ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC

TRANS-ASIAN RAILWAY ROUTE REQUIREMENTS: DEVELOPMENT OF THE TRANS-ASIAN RAILWAY IN THE INDO-CHINA AND ASEAN SUBREGION

VOLUME 3

THE TRANS-ASIAN RAILWAY IN CAMBODIA, SOUTHERN CHINA, THE LAO PEOPLE'S DEMOCRATIC REPUBLIC, MYANMAR, THAILAND (NORTH AND EAST) AND VIET NAM

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The opinions, figures and estimates set forth in this report were supplied by the respective railway administrations. They are the responsibility of the author and should not necessarily be considered as reflecting the views or carrying the endorsement of the United Nations.

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ANNEXES

INTRODUCTION

This is the third volume in a series which identifies and evaluates the requirements for developing and operationalizing the Trans-Asian Railway in the Indochina and ASEAN Subregion. In this volume, TAR development requirements in Thailand (north and east of Bangkok), the countries of Indochina, the Yunnan Province of China, and Myanmar are addressed. Earlier volumes provide an Executive Summary and an analysis of TAR development requirements in Indonesia, Singapore, Malaysia, and Thailand (south of Bangkok). These volumes constitute a report on a study conducted by ESCAP in two phases (one each for the ASEAN and Greater Mekong portions of the subregion) over a period of 21 months, from January 1994 to September 1995.

The background, mandate and overall objectives of this study, for which funds were generously provided by the Government of Japan, have been covered in Volume 1 (the Executive Summary).

The existing railway systems of the subregion are distinctive from railway systems in other parts of the ESCAP region in that they provide a network in which the one metre (1,000 mm) track gauge predominates. Metre gauge railways generally feature light track structures, light axle loads, slow speeds and small vehicle profiles. These characteristics pose unique problems of limited capacity in an era of dynamic trade and economic growth throughout the region in general and the subregion in particular. When they have to interface with wider gauge railways in neighbouring countries, they can impose capacity bottlenecks for international transportation of freight, especially of containers. This study has therefore had to focus on railway operational problems not widely encountered in other TAR Corridor studies.

In addition, the portion of the subregion which is the subject of this Volume does not at present have a continuous railway network capable of handling international traffic. Discontinuities (missing links) exist in particular between Thailand and Cambodia, Cambodia and Viet Nam, Yunnan Province and Myanmar, and between Myanmar and Thailand. A major focus of this volume, therefore, is the requirement to undertake the construction of new lines in order to provide a continuous international railway network which can offer a practical, cost effective and attractive alternative to other transport modes in the cross border movement of trade consignments.

As with the first phase of the study, covering the ASEAN countries, the approach adopted for this second phase, covering the counties of the Greater Mekong Area, is to identify a potential TAR network and to assess what is required for the future development and operationalization of this network, in order to satisfy a primary need for the international transportation of containers. As with the first phase also, particular emphasis has been given in this phase to the application of minimum standards for railway structure and vehicle dimensions, railway vehicle axle loads, and train speeds. Adherence to such standards would be required both for existing and new links in the proposed TAR network in the subregion.

2. IDENTIFICATION OF TAR LINKS (including identification of missing links)

2.1 Criteria for the Nomination of Links in the TAR Network

Criteria were set for the use of participating countries of the Indo-China and ASEAN Subregion in making their own selections of TAR links within their national territory, as a basis for further consideration at the Expert Group Meeting. TAR links so identified were to satisfy one or more of the following route significance criteria:

Capital-to-capital links (for international transport);

(b) Connections to main industrial and agricultural centres (links to important origin and destination points);

(c) Connections to major sea and river ports (integration of land and sea transport networks); and

Connections to major container terminals and depots (integration of rail and road networks).

Emphasis was given to capital-to-capital links, as these would eventually form a primary route network for international transport, and could facilitate economic and social development between or among countries in the subregion. Participating countries were also requested to assign priorities to their proposed TAR links.

2.2 Outline of the Nominated TAR Route Network in the Subregion

Figure 1 contains an integrated map of the proposed TAR links in that part of the Indo-China and ASEAN Subregion comprising Cambodia, Yunnan Province of China, the Lao People's Democratic Republic, Myanmar, Thailand and Viet Nam.

2.2.1 The TAR Network in Thailand

The State Railway of Thailand (SRT) has proposed a total of six TAR links. Four of them are categorized as capital-to-capital links, that is, Link T.1 with Malaysia, Link T.2 with the Lao People's Democratic Republic, Link T.3 with Cambodia, and Link T.4 with Myanmar. The fifth nominated TAR link, designated T.5, is positioned along an east-west axis connecting with the Lao People's Democratic Republic and providing a possible future extension to Danang Port in Viet Nam. The sixth nominated link, designated T.6, will connect Denchai on the Chiang Mai line with Chiang Rai, ultimately providing a link with Yunnan Province of China in the eastern most part of Myanmar. These six links are displayed in ***Figure 2.***

Link T.1 was described in detail in Volume 2 and is not further considered here.

The second TAR link proposed by SRT is the Bangkok - Vientiane line, designated Link T.2. The alignment, with an accumulated route length of 624 km, follows the SRT's northeastern main line, passing through Ban Phachi Junction, Kaeng Khoi Junction, Nakhon Ratchasima, and Khon Kaen before terminating at the border town of Nong Khai, on the Mekong River. An 30 km extension of the line across the Mekong River via the Friendship Bridge to Vientiane, the capital of Lao People's Democratic Republic 30, is being planned,

Figure 1: Trans-Asian Railway in Myanmar, Thailand, Cambodia, Lao PDR, Viet Nam and Southern China

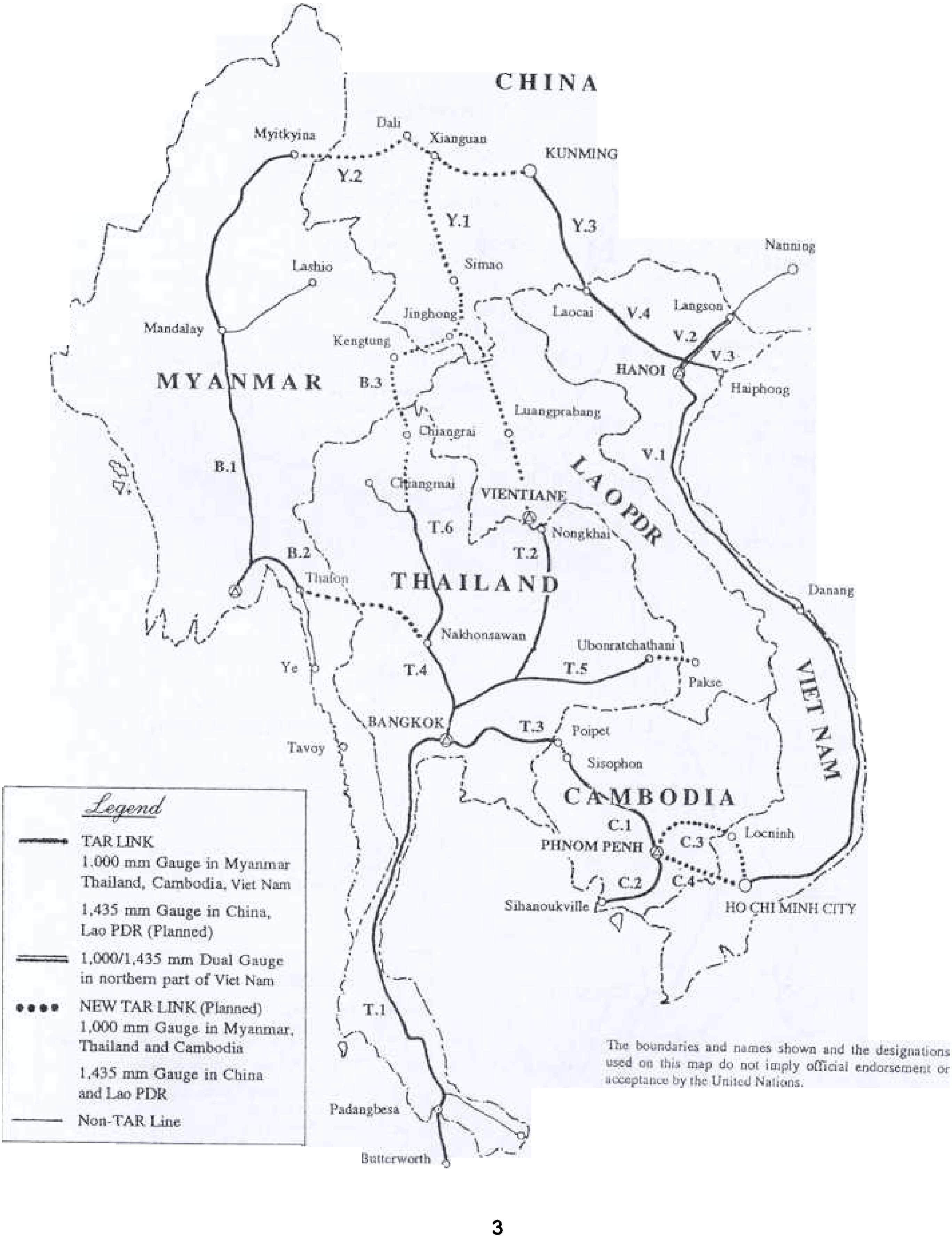

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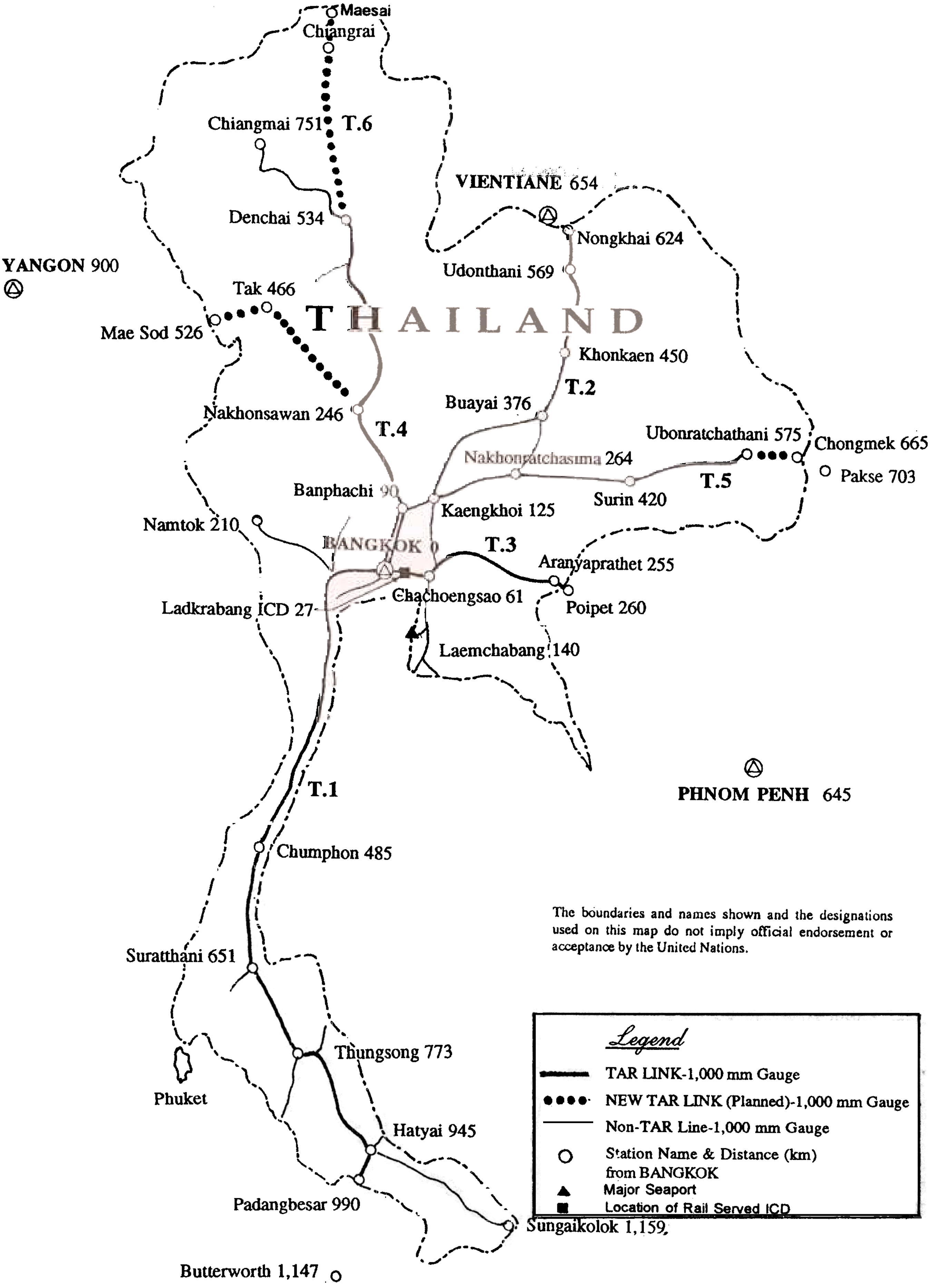
Figure 2: Trans-Asian Railway in Thailand (TAR Links T.1 - T.6



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with completion expected in 1997. This short link may be constructed on a dual gauge track of 1,000 mm and 1,435 mm, similar to that between Hanoi and Dong Dang in Viet Nam. Such a link would enable the SRT's trains to travel to Vientiane and the future Laotian as well as Chinese trains to advance as far as Nong Khai, without a break-of-gauge problem. A very high priority has been given to this link for many reasons. First, in view of the liberalization and opening up of the economies of China, the Lao People's Democratic Republic and Viet Nam, the link will provide an essential transportation route within the subregion for international trade and tourism. Second, the natural resources of these countries (in particular, their mineral, energy, agricultural and forest resources) are abundant and diversified, with huge deposits of good-quality coal, iron ore, and with ample water courses for hydro-electric power generation. Third, the sheer magnitude of the populations in these countries, especially in Southern China, would constitute a very large low cost workforce and would create the potential attraction of a large and expanding market for subregional products. Fourth, the increasing political stability of these countries is favourable to increased international economic and trade cooperation. Finally, the link within Thai territory is fully operational and in good condition, requiring comparatively little investment for upgrading of track or wayside facilities. A new Nong Khai station is to be constructed at a location closer to the Friendship Bridge than the existing station. It will occupy a large area of land containing facilities for train marshalling, breakbulk cargo and container handling, customs and immigration inspection, etc. *TAR Link T.2 would form part of the 1,700 km Kunming - Vientiane - Bangkok railway line which has been placed among the priority railway projects in the 1994 ADB Subregional Transport Sector Study.*

The third TAR link, designated Link T.3, would provide a capital-to-capital connection between Bangkok and Phnom Penh. This link follows the route of the SRT's existing eastern line, passing through Lard Krabang (the site of the SRT's major inland container depot, now in the advanced stages of construction), Chachoengsao (the gateway to Thailand's eastern seaboard development zone) and Prachin Buri, before terminating at Aranyaprathet, a border town opposite Poi Pet in Cambodia. The line will eventually connect with Cambodian railway system provided that the missing link between Poi Pet and Srisophon, a distance of 48 km, is reconstructed on the existing right-of-way. TAR Link T.3, together with TAR Link C.1 proposed by Cambodia, would form a direct rail connection between the two capitals, with a route length of 650 km, of which 265 km is within Thai territory and the remaining 385 km in Cambodia.

The fourth nominated TAR link in Thailand is the connection with Myanmar, via Mae Sod and Tak. Before the liberalization of the economies of Eastern Europe, the former Soviet Union and China, the only rail linkage between Europe and Asia assessed was through the southern corridor, passing through Turkey, Iran, Afghanistan, Pakistan, India, Bangladesh and Myanmar, entering Thailand via Mae Sod and Tak, and merging with the SRT's existing network at either Phitsanulok or Suphan Buri. The merging point was later designated as Nakhon Sawan, the major station on SRT's northern main line 246 km from Bangkok. Link T.4 would form a capital-to-capital link of 930 km in length between Bangkok and Yangon. The missing link is 450 km long, comprising two sections: the Nakhon Sawan-Tak-Mae Sod portion in Thailand accounting for 284 km, and the Myawadi - Thaton portion of 166 km in Myanmar.

The fifth nominated TAR link in Thailand (Link T.5) would follow the alignment of the SRT's northeastern main line from Bangkok to Ubon Ratchathani, with a 90 km extension to Chong Mek, opposite Pakse in the Lao People's Democratic Republic, where another combined road/rail bridge across the Mekong River is being planned. Link T.5 would provide the main connection between Northeastern Thailand, the southern part of the Lao People's

Democratic Republic, and Northern Cambodia. The line could be extended further from Pakse to Danang, an important coastal city in Viet Nam, which is being developed to become one of the major deep-sea ports of the subregion. Ubon Ratchathani is 575 km from Bangkok, 128 km from Pakse, and approximately 450 km from Danang.

The sixth nominated link in Thailand (Link T.6) would result from the construction of a new line from Denchai on the Bangkok-Chiang Mai mainline to Chiang Rai. Ultimately, this line would provide a connection with Yunnan Province of China via a line to be constructed south from Jinghong through Kengtung in Myanmar crossing the Mekong River on a bridge to be built near Mae Sai (Thailand).

2.2.2 The TAR Network in Cambodia

The Royal Cambodian Railway has nominated a total of six TAR links, four of which provide connections with Thailand, Lao People's Democratic Republic, and Vietnam. These are illustrated in ***Figure 3***.

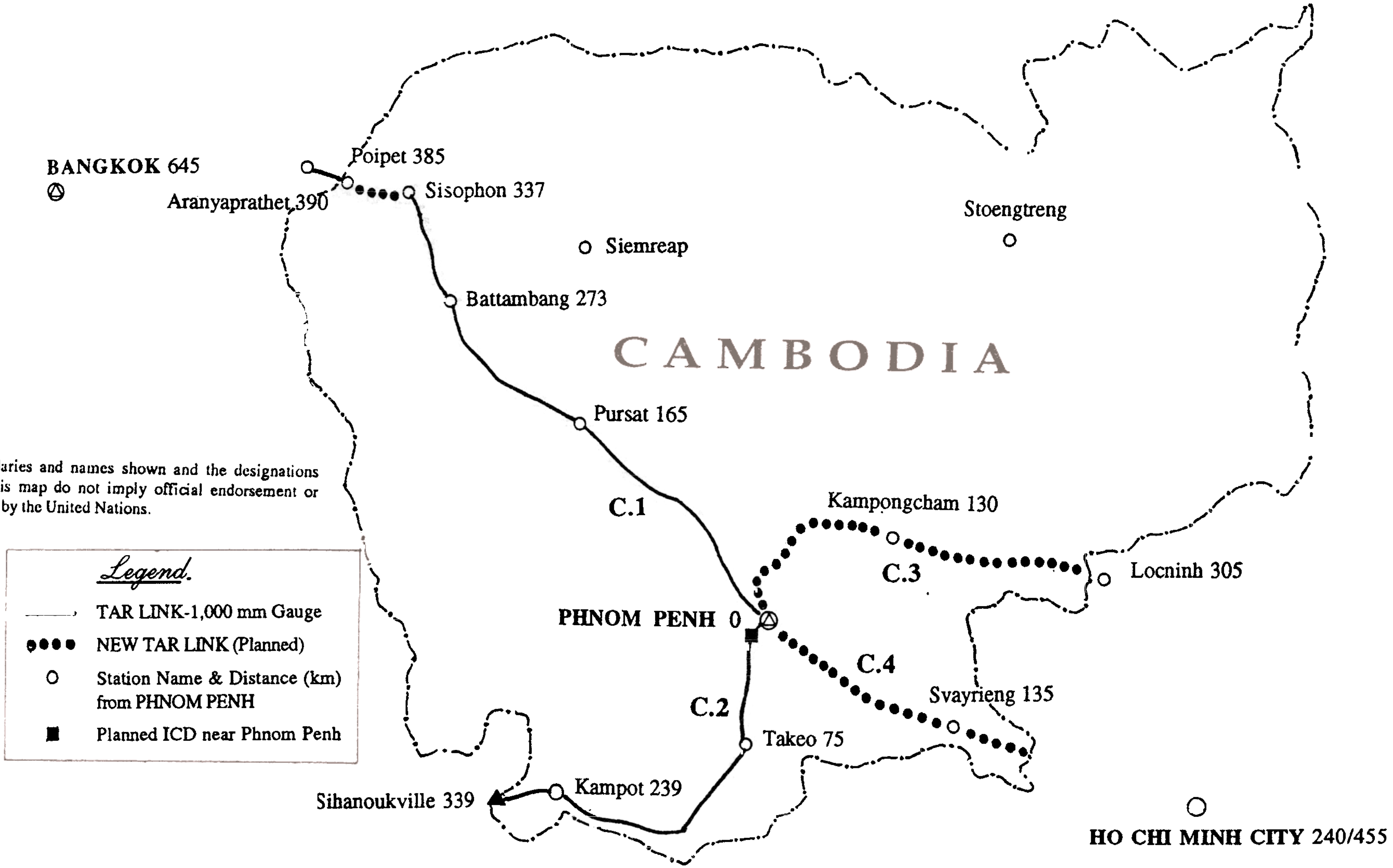
The first, designated Link C.1, is the existing main north-west line from Phnom Penh to Poipet, a distance of 385 km. Prior to 1975, the line was intact over its entire length and trains from Phnom Penh and Bangkok could meet at the joint border station of Poipet. Then in 1980, the 48 km section between Poipet and Srisophon was closed to traffic, and most track materials were removed leaving only the right-of-way remaining. At present, there are regular train services between Phnom Penh and Srisophon, albeit on an alternate day schedule.

Link C.1 constitutes a capital-to-capital link which could play a significant role in promoting international trade and tourism within the subregion, especially between Cambodia and Thailand. The 1994 ADB Subregional Transport Sector Study strongly recommends the re-establishment of this link, entailing reconstruction of the 48 km missing section, rehabilitation of the 337 km Srisophon - Phnom Penh section, and construction of a 240 km extension from Phnom Penh to Ho Chi Minh City. The alignment encounters relatively flat terrain and requires no tunnels or long viaducts. It was estimated to cost US$ 17 million to rebuild the Poipet - Srisophon section. The major problem associated with Link C.1 is the security issue. The line has been heavily mined and is subjected to frequent Khmer Rouge guerilla attacks.

The second TAR link proposed by Cambodia is the Phnom Penh - Sihanoukville line, designated Link C.2. The line is relatively new, being built in 1969 and is 263.4 km in length. It links the capital with the major deep-sea port and with the important provincial centres of Kampot and Takeo. Sihanoukville Port has had, and will continue to have, an important role in supporting the economic re-habilitation and development of Cambodia. It is expected to receive substantial funding for rehabilitation and expansion.

The third and fourth TAR links in Cambodia, designated Link C.3 and Link C.4, have been proposed as alternatives for the provision of inter-capital rail links between Phnom Penh and Ho Chi Minh City, Viet Nam. These two routes were studied by UNDP in 1968. The longer route of the two, C.3, would pass through Loc Ninh, a border town in Viet Nam, before reaching Ho Chi Minh City, covering a distance of about 450 km. The shorter route, C.4, with a length of 240 km, would connect Phnom Penh with Ho Chi Minh City, via Svay Rieng and low-lying areas of the Mekong Delta in Viet Nam. The 1994 ADB Subregional Transport Sector Study has also given high priority to the latter Thailand-Cambodia-Viet Nam link, and has estimated the total cost of construction to be US$ 475 million, about half

Figure 3: Trans-Asian Railway in Cambodia (TAR Link C.1 - C.4)



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of which would be for the Phnom Penh-Ho Chi Minh City section. The two alignment options pass through flat terrain but may require many bridge or viaduct crossings over low-lying areas.

Two other TAR links were proposed by Cambodia. These were a capital-to-capital link, Phnom Penh-Vientiane (Lao People's Democratic Republic) via Ratanakiri and Pakse, and a loop line through Siem Reap and important agricultural and mining centres to the north of Tonle Sap Lake. These routes had initially been proposed in a UNDP study of the mid 1960s. However, following discussions with the Cambodian National Expert for the study and with other officials of the railway and Ministry of Public Works and Transport, it was decided *not* to include these routes as links in the TAR as it is unlikely that their construction (which would be inordinately expensive given problems of topography) could be justified within the time frame of the study and, indeed, for several years thereafter.

2.2.3 The TAR Network in Viet Nam

Viet Nam has adopted a National Transport Plan which purports to give equal priority to all modes of transport. The main focus of the Plan is to develop all forms of transport infrastructure to serve the three principal economic zones of Viet Nam, ie. Hanoi-Haiphong-Quang Ninh, Danang-Quy Nhon, and Ho Chi Minh City-Bien Hoa-Vung Tau. This focus means that the plan will concentrate on the rehabilitation of the existing rail network to better serve the cities, ports, agricultural and industrial centres of Viet Nam, rather than on the establishment, or re-establishment, of rail links with neighbouring countries. Nevertheless, Viet Nam has nominated three TAR links, as illustrated in ***Figure 4.***

The first nominated link, designated V.1, is the existing north-south main trunk line between Hanoi and Ho Chi Minh City. It is a metre-gauge track of 1,729 km in length. From Hanoi, the line passes through the northern region of Viet Nam with its concentration of heavy industry, abundant mineral resources, fertile conditions for agriculture, and many tourist attractions. Among major northern cities served by this line are Giap Bat, Nam Dinh, Thanh Hoa, Cau Giat and Vinh. South of Vinh, the line passes through the central region which is less fertile and not as suitable for agriculture, but is a major source of canned and frozen seafood products for export. It also contains the ancient capital of Hue, key cities of Ha Tinh, Dong Hoi, Dong Ha, Tam Ky and Quang Ngai, and the strategically located port of Danang which has a major potential for development, and is presently being investigated as the Vietnamese port outlet for Laotian traffic, via the east-west Highway No. 9. The line finally passes through the southern region which has abundant reserves of oil and natural gas, and grows the bulk of the country's rice crop. Important cities in this region are Dieu Tri, Nha Trang, Quy Nhon, Tuy Hoa, Thap Cham, Phan Thiet and Ho Chi Minh City itself, which is the leading financial and commercial centre of Viet Nam. As yet unconnected to the railway network (but under serious consideration for such a connection) is Vung Tau, a coastal city near the Mekong delta which is developed as a major port for export and transit cargoes. Significantly, the Hanoi - Ho Chi Minh City Line was not listed among the subregional railway projects of the 1994 ADB Subregional Transport Sector Study, since its primary function is to serve the domestic transport needs of Viet Nam and it is not considered to be important as a transport link with the other countries of Indo-China. It was indicated to the ESCAP study team during its mission to Viet Nam that very little freight traffic travels the entire length of the line, mainly because north-south freight transportation needs are satisfied by fast, frequent and comparatively inexpensive coastal shipping services which are only occasionally interrupted during the typhoon season. The line therefore primarily serves the demand for passenger transportation between Hanoi and Ho Chi Minh City, as well as between provincial centres along the Viet Nam coast. Even this traffic is under threat from road transport competition, with the imminent commencement of work on the reconstruction of Highway One.[1]

The second TAR link nominated by the Vietnam Railways is the existing Hanoi-Dong Dang line, designated Link V.2. This line of dual metre and standard (1,000/1,435 mm) gauge configuration is 162 km in length, and extends from Hanoi to the northeastern border of Viet Nam, to connect with the Chinese standard gauge network at Youyiguan in Guangxi Province. Prior to 1979 when hostilities between China and Viet Nam ended cross border movement of trains, this line was used for international railway traffic from China, the former Soviet Union and the countries of Central East. Although the permanent way across the border remains intact, cross border railway operations have not resumed since their suspension more than 16 years ago. Gia Lam (5.5 km north of Hanoi), a major freight station for Hanoi and the location of the main locomotive and rolling stock workshops, is also the southern terminus of the dual gauge line from Dong Dang. The metre gauge track continues south from Gia Lam across two bridges, one over the Red River, to Hanoi. Gia Lam is also the junction station for the line to Haiphong (nominated by the Viet Nam Railways as TAR Link V.3). Also located on the Hanoi to Dong Dang line, about 11 km north of Hanoi, is another junction station at Yen Vien, once a very busy passenger and freight station, receiving trains from China. There are train marshalling and freight handling facilities at Yen Vien, comprising two yards, warehouses, a coal stockpiling area, and an area of vacant land, which has been proposed as the site for an Inland Container Depot (ICD). Yen Vien junction also receives trains from the northwest as far as Lao Cai, opposite the Chinese border town of Hekou. The Lao Cai - Yen Vien - Gia Lam - Haiphong section is part of the Kunming - Hanoi line built by the French colonial administration in the early 1900s to provide a sea-outlet to the land-locked Yunnan Province of China, via Haiphong Port, a distance of 855 km from Kunming. This line is entirely of 1,000 mm track gauge, as a consequence of which the 468 km portion in China is isolated from the remaining 54,000 km of Chinese railway network of China which is of 1,435 mm (standard) track gauge.The border at Lao Cai has also been closed to international rail traffic since 1979. The Hanoi - Dong Dang line serves the commercial and industrial centres of Yen Bai, Quan Trieu, Luu Xa, Dong Anh, and Kep (the latter being a junction station for a standard gauge line to Vong Bi, near the major deep-sea port of Cai Lan on Halong Bay, about 60 km northeast of Haiphong).

The third TAR link nominated by Vietnam is the Hanoi - Haiphong line, designated Link V.3. This metre gauge line of 102 km in length is considered important as it provides Hanoi and the hinterland with a seaport connection. The 1994 ADB Subregional Transport Sector Study has given high priority to the upgrading of the railway line linking Kunming with Haiphong Port (with a total length of 855 km). The rehabilitation of the entire line was estimated to cost US$ 65 million, the majority of which would be spent on the 387 km portion within Vietnamese territory.

In the light of the recommendations of the 1994 ADB Subregional Transport Sector Study and of information assembled by the ESCAP study team in Vietnam and Yunnan Province of China, it was decided that the inclusion of the 285 km Lao Cai-Yen Vien line as a link in the TAR network would be justified. Although there is a strong possibility that container trade to and from Yunnan Province will be handled through a Chinese, rather than

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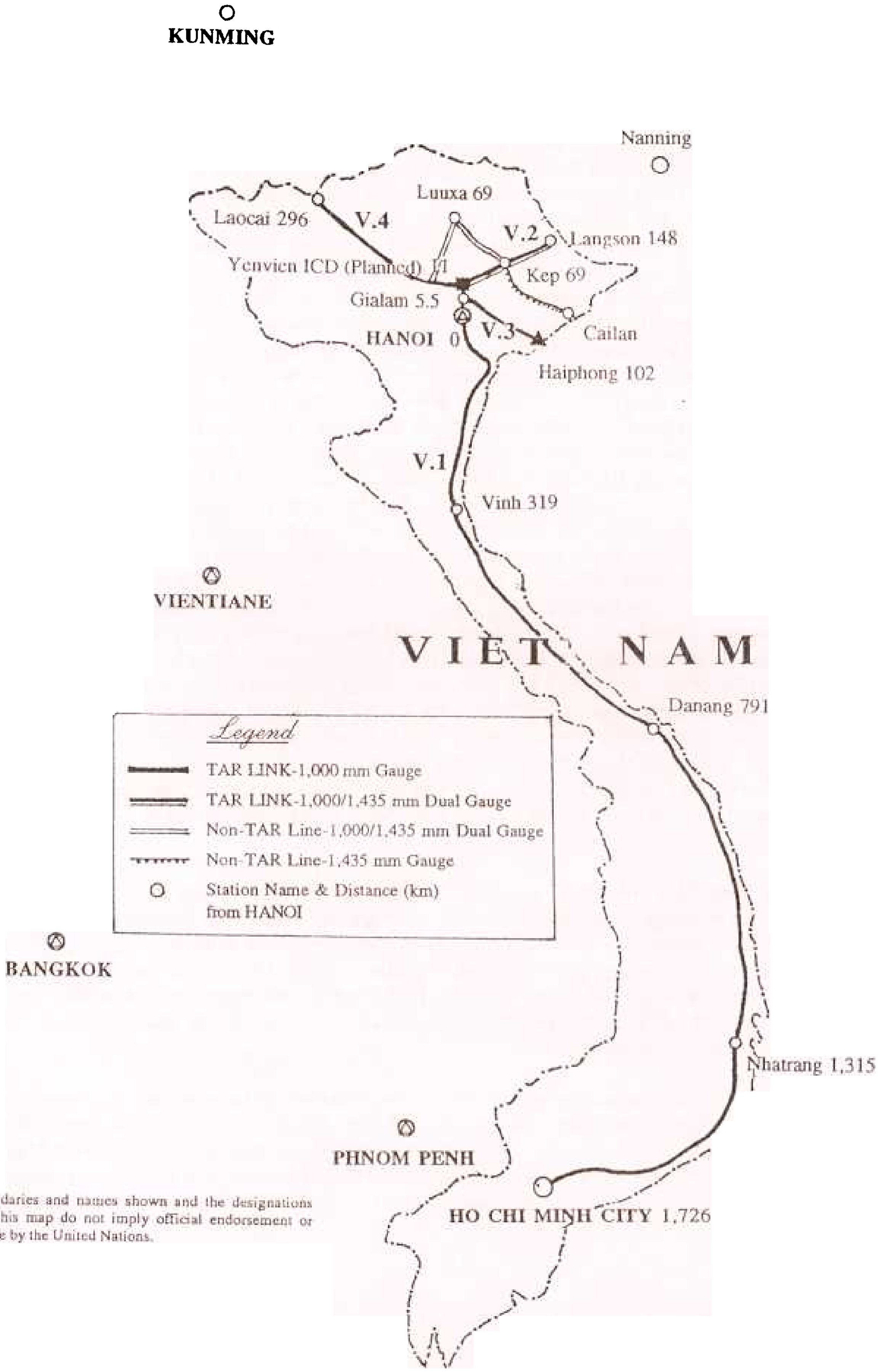
[1] Contracts were recently signed for a start early in 1996 of reconstruction of 865 km out of a total route length for Highway One of 2,300 km.

Figure 4: Trans-Asian Railway in Viet Nam (TAR Links V.1 - V.3)



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a Vietnamese port (for a discussion of the relevant issues, see Section 3), the Lao Cai-Yen Vien line provides the shortest rail connection with Yunnan Province, which is potentially the source of the largest trade volume likely to move between China and Viet Nam.[2] Accordingly, this line has been designated TAR Link V.4 in this study.

2.2.4 The TAR Network in Yunnan Province of China

The TAR links proposed for the Yunnan Province of China are shown in ***Figure 5***.

Three such links are proposed. Only one of these, TAR Link Y.3, the 468 km Kunming-Hekou metre gauge line (part of the Kunming-Haiphong rail connection to which reference is made above) is currently in operation.

TAR Link Y.1 is a new standard (1,435 mm) gauge line proposed for construction by the Yunnan Railway General Corporation. It was originally proposed as a connection between Yunnan Province and Chiang Mai (Thailand) via Jinghong and Kengtung (Myanmar), but would also have the possibility of connecting with the Thai railway system, via the Lao People's Democratic Republic. This line would branch off the Kunming-Dali line (now under construction) at Xiangyun, 70 km east of Dali, running south between two mountain ranges to Shanyong on the border with the Lao People's Democratic Republic (approximately 980 km, by rail, southwest of Kunming), via the major cities of Simao and Jinhong. From Shanyong, the line could either proceed: in a south-westerly direction to Houayxay (Lao People's Democratic Republic), thence to Chiang Rai, Thailand (via a new Mekong River crossing) and to Denchai on the existing Bangkok-Chiang Mai railway line; or continue on a southerly heading through Luangprabang (Lao People's Democratic Republic) to Vientiane and across the Mittaphab Bridge to join the Thai railway system at Nong Khai. If the first route were selected, the total distance from Kunming to Denchai would be about 1,500 km and from Kunming to Bangkok approximately 2,030 km.[3] The total cost of the project on Chinese territory (inclusive of the costs of line construction, provision of electric power distribution facilities and locomotive acquisition) is estimated by the Yunnan Railway General at RMB 11.8 billion (US$ 1.5 billion). The project was assessed as having a high priority in the 1994 ADB Subregional Transport Sector Study, and given its strong potential to satisfy demand for the transportation of bulk commodities (timber, minerals, etc) from the resource rich Yunnan Province to the port system in Thailand, it is likely to be justified in financial and economic terms. The project now awaits a funding commitment, although construction of the Kunming to Dali line (to which it would be connected) is underway, with anticipated completion at the end of 1996.

TAR Link Y.2 would be a westward extension of the Kunming-Dali line through Baoshan (West Yunnan) to Myitkyina in Myanmar. This link would provide a 2,000 km capital-to-capital connection between Kunming and Yangon, as well as a connection of the landlocked Yunnan Province to the port system in Myanmar. Distances within China are: Kunming-Dali, 330 km and Dali-Myanmar border, near Tengchong, 380 km. Myitkyina is

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[2] Arguably, Yunnan Province has a far greater potential for bilateral or transit trade with Viet Nam than Guangxi Province, which has a rail connection with Viet Nam via TAR Link V.2, nominated by the Viet Nam Railways.

[3] Discussions with the authorities of the Lao People's Democratic Republic have suggested that Government approval of a railway route via Houayxay would be unlikely, since this route would compete with a road to be built by Thai developers under a 30 year concession already granted by the Government of the Lao People's Democratic Republic.

approximately 100 km from the border. In China, the line would be constructed to a track gauge of 1,435 mm, but in Myanma the track gauge would be 1,000 mm, necessitating inter-gauge transfer facilities at the border. Link Y.2 is accorded a lower order of priority by the Yunnan Provincial Government than Link Y.1, largely as a result (it is believed) of the desire of the government to unlock the abundant natural resources of South Yunnan.

TAR Link Y.3, to which reference has already been made, covers a distance of 468 km from Kunming to Hekou at the border with Viet Nam, opposite Son Yen (near Lao Cai). The line has 43 stations and handles 23 pairs of trains (7 passenger and 16 freight) per day, but owing to a ruling gradient of 2.69 per cent and a predominance of tight curves (minimum radius, 80 metres), it is subject to low running speeds and is capacity deficient. Officials of the Yunnan Railway General Corporation indicated during the mission of the ESCAP study team that a major reconstruction of this line was necessary in order to eliminate its current severe operating constraints, and if such is the case the arguments for reconstruction to standard gauge specifications must be compelling, given this is the only line in the Chinese Railway network without a 1,435 mm track gauge. Conversion of the line to standard gauge would, of course, introduce a break-of-gauge point at the border with Viet Nam, and *might* jeopardize its future use as an international railway link.

2.2.5 The Future TAR Network in the Lao People's Democratic Republic

The establishment of a national railway system in the Lao People's Democratic Republic is now under assessment jointly by the Government of the Lao People's Democratic Republic and a Thai based private development company, the Pacific Transportation Co., Ltd., which has recently completed a feasibility study of the first phase in the establishment of such a network - the construction of a 30 km line from Nong Khai (Thailand) to Vientiane.

