F.KUHN
94.105

Le 21 novembre 1994

COMPTE RENDU

CONFERENCE INTERNATIONALE
SUR LES NOUVEAUX SYSTEMES DE TRANSPORT
ET PRESENTATION DES SYSTEMES

24-26 Octobre 1994

à PUSAN, Corée du Sud

Cette conférence internationale organisée par l'Institut des Transports Coréen (KOTI) sur le thème des nouveaux systèmes de transport a eu lieu à Pusan du 24 au 26 octobre 1994.

L'agglomération de Pusan située au sud est de la Corée avec 3,5 millions d'habitants, s'étend entre des collines et la mer du Japon, avec ses activités portuaires et un habitat très dense limité entre les collines; Pusan a des problèmes de saturation de ses voies de communication, les autoroutes d'accès sont sur viaduc et traversent les collines par de nombreux tunnels pour desservir l'ensemble de l'agglomération. Pusan a une ligne de métro en souterrain orientée nord - sud de 26 km de même conception que le métro de Séoul (métro lourd 3,00 m de large, intervalle minimum de 2,5 mn) et commence la construction de la ligne 2 (phase 2) en souterrain orientée est - ouest (cf annexes), au total elle prévoit un réseau de 5 lignes à l'horizon 2001.

La municipalité de Pusan s'intéresse aux nouveaux systèmes de transport du type transport intermédiaire pour desservir ses banlieues, elle a un projet de 26 km sur viaduc d'un système qui pourrait être soit un système de métro léger automatique, soit un métro léger soit en un premier temps un autobus guidé. Le KOTI a organisé cette conférence (dont la date coïncidait avec le lancement de la 2ième phase de travaux de la 2ième ligne de métro) afin de présenter les différents systèmes de transport dits intermédiaires qui pourraient convenir aux besoins des banlieues de Pusan, de Séoul (Hanam),etc. En effet, les grandes villes coréennes ont leur voirie saturée par la circulation générale, il est donc urgent pour les autorités d'assurer des transports publics efficaces économisant la voirie et l'utilisation du sol et étant attractifs auprès des automobilistes de plus en plus nombreux (la Corée est le 5e producteur mondial d'automobiles derrière la France).

Cette conférence s'est déroulée au Chosun beach hotel, dans le quartier de Haeundae qui devrait être desservi par le projet de métro léger à l'étude. Cette conférence a accueilli 250 participants et exposants dont une quinzaine d'étrangers (1 chinois de Taiwan, 2 japonais, 1 italien, 2 américains, 3 allemands et 6 français). La plus grande partie des participants étaient des représentants des différentes municipalités de l'agglomération de Pusan dont le Maire et un député, des industriels coréens, des représentants de différentes villes chargés des transports et du tourisme et des universitaires impliqués dans l'urbanisme et les transports publics. La première journée a été consacrée aux problèmes de transport et aux solutions que peuvent apporter les systèmes intermédiaires avec des études de cas (Taipeh, le Japon, la France), les débats ont été menés par le Dr Kang Directeur du département planification des transports du KOTI et le Dr Young président du KOTI qui outre les intervenants ont fait participer des universitaires et un journaliste à la discussion générale finale. La deuxième journée a été entièrement consacrée à la présentation par différents constructeurs internationaux de leur société et des systèmes qu'ils produisent ou qu'ils étudient (Korea Institute of Machinery and Metals), c'est ainsi qu'ont été présentés les systèmes de Mitsubishi, Siemens, Ansaldo, Matra, Gec Alsthom, AEG et les études du Korea Institute of Machinery and Metals.

Première journée :

Conférence Internationale sur les nouveaux systèmes de transport

Session 1 : Les Transports urbains en Corée et le rôle des nouveaux systèmes de transport

Dans cette première session sont intervenus le Dr. Kang directeur du département planification des Transports du KOTI qui a rappelé les problèmes de transport urbain dans les villes coréennes et les projets de systèmes de transport de Pusan et des banlieues des grandes villes, le professeur R. Gakenheimer du MIT et moi même.

Sujet 1 : Rôle des nouveaux systèmes de transport dans un réseau de transport d'une métropole

Dans sa communication le Prof. Gakenheimer retient 6 objectifs auxquels doit répondre l'introduction d'un nouveau système de transport :

- 1. Accroître la capacité de transport d'un corridor c'est à dire augmenter l'ensemble des opportunités de déplacement,

- 2. Garder à l'esprit l'augmentation des possibilités d'accès de ceux qui ne possèdent pas d'automobiles,

- 3. Permettre au réseau de transport dans son ensemble de fonctionner plus efficacement en évitant la saturation sur les corridors les plus chargés,

- 4. Aider la structure urbaine à se modeler de la meilleure façon lorsque la croissance urbaine continue,

- 5. Réduire la congestion de la circulation automobile en attirant les automobilistes vers un mode de déplacements plus efficace, en même temps réduire le besoin de construire plus d'infrastructure routière, réduire la pollution et améliorer la sécurité,

- 6. Réaliser ces objectifs au meilleur coût pour la Société.

Le Prof. Gakenheimer rappelle ensuite les conditions de transport collectif de Séoul et Pusan où le métro transportait en 1992 à Séoul 1 milliard de voyageurs avec 190 km de lignes (1,436 milliard en 92 à Mexico avec 178 km de lignes) et 120 millions de voyageurs avec une ligne de 26 km de métro à Pusan. Les coûts d'exploitation de ces métros ainsi que les coûts d'exploitation du réseau d'autobus de Séoul sont couverts par les recettes.

Dans son exposé le prof. Gakenheimer s'intéresse au coût du transport urbain sur rail, au système de transport sur rail dans un réseau de transport d'une grande métropole et enfin au transport sur rail et à la structure urbaine.

En ce qui concerne le coût de réalisation des systèmes de transport urbain sur rails qui d'après les études qui ont été faites (TRL, Banque mondiale,etc.) pour différentes réalisations dans le monde, ce coût est toujours plus élevé que le coût prévisionnel, souvent multiplié par 2 ou plus encore. Bien que les coûts d'exploitation soient sur certains réseaux couverts par les recettes, les coûts d'investissement ne sont couverts par les recettes sur aucun réseau de métro à travers le monde; une étude du TRL/HFA montre que si certains réseaux de pays à faible revenu adoptaient le coût du ticket de métro de Hong Kong, ces réseaux couvriraient non seulement leur coût d'exploitation par leur recette mais aussi une partie de leur investissement. C'est ainsi que les planificateurs concluent que la construction de métro ne peut se faire que lorsque le pays a un certain niveau de développement. Il est donc important d'effectuer des études de faisabilité des systèmes de transport sur rail étant donné leur faible performance financière, mais ces évaluations sont rendues difficiles selon l'interprétation des économies de temps de transport obtenues en utilisant le métro; d'autre part, le taux d'escompte de 12 à 13 % estimé raisonnablement pour toute autre utilisation du capital signifie que les bénéfices tendent vers zéro au bout de 20 ans, mais même si le matériel roulant a une durée de vie similaire, les équipements fixes durent entre 50 à 60 ans, les tunnels et sites propres durent encore plus.

En ce qui concerne le système sur rails et le réseau de transport d'une métropole, un métro qui a du succès doit transporter 700 000 voyageurs sur un corridor par jour soit 43 000 voyages/heure/sens, volume très difficile à transporter par d'autres modes qui plafonnent à 25 000 pas./h/sens. Aussi faut il prévoir une intégration des différents modes de transport pour obtenir des volumes élevés à transporter sinon les systèmes de transport sur rail se trouvent avec une fréquentation inférieure à celle estimée.

En ce qui concerne le système de transport sur rails et la structure urbaine, le Prof. Vuchic écrit : "une des vertus du rail est d'être inflexible par rapport à d'autres modes" ce qui donne une stabilité des perspectives et donc une confiance dans la localisation de l'activité. Les nouveaux systèmes de transport peuvent être réalisés en grand nombre en Corée en raison de la structure urbaine réalisée : la haute densité d'habitat de Séoul (plus de 300 hab/ha) entraîne une forte concentration d'automobiles; les nombreuses villes satellites construites au delà d'une ceinture verte connectées au centre par des transports rapides sont le fruit d'une intervention volontaire des autorités mais la tendance à s'éloigner du centre pourrait créer des zones à faible densité peu propices à la mise en place de système de transport. Une solution de compromis est de projeter une forme urbaine en "hub-spoke-and-cluster" plan, le centre étant la métropole, le rayon étant le corridor menant à la ville satellite, reliée à la fois par un système de transport de masse et une voie rapide pour les automobilistes. Favoriser un système de transport par rapport à l'autre serait néfaste à long terme pour un environnement urbain productif et vivable.

L'équilibre entre le coût élevé des nouveaux systèmes de transport et la structure urbaine doit être trouvé par ceux qui investissent dans chacune de ces villes.

Sujet 2 : Comparaison et évaluation de nouveaux systèmes de transport

Dans cette communication, j'ai présenté une comparaison entre deux nouveaux systèmes de transport urbain en exploitation depuis plus de 10 ans en France, le métro léger et le métro automatique.

Une première partie présente le métro léger tout d'abord avec une brève description desinfrastructures et des types de site qui permet de montrer les différences de coûts d'investissements correspondants puis les principales caractéristiques d'exploitation et de qualité de service de ce système.

Une deuxième partie présente le métro automatique, les infrastructures nécessaires, les caractéristiques d'exploitation avec la qualité de service apportée par l'automatisation de la conduite, les avantages apportés par l' intervalle réduit sur le coût du génie civil, par exemple.

Une troisième partie montre une comparaison entre les deux systèmes du point de vue des coûts d'investissement, pour cela ont été examinés 7 projets français soit 59 km de métro léger et 4 projets de métro automatique soit 42,3 km, puis les coûts d'exploitation du réseau de Nantes et celui de Lille.

Une quatrième partie décrit les nouvelles tendances du métro léger et du métro automatique en France et pour les métropoles ayant une grande densité d' habitat dans le monde.

En conclusion :

- les systèmes automatiques ont une qualité de service, une flexibilité, une régularité de métronome, un niveau de sécurité que le métro léger peut difficilement atteindre, la principale raison étant que le métro automatique est exploité en conduite automatique ce qui nécessite un site propre intégral et avec des coûts de matériel roulant et de système plus élevé, le coût total d'un projet de métro automatique est toujours plus élevé que le coût d'un projet de métro léger,

- les métros légers qui étaient exploités dans 300 réseaux en 1975 de par le monde, seront plus de 400 en l'an 2000, la principale raison étant que ces systèmes peuvent être exploités en surface, à niveau, ils peuvent être développés progressivement du tramway au métro léger. Le coût d'un projet de métro léger est inférieur au coût d'un projet de métro automatique à capacité équivalente, ce coût étant proportionnel au linéaire de site propre intégral.

- quand une ville manque d'espace public généralement dans le centre, le projet de système de transport doit être dénivelé, son coût de construction s'accroît; il y a alors un choix à faire entre les deux systèmes, le site propre intégral s'imposant normalement; un système automatique avec sa souplesse d'exploitation et sa qualité de service pourrait être réalisé avec un surcoût acceptable décroissant lorsque l'offre s'accroît.

Enfin, nous pensons que les villes étendues ou pas ont besoin de ces deux systèmes :

- une ville à haute densité d'habitat sans surface au sol pour les transports publics pourrait choisir un système automatique si les flux à transporter sont suffisants, la qualité de service est alors élevée et "l'image du métro" attire les usagers de l'automobile,

- une ville moyenne qui fait le choix d'interdire quelques voies aux automobilistes, pourrait obtenir un site propre de surface pour un métro léger : les projets de métro léger des années 80 montrent que l'exploitation dans les rues avec un pourcentage important de site réservé est viable et contribue à rendre la ville plus humaine.

Session 2 : Une approche du développement de nouveaux systèmes de transport en Corée

Dans cette deuxième session est intervenu le Dr. Seongsoon Yun qui dresse un tableau des différents systèmes automatiques en exploitation à travers le monde. A la suite d'un voyage effectué sur les sites des Docklands, Scarborough, Lille et Hiroshima,etc. le Dr Yun effectue quelques comparaisons sur les systèmes intermédiaires.

En ce qui concerne les coûts de construction, il rappelle les coûts importants de construction des systèmes japonais (tableau suivant extrait d'APM octobre 91) :

Désignation	Métro	Nouveau Système	Autobus guidé
Coût au km	200 à 300 .10^8 Yens 800 à 1200 MF	60 à 100.10^8 Yens 230 à 400 MF	30.10^8 Yens 120 MF

Ensuite parmi les avantages des métros automatiques, il rappelle que la part de main d'oeuvre dans l'exploitation des métros automatiques est inférieure à celle de métros classiques comme celui de Séoul, le tableau suivant synthétise la répartition des charges d'exploitation :

Désignation	Personnel	Energie	Maintenance	Administration
VAL de Lille	39%	14%	39%	8%
New Tram *	42%	17%	31%	10%
Métro Séoul	66%	8%	22%	4%

* Osaka

Le Dr. Yun s'intéresse ensuite aux problèmes de transport urbain en Corée. En effet la saturation de la voirie va s'amplifier puisque le parc automobile de 7 millions d'unités en 1994 devrait s'accroître à 14 millions d'unités en l'an 2001, en parallèle l'accroissement du linéaire de voirie ne serait que de 1,5%; les prévisions d'accroissement de la voirie et du parc automobile dans différentes villes de Corée entre 1986 et 2001 sont rassemblées ci-après :

Désignation	Séoul	Pusan	Taegu	Kwangju	Taejon
Augmentation du linéaire de voirie	1,29%	1,17%	3,37%	2,11%	1,67%
Augmentation du nombre d'autos	13,8%	13,3%	17,8%	15,5%	17,6%

Les principaux projets de métros automatiques dans les 5 ans à venir et leur coût prévisionnel sont répertoriés dans le tableau ci-après, ces coûts sont inférieurs au coût de métro lourd qui était en Corée de 250.10^8 Won/km (166MF/km) en 1985 et qui ont progressé à 384.10^8 Won/km (256MF/km) en 1990 soit 53,6% en 5 ans:

LIGNES	Période de réalisation	Linéaire en km	Nombre de Stations	Coût en Won & en Francs
Séoul-Hanam	1995-2000	18,65	20	$3\,271.10^8$ Won 2180 MF
Pusan-Kimhae	1995-2000	26,00	16	4919.10^8Won 3280 MF
Euijeongbu-Dobonsan-Sosandong	1995-2000	12,00		2400.10^8Won 1600 MF
Suwon-Bundang-Yongin	Phase1:95-99 Phase2:2000-2004	35,40	15	7080.10^8Won 4720 MF
Masan-Changwon-Chinhae	1998-2011	Ligne1:40,8 Ligne2: 7,4		9640.10^8Won 6427 MF
Mikum-Kuri-Sanbon-Haegui		15,96	14	3192.10^8Won 2128 MF
Shihung-Putchon		6,75	6	1350.10^8Won 900 MF
KiongnamYansanson (Hopo-Kumsan-Pukjung)	1996-2000	10,3	5	2060.10^8Won 1373 MF
PusanYok-Taejondae	1996-1999	11,25	16	2250.10^8Won 1500 MF
Salacksan-Sockchosi	1ière phase: 95-98	6,30	6	1260.10^8Won 840 MF
Total		190,81		37422.10^8Won 24 948 MF

Le coût moyen de réalisation (génie civil et système) est de l'ordre de 196.10^8Won ou 130 MF/km

La répartition du coût du projet Pusan - Kimhae de 26 km s'établit comme suit:

Etudes	Foncier	Construction	Véhicules	Total
156.10^8Won 104 MF	$200{,}5.10^8$Won 133,6 MF	$3059{,}5.10^8$Won 2039 MF	1503.10^8Won 1002 MF	4919.10^8Won 3280 MF

Le coût prévisionnel de 126 MF le km semble faible bien que le projet soit réalisé entièrement sur viaduc.

Le Dr. Yun termine son exposé par des plans de financement possible pour l'opération de Pusan - Kimhae et une liste des différents systèmes de métros automatiques à travers le monde (cf annexes).

Session 3 : Construction de nouveaux systèmes de transport à l'étranger

Dans cette troisième session sont intervenus le Dr. Chia-Juh Chang de l'Institut des Transports de Taiwan et le Prof. Shigeru Morichi de l'Institut de Technologie de Tokyo.

Sujet 1 : Construction et exploitation d'un nouveau système de transport à Taiwan

Dans cette communication, le Dr Chang décrit le projet de système de transport de moyenne capacité réalisé à Taipeh. Le réseau de métro initial comprend 7 lignes totalisant 88 km dans l'agglomération de Taipeh. Parmi ces 7 lignes une seule est de capacité moyenne, la ligne de Mucha reliant principalement en aérien le quartier de Mucha dans le sud-est au quartier de Hsinyi à l'est de la ville. Cette ligne de 10,9 km comprend 12 stations et un garage atelier. Ce système à moyenne capacité a été choisi comme étant la technologie appropriée pour une offre de transport dans ce corridor secondaire nouvellement développé. Ce système est un métro automatique, le VAL 256 qui doit pouvoir offrir une capacité située entre 10 000 et 20 000 pas./h/sens : il sera exploité en rame de 4 véhicules (capacité 336 à 456 pas/rame) avec un intervalle minimum de 80 secondes. Après une description du VAL 256, le Dr. Chang indique les coûts de l'opération qui ont augmenté de 65% par rapport à l'estimation initiale soit 926,45 M US$ dont 138 M US$ d'acquisition foncière ce qui équivaut à 72 M US$/km sans le coût du foncier soit 396 MF/km env. val 93 (parc de 102 véhicules). Ces surcoûts sont dûs aux différents retards des entreprises de génie civil et d'équipements, l'organisation du projet et du chantier et le règlement des interfaces ayant été sous-estimés par le maître d'ouvrage et les maîtres d'oeuvre.

La ligne Mucha est maintenant terminée et le système est en marche à blanc depuis plusieurs mois : il est prévu de commencer l'exploitation avant la fin de cette année. Les lignes d'autobus voisines seront restructurées et rabattues sur la ligne de métro, 5 stations sur 12 ont des parkings pour voitures, motos et bicyclettes.

Sujet 2 : Financement de nouveaux systèmes de transport

Dans cette communication le Prof. S. Morichi s'intéresse au financement des systèmes de transport et rappelle que le Japon a su maintenir le principe de réseau de transport viable sans aide gouvernementale alors qu'en Europe on trouve des pays dont l'Etat prend en charge entièrement l'investissement et entre 10 et 80% des coûts d'exploitation. En effet, la Corée planifie actuellement deux projets de métro léger dans les banlieues de grandes villes Séoul et Pusan qui devraient être financés par des investissements privés, il est temps d'arrêter la politique financière si on veut mener ces projets à terme indique le Prof. Morichi.

1. Les ressources financières pour des systèmes urbains guidés

Les ressources financières pour couvrir le coût de construction d'un projet de système de transport proviennent au Japon :

- a) des recettes payées par les usagers,

- b) du bénéfice d'autres lignes (aide interne),

- c) du produit d'autres activités de l'exploitant (aide interne),

- d) d'aides externes

1.1 La tarification

En ce qui concerne la tarification, son niveau est établi de manière à ce qu'il couvre le coût d'exploitation et inclue un niveau raisonnable de bénéfice. Mais il y a les autres modes de transport ou des lignes existantes dont le niveau de tarif est plus bas qui oblige à maintenir la tarification à un niveau tel qu'il ne permet pas d'être une source de revenu pour financer la construction et l'exploitation de nouvelles lignes. Aussi au Japon on a prévu depuis longtemps dans la tarification des transports une part qui permettra de construire de futures lignes ou d'améliorer les lignes existantes : cette méthode a stimulé les compagnies de chemin de fer privées à améliorer leur réseau et de nombreux projets ont vu le jour.

1.2 Les aides internes par d'autres lignes

En ce qui concerne les aides internes provenant des autres lignes c'est à dire prendre le produit des lignes qui sont très fréquentées pour financer la nouvelle ligne cela signifie que l'on considère le réseau dans son ensemble. L'exploitant peut augmenter la tarification d'une ligne pour réaliser une future ligne qui doit être achevée en 20 ans, réunissant ainsi des fonds qui doivent rester inférieurs à 40% du coût de construction de la nouvelle ligne.

1.3 Les aides internes provenant d'autres activités

Les entreprises de transport par chemin de fer au Japon ont investi dans d'autres activités rentables comme la promotion immobilière, la réalisation de centres commerciaux, hôtels, parcs d'attractions, etc. Le système comptable de l'entreprise de transport est indépendant des autres activités notamment pour établir la tarification des transports. Ainsi l'entreprise de transport peut réaliser une nouvelle ligne avec un financement provenant d'autres activités, continuer à faire des bénéfices avec ses autres activités lorsque l'entreprise de transport perd de l'argent en attendant par exemple que l'augmentation de la tarification soit approuvée.

La plus value foncière peut aussi être une ressource financière pour un nouveau projet de chemin de fer mais il y a le risque de ne pas obtenir les terrains, d'avoir des retards dans le développement, le futur prix du terrain, etc., tout ceci fait que les compagnies de chemins de fer ne souhaite pas commencer de nouveaux projets. Ainsi les gouvernements locaux favorisent un 3ème type de compagnie à travers les promoteurs et la plus value foncière collectée lors de la promotion immobilière. Ceci est un exemple d'aide externe.

1.4 L'aide externe

Il y a deux sortes d'aides externes, l'une qui est donnée par le gouvernement national ou local et l'autre est obtenue par le partage de la charge financière entre les bénéficiaires du nouveau système de transport à travers l'augmentation de la tarification. Les usagers sont des bénéficiaires mais il y a aussi les propriétaires fonciers et les industriels qui obtiennent une plus value foncière mais ne partagent nécessairement pas la charge de l'investissement de la nouvelle ligne. De nombreux problèmes existent au niveau du calcul, de l'identification des bénéficiaires, la part attribuée à la nouvelle ligne de chemin de fer, aux réseaux de concessionnaires (eau, gaz, électricité, etc.), les problèmes de double taxation, ces difficultés sont en cours d'étude. Les nombreuses formes d'aides externes pratiquées sont l'investissement direct par apport d'un financement, achat de terrains, aide pour le coût de construction, prise en charge d'une partie du coût du crédit, etc..

Les ressources de financement provenant de gouvernement local ou national pour les chemins de fer sont : l'impôt, l'utilisation spéciale d'impôts existants tels que la taxe sur les ventes aux USA, la taxe sur l'essence aux USA et en Allemagne, le versement transport en France et la plus value foncière.

2. Les subventions aux systèmes de transport urbain guidé au Japon

2.1 Les subventions aux chemins de fer

Les subventions pour un métro :

- Provenance : l'autorité locale à qui appartient le métro

- Ratio : 70% du coût subventionable

  dont 35% supporté par l'autorité centrale

  dont 35% supporté par l'autorité locale

- durée de la subvention : durée de construction

Les subventions pour une ligne d'une ville nouvelle

- Provenance : l'autorité locale à qui appartient le métro

  l'agence de développement urbaine

  la compagnie de développement urbain d'Osaka

- Ratio : 36% du coût subventionable

  dont 18% supporté par l'autorité centrale

  dont 18% supporté par l'autorité locale

- durée de la subvention : 6 ans (6%/an)

Les subventions pour un système de transport guidé

- Provenance : le 3ième secteur

  exemple : la compagnie de transport rapide de Saitama

- Ratio : 50% du coût subventionable

  dont 25% supporté par l'autorité centrale

  dont 25% supporté par l'autorité locale

- durée de la subvention : période de construction

Les subventions au taux d'intérêt en faveur de lignes en location ou à transférer

- Provenance : l'association publique de construction des chemins de fer du Japon

(pour une ligne en location)

- Ratio : la part d'intérêt au dessus de 5,0%

- durée de la subvention : 40 ans après le début de la location

(pour une ligne en transfert)

- durée de la subvention : 25 ans après le tranfert de l'entreprise publique à la compagnie privée

- ratio : la part d'intérêt au dessus de 5,0%

  50% supporté par l'autorité centrale

  50% supporté par l'autorité locale

Le prêt sans intérêt pour un chemin de fer urbain

- Provenance : l'association de construction des chemins de fer japonais
  l'autorité de transport rapide de Teito (Tokyo)

- Ratio : 40% du coût de construction

2.2 Les subventions pour monorail ou système de métro automatique

Les infrastructures de monorail ou métro automatique sont considérées comme une voirie construite par le secteur public, les compagnies étant propriétaires simplement des équipements hors infrastructures et véhicules. Le gouvernement a décidé de subventionner 50% du coût de construction des infrastructures ou 59,9% du coût total incluant le garage atelier et les véhicules.

3 Evaluation de la situation financière future

3.1 Les nouveaux systèmes de transport au Japon

Les différents types de nouveaux systèmes au Japon apparaissent sur la carte et le tableau suivant. De nombreuses lignes font du déficit soit depuis le début de l'exploitation surtout parce que le niveau de fréquentation prévu n'est pas atteint ou que le coût de construction a été dépassé par rapport aux études de sensibilité à la demande et au coût qui avaient été menées. Ce déficit qui avait été envisagé comme possible par l'autorité locale et le Ministère des transports qui ont approuvé les projets, est pris en charge par ces autorités.

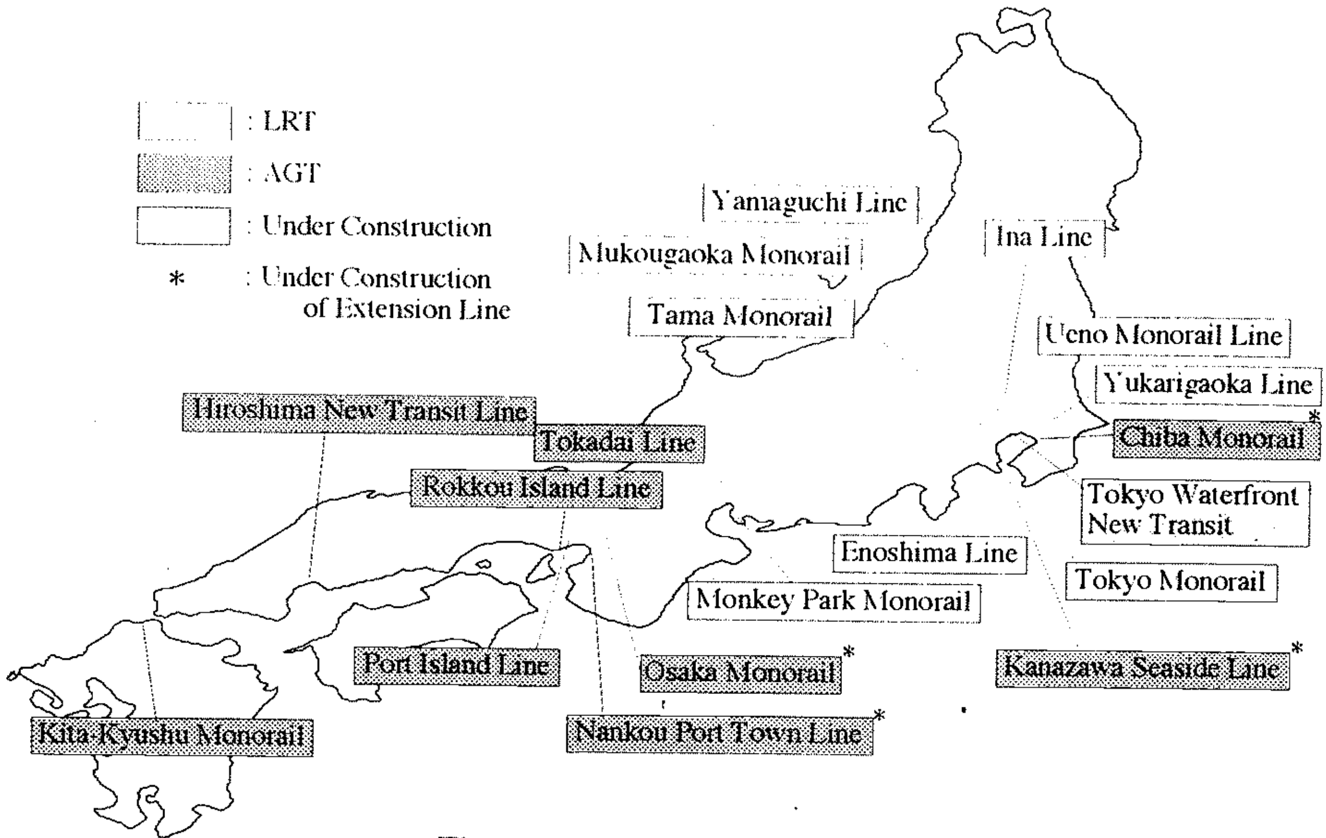


Figure 2 LRT & AGT in Japan

Table 3 Financial Situation of Monorail and AGT in Japan (1992)

Name of Company		Name of Line	Passengers (thousands per year)	Passengers per day	Profit and Loss (million Yen)			Vehicle-km (1000 km)	Number of employees (persons)	Prefecture	Capital (million Yen)	Starting Year
					Revenue	Expenditure	Net Profit					
Monorail	Tokyo Monorail	Haneda	51.081	121.246	11.255	9.581	1.674	11.761	427	Tokyo	1.530	1964
	Shonan Monorail	Enoshima	11.298	15.298	1.709	1.581	128	1.709	93	Kanagawa	8.000	1970
	Chiba Monorail	Chiba City	12.451	14,391	2.414	2.744	▲330	1.932	156	Chiba	10.000	1988
	Odakyu Electric Rail	Mukougaoka Yuen	670	1.948	46	103	▲57	.55	6	Tokyo	59.160	1966
	Tokyo Metropolis	Ueno	1.223	3.352	100	97	3	20	6	Tokyo	-	1957
	Nagoya Railway	Monkey Park	641	1,468	77	116	▲39	85	8	Aichi	66.318	1962
	Osaka Rapid Railway	Osaka	7.827	12.917	1.419	3.033	▲1.614	1.390	146	Osaka	5.800	1990
	Kita-Kyushu Rapid Railway	Kita-Kyushu	11.143	17,232	1.892	2.618	▲726	2.501	136	Fukuoka	6.400	1985
AGT & LRT	Yamaman	Yukarigaoka	567	835	120	317	▲197	324	30	Chiba	8.00	1982
	Saitama New Urban Transport	Ina	11.419	15,496	1.932	1.892	40	4.299	159	Saitama	2.000	1983
	Yokohama New Urban Transport	Kanazawa Sea Side	15.046	17,720	2.796	3.326	▲530	4.913	192	Kanagawa	7.600	1989
	Seibu Railway	Yamaguchi	1.440	3,266	46	529	▲483	392	16	Saitama	21.665	1985
	Tokadai New Transort	Toukadai	964	1,994	220	972	▲752	1.552	61	Aichi	3.000	1991
	Osaka City	Nankou Port Town	22.542	43.613	2.245	3.024	▲779	3.974	116	Osaka	-	1981
	Kobe New Transport	Port Island	19,573	33.440	3,449	4.955	▲86	3.598	68	Hyogo	9.700	1981
		Rokkou Island	8.339	16.359	1,420			1.601				

3.2 Evaluation de la future situation financière

La simulation d'un projet de ligne de métro automatique nous permet d'écrire :

- longueur de ligne :	10 km
- période de construction :	5 ans
- début de l'exploitation :	an 2000
- coût du projet : (avec véhicules)	203 à 812 millions de US$
- coût d'un véhicule :	1,01 Millions US$
- nombre de véhicules :	20
- taux d'intérêt :	6,36%/an
- capital initial :	10% du coût total de construction
- coût d'exploitation :	la moyenne de ceux existant au Japon
- taux d'inflation :	3,0% pour les coûts de main d'oeuvre 2,5% pour les autres coûts
- tarif :	tarif unique : 1,83 US$, augmente de 9% chaque 3 ans.
- subvention :	avec ou sans subvention

Si la demande est supérieure à 5000 pas./km-jour, le projet peut faire du profit s'il y a une subvention. Sans subvention, cette ligne peut faire des bénéfices si le coût est inférieur à 203 millions US$/10 km. Dans le cas où le coût de construction est de l'ordre de 609 millions US$/10 km, la demande doit être supérieure à 7500 pas./km-jour. Le plus mauvais cas est celui où il y a 2500 pas/km-jour, auquel cas l'argent disparait qu'il y ait une subvention ou pas.

