTOGRAPHIC SECTION, F.E.A.

ITABASHI-KU
233,115

OJI-KU
220,304

ADACHI-KU
231,246

KATSUSHIKA-KU
153,041

TAKINOKAWA-KU
130,705

ARAKAWA-KU
351,281

TOSHIMA-KU
312,209

HONGO-KU
146,146

SHITAYA-KU
189,191

ASAKUSA-KU
271,063

MUKOSHIMA-KU
206,402

KOISHIGAWA-KU
154,655

YODOBASHI-KU
189,152

USHIGOME-KU
128,888

HONJO-KU
273,407

EDOGAWA-KU
177,304

NAKANO-KU
214,117

SUGINAMI-KU
245,435

KANDA-KU
128,178

NIHONBASHI-KU
101,777

YOTSUYA-KU
76,440

KOJIMACHI-KU
58,521

JOTO-KU
192,400

FUKAGAWA-KU
226,754

KYOBASHI-KU
142,269

T O K Y O

SHIBUYA-KU
256,706

AKASAKA-KU
55,704

AZABU-KU
89,163

SHIBA-KU
191,445

SETAGAYA-KU
281,304

MEGURO-KU
193,795

EBARA-KU
188,100

SHINAGAWA-KU
231,303

TOKYO BAY OF

OMORI-KU
278,895

KAMATA-KU
252,797

K A W A S A K I

TSURUMI-KU
172,587

KANAGAWA-KU
169,408

Y O K O H A M A

HODOGAYA-KU
63,981

NAKA-KU
386,020

ISOGO-KU
76,966

Note
KAWASAKI —
TOTAL POPULATION
300,777
POPULATION WITHIN
1935 LIMITS
193,000 (EST.)

1935 City Limits

N

TOKYO, KAWASAKI AND YOKOHAMA
DENSITY OF POPULATION

1940

FOREIGN ECONOMIC ADMINISTRATION
BUREAU OF AREAS
FAR EASTERN ENEMY DIVISION

THOUSANDS OF PERSONS PER SQUARE MILE

- Under 5
- 5 - 14.9
- 15 - 24.9
- 25 - 34.9
- 35 - 49.9
- 50 - 74.9
- 75 - 99.9
- 100 and over

1 0 1 2 3
KILOMETERS
1 0 1 2 3
MILES

MAP NO. 1149, MARCH 23, 1944

DRAWN IN THE CARTOGRAPHIC SECTION, F E A

PROVISIONAL EDITION

T25636

SECRET

RESTRICTED

KOBE - OSAKA
DENSITY OF POPULATION
1940

FOREIGN ECONOMIC ADMINISTRATION
BUREAU OF AREAS
FAR EASTERN ENEMY DIVISION

(a) Within 1935 city limits
(b) Outside 1935 city limits

MUKO GUN *125,000
NISHINOMIYA 111,796
NADA-KU *155,498
MUKO GUN 50,000
AMAGASAKI 79,000 (b)
AMAGASAKI 102,000 (a)
HIGASHIYODOGAWA-KU 267,944
FUKIAI-KU *123,846
KOBE-KU *79,850
MINATO-KU *53,727
SOTO-KU *62,382
HYOGO-KU 149,363
NISHIYODOGAWA-KU 226,498
KITA-KU 239,432
ASAHI-KU 248,875
KONOHANA-KU 215,775
HIGASHI-KU 148,580
NISHI-KU 117,229
MINAMI-KU 104,638
HAYASHIDA-KU *229,356
SUMA-KU *113,212
MINATO-KU 322,231
NANIWA-KU 139,806
TENNOJI-KU 119,117
HIGASHINARI-KU 371,813
TAISHO-KU 137,931
NISHINARI-KU 215,828
SUMIYASHI-KU 376,643
SAKAI 182,147