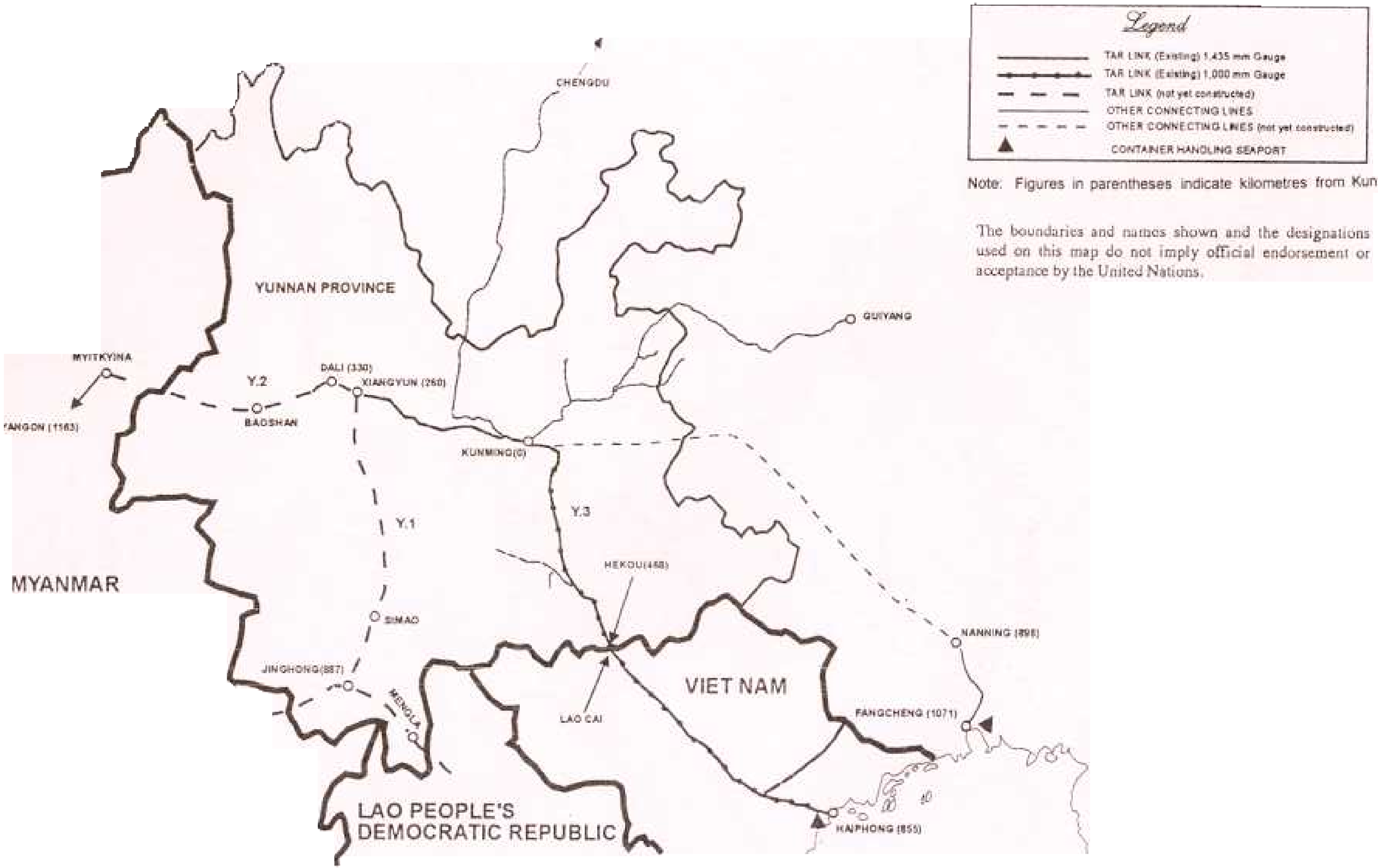
Given the tentative status of these developments - no decision to proceed has yet been announced by the Government of the Lao People's Democratic Republic - it is not yet possible to identify with certainty the alignment of future TAR links on Lao territory. However, it appears possible that the standard gauge Link Y.1 will be extended across the Chinese border to Boten, thence via Luangprabang (the ancient Laotian capital) to Vientiane, on a northwesterly to southeasterly axis. At Vientiane, this line would connect with the new line from Nong Khai which would provide the Lao People's Democratic Republic and Yunnan Province of China with rail access to the Thai port system. Distances would be: from Boten to Vientiane, 440 km and from Vientiane to Nong Khai, 30 km. From Vientiane, the future movement of containers by rail to the Port of Laem Chabang would involve a journey of 742 km (via the soon-to-be commissioned Bangkok by-pass link line from Kaeng Khoi Junction to Klong Sip Kao). The likely alignment of the TAR Links in the Lao People's Democratic Republic is illustrated in ***Figure 6.***

2.2.6 The TAR Network in Myanmar

Three TAR links have been proposed by the Myanma Railways and these are depicted in ***Figure 7***.

The first, designated Link B.1, involves an extension of the existing main north-south line from Yangon to Myitkyina (a distance of 1,163 km), to the border with China at Kachang or Houqiao, from where it would continue, as Link Y.2, to Dali. (See details under Link Y.2, above).

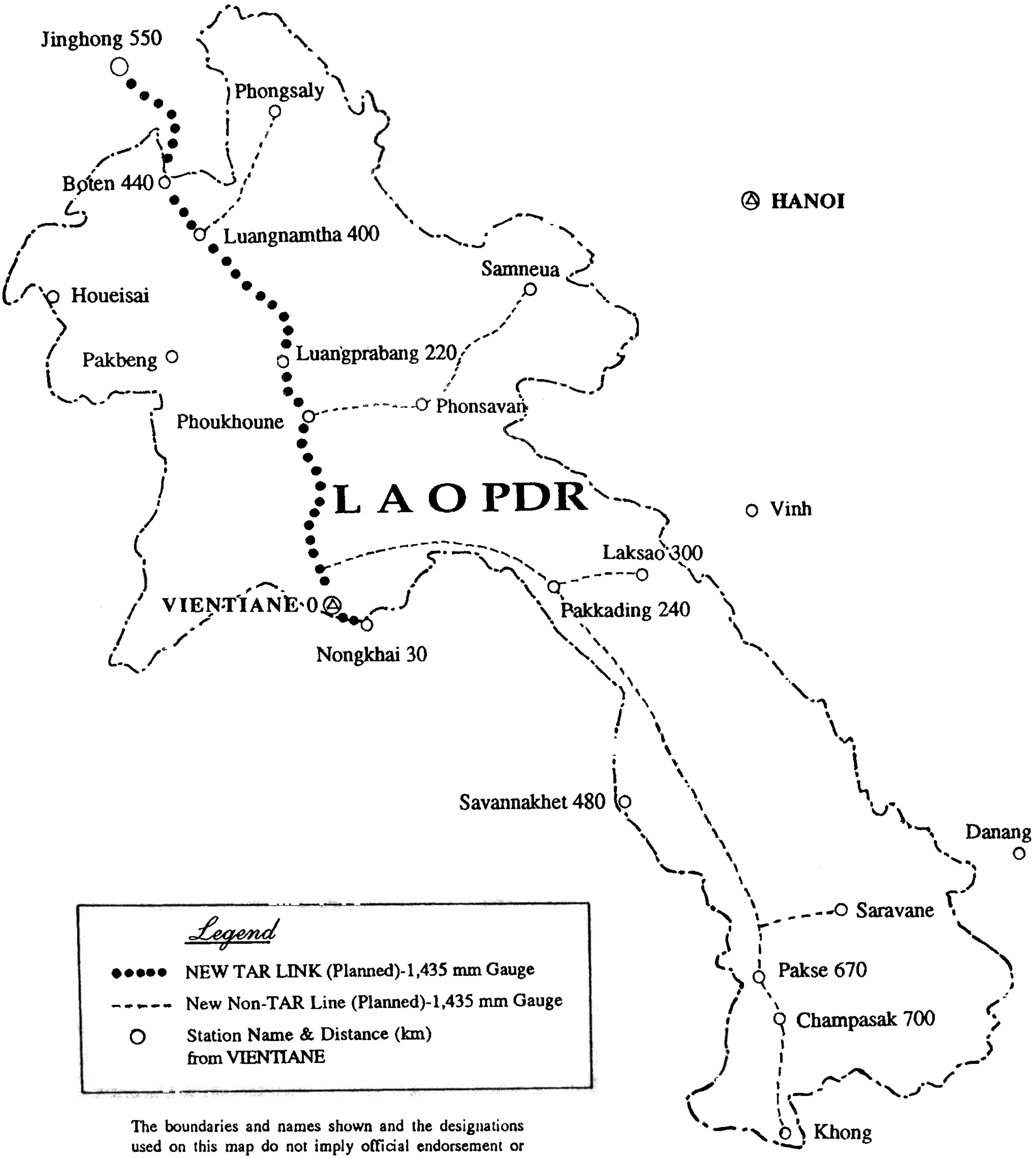
Figure 5: Trans-Asian Railway in Southern China



Note: Figures in parentheses indicate kilometres from Kunming

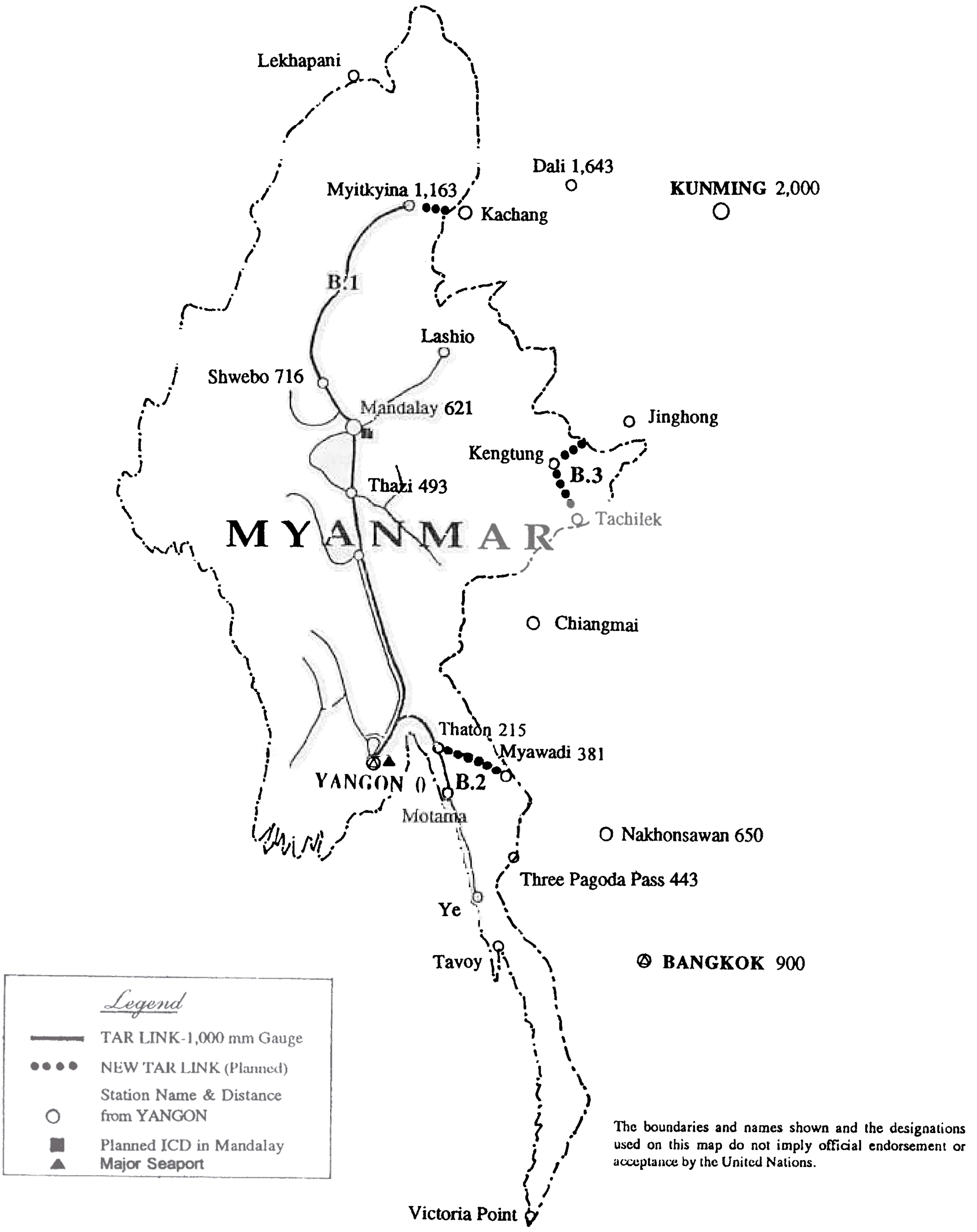
The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 6: Trans-Asian Railway in Lao PDR



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 7: Trans-Asian Railway in Myanmar (TAR Link B.1 - B.3)



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Myanmar has given high priority to this Yangon-Dali link, the existing portion of which serves many key cities including Mandalay, the second most important city of Myanmar. It should be noted also that 1994 ADB Subregional Transport Sector Study, evaluates the construction of a railway line linking Yunnan Province and Myanmar, of which the Dali-Myitkyina section is among the four alternative routings. The cost of construction was estimated at US$ 700-1,200 million, depending on the option. The total distance by rail from Kunming to the Port of Yangon is about 2,000 km.

The second TAR link nominated by Myanmar, designated B.2, is the Yangon - Thaton - Myaingalay - Myawadi line which will link with T.4 in Thailand. This line can be regarded as a capital-to-capital link between Yangon and Bangkok with a rail distance of approximately 900 km. At present there exist tracks at both ends of the line, ie. the 215 km Yangon-Thaton section and the 246 km Bangkok-Nakhonsawan section. The missing link is the 450 km middle section from Thaton to Nakhonsawan via Myawadi, Mae Sod and Tak, 166 km of which is in Myanmar.

A pre-feasibility study of the Bangkok-Mae Sod section of this route was undertaken by the Japanese Overseas Technical Cooperation Agency in 1972. The alignment near Tak would cut through high mountain ranges, and require two long tunnels of 14.6 km and 11.8 km in length to be constructed in addition a major bridge across the Moei River at the border and across the Thanlwin River in Myanmar. The 1994 ADB Subregional Transport Sector Study evaluated a rail link between Motana and Myawadi, but this link would entail a 7 km bridge crossing of the Thanlwin River near its mouth adding substantially to the capital cost of the project. After consultation with personnel of the Myanma Railways, it was decided to alter the alignment of link B.2 to proceed from Thaton via Myaingalay to Myawadi and to limit the necessary scale of bridge construction by crossing the Thanlwin River upstream from its mouth.

It might also be desirable to consider the relative advantages, disadvantages and costs of an alternative route for Link B.2, which would utilize part of the former Thailand-Burma Railway. This line linked Kanchanaburi (Thailand) with Thanbyuzayat (Burma), via the border checkpoint at Three Pagoda Pass. Most of this line was abandoned shortly after World War II, and now only a short section of 77 km from Kanchanaburi to Nam Tok is open to traffic. This alternative would not suffer the disadvantages of terrain which are likely to inflate the construction costs of the link, but certain other problems exist. The first is that part of the old railway right-of-way in Thailand is under water, following the construction of the Khao Laem Dam in the late 1970s and a new alignment would be required along either the Kwai Noi River or Highway No. 323, both of which options would entail track construction with steep gradients and sharp curves. (While rural road gradients can be as high as 12 per cent, railway gradients are generally restricted to significantly less than 3 per cent). The new alignment could also interfere with sensitive conservation areas such as the Sai Yok Wildlife Sanctuary, through which it would have to pass. Additionally, the SRT does not have the ownership of the land along the old right-of-way beyond Nam Tok Station. A final difficulty is that adoption of the alternative route would most probably require a crossing of the Salween River, near its mouth, at Moulmein. A two-mile long bridge would be needed at this site and could add US$ 40 million to the total cost of the project. On the other hand, the advantage of this alternative route is that it would connect with Tavoy, an area rich in natural gas and mineral resources and with strong potential for the development of beach resorts. Tavoy was recently connected to the Myanmar railway system, following completion of a line between the former railhead at Ye, and Tavoy. Other associated options could be an establishment of a railhead in connection with the development of a container port at

Moulmein, and the northwest extension of the alternative route to permit a crossing of the Salween River at a narrower point.

The third TAR link proposed by Myanmar, designated Link B.3, is a line of 195 km in length, from Jinghong to Chiang Rai via Kengtung. This link would not be connected to the existing Myanmar railway network, but instead would allow the connection of the Chinese and Thai railway systems through the territory of Myanmar. It is understood that development of this link is being supported by the Government of Myanmar on the basis that it would stimulate local economic development. The primary purpose of the line would be to provide a rail connection between the landlocked Yunnan Province of China and the ports of Bangkok and/or Laem Chabang. However, the line could have other advantages for Myanmar in the sense that it would provide a railway connection for eastern Shan State, having Kengtung as its commercial and administrative centre, to China and Thailand.

The 1994 ADB Subregional Transport Sector Study has attached priority to the construction of this link which would represent an extension of TAR Link Y.1 (see above), to connect with the Thai railway system at Chiang Mai, via Kengtung, Tachiliek, Mae Sai and Chiang Rai. Two other options were also considered with alignments passing through the Lao People's Democratic Republic via Luang Namtha and Chiang Mai or Luang Prabang, Vientiane and Nong Khai. The three alignment options are equally difficult to construct as they must traverse difficult terrain consisting of rugged mountains and deep valleys. The estimated cost was reported to vary by option and construction standard, but would be in the range of US$ 1.2-1.8 billion.

3. MARKET ENVIRONMENT OF THE TAR IN THE INDO-CHINA SUBREGION

3.1 Unlike the ASEAN countries where an interconnected, fully operational Trans-Asian Railway network is already in existence, in Myanmar, the countries of Indo-China and in Southern China the situations range from a complete absence of a railway network (as in the case of the Lao People's Democratic Republic) to the presence of an extensive, fully operational but as yet incompletely connected railway network (as is the case of Viet Nam).

3.2 It is difficult, therefore, to forecast the demand for international railway services on a network which is, in all probability, many years removed from realization, particularly when the governments of the countries concerned are themselves uncertain as to the timing and priority to be given to the construction of missing railway connections with neighbouring countries. Nevertheless, in some cases, detailed project proposals have been prepared for the construction of missing links and some of these proposals have in fact been based on assessments of future demand for international rail freight services.

3.3 This section provides an assessment of the market conditions and factors applying in each of the five participating countries to the rail movement of containers.

3.4 Cambodia

3.4.1 Container Trade Growth

The Port of Sihanoukville is Cambodia's main gateway for container traffic, with residual volumes of containers entering and leaving the country through the secondary port of Phnom Penh (located on the Sap River).

Containers do not currently enter or leave Cambodia through any land border checkpoints, but some of the traffic passing through the Poipet checkpoint, from Thailand, may have the potential to be containerized in future.

Details of actual container throughput during the period 1991 - 1994 were provided by the Sihanoukville and Phnom Penh Port authorities and container throughput forecasts were obtained from the Cambodia Transport Rehabilitation Study (CTRS).[1] (See *Table 1.*)

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[1] *SweRoad: Cambodia Transport Rehabilitation Study,* March 1995, Appendix 13.3, page 5(5).

Table 1: Container Throughput of Sihanoukville and Phnom Penh Ports (Number of Containers*)

Year	Sihanoukville Port	Phnom Penh Port
1991 Actual	Not Available	166
1992 "	6,636	462
1993 "	18,692	267
1994 "	17,990	
1995 Forecast	20,000	
1996 "	24,000	
1997 "	27,000	
1998 "	31,000	
1999 "	35,000	
2000 "	40,000	

* Although throughput is expressed in terms of the actual number of containers handled through the ports, the number of 40 ft containers handled is understood to be negligible, so that for practical purposes, the volumes shown can be regarded as TEU.

The container throughput of Sihanoukville Port grew dramatically during 1992 and 1993 to satisfy the needs of the United Nations Transitional Authority in Cambodia (UNTAC), but since the withdrawal of UNTAC, the volume of containers handled through the port has barely declined, and according to Ministry of Public Works and Transport officials consulted during the mission of the study team, is expected to register a strong increase in 1995.

The CTRS report in fact contained two alternative forecasts of container throughput volume for the Port of Sihanoukville - an "optimistic" forecast reflecting equal rates of growth for imports and exports, and a "pessimistic" forecast reflecting a slower growth of imports due to the imposition of restraints on the importation of consumption goods. The above forecast figures reflect the pessimistic growth scenario, but even under this scenario container throughput is still expected to increase at a rate averaging about 14 per cent per year between 1994 and 2000. The CTRS "pessimistic" forecasts of container throughput volume for the Port of Sihanoukville in the years 2005 and 2010 are respectively 70,000 TEU and 95,000 TEU, reflecting growth at more restrained rates (just under 12 per cent per year between 2000 and 2005, and just over 6 per cent per year between 2005 and 2010).

Growth in the container throughput volume of Phnom Penh port is expected to be relatively modest, although this port is currently undergoing a major rehabilitation, including the construction of a container yard and warehouses for the stripping and stuffing of containers. The Phnom Penh Port is, in any event, not expected to generate container traffic for the Trans-Asian Railway.

3.4.2 Potential Container Volume for the TAR

The potential role of the Cambodian Railway in the transportation of containers lies mainly in the feeder movement of containers on TAR Link C.2, between the Port of Sihanoukville and an Inland Container Depot planned for construction on the southwestern outskirts of Phnom Penh (see Section 6 for details).

No opportunities for the landbridging of transit containers by rail between Cambodia and Thailand, or between Cambodia and Malaysia, are foreseen, at least within the next 15 years. Such opportunities would depend vitally on the restoration of missing sections of track on the Northwestern line (TAR Link C.1), the upgrading of railway infrastructure and of the rollingstock fleet, and (not least) on the willingness by the Cambodian Government to utilize foreign ports, in preference to Sihanoukville, for at least part of the country's international container trade. It is the latter requirement which poses the most intractable problem, since (particularly from the perspective of sovereignty) it is natural for a nation to place priority on the development of sea access for its foreign trade, albeit that its trade volumes may be too small to justify either regular shipping services or major investments in port container handling facilities. It is nevertheless recommended that the possibility of utilizing rail for the movement of transit containers (particularly those originating from or destined for Europe) to and from transhipment ports in Thailand or Malaysia should be seriously investigated, since it may be argued that rail can more efficiently transport container volumes too small to be of interest to the operators of larger feeder vessels.

No assessment has yet been made of the volume of containers which might be available to be transported by rail once the planned ICD is operational, but it is unlikely that the rail share of the forecast feeder task (or effectively of the total throughput of the Port of Sihanoukville) will be less than 50 per cent. It is estimated that in 1994, the volume of containers transported by rail between Sihanoukville and Phnom Penh was 450 TEU, or only 2.5 per cent of the port's total throughput - a volume which was handled with minimal resources and on an alternate day train schedule. A 50 per cent share of the total container feeder task in 1998 (considered to be the earliest time by which the planned ICD could be operational) would amount to 15,500 TEU and with trains composed of 30 wagons each of 2 TEU carrying capacity would require 129 pairs of trains per year, or a return train movement every three days. Maintenance of this share would result in a requirement to operate 292 pairs of trains per year by 2005 and 396 pairs of trains per year (or more than a single pair of trains per day) by 2010. Clearly, the operation of railway services at these levels would require a vastly increased commitment of resources as compared with the current service, but is nevertheless achievable on the basis that the government could guarantee an adequate share of the traffic for the railway.

It is not conceivable that there will be a need for a major movement beyond Phnom Penh of containers originating in or destined for Sihanoukville. However, it is likely that traffic which currently moves in breakbulk form from Thailand to Cambodia can in future move in containers.

An example of such traffic is the movement of cement. Data supplied by the Cambodian Customs Department shows that, in 1994, the total volume of cement imported, in bags, from Thailand through the Poipet checkpoint amounted to 39,500 tonnes. Were this traffic to be moved in containers, it would currently provide a volume of about 5,000 TEU (2,500 TEU loaded and 2,500 TEU empty or re-loaded with other commodities) per year. Customs regulations do not now permit Thai vehicles to operate inside Cambodia, so that this traffic must be transhipped to Cambodian trucks for movement to the railhead at

Srisophon, where it is loaded into railway wagons for movement to Phnom Penh. Breakages of bags and damage to contents is reported to be high, and through movement of the product in containers in future from the point of origin in Thailand to the destination in Phnom Penh could be expected to be attractive to the shipper. Among the other major commodities imported from Thailand overland - steel, sugar, chemicals and soft drinks - there is the possibility of another 1,000 TEU of traffic being generated, provided the through rail connection could be restored, giving a potential total volume of 6,000 TEU per year. If the same growth were assumed for this traffic as was assumed in the CTRS for all container traffic through Sihanoukville Port, then the total container traffic which might be expected to cross the border by rail in the event of a restoration of through service would reach: 13,200 TEU by 2,000; 23,200 TEU by 2005; and 31,100 TEU by 2010. If this traffic were to be handled in block container trains, each conveying 60 TEU, then the number of train pairs required to run would be: 110 per year in 2000; 193 per year in 2005; and 259 per year in 2010.

No other major sources of container traffic for the Trans-Asian Railway were identified. Trade between Cambodia and Viet Nam is dominated by the shipment (from Viet Nam) of petroleum products, totalling about 350,000 tonnes per year, in small river vessels. Consumer goods shipped from Southern China, via Viet Nam, are also moved on the river system, but the volume is believed to be relatively small. Trade with the Lao People's Democratic Republic is negligible and is not suitable for containerization.

3.4.3 Requirements for Competitive Service on the TAR

The restoration of 48 km of track between Srisophon and Poipet which was removed at the time of the Khmer Rouge regime, as well as the restoration of another 10 km of track between the Thai/Cambodian border and Poipet, would be the major prerequisite for a through rail service between Thailand and Cambodia, along TAR Link C.1. This issue will be addressed in subsequent sections of this report, but it may be observed here that this project is not being given high priority in the transport rehabilitation plans being drawn up by the Cambodian Government, and is likely to require funding support from the Thai Government.

The rehabilitation of TAR Link C.2, from Phnom Penh to Sihanoukville, is also a prerequisite to the introduction of rail container service between the Port of Sihanoukville and Phnom Penh. Track rehabilitation work is currently underway at several sites along this line, with funding support from the ADB. Similarly, the construction of a rail served Inland Container Depot (ICD), while not being essential for the introduction of dedicated container services by rail, would at least be required if such services were to be efficiently organized (with terminal facilities, rollingstock and motive power suitable for block train operation). In this context it is understood that the Cambodian Government recently entered into an agreement with a Singaporean company for the development of an ICD near the intersection of TAR Link C.2 with Highway Number 4, about 9 km to the southwest of Phnom Penh. As an interim measure, assistance being provided by the ADB for the rehabilitation of the Cambodian Railway includes an amount of US$ 200,000 for the restoration of a container storage area near Phnom Penh Station.

Rollingstock supply currently poses a major impediment to the introduction of dedicated railway container services. The railway currently has only 15 flat cars in service (with another 33 which are capable of being repaired), but has an immediate requirement for a serviceable fleet of 60.

The competition from road transport operators for container haulage between the Port of Sihanoukville and Phnom Penh is likely to be intense, in the absence of any commitment by the Cambodian Government to regulate ICD traffic to rail or to increase the rate of road cost recovery through taxes (and it appears that such policies are inconsistent with the philosophical position of the current government). Completion of the upgrading of National Highway 4 in 1996 will result in a journey time for trucks between Sihanoukville and Phnom Penh of 3 hours, as compared with a current rail journey time of 12 hours and a future rail journey time (after track rehabilitation) of 6 hours. There is already active tariff competition between road transport operators and rail for container business. A typical road rate for the movement of a 20 ft container from Sihanoukville to Phnom Penh was quoted as US$ 300, as compared with the rail rate US$ 240. (A terminal handling charge of US$ 70 per 20 ft container has to be added to both of these rates, so that neither mode enjoys an advantage in terms of handling charges in terminals).

A forwarder organization (SCAC/SDV) is currently involved in arranging for the inland transportation of containers by road or rail.

3.5 Viet Nam

The majority of Viet Nam's international container trade is handled through the major ports of Ho Chi Minh City and Haiphong, with small container volumes being handled through minor ports, such as Danang. The Viet Nam Railways has a possibility of capturing some share of this trade, but in the case of the trade through Ho Chi Minh City is handicapped by the lack of direct rail access to the port.

3.5.1 Container Trade Growth

The growth in the container throughputs of both the Ho Chi Minh City and Haiphong Ports has been spectacular.

In the case of Ho Chi Minh City, throughput grew from 10,000 TEU in 1989 to 295,253 TEU in 1994, reflecting an average annual rate of growth of 96.8 per cent. If growth were projected at more restrained rates, for example at 11 per cent per year for the period 1995-2000 and 8 per cent per year thereafter (in line with the assumptions used for the ports of Indonesia, Malaysia, Singapore and Thailand), container throughput would reach 0.55 million TEU per year by 2000 and would exceed 1 million TEU per year by 2010.

In the case of Haiphong, a throughput of 55,000 TEU in 1993 was followed by 90,000 TEU in 1994 (reflecting growth of 64 per cent in a single year). Haiphong Port officials expect that the container throughput of their port will reach 120,000-150,000 TEU in 1995. (Certainly, a continuation of the growth experienced between 1993 and 1994 would result in the achievement of the higher figure in the range in 1995). Projection of throughput at the more modest rates of 11 per cent per year between now and 2000 and 8 per cent per year thereafter would result in the following volumes: by the year 2000 - 168,300 TEU; by the year 2005 - 247,300 TEU; and by the year 2010 - 363,400 TEU. Forecasts recently prepared independently by TESI (the Technical, Economic and Scientific Institute of Viet Nam) and by JICA (the Japanese International Cooperation Agency) have been considerably more optimistic. They have been based on the maintenance of growth *averaging* 14-15 per cent per year over the forecast period, which if realized would result in the annual container throughput of the northern ports (ie. the Port of Haiphong and the proposed port of Cai Lan) reaching as much as 800,000 - 900,000 TEU by 2010.

3.5.2 Potential Container Volume for the TAR

The potential for the railway to capture container traffic is limited to the traffic sourced in, or destined for, Haiphong Port, which has already has a direct rail connection to its container handling berths.[2]

The Port of Ho Chi Minh City has not had a railway connection for the past 15 years. A 2-3 km spur connecting the city with the port area was removed as a road traffic relief measure, after pressure from the local community. The absence of this rail connection makes it difficult for the Viet Nam Railways to participate in the long haul distribution of containers to and from major industrial centres to the north of Ho Chi Minh City, such as Danang, and has practically deprived the railway of the opportunity of capturing any container traffic in the south.

In the north, however, the railway has a strong possibility to capture a major share of the rapidly growing traffic in international containers through the Port of Haiphong.

Until very recently, almost all of the containers moved in both directions between Haiphong and Hanoi have been transported by road. This was changed with the issue of a decree (36/CP, dated 29 May 1995) which restricted the dimensions of trucks and their loads to a width of 2.5 metres and a height of 3.5 metres, followed by amendments which first (on 15 August 1995) placed a total prohibition on the carriage of containers by road and then (on 30 September 1995) allowed road operators to again carry containers on National Route 5, provided that the height of their vehicles, with container loading, does not exceed 4.2 metres. As far as is known, no containers have been or are being conveyed between Haiphong by river transport. In addition, the prospects of substantial volumes of containers being carried by this mode in future are somewhat limited, given the problems posed for container loading/unloading by a large variation in the level of the Red River in Hanoi, as well as the inability of river transport to provide transit times which are competitive with those of road and rail.

In view of the continuing (albeit relaxed) restrictions on the conveyance of containers by road between Haiphong and Hanoi, the railway now has an opportunity to capture a dominant share of this traffic, as well as of the container traffic moving between Haiphong and mining/industrial centres to the north and northwest of Hanoi.

Data provided by the Port of Haiphong suggest that the proportion of the port's container throughput originating in, or destined for, Hanoi and environs is about 70 per cent. Of the remainder (30 per cent), some portion would stay within the Haiphong area, or move to/from coastal centres to the north of Haiphong, but at least some portion should originate in, or be destined for, the hinterland to the north and northwest of Hanoi. It was not possible to determine the approximate volume of the latter, so that it was assumed that only the Haiphong-Hanoi portion (ie. 70 per cent of the container throughput volume of the port) would represent potential traffic for the railway.

The major obstacle facing the railway in establishing a presence in intermodal transport is that it currently lacks the specialized resources needed for efficient operation of a container service, such as a terminal in Hanoi and dedicated container wagons

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[2] Indeed, Haiphong Port is unique in that it has a rail spur line running just behind the berth face and directly under the ship to shore cranes used for working container vessels.

(although it is reported to be in the process of retrofitting some part of its fleet of 338 general purpose flat wagons with container anchors).

The Viet Nam Railways has the potential to develop an Inland Container Depot at its Yen Vien Station, located 10.9 km north of Hanoi (for details see Section 6). Such a development would allow the railway to capture a major share, perhaps greater than 50 per cent, of the container volume shipped through Haiphong Port for Hanoi and environs, or in future through the proposed deep sea port at Cai Lan. A 50 per cent market share could result in the following container volumes being transported by rail at least between Haiphong/Cai Lan and Yen Vien, assuming port throughput growth at the more restrained rates shown above (ie. 11 per cent per year between now and 2000 and 8 per cent per year thereafter):

Year	**Container Volume (TEU)**
2000	59,000
2005	86,000
2010	127,000

These volumes would translate into the following train numbers, assuming the current trainload limitation of 700 gross trailing tonnes[3] on the Gia Lam-Haiphong line:

Year	**Train Pairs Per Year**	**Train Pairs Per Day**
2000	819	3
2005	1,194	4
2010	1,764	6

Whether or not the railway will be able to capture additional container volume to that identified above will depend largely on the possibility that Haiphong will in future be utilized as the transhipment port for container traffic sourced in, or destined for, the landlocked Yunnan Province of southern China. This is by no means certain, for the following reasons:

(a) A new 898 km double track electrified trunk line is currently under construction between Kunming (Yunnan Province of China) and Nanning (Guangxi Province of China). Completion of this line (anticipated for mid 1997) will provide a direct (1,071 km) rail connection between Kunming and the Port of Fangcheng in Guangxi Province, via the existing branchline linking Nanning with Fangcheng. It is understood that the container handling facilities at Fangcheng are presently being re-developed in the anticipation of handling traffic to/from Yunnan Province in future; and

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[3] From this figure, assuming a gross weight for container flat wagons of 38 tonnes and a brakevan weight of 24 tonnes, the number of flat wagons (each conveying 2 TEU) may be calculated as 18, giving a total container load per train of 36 TEU. Clearly, given the large container volume involved, the trailing load limit should be increased by, for example, purchasing modern diesel locomotives of higher horsepower, so that the number of daily train movements can be reduced.

(b) Although the rail distance between Kunming and the Port of Haiphong is some 200 km shorter than the rail distance between Kunming and Fangcheng Port, the metre gauge line linking Kunming with Haiphong suffers from a relatively poor alignment (many tight curves of as little as 80 metre radius) and a concentration of steep gradients (the steepest being 2.7 per cent). The schedule speed for freight trains on the metre gauge line is reported as 25 km per hour, while it is likely that a schedule speed of at least 40 km per hour will apply to the Kunming - Nanning line, providing the latter with almost an 8 hour transit time advantage, despite its greater distance.[4]

On balance, given the additional possibility that China might have an incentive in future for re-developing the metre gauge line on its territory as a standard gauge (1,435 mm) line, it appears highly unlikely that international container traffic between Yunnan Province and the Port of Haiphong (or in future the new port at Cai Lan) will materialize - at least during the 15-20 year forecast timeframe of this study.[5]

For TAR Link V.2 (Gia Lam-Dong Dang), as proposed by the Viet Nam Railways, no potential international traffic could be identified either by the study team or Viet Nam Railways personnel. Indeed, it appears that for Viet Nam the main trade orientation is with the Province of Yunnan, rather than the Province of Guanxi with which the proposed TAR link V.2 connects.

3.5.3 Requirements for Competitive Service on the TAR

In order for the railway to achieve its traffic potential on the designated TAR links, it will first be essential to provide it with the resources to compete effectively with road transport operators for container volume.

Investment will be required not only in container terminals and rail accesses (both in the ports and in the hinterland), but also in route infrastructure, motive power and specialized rollingstock. These issues are addressed later in this report.

It must be noted that, prior to August 1995, the Viet Nam Railways had no prior experience of transporting containers and, apart from lacking, as a consequence, the physical infrastructure and equipment to be able to handle container traffic, is also without the commercial experience and approach necessary to attract this business. Accordingly, the entry of the railway into container transportation will, amongst other things, require the adoption of a marketing strategy, as well as a specific form of contract and tariff structure, for the carriage of containers.

It is understood that the railway commenced carrying containers during August 1995, following the imposition of a temporary prohibition on the carriage of containers by road between Haiphong and Hanoi. The railway appears to have recently established a tariff as

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[4] Details of operating conditions and speeds on the metre gauge line between Kunming and Haiphong were provided by the Yunnan Railway General Corporation during the mission undertaken for this study in June, 1995.

[5] This conclusion might be reinforced by the recently reported acceptance by the Government of Viet Nam of a policy to adopt the metre gauge as the standard for Viet Nam and to remove all remaining dual and standard gauge track (Meeting of study team with Dr Tran Doan Tho, Deputy Director General, Ministry of Transport, Hanoi, Viet Nam, 28 March 1995).

an interim measure to attract this container business, and this tariff is understood to be 900,000 Vietnamese Dong, or US$ 81.82, for a roundtrip of a 20 ft container (full one way, empty the other), for a unit rate equivalent to US$ 0.40 per TEU km. While this rate is lower than the published road *linehaul* tariff, with the addition of loading/unloading charges at Haiphong and in Hanoi as well as of cargo delivery charges in Hanoi, the all-up rail tariff is slightly higher than the published all-up road tariff (see *Table 2*).

The official rail linehaul tariff is expensive by the standard of charges made for rail conveyance of containers in Thailand and Malaysia.[6] It appears to have been based on the traditional commodity based freight tariff structure of the Viet Nam Railways, although on a unit rate basis it is at a significantly higher level than the most expensive commodity category. Clearly there is a need for the railway to develop and apply to container traffic a commercial tariff structure incorporating volume (and possibly time of day) incentives, as well as penalties/incentives to ensure that operational performance conforms with agreed standards.

Table 2: Comparative Rail and Road Tariffs for a Round Trip of a Twenty Foot Container, Haiphong-Hanoi

Tariff Component	Official Rail Tariff (Vietnamese Dong/TEU)	Published Road Tariff (Vietnamese Dong/TEU)
Loading/Unloading at Haiphong Port	418,000	253,000
Linehaul Charge	900,000	1,500,000
Loading/Unloading in Hanoi	320,000	253,000
Local Container/Cargo Delivery Charge	500,000	N.A.
TOTAL CHARGE	2,138,000 (US$ 194.36)	2,006,000 (US$ 182.36)

Source: Government of Viet Nam: ***National Multimodal Transport Corridor Study, Haiphong-Hanoi***, October 1995
Note: Road Loading/Unloading charge in Hanoi estimated. Rail and Road charges assume empty movement in one direction. Recent information from forwarders suggest that actual charges exceed those shown in the table.

3.6 China

3.6.1 Potential Container Volume for the TAR

Discussions with the Kunming Divisional Director of the Chinese Customs service revealed that the total foreign trade (imports and exports) of Yunnan Province amounts to 700,000 tonnes per annum, *of which 300,000 tonnes (43 per cent) is trade with Myanmar.* None of the trade with Myanmar moves in containers, and it is not known what proportion of it is containerizable.

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[6] For example, the rate proposed for the movement of a loaded 20 ft container from Laem Chabang Port to the new ICD at Lard Krabang is understood to be about Bht 7.1, or US$ 0.28, per TEU km for a trip distance of 118 km.

Details of the international container trade of Yunnan Province were also provided to the study team during their mission. It appears that a majority, if not all, of this container trade is sourced in, or destined for Kunming, and is currently shipped through Hong Kong (which is more than 2,400 kilometres by rail from Kunming). It was indicated to the study team that the volume of foreign trade originating or destined for Kunming in 1994 amounted to 230,000 tonnes, of which one third, or 76,700 tonnes is *containerized.* If the average contents weight of containers was about 12 tonnes, this would be equivalent to a container volume of approximately 6,400 TEU currently. Although this volume is currently small, the overall foreign trade volume of Yunnan Province is estimated to have grown at a rate averaging 20 per cent per annum between 1985 and 1994, and if such growth is typical also of container trade, then this volume would reach 19,000 TEU by the year 2000. Growth in subsequent years at a more restrained rate, say 8 per cent per year, could result in this volume reaching 28,000 TEU by 2005 and 41,000 TEU by 2010.

All of the container volume transported to and from Kunming currently moves by rail, and therefore it might be assumed that the above volumes would represent potential traffic for rail. However, it cannot be predicted with any confidence that these volumes would represent future traffic for the TAR, since it is not yet known which of the various alternative ports will be nominated as the future transhipment port for Yunnan trade.

Traffic forecasts were prepared In connection with the project proposed by the provincial government and railway authorities of Yunnan Province for the construction of a new railway line linking the province with Chiang Mai in Thailand, via Xiangyun, Simao, Mengla and the Lao People's Democratic Republic. These forecasts relate to the medium term (the next ten years and are shown in *Table 3.*

Table 3: Freight Traffic Forecasts, Xianyung - Chiang Mai

Direction	Total Volume (Tonnes p.a.)	Border Crossing Volume (Tonnes p.a.)
Down (Xianyung-Shanyong)	4.2 - 4.4 million	3.5 million
Up (Shanyung-Xianyung)	2.8 million	2.0 million
Both Directions	7.0 - 7.2 million	5.5 million

Source: Yunnan Railway General Corporation

No indication was given of the proportion of this traffic attributable to container movement, but it is understood that the traffic volumes on this line will be dominated by logs, other forestry products and minerals, all of which are transported in bulk form.

3.7 The Lao People's Democratic Republic

3.7.1 Potential Container Volume for the TAR

It is understood that forecasts of freight traffic volume have been prepared in connection with the feasibility study by the Pacific Transportation Company Ltd of a railway connection between Nong Khai (Thailand) and Vientiane (Lao People's Democratic

Republic). However, at the time of writing, no such forecasts were available to the study team.