Pour approuver un projet de métro automatique, le Ministère des Transports demande que le délai de remboursement soit inférieur à 25 ans avec un profit qui se dégage de l'exploitation au bout de 10 ans. Les autorités locales qui souhaitent réaliser des projets de métros automatiques doivent avoir des ressources financières qui permettent d'adopter ces projets.

Conclusion

Cette communication rappelle que les projets de transport urbain guidé ne semble pas faire de bénéfices malgré leur nécessité. Dans les pays européens et aux Etats Unis, les autorités ont entièrement payé la construction de ces projets. Au Japon la pratique veut que ces projets reçoivent un minimum d'argent public de l'Etat, un effort des autorités locales et de l'exploitant est demandé en maintenant comme idée de base que seul un projet rentable peut être promu.

Dans les Pays en développement les schémas BOT (construire, exploiter,transférer) permettent d'introduire les projets de métro léger. Cependant il faut être attentif aux retards pris par les négociations public-privé, ainsi à Bangkok la négociation du schéma de BOT pour la construction d'un projet de métro léger dure depuis plus de 10 ans.

En Corée, le gouvernement semble commencer une stratégie originale qui est de promouvoir l'investissement du secteur privé en stimulant le développement urbain. L'exemple de la ligne d'Hiroshima (18,4 km 24 stations) dont l'exploitation a débuté en juillet 1994 montre qu'il doit y avoir un partenariat public-privé, une coopération réelle entre les citoyens, le gouvernement central, les autorités locales, les industriels et les promoteurs privés.

En définitive un projet de métro automatique devrait être analysé pour ses performances physiques et le délai de mise en oeuvre du point de vue du coût des problèmes financiers et des coûts sociaux.

Session 4 Discussion Générale

Cette première journée s'est déroulée sans aucune présentation de constructeurs de matériels et systèmes de transport pour bien marquer l'indépendance du KOTI vis à vis de tel ou tel système m'a expliqué un de ses représentants; au cours de la discussion sont intervenus de nombreux universitaires, un journaliste et les différents intervenants de cette première journée.

Le Président Soogil Young a remercié l'ensemble des intervenants de cette première journée de conférence et ouvert le débat rappelant l'urgence de réaliser des systèmes intermédiaires dans la périphéries des grandes villes du Pays.

Dans le débat on a senti la difficulté de choix qu'il y a entre des systèmes éprouvés comme le métro léger, l'autobus guidé qui permet de surseoir quelques temps à une décision entre le métro léger ou le métro automatique et les nouveaux systèmes automatiques. Le Directeur du Ministère des Transport a rappelé que 20% de l'aide viendrait de l'Etat et 70% des Municipalités, il est donc important pour les municipalités d'effectuer le meilleur choix économique.

Le KOTI a rappelé que des spécifications seraient préparées et qu'un appel d'offres international serait préparé pour chaque projet de manière à faire respecter la libre concurrence et l'efficacité des coûts de réalisation.

Deuxième journée :

Présentations des systèmes par les constructeurs

Au cours de cette journée sont intervenus dans l'ordre :

- MITSUBISHI HEAVY INDUSTRIES, avec la présentation de M. Katsuro FUKUMOTO, les documents présentés sont en annexe,

- SIEMENS TRANSPORTATION, avec la présentation de M. Gerhard SCHOLTIS qui m'a adressé ses transparents joints en annexe,

- ANSALDO TRASPORTI, avec la présentation de Dr. Giacomo FORNO, les documents présentés sont en annexe,

- MATRA TRANSPORT, avec la présentation de M. Jean Maurice DUPONT, les documents présentés sont en annexe,

- AEG TRANSPORTATION SYSTEMS, avec la présentation de M. Joseph CASTELLANI dont le document présenté est en annexe,

- GEC ALSTHOM, avec la présentation de M. François COART dont le document présenté est en annexe,

- KOREA INSTITUTE OF MACHINERY AND METALS, avec la présentation du Dr. In-Kun KIM, le document présenté est en annexe.

Le 28 Octobre j'ai été invité une demi-journée au KOTI à Séoul pour parler de l'organisation des Transports publics en France.

Après une présentation des activités d'ESTAS j'ai présenté le financement des réseaux de transport public urbain en France et en région ile de France, par les recettes directes du trafic, par les employeurs (versement transport), par les Pouvoirs publics, par les automobilistes, par le produit des amendes de police, etc. Une dizaine de personnes dont le Dr. Young étaient présents, ils m'ont paru très intéressés notamment par la LOTI dont j'ai envoyé une copie du texte de loi, le gouvernement coréen préparant actuellement une législation concernant les transports publics.

PERSONNES RENCONTREES

- du Korea Transport Institute, KOTI :

  . Dr. Soogil YOUNG, President of KOTI,

  . Dr. Seung-Pil KANG, Director Transportation Planning Division,

  . Dr. Seongsoon YUN, Senior Researcher Transportation Planning Division,

  . M. Woo-Young AHN, Researcher Transport Planning Division,

  . Dr. Younggak KWON, Head Planning & Coordination Department,

  . Dr. Sunduck SUH, Head Land Transport Research Division,

  . Dr. Jae-Hoon SUL, Project manager Transportation Safety Division,

  . Dr. Jong HUR, Research fellow Aviation Policy Division,

  . Dr. Jong-Seok KIM, economist,

  . Dr. Kwang-Suk SUH, Research fellow Land Transport Research Division,

- les intervenants à la conférence le 25 octobre :

  . M. Ki-Jae KIM, Maire de Pusan,

  . Prof. Ralph Gakenheimer, M.I.T., USA,

  . M. Sang-Won KIM, Director of Transportation and Tourism Bureau, Pusan ,

  . Prof. Tschang-Ho KIM, University of Illinois, USA,

  . Prof. Jaimu WON, Seoul city University,

  . Dr. Chia-Juh CHANG, Director General of the Institute of Transportation, Taipei, Republic of China,

  . Prof. Shigeru MORICHI, Tokyo Institute of Technology, Japan,

- les constructeurs intervenant à la conférence le 26 octobre :

  . M. Katsuro FUKUMOTO, Deputy Manager , sales department Transportation Airport systems, MITSUBISHI Heavy Industries, Hiroshima, Japan,

  . M. Gerhard SCHOLTIS, Vice President SIEMENS, Erlangen, Germany,

  . Dr. Carlos DOMENE, Head of sales area B, DUEWAG, Düsseldorf, Germany,

. M. Kwang-Chi CHANG, section Chief Transportation systems SIEMENS Ltd, Seoul,

. Dr. Ulrich STOCK, Director Transportation systems SIEMENS Ltd, Seoul,

. Dr. Giacomo FORNO, managing Director, ANSALDO, Korea representative office, Seoul,

. M. Jean Maurice DUPONT, New Projects Department, MATRA Transport,

. M. Philippe LOUSTE, in charge of public relations of MATRA Transport,

. M. Michel THOMYRE, representative Director of MATRA Hachette,

. M. Sang-Woo PARK, Director Seoul office, MATRA Transport,

. M. Joseph U. CASTELLANI, marketing Representative AEG Transport Systems, Pittsburgh, Pensylvania, USA,

. M. J.B. EYMEOUD, commercial senior Manager Rolling stock GEC Alsthom Transport, Paris,

. M. François COART, responsable commercial, GEC Alsthom Transport,

. Dr. In-Kun KIM, Director of Magnetically Levitated Train Project, Korea Institute of Machinery & Metals, Daejon,

- autres personnes rencontrées :

. M. Jae-Youl KIM, Directeur à la Société Générale, branche de Séoul,

. Dr. Jong-Ho RHEE, assistant professor of Dpt of Transportation Engineering, Kyonggi University, Kyonggi-Do, Korea,

. M. Sang Kuk KIM, LRT Planning team, Hanam city, Kyunggi Province,

. M. Byung -Hak LEE, certified public tax accountant, Kyunggi-do,

. Dr. Young-Il LEE, President of the Korean Society of Plant Tissue Culture, Korea Atomic Energy Research Institute, Taejon,

. M. Jong Chan LEE, technical general Manager rolling stock division, EUKORAIL, Korea TGV Consortium,

. M. Seung-Ho HAN, landscape architect, Handsel Green Co.,Ltd, Seoul.

ANNEXES

Le Réseau de PUSAN

La première ligne orientée Nord - sud a un linéaire de 23 km entre Chung Yeong au nord et l'Hôtel de ville et le stadium au sud;

Une deuxième ligne est en construction orientée nord sud en 1ière phase commencée en 1991, et une 2ième phase est ouest commencée en octobre 1994.

Nous résumons dans le tableau ci-après quelques données sur cette ligne parues dans la presse locale :

LIGNE 2	TERMINUS	LINEAIRE	STATIONS	DELAIS	COUTS en MF
TOTAL	ROPO à HAEUNDAE	39,1 km	37	91 - 98	12 534
1re Phase	ROPO à SOMION	à 22,4 km	20	91 - 97	8 388
2ième Phase	SOMION à HAEUNDAE	16,7 km	17	94 - 98	4 145

La 1ière phase est achevée à 25,5%, 38,4% en cours de bétonnage.

La 2ième phase dont le linéaire est de 16,7 km sera construite selon deux méthodes en tunnel sur 7,36 km de Mounion à Houdon et en tranchée couverte de Houdon à Jadon sur 9,34 km : le coût de construction revient à 250 MF/km pour cette 2ième phase, 320 MF/km pour l'ensemble de la ligne.

단계 건설공사를 시작합니다.

……장산

설되면 교통편익과 지역발전이 촉진됩니다.

운대~서면간의통행시간이30분으로단축되고
폭 완화될 것입니다.
주행속도 5.1km/h가 12.5km/h로 향상)
이 건설되면 남북축인 1호선과 십자형 지하철
의 교통체계에 획기적 변화를 가져오고 시민의
될 것입니다.
율 : 20.7%)
운대와 광안리의 관광개발도 더욱 활성화 될

감안하여 공사기간중의 교통난과 주민불
정밀 지질 조사후 최선의 공법을 선택하

화하기 위해 정밀 지질 조사후 최선의 공법을

동) : 7.36km
현,우동~좌동) : 9.34km

공단

社 晨城綜合建設株式會社

한라건설주식회사

Le Réseau de Métro de PUSAN

附錄 1. 海外主要空港地域의 新都市鐵道 運行現況

국 가	설 치 지 역	개 통	연 장	역 수	시스템 제작사
미 국	Tampa공항	1971	3.9km	16	AEG, TGI
	Houston공항	1972	2.6km	11	WED, Rohr, TGI
	Seattle공항	1973	2.7km	8	AEG, TGI
	Dallas공항(Airtrans)	1974	22.4km	32	Vought
	Atlanta공항	1980	3.8km	10	AEG
	Miami공항	1980	0.8km	2	AEG
	Orlando공항	1981	3.5km	6	AEG
	Las Vegas공항	1985	0.8km	2	AEG
	Chicago O'Hare공항	1992	4.2km	5	Matra
영 국	London Gatwick공항	1983	3.0km	4	AEG
	Birmingham공항	1984	0.6km	2	PM Groups
	London Stansted공항	1991	2.7km	4	AEG
프랑스	Paris Orly공항	1991	7.2km	4	Matra(VAL)
싱가폴	Changi공항	1989	1.3km	3	AEG
일 본	나리타공항	1992	0.3km	2	Otis

Les nouveaux systèmes de transport dans le monde

(extrait la communication du Dr Yun & Jin du KOTI

附錄 2. 海外主要慰樂地域의 新都市鐵道 運行現況

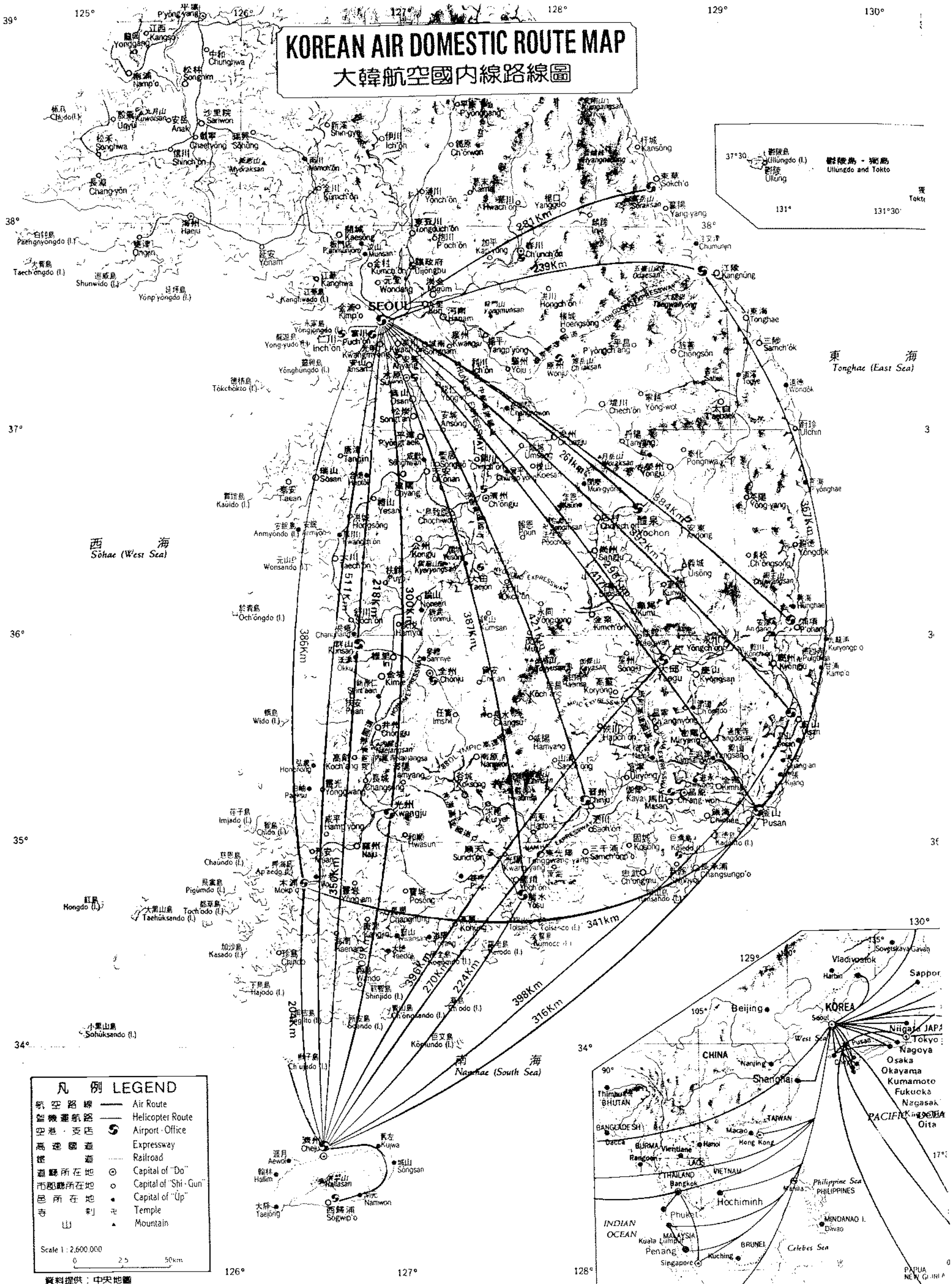
국 가	설치 지역		개 통	연 장	역 수	시스템 제작사
미 국	CA	디즈니랜드	1967	1.3km	1	WED, TGI
	CA	California Exposition	1969	2.3km	1	UMI, TGI
	PA	Hershey Park	1969	1.3km	2	UMI
	LA	Magic Mountain	1971	1.3km	3	UMI
	NC	Carowinds	1973	3.2km	1	UMI
	Ohio	King's Island	1974	3.2km	1	UMI
	VA	Busch Gardens	1975	2.1km	2	AEG
	Orlando	Disney World	1975	1.5km	1	WED
	VA	King's Dominion	1975	3.2km	1	UMI
	N.Y	Bronx Zoo	1977	3.0km	2	Rohr, AEG
	MN	Minneapolis Zoological Gardens	1979	2.0km	1	UMI
영 국	Liverpool	Chester Zoo	1991	1.5km	2	CPM
캐나다	Toronto	Toronto Zoo	1975	5.1km	3	Bendix
프랑스	Paris	Nord Exhibition Park	1987	0.6km	2	Soule
일 본	Saitama	Seibu공원	1985	2.8km	3	Niigata

附錄 3. 海外主要活動團地의 新都市鐵道 運行現況

국 가	주 / 도시	시 설	개 통	연 장	역 수	시스템 제작
미 국	WV	Morgantown Univ.	1975	14.0km	5	Boeing
	Hawaii	Pearlridge Shopping Ctr.	1978	0.4km	2	Rohr, AEG
	NC	Duke Univ./Hospital	1980	1.0km	3	Otis
	Los Angeles	Circus Hotel/Casino	1981	0.6km	3	VSL
	Tennessee	Mud Island	1982	0.5km	2	VSL
	Reno, NV	Circus Hotel/Casino	1985	0.4km	2	VSL
	Florida	Harbour Island	1985	0.7km	2	Otis
	Hawaii	Hyatt Regency Resort	1987	1.5km	5	Von Roll
	NV	Primadonna	1991	0.5km	2	VSL
영 국	Dudley	Merry Hill Shopping	1991	1.7km	4	Siemens/Duewag
독 일	Dortmund	Dortmund Univ.	1984	1.0km	2	Siemens/Duewag
	Ziegenhain	Ziegenhain Hospital	1976	0.6km	2	Cabintaxi
오스트리아	Serfaus	Ski Resort	1985	1.3km	4	Otis

附錄 4. 海外主要1都市地域의 新都市鐵道 運行現況

국 가	도 시	시 설	개 통	연 장	역 수	시스템 제작사
미 국	Miami	Metromover	1986	6.1km	10	AEG
	Detroit	DPM	1987	4.7km	13	UTDC
	Florida	Automated Skyway Express	1989	1.1km	3	Matra
	Jacksonville	VAL	1989	1.0km	3	Matra
	Texas	Las Colinas	1989	4.9km	4	AEG
프랑스	Lille	VAL	1983	25.5km	36	Matra
	Laon		1984	1.5km	3	POMA 2000
	Lyon		1991	12.0km	13	Matra/Alsthom
일 본	고베	Portliner	1981	6.4km	9	고베/가와사끼
	오사카	Newtram	1981	6.6km	8	니가타/Vought
	오미야	Ina Line	1983	11.6km	12	니가타/가와사끼
	사쿠라	유카리가오카선	1983	4.1km	6	일본 VONA/미쓰이
		야마구찌선	1985	2.8km	3	니이가타
	고베	로코섬선	1990	4.5km	6	고베/가와사끼
	고마끼	도카다이선	1990	7.4km	7	Nippon/미쓰이
	요코하마	Seaside Line	1990	10.8km	14	니가타/미쯔비시
	지바	Townliner	1988	11.8km	13	미쓰비시
	오사카	공항 모노게일	1990	6.6km	5	가와사끼
	북규슈	소창선	1985	8.4km	12	가와사끼
영 국	London	Docklands	1987	12.1km	15	GEC/Mowlem
독 일	베를린		1989	1.6km	3	AEG/M-Bahn
카나다	토론토	Scarborough RT	1985	7.1km	6	UTDC
	뱅쿠버	Skytrain	1986	21.4km	17	UTDC
호 주	시드니	Darling Harbourlink	1989	3.6km	6	Von Roll
대 만	타이페이	VAL	1992	20.7km	21	Matra


KOREAN AIR DOMESTIC ROUTE MAP
大韓航空國內線路線圖
凡 例 LEGEND
航空路線 Air Route
直升機運航路 Helicopter Route
空港·支店 Airport · Office
高速國道 Expressway
鐵道 Railroad
道廳所在地 Capital of "Do"
市郡廳所在地 Capital of "Shi · Gun"
邑所在地 Capital of "Up"
寺刹 Temple
山 Mountain
Scale 1 : 2,600,000
資料提供：中央地圖

MITSUBISHI HEAVY INDUSTRIES, LTD.

PRESENTATION
OF
MITSUBISHI
NEW TRANSPORTATION SYSTEM

International Conference on the New Transit System

and System Presentations

In Pusan

PRESENTED BY: MITSUBISHI HEAVY INDUSTRIES,LTD.

TOKYO,JAPAN

MITSUBISHI HEAVY INDUSTRIES, LTD.

PRESENTATION OF MITSUBISHI NEW TRANSIT SYSTEMS

Katsuro Fukumoto
Transportation and Airport Systems Department
Mitsubishi Heavy Industries, Ltd.
Tokyo, Japan

1. Summary

This presentation addresses the introduction of various new transit systems which can realize the network of urban transportation. Mitsubishi Heavy Industries, Ltd. has investigated throughly and developed the various kinds of transportation systems to satisfy the transportation gap issued from an expansion of the city and has been involved in many transportation projects in Japan and overseas.

The project overview, its technology and the capability will be presented in this brief presentation.

2. Introduction
   (1) Introduction of Mitsubishi Heavy Industries, Ltd. (MHI)
   (2) MHI's experiences in the field of transportation system

3. Application area of urban transportation system

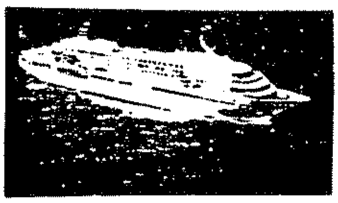
4. System overview
   (1) Medium capacity transit system (MCTS)
       (Hiroshima, Rokko, Tokadai, Chiba)
   (2) Transit system at airport and short distance transit system

5. Technology overview of MCTS and standardization of the system.

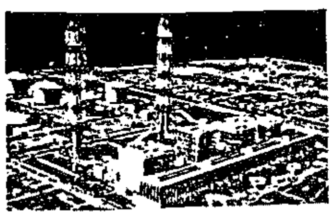
6. Implementation capability
   (1) Advantage of turn key project
   (2) Delivery performance

INTRODUCTION OF MHI

- Over one hundred years of experience and tradition are behind our outstanding results in the production of a wide variety of products including ships, power systems, aircrafts, chemical plants, ground transportation systems and industrial machinery.
- MHI HAS PLENTY OF EXPERIENCES OF TURNKEY PROJECTS IN OVERSEAS.