THOUSAND PERSONS PER SQUARE MILE

- 5 – 14.9
- 15 – 24.9
- 25 – 34.9
- 35 – 49.9
- 50 – 74.9
- 75 – 99.9

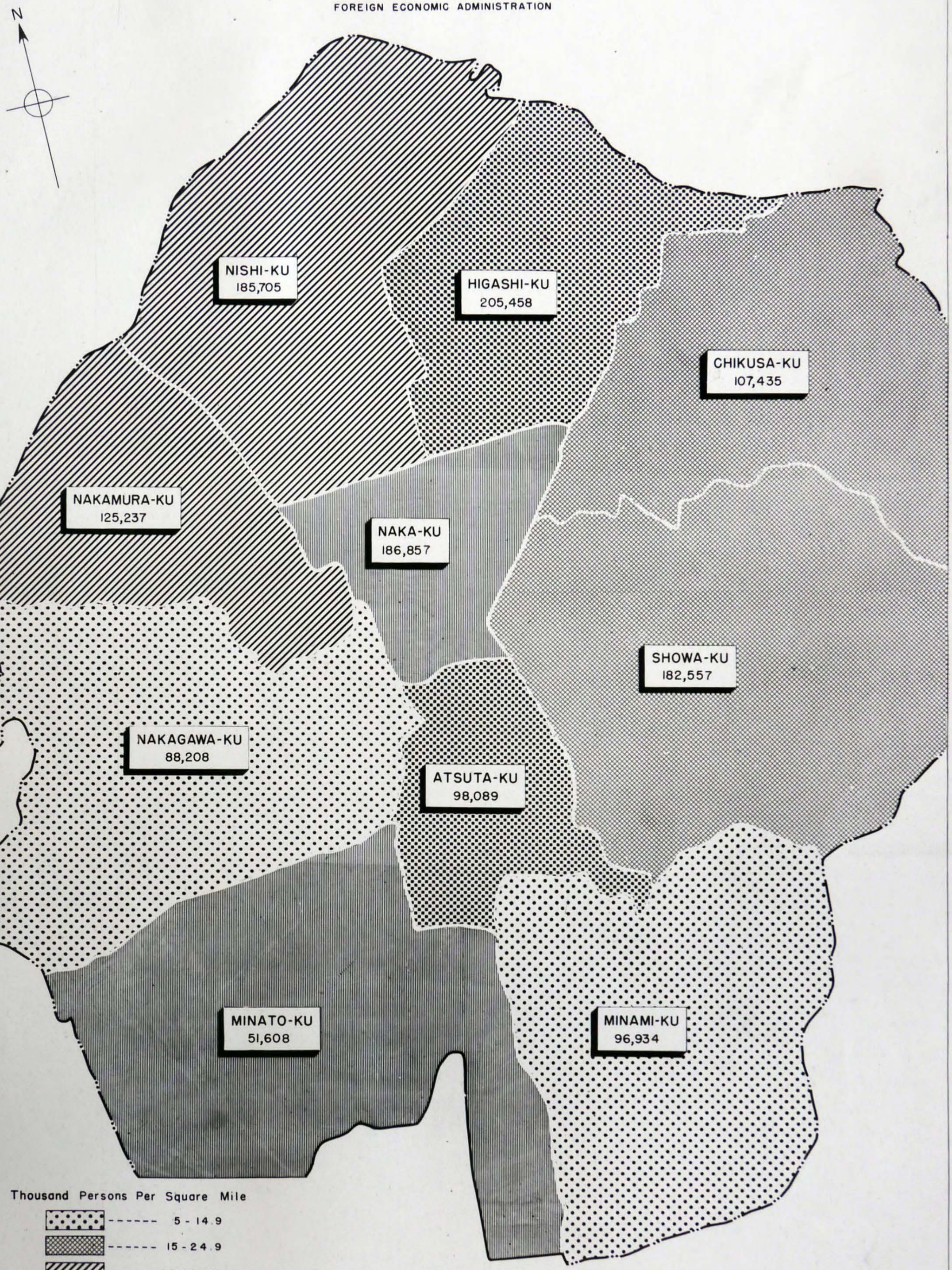
NOTE: Figures shown in boxes represent total population
* Estimated population

0 1 2 3
MILES

SECRET

NAGOYA
DENSITY OF POPULATION
1940

FOREIGN ECONOMIC ADMINISTRATION



NOTE: Figures shown in boxes represent total population

Correction: Minato Ku density 5.5 thousand per sq. mile.

MAP NO. 1150, FEBRUARY 18, 1944

DRAWN IN THE CARTOGRAPHIC SECTION, F. E. A.