Since the majority of the international trade for the Lao People's Democratic Republic, other than the trade with Thailand, is currently moved through Bangkok Port under special transit arrangements agreed with the Thai Government, it was possible to obtain details of the volume trend in this trade over the past five years. Between 1991 and 1994, the total trade volume grew from 21,998 tonnes to 49,781 tonnes, reflecting an average annual growth rate of 31.3 per cent.[7] Between January and August 1995, the volume of international trade to/from the Lao People's Democratic Republic handled through Bangkok Port was 42,908 tonnes, suggesting that the total for 1995 might reach 64,400 tonnes.

In 1994, the numbers of inbound (export) and outbound (import) containers handled at Bangkok Port for the Lao People's Democratic Republic were 554 TEU and 475 TEU respectively - for a total of 1,029 TEU. Based on an assumed average gross weight of 12 tonnes per TEU, containers would appear to account currently for only about one quarter of the total trade tonnage handled at Bangkok Port for the Lao People's Democratic Republic. It is not known what proportion of the remaining volume of this trade is containerizable.

It is understood that the majority of the containers for the Lao People's Democratic Republic are currently stripped and stuffed at Bangkok Port, and that the contents of these containers are transported by road to/from the Lao People's Democratic Republic. Thus, it is likely that in future this container trade could be transported by rail, particularly if it is decided to transfer the specialized transit facilities to Laem Chabang Port, from which there is now a direct rail connection to the Nong Khai line (TAR Link), via the new link line between Klong Sip Kao and Khaeng Khoi Junction. If trade growth were to be maintained at its present rate of increase for the next five years, the volume of container traffic potentially available to rail would reach 5,000 TEU per year by 2000. More restrained rates of increase between 2000 and 2005 (11 per cent) and between 2005 and 2010 (8 per cent) would result in potential container volumes for rail of 8,400 TEU by 2005 and 12,300 TEU by 2010. In the years prior to 2010, the potential volumes available to rail would be insufficient to be handled in block trains and thus would need to be transported on scheduled freight trains of mixed loading. By the year 2010, the potential container volume available to rail would require the operation of 103 pairs per year of container block trains, each conveying 60 TEU. (This would be equivalent to a pair of trains operating every third day).

The foregoing assessment of potential container volume for rail does **not** include the trade volume between Thailand and the Lao People's Democratic Republic, the bulk of which currently crosses the border between the two countries in trucks, across the Mittaphab Bridge (opened in April 1994). Data on the number of vehicle crossings, supplied by the authorities of the Lao People's Democratic Republic, suggest that the total volume of this trade is about 370,000 tonnes per year.[8] This figure appears to be light when compared with other data supplied by the Ministry of Communication, Transport, Post and

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[7] Source, Port Authority of Thailand.

[8] The daily number of vehicles averaged 422 (both directions) in April 1995. Approximately 40 per cent, or 170, of these vehicles were trucks, which would carry an average payload of about 6 tonnes - giving 30,600 tonnes of freight per month or 367,000 tonnes per year.

Construction, Lao People's Democratic Republic which show that 1.4 million tonnes of freight was carried by road in the whole of the Lao People's Democratic Republic in 1992, especially when little of this volume is likely to have been generated *within* the country. Clearly, better estimates of the volume of freight carried by road between the two countries, and of the proportion of this freight either now containerized or potentially containerizable, are needed, before an assessment of the volume which could be carried by rail can be made.

Myanmar

Container Trade Growth

In Myanmar, container transport is still very much in its infancy. Apart from minor volumes being handled by air, all international containers arriving in or leaving Myanmar are handled through the Port of Yangon, which although still handling relatively small volumes of containers by international standards, has nevertheless experienced dramatic growth during the past five years, as may be observed from *Table 4.*

Table 4: Trend in Container Throughput, Yangon Port

Year	TEU	Year-on-Year Growth (per cent)
1983	995	
1984	853	-14.3
1985	952	11.6
1986	448	-52.9
1987	491	9.6
1988	400	-18.5
1989	532	33.0
1990	4,589	762.6
1991	8,610	87.6
1992	22,285	158.8
1993	Not Available	
1994	24,000	
Average Rate of Growth 1983-1994		33.6

Sources: 1983-1992: *Containerisation International Yearbook;*
1994: *Myanma Port Authority.*

The commissioning of CFS (Container Freight Station) facilities for the stuffing and unstuffing of containers, inside the port area as from 1989/90 partly explains the boost in container throughput volume between the 1989 and 1990 calendar years, but container trade has continued to grow dramatically in all subsequent years, presumably as the result of overall trade growth and as the result of increasing containerization.

3.8.2 Potential Container Volume for the TAR

It has been estimated (Myanmar Comprehensive Transport Study 1993, Annex 5) that 99 per cent of the international cargo delivered to and removed from the Port of Yangon in 1991/92 was transported by road and that only 1 per cent was transported by rail. Included in these shares are volumes of breakbulk cargo either discharged from, or loaded into, containers within the port area, which at present does not have an operating direct rail connection (see Section 6 for further details).

It is probable that almost all of the import container cargoes released from the port would remain within the Yangon area, and thus would **not** represent potential traffic for rail. However, since Myanmar's exports are dominated by agricultural commodities (particularly rice and mung beans) it is likely that the vast majority of these exports originate from locations in the hinterland, many of which are served by rail. It is possible, therefore, that 50 per cent or more of export container volume could represent potential traffic for rail.

In 1994, TEU export volume through the Port of Yangon was approximately 8,000 TEU. If 90 per cent of this volume originated from outside of Yangon, then it might be assumed that some 3,500 TEU (ie. 50 per cent of 90 per cent of 8,000 TEU) was traffic which might have been carried by the railway had it the resources, equipment and port connections necessary to transport containers. If it were further assumed that, between now and 2000, this traffic would grow at about 11 per cent per year (ie. equivalent to the rate forecast for container trade in the ASEAN countries, but only one third of the actual rate of growth in container throughput at Yangon Port between 1983 and 1994), potential container volume for rail would reach 6,000 TEU by 2000. If it were assumed that the rate of growth in container trade beyond 2000 might slacken off to about 8 per cent per year, then the potential container volume for rail would reach about 9,000 TEU by 2005 and about 13,000 TEU by 2010.

On the assumption that a maximum of 23 TEU[9] can be hauled per train, the above potential volumes would translate into 260, 391 and 565 pairs of trains per year by the years 2000, 2005 and 2010, respectively. It is likely that all of these trains would operate on TAR Link B.1, between Yangon and Mandalay. The foregoing calculations have been made, however, without any allowance for an increasing market share for rail, or for the possibility that more efficient wagons, each conveying two TEU, can be introduced.

In addition to international container traffic sourced from within Myanmar, there is a possibility, albeit in the long term, that the railway will in future be able to attract container traffic sourced in neighbouring countries - specifically in China and Thailand. Capture of this traffic would depend on the construction of missing railway links, as well as on the capability of the Myanmar railway and port systems to compete effectively on price and transit time with the systems of other countries. As an example of the volume of traffic which might be

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[9] Calculated on the basis that containers would be transported on drop centre wagons (each conveying only one twenty foot container) on the Mandalay Line which has a crossing length restriction of 1,200 ft (365.76 metres). After allowing for locomotive and brakevan length totalling 30 metres, 335.76 metres would be available for container wagons, each with an overall length of 14.298 metres - giving a total of 23 wagons per train.

on offer from these sources, it was estimated that Kunming alone could generate container traffic amounting to 19,000 TEU per year by 2000.[10] This traffic is currently moving through the port of Hong Kong, but in future could be routed through Haiphong, Bangkok/Laem Chabang, or Yangon. Current indications are, however, that the Yunnan authorities will give priority for the connection of the province by rail with Thailand - *suggesting* that the Thai port system may become the outlet for trade to/from Yunnan Province of China.

A very large volume of freight traffic (estimated to be around 300,000 tonnes per annum - see Section 3.7 of this report) currently moves by road between Yunnan Province and Myanmar. None of this traffic is currently containerized, and it is not known what proportion is containerizable in future.

3.8.3 Requirements for Competitive Service on the TAR

In Myanmar, road transport provides the most formidable competition for rail, as can be seen from the modal distribution of freight traffic to and from the port (mentioned above) and from data presented in the Comprehensive Transport Study of 1993 which indicate that in 1990/91, more than 60 per cent of the estimated inter-zonal (long distance) freight volume of 11.75 million tonnes was transported on the road system, and only 14 per cent on the rail system.[11]

Rail has a substantial tariff advantage over its road competitors. For example, the rail tariff for hauling 12 tonnes of cement from Yangon to Mandalay for a private shipper (3,400 kyats) is only one fifth to one quarter of the private trucking tariff applicable to the same traffic (12,000-14,900 kyats). Notwithstanding this advantage, however, the rail share of the medium to long distance freight task has been declining, according to the Comprehensive Transport Study of 1993.[12]

This decline is attributed to the limited physical capacity of the Myanma Railways to move the traffic on offer. Wagon supply appears to be a particularly serious problem, and examples are cited of private shippers of agricultural products having to wait up to one month to receive a wagon for loading, or of such shippers receiving wagons which required major repairs (eg. even the installation of a floor) before shipments could be loaded into them.[13]

Road competition can be expected to strengthen in future, if only because the entry of new operators into trucking is unconstrained (operator licences are easy to obtain and relatively cheap, the most expensive licence for heavy goods vehicle operation costing only 180 kyats per year). With the improvement in the standard of the main highways throughout the country, truck transit times and operating costs can be expected to reduce, with the result that truck tariffs will also become more competitive.

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[10] Based on information supplied by the Customs Department of China during a mission to Kunming 30 June 1995. (See also Section 3.7 of this report).

[11] *Myanmar Comprehensive Transport Study 1993*, Annex I Roads and Road Transport, page 81.

[12] *CTS 1993*, Annex II, Railways, page 5-11

[13] *CTS 1993*, Annex II, Railways, page 5-13.

Improved operating performance would therefore seem to be a major pre-requisite for the attraction of container traffic by the railway. It is unlikely, however, that the required improvement in operating performance could be achieved unless containers could be moved in trains of fixed block formation between the Port of Yangon and a limited number of hinterland terminals. This in turn would require:

- The provision of a direct railway connection to the Port of Yangon, which would permit the direct reception and despatch of block container trains;
- The provision of compatible rail terminal facilities in the hinterland (and in this context it is understood that a rail served Inland Container Terminal is being planned for Mandalay); and
- The purchase of adequate numbers of locomotives and specialized container wagons to support a block train service (but although an order has been placed for the supply of container wagons by China, these wagons are limited to the conveyance of a single twenty foot container at a time).

In terms of tariffs and other commercial considerations, per container contract rates with minimum annual volume and service performance clauses would need to be established and negotiated with potential customers. The specialized express parcel train services currently operating between Yangon and Mandalay, to express schedules and with guaranteed delivery times, would provide a suitable model for the planning of container block train services.

3.9 Summary of Potential Container Volume for TAR Links

A summary of the container volumes identified as potential traffic for the Trans-Asian Railway in the subregion is shown in *Table 5.*

Table 5: Summary of Potential Container Transport Volume by TAR Link

Origin/Destination	TAR Link(s)	Potential Volume (TEU) in:		
		2000	2005	2010
Yangon/Mandalay/Yangon	B.1	6,000	9,000	13,000
Thailand/Phnom Penh/Thailand	T.3, C.1	13,000	23,000	31,000
Sihanoukville/Phnom Penh/Sihanoukville	C.2	20,000	35,000	47,000
Haiphong/Hanoi/Haiphong	V.3, V.2	59,000	86,000	127,000
Kunming/Haiphong/Kunming; or Kunming/Laem Chabang/Kunming*	Y.3, V.4	19,000	28,000	41,000
Vientiane/Laem Chabang/Vientiane	T.2**, T.3	5,000	8,000	12,000

* There is a strong possibility that this trade will in future be directed to a port in China.

** Including future extension to Vientiane.

4. RECOMMENDED MINIMUM STANDARDS AND REQUIREMENTS FOR FUTURE TAR NETWORK

As mentioned in Section 4 of Volume 2, the primary objective of this study is to recommend minimum technical standards for the future rehabilitation of the existing TAR network, and the new construction of missing links in this network. The recommendations were made in the context of achieving the required operational objectives for the TAR network so as to be more competitive with other transport modes operating in TAR corridors.

4.1 Principal Railway Route Design Parameters

4.1.1 Outline Gauge

The minimum clearance is required for the transport of all types of containers including the non-ISO high-cube containers with a maximum gross weight of 35 tonnes and the maximum dimensions of 2,896 mm in height, 2,591 mm in width, and 13,716-16,150 mm in length. The platform height of standard container flat wagons is normally 1,010 mm above the rail level. The **vehicle gauge** which is defined as the limiting dimensions, measured from the centreline of the track, beyond which any part of a vehicle or its load may not protrude, should at least accommodate the minimum clearance mentioned above.

The vehicle gauge is static in nature as it implies stationary trains. For moving trains, the vehicle gauge needs to be expanded to allow for dynamic effects such as track irregularity, vehicle vibration, lateral movement of wheel, wearing of wheel, and unbalanced loads on wheels. Generally, 600-800 mm should be added to the width of the vehicle gauge, and 300-400 mm to the height. This is called the **structure gauge** or a safe minimum clearance for moving trains. For tunnels, 200 mm is normally added to the all-around dimensions of the structure gauge to allow for construction tolerances and future repair. This being the case, a minimum height or clearance above rail of 4,300 mm would be required to transport high-cube containers of 9 ft 6 ins height on standard container flat wagons with a platform height of 1,010 mm. For electrified and/or standard gauge track, the structure gauge needs to be expanded further.

4.1.2 Maximum Permissible Axle Load

Locomotive weights and container transport requirements were the two major factors being considered when evaluating the suitable axle load limits in the TAR corridor. More up-to-date locomotives generally come with six axles and a gross weight of 90 tonnes which is equivalent to having an imposed load on track of 15 tonnes per axle. Similarly, standard container flat wagons carrying two ISO 20 ft containers will have a gross weight of 54 tons, or an average load per axle of 13.5 tons. Therefore, it is recommended as in Volume 2 that, a maximum permissible axle load of 15 tonnes should be made standard for the narrow-gauge TAR network.

An axle load of 15 tonnes should be regarded as the minimum target for any track rehabilitation program aimed at strengthening the existing track structure to carry heavier loads. There may be cases where the conditions of the track or bridges are so bad that it would be more economical to undertake renewal or replacement work. If so, it might be advisable to consider specifying an axle load of greater than 15 tonnes, say 18 or 20 tonnes. This applies also to the future construction of new lines or missing links.

4.1.3 Competitive Schedule Speeds

Dividing the total distance between origin and destination by the elapsed time between departure and arrival gives the magnitude of the schedule speed. Two components make up the schedule speed, that is, the stopping time at stations or crossing loops for various reasons, and the running time. In Volume 2, emphasis has been given to the competitiveness of the rail container transport. Container block trains and passenger trains should be scheduled to operate at similar speeds. A maximum speed of **70 km/hour** was recommended although higher speeds in the order of 90-100 km/hour were preferable for long-term planning. Beside heavy capital investments required to upgrade all associated facilities for higher speed operation, a joint road-rail policy should be established to settle the issue of road crossings which has been one of the major obstacles for trains to achieve faster speeds.

Other Standards

In addition to the clearances, axle load and schedule speed specified earlier, the following physical standards are highly recommended:

4.2.1 Uniform Maximum Length for Freight Trains

To achieve operational economies, the composition of container block trains should comprise **30 bogie flat wagons.** Together with a locomotive and a brakevan, the train length would measure approximately 450 metres, thus requiring **a minimum siding length of 500 metres** for crossing purposes.

Compatible Design Standards for Locomotives and Rollingstock

Locomotives and rollingstock operating within the TAR corridor should share compatible standards to allow a smooth passage of trains across the national borders. Considerations are given to the braking system design and efficiency, coupler type and height above rail level, container mounting fixtures, and materials handling system for loading and unloading of wagons. Air brakes are more efficient than the conventional vacuum brakes. AAR type automatic couplers are considered standard. They come with 50 tonne draft capacity and a height of 850 mm above rail level. Mounting fixtures should be capable of accommodating both 8 ft-0 in and 8 ft-6 in container widths.

4.2.3 Compatible Track, Structures and Signalling System Design Standards

To accomplish a maximum speed of 70 km/hour, or preferably 90-100 km/hour, for container freight trains, it is essential to have a strong, rigid and durable track with long usable life and less routine maintenance cost. Continuous long-welded rail should be utilized to enhance smooth riding comfort, and reduce wheel and rail wear. Heavy (50-60 kg/metre) rails are necessary for stability and endurance. Sixty kg/metre rail in particular, being the normal weight of rail for 1,435 mm gauge track, is highly recommended for any track renewal work. If it happens in the future that a conversion from metre to standard gauge is justifiable, it is likely that any 60 kg/metre rail used for track renewal could be re-used following gauge conversion, since the normal service life of this rail under passing tonnages typically encountered in the subregion exceeds 30 years. Elastic rail fastening systems, preferably of the "fit-and-forget" and anti-vandalism type with resilient bearing pads and durable insulators, if applicable, are equally desirable to help reduce rail creep and gauge widening and also increase the lateral stability of the rails. Monoblock prestressed concrete sleepers or ordinary reinforced concrete two-block sleepers of adequate design and structural shaped steel embedments are sturdy and currently more economical to use than timber. Sleepers should be spaced at 600-700 mm (or 1,429-1,667 pieces to each track kilometre), and uniformly laid to be suitable for future mechanized track maintenance. Granite or other good quality ballasts of 250 - 300 mm thickness are generally required to provide track stability, better load distribution to the road bed, and to protect against mud-pumping. Proper drainage systems should be installed to get rid of excess water which is the prime cause of track deterioration.

All temporary bridge crossings should be made permanent, utilizing concrete rather than steel construction. Steel bridges require considerable routine inspection and maintenance inputs, which will prove to be less economical in the long run. A problem frequently encountered with steel bridges of the through trussed type is that their upper chord members infringe the structure gauge. Concrete bridges are heavier requiring costlier abutments, but do not impose structure gauge infringement problems. Modern prestressed concrete bridges are slim and much lighter than the conventional reinforced concrete bridges. They can be precasted in segments at the factory, and transported to sites for erection, especially if their span lengths do not exceed 18 metres. To maintain an ample clearance underneath the bridge deck, the girder depths can be minimized by introducing U-shaped "cast-in-place" prestressed concrete sections. Ballasted-track bridges are more commonly employed to avoid problems associated with weak formation of the approaches, and differential settlement of the abutments.

As to standards for railway signalling and telecommunications systems, the **tokenless** absolute block system is recommended together with multiple-phase colour-light signals, all-relay interlockings, train dispatching telephones and train radio. Step-by-step conversion from mechanical interlocking to electro-mechanical and, finally, to all-relay interlocking may not be feasible due to the shortage of spare-parts and skilled workers to undertake the conversion, and the costly inspection and maintenance of the old systems. It should be noted also that modern solid-state signalling has replaced the electrical/relay system in many advanced railways. For telecommunications, transmission trunk lines employing the fibre-optic cables offer enormous channel capacity, and are more reliable than the microwave or wire-cable transmission systems.

5. CURRENT TECHNICAL AND OPERATIONAL STATUS OF TAR NETWORK

In Section 4, various technical standards and requirements are specified for the future TAR network with the main objectives of making rail transport, particularly the rail transport of containers, more competitive with other modes operating in the TAR corridors. In addition, compatible standards of locomotives, rollingstock, track, wayside facilities, and signalling, as well as telecommunication systems, would allow trains to cross the national borders with a minimum of delay, and make possible the exchange or lease of locomotives and/or rollingstock and spare parts. These recommendations are identical to those given in Volume 2 for the TAR network passing through Indonesia, Singapore, Malaysia and Southern Thailand.

The purpose of this section is to review the current technical and operational status of each railway administration within the Subregion, so that any variation from the recommended standards could be visualized together with the extent of the works and costs needed to ensure that these standards are met in future.

5.1 Present Status of Infrastructure

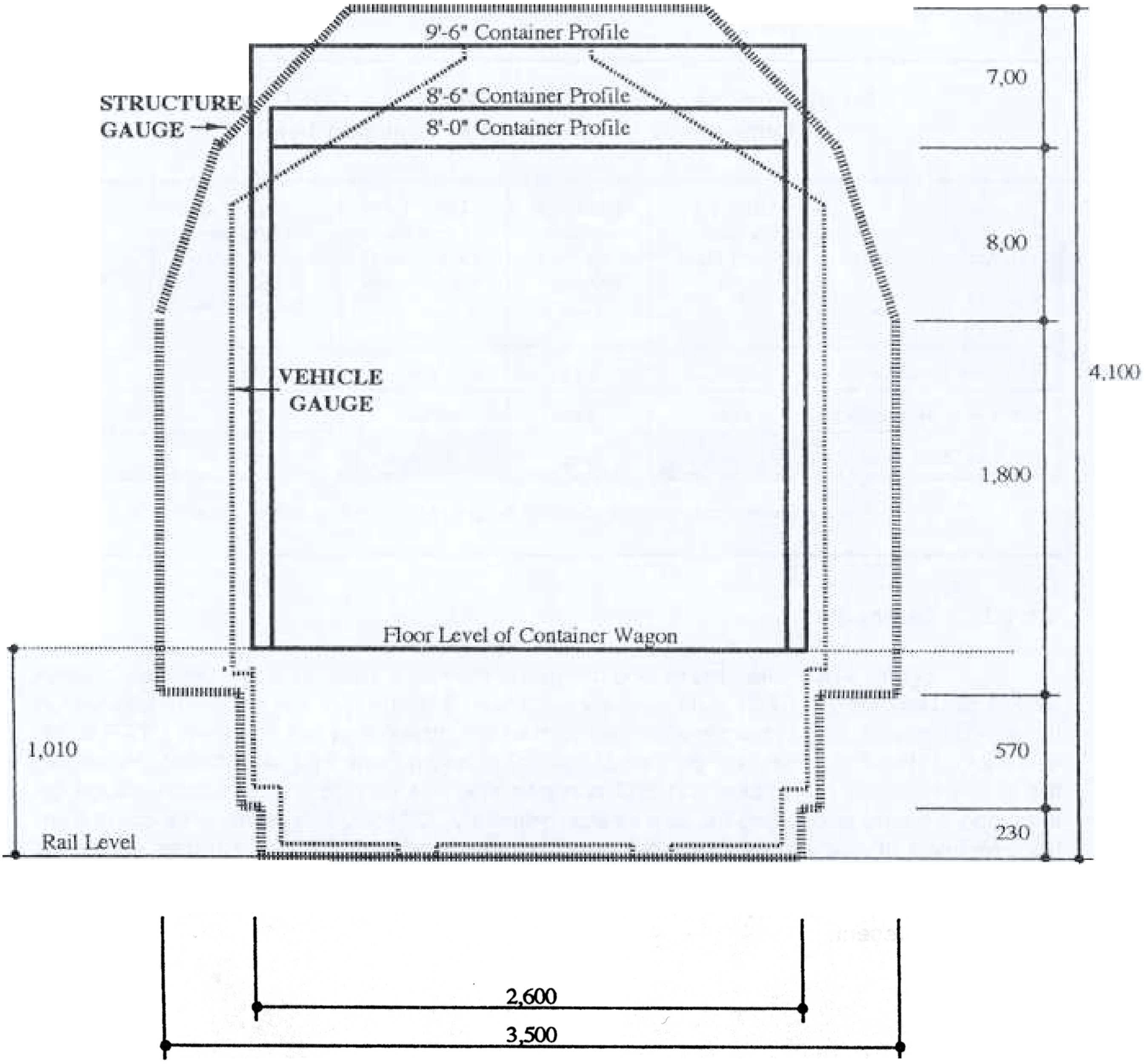
5.1.1 Outline Gauges

The investigation is made to find out whether the existing gauges of each railway provide sufficient clearance for the transport of standard ISO containers, and possibly for the non-standard super high-cube 9 ft 6 in containers. Ideally the container profile, whether it is of the ISO or non-ISO type, should not infringe the vehicle gauge which represents the largest dimension of the train in the **static** or stationary position. Once the train moves, it would require greater clearances to cope with the body-sway due largely to track irregularities and wheel wear. To save the construction cost especially of tunnels or trussed bridges but without jeopardizing operational safety, the smallest possible dimension of the **dynamic** envelope is desirable and is generally known as the structure gauge. In case of the container profile falling between the vehicle and structure gauges, it might be acceptable to run this train at low speeds to minimize the dynamic effects, or alternatively to adopt other measures, such as the use of "well" type wagons with a dropped centre section, or special wagons with small diameter wheels.

5.1.1.1 Thailand

The outline gauges of the State Railway of Thailand (SRT) are presented in *Figure 8*. The gauges are very small and cannot accommodate any size of the standard ISO containers. However, in reality, the SRT has undertaken since the 1970s, a programme of gauge expansion so that all standard ISO containers can be transported by rail without infringing the structure gauge. Super high cube non-ISO containers can also pass through most of the network. The outline gauges shown in *Figure 8* have been in use since the 1940s, and have not been updated to reflect all of the modifications made during the past years. Since 1990, modified outline gauges have been applied for all new construction of bridges and wayside facilities. They have a constant width of 3,500 mm, and a height of 4,200 mm above the rail level. Additionally, 900 mm is reserved for future electrification. Deck or girder prestressed concrete bridges which have replaced old steel bridges to minimize future routine maintenance costs, have been designed to avoid interference with oversized traffic such as double-deck passenger coaches or double-stack container trains.

Figure 8: Outline Gauges of State Railway of Thailand



At present, the super high cube non-ISO containers of 9 ft 6 in height can pass through all tunnels, all concrete bridges, the northern main line from Bangkok to Chiang Mai (TAR Link T.4), the northeastern main line from Bangkok to Nong Khai (TAR Link T.2), and the main line to Ubon Ratchathani (TAR Link T.5). The southern main line from Bangkok to Padang Besar (TAR Link T.1) has 6 restricted bridges, between km 662 and 886, and the eastern line from Bangkok to Aranyaprathet (TAR Link T.3) has another 4 restricted bridges, between km 93 and 252. To maintain a safe space of 300-400 mm between the vehicle and structure gauges, 18 additional bridges along the two TAR links need minor modifications. The remaining alteration work was estimated to cost US$ 300,000.

Summary of Thailand

Do dimensions of structures on following TAR Links permit conveyance of containers of specified height?*

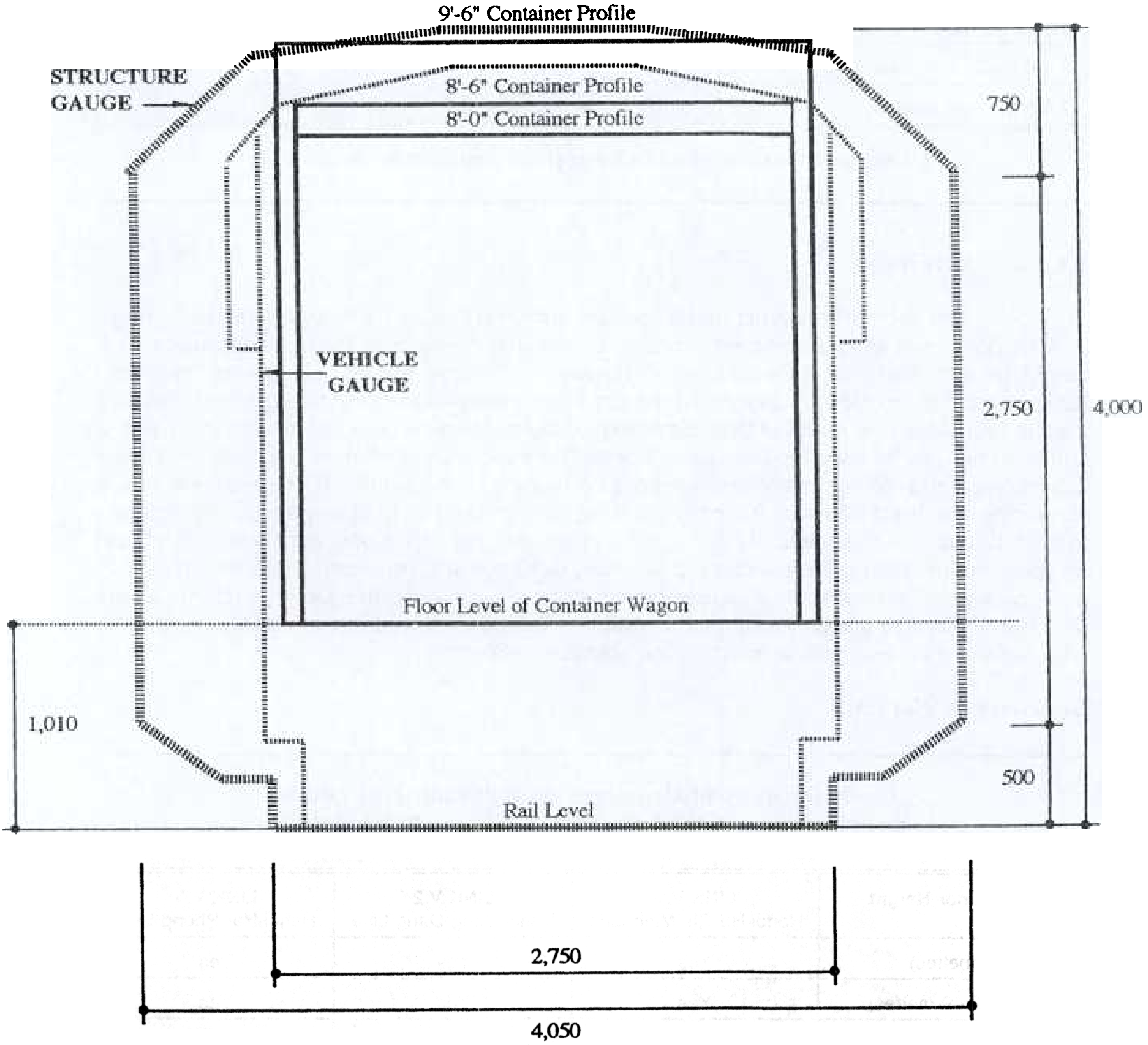
Container Height	LINK T.1 Bangkok-Padang Besar Line	LINK T.2 Bangkok-Nong Khai-Vientiane Line	LINK T.3 Bangkok-Aranyaprathet -Poi Pet Line	LINK T.4 Bangkok-Nakhon Sawan-Mae Sod-Yangon Line	LINK T.4 Bangkok-Ubon Ratchathani-Chong Mek-Pakse Line
8 ft (2.44 metres)	Yes	Yes	Yes	Yes	Yes
8 ft 6 in (2.49 metres)	Yes	Yes	Yes	Yes	Yes
9 ft 6 in (2.90 metres)	No	Yes	No	Yes	Yes

* *Assumes operation of standard height (1,010 mm) container flat wagons.*

5.1.1.2 Cambodia

Figure 9 illustrates the outline gauges of the Royal Railway of Cambodia (Chemin de Fer du Cambodge: CFC). ISO containers of both 8 ft and 8 ft 7 in height fit well within the vehicle gauge, and could be conveyed with safety throughout the nominated TAR links, ie. Link C.1 (Poi Pet - Phnom Penh) and Link C.2 (Phnom Penh - Sihanoukville). However, the 9 ft 6 in super high cube non-ISO containers would infringe the structure gauge by imposing a height exceeding the limit by approximately 320 mm. The constraints come from the presence of many steel through trussed bridges, and would entail a rather extensive survey to quantify the corrective measures. Containerization is still new to the Cambodian Railways and consequently no specialized wagons and container handling facilities are available at present.

Figure 9: Outline Gauges of Royal Railway of Cambodia



Summary of Cambodia

Do dimensions of structures on following TAR Links permit conveyance of containers of specified height?*

Container Height	LINK C.1 Poi Pet-Phnom Penh Line	LINK V.2 Phnom Penh-Sihanoukville Line
8 ft (2.44 metres)	Yes	Yes
8 ft 6 in (2.49 metres)	Yes	Yes
9 ft 6 in (2.90 metres)	No	No

* *Assumes operation of standard height (1,010 mm) container flat wagons.*

5.1.1.3 Viet Nam

The vehicle and structure gauges are shown in *Figure 10*. They are relatively large and the profiles of all ISO standard containers fall within the limits of the outline gauges. The height of 9 ft 6 in non-ISO containers, however, infringes the vehicle gauge by about 220 mm, and is too close (120 mm) to the upper boundary of the structure gauge to ensure a safe operation. It is doubtful that super high cube containers could be transported with a sufficient margin for lowering the speed alone. The inferior conditions of the track as well as locomotives and rollingstock would cause a body sway, the magnitude of which requires a clearance of at least 300 mm. As many old steel through trussed bridges need to be replaced in the future due to their severely damaged and/or corroded conditions, consideration should be given to increasing the structure clearance, or better still, replacing them with girder or deck bridges of prestressed concrete construction. Fortunately, the tunnel sections of the Viet Nam Railways are greater than the structure gauge, and would comfortably handle the high cube containers, with a minimum clearance of 480 mm.

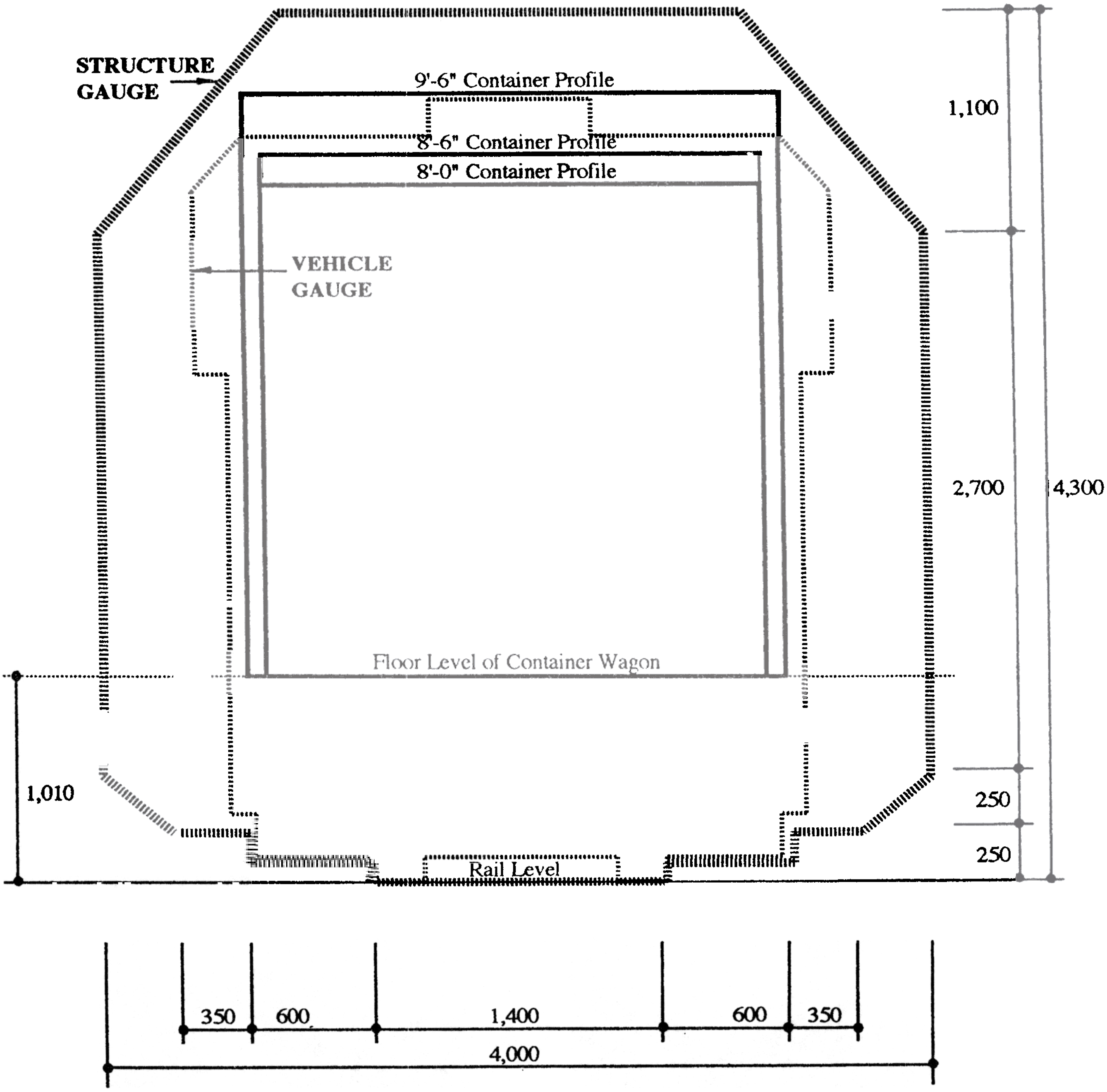
Summary of Viet Nam

Do dimensions of structures on following TAR Links permit conveyance of containers of specified height?*

Container Height	LINK V.1 Hanoi-Ho Chi Minh Line	LINK V.2 Hanoi-Dong Dang Line	LINK V.3 Hanoi-Hai Phong Line
8 ft (2.44 metres)	Yes	Yes	Yes
8 ft 6 in (2.49 metres)	Yes	Yes	Yes
9 ft 6 in (2.90 metres)	Yes	Yes	Yes

* *Assumes operation of standard height (1,010 mm) container flat wagons.*

Figure 10: Outline Gauges of Vietnam Railways



5.1.1.4 Myanmar

The structure and vehicle gauges of Myanma Railways are depicted in *Figure 11*. It is evident that none of the 8 ft, 8 ft 6 in, or 9 ft 6 in containers could be conveyed through Myanmar rail network on standard container wagons with a floor height of 1,010 mm, without infringing the vehicle gauge. Myanma Railways, however, has recently purchased "well" type wagons of Chinese manufacture. These wagons with a floor height of 632 mm can carry one 20 ft ISO container with a height of 8 ft 6 in together with two small non-standard container boxes mounted at the ends of the wagons. No tunnels are present on either of the two nominated TAR links, ie. Link B.1 (Yangon-Myitkyina) and Link B.2 (Yangon-Thaton).

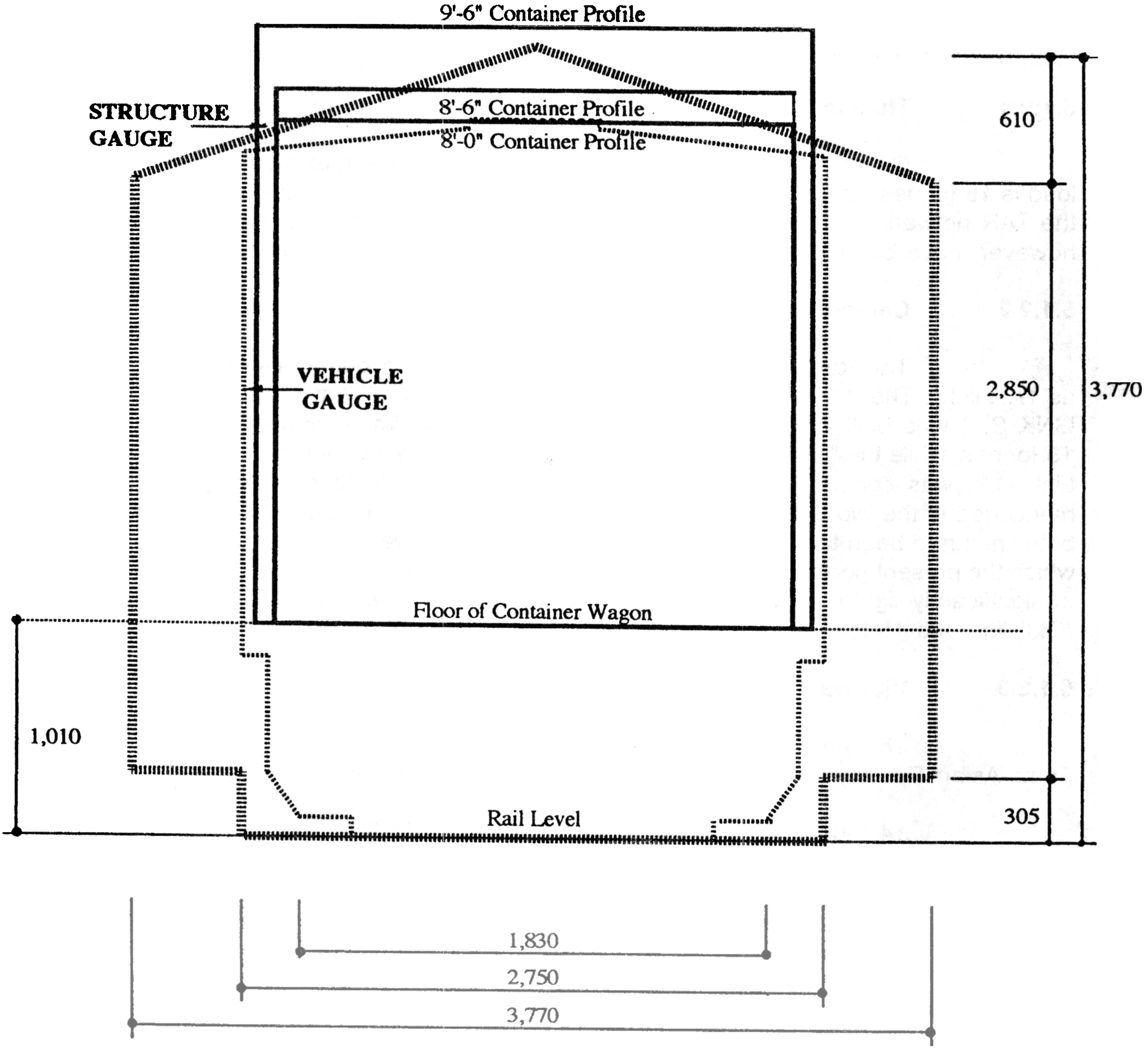
Summary of Myanmar

Do dimensions of structures on following TAR Links permit conveyance of containers of specified height?*

Container Height	LINK B.1 Yangon-Myitkyina Line	LINK B.2 Yangon-Motani-Nakhon Sawan Line
8 ft (2.44 metres)	No	No
8 ft 6 in (2.49 metres)	No	No
9 ft 6 in (2.90 metres)	No	No

* *Assumes operation of standard height (1,010 mm) container flat wagons.*

Figure 11: Outline Gauges of Myanma Railways



5.1.2 Maximum Permissible Axle Loads

With the exception of Thailand and the dual-gauge sections of Viet Nam, the proposed links in the TAR network in Myanmar and the INDO-CHINA countries do not comply with the 15 tonne axle load standard recommended in Section 4. Many of these links have been left unattended for a long period of time, and the present condition of track and structures has deteriorated to the extent that lower axle load limits have to be imposed to ensure the safe passage of trains. The axle load standards currently applied in each country are as follows:

5.1.2.1 Thailand

On all nominated TAR Links within Thailand, the maximum permissible axle load is **15** tonnes throughout, so that compliance with the recommended axle load limit for the TAR network has already been achieved. Rehabilitation and new construction works, however, have been implemented using a higher axle load of **20** tonnes.