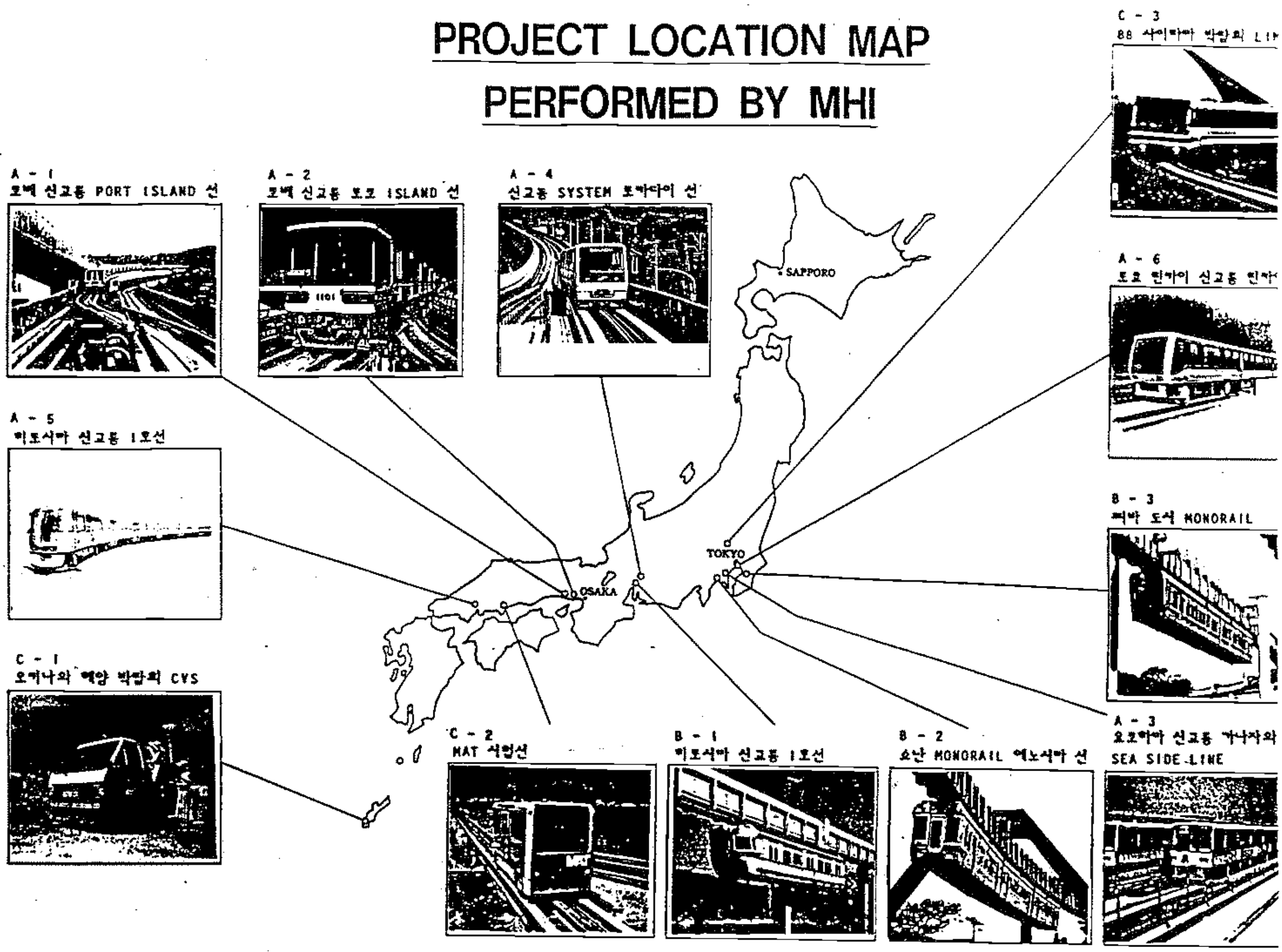




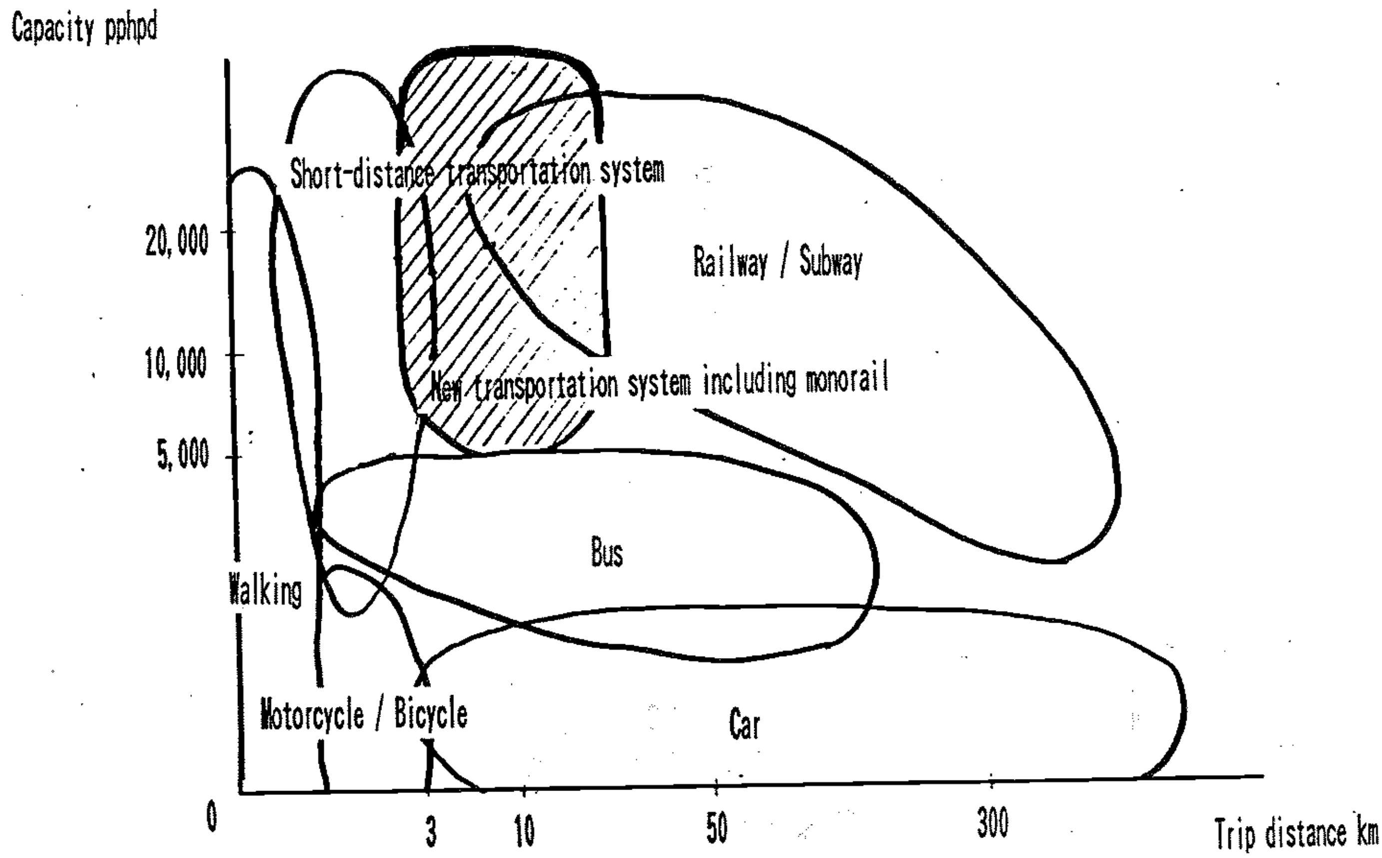

MITSUBISHI HEAVY INDUSTRIES, LTD

PROJECT LOCATION MAP PERFORMED BY MHI



PROJECT EXPERIENCE

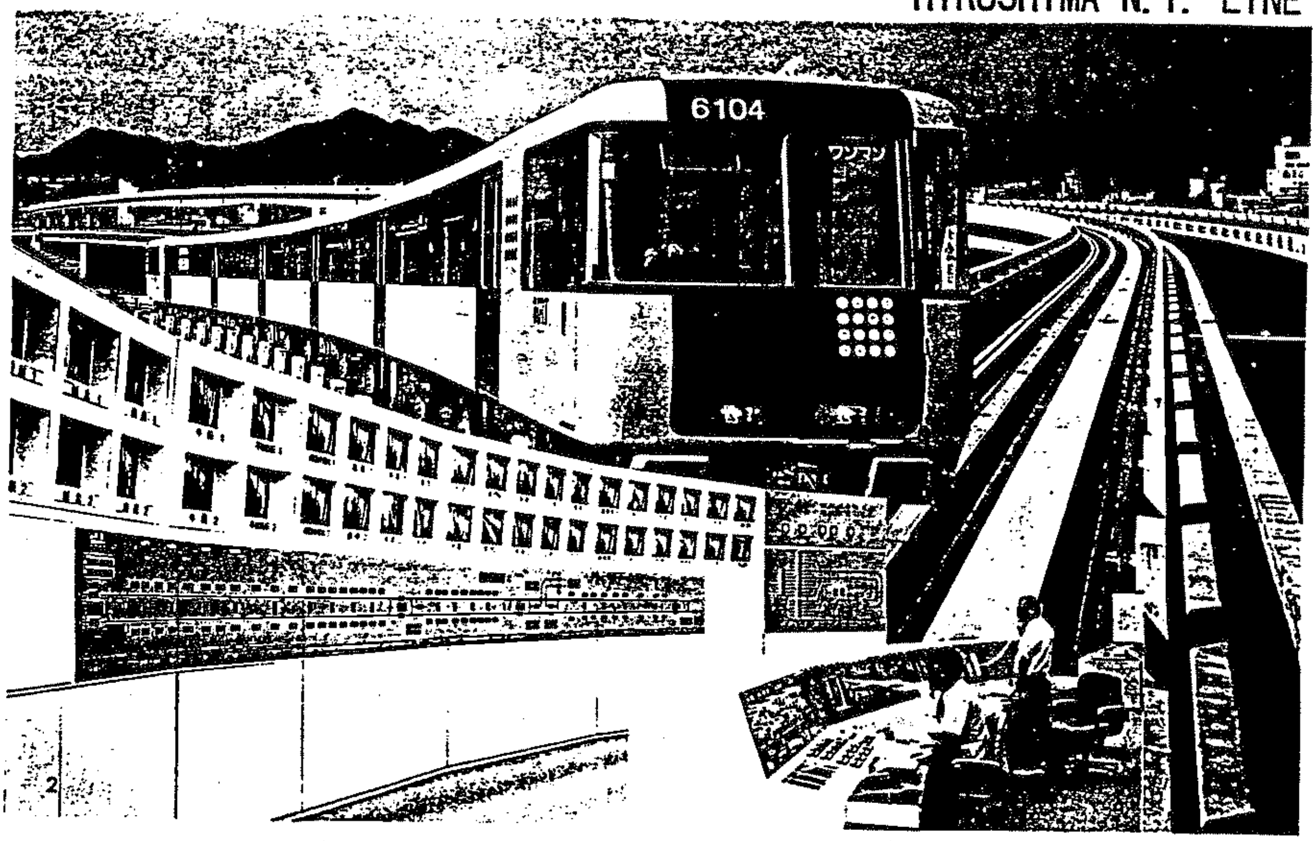
PROJECT NAME	YEAR
Shonan Monorail Enoshima Line	1970
'75 Ocean Expo CVS	1975
Chiba Urban Monorail Yamanote Line	1977
Kobe Port Island Line	1980
Yokohama Kanazawa Seaside Line	1989
Kobe Rokko Island Line	1990
Tokadai New Transit Line	1991
Hiroshima No.1 Line	1994
Tokyo Waterfront Line (Under Construction)	1995



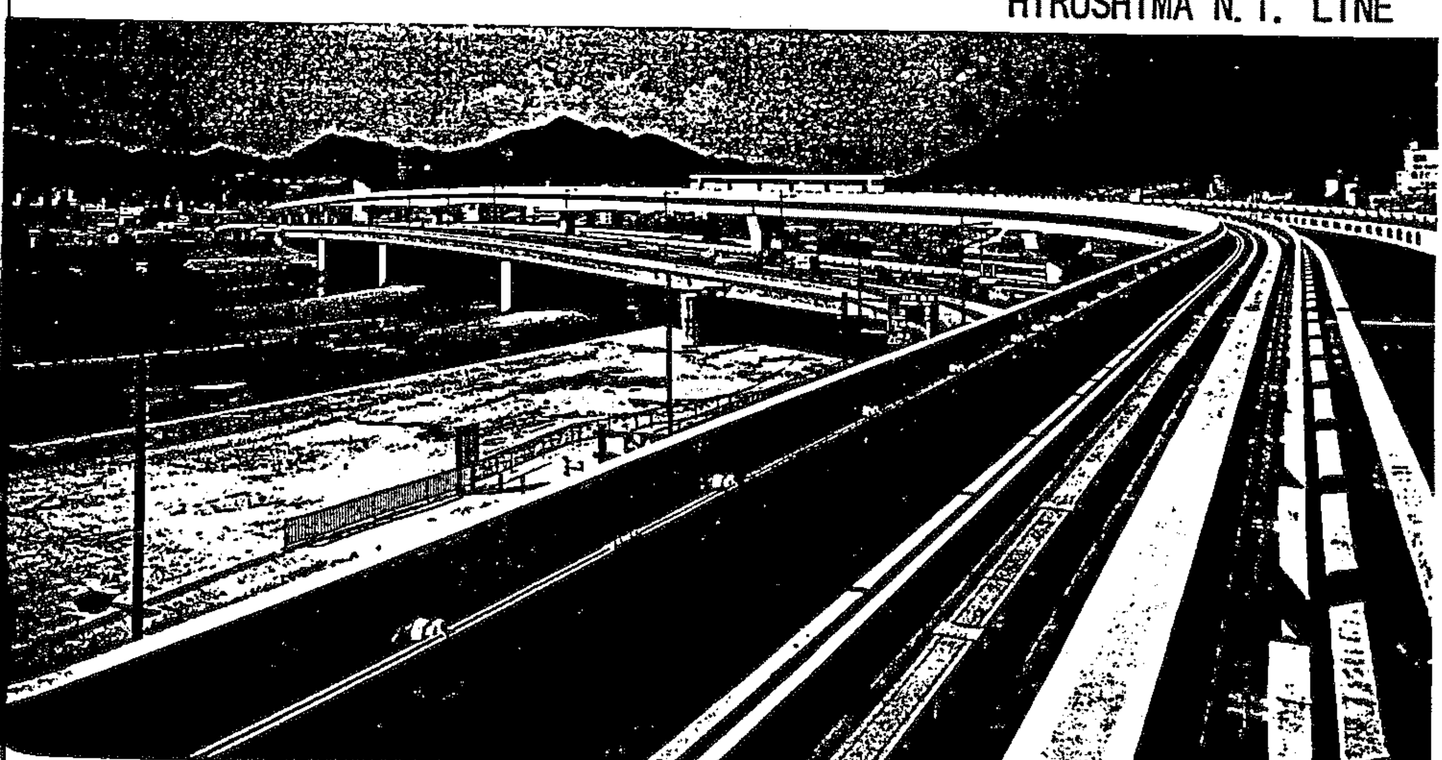
Application area of urban transportation modes

STATUS OF NEW MCTS IN JAPAN

HIROSHIMA N.T. LINE



HIROSHIMA N.T. LINE



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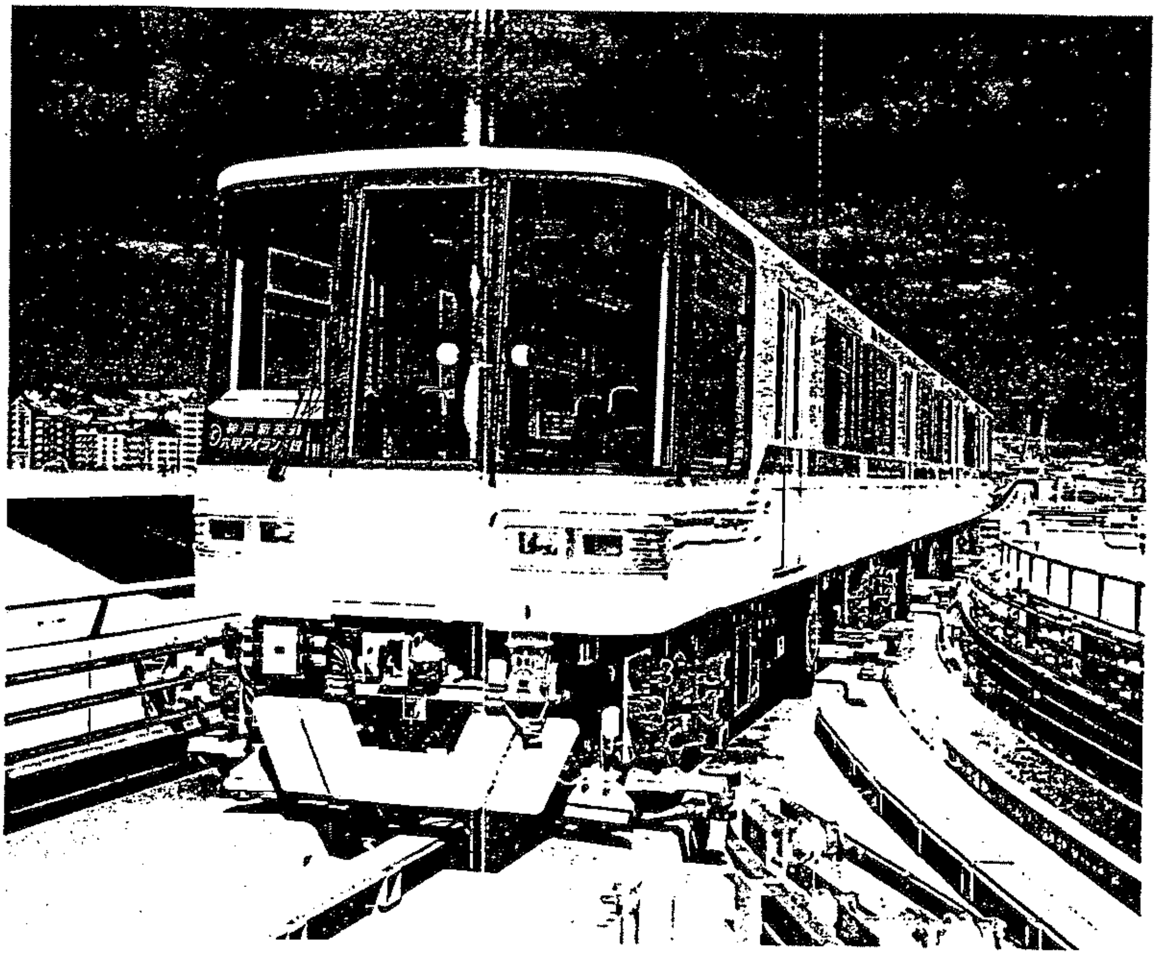
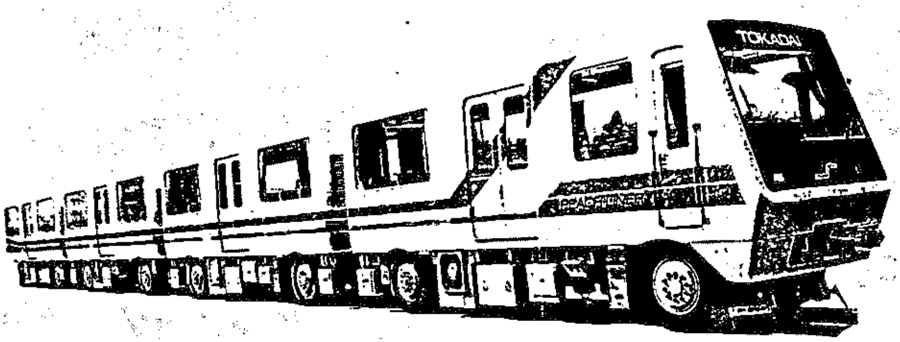
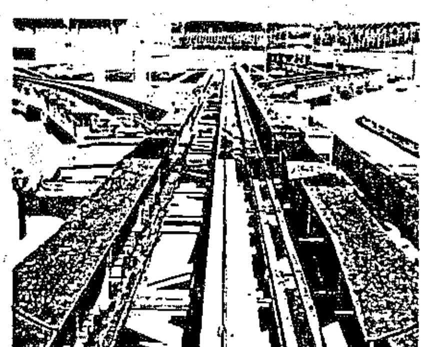
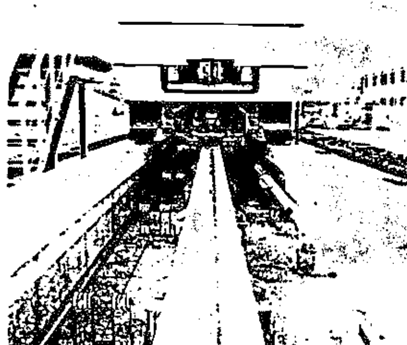
KOBE NEW TRANSIT ROKKO ISLAND LINE



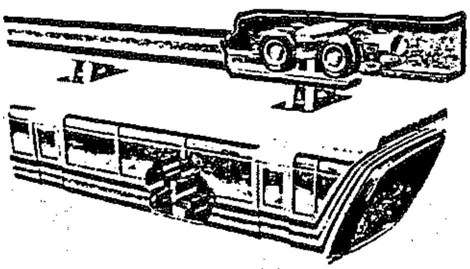
TOKADAI LINE
(CENTRAL GUIDANCE SYSTEM)





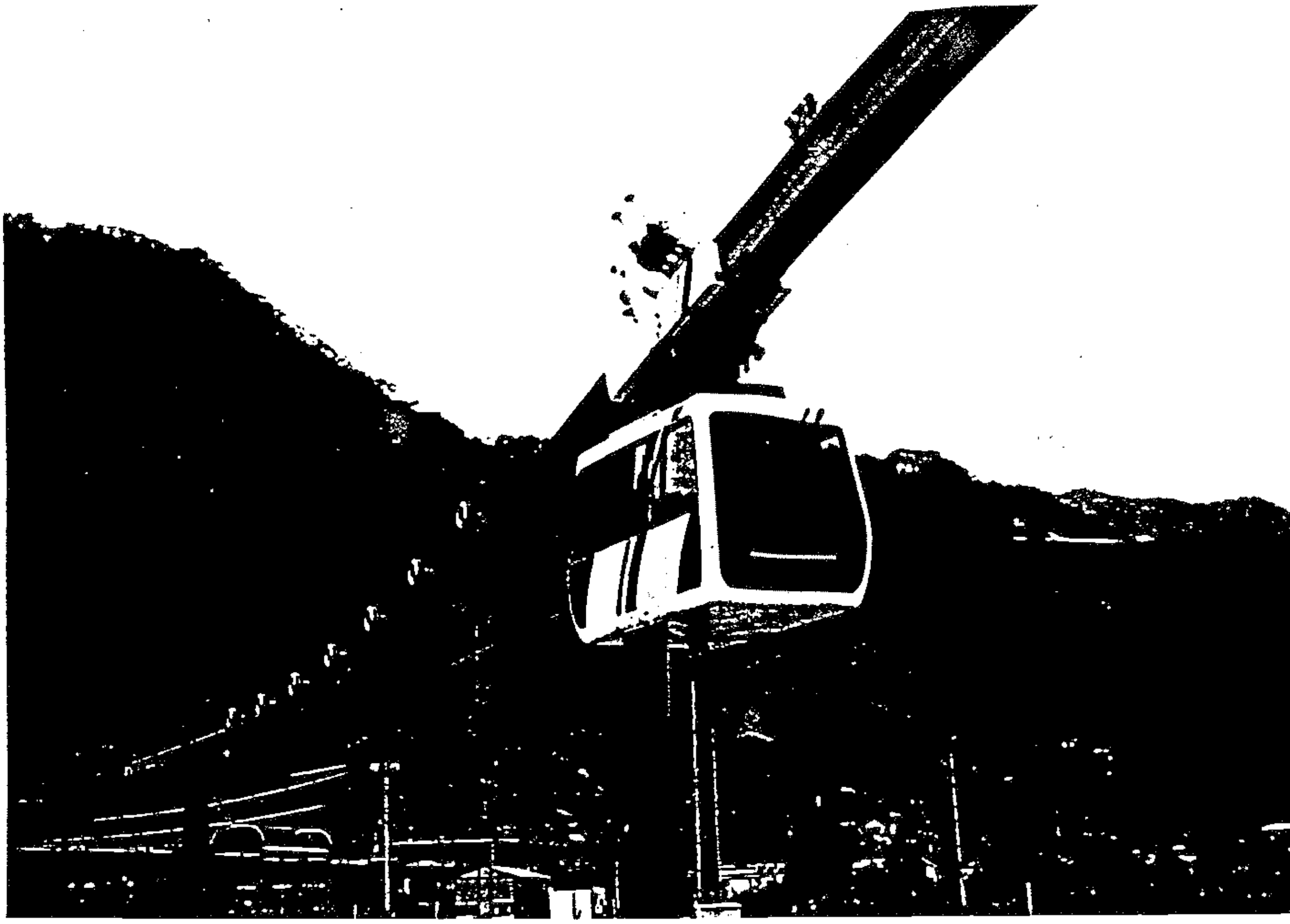


CHIBA URBAN MONORAIL

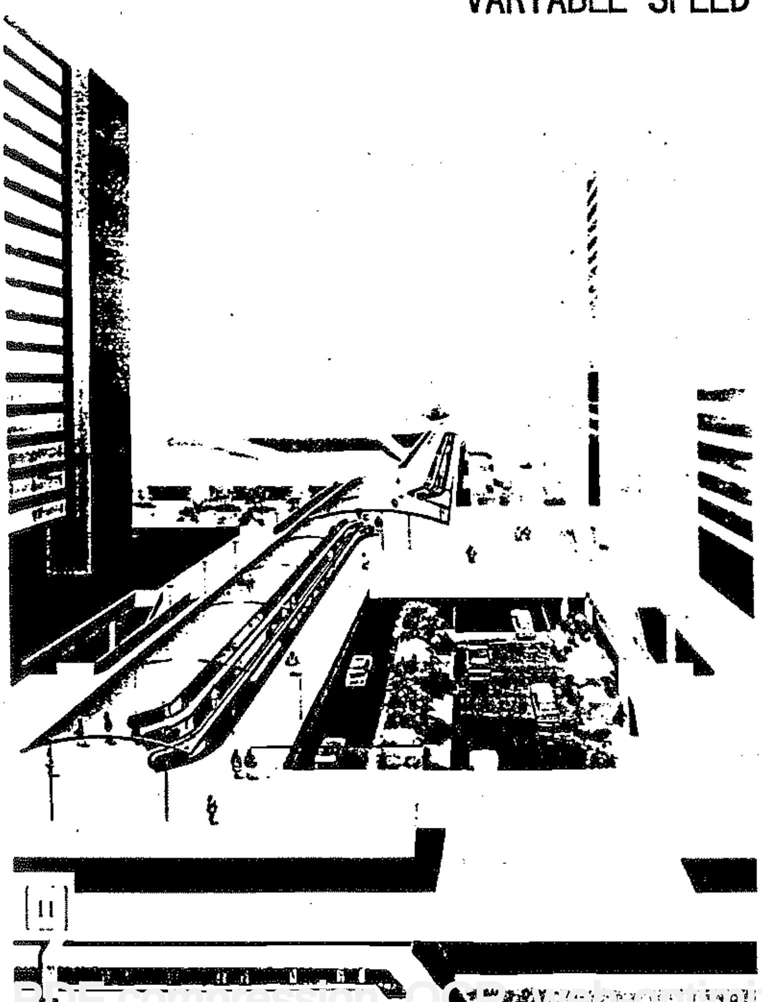


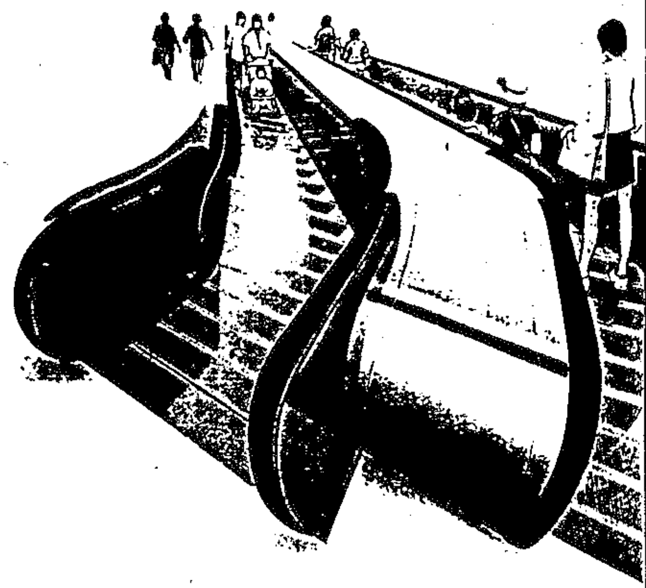
MITSUBISHI
HEAVY INDUSTRIES, LTD.

SKYRAIL



VARIABLE SPEED MOVING WALK





NEW MCTS TECHNOLOGY

- SAFE FOR PASSENGERS AND STAFF
- RROVEN IN REVENUE SERVICE
- RUBBER TIRES
- SIDE GUIDANCE OR CENTRAL GUIDANCE
- ADVANCED CHOPPER/VVVF (IGBT) CONTROL
- DRIVERLESS AUTOMATION
- FLEXIBILITY TO MATCH PATRONAGE (2-8 CAR TRAINS)

NEW MCTS TECHNOLOGY

- STANDARDIZATION OF GUIDEWAY
- LOW LIFE CYCLE COST
- LOW NOISE
- GANGWAY CONNECTS CARS OF TRAIN
- NOT PROPRIETARY TECHNOLOGY
- FUTURE PURCHASES BY COMPETITIVE BIDDING

SYSTEM PERFORMANCE

- MAX. OPERATING SPEED: 60～80 km/h
- ACCELERATION: 3.5 km/h/s
- DECELERATION
  - MAX.SERVICE BRAKE: 3.5 km/h/s
  - PROGRAMMED STOP: 2.5 km/h/s
  - EMERGENCY BRAKE: 4.5 km/h/s
- MAX.GRADE: 6%
- MIN.CURVE RADIUS: 30 m
- TRAIN CAPACITY: 80～110 Passengers per car

WORK BREAKDOWN STRUCTURE (WBS)

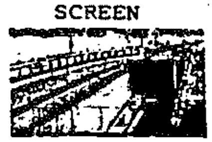
SYSTEM
- GUIDEWAY / TUNNEL
  - GUIDERAIL, OVERTRAVEL BUFFER
  - RUNNING SURFACE (PLINTH)
  - WALKWAY
  - DRAINGE SYSTEM
- STATIONS — PLATFORM EDGE DOORS, SCREEN
- VEHICLES
- AUTOMATIC TRAIN CONTROL (ATP, ATO AND ATS)
- COMMUNICATION SYSTEM
  - TRAIN RADIO
  - PA, INTERCOM
  - CCTV
- POWER SUPPLY & DISTRIBUTION
  - TRACTION S/S EQ.
  - DISTRIBUTION LINE
  - POWER RAILS
  - SCADA
- MAINTENANCE FACILITIES
- CENTRAL CONTROL ROOM
- ELECTRIC EQUIPMENT ROOM

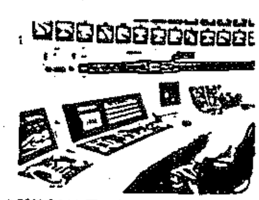

GUIDEWAY (VIADUCT AND PIER)

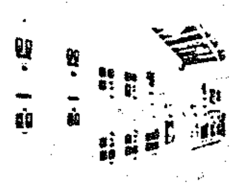
RUNNING SURFACE (PL

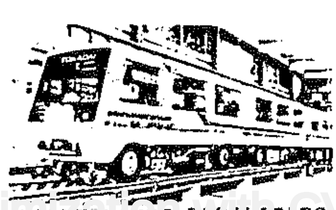

PLATFORM EDGE DOORS
SCREEN


VEHICLE

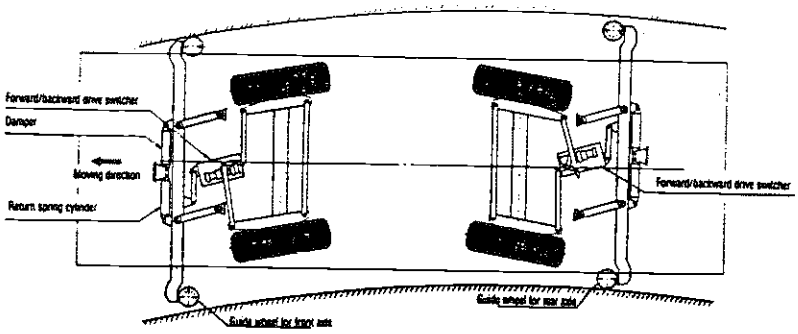

TUNNEL


AUTOMATIC TRAIN CON
COMMUNICATION SYST
SCADA

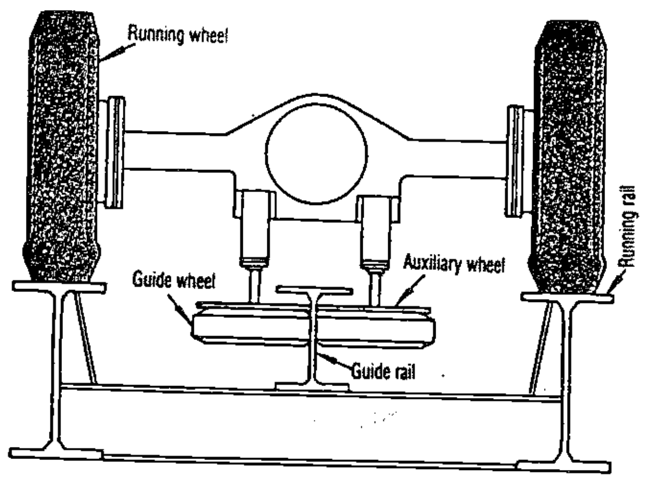

POWER SUPPLY SYSTEM


MAINTENANCE FACILITIES

BOGIE SYSTEM



SIDE GUIDANCE SYSTEM



CENTRAL GUIDANCE SYSTEM

Computer Total Control System

- Train Identification
- Train Control Display
- Route Assignment & Control
- Corrective Strategies
- Man-machine Communication
- Train Performance Monitoring & Control

- Electrification Display
- Power Supply Control
- Corrective Strategies
- Man-machine Communication

- Train Speed Regulation
- Programmed Stopping Control
- Performance Level Adjustment
- Malfunction Monitoring

- Revenue Management
- Car Maintenance Management
- Personnel Management
- Financial Affairs Management

- Operation Test of Car-carried Equipment
- Man-machine Communication

- Support Facilities Monitoring & Control
- Fare Collection

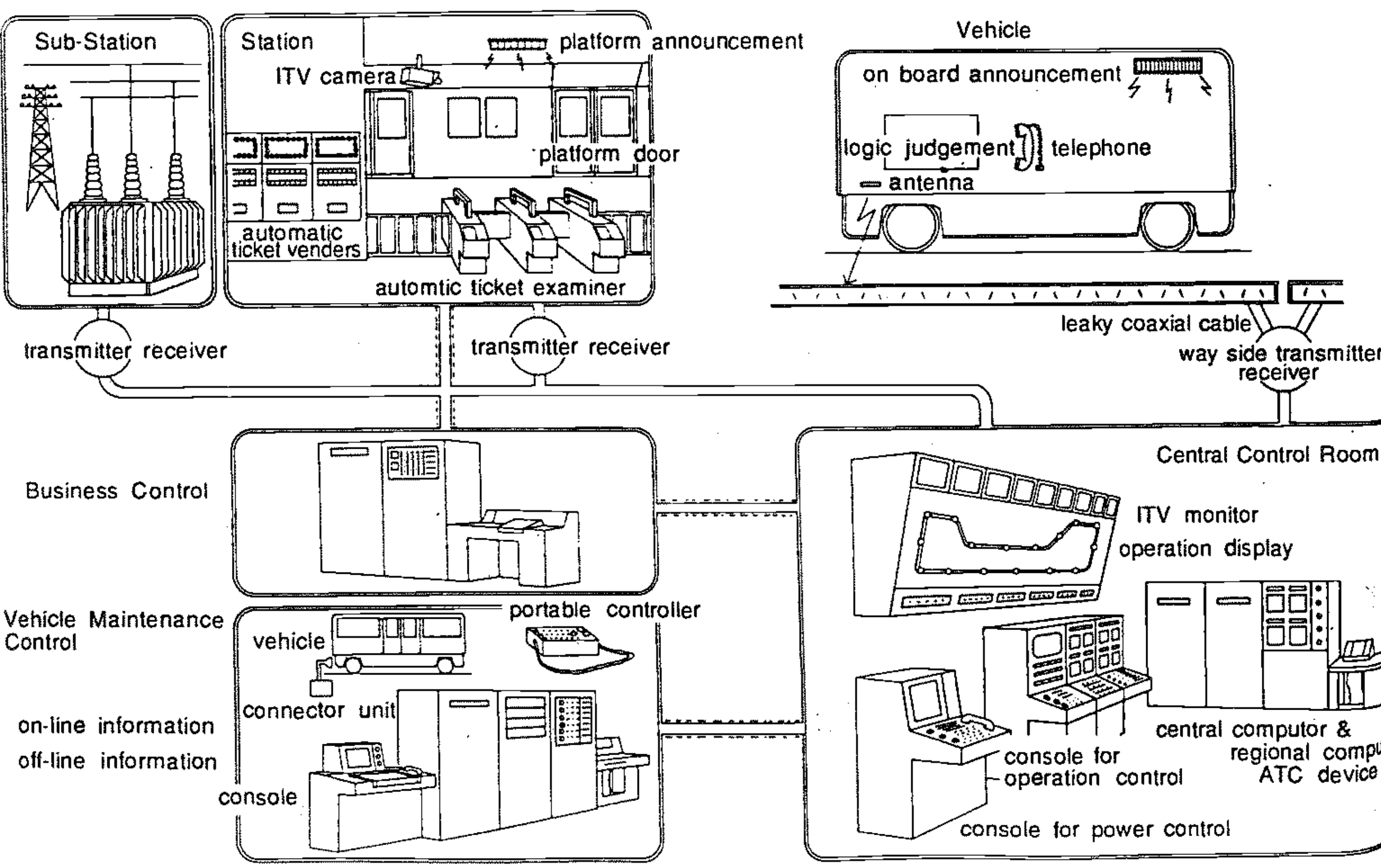
- Automatic Public Address
- Visual Information Control

- Fire Monitoring
- Emergency Facilities Monitoring & Control

- TV Monitoring of Platforms (at Central Control & in Driver's Cab)

- Train Telephone
- Telephone Network

TOTAL SYSTEM



Control Centre of Yokohama

NOISE LEVELS

- JAPANESE STANDARDS ARE 70dBA AT 10m & 1.2m HEIGHT
- STANDARDS ARE BEING MET
- GOOD PUBLIC ACCEPTANCE

ALIGNMENT CRITERIA

- JAPANESE STANDARDS FOR MCTS
- MIN. HORIZ. RADIUS 50m OPERATION
  30m DESIGN REQT.
- MIN. VERT. RADIUS 1000m OPERATION
  500m DESIGN REQT
- MAX. GRADE 6% OPERATION
  9% DEPOT
- MAX.SUPERELEVATION 10%

STANDARDIZATION OF MCTS IN JAPAN

AIM OF STANDARDIZATION

- PERMIT ADVANCE URBAN PLANS IN ADVANCE
- ALLOW VARIETY OF VEHICLES
- ALLOW FOR INDEPENDENT DESIGN AND CONSTRUCTION OF INFRA-STRUCTURE AND E&M
- COSTWISE

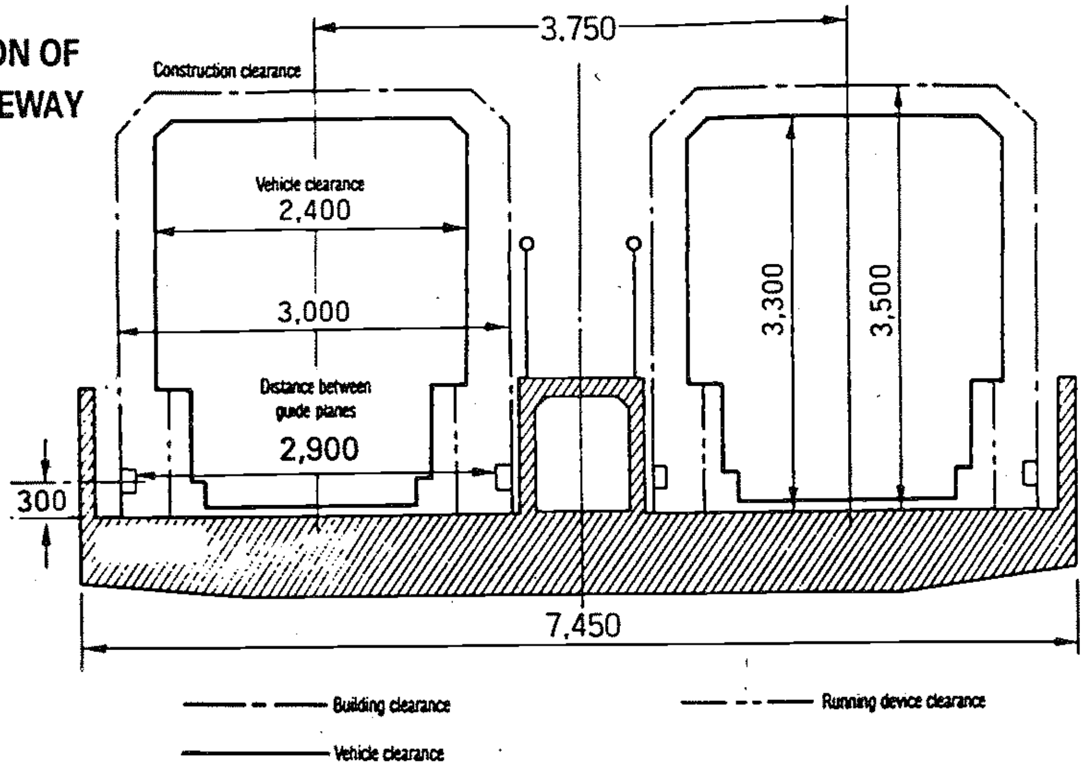
BASIC POLICIES OF STANDARDIZATION

- ESTABLISH SPECIFICATIONS FOR MINIMUM ESSENTIAL DESIGN ASPECTS WITHOUT CREATING OBSTACLES TO FUTURE TECHNICAL INNOVATIONS

FUNDAMENTAL SPECIFICATIONS

- SYSTEMS:
  1) GUIDANCE SYSTEM
  2) SWITCH SYSTEM
  3) POWER SUPPLY SYSTEM
- VEHICLES:
  1) VEHICLE CLEARANCE
  2) FULLY LOADED WEIGHT
- GUIDEWAY:
  1) CONSTRUCTION CLEARANCE
  2) GUIDERAIL SURFACE DIMENSION
  3) PLATFORM HEIGHT
  4) DESIGN LOAD

CROSS-SECTION OF
TYPICAL GUIDEWAY



MHI SUPPLIES SYSTEM TURNKEY

- MHI CAN SUPPLY THE MOST RELIABLE, EFFICIENT MCTS AS TURNKEY APPROACH
- MHI CAN GUARANTEE HIGH SERVICE AVAILABILITY
- MHI OFFERS TECHNICAL ASSISTANCE AND TRAINING FOR O & M

ADVANCED,PROVEN MCTS TECHNOLOGY FOR KOREAN APPLICATION

SYSTEM DESIGN CHOICES

- SYSTEM SIZE & CAPACITY
- ALIGNMENT
- DEGREE OF AUTOMATION
- TRAIN CONSIST
- POWER SUPPLY SYSTEM
- STATION CONFIGURATION
- ENVIRONMENTAL RESTRAINT
- OPERATION & MAINTENANCE SYSTEM

ADVANCED,PROVEN MCTS TECHNOLOGY FOR KOREAN APPLICATION

SUMMARY

MITSUBISHI

- HAS WIDE RANGE OF TRANSPORTATION TECHNOLOGIES
- HAS BEEN INVOLVED MANY TRANSIT PROJECT
- CAN PROVIDE VARIETY OF SYSTEM DESIGN CHOICES WITH PROVEN EXPERIENCE WITH ADVANCED TECHNOLOGY OPTION
- IS INTERESTED IN TURNKEY PROJECTS
- WELCOMES THE OPPORTUNITY TO DISCUSS ABOUT PUSAN & SEOUL LRT PROJECTS

Siemens Transportation Systems

Gerhard Scholtis

Hr. Hasselbacher, Hr. Neubeck / VT 4 L
Hr. Domene, Duewag
Hr. Bredehorst
Hr. Dr. Stock
Hr. Prof. Kuhn
Hr. Howard

LRT - Symposium Pusan Oct. 26, 1994

This is a presentation of Siemens Transportation Systems Group. In this division are all the worldwide railway activities of Siemens concentrated.
To Siemens Transportation Systems Group belong also the international well known car builders Duewag of Germany, SGP of Austria as well as Siemens Duewag Corp. in USA which helped make us one of the world's leading suppliers of railway mass transit systems. The current total sales amount to approximately 3.2 bill. US $ with over 16.000 employees worldwide. Siemens Transportation Group is one of the three leading companies of railway transportation in the world. As part of the international Siemens Group which records about 50 bill. US $ in sales with 400.000 employees, the Transportation Group automatically gets access to the resources and results of Research & Development of the whole group. Siemens invests nearly 5 bill US $ each year with about 50.000 employees involved.

The Transportation Group develops, engineers and manufactures any subsystem and component for all kindes of railway systems: On the one hand we have the total system capability, from signalling, control systems, catenaries, power supply to rolling stock. On the other hand we can provide different overall system solutions for a wide range of specific requirements in different situations: from light city mass transit, people movers, metros and suburban train, regional trains to high speed systems.
After this introduction let me come to urban public transportation:

More than 50% of the business volume comes out of our business segment "Mass Transit". According to the definition of "International Union of Public Transport (UITP)", we distinguish between light rail and heavy rail. More than 85 Subway-systems with nearly 50.000 motor cars & trailers worldwide belong to heavy rail. However, more than four times that figure, that means 350 cities are known to run a light rail system. And this number is increasing more and more as we heart yesterday from Prof Kuhn's paper. Our market share is not bad; Duewag i. e. has supplied 6000 LRV's during the last 35 years.

What is the reason for this trend? The answer is very simple:
Worldwide there is a high demand of non-polluting systems for public transportation. As well, however, there are problems worldwide to cope with this demand by construction of new or extension of existing railway systems. The reason is that public transport is mainly considered as a service to the public, which usually doesn't make any profit. The effects are: increase of leisure time, improvement of environment, higher quality of living and so on. But the monetary valuation for these criteria is hardly to comprehend by the public.

Therefore, whereever it is possible, there is the attempt to reduce the investment as well as to save costs for operation. That means rail-based mass transit systems have to be both attractive and economical. In my opinion Korea faces exact this situation at the moment. As a result of crowded cities by high increasing numbers of cars, higher demand for mobility and the continually strong movement of people to the big cities or their suburbs. The experience in other countries has shown that convenient and economical rail mass transit systems could be often the most reasonable solution. Many of the desired requirements for the day's mass transit systems are similar for HR & LR-Systems. Whenever the expected ridership is big enough we should continue to recommend metro systems. But it isn't easy and cheap to build metros.
In contrast to the expensive metros with their high capacities LRT-systems are often the best solution. They are systems which provide a wide range of transportation capacity between 5.000 to 25.000 people per hour and per direction on the one hand and with different levels of riding comfort on the other. The design can also be made as a preliminary stage to a metro, that means a kind of premetro.

To realize the cost advantages of LRT-systems as far as possible, however, the LRT-systems have to be built in accordance with the required specification or definition. As a result of our long, worldwide experience in this field with the whole scope of different systems, partly also realized as a tumkey system, as well out of our close cooperation with customers and consultants we consider the following items as very important for a system decision. LRT should have the following features:

- it should run as far as possible at surface; tunnels and elevated guideways only in highly crowded city areas
- it should use steel wheels on steel rails because of the following advantage compared e.g. to rubber-tyred vehicles:
  lower life-cycle-costs thru double life span, lower maintenance, etc.
- it is better adapted to difficult weather situations (snow, rain)
- it doesn't have any noise disturbs
- LRT is able to run in mix with roadway traffic in certain sections
- LRT has crossings on the same level
- LRT has simple stations and stops
- LRT can handle curve radii down to 25 m as well as short, relative steep gradients up to 60 º/00
- due to an axle load of max. 10.000kg there exists just limited stress to viaducts and elevated sections of the permanent way
- power supply is via overhead wires, today mostly 600 - 750 V DC, in future with 1500 V DC
- Third rail power supply can be used for all our systems as well
- car bodies are up to 2.65m wide
- length of train is up to 75 m normally consisting of motor cars only
- automation of all functions of the single cars, door operation, illumination, fare collection & cancellation, aircondition is standard
- one-man-operation, for special sectors also driverless operation can be offered
- operating speed inside the city: > 30km/h, outside the cities > 50km/h
- stops close to potential passengers, in short distances where desired
- max. speed: 100-120 km/h
- acceleration 1.3m/s²
- braking deceleration 1.3m/s² in case of emergency 2.7m/s², considering one level crossings with roads
- fast change of passengers by high platforms or low floor cars
- stations/stops in close series, corresponding to the passenger volume, high convenience of the stops for passengers
- light weight cars
- articulated cars for the operation on narrow curves as well as to provide high capacity
- low number of traction motors, for normal topography only 65% drive adhesion, in hilly areas 100%
- 3 breaking systems, dynamic brake preferred
- dynamic brake with energy regeneration with the effect of up to 30% energy saving

- due to light construction and priority for electrical brake energy consumption only about 70 Wh/tkm
- all electric car design whenever possible
- capacity 180 to 250 pax per unit if we just count 5 standing pax per m^2

Siemens has been providing electrical traction since more than one century when in 1879 our founder, Werner von Siemens, introduced the world's first elctrical locomotive and in 1881 the first electrical tram. Till 1960 Siemens produced the electrical equipment for main line rolling stock, subways, suburban trains and tramways. Since 1960 LRT-systems were developed and built as an alternative to metros (in Germany). The oldest systems are Frankfurt/Main (since 1965) prototyp + forrunner for many systems in the new world and Hannover (since 1970). Today 50% of the 50 LRT-systems are so called "Stadtbahnen" meeting the LRT-standards. Between Cologne and Bonn as well as in Karlsruhe LRT trains even run 100 km/h. Since people want to ride from the suburbs or surrounding countryside to downtown of big cities without changing trains, the rolling stock was modified in order to get it run also on main lines. Into the city, however, it runs on the LRT-infrastructure most comfortable for the passengers.

Moreover, there is already automatic operation under the condition that LR vehicles are run on segregated ROW - for example in Düsseldorf - which was visited by a Korean delegation, organized by KOTI, earlier this year. In order to go to the center of the city on a metro infrastructure - e.g. Rotterdam - the Light rail vehicles have third rail current collections at the bogies in addition to the pantographs on the roof. Moreover, there are folding steps at the doors in order to skip the gap between platform and LRVs which have a width of only 2.65 m whereas metro - and main line rolling stock is wider normally.

Sometimes the demand for LRT-service on an existing rail infrastructure is that urgent that the operation should be provided even before the infrastructure for power supply is finished. In such cases there are also Light rail vehicles available with diesel motor traction and with a performance which allows the attractive LRT operation as well. These diesel-LRVs are built according to the LRV-standards, that means articulated cars with low floor entrances.

All this experience since 1965 resulted in a comprehensive documentation which defines - up to the technical detail - the status of technique and proven design. This documentation has been and still is the basis of specifications of new systems in many cities worldwide. This documentation is titled "VDV-recommendation". Currently it is going to be harmonized within the European Union and will thus apply to all European countries. In the VDV-documents LRVs of various levels of comfort are defined. They have been built a lot of times and are in operation in all climatic zones worldwide.

The can be built in steel, stainless steel or aluminium. Moreover, they can be equipped with all traction systems

switched resistor control
dc chopper control
AC propulsion

LRVs are operated with mono-motor-traction, bi-motor bogies and nowadays with decentralized traction per each wheel. Moreover, the customer can choose between normal nose suspension and air suspension.

For the passenger room forced ventilation or air condition can be provided. According to different platform levels there are different entrance solutions. There is trend towards low floor cars which, however, are more expensive. On the other hand the stations on surface become cheaper and can be more easily integrated in the whole city structure.

Siemens got a lot of worldwide references for a the whole variety of mass transit systems. Examples form Canada, USA, Mexico and Europe show LRT-systems, which have been under operation for more than 10 years and serve the public. Out of these systems we have got quite a lot of data about costs for investment, operation and maintenance. This includes the driverless system SIPEM (H-Bahn) as well which provides an average capacity of people mover and is under operation since several years without any problems in the city of Dortmund.

Let me show you some examples:

a) A few weeks ago the LRT-system of Denver/Colorado (phase1) was opened to the public. It runs on surface with up to now 11 LRV's. Overall costs have been just about 10 Mill US $ per km/double track.

b) A year ago the St. Louis LRT opened. It runs in former railway tunnels in the city centre and on surface or elevated ROW outside downtown. Ridership has developed better then forcasted; extensions will come.

c) Since more then 10 years San Diego's Trolley is in public service. At that time it was the cheapest system ever built with just 6 Mill US $ per km due to the fact that to a large amount former railway ROW was available. But in downtown it runs within pedestran malls

d) Similar is Calgary Alberta/Canadawhere in downtown a special transit mall has been installed for LRV's as well as for Dieselbuses.

e) If we come to Europe I have to mention Sheffield where Phase 1 + 2 are in operation now. They use high capacity cars with all axles powered due to the fact that gradients up to 9% are to be negotiated.

f) If I go now to my home country Germany: We have about 50 tram and LR systems in operations 50% of these are in an upgrading process to LRT standards. This standards are written down in the VDV-recomendations.

For installation of new sections or upgrading of former tram infrastructur as well for workshops and stations a Government funding is available to up to 80% of the total costs. The money comes mainly out of gasoline taxes. 20% is local money.
What does a new installation cost in average:

On surface	about 10 Mill US $ per km double track
On elevations	about 30 Mill US $
In tunnels	about 75 Mill US $

Power supply, stations, signalling is included in the mentioned figures.

The avarage ticket price (over all 50 systems) is about 1.5 US $ in the moment. It covers 65% of the operational costs. The missing money comes as a subsidy from local sources.

In order to summarize our experience I would like topoint out the most important details referring to the system decision to be made in Korea, first in Pusan/Kimhae and Hanam.:

- To realize the most economical system you have decide on a system that fits optimal to requirements of topography, density of population and housing, expected passenger volume in the beginning and in the end, expected comfort etc.. Therfore you shouldn't decide on a highly integrated, more or less fixed or standardized system, but on an open, flexible system which can easily and efficiently be adapted to the specific requirements. Siemens is able to provide the whole scope of mass transit systems, Siemens is free to offer the most suitable system.

- The increasingly most important problem is the financing of a system. This is on the one hand a problem of public budgets or private investment, on the other hand it is a subject of apporiate design of the system as well.

Usually you have smaller transport volume to handle in the beginning stage which will increase step by step. Therefore, an open system has to be realized which starts on a lower level handling the required volume, but can easily and step by step be upgraded through additional investment in the future. That means the total lifecycle costs of a system have to be taken into consideration.

- Against this background the consideration about manless or autmoatic or full-automatic systems has to be carefully analysed. At first glance it seems to be very attractive in order to reduce the operation costs by saving staff. According to the experience with realized automatic systems beyond psychological limitations to the passengers there are also a lot of additional costs. Especially the costs for maintenance are considerably higher compared to conventional systems. The main aspect, however, which should be focused on is the initial investment required. The investment for a automatic system is higher, a fact which is very important especially here in Korea if we consider the high interest-rates. Moreover, an open system can always be additionally equipped with the most modern technical innovations and their benefits.
  Therfore we recommend to start with a appropriate conventional system which can if the increased transport demand requires it, be upgraded up to a fully automatic system.
  Actually we handle such a kind of project in Bochum/Germany where we develop a conventional LRT-system up to a driverless system.

- Apart from very few mass transit systems i.e. in Hongkong, Singapur, Calgary and San Diego, there is no profitable public rail transportation system worldwide. Taking the increasing difficulties of public financing of construction and operation into account as well as the demand for private investment the investor and operator has to design the total system beyond the transportation itself. Additional business opportunities as rent of land, officies, department stores and so on have be included from the beginning stage on.

- The design, construction, commishioning and operation of a public mass transportation system itself is a very complex task with a lot of interdependent subsystems and relations.
  Therefore, the thinking in different subsystems (rolling stock, signalling, maintenance, financing for example) as it may have been possible in the past-has gone. Siemens with his long-standing engineering experience,

technical expertise and sophisticated organization is able to complete complex projects and became one of the world's leading turnkey specialists. A list of intemational references for mass transit systems prove this.
Remember, I mentioned earlier Tunis, Guad., Montery, Konja and others.

I can assure you that Siemens is prepared to support Korean authorities, institutes and companies realizing that new kind of systems in order to contribute to the solution of today's and future's traffic problems by providing well experienced and innovative technologies. Siemens is ready for a close cooperation with the local industry and the transfer of technology in order to enhance the longterm local capabilities.

I would like to thank you for your attention in this presentation. For further questions, discussion, additional information I invite you to visit our exhibition room. Moreover, please don't hesitate to contact Siemens Transportation Group in Germany or directly our local office in Seoul.

ANSALDO
Trasporti

International Conference on the New Transit System and System Presentations

日 字 1994년 10월 25일(화)~26일(수)
場 所 부산 웨스틴 조선비치호텔

COMPANY PROFILE

THE COMPANY

Ansaldo Trasporti, alongside Ansaldo Industria and Ansaldo Energia, is an Ansaldo company Finmeccanica Iri Group, one of the world's leading electromechanical engineering groups. Ansaldo Trasporti designs and builds electric railway and urban transit systems, automation and signalling systems for railway and metropolitan networks and light and heavy locomotives. It also produces power supply installations for transportation networks and power semiconductors. The Company operates as a main contractor, project manager or systems engineer, and is a world leader in the production of signalling and automation systems. Ansaldo Trasporti invests considerable resources in research activities to meet the increasing demand for faster and better passenger and goods services in Italy and world-wide. One of the projects in which Ansaldo Trasporti is currently involved is Italy's "high-speed railway system". It is also the licensed operator and supplier of subsystems for most of the 33 regional railways at present undergoing modernization. Ansaldo Trasporti has 26 operating centres and 13 production units, with four in Italy, three in the rest of Europe and six throughout the rest of the world. It has a workforce of over 4,000. Ansaldo Trasporti subsidiaries include Transystem and Segnalamento Ferroviario in Italy, Union Switch & Signal Inc. in the USA, At Signalling in Ireland and At Signal System in Sweden. Cooperation agreements backed by substantial shareholdings have been signed with major industrial concerns such as Csee Transport (France's leading railway signalling company), E. Marelli Trazione and the other Firema companies in Italy. The Company's activities are closely linked to those of Ganz Ansaldo in Budapest, which manufactures components for vehicles and installations, electric traction systems and components for signalling equipment. Ansaldo Trasporti's system engineering skills are concentrated in its subsidiary Transystem, responsible for the study, planning and conceptual design of urban, metropolitan, regional and national transportation systems.

SYSTEMS

The Systems business unit builds complete railway, urban and suburban transit systems.
Numerous study and design projects have been completed or are underway in areas where increased passenger and goods mobility has led to growing demand for mass transit systems both in terms of quantity and quality. High-speed, long-distance railways, suburban transportation systems and metropolitan heavy and light railways are just some of the answers to a constantly evolving society. In Italy the Systems business unit is involved in the modernization and upgrading of regional railway systems to meet new transport requirements. It is also supplying vehicles and installations and coordinating technological and engineering activities for the entire system. The business unit has worked on the metropolitan railways in Rome, Naples and Milan. It is also the licensed operator for the metropolitan light railways in Genoa and Naples, and is therefore responsible for full turnkey supply, from civil works to in-service support. On the international scene, Ansaldo prepared the general transportation system project for Alexandria, Egypt, performed detailed signalling system planning work for the El Gourzi/El Kroub and Ramdane/Costantine railways in Algeria, the Klong 19 railways in Thailand, and the systems engineering and technological installations for the Lima metropolitan heavy metro. Recently Ansaldo Trasporti has been awarded a turn-key contract for the Midland Metro Line 1.

VEHICLES AND POWER SUPPLY

The Vehicles and Power Supply business unit designs and builds high and medium power locomotives with revolutionary electronic drives and ac and dc power supply systems. Collaboration with Firema Group companies provides additional capability in this sector and has made it possible to supply entire traction units. Over 450 locomotives and electric motor cars have been built over the last decade. Vehicles with Ansaldo Trasporti electronic drives are now in service in metropolitan transport systems in cities in Italy and across the globe. The introduction of power and control electronics into traction technology has created more efficient and reliable locomotives and urban transit vehicles. It has also simplified management and maintenance and helped in the campaign to save energy. The E 402 is the fastest and most powerful universal locomotive currently in operation on the Italian railway network and one of the most powerful in the world. Its special inverter drive with 4 asynchronous motors makes it suitable for use in pulling both heavy goods trains and high-speed passenger trains. The Etr 500 is the train that Italy will be operating on Europe's high-speed systems. Ansaldo Trasporti made particularly important contributions to the multi-voltage Etr 500's electronic drive and to "Socrate", its on-board automation-diagnostics-communications systems. Socrate turns the train into an intelligent system. Over the last decade, Ansaldo Trasporti has installed a total of 1,500 MW of power supply systems for ac and dc urban transit and railway networks in Italy and overseas.

SIGNALLING-AUTOMATION

Ansaldo Trasporti introduced solid state technology into its railway signalling safety equipment in the early '70s. Since then the company has developed its own avantgarde technology and has built up a considerable experience in the sector. A consolidated position worldwide and contributions from Union Switch & Signal (USA), Csee Transport (France) and At Signal System (Sweden), ensure that the Company can satisfy any and all requirements. Today, Ansaldo Trasporti is a world leader in the production of signalling and automation systems for railway networks, metropolitan railways and switchyards and on-board automation systems. The Omaha traffic control centre in Nebraska, USA, was built to control over 19,000 miles of track: the system can handle up to 1,500 trains a day, and also provides crew management functions. Of particular importance from both a technological and a practical point of view is the centralized traffic control system on the Rome to Florence line, Italy's first high-speed system, where speeds of up to 250 km/h are reached.