5.1.2.2 Cambodia

The Royal Cambodian Railway has nominated both of its existing mainlines as TAR links. The "Old" line running from Phnom Penh to the Thai border at Poi Pet (TAR LINK C.1) was built in the 1930s to accommodate a maximum permissible axle load of **15** tonnes, while the "New" line connecting Phnom Penh with the port of Sihanoukville (TAR Link C.2) was constructed in the 1960's to handle an axle load of **20** tonnes. It was mentioned in the World Bank Report for the 1995 ICORC Conference that maintenance of both lines had been totally neglected during and after the war years, as a consequence of which the present condition of track and structures is very poor, necessitating the imposition of significantly lighter axle loads. The axle load limits now applied are **10** tonnes for the "Old" line and **15** tonnes for the "New" line.

5.1.2.3 Viet Nam

The prevailing maximum axle load limits on the nominated links of the Trans-Asian Railway in Viet Nam vary section by section, being:

> **14** tonnes for the Hanoi - Ho Chi Minh City line (TAR Link V.1) between Hanoi and Danang, and **12** tonnes from Danang to Ho Chi Minh City;
>
> **14** tonnes for the Hanoi - Dong Dang dual-gauge line; and
>
> **14** tonnes for the Hanoi - Hai Phong Port line.

The 1992 National Transportation Sector Review described the track condition of a large portion of the rail network as still being erratic and poor, due mainly to damage caused by the long period of war and the shortage of funds to upkeep the railway facilities and equipment.

5.1.2.4 Myanmar

A maximum permissible axle load of **12.5** tonnes is applied to the existing main lines from Yangon - Myitkyina and Yangon - Moulmein, which form part of the TAR Links connecting Myanmar with Southern China and Central Thailand. According to the UNDP Report prepared by Transurb Consult in 1994, the overall track conditions of the two lines were unfavourable due mainly to the lack of funds to maintenance or rehabilitation. Consideration, however, should be given to increasing the axle load to 18 or even 22.5 tons, when undertaking the necessary rehabilitation works in the future. The decision to adopt a higher axle load is a common practice among other railways of the subregion, because it provides better operating economies in terms of longer track life, less maintenance cost, higher haulage loads, and greater flexibility and utility of the lines for container transportation.

5.1.3 Competitive Speeds

For any given TAR Link, the competitive speed is represented by the ratio of the schedule speed to the maximum permissible speed. It is desirable to obtain a high ratio so as to be more competitive with other transport modes.

The maximum permissible speed depends on several key factors. Flat terrain and straight alignment allow trains to travel at much higher speed than mountainous terrain with steep gradients and sharp curved alignment. Good and well maintained track provides safety, stability and smooth riding comfort at higher speed. Appropriate signalling and telecommunication systems are prerequisites to the effective control and monitoring of faster trains. Fenced right-of-way and a limited number and frequency of road level crossings, with proper barriers installed, enables train drivers to achieve higher speeds without fear of collision with other objects. Finally, high speed is attainable utilizing efficient locomotives and rollingstock.

The schedule speed is the distance divided by the time required to travel from an origin to a destination. The time thus includes running and all stopping time at stations and sidings to perform various functions such as discharging/loading of goods or passengers, waiting to cross with other trains, marshalling or reformation of trains, on-the-spot maintenance, immigration and customs control, etc.

The current situation with respect to competitive speeds in each country, as reflected in *Tables 6-9,* is described below . It was evaluated from data obtained by questionnaire responses, as well as from country papers, train schedules, and actual train operating diagrams.

5.1.3.1 Thailand

In general, the favourable topography and adequate maintenance of tracks in Thailand has enabled the application of maximum permissible speeds for passenger and freight trains of **120** km/hour and **70** km/hour, respectively. (See Annex 1). Ratios of schedule to maximum speed are recorded as being more than **60** per cent in most cases. There are sections, however, along the main northeastern lines (TAR links T.2 and T.5), which traverse mountainous terrain, where this ratio is considerably lower than 60 per cent. The 139 km section between Kaeng Khoi and Nakhon Ratchasima (Pak Chong) imposes major speed and load constraints, as a consequence of having a ruling gradient of greater than 2 per cent, as well as radii of curvature of as little as 180 metres. In this section, maximum speeds are reduced to 55 km/hour to maintain safety, while the schedule speed of freight trains averages only 32 km/hour. The SRT is aware of these constraints, and has undertaken a realignment study and detailed engineering design of this section, with construction scheduled for completion in 1998. A similar situation exists on the 251 km Kaeng Khoi - Bua Yai section which was built more recently, to bypass the previously described section and to shorten the distance from Kaeng Khoi to Nong Khai and, thus, to Vientiane in the Lao People's Democratic Republic. The new bypass, however, encounters several areas of rockfalls and steep grades, as it also passes thorough mountain ranges. Slope stabilization and proper drainage have been implemented as corrective measures with satisfying results.

Other major obstacles which prevent the improvement of the schedule speeds, are the presence of many unprotected road crossings, inefficient signalling and block systems employed on many single line sections, and the deteriorated conditions of existing rails and timber sleepers.

5.1.3.2 Cambodia

Little difficulty is imposed in Cambodia by terrain. Maximum gradients do not exceed 1.0 per cent, and the radii of curvature vary between 300 and 500 m. However, many track sections pass thorough low-lying areas encountering floods and unstable roadbed. For decades, the railway has been largely neglected due to the country's security problems and financial constraints. At present, there is only one mixed train operating daily on each of the two TAR links. The schedule speeds of the mixed trains are very low - about **22** km/hour on both lines. Major rehabilitation works to upgrade the existing infrastructures and equipment, as well as the acquisition of new locomotives and rollingstock, are needed.

5.1.3.3 Viet Nam

The Hanoi - Ho Chi Minh City line, TAR link V.1, runs along the Viet Nam coast, traversing many steeply graded sections (1.2 - 1.9 per cent) and many sections where the radius of curvature is as little as 95 metres. The Vinh - Nhatrang section passes thorough 27 tunnels with a combined length of 8.6 km, and crosses over 870 bridges. The maximum permissible speeds for freight trains are limited to **50-60** km/hour, while the schedule speeds vary between **27.5-35.4** km/hour. The lowest speed ratio of 46 per cent applies on the Vinh-Danang section, where the present level traffic has already reached line capacity.

The Hanoi - Dong Dang line, TAR link V.2, also passes thorough mountainous areas containing 8 tunnels with a combined length of 1,990 metres. The maximum gradient is 1.7 per cent, and the minimum radius of curvature 150 metres. The schedule speeds of freight trains are recorded as **22** km/hour for the Hanoi - Bacgiang section and **18.4** km/hour for the Bacgiang - Dongdang section, while the maximum speeds are limited to **30-40** km/hour. The line is lightly utilized at present having only two freight and four passenger trains occupying the track daily. The Hanoi - Dong Dang dual-gauge line has been closed to international traffic to/from China since 1979, following a border dispute between the two countries.

The Hanoi - Haiphong line, TAR link V.3, covers a relatively flat terrain of 0.6 per cent gradient, but contains tight curves, with a minimum radius of 100 metres. The maximum permissible speeds are **40** km/hour for freight trains and **60** km/hour for passenger trains. Freight trains typically have a schedule speed of **38.2** km/hour (very close to the maximum speed) for the entire line, but over the capacity limiting section of 21.2 km the schedule speed of freight trains is only 26 km/hour, probably due to a combination of track condition and delays incurred in crossing a major road/rail bridge on which only one mode can proceed at a time.

5.1.3.4 Myanmar

The topography of the TAR network in Myanmar is relatively flat with maximum gradients of less than 1.0 per cent except on the northern section between Shwebo and Myitkyina (where they are 1.25 per cent). Tight curves in the range of 100-300 m, however, are most common especially between Mandalay and Shwebo.

Maximum permissible speeds on all sections are unacceptably low, varying from 40 to 69 km/hour for passenger trains, and 32 to 48 km/hour for freight trains. The schedule speed of freight trains travelling between Yangon and Mandalay is only **17** km/hour. The inferior conditions of track, bridges, wayside facilities, train control equipment, locomotives and rollingstock have contributed greatly to the shortfall of speeds. Long-term investment would be required to upgrade these facilities, in order that competitive transit times can be provided in order to attract container traffic.

Table 6: Comparison of Maximum Permissible and Schedule Speeds - Thailand

TAR Link	Line Section	Dist. (km)	Passenger Trains[/1]			Freight Trains		
			(1) Weighted Max. Speed[/2] (km/hour)	(2) Schedule Speed (Typical)[/3] (km/hour)	(3)=(2)/(1) x 100 (per cent)	(4) Weighted Max. Speed[/2] (km/hour)	(5) Schedule Speed (Typical)[/3] (km/hour)	(6)=(5)/(6) x 100 (per cent)
T.2	Bangkok-Kaeng Khoi	125	120	74.5	62.1	70	42.2	60.6
	Kaeng Khoi-Bua Yai	251	75-105	65.8	62.6-87.6	70	35.9	51.3
	Bua Yai-Khon Kaen	74	115	46.8	40.7	70	24.7	35.3
	Khon Kaen-Udonthani	119	115	71.3	62.0	70	45.2	64.6
	Udonthani-Nong Khai	55	115	55.0	43.8	70	47.0	67.1
T.3	Bangkok-Chachoengsao	619	70-95	43.1	61.4	70	45.5	65
	Chachoengsao-Aranyaprathet	194	85	62.7	73.8	70	47.0	67.1
T.4	Bangkok-Ban Phachi	90	120	65.2	54.3	70	36.0	51.4
	Ban Phachi-Nakhon Sawan	156	105-120	86.0	81.9	70	43.0	61.461.4
T.5	Bangkok-Kaeng Khoi	125	120	74.5	62.1	70	42.2	60.6
	Kaeng Khoi-Nakhon Ratchasima	139	55-100	60.2	60.2	70	32.0	
	Nakhon Ratchasima-Surin	156	115	65.5	56.92	70	33.4	47.7
	Surin-Ubon Ratchathani	155	90	56.4	62.62	70	48.8	69.7

Notes:
/1 Speeds reported relate to Express Passenger Trains, wherever operated.
/2 Maximum speeds weighted by the proportionate distance over which each speed restriction applies.
/3 Includes allowance for all enroute stopping time (for whatever reason).

Table 7: Comparison of Maximum Permissible and Schedule Speeds - Cambodia

TAR Link	Line Section	Dist. (km)	Passenger Trains[1]			Freight Trains		
			(1) Weighted Max. Speed[2] (km/hour)	(2) Schedule Speed (Typical)[3] (km/hour)	(3)=(2)/(1) x 100 (per cent)	(4) Weighted Max. Speed[2] (km/hour)	(5) Schedule Speed (Typical)[3] (km/hour)	(6)=(5)/(6) x 100 (per cent)
C.1	Phnom Penh-Pursat	165	80	22.8	28.5	50	22.8	45.6
	Pursat-Battambang	108	80	22.8	28.5	50	22.8	45.6
	Battambang-Srisophon	64	80			50		
	Srisophon-Poi Pet	48	-	-	-	-	-	-
C.2	Phnom Penh-Takeo	75	90	28.3	31.4	50	28.3	56.6
	Takeo-Kampot	164	90	28.3	31.4	50	28.3	56.6
	Kampot-Sihanoukville	100	90	28.3	31.4	50	28.3	56.6

Notes: /1 Speeds reported relate to Express Passenger Trains, wherever operated.
/2 Maximum speeds weighted by the proportionate distance over which each speed restriction applies.
/3 Includes allowance for all enroute stopping time (for whatever reason).

Table 8: Comparison of Maximum Permissible and Schedule Speeds - Viet Nam

TAR Link	Line Section	Dist. (km)	Passenger Trains/1			Freight Trains		
			(1) Weighted Max. Speed/2 (km/hour)	(2) Schedule Speed (Typical)/3 (km/hour)	(3)=(2)/(1) x 100 (per cent)	(4) Weighted Max. Speed/2 (km/hour)	(5) Schedule Speed (Typical)/3 (km/hour)	(6)=(5)/(6) x 100 (per cent)
V.1	Hanoi-Vinh	319	70	52	74	60	35.4	59
	Vinh-Danang	472	70	43.5	62	60	27.5	46
	Danang-Nhatrang	523	60	51	85	50	34.3	69
	Nhatrang-HCM	414	80	47.3	59	60	35.3	59
V.2	Hanoi-Bacgiang	49	50	30.1	60	40	22	55
	Bacgiang-Dongdang	113	40	25.3	63	30	18.4	61
V.3	Hanoi-Haiphong	102	60	38.2	64	40	38.2	96

Notes:
/1 Speeds reported relate to Express Passenger Trains, wherever operated.
/2 Maximum speeds weighted by the proportionate distance over which each speed restriction applies.
/3 Includes allowance for all enroute stopping time (for whatever reason).

Table 9: Comparison of Maximum Permissible and Schedule Speeds - Myanmar

TAR Link	Line Section	Dist. (km)	Passenger Trains[1]			Freight Trains		
			(1) Weighted Max. Speed[2] (km/hour)	(2) Schedule Speed (Typical)[3] (km/hour)	(3)=(2)/(1) x 100 (per cent)	(4) Weighted Max. Speed[2] (km/hour)	(5) Schedule Speed (Typical)[3] (km/hour)	(6)=(5)/(6) x 100 (per cent)
B.1	Yangon-Taungoo	267	56	41	73	48/32	17	35/53
	Taungoo-Yamethin	175	64	47	73	48/32	17	35/53
	Yamethin-Thazi	51	64	41	64	48/32	17	35/53
	Thazi-Mandalay	128	69	51	74	48/32	17	35/53
	Mandalay-Shwebo	95	48	30	63	32	14	44
	Shwebo-Myitkyina	448	40	23	58	32	14	44
	Myitkyina-Dali	480	-	-	-	-	-	-
B.2	Yangon-Motama	276	48	39	81	32	Non-scheduled	

Notes: /1 Speeds reported relate to Express Passenger Trains, wherever operated.
/2 Maximum speeds weighted by the proportionate distance over which each speed restriction applies.
/3 Includes allowance for all enroute stopping time (for whatever reason).

5.1.4 Track Structure

5.1.4.1 Rail

The type and weight of rail used in the TAR network varies in each country from 30 to 44 kg/m.

In Thailand, different sizes of rail can be found on the TAR Links nominated by SRT. They comprise mostly **35 - 40** kg/m rails, many of which have been in use for more than 30 years. SRT is undertaking a major track rehabilitation work including replacing old 35 kg/m rail with new 50 kg/m rail.

In Cambodia, the "Old" line connecting Phnom Penh to Srisophon and Poi Pet was built in the 1930s using **30** kg/m rail, while heavier rail of **44.65** kg/m was laid on the "New" line (Phnom Penh-Sihanoukville) in the 1960s. After many years of use with only limited funds available for the maintenance or replacement of track materials as needed, the current condition of rail and track, in general, is unable to provide a safe passage for trains of normal loading and speed.

The most commonly used rail on the metre gauge track in Vietnam is the **43** kg/m size. This includes a large portion of the TAR Link V.1 from Hanoi to Nhatrang, and the other two important links, namely, the Hanoi - Dong Dang line, and the Hanoi - Haiphong line linking the capital with the major seaport. An exception is the 414 km section between Nhatrang and Ho Chi Minh City, where lighter rail of 30 kg/m is in place. It was reported in the 1992 National Transportation Sector Review that much attention had been paid to renewal and maintenance of these lines, the Hanoi - Ho Chi Minh City line in particular, and the results were remarkable as trains with heavier load and higher speed could be operated on these lines.

Myanma Railways employs several types of rails imported mostly from India. The most common type is the 75 lb/yd or **37** kg/m rail, which dominates the two nominated TAR Links (B.1, Yangon - Myitkyina and B.2, Yangon - Moulmein) with the exception of sections between Shwebo and Myitkyina, where lighter rail of 30 kg/m is used. In general, rails are old and not joined together to form continuously welded rail.

5.1.4.2 Sleepers and Rail Fastenings

The majority of the TAR network in the subregion is laid in **timber** sleepers, although there has been some use of steel sleepers in Cambodia on the 264 km Panom Penh - Srisophon line, and in Vietnam along the 414 km Nhatrang - Ho Chi Minh City section. Two-block ordinary reinforced concrete sleepers occupy about 13 per cent of SRT's network, and are more abundant in Vietnam. SRT manufactured the two-block sleepers in 1960, but ceased production in the late 1970s, due mainly to the inadequate sleeper design and obsolete plant facilities.

Monoblock prestressed concrete sleepers have more recently been used by Myanma Railways and the SRT, at a time when timber sleepers have become scarce, and prices have escalated. A plant owned by Myanma Railways and located near Yangon, is producing 600 monoblock sleepers of the pretensioned type for laying on the Yangon - Mandalay line. It was uncertain, however, that there were adequate quality assurance checks with respect to prestressing wires, concrete strength and dimensional tolerances. In the case of the SRT, prestressed monoblock concrete sleepers were supplied by private companies through competitive bidding, and laid along the double track section between Bangkok and Ban Phachi Junction, and the eastern seaboard line from Chachoengsao to Sattahip. The SRT's specification for any new line construction requires the use of only monoblock sleepers together with elastic rail fastenings. Sleepers are spaced at intervals 62 - 73 centimetres (or 1,375 - 1,600 pieces per kilometre).

Conventional rigid fastenings dominate the tracks of the subregion because of their low cost and ease of manufacturing, although concrete sleepers require elastic fastenings to effectively secure the rail in place. In Thailand elastic fastenings will in future be used, irrespective of the type of sleeper, to form part of continuous long welded rail track.

5.1.4.3 Ballast Depth

Sufficient ballast depth is required underneath sleepers to uniformly distribute the wheel loads to the sub-base of the track, in order to absorb impact and vibration from the moving trains, to offset against any differential settlement of the track, and to provide resistances to the transverse and longitudinal forces exerted to the sleepers by the swaying of the trains. A minimum depth of 250 mm is normally required. The TAR Links in the subregion do not meet this requirement because of constrained maintenance budgets. In Myanmar, 50-152 mm ballast depths were reported. A similar situation applies also in Cambodia and Viet Nam.

5.1.4.4 Bridges and Tunnels

There are no tunnels on all nominated TAR Links in Cambodia and Myanmar.

In Thailand, there is one tunnel of 230 metre length on the main northeastern line near Nakhon Ratchasima. It is in good condition. A total of 35 tunnels with a combined length of 10.57 km are located on the Hanoi - Ho Chi Minh City line (27), and on the Hanoi - Dong Dang line (8). The tunnel at Phu Gia near Danang is in urgent need of repair, while others are to be the subject of feasibility studies by foreign companies. Tunnels normally impose clearance constraints to passing trains, but this is not the case for the TAR Links in the subregion.

Bridges do pose many limits to the passage of trains, particularly in terms of the constraints they impose on axle loads, outline gauges, and speeds. It was mentioned in the 1994 UNDP - World Bank Report on Track Maintenance Planning for Myanma Railways that, there is an average of 2.3 bridges per route km, which is a high frequency as compared with other railways. Most bridges possess short spans of less than 3 metre length, are of the steel girder type and are heavily corroded. The abutments and piers are weak and unstable as the result of extensive cracks and foundation erosion. In addition, sleepers, rail fastenings and bearing plates are not securely in place and properly maintained, thereby restricting trains from carrying more load and from travelling at higher speed.

A similar situation exists in Cambodia. According to the World Bank Report for the 1995 ICORC Conference, there are 167 bridges on the "Old" Phnom Penh - Poi Pet line, of which 46 have suffered mine or war damage, but have received only temporary repairs. The "New" Phnom Penh - Sihanoukville line has 94 bridges, of which 15 are severely damaged. The Royal Cambodian Railway has undertaken bridge rehabilitation works involving 4 major bridges on the "Old" line, and 12 bridges together with 4 box culverts on the "New" line. The project is financed by an ADB loan, and is scheduled for completion in mid 1996.

The 1992 National Transportation Sector Review for Viet Nam described the condition of railway bridges to be generally poor. The bridges were either old or temporary, and lacked maintenance. On the Hanoi - Ho Chi Minh City line, 82 bridges were in satisfactory condition, 220 needed rehabilitation, and 51 required replacement. Works on the Hanoi - Dong Dang line include the rehabilitation of 8 bridges and the replacement of 1 bridge. The Hanoi - Haiphong line has several long-span bridges, which are old and have been damaged by bombs on several occasions. Among them are the Long Bien, Thang Long, Lai Vu, and Phu Luong bridges. Vietnam Railways is considering an OECF loan of US $ 100 million to finance part of the bridge rehabilitation programme.

There are no temporary bridges remaining on the SRT's proposed TAR links. Steel bridges were strengthened to accommodate a minimum axle load of 15 tons, and sufficient clearance for the passage of 9 ft high containers. Many old steel bridges were replaced by prestressed concrete deck type bridges designed for a higher axle load of 20 tons.

5.1.4.5 Signalling/Safeworking Systems

The railways of the subregion have not invested sufficiently to upgrade their signalling and train dispatching systems. The majority of the proposed TAR Links are still operated under manual token safeworking systems. Myanma Railways and the Viet Nam Railway generally employ a token block system with either semaphore or colour light signals. Semi-automatic systems can be found at major stations, including the Hanoi - Haiphong line which operates on the tokenless block with colour light signals. In the case of Cambodia, there are no fixed signals on any main line, or even within the Phnom Penh and Sihanoukville railway yard limits. Flags and hand signals are used for safeworking purposes. Point or interlocking machines are manually operated by train crews or station staff. Since early 1980s, the SRT has embarked on a major improvement of its signalling and telecommunication systems, encompassing the installation of tokenless block, colour light signals, all-relay interlockings, fiber-optic transmission lines, train dispatching telephones, and the CTC system (in the vicinity of Bangkok). Nevertheless, hand signals with manual interlockings can still be found in use on TAR Link T.3 from Klong Sip Kao to Aranyaprathet, and on TAR Link T.4 between Nakhon Ratchasima and Ubon Ratchathani.

5.1.4.6 Road Level Crossing Protection

As mentioned earlier, a high frequency of road level crossings is one of the major constraints on train speeds on various TAR links, especially those in Myanmar, Viet Nam and Thailand. Whether these crossings are protected or not, they impose delays on trains as a result of the necessity for train drivers to proceed through crossings at low speed for fear of fatal accidents.

In the 1991 JARTS Report on Preliminary Study for the Modernization and Rehabilitation of Viet Nam Railway Trunk Lines, level crossing facilities in Viet Nam were described. Guardmen were stationed at crossings with heavy road vehicle and passenger traffic to manually operate the movable barriers. Warning signs were present at the crossings, but no flashing alarms were installed.

In Thailand, more than 2,200 road crossings are equipped with level crossing protection, the types of which vary from automatic barriers interlocked with signals to simple warning signs. The installation and operating costs of the level crossing protection systems have been subsidized totally by the government. National policies have been implemented to limit future road crossings to a minimum, and to eliminate as many existing crossings as possible. These guidelines are often expensive and difficult to follow, but they are inevitable for the railroad to be competitive with other modes, and are supportive of the social and economic development of the nation.

5.2 Present Status of Locomotives and Rollingstock

In general, the main objectives of this section are to provide information on the availability, technical compatability and capacities of locomotives and rollingstock owned by the railway administrations of the subregion, so that future exchanges of equipment as well as railway operations across borders would be made possible to the mutual benefit of the participating railways.

5.2.1 Locomotives

The present distribution, by power class, of the locomotive fleets of the railways of Thailand, Cambodia, Viet Nam and Myanmar is shown in *Table 10.*

Table 10: Number of Locomotives Classified by Horsepower

SYSTEM	Number Within Horsepower Range:					Number by Traction Type:	
	Up to 750	750 - 1500	1501 - 2000	Above 2000	TOTAL	Diesel Electric	Diesel Hydraulic
SRT	43	124		134	301	227	74
ROYAL CAMBODIAN RWY	6	12			18		
VIET NAM RWYS		52	16				
MYANMA RWYS	24	178	66		268	157	111

The only metre gauge railway which has locomotives with rated power in excess of 2,000 HP is that of Thailand. In Myanmar, 15 Alsthom diesel electric of 2,000 HP were procured in the 1980s, and should have no difficulties achieving the recommended schedule speed and haulage load for container trains. This is not generally the case in Viet Nam where a freight train was observed near Hanoi being powered by a single 1,200 HP steam locomotive, with another being powered by triple headed 400 HP Russian made diesel locomotives.

Recently, the Viet Nam Railways acquired 20 re-conditioned locomotives of 800 HP from the Queensland Railway to service the Hanoi - Lao Cai line, and it is planned to acquire 10 more of the rebuilt units. The Russian locomotives were purchased during the war when locomotives of light axle loads were needed to run over temporary structures hastily erected to replace damaged structures. Viet Nam Railways, however, has 16 used locomotives from Belgium with a power rating of 1,800 HP operating between Hanoi and Danang. These units could as well satisfy the requirements for haulage of container trains. In the case of Cambodia, French Alsthom locomotives of 1,200 HP, and Czech Skoda locomotives of 1,100 HP are used on the two nominated TAR links. They do not have sufficient hauling capacity to haul container trains of the recommended length and speed (30 flat wagons at 70 km/hour) .

Trailing load restrictions, per single locomotive unit, are summarized as follows:

In Thailand, on level track, a restriction of 1,200 tonnes applies when using 2,400 HP Alsthom locomotives, and 1,800 tonnes in the case of 2,900 HP Hitachi locomotives. The restriction applying on the steep graded section of Link T.2 and T.5 between Kaeng Khoi and Nakhon Ratchasima is about 700 tonnes.

In Cambodia, 950-1,100 tonnes throughout the two nominated TAR links.

In Viet Nam, 1,200 tonnes applies to the Hanoi - Vinh section of TAR link T.1, 600 tonnes from Vinh to Danang, and 700 tonnes from Danang to Ho Chi Minh City. TAR link V.2 carries a trailing load restriction of 700 tonnes for the Hanoi - Dong Mo, section, and 400 tonnes from Dong Mo to Dong Dang. The entire Hanoi - Haiphong line (TAR link V.3) is limited to a 700 tonne load per locomotive.

In Myanmar, 1,300 tonnes throughout Link B.2 and also Link B.1 between Yangon and Mandalay, and 500-550 tonnes from Mandalay to Myitkyina.

It is advisable, and a common practice in the ASEAN countries, to haul 30 bogie container flat wagons using only a single locomotive. This train formation would normally have a trailing load of approximately 1,200 tonnes and a train length of about 450 metres.

Container Wagons

Table 11 provides details of the composition of the container wagon fleets. Cambodia and Viet Nam have not yet seriously embarked on railway transportation of containers, as only general purpose flat wagons are available for container transport (although Viet Nam is in the process of retrofitting a portion of its fleet with container anchors). Myanma Railways recently purchased 12 low floor ("well" type) bogie container flat wagons from China for the conveyance of ISO containers between Yangon and Mandalay. These wagons have a floor height of 632 mm, and each can carry one 20 ft ISO container of 8 ft 6 ins height. Thailand has developed railway container transport since the 1970s, but does not have low floor wagons in the fleet. However, the SRT's standard bogie wagons can accommodate containers of 9 ft 6 ins height on all TAR links, except for the section of TAR Link T.3 between Klong Sip kao and Aranyaprathet.

The competitive environment would require the conveyance of international containers across the borders of the countries of the subregion. Compatabilty of the wagons in terms of floor height, container carrying capacity, design speed, etc. needs to be considered in order to achieve best mutual benefits.

Coupler Systems

All Viet Nam rollingstock is equipped with automatic couplers at an average height of 825 mm above rail level. The SRT has the AAR type automatic coupler of 50 tonne draft capacity, and at a height of 850 mm above rail level.

Myanma Railways' low floor bogie container wagons come with automatic couplers located at a height of 584 mm above rail level.

Wagons of different couplers can still be marshalled together through the use of "connector" wagons having a different coupler type at each end. This is a temporary measure being taken by Malaysia and Thailand.

Table 11: Number of Container Wagons, by Class and Technical Characteristics

SYSTEM	Wagon Class	Maximum Loads (tonnes)			No. of Axles	Length over couplers (metres)	Floor Height (metres)	Speed (km/hour)	No. in Fleet
		Payload	Tare	Gross					
MYANMA RWYS	BCF	31	14.9	45.9	4	14.30	0.63	-	12
ROYAL CAMBODIAN RWY	FW				4	12-18	1.007		16
VIET NAM RWYS	M6318	30	15	45	4	11.4	1.10		18
	M6298	27	14	41	4	11.4	1.10		10
	M6228	25	12.6	37.6	4	11.9	1.10		5
	Subtotal								33
SRT	CF	20	7	27	2	7.7	1.01	70	104
	BCF	30	12	42	4	12.8	1.01	70	129
	BCF	47	13	60	4	12.8	1.01	70	20
	BCF	46	14	60	4	13.3	1.01	80	40
	BCF	45	15	60	4	14.8	1.01	70	20
	BCF	44	16	60	4	15.0	1.01	100	132
	BCF	49	11	60	4	13.3	1.00	80	6
	Subtotal								451

Source: Questionnaires, Country Papers and Railway System Rollingstock Registers

Notes:		
	BCF	Bogied Container Freight Wagon
	FW	Flat Wagon (Not specialized container wagons)
	M	Bogied Flat Wagon (Not specialized container wagons)

5.2.4 Brake Systems

Air brakes are standard on all Viet Nam rollingstock. Vacuum brakes, however, are still in extensive use in Myanmar and Cambodia. In Thailand, more recently purchased rollingstock is equipped with air brakes, and a programme to convert the existing fleet from vacuum to air brakes has been in effect for some years.

5.3 Operational Compatability

Two key parameters are vital to the efficient operation of international rail services across the borders of the participating countries. They are the hauling capacities of locomotives, and the available length of crossing loops or station sidings. Other less important parameters include different procedures required for the inspection, servicing, and non-scheduled repair of locomotives and rollingstock at the borders, as well as the level of training and the knowledge and experience of the relevant train crews of the neighbouring railway systems.

5.3.1 Compatability of Train Lengths

Assuming a locomotive length of 17 m, a bogie container flat wagon length of 14 m, and a brakevan length of 10 m, the recommended train formation of 30 wagons would require a minimum crossing loop or siding length of 450 m. With an adequate allowance for stopping distance, etc, the standard loop length would be 500 m.

In Thailand, the standard siding length for train crossing is at least **500** m.

In Cambodia, the Phnom Penh - Poipet line has shorter crossing lengths in the range of **350-450** m, while longer lengths of **450-600** m are standard on Phnom Penh - Sihanoukville line.

In Viet Nam, **450** m loop lengths are available on the main Hanoi - Ho Chi Minh City line (TAR link V.1), and also on the Hanoi - Haiphong line (TAR link V.3). On the Hanoi-Dong Dang line (TAR Link V.2), however, loop lengths are much shorter, ranging between **250** and **350** m.

In Myanmar, a standard crossing length of **518** metres is available on both proposed TAR links and thus these link could already accommodate container trains composed of 30 bogie flat wagons.

5.3.2 Compatability of Operating Procedures

It might be premature to discuss suitable operating procedures for international trains, as currently no trains cross borders in that part of the subregion under consideration in this Volume. Nevertheless, the compatability of operating procedures is absolutely necessary to ensure the competitiveness of the rail services. The "Agreement for Joint Traffic Working Over the Malayan Railway and the State Railway of Thailand, 1954" is a good example of the operational compatability which can be achieved between two neighbouring railway systems, as it contains, amongst other things, rules for the maintenance and servicing of one system's locomotives and rollingstock on the territory of the other system.

Consideration is being given by the Government of the Lao People's Democratic Republic to adopt a joint agreement, based on that in force between Malaysia and Thailand, for the future transit of trains across the Mekong River bridge from Vientiane to Nong Khai, and vice versa.

5.4 Traffic Growth Trends and Their Implications for Line Capacity

Traffic Growth

Tables 12 and 13 show the traffic growth, on a systemwide basis, of both freight and passenger services over the past eight years (1986-1993).

In terms of freight traffic, Myanma Railways has enjoyed continuous growth at a rate averaging 22 per cent per year. The Royal Cambodian Railway saw a drop in traffic for two consecutive years in 1990 and 1991, but has resumed a positive growth path since 1992. The Viet Nam Railways had a no-growth situation during 1986-1988, and a sharp drop in traffic volume in 1989. A slight recovery was observed in 1993, with volume being equal to that in 1988. The SRT recorded its highest level of freight traffic in 1991, but has experienced a small decline since then. In terms of million tonne-km carried by individual railways in 1993, the SRT had 3,059 as compared with 1,026 for Viet Nam, 861 for Myanmar, and 36 for Cambodia.

In terms of passenger traffic, Myanmar and Thailand have enjoyed a continuous increase each year. Viet Nam, however, has experienced a significant drop averaging 9 per cent per year. Cambodia saw a sharp increase of 300 per cent within one year in 1992, but a drop by 30 per cent in the following year. In terms of million passenger-km, the SRT handled 14,718 in 1993 as compared with 5,045 for Myanmar, 1,700 for Viet Nam, and 80 for Cambodia.

Traffic Forecasts

For its passenger services, the SRT has forecasted growth, on a systemwide basis, at a rate averaging 19.37 per cent per year during the 20 year period (1990 - 2011). This forecast assumes that the railway will maintain its market share of 16 per cent, which was the 1990 figure. These expectations could dramatically change if and when the rail network, as well as the railway performance begin to approach the system's potential for speed, safety and efficiency when double tracking, new fleets of rollingstock and other facilities have been put in place.

The rail market share of freight traffic in Thailand is very small compared with the share of passenger traffic. However, rail freight traffic is projected to increase by an average of 15 per cent every year during the same 20 year period (1990 - 2011). The freight segment which is expected to produce the largest increase is container rail traffic. The forecast shows a jump in volume of 860 per cent in 8 years, that is, from 57,500 TEU in 1993 to 495,800 TEU in 2001.

5.4.3 Traffic Forecast Assumptions Used for This Study

Similar to the procedures adopted in Volume 2, projected rates of traffic growth were used to predict the required extent and schedule of line capacity expansion on each of the TAR links in the subregion. As was the case in Volume 2, annual growth rates of 4 per cent and 8 per cent in the daily densities of trains (both freight and passenger) were used to represent pessimistic and optimistic expectations, respectively, over the 20 year forecast timeframe.

Table 12: Freight Traffic Growth, 1986 - 1993

SYSTEM	STATISTIC	Year:								Ave.per cent Change p.a.
		1986	1987	1988	1989	1990	1991	1992	1993	
SRT	Tonnes - mill.	5.29	5.59	6.22	7.05	7.89	7.99	7.60	7.50	5.1
	Tonne-Km - mill.	2,583	2,729	2,867	3,065	3,291	3,365	3,075	3,059	2.4
ROYAL CAMBODIAN RWY	Tonnes - mill.	-	-	-	0.16	0.13	0.08	0.13	0.14	4.0
	Tonne-Km - mill.	-	-	-	30.20	27.82	14.17	31.06	35.80	44.4
VIET NAM RWYS	Tonnes - mill.	4.14	4.00	3.93	2.43	2.34	-	-	3.40	
	Tonne-Km - mill.	961	1,001	1,016	743	847			1,026	
MYANMA RWYS	Tonnes - mill.	-	-	1.27	1.73	1.93	2.14	3.13	3.30	22.1
	Tonne-Km - mill.	-	-	315	424	491	515	836	861	24.1

Sources: Participating Railway Systems

Table 13: Passenger Traffic Growth, 1986 - 1993

SYSTEM	STATISTIC	Year:								Ave.per cent Change p.a.
		1986	1987	1988	1989	1990	1991	1992	1993	
SRT	Pass. - mill.	76.70	77.93	82.71	84.00	85.30	86.91	87.76	87.78	1.9
	Pass.Km - mill.	9,274	9,583	10,301	10,936	11,612	12,820	14,136	14,718	6.8
ROYAL CAMBODIAN RWY	Pass. - mill.				0.81	0.46	0.60	1.15	0.88	13.9
	Pass.Km - mill.				59.19	33.50	37.51	110.37	80.20	58.9
VIET NAM RWYS	Pass. - mill.	21.13	24.04	17.75	11.77	10.44	-	-	7.80	
	Pass.Km - mill.	4,196	4,884	3,506	2,109	1,913	-	-	1,700	
MYANMA RWYS	Pass. - mill.	-	-	36.66	48.49	53.18	55.19	56.61	58.60	10.4
	Pass.Km - mill.	-	-	2,672	3,672	3,907	4,325	4,896	5,045	14.1

Sources: Participating Railway Systems

5.4.4 Line Capacity and Line Capacity Utilization

The purpose of this section is to demonstrate the relationship between the existing line capacity and the current and forecasted daily train density. The results are tabulated in Annex 2.

5.4.4.1 Measurement of Line Capacity

The line capacity of each TAR link was calculated and reported by the participating railways, employing the standard formula applicable to single track sections, generally known as "Scott's Formula" , repeated here as:

$$\mathbf{LC = 1{,}440 \times f / (T + t)}$$

Where **LC** = Line capacity of the section, expressed in terms of number of trains per day.

1,440 = Number of minutes in a day

f = Track usage rate, 0.7 in general, to allow time for track occupation for purposes other than handling revenue earning traffic, such as track maintenance.

T = average time taken in minutes by trains to travel between two adjacent stations or passing loops.

t = average stopping time required in minutes as a result of signalling and safeworking procedures, 2.5 minutes in general and 1.5 minutes for automatic block systems

The "Scott's Formula" offers a rough estimate of the line capacity for a given section, knowing that a more detailed investigation would be needed to justify the high investment if it were decided to undertake new track addition or signalling system upgrading. ESCAP has developed a railway capital project appraisal model, which could be used to obtain a more accurate estimate of required track capacity.

5.4.4.2 Relationship of Current and Projected Traffic Density to Line Capacity

The rough estimates of the existing track capacities of sections forming TAR network within the subregion, together with the schedule of track expansion to accommodate the assumed 4 per cent and 8 per cent annual increases of rail traffic during the next 20 years period, are shown in Tables A-D of Annex 2.

In Myanmar, the last stretch TAR Link B.1 is congested, having 16 trains operating with a capacity reported by the Myanma Railways as only 12 trains per day.[1] Once the line is expanded to connect with the Chinese rail network at Kachang or Houqiao, a severe bottleneck will be encountered here. For the assumed 8 per cent traffic growth, the Thazi - Mandalay - Shwebo section will require more track capacity by the year 2002.

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[1] Additional comments on this capcity estimate have been provided in Section 7.