Maggaly, the first metropolitan heavy railway automation system providing unmanned train operation. is now in service at Lyon, in France. All system functions are controlled from a single, central control room.
Extensive research and design work in solving railway traffic problems has led to breakthroughs in automatic interlock system, relay and computer equipment, on-board automation and automation of metropolitan and railway traffic, remote control electrification. In recent years, the Signalling-Automation business unit has installed signalling systems on railway and metropolitan networks in 20 countries from the Usa, to Indonesia, in addition to its work on Italian rail transport systems.

SPECIAL PROJECTS

Ansaldo Trasporti is heavily involved in three special, long-running projects of national importance, which will keep it busy up to 2000:

A. High Speed Program.
B. Rolling Stock Modemization
C. Innovative Light Rail Transit System.

A. High Speed Program.
The Italian High Speed Program is implemented through Consortia in which Ansaldo Trasporti plays a significant role:

- Trevi Consortium, encharged with the design and manufacture of the High Speed Train (Etr 500). This Consortium has recently been awarded an Italian State Railways contract for 100 Etr 500 trains, each composed of 2 x 4,4 MW locomotives and 10 coaches.
- Saturno Consortium, encharged with the design, manufacture and installation of signalling, automation, catenary, electrical substations and telecommunications for the whole Italian High Speed Network.
- Iricav - 1 Consortium, encharged with the civil works and permanent way of the Rome/Naples high speed line section (226 Km).
- Iricav - 2 Consortium, encharged with the civil works and permanent way of the Verona/Venice high speed line section (111 Km).

B. Main Line Rolling Stock Modemization.
The Italian Rolling stock Modernization Program (1992/1999) will be implemented by Italian State Railways (FS) in cooperation with the Capri Consortium, encharged with the design, manufacture and testing of 6 and 4 MW Locomotives. Ansaldo Trasporti is the main contractor for the 6 MW Gto/Inverter, watercooled locomotive, considered the most innovative and important part of the whole program.

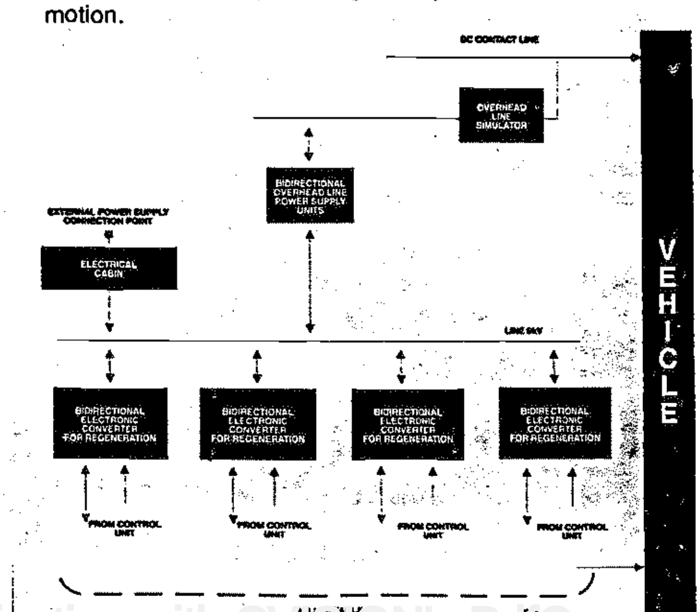
C. Innovative Light Rail Transit Systems.
Ansaldo Trasporti is now at an advanced stage in the research program aimed at developing an "innovative railbased urban transportation system" which can be described as an "Automatic Metropolitan Light Railway". The overall aim of this program is to develop and automatic, integrated transportation system with an optimized capacity of 5,000 - 22,000 passengers per hour in each direction. A test track designed to reproduce normal operating conditions and test equipment at limit operating conditions is at an advanced stage of completion. A section of the line with sharp curves and steep gradients has also been successfully simulated. The test facility also comprises a station, an automatic railway depot and an automatic/manual transition zone, sized using authentic operating criteria. The test track may be used in the future for experiments on systems, subsystems and/or components for light railways.

THE RAILWAY VEHICLE TEST FACILITY

The facility is used to qualify the electrical equipment of heavy and light railway vehicles by reproducing power supply and load conditions as close to actual ones as possible. It uses rational infrastructures to carry out all tests required to guarantee vehicle for the vehicle performance. The test facility is designed to reproduce both normal operating condition (simulation of a section of railway line) and exceptional situation (such as the wheelslip and wheelslide). The vehicle under test is installed on a roller table equipped with special driven axles to act as inertia simulator. This enables the vehicle to be subjected to maximum effort and speeds conditions. A comprehensive control unit implements system command logic, acquires data for supervision and diagnostics and logs all electrical and mechanical values to be measured during testing.

FUNCTIONAL BLOCK DESCRIPTION

The facility's power supply section delivers a wide range of voltages to enable different types of vehicle to be tested including heavy locomotive and metro railway vehicles and tram cars. Components are also provided to simulate the overhead line and voltage profiles present of all main railway supply systems. The mechanical energy at the vehicle axle is returned to the main power supply after conversion using rotary electrical machines and bidirectional electronic converter. The energy set applies a torque with the correct amplitude and sign to reproduce resistance related to the section of the line (gradients for example) and resistance due to the mass of vehicle itself aerodynamic resistance etc. as closely as possible opposite torque is regulated by a central processing unit. Train composition (number and type of carriages) and planimetric and altimetric characteristics (gradients, curves, tunnels, etc.) for the section can be modified under software control. The control unit therefore acts as an inertia simulator reproducing the dynamics of the train in motion.



ELECTRICAL AND MECHANICAL CHARACTERISTICS

The limit characteristics for vehicles which can be tested in the test facility are given below.

• Max. weight of vehicle on rollers		120	t
• Wheel diameter		500 ÷ 1400	mm
• Max. traction effort per axle: with 1250 mm rollers to a maximum speed of 250 km/h		100	kN
with 1500 mm rollers to a maximum speed of 300 km/h		83	kN
• Maximum speed		300	km/h
• Gauge range		600 ÷ 1700	mm
• Bogie wheel base		400 ÷ 3500	mm
• Distance between bogies		5400 ÷ 22000	mm
• Max. vehicle length		30	m
• Max continuos power of axle		1500	kW
Mass per axle			
• Vmax	250 ÷ 300 km/h	22	t
• Vmax	140 ÷ 250 km/h	25	t
• Vmax	up to 140 km/h	30	t
Nominal line voltage		750 ÷ 3000	V

AUTOMATION SYSTEM

The facility's automation system comprises a control and computing unit with 4 main sub systems:
- Host computer
- Basic system
- Communication system
- Data acquisition system

Host computer
The main functions of the host computer are equipment control, supervision and diagnostics. It also manages the data acquisition system

Basic automation system
The basic automation system is divided into sub-systems which manage the various sections of the facility, and is made up a series of programmable controllers.

Communication system
The communication system manages communications between the host computer, the basic automation system and the various basic automations sub-system.

Data acquisition system
This system is used to acquire signals from the vehicle under test which are not processed by the basic automation system but may be considered significant in particular situation. The acquisition system can detect 400 signals incoming from the vehicle, including:
- High voltage/high frequency signals
- High frequency signals
- Low frequency signals
- Digital signals
- Temperature reading

OPERATIONAL TESTS FOR RAILWAY VEHICLES

The facility can simulate all aspects of a railway vehicle behaviour on the line. The following sets of tests are provided:
- Performance tests
- Dynamic behaviour tests, including:
  loss of adhesion simulations;
  operation with line voltage transients;
  vehicle behaviour when protection devices are triggered;
- Mechanical and thermal tests
- Measurement of the harmonic content of the line current
- Endurance tests.

Performance tests include:

Start-up test
Vehicle start-up is simulated in a wide range of electrical (power supply voltage, line current limitation, neutral sections, overvoltages, ect.)

Braking
The vehicle under test is braked from gradually increasing speeds. Vehicle braking is electric down to a given speed when mechanical braking takes over. Braking can be rheostatic, with energy regeneration, mechanical or mixed.

Loss of adhesion tests include:

Wheelslip
Wheelslip occurs when the traction effort applied to the wheels exceeds the maximum transmittable effort given istantaneous wheel-rail traction conditions determined by weight per axle (and any correction factor) and speed. Simulation of wheelslip (to verify vehicle behavior when they occur) is achieved by the controlled reduction of the resistive torque of one axle, so causing its speed to increase with respect to the other axles. By controlling the resistive torque applied to the axle as a function of the difference in speed between the skidding axle and the other axles, the test facility can reproduce adhesion factor variations as a function of wheelslip speed.

Wheelslide
Wheelslide occurs when the braking effort applied to the wheel is higher than the maximum force that can be transmitted to the truck. This phenomenon is simulated by reducing the torque applied to the roller during vehicle braking as for wheelslip simulation.

The number of electrical, thermal and mechanical values to acquire using the data acquisition system are set for each test. The set of test provided and other additional tests dependind on the vehicle in question make rapid qualification of innovative railway vehicles possible.

OPERATING CONDITIONS

The inertia simulator controls its rotary motor/generators to generate a opposite torque to reproduce all permanent (traction, braking, ect) and exceptional (wheelslip or wheelslide) train operating conditions.

- **Traction**

The facility's rotary electrical machine impedes the acceleration of the traction motor according to the dynamics of the complete train on the simulated line. It therefore applies opposite torque and acts as a generator, regenerating energy which is delivered to the main supply bus bar.

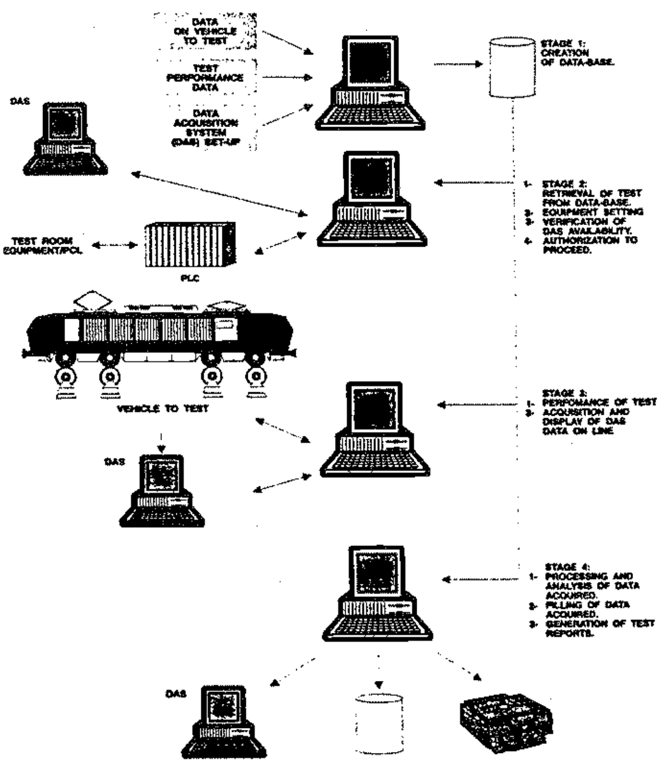
- **Braking**

The facility's rotary electrical machine impedes the deceleration of the traction motor according to the dynamics of the complete train on the simulated line. It therefore applies tracing torque to the axle, absorbing power from the main power supply bus bar.

• Wheelslip

The facility's rotary electrical machine reproduces a rapid reduction of an axle's opposite torque, with a consequent increase in the speed of this axle with respect to the other axles.

TEST PERFORMANCE METHOD



THE MASS TRANSIT SYSTEMS

During the 1980's there has been a rapid increase in the planning and building of new urban passenger transit systems. To meet the requirements of this market Ansaldo Trasporti has developed a modular range of equipment and sub-systems that can be applied to provide urban transport solutions throughout the world.

The systems being planned range from heavy semi-automatic metros with passenger flows upto 46000 per hour to automatic light rail people mover systems for between 7000 and 15000 passengers per hour. By adopting a modular design concept Ansaldo Trasporti can supply either complete systems on a turnkey basis or subsystems for all market requirements whilst retaining the confidence and reliability associated with standard equipment supplied in accordance with UNIFER standards. Ansaldo Trasporti is the leading supplier of urban transport systems and equipment in Italy and in the world.

The system building blocks can be defined as:

Automation and Control;
Power Supply;
Vehicles;
Communications and Surveillance;
Integrated Station Equipments;
Integrated Control Centres;
Stations and Civil Works;
Depots, Workshops and Service Vehicles;
Fare Collection.

And these building blocks, used in conjuction with Ansaldo Trasporti's Project Management, Project Engineering, Financial Control and other resources are the basis of their rapidly growing business in turnkey transit systems.

The provision of a system, engineered to operate with low running costs and low staffing requirements is not the total commitment. The company will provide training for operators staff, and an after sales service to provide assistance during system operation.

Ansaldo Trasporti is the concessionaire for Genoa metro and Naples LRT and supplies vehicles and plants for the heavy metros in Naples, Rome, Milan, Lima and many cities in the USA. Midland Metro Line 1 in Birmingham

There are many elements which lead us to intervene and to choose the best transport system to meet the customers' specific requirements of mobility.

A close interdipendence exists between territorial variables (population, social classes, the use of the soil, activities and infrastructures) and the transport system in which we are about to intervene.

The analysis of the relationships between the significant variables to forecast and estimate the features of the transport system to meet the customer's needs requires the use of resources and high-skilled know-how.

Ansaldo Trasporti, thanks to Transystem, is gifted with its own operative facilities concerning exclusively transport engineering:

studies on feasible interventions in transport infrastructures;
analysis of costs and profits;
transport plans;
traffic and mobility plans;
studies on transport demand and construction of demand scenaries;
studies to optimize the management of transport systems.

Some studies on the planning of transport systems carried out by Ansaldo Trasporti.

Object	Customer
General Plan of Transport, railway Tansport and local transport.	Ministery of Public Transport. General Secretary of the General Plan of Transport
Regional Transport Plans	The Veneto, Campania and Apulia Region
City Transport Plans	Municipality of Alexandria (Egypt), Genoa, Naples
Studies on the feasibility of the light underground railway of Brescia	Municipality Service Company
Study on the feasibility of the light rail transit system of Milan-S. Siro	Milan Municipality
Proposal of requalification of the FS urban railway section of Naples	Italian State railways
Study on low traffic FS-network railway lines	Ministery of Public Transport. General Secretary of the General Plan of Trasport
Building plan of Klong 19 Kaend Khai railway in Thailand	State railways of Thai
Study on the feasibility and preliminary plan of the railway junction of Maputo	Southern African Transport and Communication Commission
Feasibility study for teh restructuring of the railways Rome-Fiuggi and Rome-Viterbo	Public Transport Consortium of Lazio Region

ANSALDO
Trasporti

APPROACH TO MASS TRANSIT SYSTEMS

TECHNOLOGY

Automation and control

- Automatic driving
- Automatic Train Protection
- Automatic traffic regulation
- Data trasmission
- Automatic train dispatch from depot
- Automatic train reversal
- Centralized traffic and power supply control
- Platform route indication
- Optimisation of maintenance costs

Integrated control centres

Integrated station equipment

Stations and civil works

- Public Address System
- Train information
- Mobile Radio
- Telephone System

Power supply

Vehicles

- Depot workshops and service vehicles

Communications and surveillance(CCTV)

Fare collection

FINANCE

Feasibility Study

- Foundamental condition
- Tracks and Routes
- Trains
- Power supply
- Signalling
- Operation Schedule/period
- Passengers
- Fare structure
- ROI Return or Investment
- IRR Internal ratio of Return

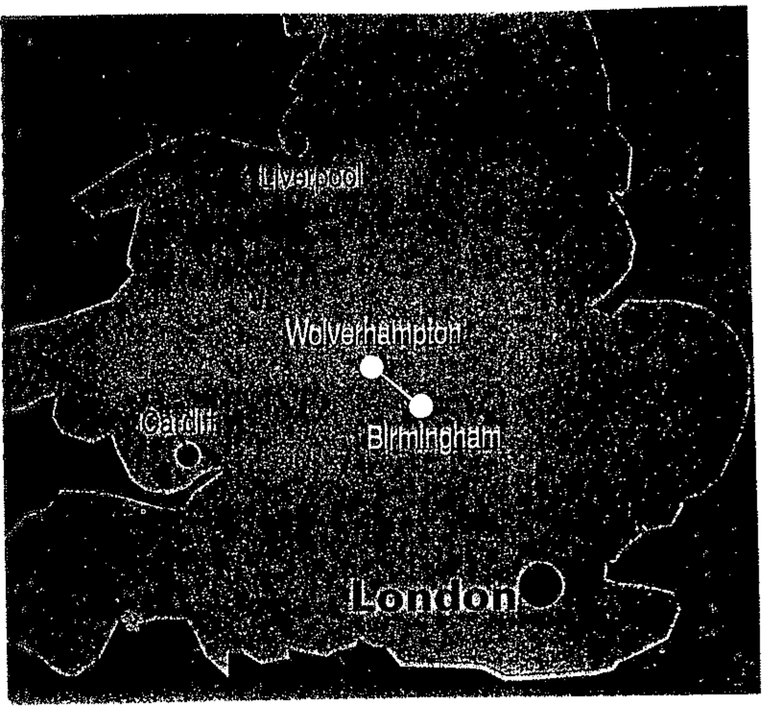
Project Financing

- Financing sources
- Financing Grants
- Patronage
- Loan amount
- Loan period

Operating management

- BOT Build Operate & Transfer
- SOC Social Over head Capital

THE LIGHT RAIL MIDLAND METRO LINE 1

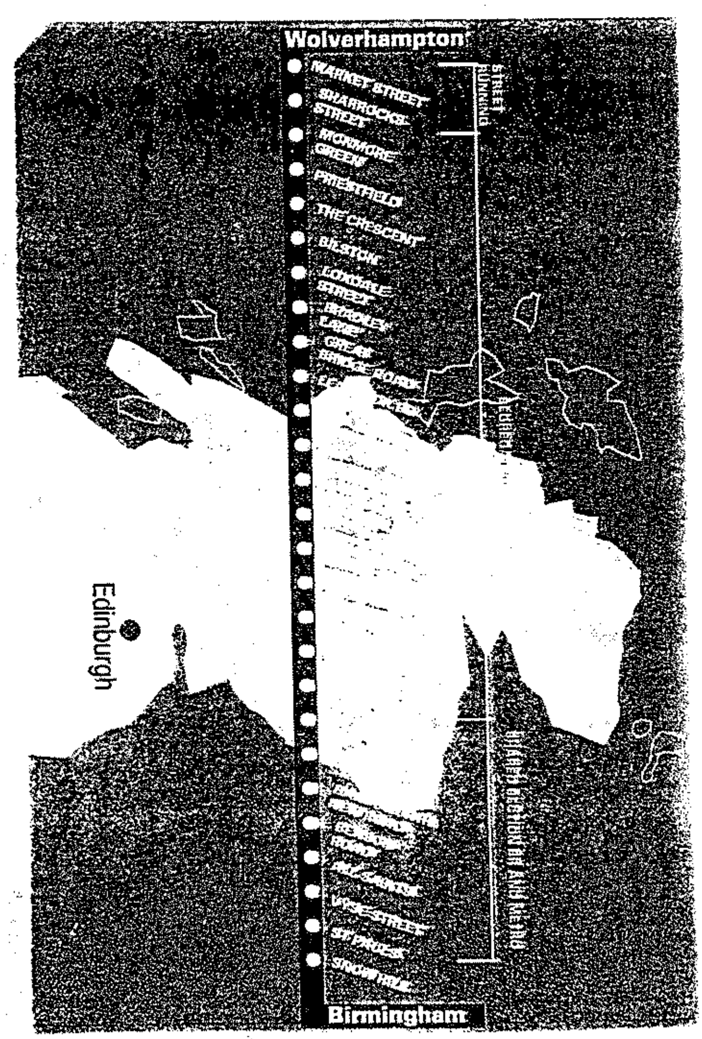


Ansaldo Trasporti, in consortium with Laing Civil Engineering will design, build, operate and maintain the Midland Metro Line 1 over a period of 23 years.
The concession is of the Build, Operate and Transfer type (B.O.T.), where considerable risk is transferred to the constructor.
The line runs from Snow Hill station in Birmingham to Bilston Street station in Wolverhampton.
Midland Metro Line 1 will be the first light rail system in the Midlands region.
Birmingham, the second largest UK city, is situated in the center of the major manufacturing area.

Midland Metro Line 1 is a pilot project in that its innovative features are of great significance with private-sector investment and transfer of risk to the private-sector.

Firstly, the constructor receives a significant part of its revenues from operating profits, which are tied to operating efficiency, reliability of rolling stock and wayside installations, and the quality of service. The roles of constructor and operator merge in a rational and cost-effective investment scenario in which the performance of both the constructor and, crucially, the operator (quality of service) can be optimized.

Secondly the cost of the service must be economical for the user, in order to attract passengers from the existing forms of transport such as buses and private cars.



Birmingham's line 1, in fact, will not be operating in a monopoly situation and therefore must be competitive in free market conditions. The third feature therefore is that after decades in which cars have taken more and more trade away from trains, we now have a rail transportation project designed to turn this trend around. To do this it envisages the use of existing network and new surface track, which means huge saving in the cost of civil works (from 80% for underground line to the 50% of the Birmingham line), the traditional drawback of collective transportation.

Line 1 of the metro will run above ground and be approximately 20 km of double track, 18 will be a segregated sector and use an abandoned railway line. The remaining 2 km will be street running and a new traffic light system will give precedence to the rail vehicles at the cross street junctions.

The civil works include the building of new bridges and strengthening of existing ones, the construction of an Operations and Maintenance center which also includes the control center and the construction of 27 passenger stations (23 first phase). The station platforms will be 30 meters long, and they only need to be 30 cm high to allow passenger to board the low floor vehicle without a step.

There will be a quantity of 15 specially designed low floor vehicles, these will be driver operated. Capable of 70 kph, each will be 24 meters long and carry up 160 passengers with 58 seated.
The ride will be smooth and safe with low vibration and noise levels.

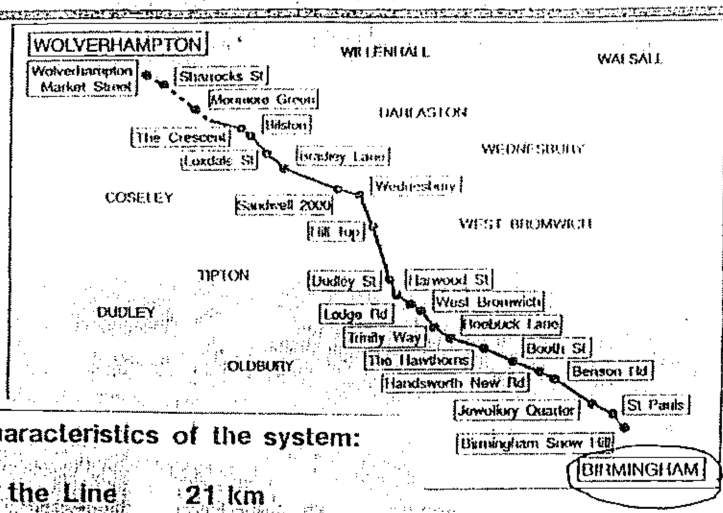
The electric power will be supplied at 750 V to the vehicles by an overhead contact line 5.6 meters above the track. There will be 6 power distribution substations and one for the depot which are connected with the Supervisory and Data Acquisition System.

There will be a centralized communications system providing information to passengers both at the stations and on-board the vehicles.

The metro will operate between 07.00 hrs to 19.00 with a 6 minute service frequency, and 10 minutes at other times, the commercial speed will be 32 kph.

There will be closed circuit security television at all stops, together with passenger alarm unit. All stops will be landscaped, and accessible by mobility impaired people.

Midland Metro Line 1



Technical Characteristics of the system:

- Length of the Line — 21 km
- Quantity of Stops — 23
- Passenger Capacity — 8,000 per hr per direction
- Power Supply System — 7 substations and overhead contact wire
- Signalling System — vehicle on-board control of points, train location, train stop at termini, cab signal
- Comprehensive Telecommunications System
- Centralized Control Post and Depot/Workshop

Low Floor Light Rail Vehicle type T69 for Midland Metro

The low floor articulated Light Rail Vehicle type T69 is especially designed for Midland Metro, so to meet the high standards of design quality expected by the West Midlands Passenger Transport Executive (CENTRO).
The LRV T69 is bidirectional, with a driver cab at both ends, and consists of two aluminium alloy carbodies connected via one articulated section.
The two outer bogies are motored; the inner bogie is trailer and incorporates independent rotating wheels, in order to permit low floor throughout the central part of the vehicle, between the motored bogies. The low floor section extends for approximately 60% of LRV length.
Motor and trailer bogies have steel welded frames, resilient wheels, primary suspension with rubber springs and secondary suspension with air springs. The motor bogies have a brake disc per axle; the trailer bogie a brake disc per each wheel. The traction motor is longitudinally arranged in the bogie and is fully suspended. The gear boxes incorporate a pair of hypoidal bevel gears. Each gear box drives a wheelset by means of a quill drive.
Three wide passenger doors per side are provided. They are conveniently distributed along the low level floor portion of the vehicle. The doors are of swing-plug design and are electrically driven. Two positions for wheelchair are provided adjacent to the door areas. Access by wheelchair to these positions is possible from any passenger door. Floor height at the boarding sills is only 335 mm.
The high floor areas, where the seats are arranged so to face the glass cab partition, are given a character of more relaxing 'first class' observation compartments.
All seats are upholstered. The passenger saloon has wide windows provided with hopper-type opening section. The interior lighting, with fluorescent lamps, is in two strips of modular ceiling fittings, which run the length of the vehicle. Heating and ventilation systems are provided, both in the passenger saloon and the driver cabs.
A public address system provides station announcements and other messages from the driver and the central operator.

The traction equipment features microprocessor controlled DC choppers utilizing gate-turn-off (GTO) thyristors. The cooling of the semiconductors is obtained by natural ventilation. The traction equipment is divided into two identical and separate drives, accommodated in containers on the roof of the two carbodies, thus consenting the mobility of the vehicle in the event of fault of one drive. Each chopper feeds a DC series excitation, 4 poles, self cooled and lamellar type frame, traction motor.
Current collection from the overhead line is via a single arm pantograph electrically driven. An appropriate filter protects the signalling and the telecommunication systems from electromagnetic noises.
A static converter and a storage battery provide the energy for the auxiliary equipment.
Service braking is electrodynamic (re-generative and/or rheostatic type) assisted at low speed, if necessary, by a friction brake of electro-hydraulic type. Track brakes are foreseen for emergency braking.
The LRV is designed so to accommodate automatic couplers, if required for multiple operation, the coupler being hidden behind the front skirts when not in use.

Technical Characteristics

Wheel arrangement	B+2+B
Track gauge	1435 mm
Total length	24240 mm
Total width	2650 mm
Maximum height with pantograph in its housed position	3675 mm
Minimum height of contact wire	3865 mm
Bogie centres	7750 mm
Bogies wheelbase	1800 mm
Wheel diameter (new)	680 mm

Floor height		Passengers: seated	58
• at the boarding sills	335 mm	standing (4/m²)	102
• in the low floor areas	350 mm	Min. horizontal curve radius	25 m
• in the articulation	370 mm	Min. vertical curve radius	250 m
• in the high floor areas	850 mm	Maximum gradient	62.5 ‰
Headroom		Line voltage	750 Vdc
• in the high floor areas	2100 mm	Auxiliary voltage	24 Vdc
• in the low floor areas	2400 mm	Total continuous power	420 kW
Door opening width	1250 mm	Maximum speed	75 km/h
Tare weight	34000 kg	Acceleration	1 m/s^2
Gross weight	44500 kg	Service deceleration	1 m/s^2
		Emergency deceleration	2.5 m/s^2

LA LINEA 1 DELLA METROPOLITANA LEGGERA DEL MIDLAND
THE LIGHT RAIL MIDLAND METRO LINE 1

Ansaldo Trasporti e Laing Civil Engineering sono concessionari dell'opera	Ansaldo Trasporti and Laing Civil Engineering have been awarded a concession contract

CARATTERISTICHE PRINCIPALI DEL SISTEMA
SYSTEM MAIN DATA

Capacità di trasporto Transport capacity	8000 pass/h per senso di marcia 8000 pphpd (1450 first phase)	Pendenza massima Maximum slope	62.5 ‰
Cadenza minima dei convogli Minimun headway	2.5 min.	Lunghezza banchina Platform length	60 m (30 m first phase)
Lunghezza linea Length of the line	20136 m	Raggio minimo di curvatura Min. curve radius	100 m
Stazioni Stations	27 (23 first phase)	Velocità commerciale Commercial speed	32 km/h

SISTEMA DI ALIMENTAZIONE
POWER SUPPLY SYSTEM

N. sottostazioni Substations N°	tensione secondaria catenary voltage (V)	potenza rating (kW)	alimentatori feeders N°
6+1 (depot)	750c.c. - d.c.	2x750+5x1500	24

APPARATI CENTRALI ELETTRICI DI STAZIONE
ALL RELAY INTERLOCKINGS

N. apparati Sets N°	manovre di scambio switch machines	controlli degli scambi local swith control	passaggio a livello automatico automatic level crossing
3+1 (depot)	22+15 (depot)	11	1

TELEOPERAZIONI - TELECOMANDO ELETTRIFICAZIONE
REMOTE CONTROL SYSTEMS

Km Km	posti centrali central locations	posti periferici remote locations	n. comandi controls N°	n. controlli indications N°	n.misure measures N°
2x21	1	6	300	1200	300

CONTROLLO CENTRALIZZATO DEL TRAFFICO
TRAFFIC CONTROL WITH TRAIN DESCRIBER (INTERMITTENT TYPE)

N. stazioni Stations N°	n. convogli controllati controlled trains N°	cadenzamento minimo minimum headway
27	30 (max.)	150"

APPARATO ELETTRONICO DI BORDO
ON BOARD SWITCH CONTROL

Convogli equipaggiati Equipped trains N°	frenatura a bersaglio automatic train stop
15x2	•

VEICOLI
VEHICLES

Unità Units	controllo control	frenatura elettrica electric braking	interruttore extrarapido high speed circuit breaker
15	Chopper a GTO raffreddato al flourinert GTO chopper flourinert cooled	recupero + reostatica regenerative + rheostatic	bidirezionale bidirectional

THE LIGHT RAIL TRANSIT SYSTEM OF GENOA

In June 1990, the first stretch of the Genoa light rail transit system entered into operation. Three kilometres of the line connect the Brin station to the station of Dinegro, from the Val Polcevera to the coast in a rapid and comfortable manner.
Thus Genoa became the third city after Rome and Milan to boast a rail mass transit system.
The stretch Brin-Dinegro is part of the line from Rivarolo to Brignole, entrusted to Ansaldo Trasporti, and covering a distance of 8 km with 11 stations.
Its layout connects the axes of the city and it helps to link Val Polcevera, from Val Bisagno and Sampierdarena to the centre.
Connections with the railway system are planned at Rivarolo, Principe, Brignole and Sampierdarena.
This mass transit system features both elevated and underground stretches and was conceived to innovative criteria.
The adoption of reduced-size rolling stock allowed the re-usage of numerous existing installations and the construction of smaller elevated sections and stations with platforms of less length.
Thanks to the high level of automation on the trains and the fixed installations, the system has a high transport capability, with reduced operating costs and a small number of employees.
Planning has been based on assembly-line products and fully-modular stations, for which a «Component catalogue» has been drawn up. In this way, the system will attain maximum safety and longevity.

Work in progress

Work is underway (may '93) on the Principe-Caricamento section of the underground.
An "EPB" Earth Pressure Balanced type shield cutter has been lowered into the Principe Shaft. This machine is of proven reliability (equipment of the same type has been used for the Channel Tunnel and many others in Japan and Europe) and perfectly suited to the delicate work involved in this section. The need to work at up to 15 m below sea-level (with infiltrations of water and pressures of up to 1/1.5 bar), combined with the heterogeneous ground and geotechnical conditions, make specialized and reliable equipment an essential.
When the shield cutter reaches Caricamento, so completing the first tunnel, it will be removed by way of a shaft sunk to the east of Palazzo S. Giorgio and taken back to the Principe Shaft to begin the second tunnel (further inland).
In the meantime, the 25 m deep seawalls for Darsena station have already been completed.

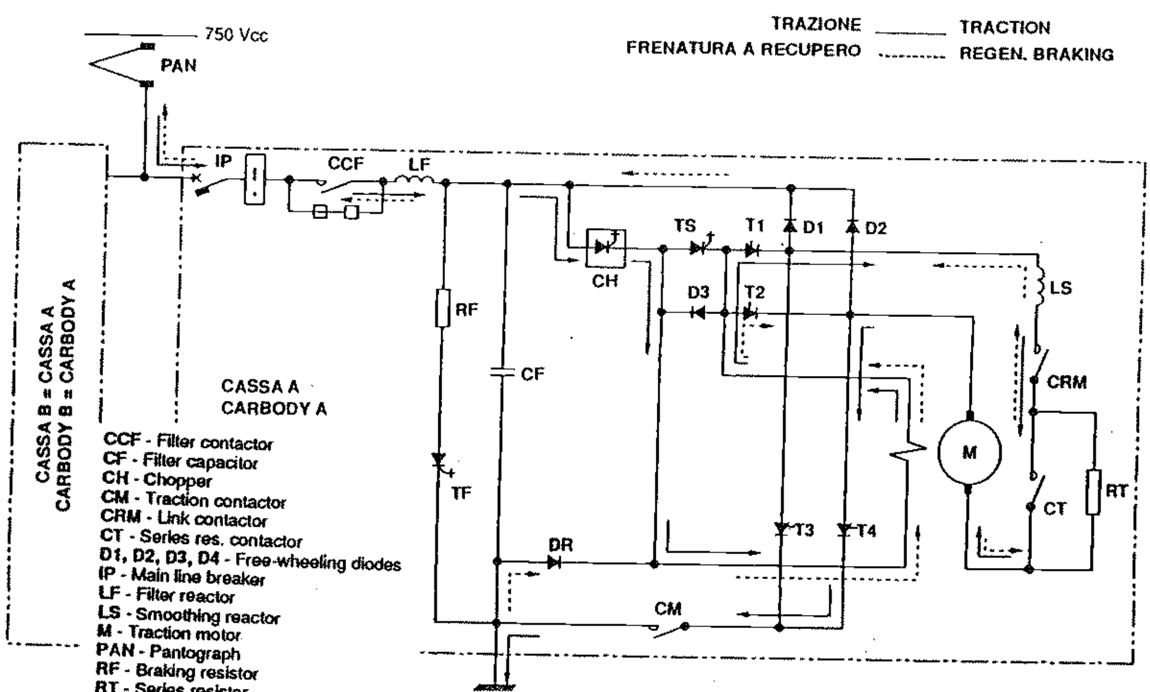
LRV GENOA 2nd GENERATION

The traction unit of Genoa metro is a bidirectional vehicle, two bodies, three trucks, articulated type. The two end trucks are motorized. The trains are able to travel coupled in multiples of three by means of automatic head integral connectors. Each traction unit has two independent chopper equipments, every of them feeds a series excitation, 4 poles, self cooled and lamellar type frame, traction motor. The chopper is the automatic switching GTO type, the semiconductor are entirely immersed in a refrigerating fluid contained in a sealed stainless steel tank. The cooling of the semi-conductors is obtained through changing-of-state techniques natural ventilation. Each chopper is microprocessor contolled guaranteeing a high level of reliability. The whole unit is underframe mounted. The ATO and ATP devices for automatic train drive and protection are installed on board.

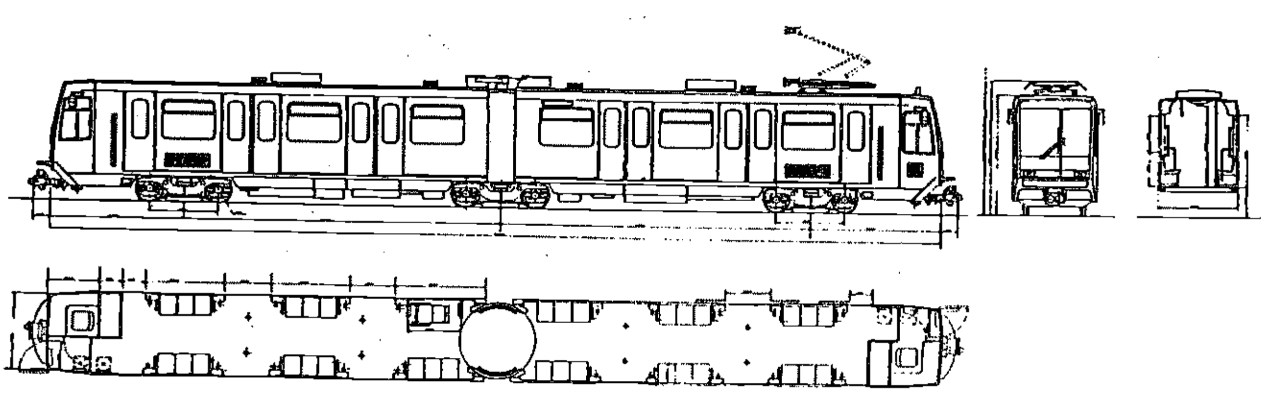
TECHNICAL CHARACTERISTICS

Power supply	750 Vdc, overhead line
Gauge	1435 mm
Trainset arrangement	2 articulated carbodies
Wheel arrangement	B - 2 - B
Length	23600
Width	2200 mm
Floor height from top of rail	850 mm
Empty weight	34000 Kg
Full load weight	47600 Kg
Seats	35
Passengers capacity	213
Continuous power	370 kW
Maximum speed	75 Km/h
Service acceleration	1m/s²
Service deceleration	1 m/s²
Control equipment	1 microprocessor controlled GTO chopper for each motor

SCHEMA DI POTENZA - POWER SCHEME



CCF - Filter contactor
CF - Filter capacitor
CH - Chopper
CM - Traction contactor
CRM - Link contactor
CT - Series res. contactor
D1, D2, D3, D4 - Free-wheeling diodes
IP - Main line breaker
LF - Filter reactor
LS - Smoothing reactor
M - Traction motor
PAN - Pantograph
RF - Braking resistor
RT - Series resistor
T1, T2, T3, T4 - Pricipal thyristors
TF - Braking thyristor
TS - Shunt thyristor



LA METROPOLITANA DI GENOVA
THE LIGHT RAIL TRANSIT SYSTEM OF GENOA

Ansaldo Trasporti è concessionaria dell'opera.

Ansaldo Trasporti has been awarded a turn key contract

CARATTERISTICHE PRINCIPALI DEL SISTEMA
SYSTEM MAIN DATA

Capacità di trasporto Transport capacity	25000 pass/h per senso di marcia in each direction
Cadenza minima dei convogli Minimum Headway	90"
Lunghezza linea Length of the line	7933 m
Stazioni Stations	11
Pendenza massima Maximum slope	56‰
Lunghezza banchina Platform length	80 m
Raggio minimo di curvatura Min. curve radius	20 m
Velocità commerciale Commercial speed	32 km/h 75 Km/h max chopper GTO 80 Km/h max inverter IGTB

SISTEMA DI ALIMENTAZIONE
POWER SUPPLY SYSTEM

n. sottostazioni *substations No*	tensione secondaria *catenary voltage (V)*	poenza *rating (kW)*	alimentatori *feeders No*
3 + 1 (deposito) (depot)	750 c.c.-d.c.	3 × 3 × 1500 + (1 × 1500)	12 + 1

SISTEMA DI SEGNALAMENTO **SIGNALLING SYSTEM**	2 × 8 km	Blocco automatico a correnti codificate Coded currents automatic block

APPARATI CENTRALI ELETTRICI DI STAZIONE
ALL RELAY INTERLOCKINGS

TELEOPERAZIONI - TELECOMANDO ELETTRIFICAZIONE **REMOTE CONTROL SYSTEMS**	2 × 9 km	1 posto centrale central location
PROGRAMMATORE DEL TRAFFICO **COMPUTERIZED TRAFFIC REGULATION**	11 stazioni stations	90" cadenzamento interval
D.C.T. **TRAFFIC AUTOMATION**	2 × 8 km	

GUIDA AUTOMATICA
AUTOMATIC TRAIN OPERATION

azionamento veicoli *vehicle control*	arresto a bersaglio *progr. station stopping*	marcia automatica rigida *full automatic running*	marcia automatica programmata *flex automatic running*
Chopper	•	•	•

VEICOLI
VEHICLES

LIGHT ALLOYS

unità *units*	controllo *control*	frenatura elettrica *electric braking*	interruttore extrarapido *high speed circuit breaker*
75 2ª Generaz.	Chopper a GTO raffreddato al freon GTO chopper freon cooled	recupero + reostatica regenerative + rheostatic	SACE
1ª Generaz.	Chopper a tiristori Ventilaz. forzata Thyristor chopper forced air cooling		

METROPOLITANE LEGGERE E TRAM
LIGHT RAIL VEHICLES AND TRAMWAYS

anno *year*	cliente *customer*	n. carrelli *bogies No*	controllo *control*	n motori *motors No*	potenza continuativa veicolo kW *continuous rating vehicle*	frenatura *braking system*	unità *units*
1950	ATM Milano Italia	2	MPF (1)	4	33 × 4	pneum. + elettr.	85
1950	ATM Torino Italia	2	PCM (1)	4	33 × 4	pneum. + elettr.	125
1953	ACT Cagliari Italia	2	PCM (1)	4	44 × 4	pneum.	10
1953	ATM Milano Italia	2	PC (1)	4	100	pneum.	10
1956	ATAC Roma Italia	2	all electric (1)	4	40 × 4	all electric	20
1957	ATM Milano Italia	2	all electric (1)	4	40 × 4	all electric	3
1976	ATM Milano Italia	3 articolato *	KM 48 (1)	2	250	pneum. + elettr.	50
1980	AMT Genova Italia	2 articolato *	chopper	2	300	elettroidraulica + (**) elettrica (reostatica e a recupero)	6
1981	ATM Torino Italia	2 articolato *	inverter	2	420	pneumatica + elettrica (***) (reostatica e a recupero)	11
1986	ATM Torino Italia	2 articolato*	chopper (2)	2	300	pneumatica + elettrica (***) (reostatica e a recupero)	54
1987	AMT Genova Italia	2 articolato*	chopper (2)	2	370	elettroidraulica + (**) elettrica (reostatica e a recupero)	12
1989	ATAN Napoli Italia	3 articolato*	chopper (2)	2	370	elettroidraulica + (**) elettrica (reostatica e a recupero)	12
1950	EMT Madrid España	2	PCM (1)	4	33 × 4	pneum. + elettr.	100
1955	Oporto Portogallo	2	PCM (1)	2	50 × 2	pneum.	10
1993	Birmingham United Kingdom	3 articolato*	chopper (2)		370	elettroidraulica + elettrica (reostatica e a recupero)	19

(*) *double articulated*
(**) *electrohydraulic + electric (rheostatic and regenerative)*
(***) *pneumatic + electric (rheostatic and regenerative)*
(1) *Electromechanical control*
(2) *GTO, natural cooling*

Metropolitana leggera - Torino
Light rail vehicle for Turin municipality (Italy)

UNDERGHOUND VEHICLES

anno *year*	cliente *customer*	linea *line*	controllo *control*	frenatura elettrica *electric braking*	interruttore extrarapido *high speed circuit breaker*	unità *units*
1955	STEFER-Roma-Italia	B	PCM (²)	E	JR Ansaldo	18
1959	STEFER-Roma-Italia	B	PCM (²)	E	JR Ansaldo	22
1964	ATM Milano-Italia	1	PCM (²)	E		30
1966	ATM Milano-Italia	1	PCM (²)	E		12
1968	ATM Milano-Italia	1	PCM (²)	E		13 M + 14R
1970	ATM Milano-Italia	2	JH (²)	E	JR Ansaldo	40 (M + R + M)
1971	ATM Milano-Italia	2 1	JH (²) PCM (²)	E E	JR Ansaldo	14 M 27M + 15R
1974	ATM Milano-Italia	2	JH (²)	E	JR Ansaldo	34 (M + R + M)
1974	ATM Milano-Italia	2	JH (²)	E	JR Ansaldo	34 (M + R + M)
1976	STEFER-Roma-Italia	B	KM 49 (²)	E	IRB Ansaldo	16 M
1976	Acotral-Intermetro Roma-Italia	A	JH (²)	E	IRB Ansaldo	152 M
1979	ATM Milano-Italia	2 1	JH (²) PCM (²)	E E	IRB 4 Ansaldo JR Ansaldo	15M
1983	Intermetro Roma-Italia	B	Chopper	Recupero + reostat.(¹)	IRBS Ansaldo	53 (M + M)
1983	ATM Milano-Italia	2	JH	E	IRB Ansaldo	14 (M + R + M)
1985	ATM Milano-Italia	2	Inverter (³)	Recupero + reostat.(¹)	IRBS Ansaldo	4 (M + R + M)
1985-88	ATM Milano-Italia	1	PCM (²)	E	JR Ansaldo	14 (M + R + M)
1986	Intermetro Roma-Italia	B	JH	E	IRB Ansaldo	6 (M+M+R+R+ +M+M)
1987	ATM Milano-Italia	3	Inverter (³)	Recupero + reostat.(¹)	IRBS Ansaldo	34 (M + R + M)
1988	Intermetro Roma-Italia	B	Chopper	Recupero + reostat.(¹)	IRBS Ansaldo	41 (M + M)
1988	Metropolitana di Napoli-Italia	1	Inverter	Recupero + reostat.(¹)		45 (M + M)
1990	ATM Milano-Italia	2	JH (²)	E		20 (M + R + M)
1992	Intermetro Roma-Italia	A (prol.)	Inverter (³)	Recupero + reostat.(¹)	IRBS Ansaldo	10 (M + R + M)
1988	ANF Ind × RATP France	7 Paris	Inverter	Recupero + reostat.(¹)		2M
1990	Metropolitana di Lima - Peru		Chopper	Recupero + reostat.(¹)	IRBS Ansaldo	11

(¹) *Regenerative + Rheostatic* (²) *Electromechanical Control equipment* (³) *GTO, natural cooling* M = *Electric railcar*

Veicolo per la linea 2 della Metropolitana di Milano
Vehicle for the line 2 of Milan underground (Italy)

COMPARISON OF TRANSIT SYSTEM

*P.P.H.D. : PASSENGERS/HOUR/DIRECTION

	METROS	VAL	TRAMWAYS
DEDICATED RIGHT OF WAY	YES	YES	NO
CAPACITY (P.P.H.D.*)	10-60 000	3-35 000	3-10 000
HEADWAY peak off peak	2-3 mn 5-10 mn	60-90 s 3-5 mn	3-5 mn 10 mn
COMMERCIAL SPEED	25-40 km/h	30-40 km/h	15-20 km/h
RIDERSHIP	HIGH	HIGH	LOWER

MATRA TRANSPORT

BFA13L

VAL HISTORY IN LILLE

1972 - 1974	• Initial development & prototype phase
1974	• VAL adopted for LILLE
1974 - 1977	• Finance structuring • Environmental impact assessment • Detailed project definition
1977 - 1978	• Contracts award for system and civil works
1979 - 1981	• Delivery of hardware elements
MAY 83	• Start revenue service of line 1
1984	• LILLE orders additionnal line : line 2
1989	• Second line opening : 12 km, 18 stations
TODAY	• A 25 km network in revenue service - 20 km (12.4 miles) further extension under construction or planning

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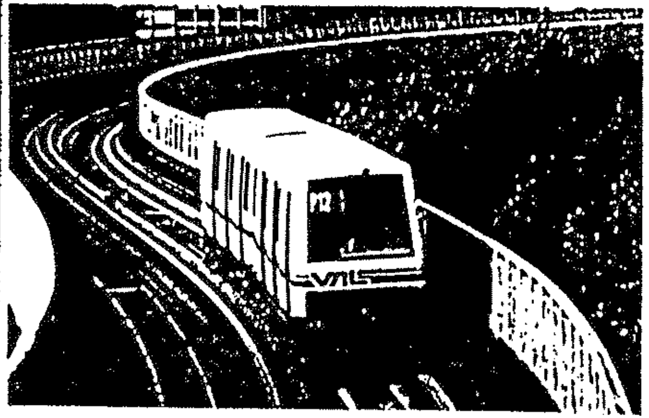
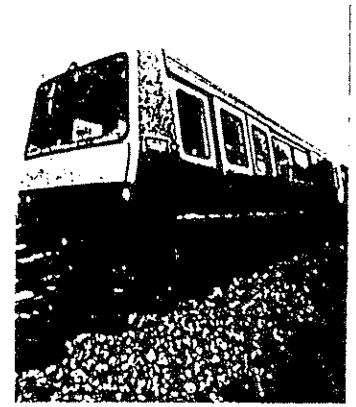
VAL VEHICLE

3 VEHICLE VERSIONS





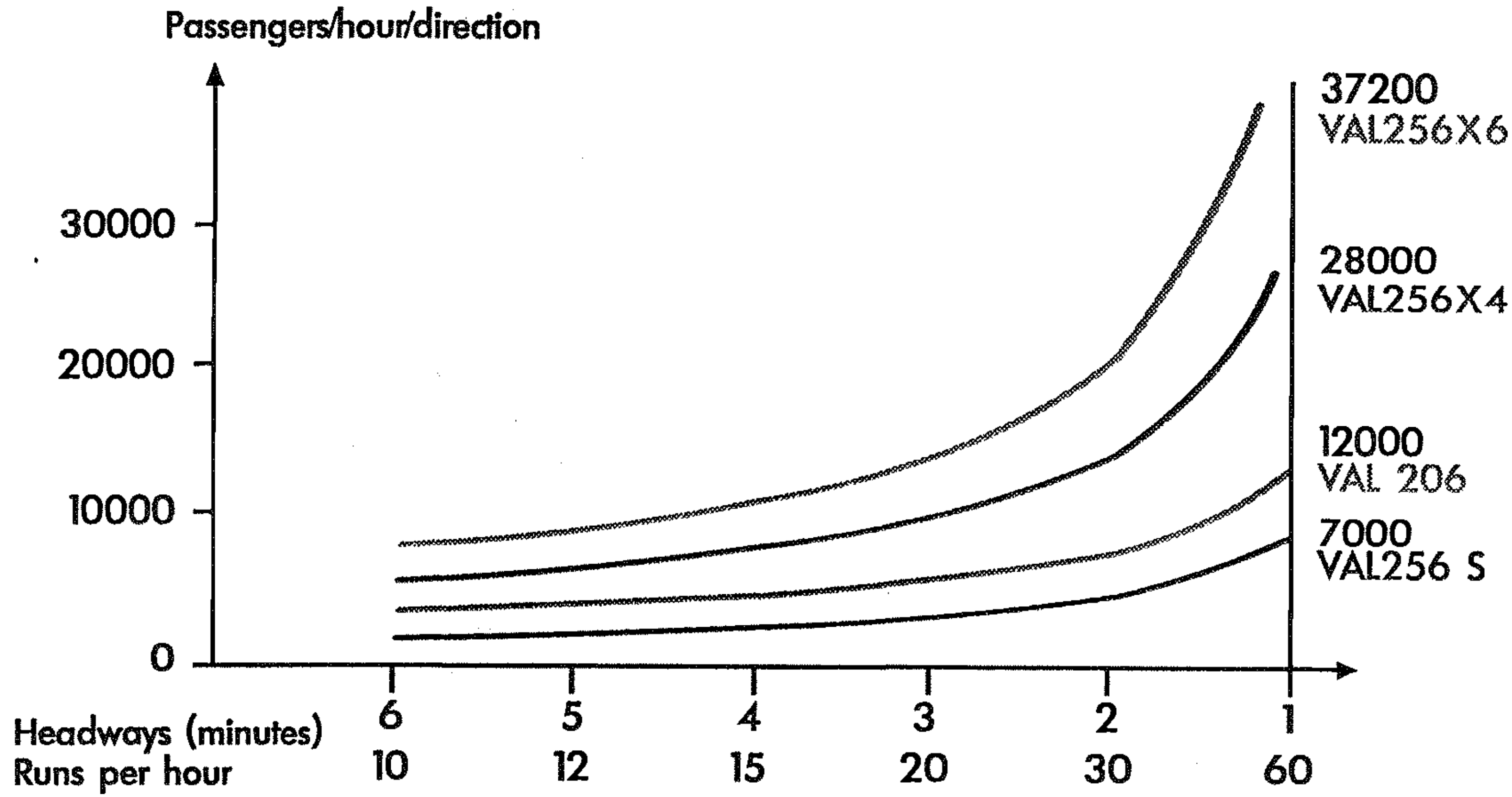
- **206 - MARRIED PAIRS**
  - W : 2.06 m
  - L : 26 m
  - H : 3.25 m
  - WT : 31 metric ton (EMPTY)

- **256 - SINGLE VEHICLE**
  - W : 2.56 m
  - L : 13 m
  - H : 3.53 m
  - WT : 19.3 metric ton (EMPTY)

- **256 - MARRIED PAIRS**
  - W : 2.56 m
  - L : 26 m
  - H : 3.53 m
  - WT : 38.5 metric ton (EMPTY)

MATRA TRANSPORT

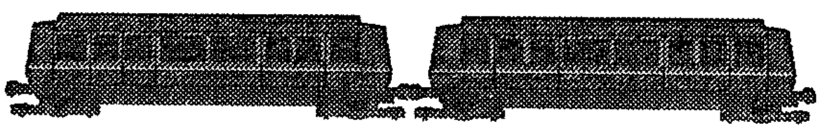
VAL : CAPACITY

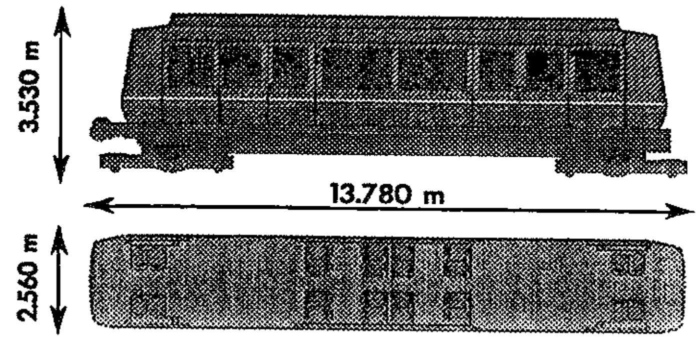


VAL 256

VAL 256
VEHICLE SPECIFICATIOIN

CONFIGURATIONS (TYPICAL)





ERFORMANCE :

- Max speed 80 Km/h (49.7 miles)
- Service Accel./Decel 1.3 m/s^2
- Emergency deceleration 1.8 - 24 m/s^2
- Air conditioning

AXIMUM CAPACITY :

VAL 256 urban application

- 118 to 127 passengers per car (6 Standing/m^2)
- Including 18 to 24 seats
- 236 to 254 passengers per married-pair

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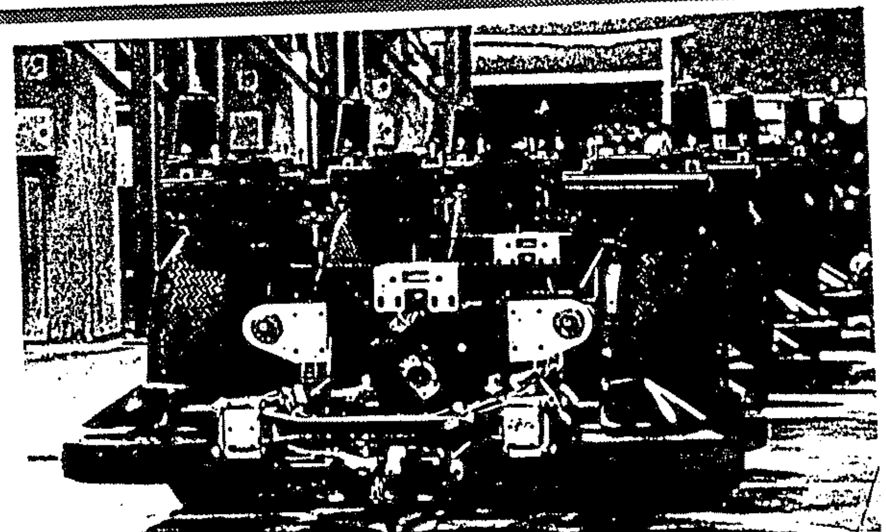
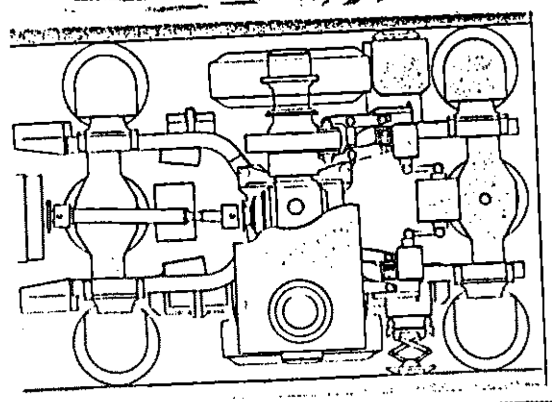
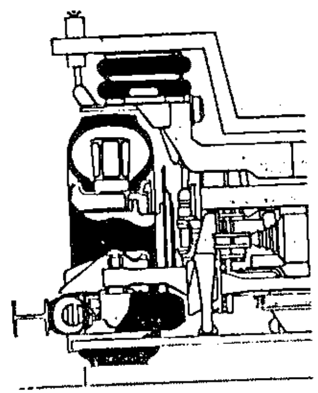
VAL BOGIES AND TIRES