Based on the present environment, track capacities of the two TAR links in Cambodia are sufficient for the next 20 years. However, a different scenario could be experienced if the 48 km missing rail link with Thailand was resumed, or the port of Sihanoukville was expanded and modernized.

In case of Viet Nam, the Vinh - Danang portion of the main Hanoi - Ho Chi Minh City line (TAR link V.1), has already reached capacity, while other portions are still capable of handling additional traffic until the year 2000. The Hanoi - Dong Dang line as well as the Hanoi - Haiphong line will not be saturated at least until the year 2007.

The situation is rather different in Thailand which has already experienced many train delays because of track congestion. All nominated TAR links originating from Bangkok, especially the first 150 km portion, are heavily used for commuter rail services as the Bangkok Metropolis has greatly expanded during the past decade. Consequently, SRT has undertaken, since 1994, a track doubling project, the first phase of which covers a track length of 234 km in the Bangkok vicinity . The work was estimated to cost US $ 300 million, and is expected to be completed by 1997. The second phase would entail another 2,510 km of track doubling with a completion date set for the year 2000.

As mentioned earlier, increasing track capacity can be achieved in many ways with or without major capital expenditure. It is worthwhile to list some elementary features of railway operation and engineering, which help enhance and sustain a higher volume of traffic on the existing track capacity. They are, among others:

(a) Operational Organization: involving a detailed study of the traffic requirements, and a preparation of responsive train diagrams to give effect to the requirements with the best use of the available resources.

(b) Methods of Train Working: comprising a review of the existing methods to reduce the time for trains to spend at stations or passing/crossing the sidings and loops.

(c) Station and Yard Layouts: entailing a better design and facilities arrangement to ensure a minimum time required for trains to cross, marshal, or receive necessary services.

(d) Equipment Maintenance: encompassing routine check-up and quality maintenance of train working equipment such as points, track circuits, signals, cables, etc.

(e) Staffing: requiring a careful selection of well-qualified operators, and provision of a sound system of training.

All the above improvements can be realized without major capital expenditure such as track rehabilitation, track realignment, new track addition, signalling system upgrading, increasing motive power, and introduction of electric traction.

6. SPECIFIC CONTAINER TRANSPORT ISSUES

This section has a specific focus on the status of, and requirements for, container transport in the nominated TAR corridor in the greater Indo-China. These requirements, while being prerequisites for the transport of containers by rail in the TAR Corridor, are additional to requirements which the railway organizations themselves can satisfy and include the provision of adequately equipped rail served port and inland container handling terminals. Other requirements which are within the capability of the railway organizations themselves to provide, such as an adequate fleet of specialized container carrying wagons and an adequate locomotive fleet, are addressed in this section.

6.1 Current Development Status of Ports in the Subregion

6.1.1 Cambodia

The Port of Sihanoukville, 263 km by rail and 226 km by road from Phnom Penh handles more than 95 per cent of the containers entering and leaving Cambodia. The port is connected to Phnom Penh by National Road 4 and by the "new" railway line completed in 1969 and in this study designated TAR Link C2.

The port is currently served by two feeder ship calls per week, both provided by the Maersk subsidiary, C.M.C. One vessel is of 247 TEU capacity and the other of 81 TEU, and the average exchange (lift on/lift off) per vessel call is only 50 TEU.

The port comprises two wharves, one of 350 m length dedicated to container vessels and another of 300 m length for general cargo vessels. All container vessels serving the port have their own lifting gear, there being no shoreside facilities for the lifting of containers to/from vessels. The berth backup area comprises a container yard of about 17,600 square metres with a current capacity for 144 TEU (two tier stacking) and a total of five warehouses serving both wharves. The berth backup areas of both wharves are rail connected. The CY has the possibility of providing a future capacity of up to 400 TEU, or up to 600 TEU with three tier stacking of containers.

Two reachstackers, each of 45 tonne lifting capacity work the container yard. In addition, small forklifts and mobile cranes of limited lifting capacity are used in the CY and other berth backup areas.

The ADB is funding the resurfacing of the CY (to accept the wheel loadings imposed by the operation of reachstackers) and repairs to three out of the five warehouses as part of its Special Rehabilitation Assistance Programme (SRAP) which commenced in mid 1993.

6.1.2 Viet Nam

Since the Port of Ho Chi Minh City is not expected to generate container traffic for the railway, the development of container handling facilities in this port has not been considered here.

The Port of Haiphong, on the other hand, might be expected to provide the main potential for rail-borne container traffic, and the development of this port's container handling capacity is therefore of importance to this study, as is the longer term project to construct container terminal facilities at the port of Cai Lan.

The Port of Haiphong is located on the Cam River, 103 km by road to the southeast of Hanoi. The port handles import and export traffic for 24 provinces (out of a total of 53) in Viet Nam.

Draft available at low water is only 7.3 metres, restricting the size of vessels which may be handled to 7,000-8,000 DWT. The largest container vessel which may be accepted can carry 400 TEU. Six shipping lines serve the Port of Haiphong.

Three 40 tonne portal cranes manufactured in Russia (with container spreaders attached) are available for working vessels at the container berth. For loads of greater than 40 tonnes, vessel gear is used. It was claimed by an official of the Port of Haiphong that the shore cranes had the capability of loading and unloading a 400 TEU vessel in 20 hours (20 TEU per hour).

The shore cranes are backed up in the container stacking area by two Swedish built toplifter trucks each of 40 tonne capacity. Road prime movers and chassis are used to transfer containers between the berth and the stacking yard. However, railway sidings run along the entire length of the berths and are straddled by the shore cranes, thereby providing the basic infrastructure for shipside loading and unloading of railway wagons, once suitable wagons are acquired for the operation of container block trains.. There appeared to be sufficient clearance to permit flatcars conveying super high cube containers to run through the portal of each crane. The sidings along the container berth can accomodate 20 bogie wagons at any one time and are connected to a marshalling yard within the boundary of the port, as well as to the main marshalling yard at the Haiphong Station, two kilometres from the port.

The container stacking yard has an area of 60,000 m^2, which with 3 tier stacking of containers, gives a capacity of about 3000 TEU.[1]

There is a Container Freight Station (CFS) inside the port, but there is some off-port stuffing/unstuffing of containers. If a container is required to be transported to another province, it must be customs inspected and have all taxes paid in the port before being transported.

The vessel draft limitations at the Port of Haiphong, coupled with the unlikelihood that these limitations can be eliminated by further dredging, have encouraged the development of a new port facilities at Cai Lan on the shores of Halong Bay, about 60 km from Haiphong. Initial work at Cai Lan (from 1987) involved the construction of one general purpose berth of 160 m length (completed in September 1993). Further

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[1]. With a current throughput of 90,000 TEU, this would suggest a stack turn of 30 times per year and an average container dwell time in the port of about 12 days.

development of the port was to have included the construction of two berths with a dredged depth of 14 metres (to accomodate vessels of at least 10,000-15,000 DWT), resulting in an overall port capacity of 2 million tonnes per year. However, recently submerged rocks were found at a shallow depth in the access channel to the port, calling into question the environmental and economic justification for the further development of Cai Lan as a deepwater alternative to the Port of Haiphong. At the time this report was prepared, this issue had been unresolved.

A master plan (funded by the Japanese International Cooperation Agency) for the deverlopment of Cai Lan Port is in the course of preparation. Among the factors being considered in this master plan is the construction of a 6 km railway line to connect the port with the existing 1435 mm gauge line between Kep and Halong, as well as the possible dual gauging of this line to enable international traffic to/from Yunnan Province to be handled at the port. However, the subsequent announcement (during 1995) of a commitment by the Vietnamese Government to the adoption of the metre gauge as the standard for the railway network has implied the need for the port master plan study to consider the construction of the Cai Lan rail connection in metre gauge, as well as the conversion of the Kep-Halong line to metre gauge, in conformity with this policy.

6.1.3 China

The options of the Province of Yunnan for the movement of its export trade to seaports were addressed in Section 3 of this report. Despite the comparative proximity of the Vietnamese ports of Haiphong and Cai Lan to the international trade sources in Yunnan Province, it is likely that factors of national interest, as well as the construction of a double tracked electrified line linking Kunming with Nanning, will operate to have a Chinese port designated as the outlet for Yunnan trade.

The port of Fancheng in Guangxi Province is most likely to be designated as the outlet for Yunnan trade. In common with the port of Haiphong and now apparently the port of Cai Lan, Fancheng has the disadvantage of shallow draft (7.5 m at low tide), but is does have established infrastructure, including 7 berths (five for bulk cargoes and two for general cargo) and a rail connection, as well as an active development programme. The latter includes the construction of a specialized container berth and an additional bulk berth, for which the Fancheng Port Authority is seeking about US$ 50 million in funding assistance from the ADB.

6.1.4 Myanmar

Currently, almost all of the container trade of Myanmar is handled through the Port of Yangon. Container handling is undertaken at the Bo Aung Gyaw Street Wharf 2, which comprises two berths for geared container carrying vessels, a container yard with an estimated capacity to hold 1515 TEU[2] at any one time (606 TEU ground slots, with an average 2.5 container stacking height), and 2 container freight stations (CFS) - one each for the stripping of import containers and the stuffing of export containers.

The container berth is equipped with one 40 tonne rubber tyred gantry crane (RTG), one 40 tonne toplifter and one 15 tonne forklift (for empty container handling). An unspecified number of 2.5 tonne forklifts operates in the CFS buildings.

The maximum realistic throughput of the container port has been calculated at 67,200 TEU per year. The current throughput is barely one third of this figure, but throughput growth is restricted by several factors which operate to reduce the efficiency of road vehicle access to the port. The Bo Aung Gyaw St Wharf 2 is located near the Yangon Central Business District and vehicular traffic in the vicinity is frequently congested.

In theory, the Port's container yard is connected to the rail network, but in practice the rail link cannot be used for container transport. When the container port was constructed in 1990, two railway sidings were built, bisecting the CY itself. When the port was inspected by the study team, these sidings were covered with stacked containers, and it was indicated that the sidings had not in fact been used for the purpose for which they were intended since the container port has been in service.

The restricted area available for the CY would make it difficult to release the sidings for the receipt and despatch of railway wagons, but that is precisely what must happen if the railway is to successfully introduce intermodal services to hinterland centres. Each siding has sufficient length to accomodate 10 bogie flat wagons at one time, and while both sidings together would not hold sufficient wagons to make up a block train, the vastly inferior alternative would be to transfer containers by road to/from the marshalling sidings, some distance from the port. While the container port does not have a practical direct rail access, the Botataung Railway Goods Sidings opposite the port provide facilities from which several freight forwarders operate and at which limited stuffing of export containers is done.

An alternative to the handling of containers at the present container port exists in the form of the new port location at Thilawa on the eastern bank of the Yangon River and southeast of the present port. The recent completion of a combined road and rail bridge across the Bago River (with Chinese Government technical and financial assistance) has provided the Thilawa site with a potential land transport access to Yangon, but development of container handling facilities at this location is unlikely to proceed in the medium term (within the next ten years). In the meantime, therefore, it will be necessary to adapt facilities at the existing container port for direct rail operation.

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[2]. With port container throughput currently at about 24,000 TEU per year, the container stack in the CY would turn only 15.8 times per year, meaning that the average port dwell time for a container is as much as 23 days. (This would appear to agree with the observation in the Comprehensive Transport Study that a typical container dwell time of 15-20 days is currently experienced in the Port of Yangon, as compared with a dwell time of 8.2 days required for the port to reach its estimated throughput capacity).

6.2 Development of Rail Served Inland Container Depots (ICDs) in the Subregion

6.2.1 Cambodia

An ICD is planned for development (commencing in 1996) near the intersection of TAR Link C2 with National Road 4, some 9 km to the southwest of Phnom Penh. It is understood that this project will be undertaken as a joint venture between the Port of Sihanoukville and Singaporean interests. No details of the planned capacity and equipment of this facility are yet available.

6.2.2 Viet Nam

As mentioned in earlier sections of this report, the Vietnam Railways has a plan to construct an ICD at Yen Vien Station, 10.9 km and 101.9 km by rail from Hanoi and Haiphong respectively, and potentially 169.7 km by rail from Cai Lan. However, a recent seminar organized by the Ministry of Transport of Viet Nam and sponsored by UNDP on the subject of the "National Multimodal Transport Corridor Study, Haiphong-Hanoi" has cast doubt on the suitability of Yen Vien as a site for an ICD, given the softness of its sub-soil, its susceptibility to flooding and its lack of adequate area for future expansion.

While it was mentioned during the visit of the study team that discussions had been held in early 1995 with New Zealand Rail about the possibility of a joint venture to develop this project, there has been no indication of further progress with this proposal.

Yen Vien has the advantage of being located on the dual gauged part of the system (giving it a connection with Guangxi Province of China and with the new port at Cai Lan), although this may no longer be an advantage if the Government of Viet Nam adheres to its plan to remove standard and dual gauged track from the system.

6.2.3 Yunnan Province of China

It is understood that ICD facilities are in operation in Kunming, although no details of the capacities and equipment of these facilities were made available to the study team.

6.2.4 The Lao People's Democratic Republic

The limited volume of international containers arriving in and departing from the Lao People's Democratic Republic is at present handled at the Tarnaleng Freight Terminal, near the new Mittaphab Bridge linking the Lao People's Democratic Republic with Thailand across the Mekong River, and approximately 20 km east of Vientiane. Bonded storage facilities are available at this terminal, as are container stripping/stuffing facilities.

It is not planned to use the Tarnaleng Terminal in conjunction with the proposed development of a railway line linking Vientiane with Nong Khai (Thailand). Instead, the latter proposal makes provision for the construction of a specialized rail freight terminal 4 km east of the centre of Vientiane. It is understood that this terminal will be provided with container handling facilities and equipment, although no details of the latter were available in advance of a feasibility study being conducted by the Pacific Transportation Company Ltd (the joint venture partner with the Government of the Lao People's Democratic Republic in the proposed Lao National Railway Company Ltd).

6.2.5 Myanmar

It was indicated to the study team during their mission that a rail served container terminal was being constructed on railway property at Mandalay. The function of this terminal will be to transfer containers to and from rail vehicles for transport between Mandalay and Yangon port. It is **not** intended to provide full container handling services there - eg. stuffing/unstuffing would be undertaken at consignor/consignee premises. A mobile crane with 40 tonne lifting capacity would be provided at this terminal. No other details of this facility were provided to the study team.

7. DEVELOPMENT NEEDS FOR THE TAR NETWORK

It is the purpose of this section to identify the physical needs and associated costs of a programme to upgrade existing TAR Links, or to construct new TAR Links, for that part of the subregional TAR under consideration in this Volume, in conformity with the *minimum* technical and operational standards identified and recommended in Section 4. This programme would be designed to accomodate the projected traffic in the TAR network of the subregion over the next 20 years.

The four major objectives of such a programme are to:

(a) Allow the transport by rail of ***high cube (9ft high)*** and ***super high cube (9ft 6 ins high)*** containers;

(b) Increase maximum permissible axle loads to at least ***15 tonnes***;

(c) Increase maximum speeds for container carrying freight trains to ***70 km/hour*** ; and

(d) Increase line capacities to accomodate forecasted traffic growth.

Additionally, this section addresses the needs of railway systems participating in container transport services in the TAR corridor for adequate numbers of specialized rollingstock and locomotives to handle the forecast container movement task over a 20 year period.

7.1 Network Upgrading to Handle High Profile Containers

The current structure and vehicle outline dimensions applicable in all participating countries were reviewed in Section 5. The physical work (and associated expenditures) necessary to modify structures in order to provide sufficicient dimensional clearance to permit the passage of high profile containers in each country is considered below.

7.1.1 Thailand

As already mentioned in Section 5, the State Railway of Thailand has already undertaken an extensive programme of structure gauge enlargement in order to remove all obstacles which might interfere with the transport of high profile containers.

At present, there remain only 6 bridges on the Bangkok-Padang Besar line (TAR Link T.1) and 4 on the Bangkok-Aranyaprathet line (TAR Link T.3) to be modified, at an estimated cost of ***US$ 300,000***. Included in this cost is the value of minor work to be done on 18 bridges along the two TAR links in order to ensure a minimum gap between the structure gauge and the outside dimensions of super high cube containers loaded on standard height (1,010 mm) flat wagons.

7.1.2 Cambodia

Existing outline dimensions on both of the nominated TAR links are sufficient to permit safe conveyance of ISO containers of both 8ft and 8ft 6ins height. Containers of 9ft 6ins height, however, would infringe the structure gauge by approximately ***320 mm***, due largely to the presence of many steel through trussed bridges (as there are no tunnels) along both links. One solution to this problem is to adopt ***well-type*** wagons, or wagons with small diameter wheels, with a floor height not exceeding 690 mm above rail level.

Although a size breakdown of port container throughput statistics for Cambodia was not available (making an forecast of the container transport task for rail difficult), it was assumed that the proportion of high and super high cube containers in the current port throughput was nil or close to nil. Based on the further assumption that the proportion of high cube and super high cube containers in the total TEU of containers to be conveyed by rail between Sihanoukville and Phnom Penh will be approximately 1 per cent in the year 2000, rising to 2 per cent by 2005, 2.5 per cent by 2010 and 3.0 per cent by 2015, the numbers of such containers to be conveyed by rail in those years can be anticipated as 90, 310, 520, and 840 units respectively.[1] In future years, it would not be unreasonable to expect that a three day turnround of wagons could be achieved in container feeder services between Sihanoukville and Phnom Penh. Thus, approximately 200 single trips per year could be achieved by each wagon. With a 10 per cent spares allowance, the number of low floor wagons required can be calculated as one unit in 2000, 2 units in 2005, 3 units in 2010 and 5 units in 2015. At an estimated cost of US$ 100,000 per wagon, the total cost of acquiring the above indicated number of wagons would be US$ 100,000 in each of 1999, 2004 and 2009, and US$ 200,000 in 2014. Clearly, therefore, the required investment in low floor container wagons for the movement of high profile containers in Cambodia would be negligible, and certainly much less than if adjustments to bridge structures had to be undertaken. It should be noted that there is no expectation of a movement of high profile containers on the Phnom Penh-Poipet line (TAR Link C.1).

7.1.3 Viet Nam

There are many tunnels along the nominated TAR links in Viet Nam - 27 on the Hanoi-Ho Chi Minh City link (V.1), and 8 on the Hanoi-Dong Dang link (V.2). Fortunately, the tunnel sections are large, allowing the conveyance of super high cube containers with an ample clearance of about 480 mm. However, the structure gauge, which is controlled by the dimensions of fixed installations, such as steel through trussed bridges, wayside signs, signal posts, platform hangars, etc., clears the top profile of super high cube containers by only 120 mm. To provide a sufficient margin of safety, without the need for substantial speed reduction, a minimum gap of 300 mm is normally required. One solution is to reduce train speeds sufficiently to compensate for the dynamic effects of moving trains, but this would not be desirable as it could extend transit times and make the railway service uncompetitive. Another solution would be to introduce low floor wagons, similar to those suggested for Cambodia. In this case, the floor height of the special wagons should not exceed 830 mm above rail level. Again, there was insufficient information on which to base

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[1] These numbers are based on the forecasts of the total rail container task as shown in Table 5 of Section 3 of this volume.

a judgement about the number of such wagons required over the 20 year forecast timeframe.

Using similar assumptions to those used in the case of Cambodia, the numbers of low floor wagons required for container feeder services between Haiphong and Hanoi would be 1 unit in 2000, 3 units in 2005, 5 units in 2010 and 9 units in 2015.[2] Purchase of these wagons would require expenditures of US$ 100,000 in 1999, US$ 200,000 in 2004 and 2009, and US$ 400,000 in 2014.

7.1.4 Yunnan Province of China

It is understood that the new TAR links being proposed for construction in Yunnan Province (Y.1 and Y.2) will have a structure gauge providing ample clearance for the passage of super high cube containers mounted on standard height flat wagons. Although no specific details were provided, it was indicated during discussions with officials of the Yunnan Railway General Corporation that the metre gauge TAR Link Y.3 (Kunming-Hekou) is unable to accomodate high profile containers. The use of low floor wagons would provide a solution to this problem, but in view of the *possibility* that this link may be reconstructed with a track of 1435 mm gauge, it is likely that the problem will be automatically eliminated in the longer term.

7.1.5 Myanmar

Throughout the nominated TAR links in Myanmar, outline gauges are very restricted, and indeed are unable to accomodate even 8 ft high containers mounted on standard height (1,010 mm) container flat wagons. The restrictions are presented by bridges, as there are no tunnels on the nominated TAR links. Any attempt to modify these bridges would need to take account of their current condition. According to the Myanmar Comprehensive Transport Study of 1993, most of the bridges on the Mandalay line (TAR Link B.1) are old and it is probable that in the longer term their repair would be more expensive than their replacement with lower maintenance concrete bridges. The costs of repairing these bridges would in any event be inflated by the costs associated with having to replace their weak and inadequate foundations.

The conclusions of the foregoing study would appear to have stong merit, as well as the further advantage that bridge replacement would effectively remove physical restrictions on the conveyance of high profile containers, while at the same time allowing axle loads and train speeds to be increased.

In order to prepare a cost estimate of the required bridge replacement work, a factor of 0.7 was applied to the combined length of all bridges on the TAR links. The reason for this is that some of the existing openings could be abandoned or reduced in size because of new hydrological developments. The combined length of many existing short-span bridges can also be reduced without reducing the width of openings, because new

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[2] In this case, however, the turnround of wagons operating between Haiphong and Hanoi was assumed to be 2 days, meaning that the annual single trip capability per wagon is 300 (based on 300 operating days per year)..

bridges come with much larger spans thereby requiring a lesser number of abutments which account for the sizes of openings.

Prestressed concrete bridges with span lengths of 6-15 metres are strongly recommended. The main girders can be precasted in the factory and transported to the construction site by rail. The girders are then assembled on site to form a ballast deck before being positioned on the abutments. For longer span lengths of 20-40 metres, in site casting of post-tensioned U-shaped bridge sections could be introduced with substantial benefits. Based on current SRT cost data, the average cost per metre length of prestressed concrete bridges is ***US$ 11,000***. Application of this unit rate to the relevant bridge lengths results in the total costs shown in Table 14.

Table 14: Cost of Bridge Repacement, TAR Links in Myanmar

TAR Link	Line Section	Length of Bridges (m)	COST (US$ million)
B.1	Yangon-Mandalay	3,653 x 0.7 = 2,557	28.1
	Mandalay-Myitkyina	2,850 x 0.7 = 1,995	21.9
B.2	Yangon-Motama	1,642 x 0.7 = 1,149	12.6
	TOTAL	**5,701**	**62.6**

7.2 Network Upgrading to Increase Axle Load Limits

In Section 4, it was recommended that a *15 tonne* axle load limit should be adopted throughout the metre gauge portion of the TAR network in the subregion. This recommendation was made having regard for the prevailing gross weights of modern six axled locomotives and of standard container flat wagons carrying two ISO 20ft containers. The following sub-sections outline the physical requirement and associated cost of a works programme to achieve compliance with this standard in each participating country.

7.2.1 Thailand

A works programme to increase the axle load carrying capacity of the TAR links nominated for Thailand will not be necessary, as all of the nominated links (T.1-T.5) are currently capable of carrying the the recommended 15 tonne axle load.

7.2.2 Cambodia

According to the 1995 Cambodia Transport Rehabilitation Study report, the line connecting Phnom Penh and Poipet (TAR Link C.1) was originally designed for an axle load of only 10 tonnes, while the line linking Phnom Penh and the port of Sihanoukville (TAR Link C.2) was designed for an axle load of 20 tonnes. It was further mentioned in the Country Report submitted to ESCAP in July 1995 by the Royal Railways of Cambodia that, after some 60 years of operation, the track condition of the Phnom Penh-Poipet line, known locally as the "Old" line, was very poor as a result of limited maintenance and virtually no replacement of track materials. The 30 kg/m rails used on this line are now showing excessive wear and rail breakages are common. In addition, roadbed erosion is severe with the result that the width of the track formation throughout the entire length of the line has reduced considerably. During the war period of the 1970s, the entire railway network was devastated, with 70 per cent of bridges, 80 per cent of station buildings, and the 48 km stretch between Sisophon and Poipet sustaining severe damage. The line was heavily mined, and several sections have in recent years been subjected to frequent guerilla attacks. The Phnom Penh-Sihanoukville line, known locally as the "New" line, built in 1960s, employs heavier rails of 43 kg/m, but was reported to have similar problems to the Old line, with respect to track instability. A lack of sufficient ballast, of proper drainage, and of adequate replacement of life expired timber sleepers pose critical problems for the continuing operation of the New line.

In view of the current condition of the Old line, it is estimated that an increase of its axle load limit from 10 to 15 tonnes would require the replacement of up to 70 per cent of its bridges and the renewal of up to 80 per cent of its mainline trackage. *This would involve 2,538 metres of bridge replacement at a cost of US $ 27.9 million, and 270 kilometres of track renewal at a cost of US $ 59.4 million.* Excluding the cost of clearing the land mines along the track, the overall cost of upgrading the "Old" line to accomodate a 15 tonne axle load would be approximately *US $ 87.3 million.*

For the "New" line, which was originally designed to carry an axle load of 20 tonnes, it is estimated that minor rehabilitation work such as ballasting, installation of proper drainage, sleeper renewal and bridge repairs, etc. would be required in order to ensure safe operation of rail vehicles imposing a 15 tonne axle load. It was estimated in the 1995 Cambodia Transport Rehabilitation Study Report that the restoration of the "New" line to its original condition would cost some *US $ 8 million.* This estimate appears to be on the low side, but should be sufficient to achieve the recommended 15 tonne axle load, representing as it would a 25 per cent reduction from the original design axle load standard. For long-term improvement, the line should be upgraded to the minimum standards of metre gauge track, thus requiring an expenditure of about *US $ 63 million.*

7.2.3 Viet Nam

The main railway artery of Viet Nam is the Hanoi - Ho Chi Minh City line, TAR Link V.1, comprising 1,726 km single track of 1,000 mm gauge, 1,300 bridges with a combined length of 25.71 km, and 27 tunnels of 8.57 km in length. The axle load limits vary from 14 tons between Hanoi and Danang (791 km), and 12 tons from Danang to Ho Chi Minh City (935 km).

According to JARTS' 1991 Preliminary Study for the Modernization and Rehabilitation of Viet Nam Railway Trunk Lines, the railway network was heavily damaged during the war which lasted for 15 years. After the war, the Hanoi - Ho Chi Minh City link, being the main artery of land transport, was repaired hastily so that train services could be resumed without delay. Major repair works included rerailing with 43 kg/m rails, replacement of many worn-out sleepers with locally-made two-block ordinary reinforced concrete sleepers, roadbed stabilization at critical locations, bridge repair (involving steel girder strengthening and/or replacement), and installation of temporary piers as additional bridge supports, etc.

Despite these immediate measures, there remained many works to be done to secure safety and reliability for the passage of express passenger trains at speeds of 90 - 120 km/hr. It was obvious that, the main concern or objective of the rehabilitation program was to increase the permissible speed of the line, thereby reducing travelling time between Hanoi and Ho Chi Minh City from 36 to 24 hours or less. The axle load limit was not the issue as the existing 14 tonnes was adequate for the present traffic.

Upgrading works needed to achieve the above-mentioned line speed improvements were estimated by JARTS to include: installation of additional 43 kg/m rail and concrete sleepers; ballast addition; replacement of bridges at the six most critical locations on the line; replacement of all temporary abutments and piers; rehabilitation of other bridges; repair of tunnels to protect against rock-falls and further cracking of walls; roadbed improvement especially in frequently flooded sections; realignment of sections with sharp curves and steep gradients; and provision of level crossing barriers and warning signs. No cost estimates for these works were provided in the JARTS report.

The report, however, strongly recommended that, as a long term measure, the line should be fully upgraded to international standards for metre gauge track *which would include a maximum permissible speed of 120 km/hr, and an axle load limit of 20 tonnes.* Adoption of these standards would require, amongst other things, the use of 50 kg/m rail, monoblock prestressed concrete sleepers, elastic rail fastenings, continuously welded long lengths of rail, standard size ballast with sufficient depth, and high speed turnouts. Additionally, such an upgrading programme would involve the replacement of all steel bridges on the line, except 27 welded through-trussed bridges which are designed for a 22 tonne axle load, with prestressed concrete bridges which are insusceptible to saltwater corrosion. All tunnels would require detailed investigation and permanent repair, and block, signal, interlocking and communications equipment would also have to be improved.

It appears, however, the rehabilitation work undertaken thus far on the line has already placed it in a condition suitable for accepting a maximum axle load of 15 tonnes, provided that speed limits are imposed on sections and structures where the load bearing condition remains relatively weak. Ultimately, however, there is merit in the JARTS recommendation that the line should be upgraded to meet the international standards described above, in that the railway would thereby be made more competitive and supportive of the economic development of the nation. The preliminary estimate made for this study indicates that it would cost approximately ***US$ 510 million*** to upgrade track, bridges, tunnels and buildings in order to achieve the above-mentioned operational standards on TAR Link V.1. Upgrading/modernization of signalling and telecommunications systems would possibly account for another ***US $ 200-250 million.***

TAR Link V.2 (the 162 km Hanoi - Dong Dang dual-gauge line) has a theoretical axle load limit of 14 tonnes. However, according to the 1992 National Transportation Sector Review for Viet Nam, the condition of track, bridges and tunnels on this line is similar to that of the Hanoi - Ho Chi Minh City line. Most of the bridges were damaged during the war, and received only temporary repairs. Among them were 10 bridges between Lang Son and Dong Dang which were vastly destroyed, and have not been rebuilt. The line, originally built as a metre gauge line, was later modified in 1960s to become a dual metre/standard gauge line, without any widening and strengthening of the existing track formation. Consequently, the roadbed was overloaded and deteriorated within a short period of time. A recommendation endorsed by the National Transportation Sector Review was that, in order to save the costs of track renewal and future maintenance, the line should be re-converted to a metre track gauge. A cost estimate for this work was not provided, but it was estimated that renewal of track, bridges, tunnels and buildings to meet minimum standards for metre gauge track would cost some ***US $ 60 million.***

The third proposed TAR link in Viet Nam, Link V.3 (the 102 km Hanoi - Haiphong line), has an axle load limit of 14 tonnes, and contains 12 bridges, including the historic Long Bien bridge across the Song Hong river near Hanoi, which was built in 1902 and damaged several times during the war. According to the National Transportation Sector Review, the condition of the bridge places it beyond economic repair, and an alternative solution was proposed to cross the river via the Thang Long bridge located upstream. The overall condition of the Hanoi-Haiphong line is equally bad. The cost of renewing track and bridges to put them in safe condition for operation with axle loads of 15 tonnes is estimated to be approximately ***US $ 25 million.***

The final TAR link proposed for Viet Nam is Link V.4, the 285 km metre gauge line from Yen Vien, near Hanoi, to Lao Cai on the border with China. This line traverses mountainous terrain and is subject to frequent landslides and flooding at its lower elevations. Track condition is described as poor and most of its bridges require extensive repair, or replacement. Upgrading of this line to meet the minimum 15 tonne axle load standard is estimated to cost US$ 30 million at 1990 prices, or approximately ***US$ 38 million*** at 1995 prices.

7.2.4 Yunnan Province of China

The continuation of TAR Link V.4 into Yunnan Province of China is the 468 km metre gauge line connecting the border town of Hekou with Kunming, designated TAR Link Y.3 in this study. It is believed that this line, which is under the control of the Chinese Ministry of Railways, has recently been rehabilitated, but the adverse topography of the line limits maximum speeds to only 40-45 km/hr. The axle load limit of the line is understood to be 18 tonnes which while lower than the standard applying to the 1435 mm gauge in China is nevertheless well above the 15 tonne standard recommended for the TAR metre gauge network.

7.2.5 Myanmar

It was reported in the UNDP's 1994 Track Maintenance Planning Study for Myanma Railways that the overall track condition is very bad. The system overall was designed only for a maximum permissible load of **12 tonnes** and consequently only relatively light rail of 25 - 37 kg/m was installed in track. Over time weaknesses have been revealed in the form of undulated wear and breakage of rail. Some 99 per cent of sleepers are of timber and untreated except with the application of creosote. They have a short lifetime and their deteriorated condition, together with widespread use of dog spike fastenings (on more than 90 per cent of track), means that rails cannot be held in place securely on much of the system. The entire network suffers from a severe lack of ballast.

It is evident that there will be a need to renew almost the entire network if axle loads are to be raised from 12 to 15 tonnes or higher. Bearing in mind that some track rehabilitation works have been undertaken more recently, and that certain track components might be capable of re-use, the cost estimate in this study is based on **80 per cent** of the total track length.

According to SRT experience, rails and accessories account for about 40 per cent of the total track renewal cost, sleepers and rail fastenings 30 per cent, ballast 5 per cent, and labour 25 per cent. Based on the use of 50 kg/m rail, in association with a design axle load of 20 tonnes, the unit cost for track renewal is US $ 280,000 per kilometre of track. The unit cost reduces to ***US $ 220,000/km*** when 40 kg/m rails and a 15 tonne axle load are specified. The Yangon - Myitkyina line (TAR Link B.1) comprises a double track from Yangon to Pyinmana (360 km), and a single thereafter. The double line portion also requires track renewal.

The estimated total costs of track renewal required to achieve 15 tonne axle loads are shown in Table 15.

Table 15: Cost of Upgrading for 15 tonne Axle Loads, TAR Links, Myanmar

TAR Link	Line Section	Track Length (Km)	Cost (US$ million)
B.1	Yangon-Pyinmana	724 *	159.28
	Pyinmana-Myitkyina	802	176.44
B.2	Yangon-Thaton	215	47.3
	TOTAL	**1,741**	**383.02**

** Route length of 362 km, multiplied by 2.*

When the cost of bridge replacement (see Section 7.1) is added to the above costs, the overall cost of system renewal to achieve a 15 tonne axle load standard amounts to approximately ***US$ 460 million.***

7.3 Network Upgrading to Increase Speeds

The recommended maximum speed for container trains throughout the TAR metre gauge network is **70 km/hr** (see Section 4). With the exception of the Thai system, none of the participating metre gauge railway systems is capable of achieving that speed. Data presented in Annex 1 indicate that low speed limits for freight trains apply throughout the TAR metre gauge network. For example, speed limits applying to freight train operations are 35-40 km/hr in Cambodia, 30-60 km/hr in Viet Nam, 40-45 km/hr on the metre gauge Link

Y.3 in China, and 32-48 km/hr in Myanmar. Almost without exception, these low speed limits have been necessitated by the deteriorated state of tracks, bridges, and rollingstock.

If the investment in track and structure upgrading outlined in Section 7.2 were carried out, both the axle load and maximum speed requirements recommended for the TAR metre gauge network would have been fulfilled, provided that locomotives and rollingstock in a satisfactory state of repair are available for operation.

7.4 Network Upgrading to Expand Line Capacity

Single line, metre gauge track dominates the TAR network in the subregion. With the exception of the double track 362 km Yangon-Pyinmana section of TAR Link B.1 in Myanmar and of the double track 90 km Bangkok-Ban Pachi section of TAR Link T.2 in Thailand, all of the TAR network in the subregion is of single track configuration. Depending upon:

- the topographical features of these routes (principally prevailing gradients and line curvature);
- the spacing and length of tracks for the passing or crossing of trains;
- the signalling/safeworking systems in use; and
- other constraints on operating speeds (such as the condition of track and bridges, the frequency of road level crossings, the horsepower capacity and condition of locomotives, and the condition of rollingstock),

the *capacity of the single track sections* comprising these routes will be the limiting factor on their ability to transport the international container traffic forecasted for the TAR Corridor. For this reason, the measurement of line capacity and of the extent and timing of the required expansion of this capacity is an important element of this study.

Three complementary measures aimed at line capacity expansion were evaluated in this study - the upgrading of track and structures to achieve a maximum line speed for freight trains of 70 km per hour, the upgrading of signalling/safeworking systems and the provision, where necessary, of additional trackage for the crossing (opposing) or passing (same direction) movement of trains through individual line sections.

In the case of the upgrading of track and bridges for higher speed operation, the physical improvements required, and their associated costs, would be identical to those required for increased axle load limits. These were outlined in Section 7.2. Such improvements would lift the maximum speeds for freight trains from their current levels to 70 km per hour, with a pro-rata increase in average transit, or schedule, speeds which in turn would increase the daily train throughput capability of individual single line sections. However, such improvements might not of themselves provide sufficient additional line capacity to support the projected traffic growth on these sections. Consequently, it might be necessary to complement them with the construction of additional trackage and/or with signalling/safeworking system improvements.

It becomes important, therefore, to assess the extent and timing of any requirement for line capacity improvements which would be *incremental* to the speed improvements resulting from the upgrading of track and bridges.

7.4.1 Method for Calculating Line Capacity Expansion Requirements

Where relevant and where sufficient data were available, such assessments were made with the assistance of the ***ESCAP Railway Capital Project Appraisal Model.***

The physical facilities planning component of this model ***(RFACIL)*** estimates, among other things, the train crossing capacity requirements on a single track section, given the number and length of crossing tracks in the section, the maximum daily number of trains transitting the section in the starting year, the expected growth rate in the daily number of trains over the forecast period, and the schedule (or average transit) speed of the *slowest* train transitting the section.

The model first calculates, for each of the forecast years, the maximum number of trains expected to pass through the specified line section within a 24 hour period. This it does by applying a given growth rate to the existing number of trains.

From the daily number of trains it then calculates, by apportionment (and with the application of a factor to allow for concentrated despatching of trains during peak periods), the maximum number of trains which can be expected to be within the line section during the time period taken by the slowest train to transit the section. From the latter figure, the model calculates the number of crossing tracks required (which is the total number of trains in the section during the maximum transit period less one). If the spacing of the crossing tracks determined by this process falls below a specified minimum distance, the model then indicates that line doubling (ie. the construction of a second track) is required.

The final output of the ***RFACIL*** component of the model is a schedule of the physical trackwork construction (in kilometres) needed to provide the additional train crossing capacity compatible with forecast traffic growth in the given line section.

At best, the model can only provide a ***guide*** to the additional line capacity needed. It should not be regarded as a substitute for a more detailed assessment of capacity needs. Such a detailed assessment would allow considerably more refinement in the estimation process. For example, while the model necessarily has to treat all existing crossing tracks as optimally located (owing to computer capacity and data limitations), a detailed assessment perhaps assisted by a single line operational simulation model, would critically evaluate the locations of all existing crossing tracks. Nevertheless, within these limitations, the model has the capability of providing a valid indication of train crossing capacity requirements.

A sample of the output from the model is provided in Annex , to provide an indication of its capabilities as an analytical tool for line capacity assessment.

7.4.2 Determination of Line Capacity Expansion Requirements in Participating Countries

Not all of the participating countries supplied adequate data to enable the model to be used in assessing line capacity expansion requirements on the TAR links within their territory. In some other cases - for example, where current service frequency was clearly well below the capacity of lines - it was not considered necessary to run the model. Nevertheless, an assessment of capacity expansion requirements on all existing TAR links was attempted, from whatever sources were available, and the results of this assessment are given below.

7.4.1.2 Traffic Growth Assumptions

In all cases, line capacity was assessed against two alternative traffic growth scenarios - a "low growth" scenario in which the maximum number of trains operating within a 24 hour period on each line section would increase by 4 per cent a year, and a "high growth" scenario in which the maximum daily numbers of trains on each section would increase by 8 per cent a year. It should be noted that in the case of all TAR links, line capacity expansion will be justified by growth in the *total traffic task* and hence all traffic segments, including containers, can be expected to benefit from capacity expansion. It therefore becomes difficult, if not impossible, to assign benefits and to attribute costs to individual traffic segments. *Nevertheless, it is possible to conclude that without this capacity expansion, it is most unlikely that the TAR links could accomodate the potential container traffic identified in Section 3.*

7.4.2.3 Assumptions Related to Schedule Speeds

The model was run with the assumption that the maximum line speed permitted for freight trains (including container trains) would be increased on all line sections to ***70 km per hour.*** The schedule speeds resulting from a maximum speed of 70 km per hour were, for each section, calculated in proportion to the same relationship which exists between current schedule and current maximum speeds. For example, where currently a 29 km/hour schedule speed results from a 48 km/hour maximum speed, the new schedule speed was calculated as 42 km/hour (ie. *29/48 x 70*).

Schedule speeds can also be significantly affected by the type of signalling or block working system in use on a line section. For example, electronic relay interlocking of points and signals, coupled with colour light signalling, can allow trains to enter crossing tracks or stations on single line sections at higher speed, safely and with minimal loss of momentum.[3]

However, it was not possible to estimate with confidence the time savings which would result from the installation of automated signalling/safeworking systems, since these would very much depend upon the actual operating circumstances encountered on each

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[3] Automatic control of points and signals can allow trains to enter station sidings or crossing tracks without the need to decelerate or indeed come to a complete stop on the mainline.

line. Instead, it was assumed that the installation of such systems would be required: (a) if a requirement for line doubling was indicated by a run of the line capacity planning sub-model, or (b) in the case of traffic growing at the higher forecast rate of 8 per cent, in which case it was assumed that signalling system improvements on single line sections would be undertaken at the end of the 20 year forecast timeframe.