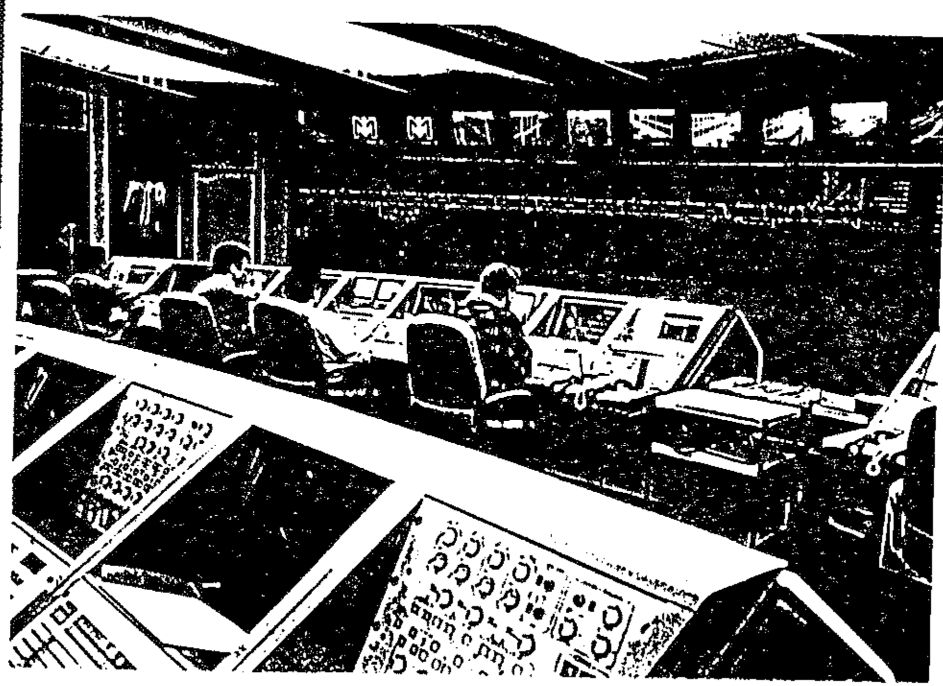






MATRA TRANSPORT

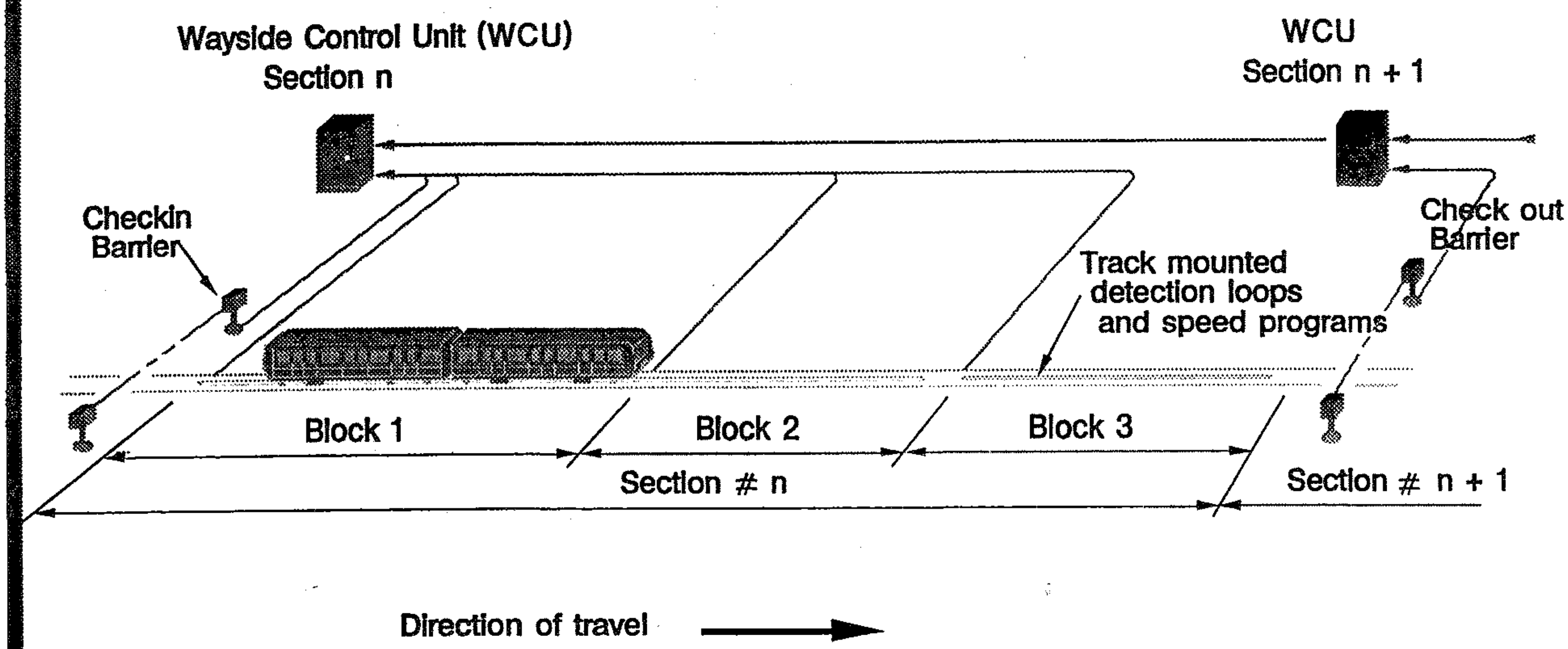
VAL SYSTEM
AUTOMATION SYSTEM



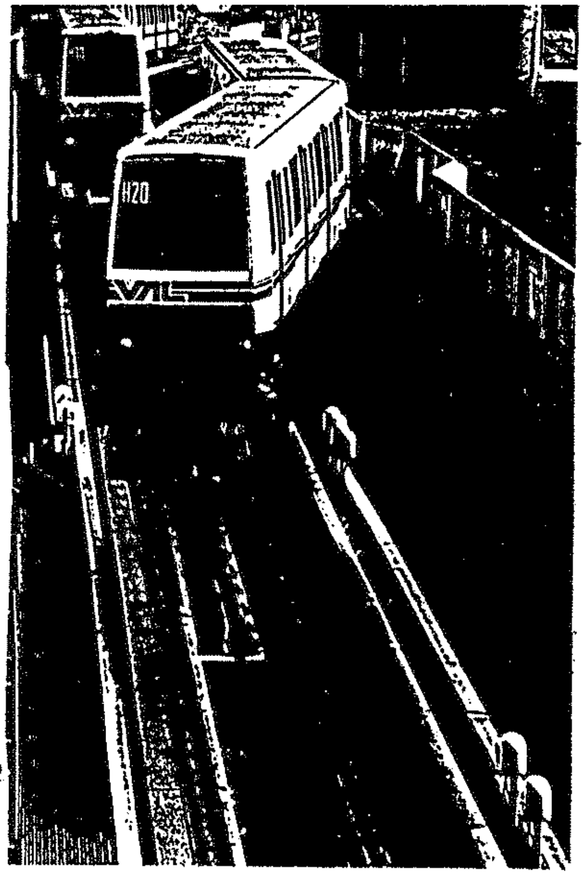
- CONTINUOUS TRANSMISSION LINE
  FOR VEH/GROUND COMMUNICATIONS
  CONTACTLESS VEHICLE DETECTION
- FIXED BLOCK
- FULLY REDUNDANT
- FAIL SAFE CONCEPT
- INCLUDES 3 SUBSYSTEMS:
  - ATP : SAFETY FUNCTIONS
  - ATO: TRAIN OPERATION
  - ATS : LINE & SYSTEM SUPERVISION AND TRAFFIC CONTROL
- CONTROL CENTER IS FOR SUPERVISION ONLY
  TRAIN SAFETY IS DECENTRALIZED

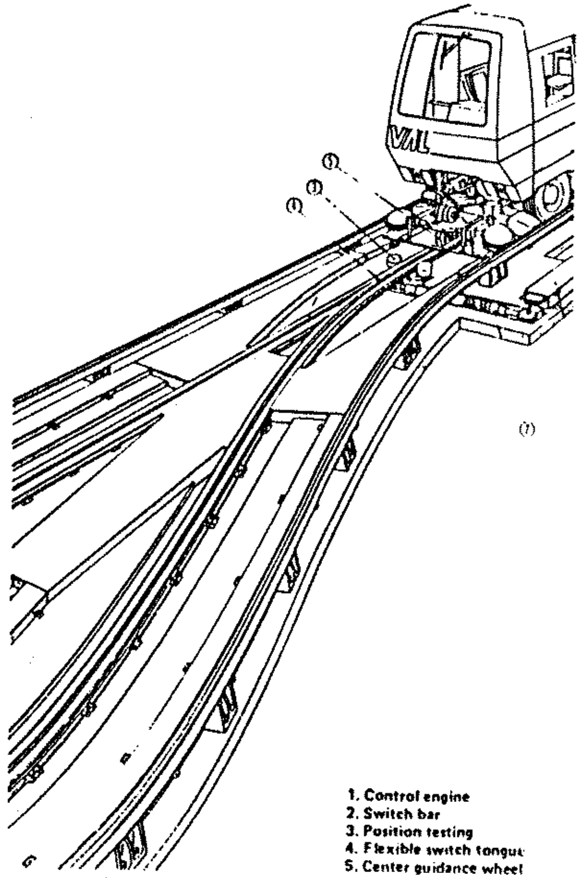
MATRA TRANSPORT

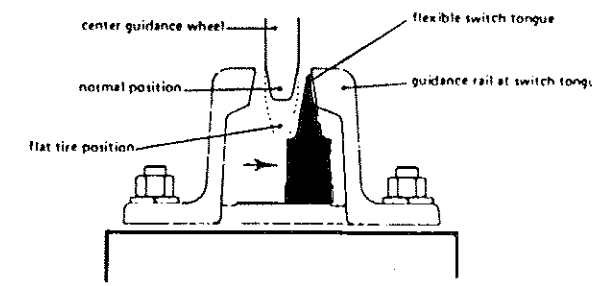
VAL ATC
FIXED BLOCK TRAIN DETECTION



VAL SYSTEM SWITCHING SIMPLE, FAST ACTION, TRAILABLE SWITCH







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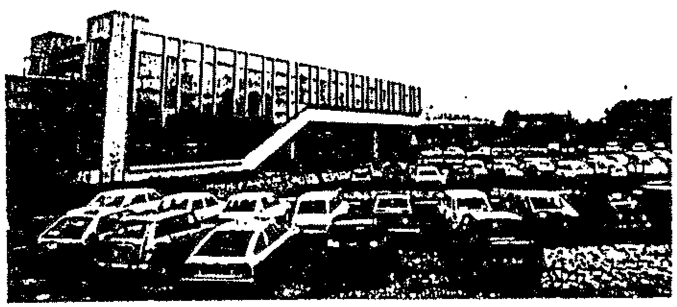
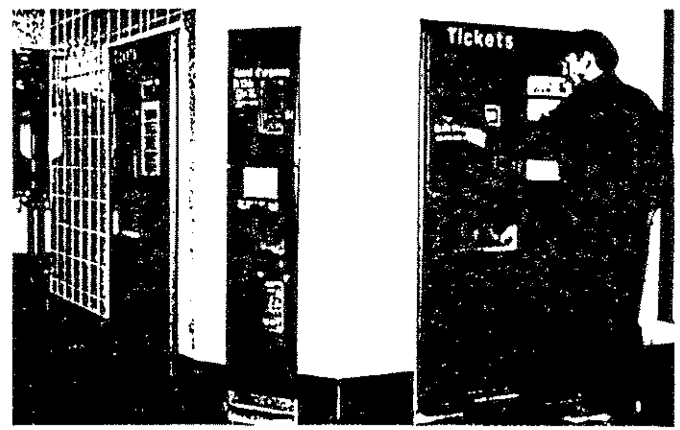
VAL SYSTEM
TYPICAL STATION EQUIPMENT





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PASSENGER SAFETY AND SECURITY

IN VEHICLE

- Passenger alarm interphone with control center
- Emergency handle
- Fail safe emergency braking
- Materials
  non consumable
  non toxic smokes
- High level supervision system (30000 info./2 sec.)
- Walk way along the track

IN STATION

- Platform doors
- Video & interphone systems with Control center
- Circulating inspectors

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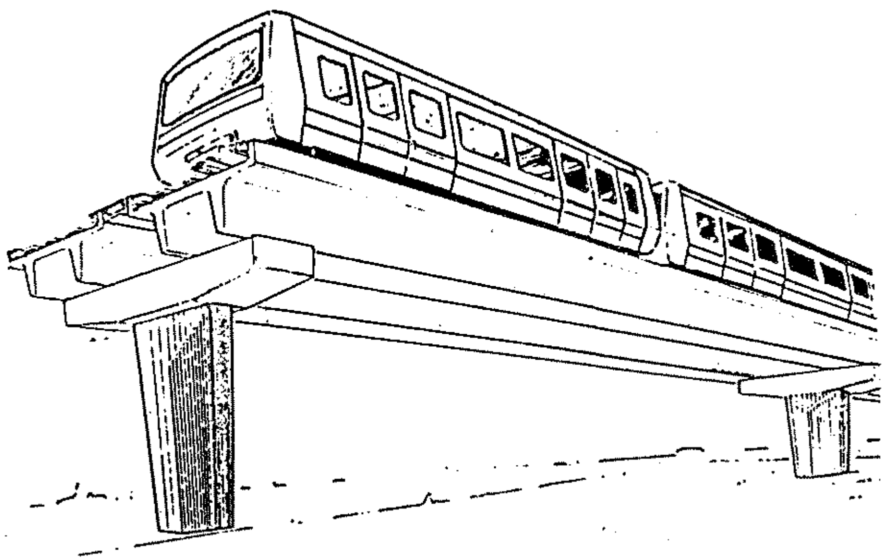
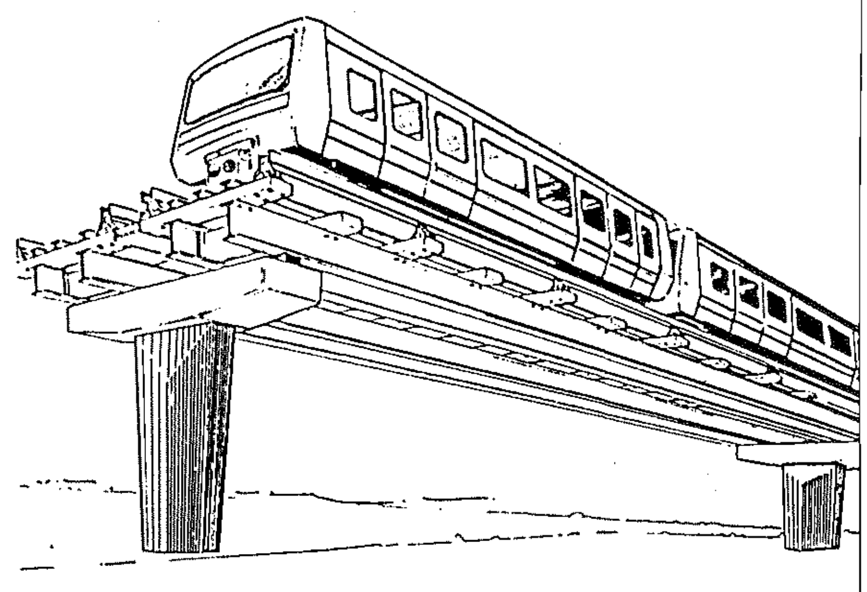
ELEVATED GUIDEWAY

TYPICAL DOUBLE TEE VIADUCT



TYPICAL METALLIC VIADUCT



LILLE RAPID TRANSIT OPERATION AND MAINTENANCE COSTS

BUDGET 1990

Ridership	
- Bus and light rail	50 million / year
- VAL	45 million / year
Total	95 million / year (1982 = 48 millions)
O. & M. Expenditures	
- Bus and light rail	US $ 53.5 million
. cost per trip	US $ 1.07
- VAL metro	US $ 30.0 million 5,45. = 163,5 mill F. 1990
. cost per trip	US $ 0.66
Labor Productivity	
- Staff : Bus and light rail	1.115
. trips per staff per year	45,000
- Staff : VAL metro	285
. trips per staff per year	158,000

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BFA16

OPERATIONAL PERFORMANCE
LILLE OPERATING AND MAINTENANCE COSTS

- Total staff : 285
  for 25 km (15.4 miles) line, 36 stations, 83 units
- Staff productivity : 158,000 pass./yr/person
- Yearly farebox revenue exceeds costs : no subsidy

ypical breakdown

	%
MANPOWER	42
ENERGY	13
SPARES & MAINTENANCE SUBCONTRACTS	
- VAL	18
- ANCILLARIES	19
ADM. INSURANCE, MISC	8

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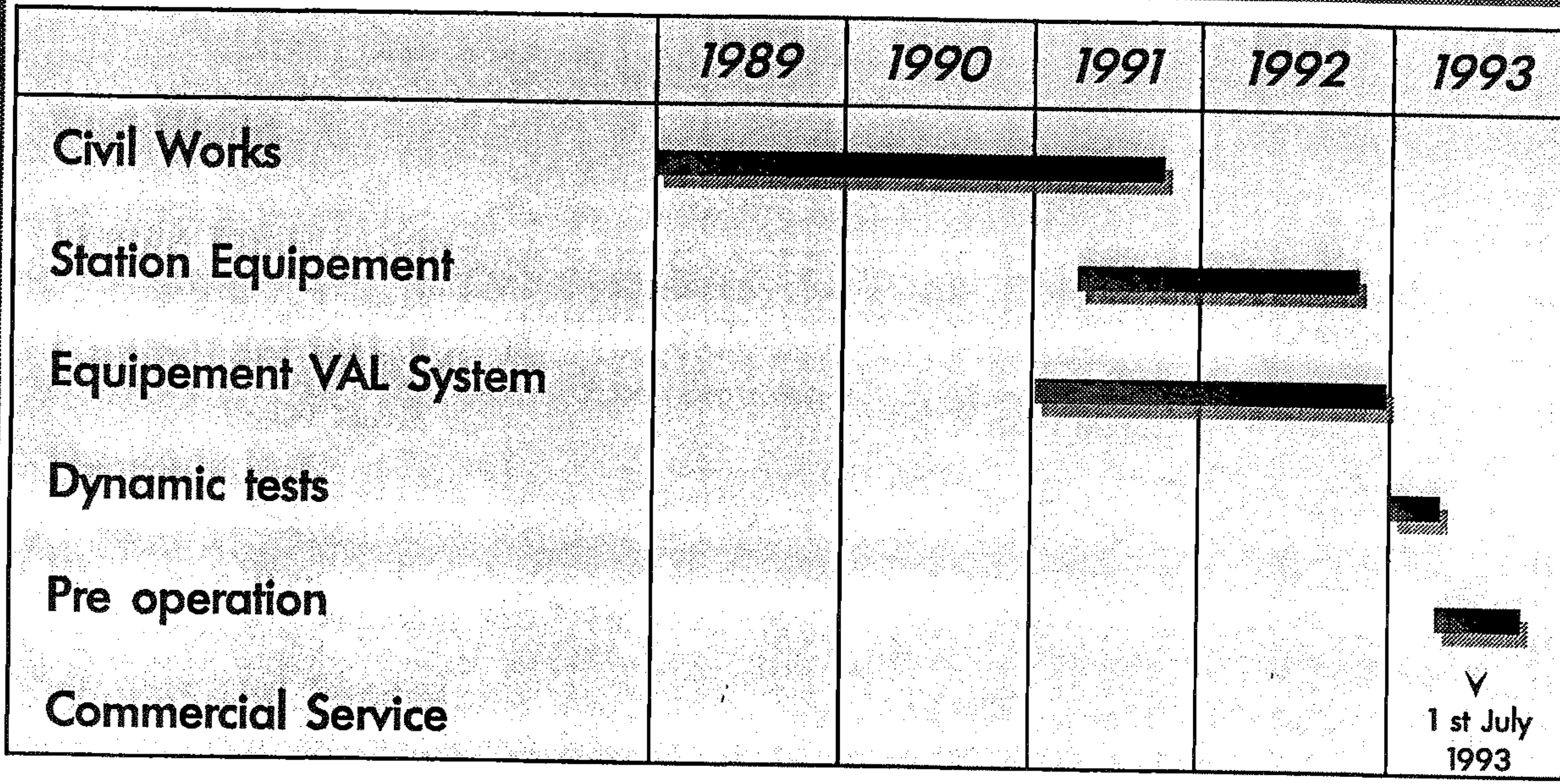
TOULOUSE - LINE A



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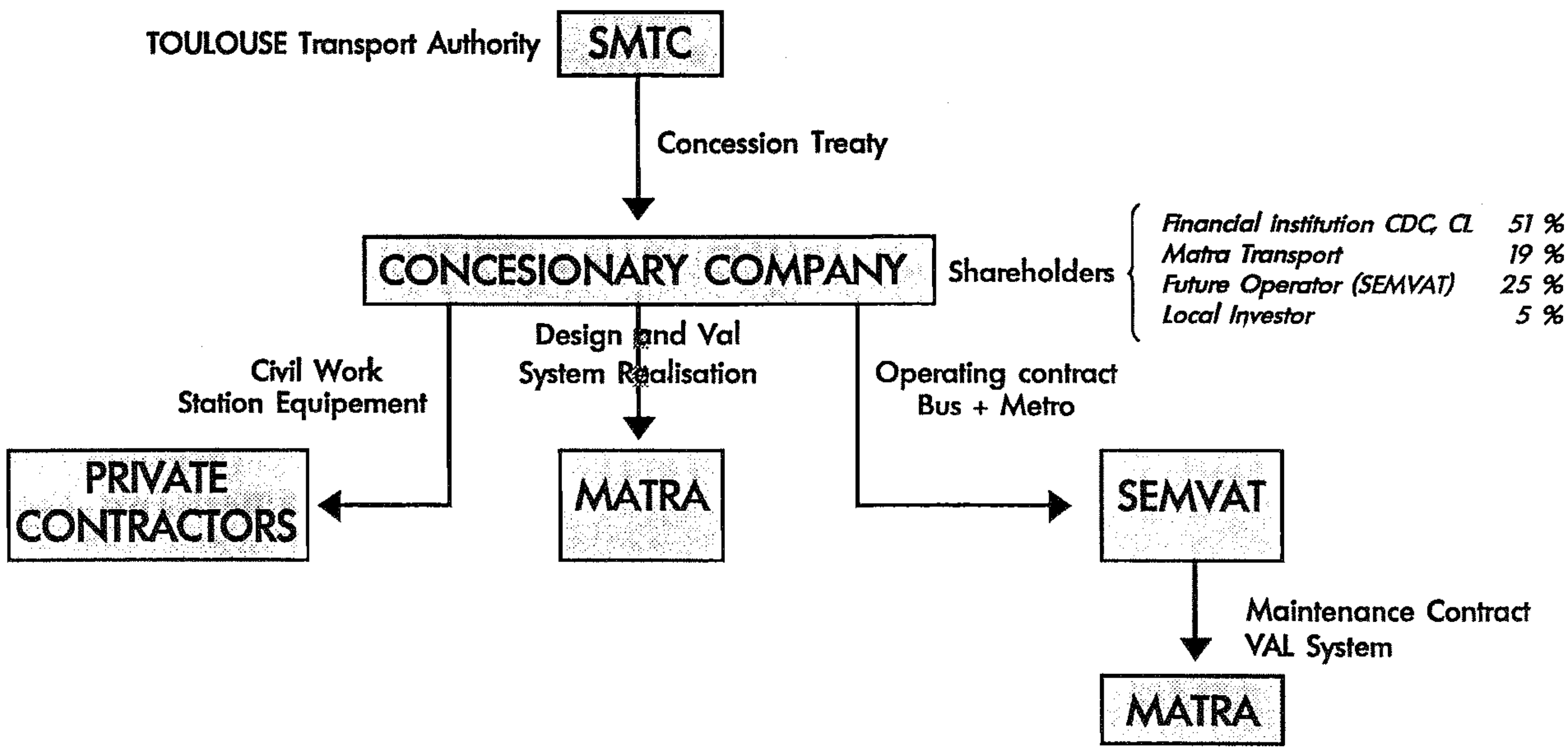
CONTRACTS ORGANISATION



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LINE A - MIRAIL / JOLIMONT

LINE CHARACTERISTICS	1st phase
Line length	*10 km / 6.2 miles*
Viaduct	*1 km / 0.6 mile*
Underground	*9 km / 5.6 miles*
Number of stations	*15*
Rolling stock (married pairs VAL 206)	*29*
Initial capacity (passenger / hour / direction)	*8,000*
Maximum capacity (passenger / hour / direction)	*15,000*

OPERATION	
Trains km / year (million)	*2.34*
Passengers carried (million / year)	*35*
Operating personnel	*145*
Productivity (passenger / employee / year)	*240,000*
VAL share of public transport	*50 %*
Population density : km of line (R = 600 m)	*11,000*

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LINE A - MIRAIL / JOLIMONT

Operation caracteristics

- **Commercial service** — *1st July 1993*
- **Passengers** — *Frequenting increase of 32 %*
  to reach 30 millions travelers per year
- **Service from** — *05 h 00 to 00 h 30*
- **Maximum headway** — *From 06 h 00 to 20 h 30 : 4 minutes*
  From 20 h 30 to 00 h 30 : 6 minutes
  In peak hour = 1 minute 30 seconds

Total trip MIRAIL / JOLIMONT in 18 minutes

MATRA

New Automated Transit System

of AEG Transportation Systems

International Conference on

New Transit Systems for Korea

Pusan October 26TH, 1994
Lecturer: Mr. Joseph U. Castellani
AEG Transportation Systems Inc.

AEG

NEW TRANSIT SYSTEMS/ AUTOMATED TRANSIT SYSTEMS

Joseph U. Castellani
AEG Transportation Systems, Inc.
Pittsburgh, PA USA

1. INTRODUCTION OF TECHNOLOGIES

Over 25 years ago, AEG Transportation Systems, Inc., then known as Westinghouse Transportation, installed its first automated transit system in Pittsburgh, Pennsylvania in the United States, and demonstrated an innovative alternative to traditional transportation modes. In the years since, automated transit system technology has been refined through the use of microprocessors and solid-state electronics and extensive application experience.

In 1971, the first fully automated, driverless system went into operation at Tampa International Airport, Florida USA.

And in 1972, the Bay Area Rapid Transit in San Francisco, known as BART, began public service. It was the first totally new metropolitan rapid transit system to be built in the United States in almost 60 years and the first fully automated system.

Automated Transit Systems from AEG consist of attractive, comfortable vehicles operating on a dedicated guideway under a totally automatic control system and are available in differing system configurations.

The Automated People Mover Systems, designated as C-45 and CX-100, consist of electrically powered, rubber-tired vehicles with four pairs of guidewheels which lock onto and are steered by a steel guidebeam anchored to the guideway.

The CX-100 is 11.89 meters long and features a spacious interior designed for passenger comfort and convenience.

The C-45 is 8.5 meters in length and allows lighter, less expensive guideway structures for systems with lower passenger densities.

Both types can be used individually or coupled together to form multi-car trains, depending on system requirements.

The AEG Monorail technology is often referred to as a straddle-beam monorail. Individual cars are linked together into an articulated train unit with each car module supported by bogies placed between the individual cars, operating on pneumatic tires. The electrically propelled cars are steered by guidewheels along the elevated guideway providing total segregation from other traffic.

The C-200 is a 28 meter articulated steel wheel system for urban applications. The C-200 combines rail technology with the characteristics of automated transit systems.

2. APPLICATIONS / CAPACITIES

The AEG family of Automated Transit Systems serve a wide variety of applications which benefit from this relatively new form of transportation system. The applications include activity centers such as amusement parks and fairgrounds, transportation and circulation of passengers within airports and the movement of large numbers of peoples in urban corridors.

Automated People Movers and Monorails may be characterized by smaller vehicles and shorter trains operating on dedicated guideways and running at frequent intervals to provide a high overall level of operational capabilities. Due to the nature of their design, including their ability to turn in small radiuses, they can be integrated into existing downtown environments, into new or existing airports and can be routed through buildings or to stations within buildings. Operation can also be placed in tunnels.

The C-200 Advanced Automated Rail System typically operating on a dedicated, overhead guideway, maintains the people mover's high performance characteristics of automation, short headway, small turning radius and passenger comfort to form a customized system well suited to urban environments. The C-200 may also operate within tunnels.

All of the automated transit systems operate with passenger carrying capacities typically above that found with buses and below those of heavy rail (full metro) rapid transit.

The Monorail is usually applied to special activity centers with system capacity requirements up to approximately 5,000 passengers per hour per direction (pphpd). Train lengths up to 10 cars are possible with each car carrying from 12 to 20 passengers. The monorail may run with top speeds of up to 40 km/hr.

The Automated People Movers may also be applied to activity centers including airports and as downtown circulators with passenger carrying capacities of up to approximately 20,000 pphpd. Trains lengths may vary between one to four cars in most applications with the C-45 accommodating 39 passengers nominally and the CX-100 accommodating 95 passengers nominally.

The C-200 Advanced Automated Rail System has application in urban corridors, particularly in congested areas where concerns of the impact of construction, environmental concerns of aesthetics and noise, and the impact of placing a rail line is of concern. The C-200 can provide passenger capacities of up to approximately 40,000 passengers per hour per direction with train lengths of 1 to 5 cars. The C-200 vehicle nominally carries 208 passengers per car with top speeds of up to 104.6 km/hr.

3. ROUTE CONFIGURATIONS

The increased use of automated transit systems, together with the variety of applications in which they are employed, has led to an assortment of possible network configurations. Planners have several basic configurations from which to create numerous routing concepts, and these decisions significantly affect system performance. Most automated transit systems in use today are either of the shuttle, loop (typically contra-rotating loop) and pinched loop (turnback) configuration.

Shuttle systems are ideal for connecting activity centers and for serving remote areas such as car parks. In airports, they have proven ideal for connecting "landside" functions such as bag claim and ticketing with "airside" gate areas. Shuttle systems generally fall within three basic types:

- Single lane, with one train shuttling back and forth
- Single lane with bypass, allowing dual-train operation
- Dual-lane, with trains operating on their own guideway

The single lane configuration is the least expensive and serves applications where wait time and capacity are not major concerns.

The addition of a bypass in a single-lane shuttle system increases the system capacity and decreases wait time. Trains are synchronized so that they cross every time in the bypass area.

The most flexible shuttle system is the dual lane system. While each lane is independent and responds individually to passenger demand, the trains are continually synchronized with the goal of crossing mid-distance for maximum efficiency. System capacity is maximized and passenger waiting times are minimized with this configuration..