7.4.2.3 Assumed Unit Costs of Track Construction and Signalling System Improvement

With the exception of the TAR links in Myanmar (for which actual signalling cost estimates were available), the unit costs of constructing additional trackage for train crossing purposes and of installing automated signalling on all existing TAR links were based on the per kilometre costs recently incurred in the construction of a new link line in Thailand (the Kaeng Khoi Junction to Klong Sip Kao line which provides a connection between the North/Northeast and East lines, bypassing Bangkok). These were:

Track Construction (including the cost of earthworks, trackwork and bridge construction comprising not more than 10 per cent of the total route length): *US$ 1.35 million per kilometre*[4]

Automated Signalling System Installation: *US$ 150,000 per kilometre*

7.4.2.4 Requirements and Costs by Country

(a) Thailand

(i) Physical Requirements

Line capacity requirements were assessed for the four TAR Links identified north and east of Bankok, ie. TAR Links T.2-T.5.

The first 90 route kilometres of all four links consists of a common double tracked section, from Bangkok to Ban Pachi. This section carries 180-200 trains per day and, despite the recent installation of Centralized Traffic Control (CTC) in the vicinity of Bangkok and the imminent rerouting of northeastern traffic via the new Kaeng Khoi-Klong Sip Kao line, remains a bottleneck section which is seriously short of capacity. It has received priority within the SRT's multiple tracking programme for the construction of a third running track. For the purposes of this study it was assumed that provision of this third track would be necessary early in the forecast timeframe.

For the remaining sections of all four TAR Links considered in this Volume, line capacity requirements were assessed with the assistance of the line capacity planning sub-model (RFACIL). The physical line capacity expansion requirements identified in this way have been set out in detail in Annex 3.3, but are summarized in Table 16, below.

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[4] This figure falls between the cost of construction in poor soil conditions (requiring stabilization and piling) of 37.9 million baht (US$ 1.52 million) per kilometre and the cost of construction in generally good soil conditions of 22.9 million baht (US$ 0.92 million) per kilometre.

Table 16: Summary of Line Capacity Expansion Requirements, TAR Links in Thailand

TAR Link	Forecast Time Frame			
	1996-2000	2001-2005	2006-2010	2011-2015
T. 2, 4 and 5 (Bangkok - Ban Pachi) 4% and 8% Traffic Growth	Construction of 3rd track (90 km)			
T. 2 (Ban Pachi-Nong Khai)				
4% Traffic Growth		C.T.Addition (Two, 1 Km); C.T. Extension (0.4 km)	Line Doubling (35 km)	
8% Traffic Growth	C.T. Addition (One, 0.5 km)	Line Doubling (35 km); C.T. Extension (0.4 km)	C.T. Addition (Eleven, 5.5 km)	C.T. Addition (Sixteen, 8 Km)
T. 3 (Bangkok-Aranyaprathet)				
4% Traffic Growth	C.T. Extension (0.1 km)	C.T. Extension (0.4 km)	Line Doubling(13.2km); C.T. Addition (One, 0.5 km)	C.T. Addition (One, 0.5 km)
8% Traffic Growth	C.T. Extension (0.1 km)	Line Doubling (58.8 km); C.T. Addition (One, 0.5 km); C.T. Extension (1.9 km)		
T.4 (B.Pachi-Nakhon Sawan-Mae Sod)				
4 % Traffic Growth	Line Doubling (42.9 km)	Line Doubling (113 km)		
8 % Traffic Growth	Line Doubling (155.9 km)			
T. 5 (Kaeng Khoi-Ubon Ratchathani)				
4 % Traffic Growth	Line Doubling (9.2 km); C.T. Extension (0.3 km)		Line Doubling (129.4 km); C.T. Addition (Four, 2 km)	C.T. Addition (Four, 2 km)
8 % Traffic Growth	Line Doubling (9.2 km); C.T. Extension (0.3 km)	Line Doubling (285.5 km)	C.T. Addition (Eight, 4 km)	C.T. Addition (Six, 3 km)

C.T.Addition = Construction of additional track(s) in the section for train crossing/passing purposes; C.T. Extension = Extension of crossing/passing tracks to the standard length (500 metres).

Apart from the double track section, Bangkok-Ban Pachi (to which reference was made above), line sections which are particularly short of capacity include those between: Kaeng Khoi Junction and Map Kabao on TAR Link T.5 (9.2 km); and Ban Pachi and Lop Buri on TAR Link T.4 (42.9 km). All three sections would require the addition of an extra running track, under *either traffic growth scenario,* within the next five years. The Kaeng Khoi-Map Kabao section has the distinction of having the steepest ruling gradient on the SRT system (2.5 per cent) and the train throughput capacity of the section is severely limited by the speed and trainload restrictions imposed by this gradient and by the sharp curves (minimum radius, 180 metres) encountered in the section.

The four TAR links proposed for Thailand have a combined route length of 1,517 km. If train densities on these links were to grow by 4 per cent per annum for the next 20 years, additional running tracks would have to be provided on 343 km, or 23 per cent of the total route length. *However, if train densities were to grow by 8 per cent per annum, the length of additional running track required would increase to 544 km, or 36 per cent of the total route length.* Included in the figure of 544 km would be 156 km on TAR Link T.5, between Nakhon Ratchasima and Surin, which could require doubling by 2010 in order to avoid the emergence of another capacity bottleneck on this link, which would ultimately connect the mainline from Bangkok to Ubon Ratchathani with the Lao People's Democratic Republic.

While it was indicated in Section 5.1.3 that the SRT has embarked on a programme of line capacity expansion involving the construction of an additional 234 km of track by 1997, and an additional 2,510 km of track by 2000, it is not certain that all of the line capacity expansion requirements identified in this study will be accomodated within this programme. It is therefore suggested that these identified requirements and their timimg should be cross checked with the detail of the SRT's programme.

(ii) Costs

The physical requirements for line capacity expansion identified in the foregoing section were costed at the unit rates given in sub-section (iii), above, resulting in the cost estimates shown in Table 17. A detailed schedule of these cost estimates appears in Annex 3.3.

Table 17: Estimated Costs of Line Capacity Expansion, TAR Links in Thailand (US$ million)

TAR Link	Forecast Timeframe									
	1996-2000		2001-2005		2006-2010		2011-2015		TOTAL 1996-2015	
	4% Grth	8% Grth	4% Grth	8% Grth	4% Grth	8% Grth	4% Grth	8% Grth	4% Grth	8% Grth
T.2/T.4/T.5 (Common Section)										
Track Construction	121.5	121.5							**121.5**	**121.5**
Signalling	13.5	13.5							**13.5**	**13.5**
Sub-Total	135.0	135.0							**135.0**	**135.0**
T.2										
Track Construction			1.9	47.8	47.3	7.4		10.8	**49.2**	**66.0**
Signalling				25.2	25.3	73.8	73.0	1.2	**98.3**	**100.2**
Sub-Total			1.9	73.0	72.6	81.2	73.0	12.0	**147.5**	**166.2**
T.3										
Track Construction	0.1	0.1	0.5	82.6	18.5		0.7		**19.8**	**82.7**
Signalling			0.1	18.0	14.5	8.5	27.9	23.0	**42.5**	**49.5**
Sub-Total	0.1	0.1	0.6	100.6	33.0	8.5	28.6	23.0	**62.3**	**132.2**
T.4										
Track Construction	96.0	210.5	114.5						**210.5**	**210.5**
Signalling	23.0	50.1	27.1						**50.1**	**50.1**
Sub-Total	119.0	260.6	141.6						**260.6**	**260.6**
T.5										
Track Construction	12.8	140.5		257.6	177.4	5.4	2.7	4.1	**192.9**	**407.6**
Signalling	2.8	32.5		61.2	42.0	1.6	2.6	0.5	**47.4**	**95.8**
Sub-Total	15.6	173.0		318.8	219.4	7.0	5.3	4.6	**240.3**	**503.4**
TOTAL	**269.7**	**568.7**	**144.1**	**492.4**	**325.0**	**96.7**	**106.9**	**39.6**	**845.7**	**2043.1**

(b) Cambodia

Owing to the continuing security problem and the depleted condition of the railway in Cambodia, only an alternate day mixed train single service is run on both the Phnom Penh-Battambang-Sisophon (TAR Link C.1) and Phnom Penh-Sihanoukville (TAR Link C.2) lines. It is understood, however, that a container block train comprising 15-16 bogie flat wagons will run between Sihanoukville Port and Phnom Penh on an "as required" frequency, commencing in December 1995.

The poor condition of the permanent way and rollingstock restricts schedule speeds to only about 22 km/hour on both lines (with maximum speeds of only 35-40 km/hour). The track capacity with the existing speed restrictions was calculated by the ESCAP study team for both lines at only about 20-22 trains per day.

There is an urgent need to upgrade permanent way and rollingstock on TAR Link C.2 in order to provide rail transit times closer to those which can now be achieved by trucks conveying containers along National Road Route 4 between Sihanoukville Port and Phnom Penh. In time, there will be a similar requirement to upgrade track, bridges and rollingstock for higher speed operation on TAR Link C.1.

It is envisaged that the civil works programme to increase axle loads to 15 tonnes and maximum freight train speeds to 70 km/hour, as outlined in Section 7.2, will be sufficient to meet competitive transit time targets for both TAR routes in Cambodia. For example, lifting of the schedule speed between Sihanoukville and Phnom Penh from 22 km/hour to 42 km/hour (compatible with a 70 km/hour maximum speed) would reduce the rail transit time from 12 hours currently to only 6 hours 15 minutes - which would be more competitive with the 4 hour transit time for trucks.

The effect of a 42 km/hour schedule speed on line capacity would be to increase the maximum number of trains which can be operated per day on both routes to 37-40. Clearly, this capacity would be more than sufficient to accomodate traffic growth at the rate of 8 per cent per annum for the next 20 years, or even at rates averaging up to 12 per cent per annum over the same timeframe. No additional trackage would be required to facilitate train crossing, but it is likely that signalling system improvements will be required towards the end of the forecast period, at an estimated cost for TAR Links C.1 and C.2 of US$ 38.1 million and US$ 50.6 million respectively.

(c) Viet Nam

The availability of only partial information on line section length and train density by line section precluded the testing of the adequacy of line capacity on all TAR links in Viet Nam, except Link V.3 (Hanoi-Haiphong). The operation of local trains, which account for a majority of the trains operating on the TAR links, is scheduled by the responsible Railway Union and details of these schedules are not available at the headquarters of the Viet Nam Railways.

Nevetheless, the requirements for line capacity expansion on TAR Link V.3 were tested with the assistance of the ESCAP Railway Capital Project Appraisal Model.

(i) Physical Requirements

On the single track Link V.3, between Hanoi and Haiphong there are 5 stations at which trains may cross, the minimum track length for crossing purposes being 476 metres.

The train operating graph provided by the Viet Nam Railways indicates that the schedule speed of the slowest train over the longest section (21.2 km) is 26 km/hour. Thus, this line has capacity for 21 trains per day. If the track and bridge upgrading works outlined in Section 7.2 were carried out and complemented with signalling system improvements, the schedule speed of the slowest train could be expected to increase to 42 km/hour, and line capacity would increase to 33 trains per day, *without any increase in the number of crossing stations on the line.*

Currently, the line carries a maximum of 6 train pairs per day (3 passenger and 3 freight). On the assumption that train schedule speeds would increase following permanent way improvements, traffic growth at the rate of 4 per cent per annum would not result in a need for additional train crossing stations. *However, traffic growth at the rate of 8 per cent per annum under the same speed assumptions would result in a need for an additional 2 crossing stations to be provided by 2010.*

Ultimately, this track expansion work would need to be complemented by signalling system improvements, most probably involving the installation towards the end of the forecast period of relay interlocking and colour light signalling throughout the line.

(ii) Costs

The cost of constructing two additional crossing loops, with lengths of 500 m each, on TAR Link V.3 was estimated as US$ 1.35 million (see detailed schedule of cost estimates in Annex 3.4). This work would need to be undertaken during the period 2006-2010, in order to provide sufficient line capacity to handle traffic growing at the rate of 8 per cent per annum. Additionally, signalling system improvements for the entire line costing US$ 10.30 million could be needed during the same period, giving a total cost for line capacity expansion of ***US$ 11.7 million.***

(d) Yunnan Province of China

On the basis of information supplied by the Yunnan Railway General Corporation and obtained from a Chinese Railways system map, the Kunming-Hekou metre gauge line would have a theoretical capacity for only 30-37 trains per day, yet it appears that the line is already handling about 46 trains per day. Calculations performed with the assistance of the ESCAP Railway Capital Project Appraisal Model suggest that double tracking is an immediate priority on this line, but it is understood that any decision to upgrade the capacity of the line will be taken in the context of its probable re-construction to 1435 mm gauge standards.

(e) Myanmar

(i) Physical Requirements

Line capacity requirements were assessed for the Yangon-Mandalay-Myitkyina line, designated as Link B.1 in the TAR network.

The first 362 km of this link, ie. the section from Yangon to Pyinmana, is of double track construction.Despite the fact that the Myanma Railways has calculated its capacity at only 80 trains per day, it is likely that this section would offer a significantly greater capacity if the upgrading works detailed in Sections 7.1 and 7.2 were undertaken and if the remaining line lengths under manual safeworking and mechanical signalling were replaced with automatic block signalling, enabling existing headways (intervals between successive trains) to be reduced. It is unlikely that additional passing tracks would need to be provided in this double line section. Currently train density in this section is about 26 per day, and growth at the "high" rate of 8 per cent per annum would result in a train density of 121 per day by 2015 which could easily be accomodated by the improvements already mentioned.

The remaining 801 km, from Pyinmana to Myitkyina, is of single track construction, with mainly manual safeworking and mechanical safeworking systems in place throughout. The line from Pyinmana to Myitkyina was divided into 5 sections - Pyinmana to Yamethin (80 km), Yamethin to Thazi (50.7 km), Thazi-Mandalay (127.9 km), Mandalay to Shwebo (95.0 km) and Shwebo to Myitkyina (447.8 km) - in order to calculate line capacity requirements. These sections reflect either differing train densities or differing levels of daily train throughput capacity. The project appraisal model was run for each of these five line sections and the detailed results are shown in Annex .

Traffic growth at the "low" rate of 4 per cent per annum would not in fact result in a requirement for additional train crossing capacity on any line section within the forecast timeframe, 1996-2015, but growth at the rate of 8 per cent per annum would result in a need to provide additional trackage for train crossing in three out of the five single line sections assessed. In this case, a total of 12 additional crossing tracks would need to be provided during the last five years of the forecast period (2011-2015). Six of these crossing loops would be required in the Shwebo-Myitkyina section of TAR Link B.1, which appears to have major capacity problems (see Section 7.3). It is likely that complementary signalling improvements on Link B.1 would have to be effected, probably during the period 2007-2015.

(ii) Costs

The cost of constructing twelve additional crossing loops, with lengths of 500 m each, on TAR Link B.1 was estimated as US$ 8.11 million (see detailed schedule of cost estimates in Annex 3.5). The cost of signalling system improvements on this line was estimated at US$ 154.95 million, which when added to the track construction costs, gives a total for line capacity expansion of ***US$ 163.1 million.***

7.5 Capital Costs of Programme to Construct Missing Links in the TAR

The realization of a continuous Tans-Asian Railway network in the subregion depends vitally on the construction of missing links, totalling about 3,200 km. The estimated capital costs of the construction of these links are shown in Table 18, below.

With the exception of the costs of constructing missing links in China, the above cost estimates were based on the unit construction cost of the newly completed Kaeng Khoi Junction to Klong Sip Kao Line in Thailand. This line was considered to most closely represent the standards to be adopted for future development of the TAR network. (It will be noted that the unit costs of new line construction can vary within a wide range, depending upon the condition of the subsoil, the number and length of bridges and/or tunnels, the number of stations and sidings and the type of signalling/safeworking system employed). The all inclusive unit construction cost for this line was US$ 1.5 million per kilometre.

Table 18: Capital Costs of TAR Missing Link Construction

Country/TAR Link	Section	Length (Km)	Estimated Cost (US$ million)
Thailand			
T.4	Nakhon Sawan-Mae Sod	284	426.0
T.5	Ubon Ratchathani-Chong Mek	90	135.0
T.6	Denchai-Chiang Rai	270	405.0
	Mae Sai-Chiang Rai	60	90.0
Cambodia			
C.1	Sisophon-Poipet	48	72.0
C.3	Phnom Penh-Loc Ninh (Viet Nam)	305	457.5
or			
C.4	Phnom Penh-Svay Rieng	135	202.5
Viet Nam	Ho Chi Minh City-Cambodian Border	105	157.5
China			
Y.1	Xiangyun-Jinhong	627	1134.9
	Jinghong-Shangyong	94	170.1
	Jinghong-Daluo (Myanmar)	141	255.2
Y.2	Dali-Kachang/Houqiao (Myanmar)	330	597.3
Lao PDR	Vientiane-Nong Khai (Thailand)	30	45.0
	Vientiane-Boten (Border with China)	510	765.0
	Pakse-Chong Mek (Thailand)	30	45.0
Myanmar			
B.1	Myitkyina-Kachang/Houqiao	100	150.0
B.2	Thaton-Myawaddy	166	249.0
B.3	Daluo-Tachilek	195	292.5
	TOTAL	**3,215**	**5,192.0**

Notes: (1) Y.2 Kunming-Dali (380 km) not inlcuded, as construction already underay.

(2) Total <u>excludes</u> cost of constructing Link C.3 which is an alternative to Link C.4

In the case of new TAR links in China, unit costs were based on the current cost estimates for the Xiangyun-Shangyong line construction project, as supplied by the Yunnan Railway General Corporation. The unit cost for the latter project (US$ 1.81 million/km) reflect construction of an *electrified* line to 1435mm gauge standards.

The Kaeng Khoi Junction to Klong Sip Kao line was constructed to the following specifications and standards:

- Single line, 1000 mm gauge track
- 20 tonne axle load
- 120 km/hr maximum speed
- 1000 metre minimum radius of curvature
- 1 per cent maximum gradient
- 5,100 mm minimum clearance from rail level (structure gauge)
- 500 metre minimum sidingor loop length
- Semi-automatic (tokenless) block, colour light signals and train despatching telephone

The recent experience of the State Railway of Thailand has indicated that the percentage distribution, by type, of the costs of new line construction is typically as follows:

- Civil works (embankments, tunnels and bridges): 50-65%
- Track Works (rail/sleeper laying and ballasting): 15-25%
- Buildings and utilities: 3-5%
- Signalling and telecommunications: 10-15%
- Project management: 3-5%

7.6 Requirements of Specialized Container Rollingstock

With the possible (but unlikely) exception of China, none of the countries of the subregion has an adequate number of specialized container flat wagons in its fleet to be able to accept large volumes of container traffic, to the extent envisaged in the forecasts contained in Section 3. Indeed, in the case of the Lao People's Democratic Republic (which does not currently have a railway system) and Vietnam (which does not possess any specialized container rollingstock), there would need to be substantial investment in a fleet of specialized container carrying wagons.

Table 19 contains estimates of the wagon requirements to serve the forecast demand identified in Section 3. The calculation of these requirements was based on wagon cycle times reflecting current running speeds and transit times as well as an allowance for loading/unloading time and time for running maintenance.

Table 19: Forecast Requirement of Container Wagons for TAR Traffic

Country	Route	Forecast Year			
		2000	2005	2010	2015
		No. Required	No. Required	No. Required	No. Required
Cambodia/ Thailand	Bangkok-Phnom Penh		148	225	340
Cambodia	Phnom Penh-Sihanoukville	55	96	129	173
Vietnam	Haiphong-Hanoi	54	79	116	172
China/ Vietnam	Kunming-Haiphong??	87	128	188	275
Lao PDR/ Thailand	Laem Chabang-Vientiane	23	39	56	83
Myanmar	Yangon-Mandalay	22	33	48	69

It is assumed that the container wagon fleet requirements identified in Table 19, above, will be satisfied by new wagon purchases, although it is known that in some cases (eg. in Vietnam) there are opportunities to convert existing general purpose flat wagons for container transportation. In all cases, the purchase of wagons with capacity to carry at least a single 45 ft container was assumed, although on some sections of the routes involved, there could be persuasive arguments in favour of the purchase of wagons with capacity to carry three 20 ft containers. The unit cost of these wagons was assumed to be US$ 80,000.[5] The resulting net numbers of wagons required to be purchased and the associated costs are shown in Table 20.

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[5] Based on cost of 45 ft container wagons supplied to the State Railway of Thailand by China in 1989 (US$ 59,000), inflated at the rate of 5% per annum over the six year period since purchase.

Table 20: Forecast Container Wagon Purchase Requirement and Cost

Country/Route/No./Cost	**Purchase Period**				
	1996-1999	**2000-2004**	**2005-2010**	**2011-2015**	**TOTAL, 1996-2015**
Cambodia/Thailand					
Bangkok-Phnom Penh					
No. Wagons to be purchased		148	77	115	340
Cost (US$ million)		11.84	6.16	9.20	27.20
Cambodia					
Phnom Penh-Sihanoukville					
No. Wagons to be purchased	55	41	33	44	173
Cost (US$ million)	4.40	3.28	2.64	3.52	13.84
Viet Nam					
Haiphong-Hanoi					
No. Wagons to be purchased	54	25	37	56	172
Cost (US$ million)	4.32	2.00	2.96	4.48	13.76
China/Viet Nam					
Kunming-Haiphong (???)					
No. Wagons to be purchased	87	41	60	87	275
Cost (US$ million)	6.96	3.28	4.80	6.96	22.00
Lao PDR/Thailand					
Laem Chabang-Vientiane					
No. Wagons to be purchased	23	16	17	27	83
Cost (US$ million)	1.84	1.28	1.36	2.16	6.64
Myanmar					
Yangon-Mandalay					
No. Wagons to be purchased	22	11	15	21	69
Cost (US$ million)	1.76	0.88	1.20	1.68	5.52

7.7 Locomotive Requirements

Transportation of the container volumes forecast for the Trans-Asian Railway network of the Greater Mekong Area subregion (as identified in Section 3) would also require investment in new locomotives. The required number of locomotives was calculated by dividing the number of locomotive hours needed to operate container block trains (consisting of 30 bogie flat wagons each carrying equal to two 20 ft containers) on the TAR links by the typical number of available hours per locomotive per year.[6]

The detailed calculations of locomotive requirements are given in Annex 5, and the number required in each of the four reference years of the forecast timeframe is shown in Table 21, below.

Table 21: Forecast Requirement of Locomotives for TAR Container Traffic

Country	Route	Forecast Year			
		2000	2005	2010	2015
		No. Required	No. Required	No. Required	No. Required
Cambodia/ Thailand	Bangkok-Phnom Penh		1	2	3
Cambodia	Phnom Penh-Sihanoukville	1	1	1	2
Vietnam	Haiphong-Hanoi	1	1	2	3
China/ Vietnam	Kunming-Haiphong??	1	2	3	4
Lao PDR/ Thailand	Laem Chabang-Vientiane	1	1	1	2
Myanmar	Yangon-Mandalay	1	1	1	2

These calculations assume that, that for all routes, only a single locomotive would be required to haul container trains. In fact, there may be some steeply graded line sections which might require the assignment of "helper locomotives" over short distances, but these are not expected to result in a full time requirement for additional locomotives.

Additionally, it was assumed that the locomotives purchased would have a power rating of at least 2500 HP, and possibly as high as 3000 HP, giving them sufficient capacity to haul trailing loads of at least 1200 tonnes (ie. the typical trailing load of a 30 wagon block

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[6] In this case, the calculation "available hours" per year assumes that a locomotive will typically be available for revenue earning service for 80 per cent of the total operating hours per year, ie. Available hours = 300 days per year x 24 hours x availability rate of 80%. The time for which locomotives would not be available (ie. the portion of 20%) would be dedicated to routine maintenance and overhaul, servicing and unplanned operational delays.

container train). The unit purchase cost of 3000 HP diesel electric locomotives was assumed to be US$ 2.5 million. This figure was based on a purchase price of Bht 53.61 million (US$ 2.1 million) recently paid by the State Railway of Thailand for diesel electric locomotives with a rating of 2538 HP.

The required physical locomotive purchases and associated costs are given in Table 22.

Table 22: Forecast Locomotive Purchase Requirement and Cost

Country/Route/No./Cost	**Purchase Period**				
	1996-1999	**2000-2004**	**2005-2010**	**2011-2015**	**TOTAL, 1996-2015**
Cambodia/Thailand					
Bangkok-Phnom Penh					
No. Locomotives to be purchased		1	1	1	3
Cost (US$ million)		2.50	2.50	2.50	7.50
Cambodia					
Phnom Penh-Sihanoukville					
No. Locomotives to be purchased	1		1		2
Cost (US$ million)	2.50		2.50		5.00
Viet Nam					
Haiphong-Hanoi					
No. Locomotives to be purchased	1	1		1	3
Cost (US$ million)	2.50	2.50		2.50	7.50
China/Viet Nam					
Kunming-Haiphong (???)					
No. Locomotives to be purchased	1	1	1	1	4
Cost (US$ million)	2.50	2.50	2.50	2.50	10.00
Lao PDR/Thailand					
Laem Chabang-Vientiane					
No. Locomotives to be purchased	1			1	2
Cost (US$ million)	2.50			2.50	5.00
Myanmar					
Yangon-Mandalay					
No. Locomotives to be purchased	1			1	2
Cost (US$ million)	2.50			2.50	5.00

7.8 Consolidated Cost of TAR Network Development

Table 23 presents a summary, by category and country, of the capital costs estimated to be required for the future development of the TAR network in the subregion.

Table 23: Consolidated Capital Costs of TAR Network Development, Twenty Year Forecast Timeframe, 1996- 2015

(US$ million)

CATEGORY/ Growth Rate (if applicable)	COUNTRY						TOTAL
	Thailand	Cambodia	Viet Nam	China	Lao PDR	Myanmar	
Upgrade Outline Gauge	0.3	0.5	0.7			62.6	**64.1**
Upgrade Axle Load/Increase Speed		87.3	123.0			383.01	**593.3**
Line Capacity Expansion							
4% Growth	845.7						**845.7**
8% Growth	2043.1		11.7			163.1	**2217.9**
Missing Link Construction	1,056.0	274.5	157.5	2157.5	855.0	691.5	**5192.0**
Container Wagon Acquisition	27.2*	13.8	13.8	22.0	6.6**	5.5	**88.9**
Locomotive Acquisition	7.5*	5.0	7.5	10.0	5.0**	5.0	**40.0**
TOTAL							
4% Growth	**1,936.7**	**381.1**	**302.5**	**2,189.5**	**866.6**	**1,147.6**	**6,824.0**
8% Growth	**3,134.1**	**381.1**	**314.2**	**2,189.5**	**866.6**	**1,310.7**	**8,196.2**

* Shared with Cambodia **Shared with Thailand

8. FACILITATION MEASURES FOR CROSS BORDER TRANSPORT ON THE TAR IN THE INDOCHINA SUBREGION

This section reviews the arrangements currently in place and required in future in order to minimize delays and to facilitate a smooth flow of international rail traffic across national borders in the greater Indochina subregion. As was observed in Volume 2, an absence of adequate and harmonized administrative arrangements governing the passage of traffic across borders has on occasions frustrated the efforts of some railway organizations of the region to develop international container traffic despite their often heavy investments in handling equipment and servicing facilities at borders. The two main types of delay which can interfere with the smooth flow of border crossing railway traffic are:

- Delays due to customs and security control procedures; and
- Delays due to railway operational procedures (such as train inspection, brake testing, checking of wagons and their equipment, recording of wagon and consignment details, etc)

The delay to trains at borders can often be much greater than en-route operational delays, and unless the relevant arrangements between neighbouring countries and railway systems can contribute to the minimization, rather than to the prolongation, of these delays, there is little hope that railways can offer the transit time performance which freight, and especially container, customers require before directing their business to rail.

The current absence of any border crossing railway traffic in the Greater Mekong Area makes consideration of border crossing administrative arrangements at this time somewhat academic; yet it is vital that these matters be addressed concurrently with other issues affecting the development of the Trans-Asia Railway in the subregion, so that when the necessary physical linkages are in place, the institutional linkages will ensure that the former are used efficiently. To some extent, the adoption by countries participating in the TAR project of international transit conventions could increase the chances of acceptable bilateral arrangements being worked out for the exchange of trains with their neighbours, and this is an issue addressed in this section.

8.1 Current Status of Administrative Arrangements for Cross Border Rail Traffic

There is currently only one border in the Indochina subregion across which it is physically possible for railway traffic to pass, and this is the border between China and Viet Nam. However, rail traffic has not in fact moved across this border since 1979.

In recent years, there has been a marked improvement in the relationship between China and Viet Nam, and border crossing trade between the two countries has resumed, albeit on an informal basis.

Transit agreements for border crossing by road and rail were signed by the Governments of China and Viet Nam in November 1994, but the protocols attached to these agreements have yet to be approved by both countries. The agreements signed in 1994 allow vehicles of each country to operate into the bordering provinces of the other country, but, in the absence of protocols, the exact limits of operation have not been specified. In the case of road traffic which is currently crossing the border on an informal basis, goods are being transhipped at the border from the vehicles of one country to the vehicles of the other, simply because, without a protocol, there is doubt about the permitted range of operation into foreign territory.

Clearly, protocols are also essential in the case of rail transport, but in themselves are not sufficient to ensure the smooth passage of railway vehicles and loading across borders. What is needed in addition is a workable joint operating agreement between the two neighbouring railway systems. Further mention will be made of such agreements in Sub-section (iii), below. It is not known when the matter of protocols between China and Viet Nam will be resolved, but there appears to be an increasing desire on the part of the relevant high level officials of both countries to secure agreement on the matter.

Of the other countries of the subregion, those perhaps nearest to closing the physical gaps between them are Thailand and the Lao People's Democratic Republic, on the one hand and Thailand and Cambodia, on the other.

A 30 km rail link from Nong Khai in Thailand to Vientiane in the Lao People's Democratic Republic has been the subject of a recent feasibility study and is believed to be awaiting a decision by the Government of the Lao People's Democratic Republic to proceed. Thailand and the Lao People's Democratic Republic have recently enjoyed good relations and there is at present a thriving trade between them. Thailand also for many years has handled transit trade for the Lao People's Democratic Republic through a specially bonded warehousing facility in the Port of Bangkok. Since the opening in April 1994 of the Mittapharb (Friendship) Bridge across Mekong River between Nong Khai (Thailand) and Tarnaleng (Lao People's Democratic Republic), road traffic between the two countries has grown substantially to a level of about 420 vehicles per day, of which 170 (or 40 %) are trucks, and there is close cooperation between the customs authorities of both countries, with the objective of minimizing the delay to this traffic due to customs formalities. The officials of the Lao People's Democratic Republic customs service who were consulted during the mission of the ESCAP study team appeared to be amenable to considering with their Thai counterparts the possibility of establishing joint customs facilities to handle the inspection of containers and freight transported by rail, once the proposed rail link has been constructed.

In the case of Thai-Cambodian trade, trains of either country used to work through the border prior to 1975, when a 48 km section of track between Sisophon (the present terminus of rail services from Phnom Penh) and Poipet was removed. Poipet (in Cambodia) was used as the joint border station for railway and customs purposes, although on occasions Cambodian trains would work through to Aranyaprathet (in Thailand). The representative of the Cambodian customs service consulted during the mission of the ESCAP study team was of the view that customs control would not be a major source of delay following restoration of this line, provided that a majority of the freight crossing the border could be containerized and subjected to detailed inspection at Inland Container Depot (ICD) facilities. In this situation, border inspections would be confined to a brief inspection of container seals and documentation.

8.2 The Importance of Railway Joint Working Agreements

The cooperation between the Malayan Railway (KTM) and the Thai State Railway (SRT) in the exchange of international passenger and freight traffic is frequently hailed as a good example of what can be achieved when the railway systems of neighbouring countries agree to establish joint facilities at the border for the reception, marshalling, inspection and light repair of trains from both systems. Such is the arrangement currently applying on one border crossing line at Padang Besar Station (on Malaysian territory) and on another border crossing line at Sungei Golok Station (on Thai territory). Operation of these stations is governed by a Joint Working Agreement between the two railway organizations, which has been in force since 1954. A full description of this agreement is contained in Volume 2.

In addition, the joint working agreement sets out rules for the exchange of rollingstock, locomotives and other railway equipment, for tariff setting in relation to cross border traffic, for financial settlements related to the distribution of revenue and the sharing of costs, and for liability in the case of accidents or misadventure to passengers, goods, and railway equipment and other property. The essential feature of the agreement which distinguishes it from working agreements between railway organizations in other parts of the region is that it is centred around the joint operation of ***a single border station***, thereby avoiding the duplication of facilities and resources, as well as the transit delay, inherent in the more conventional system of having a station each side of the border, each under the separate administrative control.

The Malaysia/Thailand Railway Joint Working Agreement can therefore be commended as a model for adoption by other railway organizations of the sub-region, as they move closer to the realization of a continuous Trans-Asia Railway network on which international rail services (and in particular container transport services) can be provided.

Another type of approach to international railway cooperation is available in the form of ***OSShD***, or the Organization for Railways Cooperation, which originally comprised the railway organizations of the former Soviet Union, the Eastern bloc countries, China Mongolia, the Democratic People's Republic of Korea and Viet Nam. Recently, the membership of this organization has been expanded and it is understood that it now encompasses about 21 member railways. OSShD formulates and monitors the application of operating rules (known as SGMS rules) for international railway traffic amongst its member countries. These rules specify conditions, standards and targets for the handling of border crossing railway traffic. Additionally, an international transit container tariff (known as the "ETT" tariff) has been developed under the auspices of the OSShD organization, and is generally applied throughout the territory of its member railway systems. It is important to note, however, that OSShD agreements need to be complemented by appropriate bi-lateral agreements between neighbouring railway organizations. They are not in themselves adequate as a mechanism for achieving the smooth flow of railway traffic across borders, and there have been instances where OSShD members have not observed the established operating rules or tariff structures in exchanging international transit traffic with neighbouring railway organizations. This has created considerable difficulty when close cooperation between two or more railway organizations has been necessary in order to provide transit times and tariffs which are competitive with those of alternative transport modes, especially shipping.

8.3 International Transit Conventions

At its forty-eighth session, the ESCAP Commission adopted resolution 48/11 of 23 April 1992 on road and rail transport facilitation measures. In that resolution, the Commission recommended that the countries of the region, if they had not already done so, consider the possibility of acceding to seven international conventions in the field of transport facilitation.

Of these seven conventions, two - the Customs Convention on Containers (1972) and the International Convention on the Harmonization of Frontier Control of Goods (1982) - are of direct relevance to railway transport. However, of the countries participating in the Trans-Asia Railway project in this sub-region, only China to date has acceded to at least one of these coventions (the Customs Convention of Containers, 1972).

The advantages of accession to these conventions arise mainly from the fact that they would establish standards for border customs control which might form a suitable basis for future bi-lateral agreements between neighbouring countries. In the longer term, the uniformity of customs control procedures provided through the observance of these conventions would also be beneficial to the smooth and rapid flow of border crossing railway traffic, since the railway organizations concerned would not have to adapt and adjust their administrative systems to accomodate more than one set of procedures.

Active consideration of the benefits of accession to these conventions by the countries participating in this project is therefore strongly recommended.

9. SUMMARY OF MAIN CONCLUSIONS AND RECOMMENDATIONS

The principal conclusions and recommendations of the report are summarized in this section. The report itself can provide a suitable foundation for a comprehensive Development Plan for the Trans-Asian network in the subregion. Such a Development Plan is a prerequisite for the **harmonized** development of the components of the subregional Trans-Asian Railway under the control of various national railway organizations. Before such a Development Plan can be finalized, however, it will be necessary to fill in various information gaps which have been identified during the course of this study. These information gaps are addressed in this section, as are recommendations for follow-up actions by all parties participating in the study.

9.1 An Operational Objective for the Trans-Asian Railway in the Indo-China and ASEAN Subregion

Conclusion 1: *A guiding operational objective, which adequately defines the expected role of the subregional TAR, must be established.*

It was apparent from the outset of the study that a TAR network in the subregion was only ever likely to satisfy demand for the movement of freight and people between and among the countries of the subregion itself. Unlike the Northern TAR Corridor (Northeast Asia to Europe), the network in the ASEAN and Indo-China subregion, even if linked to Europe through China or the Indian subcontinent and the Islamic Republic of Iran, is unlikely to provide a viable alternative to the shipping mode for inter-regional movements of freight. The reason for this is the multiplicity of national borders through which trains would have to pass, coupled with the expense of providing missing links in the network and the expense of bridging differences in track gauge. Thus, the operational objective for the subregional network must reflect the primary advantages of the network in satisfying ***subregional transport demands***.

Recommendation 1: It is recommended that the following operational objective for the Trans-Asian Railway be adopted:

> *"The Trans-Asian Railway in the Indo-China and ASEAN Subregion should in future provide an efficient and competitive means of transporting containers between and among the countries of the subregion, with a minimum of border crossing delays"*

9.2 Network Designation (Ref. Section 2 of this report)

Conclusion 2: *A Trans-Asian Railway network in the countries of the Greater Indo-China subregion was identified by the participating railway organizations on the basis of the* ***four*** *line inclusion criteria set out in Section 2 of this report.*

The network (including missing links) would have a route length of 10,050 km, of which 2,517 km would be in Thailand; 784 km in Cambodia; 2,374 km in Viet Nam; 2,040 km in China; 570 km in the Lao People's Democratic Republic; and 1,765 km in Myanmar. The identified network would connect five national capital cities (Bangkok, Phnom Penh, Vientiane and Yangon) as well as one provincial capital city (Kunming) and would provide connections between these cities and major container handling ports at Laem Chabang (Thailand), Sihanoukville (Cambodia), Haiphong (Viet Nam) and Yangon (Myanmar). Of the consolidated route length of 10,050 km, some 7,461 km would be of metre (1,000 mm) track gauge and 2,589 km would be of standard gauge (1,435 mm) or dual standard/metre gauge (1,435/1,000 mm) track - most of the latter being in China and (in future) in the Lao People's Democratic Republic.

Recommendation 2: *It is recommended that the TAR network in the ASEAN countries identified by the participating railway organizations be formally designated as such.*

9.3 Benchmarks for Competitive Service (Ref. Section 3 of this report)

Conclusion 3: *The main competition for rail is provided by road transport container feeder services between the main container handling ports and the inland manufacturing centres of the subregion. Subject to its ability to provide transit times and tariffs which are competitive with those of its road competitors, rail has the opportunity of capturing a large share of container feeder transport in: Cambodia (between Sihanoukville Port and Phnom Penh); Viet Nam (between Haiphong Port and Hanoi); the Lao People's Democratic Republic (between Vientiane and Laem Chabang Port); and Myanmar (between Yangon and Mandalay).*

Recommendation 3: It is recommended that: *the railway organizations of the subregion actively develop a focussed marketing strategy, operational plan (incorporating the operation of block container trains) and tariff structure aimed at securing container transport business.*

9.4 Recommended Minimum Technical Standards (Ref. Section 4 of this report)

Conclusion 4: *A primary requirement for the subregional TAR to carry* ***all*** *kinds of containers, including high cube and super high cube containers, imposes on the railway systems of the subregion structure gauge dimensions which are compatible with the highest profile containers - unless alternative measures, such as the adoption of low profile wagons, can be applied. In terms of required* ***axle load****, neither the prevailing locomotive gross weights nor the prevailing gross weights for container wagons* *would suggest a need to adopt axle loads of greater than 15 tonnes. Although there may be operational advantages in scheduling container block trains to run at or near passenger train speeds, such a measure would* ***not*** *be necessary in order for rail to secure a competitive advantage over road operators in the transport of containers, although improved transit times could be achieved if the maximum speeds of freight trains were lifted to* ***70 km/hr*** .

Recommendation 4: The following technical and operational standards are recommended for the future development of the subregional TAR network:

(i) *Structure gauge dimensions to be compatible with the dimensions of super high cube (ie. 9 ft 6 ins high) containers - unless alternative measures can be applied to ensure the unimpeded passage of these containers through structures on designated TAR routes;*

(ii) *An axle load limitation of* ***15 tonnes*** *to apply on all designated TAR routes;*

(iii) *For designated TAR links, the standard of track and structures should be upgraded to the extent necessary to achieve maximum speeds for freight trains of 70 km/hr.*

(iv) *Uniform train lengths to apply for cross border operations. The train length which should apply in the case of container trains operating on the TAR network in the subregion is about 460 metres.This would require a standard crossing track length on single line sections of 500 metres.*

9.5 Specific Container Handling Needs (Ref. Section 6 of this report)

Conclusion 5: *Adequate container handling capacity appears to be available in existing and planned port facilities to permit growth in rail transported container volume at the rates forecasted (8-11 per cent per annum) for at least the next 10 years. However, improved linkages of rail to port facilities will be required at some locations (eg. Haiphong and Yangon) in the short term. In addition, the development of rail served Inland Container Depots (ICDs), now in its infancy in the subregion needs to be accelerated and the development of these facilities needs to accomodate the most efficient railway operating practices* *(such as the ability to operate full length block trains into ICD rail loading/unloading areas).*

Recommendation 5: *Consideration should be given to improving rail access to container berths and stacking areas at the ports of Haiphong and Yangon, as well as to accelerating the development of ICDs in Phnom Penh, Hanoi and Mandalay.*

9.6 TAR Network Development Needs (Ref. Section 7 of this report)

Conclusion 6: *Comparison of the current technical status of designated TAR links with the recommended standards (identified in Section 4 of this report) revealed that relatively few of these links can accomodate the transportation of super high cube (9ft 6ins high) containers, and that some links do not conform with the required axle load limitation of 15 tonnes.*

Recommendation 6: It is recommended that:

(i) *The railway organizations of Cambodia and Viet Nam, in particular, undertake a detailed study of the relative costs and benefits of investing in low floor container wagons as an alternative to expanding the dimensions of critical structures in order to accomodate super high cube containers.* (It should be noted that such a detailed study will require that detailed site surveys of all structures, especially bridges, on designated TAR links be undertaken, since the full extent of structure limitations on most TAR links is not known);

(ii) *Consideration should be given by the Myanma Railways to the timing and methods of upgrading approximately 1,439 route km of designated TAR route to 15 tonne axle load standards.* (In the short term, it may be possible to limit the scale of this upgrading work to those line sections which are critical for container movement, involving no more than about 650 km of the total route km estimated to require upgrading).

9.7 Facilitation Measures for Cross Border Transport on the TAR in the ASEAN Countries (Ref. Section 8 of this report)

Conclusion 7: *(i)* *Although there is currently no border crossing railway traffic in the Indo-China subregion, consideration needs* *to be given to the adoption of bilateral and international transit agreements and customs control procedures which will minimize the delay to border crossing traffic, in order to secure a competitive advantage for rail in the future international transportation of containers. In particular, the Customs Convention on Containers (1972) and the International Convention on the Harmonization of Frontier Control of Goods (1982) could provide benefits to the countries of the subregion in implementing customs control procedures which will contribute to a smooth and rapid flow of rail traffic across their borders.*

(ii) *The Railway Joint Working Agreement between Thailand and Malaysia is a good example of the cooperative spirit which can and should exist between the railway organizations of adjoining countries in managing the flow of railway traffic across their national borders. By establishing a single "joint" border station, instead of independent stations either side of the border, this Agreement avoids the duplication and wastage of operating resources and personnel and contributes to the speedy transfer of traffic from one railway system to the other.*

Recommendation 7: It is recommended that:

(i) *strong consideration be given by the countries of the subregion to their accession to the abovementioned international conventions relevant to rail traffic, and to adopting bilateral railway operating agreements (such as the Malaysia/Thailand Joint Working Agreement) which will facilitate the efficient exchange of international rail traffic with neighbouring railway systems.*

(ii) *ESCAP develop, with the possible cooperation of the Thai and Malaysian railway organizations a model railway joint working agreement, based on the proposed Thailand/Malaysia Agreement, for application throughout the region.*

ANNEX 1.

BASIC TECHNICAL AND OPERATIONAL DATA

TRANS–ASIA RAILWAY IN THE INDOCHINA AND ASEAN SUB–REGION

BASIC TECHNICAL AND OPERATIONAL DATA

Country: CAMBODIA
TAR Link: C.1

Phnom Penh – Poipet Line

Station	Phnom Penh	Pursat	Battambang	Sisophon	Poipet
Chainage (km)	0	165	273	337	385
	0 25 50 75 100 125 150 175 200 225 250 275 300 325 350 375 400 425 450 475				
Max. Speed (km/h) Passenger Trains Freight Trains	 80 50				
Commercial Speed (km/h) Passenger Trains Freight Trains	30				
Axle Load (tonnes/axle)	15				
Hauling Capacity (tonnes) (new locomotive)	950–1,100				
Crossing Length (m)	350–450				
Line Capacity (2–way)	–				
Number of Trains/day (2–way) Passenger Freight	1		2		
Block and Signal Systems	Flag and hand signals				
No. of Crossing Stations	16	10	6		
Operational Gradient (%) For Down Trains Up Trains	0.5 0.5				
Minimum Curvature (m)	500				
Rail (kg/m)	30				
Sleeper Type/Density (pieces/km)	Steel/1,450				
Rail Fastening System	Rigid				
Ballast Depth (mm)	290				
No. of Bridges/Length (m)	–	174/3,625	–		
No. of Tunnels/Length (m)	–				
Distance between Stations (km)	165	108	64	48	
Freight (million tonnes/year)	–				
Passenger (million/year)	–				
Min. Running Time	12				

Remark: Distance from Poipet to Bangkok is 260 km

TRANS–ASIA RAILWAY IN THE INDOCHINA AND ASEAN SUB–REGION

BASIC TECHNICAL AND OPERATIONAL DATA

Country: CAMBODIA
TAR Link: C.2

Phnom Penh – Sihanoukville Line

Station	Phnom Penh	Takeo	Kampot	Sihanoukville
Chainage (km)	0	75	239	339
	0 25 50 75 100 125 150 175 200 225 250 275 300 325 350 375 400 425 450 475			
Max. Speed (km/h) Passenger Trains Freight Trains	90 50			
Commercial Speed (km/h) Passenger Trains Freight Trains	30			
Axle Load (tonnes/axle)	20			
Hauling Capacity (tonnes) (new locomotive)	950–1,100			
Crossing Length (m)	450–600			
Line Capacity (2–way)	–			
Number of Trains/day (2–way) Passenger Freight	1			
Block and Signal Systems	Flag and hand signals			
No. of Crossing Stations	5	6	6	
Operational Gradient (%) For Down Trains Up Trains	0.4 0.4	0.45 0.45	0.65 0.65	
Minimum Curvature (m)	300			
Rail (kg/m)	44.65			
Sleeper Type/Density (pieces/km)	Wood/1,520			
Rail Fastening System	Rigid			
Ballast Depth (mm)	300			
No. of Bridges/Length (m)	18/672.5	11/389.5	58/2,281.5	
No. of Tunnels/Length (m)	–			
Distance between Stations (km)	75	164	100	
Freight (million tonnes/year)				
Passenger (million/year)				
Min. Running Time	12			

ANNEX 1

TRANS-ASIA RAILWAY IN THE INDOCHINA AND ASEAN SUB-REGION

BASIC TECHNICAL AND OPERATIONAL DATA

Country: CAMBODIA
TAR Link: C.3

Phnom Penh – Loc Ninh – Ho Chi Minh City Line

Station	Phnom Penh	Skoun	Kampong Cham	Loc Ninh	Ho Chi Minh City
Chainage (km)	0	75	130	305	455
	0 25 50 75 100 125 150 175 200 225 250 275 300 325 350 375 400 425 450 475				
Max. Speed (km/h) Passenger Trains Freight Trains					
Commercial Speed (km/h) Passenger Trains Freight Trains					
Axle Load (tonnes/axle)					
Hauling Capacity (tonnes) (new locomotive)					
Crossing Length (m)					
Line Capacity (2-way)					
Number of Trains/day (2-way) Passenger Freight					
Block and Signal Systems					
No. of Crossing Stations					
Operational Gradient (%) For Down Trains Up Trains					
Minimum Curvature (m)					
Rail (kg/m)					
Sleeper Type/Density (pieces/km)					
Rail Fastening System					
Ballast Depth (mm)					
No. of Bridges/Length (m)					
No. of Tunnels/Length (m)					
Distance between Stations (km)	75	55	175	150	
Freight (million tonnes/year)					
Passenger (million/year)					
Min. Running Time					

ANNEX 1

TRANS-ASIA RAILWAY IN THE INDOCHINA AND ASEAN SUB-REGION

BASIC TECHNICAL AND OPERATIONAL DATA

Country: CAMBODIA
TAR Link: C.4

Phnom Penh – Svay Rieng – Ho Chi Minh City Line

Station	Phnom Penh	Prey Veng	Svay Rieng	Ho Chi Minh City
Chainage (km)	0	65	135	240
	0 25 50 75 100 125 150 175 200 225 250 275 300 325 350 375 400 425 450 475			
Max. Speed (km/h) Passenger Trains Freight Trains				
Commercial Speed (km/h) Passenger Trains Freight Trains				
Axle Load (tonnes/axle)				
Hauling Capacity (tonnes) (new locomotive)				
Crossing Length (m)				
Line Capacity (2-way)				
Number of Trains/day (2-way) Passenger Freight				
Block and Signal Systems				
No. of Crossing Stations				
Operational Gradient (%) For Down Trains Up Trains				
Minimum Curvature (m)				
Rail (kg/m)				
Sleeper Type/Density (pieces/km)				
Rail Fastening System				
Ballast Depth (mm)				
No. of Bridges/Length (m)				
No. of Tunnels/Length (m)				
Distance between Stations (km)	65	70	105	
Freight (million tonnes/year)				
Passenger (million/year)				
Min. Running Time				

TRANS–ASIA RAILWAY IN THE INDOCHINA AND ASEAN SUB–REGION

BASIC TECHNICAL AND OPERATIONAL DATA

Country: MYANMAR
TAR Link: M.1

Yangon – Myitkyina – Dali Line

Station	Yangon	Taungoo	Yamethin	Thazi
Chainage (km)	0	267	442	493
	0 25 50 75 100 125 150 175 200 225 250	275 300 325 350 375 400 425	450 475	
Max. Speed (km/h) Passenger Trains Freight Trains	56 48/32	64 48/32	64 48/32	
Commercial Speed (km/h) Passenger Trains Freight Trains	50 43/29	58 43/29		
Axle Load (tonnes/axle)	12.5			
Hauling Capacity (tonnes) (new locomotive)	1,300			
Crossing Length (m)	518			
Line Capacity (2–way)	80	72	41	
Number of Trains/day (2–way) Passenger Freight	26 20 6	19 13 6	26 20 6	
Block and Signal Systems	Token block with either colour light or semaphore signals			
No. of Crossing Stations	35	24	7	
Operational Gradient (%) For Down Trains Up Trains	0.5 0.5			
Minimum Curvature (m)	291			
Rail (kg/m)	37			
Sleeper Type/Density (pieces/km)	Wood and monoblock prestressed concrete/1,375			
Rail Fastening System	Rigid and elastic			
Ballast Depth (mm)	76–152			
No. of Bridges/Length (m)	233/1,881	267/1,808	103/717	
No. of Tunnels/Length (m)	–			
Distance between Stations (km)	267	175	51	
Freight (million tonnes/year)	4.2	3.3	2.6	
Passenger (million/year)	–			
Min. Running Time	6 h – 30 m	3 h – 45 m	1 h – 15 m	

Remark: 48/32 – max. speeds of freight trains with bogie and four–wheeler construction respectively

TRANS–ASIA RAILWAY IN THE INDOCHINA AND ASEAN SUB–REGION

BASIC TECHNICAL AND OPERATIONAL DATA

Country: MYANMAR
TAR Link: M.1

Yangon – Ayitkyina – Dali Line (Con't)

Station		Thazi	Mandalay	Shwebo	Myitkyina	Dali (China)
Chainage (km)		493	621	716	1,163	1,643
	475	500 525 550 575 600	625 650 675 700	725 1,000	1,100 1,200 1,300 1,400 1,500 1,600	1,700 1,800
Max. Speed (km/h) Passenger Trains Freight Trains		 69 48/32	 48 –/32	 40 –/32		
Commercial Speed (km/h) Passenger Trains Freight Trains		 62 43/29	 43 –/29	 36 –/29		
Axle Load (tonnes/axle)		12.5				
Hauling Capacity (tonnes) (new locomotive)		1,300	550	500		
Crossing Length (m)	518					
Line Capacity (2–way)		36	25	12		
Number of Trains/day (2–way) Passenger Freight		22 *16* *6*	16 *14* *2*			
Block and Signal Systems	Token block with either colour light or semaphore signals					
No. of Crossing Stations		16	12	41		
Operational Gradient (%) For Down Trains Up Trains		 0.5 0.5		 1.25 1.25		
Minimum Curvature (m)		291	103	175		
Rail (kg/m)		37		37 & 30		
Sleeper Type/Density (pieces/km)	Wood and monoblock prestressed concrete/1,375					
Rail Fastening System	Rigid and clastic					
Ballast Depth (mm)		76–152	50–101			
No. of Bridges/Length (m)		99/813	95/1,500	316/2,572		
No. of Tunnels/Length (m)		–				
Distance between Stations (km)		128	95	448	480	
Freight (million tonnes/year)		2.9	1.6	2.1		
Passenger (million/year)		–				
Min. Running Time		2 h – 30 m	23 h			

Remark: Myitkyina–Dali section will cross border at either Kachang or Houqiao, a distance of about 100 km from Myitkyina

TRANS-ASIA RAILWAY IN THE INDOCHINA AND ASEAN SUB-REGION

BASIC TECHNICAL AND OPERATIONAL DATA

Country: MYANMAR
TAR Link: M.2

Yangon – Motama – Myawadi – Nakhonsawan Line

Station	Yangon	Motama	Myawadi/Mae Sod	Nakhonsawan
Chainage (km)	0	276	366	650
	0 25 50 75 100 125 150 175 200 225 250	275 300 350	400 450 500 550 600	650
Max. Speed (km/h) Passenger Trains Freight Trains	 48 32			
Commercial Speed (km/h) Passenger Trains Freight Trains	 43 29			
Axle Load (tonnes/axle)	12.5			
Hauling Capacity (tonnes) (new locomotive)	1,300			
Crossing Length (m)	518			
Line Capacity (2–way)	24			
Number of Trains/day (2–way) Passenger Freight	10 8 2			
Block and Signal Systems	Token block with colour light/semashore signals			
No. of Crossing Stations	31			
Operational Gradient (%) For Down Trains Up Trains	 1.0 1.0			
Minimum Curvature (m)	250			
Rail (kg/m)	37			
Sleeper Type/Density (pieces/km)	Wood/1,375			
Rail Fastening System	Rigid			
Ballast Depth (mm)	50–101			
No. of Bridges/Length (m)	180/2,345			
No. of Tunnels/Length (m)	–			
Distance between Stations (km)	276	90	284	
Freight (million tonnes/year)	3.9			
Passenger (million/year)	–			
Min. Running Time	7 h			

Remark: Distance from Notana to border with Thailand at Mywadi/Mae Sod is 90 km, and from border to Nakhornsawan is 284 km

TRANS–ASIA RAILWAY IN THE INDOCHINA AND ASEAN SUB–REGION

BASIC TECHNICAL AND OPERATIONAL DATA

Country: MYANMAR
TAR Link: M.3

Jinghong – Kengtung – Chiangmai Line

Station	Jinghong	Daluo	Kengtung	Tachilick/Maesai
Chainage (km)	0	141	225	336
	0 25 50 75 100 125 150 175 200 225 250 275 300 325 350 375 400 425 450 475			
Max. Speed (km/h) Passenger Trains Freight Trains				
Commercial Speed (km/h) Passenger Trains Freight Trains				
Axle Load (tonnes/axle)				
Hauling Capacity (tonnes) (new locomotive)				
Crossing Length (m)				
Line Capacity (2–way)				
Number of Trains/day (2–way) Passenger Freight				
Block and Signal Systems				
No. of Crossing Stations				
Operational Gradient (%) For Down Trains Up Trains				
Minimum Curvature (m)				
Rail (kg/m)				
Sleeper Type/Density (pieces/km)				
Rail Fastening System				
Ballast Depth (mm)				
No. of Bridges/Length (m)				
No. of Tunnels/Length (m)				
Distance between Stations (km)	141	84	111	
Freight (million tonnes/year)				
Passenger (million/year)				
Min. Running Time				

Remark: Tachilick/Maesai is about 254 km from Chiangmai and 1,000 km from Bangkok

ANNEX 1

TRANS–ASIA RAILWAY IN THE INDOCHINA AND ASEAN SUB–REGION

BASIC TECHNICAL AND OPERATIONAL DATA

Country: MYANMAR
TAR Link: M.4

Mawlamyine – Kanchanaburi Line

Station	Mawlamyine	Thanoyuzayat	Three Paguda Pass	Namtok (Kanchanaburi)
Chainage (km)	0	56	151	358
	0 25 50 75 100 125 150 175 200 225 250 275 300 325 350 375 400 425 450 475			
Max. Speed (km/h) Passenger Trains Freight Trains				
Commercial Speed (km/h) Passenger Trains Freight Trains				
Axle Load (tonnes/axle)				
Hauling Capacity (tonnes) (new locomotive)				
Crossing Length (m)				
Line Capacity (2–way)				
Number of Trains/day (2–way) Passenger Freight				
Block and Signal Systems				
No. of Crossing Stations				
Operational Gradient (%) For Down Trains Up Trains				
Minimum Curvature (m)				
Rail (kg/m)				
Sleeper Type/Density (pieces/km)				
Rail Fastening System				
Ballast Depth (mm)				
No. of Bridges/Length (m)				
No. of Tunnels/Length (m)				
Distance between Stations (km)	56	95	207	
Freight (million tonnes/year)				
Passenger (million/year)				
Min. Running Time				

Remark: Mawlamyine is 292 km from Yangon, and Namtok (Kanchanaburi) is 210 km from Bangkok

ANNEX 1

TRANS–ASIA RAILWAY IN THE INDOCHINA AND ASEAN SUB–REGION

BASIC TECHNICAL AND OPERATIONAL DATA

Country: VIET NAM
TAR Link: V.1

Hanoi – Ho Chi Minh City Line

Station	Hanoi	Vinh	Danang	Nhatrang	Ho Chi Minh City
Chainage (km)	0	319	791	1,315	1,726
	0 100 200 300	400 500 600 700	800 900 1,000 1,100 1,200	1,300 1,400 1,500 1,600	1,700 1,800 1,900
Max. Speed (km/h) Passenger Trains Freight Trains	70 60	70 60	60 50	80 60	
Commercial Speed (km/h) Passenger Trains Freight Trains	52.0	43.5	51.0	47.3	
Axle Load (tonnes/axle)	14	14	13	13	
Hauling Capacity (tonnes) (new locomotive)	1,200	600	700	700	
Crossing Length (m)	450				
Line Capacity (2–way)	32	20	31	22	
Number of Trains/day (2–way) Passenger Freight	14 6 8	24 12 12	22 10 12	26 16 10	
Block and Signal Systems	Token block system with semaphore signals *				
No. of Crossing Stations	8	7	8	6	
Operational Gradient (%) For Down Trains Up Trains	1.2	1.7	1.9	1.5	
Minimum Curvature (m)	100	95	–	–	
Rail (kg/m)	43	43	43	30	
Sleeper Type/Density (pieces/km)	Wood and two–block concrete/1,440			Steel/1,440	
Rail Fastening System	Dog spikes, clips			Rigid	
Ballast Depth (mm)	250				
No. of Bridges/Length (m)	130/1,080	351/7,440	520/9,920	299/7,270	
No. of Tunnels/Length (m)	–	14/4,168	13/4,406	–	
Distance between Stations (km)	319	472.4	523.5	414.3	
Freight (million tonnes/year)	3.15	1.52	–	0.70	
Passenger (million/year)	2.70	2.66	–	2.25	
Min. Running Time	6 h – 8 m	10 h – 52 m	10 h – 15 m	8 h – 45 m	

Remark: Express passengers train taken 36 hours at an average speed of 47.9 km/m
Rapid freight train taken 52 hours at an average speed of 33.2 km/m

* Token block system with colour light signals between Hanoi and Nam Dinh (86.7 km)

ANNEX 1

TRANS–ASIA RAILWAY IN THE INDOCHINA AND ASEAN SUB–REGION

BASIC TECHNICAL AND OPERATIONAL DATA

Country: VIET NAM
TAR Link: V.2

Hanoi – Dong Dang Dual – Guage Line

Station	Hanoi Yen Vien Gialam	Bac Giang Kep Dong Mo Lang Son	Dong Dang
Chainage (km)	0 5.5 10.9 0 10 20 30 40	49.4 68.6 113.1 147.6 50 60 70 80 90 100 110 120 130 140 150	162.5 160 170 180 190
Max. Speed (km/h) Passenger Trains Freight Trains	50 40	40 30	
Commercial Speed (km/h) Passenger Trains Freight Trains	30.1	25.3	
Axle Load (tonnes/axle)	16		
Hauling Capacity (tonnes) (new locomotive)	700	400	
Crossing Length (m)	350	250	
Line Capacity (2–way)	14	14	
Number of Trains/day (2–way) Passenger Freight	6 4 2		
Block and Signal Systems	Token block system with semaphore signals *		
No. of Crossing Stations	2	4	
Operational Gradient (%) For Down Trains Up Trains	0.7	1.7	
Minimum Curvature (m)	150		
Rail (kg/m)	43		
Sleeper Type/Density (pieces/km)	Wood and two–block concrete/1,600		
Rail Fastening System	Classical (rigid)		
Ballast Depth (mm)	350		
No. of Bridges/Length (m)	44/3,485		
No. of Tunnels/Length (m)	–	8/1,991	
Distance between Stations (km)	49.4	113.1	
Freight (million tonnes/year)	–		
Passenger (million/year)	–		
Min. Running Time	1 h – 37 m	4 h – 28 m	

Remark: * Automatic block system between Hanoi and Gia Lam

TRANS–ASIA RAILWAY IN THE INDOCHINA AND ASEAN SUB–REGION

BASIC TECHNICAL AND OPERATIONAL DATA

Country: VIET NAM
TAR Link: V.3

Hanoi - Hai Phong Line

Station	Hanoi Gialam Bac Giang Hai Duang P. Thai Hai Phong	
Chainage (km)	0 5.5 40.1 57.0 78.3 101.8	
	0 10 20 30 40 50 60 70 80 90 100	110 120 130 140 150 160 170 180 190
Max. Speed (km/h) Passenger Trains Freight Trains	 60 40	
Commercial Speed (km/h) Passenger Trains Freight Trains	38.2	
Axle Load (tonnes/axle)	14	
Hauling Capacity (tonnes) (new locomotive)	700	
Crossing Length (m)	450	
Line Capacity (2–way)	23	
Number of Trains/day (2–way) Passenger Freight	12 6 6	
Block and Signal Systems	Tokenless block system with colour light signals *	
No. of Crossing Stations	5	
Operational Gradient (%) For Down Trains Up Trains	0.6	
Minimum Curvature (m)	100	
Rail (kg/m)	43	
Sleeper Type/Density (pieces/km)	Two–block concrete/1,440	
Rail Fastening System	Classical (rigid)	
Ballast Depth (mm)	250	
No. of Bridges/Length (m)	12/2,829 **	
No. of Tunnels/Length (m)	–	
Distance between Stations (km)	101.8	
Freight (million tonnes/year)	–	
Passenger (million/year)	–	
Min. Running Time	2 hr – 40 min	

Remark:

* Automatic block system between Hanoi and Gialam

** Includes Long Bien Bridge – 2,000 m long

ANNEX 2.

REQUIRED TIMING OF SINGLE LINE CAPACITY EXPANSION

REQUIRED TIMING OF SINGLE LINE CAPACITY EXPANSION

A. THAILAND

TAR Link	Section	Route Length (Kms)	Number of Trains per day:		Year in which capacity expansion required, if:	
			Capacity	Existing	4% p.a. Traffic Growth	8% p.a. Traffic Growth
T.1	Padang Besar-Hat Yai Junction	45	26	5	-	-
	Hat Yai Junction-Surat Thani	294	10	126	2,006	2,001
	Surat Thani-Hua Hin	422	42	28	2,006	2,001
	Hua Hin-Nong Pladuk Junction	149	56	44	2,001	1,999
	Nong Pladuk Junction-Bangkok (Bangsue Junction)	80	72	56	2,002	1,999
T.2	Bangkok-Bangsue*	8	227	225	1,995	1,995
	Bangsue-Don Muang*	14	227	178	2,002	1,999
	Don Muang-Rangsit*	7	182	166	1,998	1,997
	Rangsit-Ayutthaya*	42	151	164	1,995	1,995
	Ayutthaya-Ban Phachi*	19	169	161	1,997	1,996
	Ban Phachi-Kaengkhoi	35	113	96	2,000	1,998
	Kaengkhoi-Mabkabao	9	40	56	1,995	1,995
	Mabkabao-Nakon Ratchasima	129	53	44	2,001	1,998
	Nakon Ratchasima-Buayai	82	43	52	1,995	1,995
	Buayai-Khonkaen	104	32	28	1,999	1,997
	Khonkaen-Udonthani	119	48	24	-	2,008
	Udonthani-Nong Khai	55	14	8	2,104	2,005
T.3	Yommaraj-Makkasan	5	90	33	-	-
	Makkasan-Huamak	10	43	61	1,995	1,995
	Huamak-Ladkrabang	11	113	56	-	2,008
	Ladkrabang-Huatakae	4	83	54	2,009	2,002
	Huatakae-Chachoengsao	30	65	48	2,004	2,000
	Chachoengsao-Klongsipkao	24	32	14	-	2,012
	Klongsipkao-Prachinburi	37	32	14	-	2,012
	Prachinburi-Kabinburi	40	65	10	-	-
	Kabinburi-Aranyaprathet	93	27	6	-	-

* Double track

REQUIRED TIMING OF SINGLE LINE CAPACITY EXPANSION

B. THAILAND (Cont'd)

TAR Link	Section	Route Length (Kms)	Number of Trains per day:		Year in which capacity expansion required, if:	
			Capacity	Existing	4% p.a. Traffic Growth	8% p.a. Traffic Growth
T.4	Bangkok-Ban Phachi (Same as T.2)					
	Ban Phachi-Ban Mor	19	60	81	1,995	1,995
	Ban Mor-Lopburi	24	65	73	1,995	1,995
	Lopburi-Takli	60	65	66	1,995	1,995
	Talki-Kanhon Sawan	53	57	62	1,995	1,995
T.5	Bangkok-Nakhon Ratchasima (Same as T.2)	264				
	Nakhon Ratchasima-Surin	156	53	54	1,995	1,999
	Surin-Sisaket	95	53	27	-	2,007
	Sisaket-Ubon Ratchathani	60	57	25	-	2,011

REQUIRED TIMING OF SINGLE LINE CAPACITY EXPANSION

B. CAMBODIA

TAR Link	Section	Route Length (Kms)	Number of Trains per day:		Year in which capacity expansion required, if:	
			Capacity	Existing	4% p.a. Traffic Growth	8% p.a. Traffic Growth
C.1	Phnom Penh-Pursat	165	12	1	-	-
	Pursat-Battambang	108	12	1	-	-
	Battambang-Sisophon	64	12	2	-	-
	Sisophon-Poipet	48	12	-	-	-
C.2	Phnom Penh-Takeo	75	12	1	-	-
	Takeo-Kampot	164	12	1	-	-
	Kampot-Sihanoukville	100	12	1	-	-
					-	-

ANNEX 2

REQUIRED TIMING OF SINGLE LINE CAPACITY EXPANSION

C. VIET NAM

TAR Link	Section	Route Length (Kms)	Number of Trains per day:		Year in which capacity expansion required, if:	
			Capacity	Existing	4% p.a. Traffic Growth	8% p.a. Traffic Growth
V.1	Hanoi-Vinh	319	32	12	-	-
	Vinh-Danang	472	20	20	1 995	1 995
	Danang-Nhatrang	524	31	20	2 009	2 002
	Nhatrang-Ho Chi Minh	414	22	16	2,005	2,000
V.2	Hanoi-Bac Giang	49	14	6	-	2,012
	Bac Giang-Dong Dang	113	14	6	-	2,012
V.3	Hanoi-Hai Phong	102	23	12	-	2,007

REQUIRED TIMING OF SINGLE LINE CAPACITY EXPANSION

D. MYANMAR

TAR Link	Section	Route Length (Kms)	Number of Trains per day:		Year in which capacity expansion required, if:	
			Capacity	Existing	4% p.a. Traffic Growth	8% p.a. Traffic Growth
M.1	Yangon-Taungoo	267	80	26	-	-
	Taungoo-Yamethin	175	72	19	-	-
	Yamethin-Thazi	51	41	26	-	-
	Thazi-Mandalay	128	36	22	2,011	2,003
	Mandalay-Shwebo	95	25	16	2,009	2,002
	Shwebo-Myitkyina	448	12	16	1,995	1,995
	Myitkyina-Dali	480	-	-	-	-
M.2	Yangon-Motama	276	24	10	-	2,013
	Motama-Nakhonsawan	374	-	-		
M.3	Jinghong-Daluo	141	-	-		
	Daluo-Tachileik	195	-	-		
	Tachileik-Chiangmai	255	-	-		
M.4	Mawlamyine-Thanbyuzayat	56	26	4	-	-
	Thanbyuzayat-Namtok (Kanchanaburi)	302	-	-		

ANNEX 3.

LINE CAPACITY ASSESSMENT

RAIL PROJECT FINANCIAL AND ECONOMIC APPRAISAL MODEL
Version 2.0

PHYSICAL FACILITIES PLAN (RFACIL) -RAIL LINE UPGRADING PROJECT >>>>>> 4% TRAFFIC GROWTH CASE <<<<<<
(FILENAME= TARAS:\VHHACAP3.WK4) INCREASED MAXIMUM SPEEDS

* PROJECT DESCRIPTION: TRAIN CROSSING CAPACITY EXPANSION, HAIPHONG-HANOI (TAR LINK V3)

NOTE: * means original input of users is required
** means data should be transferred from another worksheet

PROJECT TYPE
(Enter "1", if applicable, or "0", if inapplicable.)

* Track Reconstruction	0
* Train Crossing Capacity Expan.	1
* Station/Siding Capacity Expan.	0
* Electrification	0
* Re-Signalling	0

CASE FOR EVALUATION

* Base Case - "Do Nothing"	0
* Base Case - Alt. Rail Investment	0
* Project Case	1

OPERATIONAL SCENARIO FOR THIS WORKSHEET

* Pre-Upgrading	0
* Post-Upgrading	1

***1. PROJECT START-UP YEAR:** 1996 **2. OPERATING DAYS/YEAR:** 300 (Freight) 360 (Passenger)

3. ROUTE CHARACTERISTICS

3.1 SECTION LENGTHS AND RULING GRADIENTS

Line Section	Direction	Section Length	Ruling Gradient
* 1	Up		0.6%
*		102 km.	
*	Down		0.6%
* 2	Up		
*			
*	Down		
* 3	Up		
*			
*	Down		
* 4	Up		
*			
*	Down		
* 5	Up		
*			
*	Down		
TOTAL LINE	Up		
		102 km.	0.6%
	Down		

Ruling gradient on other lines forming a route network with this line:

UP
DOWN

3.2 STATIONS AND TRAIN CROSSING FACILITIES

	Line Section: 1	2	3	4	5	Line Total
Stations Existing						
-Freight Handling:						
* Major (Number)						0
* Minor (Number)						0
Sub-Total	0					0
-Passenger Handling:						
* Major (Number)						0
* Minor (Number)						0
Sub-Total	0	0	0	0	0	0
Freight Sidings Existing (Number, by Length)						
* metres						0
* metres						0
* metres						0
Total number	0	0	0	0	0	0
Total kilometres	0.0	0.0	0.0	0.0	0.0	0.0
Passenger Sidings Existing (Number, by Length)						
* metres						0
* metres						0
* metres						0
Total number	0	0	0	0	0	0
Total kilometres	0.0	0.0	0.0	0.0	0.0	0.0
Crossing Loops Existing (Number, by Length)						
* 476 metres	5					5
* metres						0
* metres						0
Total number	5	0	0	0	0	5
Total kilometres	2.4	0.0	0.0	0.0	0.0	2.4

4. OPERATING SPEEDS AND AVERAGE TRANSIT TIMES

	Line Sect ion	Direction	Max.Allowable Speeds (Kms/Hr)		Average Speed as a % of Max. Speed		Average Speeds (Kms/Hr)		Net Transit Times (Hrs) (excl.s'working & stopping)	
			Freight	Passenger	Freight	Passenger	Freig	Passenger	Freight	Passenger
*	1	Up			60%	70%	42	84	2.4	1.2
*			70	120						
*		Down			60%	70%	42	84	2.4	1.2
*	2	Up								
*										
*		Down								
*	3	Up								
*										
*		Down								
*	4	Up								
*										
*		Down								
*	5	Up								
*										
*		Down								
							TOTAL FOR LINE	Up	2.4	1.2
								Down	2.4	1.2

5. CROSSING LOOP AND FREIGHT SIDING LENGTH REQUIREMENTS

* Expected Maximum Train Trailing Length:			270 metres
* Plus Locomotive Allowance		:	17 metres
* Plus Stopping Allowance	10%	:	29 metres
* Equals Track Length Requirement		:	316 metres

6. PEAK DAY TRAFFIC DENSITY (NO. OF TRAIN TRANSITS PER PEAK DAY)

		Year:																			
LINE SECTION	DIRECTION/TRAIN DESCRIPTION	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	UP DIRECTION																				
1	Freight Trains:																				
**	Block, Non-Container																				
**	Block, Container	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
**	Non-Block	3	3	3	3	4	4	4	4	4	4	4	5	5	5	5	5	6	6	6	6
	Sub-Total	3	3	3	3	4	4	4	4	4	4	4	5	5	5	5	5	6	6	6	6
	Passenger Trains:																				
**	Long Distance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
**	Local	3	3	3	3	4	4	4	4	4	4	4	5	5	5	5	5	6	6	6	6
	TOTAL	6	6	6	7	7	7	8	8	8	9	9	9	10	10	10	11	11	12	12	13
2	Freight Trains:																				
**	Block, Non-Container																				
**	Block, Container																				
**	Non-Block																				
	Sub-Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Passenger Trains:																				
**	Long Distance																				
**	Local																				
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Freight Trains:																				
**	Block, Non-Container																				
**	Block, Container																				
**	Non-Block																				
	Sub-Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Passenger Trains:																				
**	Long Distance																				
**	Local																				
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Freight Trains:																				
**	Block, Non-Container																				
**	Block, Container																				
**	Non-Block																				
	Sub-Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Passenger Trains:																				
**	Long Distance																				
**	Local																				
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Freight Trains:																				
**	Block, Non-Container																				
**	Block, Container																				
**	Non-Block																				
	Sub-Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Passenger Trains:																				
**	Long Distance																				
**	Local																				
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DOWN DIRECTION

1	Freight Trains:																				
**	Block, Non-Container																				
**	Block, Container	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
**	Non-Block	3	3	3	3	4	4	4	4	4	4	4	5	5	5	5	5	6	6	6	6
	Sub-Total	3	3	3	3	4	4	4	4	4	4	4	5	5	5	5	5	6	6	6	6
	Passenger Trains:																				
**	Long Distance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
**	Local	3	3	3	3	4	4	4	4	4	4	4	5	5	5	5	5	6	6	6	6
	TOTAL	6	6	6	7	7	7	8	8	8	9	9	9	10	10	10	11	11	12	12	13
2	Freight Trains:																				
**	Block, Non-Container																				
**	Block, Container																				
**	Non-Block																				
	Sub-Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Passenger Trains:																				
**	Long Distance																				
**	Local																				
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Freight Trains:																				
**	Block, Non-Container																				
**	Block, Container																				
**	Non-Block																				
	Sub-Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Passenger Trains:																				
**	Long Distance																				
**	Local																				
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Freight Trains:																				
**	Block, Non-Container																				
**	Block, Container																				
**	Non-Block																				
	Sub-Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Passenger Trains:																				
**	Long Distance																				
**	Local																				
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Freight Trains:																				
**	Block, Non-Container																				
**	Block, Container																				
**	Non-Block																				
	Sub-Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Passenger Trains:																				
**	Long Distance																				
**	Local																				
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

7. CALCULATION OF CROSSING LOOP REQUIREMENTS

7.1 MAXIMUM SECTIONAL TRANSIT TIMES

Line Section		1	2	3	4	5
Max. Time for Transit (Hours)		2.4	0.0	0.0	0.0	0.0
Plus Allowance for delays, etc.	0%	0.0	0.0	0.0	0.0	0.0
Gross Transit Time		2.4	0.0	0.0	0.0	0.0

7.2 NUMBER OF TRANSITS DURING MAX. TRANSIT TIME

* Traffic Concentration Factor: 1.70

Year:

Line Section	Direction	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	Up	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2
2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	Down	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2
2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

7.3 NUMBER OF CROSSING LOOPS REQUIRED

Year:

Line Section		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	No.	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3	3	3	3	3	3
2	No.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	No.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	No.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	No.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Line Total	No.	1	1	1	1	1	1	1	1	1	1	3	3	3	3	3	3	3	3	3	3

7.4 REQUIRED SPACING OF CROSSING LOOPS

Line Section 1	Kms	51	51	51	51	51	51	51	51	51	51	25	25	25	25	25	25	25	25	25	25
Line Section 2	Kms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Line Section 3	Kms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Line Section 4	Kms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Line Section 5	Kms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

7.5 MIN. LOOP SPACING

MIN. LOOP SPACING	Kms	5
(Before Line Doubling Considered)		
Line Doubling Required	NO	

7.6 INCREMENTAL REQUIREMENT OF CROSSING LOOPS

Line Section		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	No.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	No.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	No.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	No.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	No.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Line Total	No.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

			1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
8.	CONSTRUCTION PHASING (%)																					
*	Mainline Track Reconstruction																					
*	Mainline Track Duplication																					
	Line Section 1																					
	Line Section 2																					
	Line Section 3																					
	Line Section 4																					
	Line Section 5																					
*	Freight Siding Track																					
*	Passenger Siding Track																					
*	Crossing Loop Extension																					
*	Electrification																					
*	Re-signalling																					

9.	TRACK CONSTRUCTION SCHEDULE		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
9.1	M/LINE TRACK RECONSTRUCT.	Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9.2	MAINLINE TRACK DUPLICATION																					
	Line Section 1	Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Line Section 2	Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Line Section 3	Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Line Section 4	Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Line Section 5	Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total for Line	Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9.3	SIDING TRACK RECONSTRUCTION																					
9.3.1	Freight Handling																					
	- Length Reconstructed	Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9.3.2	Passenger Handling																					
	- Length Constructed	Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9.4	SIDING TRACK CONSTRUCTION/EXTENSION																					
9.4.1	Freight Handling																					
	- Length Constructed	Kms																				
	(Length/Siding: 500 metres)																					
9.4.2	Passenger Handling																					
	- Length Constructed	Kms																				
	(Length/Siding: metres)																					
9.5	CROSSING LOOP CONSTRUCTION	Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(Length/Loop: 500 metres)																					
9.6	CROSSING LOOP EXTENTION	Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(Length/Loop: 500 metres)																					
9.7	TOTAL TRACK CONSTRUCTION	Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	ELECTRIFICATION WORKS SCH	Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.	RESIGNALLING WORKS SCH	Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	No. Loops and Sidings Signalled																					
	Sidings		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Crossing Loops		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sub-Total		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

RAIL PROJECT FINANCIAL AND ECONOMIC APPRAISAL MODEL
Version 2.0

PHYSICAL FACILITIES PLAN (RFACIL) -RAIL LINE UPGRADING PROJECT >>>>>> 8% TRAFFIC GROWTH CASE <<<<<<
(FILENAME= TARAS:\VHHACAP4.WK4) INCREASED MAXIMUM SPEEDS

* PROJECT DESCRIPTION: TRAIN CROSSING CAPACITY EXPANSION, HAIPHONG-HANOI (TAR LINK V3)

NOTE: * means original input of users is required
** means data should be transferred from another worksheet

PROJECT TYPE
(Enter "1", if applicable, or "0", if inapplicable.)

* Track Reconstruction	0
* Train Crossing Capacity Expan.	1
* Station/Siding Capacity Expan.	0
* Electrification	0
* Re-Signalling	0

CASE FOR EVALUATION

* Base Case - "Do Nothing"	0
* Base Case - Alt. Rail Investment	0
* Project Case	1

OPERATIONAL SCENARIO FOR THIS WORKSHEET

* Pre-Upgrading	0
* Post-Upgrading	1

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1. PROJECT START-UP YEAR: 1996 **2. OPERATING DAYS/YEAR:** 300 (Freight) 360 (Passenger)

3. ROUTE CHARACTERISTICS

3.1 SECTION LENGTHS AND RULING GRADIENTS

Line Section	Direction	Section Length	Ruling Gradient
* 1	Up	102 km.	0.6%
*	Down		0.6%
* 2	Up		
*	Down		
* 3	Up		
*	Down		
* 4	Up		
*	Down		
* 5	Up		
*	Down		
TOTAL LINE	Up	102 km.	0.6%
	Down		

Ruling gradient on other lines forming a route network with this line:

UP
DOWN

3.2 STATIONS AND TRAINCROSSING FACILITIES

Line Section:

		1	2	3	4	5	Line Total
	Stations Existing						
	-Freight Handling:						
*	Major (Number)						0
*	Minor (Number)						0
	Sub-Total	0					0
	-Passenger Handling:						
*	Major (Number)						0
*	Minor (Number)						0
	Sub-Total	0	0	0	0	0	0
	Freight Sidings Existing (Number, by Length)						
*	metres						0
*	metres						0
*	metres						0
	Total number	0	0	0	0	0	0
	Total kilometres	0.0	0.0	0.0	0.0	0.0	0.0
	Passenger Sidings Existing (Number, by Length)						
*	metres						0
*	metres						0
*	metres						0
	Total number	0	0	0	0	0	0
	Total kilometres	0.0	0.0	0.0	0.0	0.0	0.0
	Crossing Loops Existing (Number, by Length)						
*	476 metres	5					5
*	metres						0
*	metres						0
	Total number	5	0	0	0	0	5
	Total kilometres	2.4	0.0	0.0	0.0	0.0	2.4

4 OPERATING SPEEDS AND AVERAGE TRANSIT TIMES

	Line Section	Direction	Max. Allowable Speeds (Kms/Hr)		Average Speed as a % of Max. Speed		Average Speeds (Kms/Hr)		Net Transit Times (Hrs) (excl.s' working & stopping)	
			Freight	Passenger	Freight	Passenger	Freight	Passenger	Freight	Passenger
*	1	Up			60%	70%	42	84	2.4	1.2
*			70	120						
*		Down			60%	70%	42	84	2.4	1.2
*	2	Up								
*										
*		Down								
*	3	Up								
*										
*		Down								
*	4	Up								
*										
*		Down								
*	5	Up								
*										
*		Down								
							TOTAL FOR LINE	Up	2.4	1.2
								Down	2.4	1.2

5. CROSSING LOOP AND FREIGHT SIDING LENGTH REQUIREMENTS

- Expected Maximum Train Trailing Length: 270 metres
- Plus Locomotive Allowance : 17 metres
- Plus Stopping Allowance 10% : 29 metres
- Equals Track Length Requirement : 316 metres

6. PEAK DAY TRAFFIC DENSITY (NO. OF TRAIN TRANSITS PER PEAK DAY)

		Year:																			
LINE SECTION	DIRECTION/ TRAIN DESCRIPTION	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	UP DIRECTION																				
1	Freight Trains:																				
**	Block, Non-Container																				
**	Block, Container	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
**	Non-Block	3	3	3	4	4	4	5	5	6	6	6	7	8	8	9	10	10	11	12	13
	Sub-Total	3	3	3	4	4	4	5	5	6	6	6	7	8	8	9	10	10	11	12	13
	Passenger Trains:																				
**	Long Distance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
**	Local	3	3	3	4	4	4	5	5	6	6	6	7	8	8	9	10	10	11	12	13
	TOTAL	6	6	7	8	8	9	10	10	11	12	13	14	15	16	18	19	21	22	24	26
2	Freight Trains:																				
**	Block, Non-Container																				
**	Block, Container																				
**	Non-Block																				
	Sub-Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Passenger Trains:																				
**	Long Distance																				
**	Local																				
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Freight Trains:																				
**	Block, Non-Container																				
**	Block, Container																				
**	Non-Block																				
	Sub-Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Passenger Trains:																				
**	Long Distance																				
**	Local																				
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Freight Trains:																				
**	Block, Non-Container																				
**	Block, Container																				
**	Non-Block																				
	Sub-Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Passenger Trains:																				
**	Long Distance																				
**	Local																				
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Freight Trains:																				
**	Block, Non-Container																				
**	Block, Container																				
**	Non-Block																				
	Sub-Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Passenger Trains:																				
**	Long Distance																				
**	Local																				
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DOWN DIRECTION

1	Freight Trains:																				
**	Block, Non-Container																				
**	Block, Container	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
**	Non-Block	3	3	3	4	4	4	5	5	6	6	6	7	8	8	9	10	10	11	12	13
	Sub-Total	3	3	3	4	4	4	5	5	6	6	6	7	8	8	9	10	10	11	12	13
	Passenger Trains:																				
**	Long Distance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
**	Local	3	3	3	4	4	4	5	5	6	6	6	7	8	8	9	10	10	11	12	13
	TOTAL	6	6	7	8	8	9	10	10	11	12	13	14	15	16	18	19	21	22	24	26
2	Freight Trains:																				
**	Block, Non-Container																				
**	Block, Container																				
**	Non-Block																				
	Sub-Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Passenger Trains:																				
**	Long Distance																				
**	Local																				
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Freight Trains:																				
**	Block, Non-Container																				
**	Block, Container																				
**	Non-Block																				
	Sub-Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Passenger Trains:																				
**	Long Distance																				
**	Local																				
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Freight Trains:																				
**	Block, Non-Container																				
**	Block, Container																				
**	Non-Block																				
	Sub-Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Passenger Trains:																				
**	Long Distance																				
**	Local																				
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Freight Trains:																				
**	Block, Non-Container																				
**	Block, Container																				
**	Non-Block																				
	Sub-Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Passenger Trains:																				
**	Long Distance																				
**	Local																				
	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

7 CALCULATION OF CROSSING LOOP REQUIREMENTS

7.1 MAXIMUM SECTIONAL TRANSIT TIMES

Line Section		1	2	3	4	5
Max. Time for Transit (Hours)		2.4	0.0	0.0	0.0	0.0
Plus Allowance for delays, etc.	0%	0.0	0.0	0.0	0.0	0.0
Gross Transit Time		2.4	0.0	0.0	0.0	0.0

7.2 NUMBER OF TRANSITS DURING MAX. TRANSIT TIME

* Traffic Concentration Factor: 1.70

Year:

Line Section	Direction	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	Up	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3	4	4	4	4
2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	Down	1	1	1	1	1	2	2	2	2	2	2	2	3	3	3	3	4	4	4	4
2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

7.3 NUMBER OF CROSSING LOOPS REQUIRED

Year:

Line Section		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	No.	1	1	1	1	1	3	3	3	3	3	3	3	5	5	5	5	7	7	7	7
2	No.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	No.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	No.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	No.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Line Total	No.	1	1	1	1	1	3	3	3	3	3	3	3	5	5	5	5	7	7	7	7

7.4 REQUIRED SPACING OF CROSSING LOOPS

Line Section 1	Kms	51	51	51	51	51	25	25	25	25	25	25	25	17	17	17	17	13	13	13	13
Line Section 2	Kms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Line Section 3	Kms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Line Section 4	Kms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Line Section 5	Kms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

7.5 MIN. LOOP SPACING Kms 5

(Before Line Doubling Considered)

Line Doubling Required NO

7.6 INCREMENTAL REQUIREMENT OF CROSSING LOOPS

Line Section		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	No.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2
2	No.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	No.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	No.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	No.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

				1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
8.	CONSTRUCTION PHASING (%)																						
*	Mainline Track Reconstruction																						
*	Mainline Track Duplication																						
	Line Section 1																						
	Line Section 2																						
	Line Section 3																						
	Line Section 4																						
	Line Section 5																						
*	Freight Siding Track																						
*	Passenger Siding Track																						
*	Crossing Loop Extension																						
*	Electrification																						
*	Re-signalling																						
9.	TRACK CONSTRUCTION SCHEDULE																						
				1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
9.1	M/LINE TRACK RECONSTRUCT.		Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9.2	MAINLINE TRACK DUPLICATION																						
	Line Section 1		Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Line Section 2		Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Line Section 3		Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Line Section 4		Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Line Section 5		Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total for Line		Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9.3	SIDING TRACK RECONSTRUCTION																						
9.3.1	Freight Handling																						
	- Length Reconstructed		Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9.3.2	Passenger Handling																						
	- Length Constructed		Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9.4	SIDING TRACK CONSTRUCTION/EXTENSION																						
9.4.1	Freight Handling																						
	- Length Constructed		Kms																				
	(Length/Siding:	500 metres)																					
9.4.2	Passenger Handling																						
	- Length Constructed		Kms																				
	(Length/Siding:	metres)																					
9.5	CROSSING LOOP CONSTRUCTION		Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
	(Length/Loop:	500 metres)																					
9.6	CROSSING LOOP EXTENTION		Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(Length/Loop:	500 metres)																					
9.7	TOTAL TRACK CONSTRUCTION		Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
10.	ELECTRIFICATION WORKS SCH		Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.	RESIGNALLING WORKS SCH		Kms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	No. Loops and Sidings Signalled																						
	Sidings			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Crossing Loops			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sub-Total			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TRACK CONSTRUCTION DUE LINE CAPACITY EXPANSION

THAILAND - TAR LINK T.2 (BANGKOK-NONG KHAI)

Section	Route Length (Kms)	Number of Crossing Stations	Schedule Speed (Slowest Train) km/hr	No.Trains/day -capacity*	-existing	Annual Growth Rate (No. of Trains)	Line Doubling Required?	TRACK CONSTRUCTION TO EXPAND LINE CAPACITY (KM) IN:										TOTAL
								1996	1997	1998	1999	(Year) 2000	2001	2002	2003	2004	2005	1996-2006
Ban Pachi-Kaeng Khoi	35	6	42	113	78	4%	YES											0.0
						8%	YES								17.5	17.5		35.0
Kaeng Khoi-Bua Yai	250.8	16	37	50	18	4%	NO						0.2				0.5	0.7
						8%	NO						0.2					0.2
Bua Yai-Kon Khaen	104.3	7	39	35	18	4%	NO						0.2					0.2
						8%	NO						0.2					0.2
Kon Khaen-Udorn Thani	119.1	12	41	48	22	4%	NO											0.0
						8%	NO											0.0
Udorn Thani-Nong Khai	54.7	0	46	14	10	4%	NO						0.5					0.5
						8%	NO			0.5								0.5
TOTALS: TAR LINK T.2 Km for Construction						4%		0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.5	1.4
						8%		0.0	0.0	0.5	0.0	0.0	0.4	0.0	17.5	17.5	0.0	35.9

Section	Route Length (Kms)	Number of Crossing Stations	Schedule Speed (Slowest Train) km/hr	No.Trains/day -capacity*	-existing	Annual Growth Rate (No. of Trains)	Line Doubling Required?	TRACK CONSTRUCTION TO EXPAND LINE CAPACITY (KM) IN:										TOTAL
								2006	2007	2008	2009	(Year) 2010	2011	2012	2013	2014	2015	1996-2015
Ban Pachi-Kaeng Khoi	35	6	42	113	78	4%	YES			17.5	17.5							35.0
						8%	YES											35.0
Kaeng Khoi-Bua Yai	250.8	16	37	50	18	4%	NO											0.7
						8%	NO	1.0		1.0	1.0	1.0	1.0	1.0	1.0			7.2
Bua Yai-Kon Khaen	104.3	7	39	35	18	4%	NO											0.2
						8%	NO				1.0		1.0		1.0			3.2
Kon Khaen-Udorn Thani	119.1	12	41	48	22	4%	NO											0.0
						8%	NO					0.5		1.0	1.0			2.5
Udorn Thani-Nong Khai	54.7	0	46	14	10	4%	NO											0.5
						8%	NO							1.0				1.5
TOTALS: TAR LINK T.2 Km for Construction						4%		0.0	0.0	17.5	17.5	0.0	0.0	0.0	0.0		0.0	36.4
						8%		1.0	0.0	1.0	2.0	1.5	2.0	3.0	3.0		0.0	49.4

Sources:
1. State Railway of Thailand (Information supplied during ESCAP Mission June, 1994).
2. ESCAP: Railway Capital Project Appraisal Model (RFACIL Sub-Model).

TRACK CONSTRUCTION DUE LINE CAPACITY EXPANSION

THAILAND - TAR LINK T.3 (BANGKOK-ARANYAPRATHET)

Section	Route Length (Kms)	Number of Crossing Stations	Schedule Speed (Slowest Train) km/hr	No.Trains/day -capacity*	-existing	Annual Growth Rate (No. of Trains)	Line Doubling Required?	TRACK CONSTRUCTION TO EXPAND LINE CAPACITY (KM) IN:				(Year)						TOTAL
								1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	1996-2006
Yommarat-Hua Mark	13.2	2	26	79	48	4%	YES											0.0
						8%	YES								13.2			13.2
Hua Mark-Lard Krabang	11.3	1	26	75	46	4%	NO		0.1									0.1
						8%	YES		0.1								11.3	11.4
Lard Krabang-Chachoengsao	34.2	4	34	67	46	4%	NO											0.0
						8%	YES						10.3	10.3	13.7			34.3
Chachoengsao-Klong Sip Kao	22.1	0	37	28	14	4%	NO											0.0
						8%	NO								0.5			0.5
Klong Sip Kao-Prachinburi	38.7	3	37	45	14	4%	NO						0.4					0.4
						8%	NO						0.4					0.4
Prachinburi-Kabinburi	39.5	4	39	73	10	4%	NO						0.7					0.7
						8%	NO						0.7					0.7
Kabinburi-Aranyaprathet	97.7	6	55	32	6	4%	NO						0.8					0.8
						8%	NO						0.8					0.8
TOTALS: TAR LINK T.3 Km for Construction						**4%**		**0.0**	**0.1**	**0.0**	**0.0**	**0.0**	**0.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.5**
						8%		**0.0**	**0.1**	**0.0**	**0.0**	**0.0**	**12.2**	**10.3**	**27.4**	**0.0**	**11.3**	**61.3**

Section	Route Length (Kms)	Number of Crossing Stations	Schedule Speed (Slowest Train) km/hr	No.Trains/day -capacity*	-existing	Annual Growth Rate (No. of Trains)	Line Doubling Required?	TRACK CONSTRUCTION TO EXPAND LINE CAPACITY (KM) IN:			(Year)							TOTAL
								2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	1996-2015
Yommarat-Hua Mark	13.2	2	26	79	48	4%	YES					13.2						13.2
						8%	YES											13.2
Hua Mark-Lard Krabang	11.3	1	26	75	46	4%	NO											0.1
						8%	YES											11.4
Lard Krabang-Chachoengsao	34.2	4	34	67	46	4%	NO				0.5							0.5
						8%	YES											34.3
Chachoengsao-Klong Sip Kao	22.1	0	37	28	14	4%	NO						0.5					0.5
						8%	NO											0.5
Klong Sip Kao-Prachinburi	38.7	3	37	45	14	4%	NO											0.4
						8%	NO											0.4
Prachinburi-Kabinburi	39.5	4	39	73	10	4%	NO											0.7
						8%	NO											0.7
Kabinburi-Aranyaprathet	97.7	6	55	32	6	4%	NO											0.8
						8%	NO											0.8
TOTALS: TAR LINK T.3 Km for Construction						**4%**		**0.0**	**0.0**	**0.0**	**0.5**	**13.2**	**0.5**	**0.0**	**0.0**	**0.0**	**0.0**	**14.7**
						8%		**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**61.3**

Sources:
1. State Railway of Thailand (Information supplied during ESCAP Mission June, 1994).
2. ESCAP: Railway Capital Project Appraisal Model (RFACIL Sub-Model).

TRACK CONSTRUCTION DUE LINE CAPACITY EXPANSION

THAILAND - TAR LINK T.4 (BANGKOK-MAE SOD)

Section	Route Length (Kms)	Number of Crossing Stations	Schedule Speed (Slowest Train) km/hr	No.Trains/day -capacity*	-existing	Annual Growth Rate (No. of Trains)	Line Doubling Required?	TRACK CONSTRUCTION TO EXPAND LINE CAPACITY (KM) IN:										
								1996	1997	1998	1999	(Year) 2000	2001	2002	2003	2004	2005	TOTAL 1996-2006
Ban Pachi-Lop Buri	42.9	6	36	78	82	4%	YES			21.4	21.5							42.9
						8%	YES		21.4	21.5								42.9
Lop Buri-Nakhon Sawan	113.0	16	36	59	66	4%	YES					28.2	28.2	28.3	28.3			113.0
						8%	YES		28.2	28.2	28.3	28.3						113.0
TOTALS: TAR LINK T.4 Km for Construction						4%		0.0	0.0	21.4	21.5	28.2	28.2	28.3	28.3	0.0	0.0	155.9
						8%		0.0	49.6	49.7	28.3	28.3	0.0	0.0	0.0	0.0	0.0	155.9

Section	Route Length (Kms)	Number of Crossing Stations	Schedule Speed (Slowest Train) km/hr	No.Trains/day -capacity*	-existing	Annual Growth Rate (No. of Trains)	Line Doubling Required?	TRACK CONSTRUCTION TO EXPAND LINE CAPACITY (KM) IN:										
								2006	2007	2008	2009	(Year) 2010	2011	2012	2013	2014	2015	TOTAL 1996-2015
Ban Pachi-Lop Buri	42.9	6	36	78	82	4%	YES											42.9
						8%	YES											42.9
Lop Buri-Nakhon Sawan	113.0	16	36	59	66	4%	YES											113.0
						8%	YES											113.0
TOTALS: TAR LINK T.4 Km for Construction						4%		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	155.9
						8%		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	155.9

Sources:
1. State Railway of Thailand (Information supplied during ESCAP Mission June, 1994).
2. ESCAP: Railway Capital Project Appraisal Model (RFACIL Sub-Model).

TRACK CONSTRUCTION DUE LINE CAPACITY EXPANSION

THAILAND - TAR LINK T.5 (BANGKOK-UBON RATCHATHANI)

Section	Route Length (Kms)	Number of Crossing Stations	Schedule Speed (Slowest Train) km/hr	No.Trains/day -capacity*	-existing	Annual Growth Rate (No. of Trains)	Line Doubling Required?	TRACK CONSTRUCTION TO EXPAND LINE CAPACITY (KM) IN:										TOTAL
								1996	1997	1998	1999	(Year) 2000	2001	2002	2003	2004	2005	1996-2006
Kaeng Khoi-Map Kabao	9.2	0	25	46	56	4%	YES		9.2									9.2
						8%	YES		9.2									9.2
Map Kabao-N. Ratchasima	129.4	19	28	56	52	4%	YES											0.0
						8%	YES					32.3	32.3	32.4	32.4			129.4
Nakhon Ratchasima-Surin	156.1	17	44	56	54	4%	NO		0.1									0.1
						8%	YES				31.2	31.2	31.2	31.2	31.3			156.1
Surin-Si Sakhet	95.3	9	37	56	28	4%	NO		0.1									0.1
						8%	NO		0.1									0.1
Si Sakhet-Ubon Ratchathani	60.0	5	40	56	26	4%	NO		0.1									0.1
						8%	NO		0.1									0.1
TOTALS: TAR LINK T.5 Km for Construction						4%		0.0	9.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.5
						8%		0.0	9.4	0.0	31.2	63.5	63.5	63.6	63.7	0.0	0.0	294.9

Section	Route Length (Kms)	Number of Crossing Stations	Schedule Speed (Slowest Train) km/hr	No.Trains/day -capacity*	-existing	Annual Growth Rate (No. of Trains)	Line Doubling Required?	TRACK CONSTRUCTION TO EXPAND LINE CAPACITY (KM) IN:										TOTAL
								2006	2007	2008	2009	(Year) 2010	2011	2012	2013	2014	2015	1996-2015
Kaeng Khoi-Map Kabao	9.2	0	25	46	56	4%	YES											9.2
						8%	YES											9.2
Map Kabao-N. Ratchasima	129.4	19	28	56	52	4%	YES		32.3	32.3	32.4	32.4						129.4
						8%	YES											129.4
Nakhon Ratchasima-Surin	156.1	17	44	56	54	4%	NO	1.0			1.0		1.0		1.0			4.1
						8%	YES											156.1
Surin-Si Sakhet	95.3	9	37	56	28	4%	NO											0.1
						8%	NO	1.0		1.0		1.0		1.0	1.0			5.1
Si Sakhet-Ubon Ratchathani	60.0	5	40	56	26	4%	NO											0.1
						8%	NO			1.0				1.0				2.1
TOTALS: TAR LINK T.5 Km for Construction						4%		1.0	32.3	32.3	33.4	32.4	1.0	0.0	1.0		0.0	142.9
						8%		1.0	0.0	2.0	0.0	1.0	0.0	2.0	1.0		0.0	301.9

Sources:
1. State Railway of Thailand (Information supplied during ESCAP Mission June, 1994).
2. ESCAP: Railway Capital Project Appraisal Model (RFACIL Sub-Model).

CIVIL WORKS, SIGNALLING AND COMMUNICATIONS COSTS, DUE LINE CAPACITY EXPANSION

THAILAND - TAR LINK T.2

ITEM	Unit Cost (US$/KM)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	TOTAL 1996-2015
Km of Track Construction																						
(From Annex , 4% Growth)																						
Line Doubling		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5	17.5	0.0	0.0	0.0	0.0	0.0	0.0	35.0
Crossing Track Addition		0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4
(From Annex , 8% Growth																						
Line Doubling		0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5	17.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.0
Crossing Track Addition		0.0	0.0	0.5	0.0	0.0	0.4	0.0	0.0	0.0	0.0	1.0	0.0	1.0	2.0	1.5	2.0	3.0	3.0	0.0	0.0	14.4
Track Length for S&C Installation (km)																						
4%Traffic Growth																						
Double Track Selections		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5	17.5	0.0	0.0	0.0	0.0	0.0	0.0	35.0
Single Track Selections		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	98.7	97.4	97.4	97.4	97.4	97.4	585.5
8%Traffic Growth																						
Double Track Selections		0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5	17.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.0
Single Track Selections		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	98.0	98.3	97.3	98.3	99.3	98.8	2.0	3.0	3.0	0.0	0.0	598.2
Track Construction Cost (US$ million)																						
4%Traffic Growth																						
Double Track Selections	1,350,000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.63	23.63	0.00	0.00	0.00	0.00	0.00	0.00	47.3
Single Track Selections	1,350,000	0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.9
Sub-Total		0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00	0.00	0.68	0.00	0.00	23.63	23.63	0.00	0.00	0.00	0.00	0.00	0.00	49.14
8%Traffic Growth																						
Double Track Selections	1,350,000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.63	23.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	47.3
Single Track Selections	1,350,000	0.00	0.00	0.68	0.00	0.00	0.54	0.00	0.00	0.00	0.00	1.35	0.00	1.35	2.70	2.03	2.70	4.05	4.05	0.00	0.00	19.4
Sub-Total		0.00	0.00	0.68	0.00	0.00	0.54	0.00	23.63	23.63	0.00	1.35	0.00	1.35	2.70	2.03	2.70	4.05	4.05	0.00	0.00	66.69
Signalling & Communication System Cost (US$ million)																						
4%Traffic Growth																						
For Double Line	300,000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.25	5.25	0.00	0.00	0.00	0.00	0.00	0.00	10.50
For Single Line	150,000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.81	14.60	14.60	14.60	14.60	14.60	87.82
Sub-Total		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.25	5.25	14.81	14.60	14.60	14.60	14.60	14.60	98.32
8%Traffic Growth																						
For Double Line	300,000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.25	5.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.50
For Single Line	150,000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.70	14.75	14.60	14.75	14.90	14.82	0.30	0.45	0.45	0.00	0.00	89.73
Sub-Total		0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.25	5.25	14.70	14.75	14.60	14.75	14.90	14.82	0.30	0.45	0.45	0.00	0.00	100.23
TOTAL COST - Line Capacity Expansion																						
4%Traffic Growth		0.00	0.00	0.00	0.00	0.00	1.22	0.00	0.00	0.00	0.68	0.00	0.00	28.88	28.88	14.81	14.60	14.60	14.60	14.60	14.60	147.46
8%Traffic Growth		0.00	0.00	0.68	0.00	0.00	0.54	0.00	28.88	28.88	14.70	16.10	14.60	16.10	17.60	16.85	3.00	4.50	4.50	0.00	0.00	166.92

Sources:	1. State Railway of Thailand (information supplied during ESCAP Mission June 1994).
	2. ESCAP: Railway Capital Project Appraisal Model (RFACIL Sub-Model).

CIVIL WORKS, SIGNALLING AND COMMUNICATIONS COSTS, DUE LINE CAPACITY EXPANSION

THAILAND - TAR LINK T.3 (Bangkok-Aranyaprathet) Year:

ITEM	Unit Cost (US$/KM)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	TOTAL 1996-2015
Km of Track Construction																						
(From Annex , 4% Growth)																						
Line Doubling		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.2	0.0	0.0	0.0	0.0	0.0	13.2
Crossing Track Addition		0.0	0.1	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5	0.0	0.0	0.0	0.0	1.5
(From Annex , 8% Growth																						
Line Doubling		0.0	0.0	0.0	0.0	0.0	10.3	10.3	26.9	0.0	11.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.8
Crossing Track Addition		0.0	0.1	0.0	0.0	0.0	1.9	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5
Track Length for S&C Installation (km)																						
4%Traffic Growth																						
Double Track Selections		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.2	0.0	0.0	0.0	0.0	0.0	13.2
Single Track Selections		0.0	0.1	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.4	34.9	35.4	37.9	37.9	37.9	37.0	256.9
8%Traffic Growth																						
Double Track Selections		0.0	0.0	0.0	0.0	0.0	10.3	10.3	26.9	0.0	11.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.8
Single Track Selections		0.0	0.1	0.0	0.0	0.0	1.9	0.0	0.5	0.0	0.0	0.0	0.0	0.0	28.3	28.3	28.3	31.3	31.3	31.3	30.8	212.1
Track Construction Cost (US$ million)																						
4%Traffic Growth																						
Double Track Selections	1,350,000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.82	0.00	0.00	0.00	0.00	0.00	17.82
Single Track Selections	1,350,000	0.00	0.14	0.00	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00	0.68	0.00	0.00	0.00	0.00	2.03
Sub-Total		0.00	0.14	0.00	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	17.82	0.68	0.00	0.00	0.00	0.00	19.85
8%Traffic Growth																						
Double Track Selections	1,350,000	0.00	0.00	0.00	0.00	0.00	13.91	13.91	36.32	0.00	15.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	79.4
Single Track Selections	1,350,000	0.00	0.14	0.00	0.00	0.00	2.57	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.4
Sub-Total		0.00	0.14	0.00	0.00	0.00	16.47	13.91	36.99	0.00	15.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	82.76
Signalling & Communication System Cost (US$ million)																						
4%Traffic Growth																						
For Double Line	300,000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.96	0.00	0.00	0.00	0.00	0.00	3.96
For Single Line	150,000	0.00	0.02	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.31	5.24	5.31	5.69	5.69	5.69	5.55	38.54
Sub-Total		0.00	0.02	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.31	9.20	5.31	5.69	5.69	5.69	5.55	42.50
8%Traffic Growth																						
For Double Line	300,000	0.00	0.00	0.00	0.00	0.00	3.09	3.09	8.07	0.00	3.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.64
For Single Line	150,000	0.00	0.02	0.00	0.00	0.00	0.29	0.00	0.08	0.00	0.00	0.00	0.00	0.00	4.25	4.25	4.25	4.70	4.70	4.70	4.62	31.82
Sub-Total		0.00	0.02	0.00	0.00	0.00	3.38	3.09	8.15	0.00	3.39	0.00	0.00	0.00	4.25	4.25	4.25	4.70	4.70	4.70	4.62	49.46
TOTAL COST - Line Capacity Expansion																						
4%Traffic Growth		0.00	0.15	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.99	27.02	5.99	5.69	5.69	5.69	5.55	62.34
8%Traffic Growth		0.00	0.15	0.00	0.00	0.00	19.85	17.00	45.14	0.00	18.65	0.00	0.00	0.00	4.25	4.25	4.25	4.70	4.70	4.70	4.62	132.21

Sources:
1. State Railway of Thailand (information supplied during ESCAP Mission June 1994).
2. ESCAP: Railway Capital Project Appraisal Model (RFACIL Sub-Model).

CIVIL WORKS, SIGNALLING AND COMMUNICATIONS COSTS, DUE LINE CAPACITY EXPANSION

THAILAND - TAR LINK T.4 (Bangkok-Mae Sod)

ITEM	Unit Cost (US$/KM)	Year																				TOTAL 1996 - 2015
		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
Km of Track Construction																						
(From Annex , 4% Growth)																						
Line Doubling		0.0	0.0	21.4	21.5	28.2	28.2	28.3	28.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	155.9
Crossing Track Addition		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(From Annex , 8% Growth)																						
Line Doubling		0.0	49.6	49.7	28.3	28.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	155.9
Crossing Track Addition		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Track Length for S&C Installation (km)																						
4% Traffic Growth																						
Double Track Sections		0.0	0.0	21.4	21.5	33.6	33.7	28.3	28.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	166.8
Single Track Sections		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8% Traffic Growth																						
Double Track Sections		0.0	49.6	49.7	33.7	33.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	166.8
Single Track Sections		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Track Construction Cost (US$ million)																						
4% Traffic Growth																						
Double Track Sections	1,350,000	0.00	0.00	28.89	29.03	38.07	38.07	38.21	38.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	210.47
Single Track Sections	1,350,000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub-Total		0.00	0.00	28.89	29.03	38.07	38.07	38.21	38.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	210.47
8% Traffic Growth																						
Double Track Sections	1,350,000	0.00	66.96	67.10	38.21	38.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	210.5
Single Track Sections	1,350,000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Sub-Total		0.00	66.96	67.10	38.21	38.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	210.47
Signalling and Comm. System Cost (US$ million)																						
4% Traffic Growth:																						
For Double Line	300,000	0.00	0.00	6.42	6.45	10.08	10.11	8.49	8.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.04
For Single Line	150,000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub-Total		0.00	0.00	6.42	6.45	10.08	10.11	8.49	8.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.04
8% Traffic Growth:																						
For Double Line	300,000	0.00	14.88	14.91	10.11	10.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.04
For Single Line	150,000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sub-Total		0.00	14.88	14.91	10.11	10.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.04
TOTAL COST - Line Capacity Expansion																						
4% Traffic Growth		**0.00**	**0.00**	**35.31**	**35.48**	**48.15**	**48.18**	**46.70**	**46.70**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**260.51**
8% Traffic Growth		**0.00**	**81.84**	**82.01**	**48.32**	**48.35**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**260.51**

Sources:
1. State Railway of Thailand (information supplied during ESCAP Mission June 1994).
2. ESCAP: Railway Capital Project Appraisal Model (RFACIL Sub-Model).

CIVIL WORKS, SIGNALLING AND COMMUNICATIONS COSTS, DUE LINE CAPACITY EXPANSION

THAILAND - TAR LINK T.5 (Bangkok-Ubon Ratchathani)

Year:

ITEM	Unit Cost (US$/KM)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	TOTAL 1996-2015
Km of Track Construction																						
(From Annex , 4% Growth)																						
Line Doubling		0.0	9.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.3	32.3	33.4	32.4	0.0	0.0	0.0	0.0	0.0	139.6
Crossing Track Addition		0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	3.3
(From Annex , 8% Growth																						
Line Doubling		0.0	9.2	0.0	31.2	63.5	63.5	63.6	63.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	294.7
Crossing Track Addition		0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	2.0	0.0	1.0	0.0	2.0	1.0	0.0	0.0	7.3
Track Length for S&C Installation (km)																						
4%Traffic Growth																						
Double Track Selections		0.0	9.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.3	41.5	33.4	32.4	0.0	0.0	0.0	0.0	0.0	148.8
Single Track Selections		0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	8.6	7.6	1.0	0.0	0.0	18.5
8%Traffic Growth																						
Double Track Selections		0.0	9.2	0.0	31.2	67.9	67.9	68.0	68.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	312.3
Single Track Selections		0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.4	5.4	0.0	1.0	0.0	2.0	1.0	0.0	0.0	14.0
Track Construction Cost (US$ million)																						
4%Traffic Growth																						
Double Track Selections	1,350,000	0.00	12.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	43.61	43.61	45.09	43.74	0.00	0.00	0.00	0.00	0.00	188.46
Single Track Selections	1,350,000	0.00	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.35	0.00	0.00	0.00	0.00	1.35	0.00	1.35	0.00	0.00	4.46
Sub-Total		0.00	12.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.35	43.61	43.61	45.09	43.74	1.35	0.00	1.35	0.00	0.00	192.92
8%Traffic Growth																						
Double Track Selections	1,350,000	0.00	12.42	0.00	42.12	85.73	85.73	85.86	86.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	397.8
Single Track Selections	1,350,000	0.00	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.35	0.00	2.70	0.00	1.35	0.00	2.70	1.35	0.00	0.00	9.9
Sub-Total		0.00	12.83	0.00	42.12	85.73	85.73	85.86	86.00	0.00	0.00	1.35	0.00	2.70	0.00	1.35	0.00	2.70	1.35	0.00	0.00	407.7
Signalling & Communication System Cost (US$ million)																						
4%Traffic Growth																						
For Double Line	300,000	0.00	2.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.69	12.45	10.02	9.72	0.00	0.00	0.00	0.00	0.00	44.64
For Single Line	150,000	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	1.29	1.14	0.15	0.00	0.00	2.78
Sub-Total		0.00	2.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	9.69	12.45	10.02	9.72	1.29	1.14	0.15	0.00	0.00	47.42
8%Traffic Growth																						
For Double Line	300,000	0.00	2.76	0.00	9.36	20.37	20.37	20.40	20.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	93.69
For Single Line	150,000	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.51	0.81	0.00	0.15	0.00	0.30	0.15	0.00	0.00	2.10
Sub-Total		0.00	2.79	0.00	9.36	20.37	20.37	20.40	20.43	0.00	0.00	0.15	0.51	0.81	0.00	0.15	0.00	0.30	0.15	0.00	0.00	95.79
TOTAL COST - Line Capacity Expansion																						
4%Traffic Growth		0.00	15.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50	53.30	56.06	55.11	53.46	2.64	1.14	1.50	0.00	0.00	240.33
8%Traffic Growth		0.00	15.62	0.00	51.48	106.10	106.10	106.26	106.43	0.00	0.00	1.50	0.51	3.51	0.00	1.50	0.00	3.00	1.50	0.00	0.00	503.49

Sources:
1. State Railway of Thailand (information supplied during ESCAP Mission June 1994).
2. ESCAP: Railway Capital Project Appraisal Model (RFACIL Sub-Model).

TABLE :TRACK CONSTRUCTION DUE LINE CAPACITY EXPANSION

VIETNAM - TAR LINK V3. (HANOI-HAIPHONG)

Route Length	Number of Crossing Stations	No.Trains/day -capacity	-existing	Annual Growth Rate (No. of Trains)	Line Doubling Required?	TRACK CONSTRUCTION TO EXPAND LINE CAPACITY (KM) IN: (Year)									
						1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
101.75	5	21	12	4%	NO										
				8%	NO										
TOTAL FOR TAR LINK V3.				4%		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				8%		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Route Length	Number of Crossing Stations	No.Trains/day -capacity	-existing	Annual Growth Rate (No. of Trains)	Line Doubling Required?	TRACK CONSTRUCTION TO EXPAND LINE CAPACITY (KM) IN: (Year)								
						2006	2007	2008	2009	2010	2011	2012	2013	2014
101.75	5	21	12	4%	NO									
				8%	NO					1.0				
TOTAL FOR TAR LINK V3.				4%		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				8%		0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0

Sources: 1. Vietnam Railways (Information supplied during ESCAP Mission , April 1995)
2. ESCAP: Railway Capital Project Appraisal Model (RFACIL Sub-Model).

TABLE :CIVIL WORKS, SIGNALLING AND COMMUNICATIONS COSTS, DUE LINE CAPACITY EXPANSION

VIETNAM - TAR LINK V.3

ITEM	Unit Cost (US$/KM)									Year:											
		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
Km of Track Construction (From Table , 8% Growth)																						
Crossing Track Addition		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	
Track Length for S&C Installation (km)																						
Double Track Sections		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Single Track Sections		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.9	33.9	34.0	0.0	0.0	0.0	0.0	0.0	
Track Construction Cost (US$ million)																						
Crossing Track Addition	1,350,000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.35	0.00	0.00	0.00	0.00	0.00	1.35
Signalling and Comm. System Cost (US$ million)																						
For Double Line	202,376	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
For Single Line	101,188	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.43	3.43	3.44	0.00	0.00	0.00	0.00	0.00	
Sub-Total		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.43	3.43	3.44	0.00	0.00	0.00	0.00	0.00	10.30094
TOTAL COST - Line Capacity Expansion		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**3.43**	**3.43**	**4.79**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	11.65094

Sources:
1. Myanma Railways (information supplied during ESCAP Mission 05-09/03/95).
2. Myanmar Comprehensive Transport Study 1993 , Annex II: Railways.
3. ESCAP: Railway Capital Project Appraisal Model (RFACIL Sub-Model).

TABLE :TRACK CONSTRUCTION DUE LINE CAPACITY EXPANSION

MYANMAR - TAR LINK B.1

Section	Route Length	Number of Crossing Stations	Schedule Speed (Slowest Train) km/hr	No.Trains/day -capacity*	-existing	Annual Growth Rate (No. of Trains)	Line Doubling Required?	TRACK CONSTRUCTION TO EXPAND LINE CAPACITY (KM) IN: (Year)									
								1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Pyinmana-Yamethin	80	10	42		19	4%	NO										
						8%	NO										
Yamethin-Thazi	50.69	5	42	41	26	4%	NO										
						8%	NO										
Thazi-Mandalay	127.94	14	42	36	22	4%	NO										
						8%	NO										
Mandalay-Shwebo	94.95	11	42	25	16	4%	NO										
						8%	NO										
Shwebo-Myitkyina	447.79	39	42	12	16	4%	NO										
						8%	NO										
TOTALS: TAR LINK B.1 **Km for Construction**						4%		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
						8%		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Section	Route Length	Number of Crossing Stations	Schedule Speed (Slowest Train) km/hr	No.Trains/day -capacity*	-existing	Annual Growth Rate (No. of Trains)	Line Doubling Required?	TRACK CONSTRUCTION TO EXPAND LINE CAPACITY (KM) IN: (Year)								
								2006	2007	2008	2009	2010	2011	2012	2013	2014
Pyinmana-Yamethin	80	10	42		19	4%	NO									
					19	8%	NO									
Yamethin-Thazi	50.69	5	42	41	26	4%	NO									
					26	8%	NO						1.0			0.5
Thazi-Mandalay	127.94	14	42	36	22	4%	NO									
					22	8%	NO						0.5		1.0	
Mandalay-Shwebo	94.95	11	42	25	16	4%	NO									
					16	8%	NO									
Shwebo-Myitkyina	447.79	39	42	12	16	4%	NO									
					16	8%	NO							1.0	2.0	
TOTALS: TAR LINK B.1 **Km for Construction**						4%		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
						8%		0.0	0.0	0.0	0.0	0.0	1.5	1.0	3.0	0.5

* Capacity as calculated by Myanma Railways. Capacity calculations by ESCAP differed significantly, because they assumed that all stations in the section could be used for train crossing purposes.

Sources:
1. Myanma Railways (Information supplied during ESCAP Mission 05-09/03/95).
2. ESCAP: Railway Capital Project Appraisal Model (RFACIL Sub-Model).

TABLE: CIVIL WORKS, SIGNALLING AND COMMUNICATIONS COSTS, DUE LINE CAPACITY EXPANSION

MYANMAR - TAR LINK B.1 Year:

ITEM	Unit Cost (US$/KM)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
Km of Track Construction (From Table , 8% Growth)																						
Crossing Track Addition		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.0	3.0	0.5	0.0	
Track Length for S&C Installation (km)																						
Double Track Selections		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.7	51.7	51.7	51.7	51.7	51.7	51.7	0.0	0.0	
Single Track Selections		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	193.0	193.0	127.6	96.0	65.5	65.0	67.0	0.5	0.0	
Track Construction Cost (US$ million)																						
Crossing Track Addition	13,500,000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.03	1.35	4.05	0.68	0.00	
Signalling & Communication System Cost (US$ million)																						
For Double Line	202,376	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.46	10.46	10.46	10.46	10.46	10.46	10.46	0.00	0.00	
For Single Line	101,188	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.53	19.53	12.91	9.71	6.62	6.57	6.78	0.05	0.00	
Sub-Total		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.99	29.99	23.38	20.17	17.09	17.04	17.24	0.05	0.00	
TOTAL COST - Line Capacity Expansion		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.99	29.99	23.38	20.17	19.11	18.39	21.29	0.73	0.00	163.0532

Sources:

1. Myanma Railways (information supplied during ESCAP Mission 05-09/03/95).
2. Myanmar Comprehensive Transport Study 1993, Annex II: Railways.
3. ESCAP: Railway Capital Project Appraisal Model (RFACIL Sub-Model).