System maintenance for shuttle systems is normally accomplished on-line, typically below one of the stations. An added benefit of the dual lane shuttle configuration is that maintenance may be performed on one lane while service continues on the other lane.

Shuttle systems may also operate on-demand, utilizing call buttons similar to lift systems.

Loop systems have been used in applications where service to multiple stations is required. Two or more trains travel in the same direction at safe following distance, serving stations at close headways thereby allowing high system capacities. To improve system performance, contra-rotating loop systems have been used which reduces maximum travel time for passengers. An example is the downtown people mover employed in Miami, Florida, USA. Multiple trains travel in a clockwise direction on one lane and in a counter-clockwise direction on the other. This system is currently being expanded to include north and south traveling routes accessed from the outer downtown loop. Also note that this system is fed by a north-south metro system thereby providing convenient connections for suburban passengers into the downtown area.

The final configuration commonly used with automated transit systems is the pinched loop or turnback system, as seen with most urban metro systems. The use of automation allows trains to follow each other at close headways for maximum system capacity. Turnbacks at the ends of the line typically employ multiple switches to allow for the short headways and to maximize the system reliability. Bypass switches and sidings are also employed along the guideway in the event of a train failure and to reduce system downtime.

Most automated loop and pinched-loop systems can be used bi-directionally for added flexibility. In off-peak hours, these systems can operate in alternate loop mode or in single tracking modes which allows for track and wayside maintenance to take place while still maintaining service.

4. MONORAIL CHARACTERISTICS

Monorail trains are of modular design using standard center and nose cars units to form a fully articulated train. Each car rests on its own bogie assembly rigidly attached to one end of the car. The other end receives a ball-joint coupler that is rigidly connected to the next car bogie.

The car body is a fully-enclosed, double-wall unit. It has a low-body frame design that permits a low floor to ground height of only 200 mm.

The all aluminum structure features generous use of glass and provides a pleasing appearance. Seating arrangements can be customized.

Lateral guidance is accomplished by four guidewheels per axle. Each guidewheel is preloaded against the side wall of the trackway beam by springs.

Train braking is accomplished by two independent braking systems, including an electrical regenerative system for normal service braking and a mechanical disk-type friction brake system for emergency braking.

The electrical propulsion control system is based on the use of thyristor control with continuously adjustable voltage regulating the DC traction motors to allow stepless acceleration and deceleration of the train.

Train propulsion power is obtained from a three phase rail at 500-600 volts.

The monorail guideway utilizes a standard composite steel box girder formed by welding standard rolled steel plates into the box beam configuration. All steel sections are shop fabricated, pre-cut and contoured requiring only one field weld near each column to form a continuous guidebeam structure. The beam is supported by steel columns that are securely fastened to base plates anchored to concrete foundations. Typical spans are 24 to 28 meters with special spans up to 49 meters possible with the use of deeper box beams.

Guideway switches are used for route network designs. Switching is accomplished by automatically aligning a tangent or curved section of box beam at the switching area. Switches may be of the pivot-type or rotating-type.

Control of monorails is usually performed semi-automatically, with a cab attendant overseeing various functions, although monorails have been implemented as fully automatic as well as in full manual operation.

Monorail stations may vary a great deal depending on the requirements with respect to their location, architectural theme and passenger interface.

Stations must be accessible to elderly and handicapped persons and typically include fare collection, TV monitoring, public address and other passenger information systems.

5. AUTOMATED PEOPLE MOVER CHARACTERISTICS

Automated People Mover systems are an innovative transportation technology adaptable to the requirements of any medium to high capacity activity center, including airports, industrial parks, recreation complexes, shopping/apartment or office complexes and business districts.

The automated people mover systems feature attractive, comfortable vehicles operating on a dedicated guideway under a totally automatic control system and are available in two standard vehicle configurations.

The CX-100 vehicle is 12 meters long and accommodates 95 standing passengers (using 4 passengers per square meter). The C-45 car design is smaller and lighter than the CX-100, but utilizes virtually the same technology. The C-45 is 8.5 meters long and accommodates 39 standing passengers.

For the purposes of this presentation, the CX-100 model will be specifically discussed.

The people mover vehicles ride on rubber tires. Four pairs of horizontally-mounted guidewheels lock the vehicle to a steel guidebeam anchored to the concrete guideway to prevent derailment and to provide continuous guidance for each moving vehicle. The people mover system allows system designs to include turning radiuses as low as 22.9 meters. This combined with low weight and negligible vibrations allows systems to be placed in congested areas and even cantilevered from or through buildings.

The interior of the vehicle is designed for passenger comfort and easy maintenance. A wide open space is provided making the people mover extremely efficient in terms of its passenger carrying capacity as opposed to its empty car weight of about 14,787 kg. Since travel times are typically short, most internal configurations provide for a large standee area, although seats may be provided in varying configurations.

Side windows make up about 35% of the vehicle wall, and large windows at both ends of the car provide a wide open feel for the passengers. Two, wide door openings of over 2 meters each are provided on each side of the car. The wide openings allow for increased flow of passengers which in turn minimizes the time a train must be stopped in the station.

Cars may be operated in trains, typically up to 4 vehicles in length, and are designed to run in all weather conditions.

The CX-100 car body consists of a steel underframe and floor pan, and aluminum body, with fiberglass end pieces. These pieces can be customized to suit a particular requirement.

The guideway for the CX-100 system consists of twin concrete running pads on which the vehicle rides. The running pads are placed on top of a support structure which may be of steel or concrete construction. The steel guidebeam is set in-between the running pads.

Columns, typically of concrete, support the structure and are usually provided in span lengths of 27 to 30 meters, although varying span lengths can be used as required.

Propulsion and braking are performed in a similar manner as that on the monorail technology. Power is provided from guideway mounted power rails at 600V, 3 phase for the CX-100 and 480V, 3 phase for the C-45.

Switching is also accomplished in a similar manner as that for the monorail, with curved and tangent guidebeam section that pivot or rotate to complete the switching operation.

Control of people movers is completely automatic, utilizing a sophisticated, microprocessor-based train control system, with electronic equipment mounted on board vehicles, in station equipment rooms and in a central control facility. The automatic train protection system utilizes a fixed block approach for safe train separation, and headways as low as 70 seconds have been implemented.

In the central control facility, large screen, high resolution color monitors and touch-screen control consoles use real time display and control. Much of the implementation is by computer software, allowing for easier expansion capabilities.

The automated people movers are designed with service in mind. In fact, AEG provides operations and maintenance services on many of these systems after they are fully commissioned.

6. THE C-200 ADVANCED AUTOMATED RAIL SYSTEM

Today's urban metro systems must meet stringent requirements, both from the professional transportation planner's perspective, and from the perspective of the passengers. These perspectives typically are quite different.

The transportation planner may view these issues most importantly:

- Safety
- Reliability
- Performance
- Cost
- Constructability
- Schedule
- Environmental

The passenger view can be quite different, with these issues often seen as most important:

- Comfort
- Convenience
- Aesthetics

For cities developing entirely new metro systems or feeder lines to existing metros, and where the ability to use tunneling, or where space at surface level is severely limited or other environmental concerns may rule out conventional rail systems, AEG has developed the C-200 Advanced Automated Rail System. The C-200 concept considers both planner's and passenger's perspectives to form a complete urban metro system. This system, typically operating on a dedicated, overhead guideway, combines the high performance, highly automated, tight turning radius and passenger comfort aspects of automated transit systems together with the high technology of rail systems to form a customized system well suited to special urban requirements.

The C-200 draws its rail technology from high quality and well proven subsystems. The C-200 is unique in that it also includes the technology of automated transit systems, such as those in service on Automated People Mover Systems described previously.

The C-200 is usually implemented under a design-build, or turnkey arrangement, so that all aspects of the metro system, such as safety, reliability, performance, comfort, constructability and environmental concerns can all be considered concurrently. This systems approach allows all elements of the design and construction process to be considered together and to determine the effect of one design on another. Cost can also be reduced because a single contractor team is responsible for designing, building and, at option of the responsible authority, operating and maintaining the system.

The C-200 system operates fully automatically without drivers, and normally operates in a "pinched loop" mode, with trains servicing all stations. Stations are designed with either side or center platforms.

The C-200 vehicle is a 28 m long, articulated vehicle featuring a spacious interior with wide aisles, upholstered seating, air-conditioning and large tinted windows. The vehicle interior features a modern, clean look and incorporates sound-attenuating materials for a quiet ride. The carbody design draws upon AEG's experience in Germany and throughout the world.

The C-200 suspension system utilizes the AEG design proven on over 2,000 operating bogies on rail vehicles in service around the world. This AEG design uses the new noise-limiting steel wheels. The rail gauge is 1,435 mm.

AC propulsion is used which permits energy efficient, low maintenance and quiet operations. The use of force-ventilated AC technology also ensures that the C-200 will contribute to an overall low-noise operating system.

A state-of-the-art automatic train control which has been well proven on many automated transit systems, is utilized and will permit driverless operation. The ATC incorporates the latest microprocessor technology, including the use of fiber optic transmission techniques and multiplexing of signals.

The vehicles and stations feature electronic signs and automated voice announcements. The automatic train control system ensures the accuracy of train stops in stations, making it easier for persons with disabilities to use the system.

The C-200 system features the AEG Integrated Central Control. This computerized, completely automated system utilizes touch screen technology with advanced human interfaces. Thousands of system inputs are tracked by the system and an advanced diagnostic system is featured. The system is completely redundant for high reliability and also provides automatic reporting of events and calculates system availability. Train Control and Monitoring, Power Distribution Control and Monitoring, Communications and SCADA functions are all integrated into the system composed of OEM equipment configured for this application. A unique feature of this system is the ability for remote diagnostics, so that engineers who designed the system elements can assist operating personnel with the use of a personal computer, from anywhere in the world.

AEG also provides operations and maintenance of the system once it begins service. This arrangement ensures that operational and maintenance considerations are made part of the rail system design and development, since the same team responsible for design and commissioning must also operate and maintain the system, largely using its own personnel.

AEG will provide the design and construction of the maintenance and yard facilities, as well as preparing detailed operations and maintenance plans during the design process.

The operational plan features the use of "roving" personnel. Because the entire rail system is automated, cab operators are not required, and in their place the roving personnel who understand all aspects of the operation are free to circulate within the system. They assist passengers, answer questions, provide security and watch for situations before they develop into problems.

The C-200 systems approach to urban transit provides an efficient transportation solution which complements the environment while fitting into the already developed city landscape.

7. CONCLUSION

The Automated Transit Systems presented are designed to solve specific transportation problems and will complement higher capacity urban metro systems and light rail lines which may be implemented. You have seen how these systems can work in airport, downtown areas, amusement parks and fairgrounds, as well as in congested urban corridors. The systems approach to implementing modern transit systems is a powerful way to ensure that demanding requirements are met.

JOSEPH U. CASTELLANI

Mr. Castellani received his Bachelor of Science Degree in Electrical Engineering from Syracuse University, Syracuse, New York (USA) in 1980.

Mr. Castellani has been with AEG Transportation Systems, Inc. (formally Westinghouse Electric Corporation Transportation Division) for five years working in the application engineering and marketing departments.

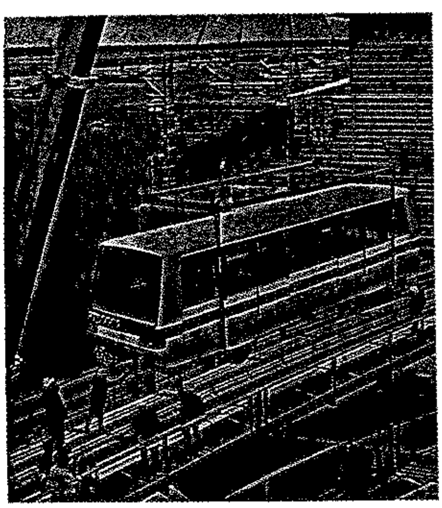
In 1980, Mr. Castellani began working for the Westinghouse Electric Corporation, where he held various application and field engineering positions in the area of control systems and automation of steel mills. In 1982, Mr. Castellani became the District Field Engineer for the Northern Midwest area of the USA, working mainly with customers and suppliers of electric powered machinery for the mining industry. In 1983, Mr. Castellani was transferred to Pittsburgh and began working as an application engineer of rectifier systems for the transportation and process control industries.

In 1986, Mr. Castellani began working with the Rail Systems Center at Carnegie Mellon University in Pittsburgh, PA (USA). As assistant director of the Rail Systems Center, Mr. Castellani managed a group of engineers who perform consulting work in the area of energy management of electric transportation system.

Mr. Castellani joined AEG Transportation Systems, Inc. in 1989 and is presently a marketing representative for complete transit systems.

Rail Systems

	1993	1992
Sales		
Revenue (DM mill.)	**1,501**	1,493
Foreign Share (in %)	**35**	39
Employees (12/31)	**8,257**	7,490



Automated "people mover" systems were one focus of our global activities. As of 1994, a people mover system will be introduced at Frankfurt Airport, connecting the new Terminal-East with the existing facilities.

The AEG Rail Systems field of activity comprises the divisions *Integrated Rail Systems, Rail Track Systems, Mainline Railroads, Mass Transit and Railcars* and *Mass Transit and Railcars America.*

The slight rise in sales from the already high level of the previous year to DM 1.5 billion was attributable to the take-over of Kiepe Elektrik GmbH, of Düsseldorf and Vienna. With the acquisition of this company we were able to expand our market position particularly in the field of electric equipment for mass transit vehicles. Due to the formation of provisions for a structural concept launched, negative earnings were recorded.

Further Expansion of ICE High-Speed Systems

AEG's Rail Systems field of activity is playing a leading part in the expansion of Germany's ICE system. In the 1993 financial year, German Federal Railways decided to order a further 60 half-trains. For the electrification of the high-speed line between Hanover and Berlin we supplied overhead contact lines. We were also involved in the modernization work on the line between Berlin and Hamburg and in the linking of Berlin to the ICE network. With these and other contributions to one of the most impressive and advanced examples of modern railway engineering, AEG's Rail Systems field of activity has demonstrated its competence as a supplier of complete systems.

Successful Business in Efficient Mass Transit Systems

The mass transit market both in Europe and around the world has enormous potential for growth in the future.

Low-floor streetcar business is exceptionally brisk, both internationally and particularly in Germany. The user-friendly low-floor design developed by AEG Schienenfahrzeuge Nahverkehr und Wagen GmbH offers particularly convenient passenger entry. Following Augsburg, Brunswick, Bremen, Mainz, Nuremberg and Munich, we have now also received orders from the new Federal states. The Zwickau public transport authority has requested 12 of these streetcars for city use; orders have also been received from Frankfurt an der Oder and Jena. AEG will also be equipping the new streetcars in the East German city of Halle. An outline agreement regarding the supply of 120 streetcars was signed with the public transport authority in Berlin. In total we have so far received orders for almost 600 of these newgeneration low-floor streetcars.

AEG also supplied new vehicles and equipment for the metro systems in Berlin and Nuremberg and for the Bay Area Transit System in San Francisco.

The modernization of Berlin's rapid transit system continued in 1993. AEG is extensively involved in work on the contract to supply more than 100 two-part rapid transit vehicles of the 481 series to German Federal Railways.

Kiepe Elektrik GmbH

Our subsidiary Kiepe Elektrik GmbH received an order to supply electric equipment for 40 new low-floor vehicles to the Cologne public transport authority.

Deliveries of electric equipment for trolley buses in Denmark, Germany, Austria and Hungary over the past years helped Kiepe Elektrik to secure an order to supply modern three-phase equipment for 18 articulated trolley buses to the city of Montreux in Switzerland.

"Moving People" Around the World

The automated people mover systems built by AEG Transportation Systems, Inc., were a further major focus of global activities. We expanded the leading position we have held in this segment for many years. Such people mover systems are to be found at many of the world's airports, including those of major American cities, for example the new Denver International Airport. The international airport in Tampa, Florida, also commissioned AEG Transportation Systems to expand its people mover system. The installation of people mover systems at airports in London will be followed as of 1994 by the introduction of a people mover system at Frankfurt Airport, connecting the new Terminal-East with the existing facilities. We have already supplied the first vehicles under the terms of this contract.

Increased Involvement in International Markets

AEG Rail Systems' competence in the area of complete systems also facilitates access to the growing markets of Asia, which hold considerable potential for future growth on account of increasing traffic and transport problems.

In the space of four years, the AEG-led consortium "German Shanghai Metro Group" developed and installed a modern metro system which will be extended in stages. At the end of May 1993, the new Shanghai metro commenced operation on the first seven-kilometer section of track. In mid-1994, the last of the 16 six-part metro trains for Line 1 will be supplied.

Together with the British construction company Taylor Woodrow International we also received an order to build a streetcar system in the Malaysian capital of Kuala Lumpur. This project is a BOT (Build-Operate-Transfer) model for the supply of a complete system. It documents our internationally recognized competence in the planning and construction of integrated systems.

AEG Rail Systems stepped up its activities in other continents too. For example AEG Schienenfahrzeuge received a follow-up order for a further eight diesel-electric Intercity multiple units for Greece's state railway. AEG also provided traction contact systems and the complete power supply for Copenhagen's duo bus, which can be powered by electricity or by diesel engine.

In the USA, demonstration runs by an ICE train showed Germany's technological competence in this area and aroused great interest. Our largest projects in North America however were in the field of mass transit systems, with expansion of the train protection system for the New York City subway and the supply of three-phase propulsion equipment for 216 new metro vehicles in Toronto.

Systems Capability All-Important

The changing face of society – for example increased mobility, the desire for short journey times and ecological requirements – is resulting in ever more complex solutions in both engineering and financing. This in turn is leading to increased demand for integrated transport systems. Complete systems capability is particularly important in our Rail Systems field of activity. It is our aim, as one of the world's leading operators in this field, to cater for this demand by offering integrated product and service packages. These efforts take place against the background of a changed operating environment for the German rail industry, marked by considerable surplus capacity, intensified national and international competition and resulting low price levels. We regard the strengthening of AEG Rail Systems' competitiveness in this changed environment as the major challenge of the coming years.

GEC ALSTHOM

TRANSPORT

DTR/S.CM 10/93

GEC ALSTHOM
TRANSPORT

Division size

- 15,900 People
- Turnover: ECU 1,966 million
- Orders in hand (3 years) : ECU 5,701 million
- Registered orders for the year : ECU 1,939 million
- Research, development and investment : ECU 100 million
- Head quarters in Paris La Defense
- Organized in six Groups:
  - Rolling Stock U.K. Group
  - Spanish Group
  - French Main Lines Group
  - French Mass Transit Group
  - Equipments Group
  - Signalling Group

  ⇨ + a fully owned Belgium subsidiary : GEC ALSTHOM ACEC Transport
- main crafts:
  - Project management (Head quarters)
  - Rolling stock
  - Traction
  - Signalling systems

1 ECU = 6,970 FFR / 1 ECU = 0,702 GBP

DTR/S.CM 10/93

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GEC ALSTHOM
TRANSPORT

Products

- TGV - Very high speed train
- Electric and Diesel locomotives
- Single and double deck EMUs
- Metros
- Light Rail Vehicles
- On board computerized data systems
- Equipment (Electrical and mechanical)
- Signalling systems

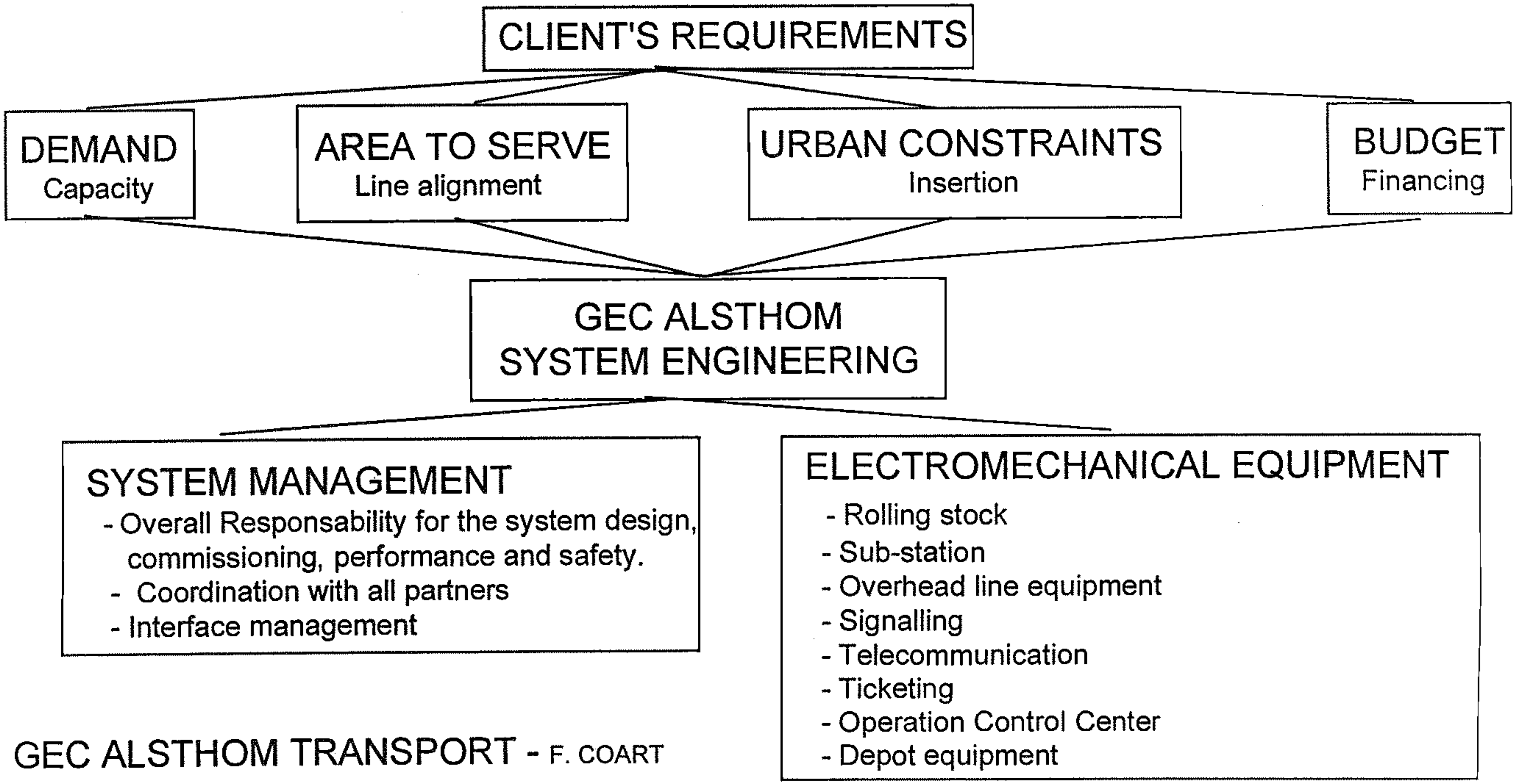
DTR/S.CM 10/93

GEC ALSTHOM LIST OF REFERENCES IN KOREA

- PRESENCE AND PARTNERSHIP - TECHNOLOGY TRANSFER WITH KOREAN COMPANIES SINCE 1970.
- URBAN TRANSPORT
  - SMSC (lines 3 & 4):
    - Chopper controlled traction equipment of 588 vehicles supplied between 1982 and 1990.
    - VVVF traction equipment for 252 vehicles signed in 1992 (under delivery).
  - SMG (line 7 & 8):
    - VVVF traction equipment for 226 vehicles signed in 1992 (under delivery).
- ELECTRIC LOCOMOTIVES
  - KNR:
    - 90 BBB type units supplied between 1970 and 1976
- TGV
  - Contract signature in 1994 for the system engineering and the supply of 46 trainsets (1000 seats), catenary, ATC, CTC, IXL and services (maintenance, training, ...) for the HSR Seoul - Pusan.

'94 INTERNATIONAL SYMPOSIUM ON NEW TRANSIT SYSTEM

SYSTEM ENGINEERING



GEC ALSTHOM TRANSPORT - F. COART

5

URBAN TRANSPORTATION SYSTEMS:

- TRAMWAYS
- LIGHT RAIL VEHICLES
- MASS TRANSIT
- SUBURBAN RAILWAYS

TRAMWAYS

- 2 000 TO 6 000 PASS/H*DIR
- AT GRADE
- PARTIAL SEGREGATED TRACK
- CROSSING AT GRADE
- COMMERCIAL SPEED : 15 TO 20 KM/H (max speed 60 to 80 km/h)

LIGHT RAIL VEHICLES

- 3 000 TO 30 000 PASS/H*DIR
- AT GRADE OR SUPERELEVATED
- MAINLY SEGREGATED TRACK
- LOW COST INFRASTRUCTURE
- COMMERCIAL SPEED: 20 TO 30 KM/H **(max speed 80 to 100 km/h)**

MASS TRANSIT

- 20 000 TO 60 000 PASS/H*DIR
- IN TUNNEL OR SUPERELEVATED
- 100 % SEGREGATED TRACK
- HIGH CAPACITY
- COMMERCIAL SPEED: 20 TO 40 KM/H (max speed 60 to 100 km/h)

SUBURBAN RAILWAYS

- OVER 40 000 PASS/H*DIR
- 100 % SEGREGATED TRACK
- VERY HIGH CAPACITY
- COMMERCIAL SPEED OVER 40 KM/H

TRAM AND LIGHT RAIL : 2 DIFFERENT APPROACHES

- LOW FLOOR
  - ALLOWS ACCESS FROM STREET OR FROM LOW PLATEFORM (+- 300 mm)
  - MORE EASY TO INSERT IN CITY CENTER
  - INFRASTRUCTURE LESS EXPENSIVE
  - VEHICLE MORE COMPLEX
  - PARTIAL OR INTEGRAL LOW FLOOR
- HIGH FLOOR
  - ACCESS FROM HIGH PLATEFORM (+- 1 m)
  - CONVENTIONAL TECHNOLOGY

GEC ALSTHOM : A COMPLETE RANGE OF PRODUCTS

- **LOW FLOOR**
  - **PARTIAL LOW FLOOR**
    - **GRENOBLE**
    - **MAGDEBURG**
    - **ST ETIENNE**
  - **INTEGRAL LOW FLOOR**
    - **WURZBURG**
- **HIGH FLOOR**
  - **NANTES**
  - **DOCKLANDS (AUTOMATED)**
  - **MANCHESTER**

NEWEST SIGNIFICANT REFERENCES IN THE FIELD LIGHT RAIL VEHICLE

Nantes City (France)

Length x width	39,150 m x 2,30 m
Capacity	317 (6 pas. per sq.m.)
Voltage	750 VDC
Quantity	46 train-sets ordered between 1982 and 1991

Grenoble City (France)

Length x width	29,400 m x 2,30 m
Capacity	252 (6,6 pas. per sq.m.)
Voltage	750 VDC
Quantity	112 train-sets ordered between 1984 and 1994 by Grenoble City, Paris Metro and Rouen City.

Saint-Etienne City (France)

Length x width	23,200 m x 2,10 m
Capacity	204 (7 pas. per sq. m.)
Voltage	600 VDC
Quantity	15 train-sets ordered in 1988

Docklands City (U.K.)

Length x width	28 m x 2,650 m
Capacity	222 (5 pas. per sq.m.)
Voltage	750 VDC
Quantity	14 train-sets ordered in 1986

Würzburg City (Germany)

Length x width	28,810 m x 2,400 m
Capacity	213 (6,7 pas. per sq.m.)
Voltage	750 VDC
Quantity	20 train-sets ordered in 1992

Magdeburg City (Germany)

Length x width	30 m x 2,30 m
Capacity	234 (6,7 pas. per sq.m.)
Voltage	700 VDC
Quantity	15 + 105 train-sets ordered in 1992

GEC ALSTHOM : Your partnership in Mass Transit and LRV.

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Citicorp Center Building - 5th floor
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Chongro-Ku - C.P.O. Box 1514
SEOUL (Corée)
Tel. 82 (2) 736.40.47
Fax 82 (2) 737.35.91

GEC ALSTHOM

TRANSPORT

TRACTION

- AC traction unit for urban vehicle 600V dc. vc 750 Vdc for 1 or 2 motor bogie per unit
- Power : 200 to 450 kw / inverter
- Vehicles : trolleys, tramways, LRV, Mass Transit
- Based on 1G BT (air cooled)
- Reduction of volume, weight and cost
- Improved reliability

15

2 CASES STUDY

- NANTES
  - START LRT OPERATION IN 1985
  - 2 LINES: 22 km
  - 46 VEHICLES
- GRENOBLE
  - START LRT OPERATION IN 1987
  - 2 LINES: 15 km
  - 38 VEHICLES

'94 INTERNATIONAL SYMPOSIUM ON NEW TRANSIT SYSTEM

NANTES

	1985	1992	variation
	(1 st year of LRV)		
RIDERSCHIP	60.000.000	78.000.0000	+ 47 %
STATE FUNDING	16[illegible].000	150.000.000	- 8 %
COST COVERAGE	46 %	54 %	+ 17 %

GEC ALSTHOM TRANSPORT - F. COART - PUSAN 10/94

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GRENOBLE

	1987	1993	Variation
	(1 st year of LRV)		
RIDERSCHIP	38.608.000	50.266.000	+ 30 %
STATE FUNDING	107.853.000	102.232.000	- 5 %
COST COVERAGE	50 %	58 %	+ 16 %

환경을 생각하는 새시대의 대중교통수단 !

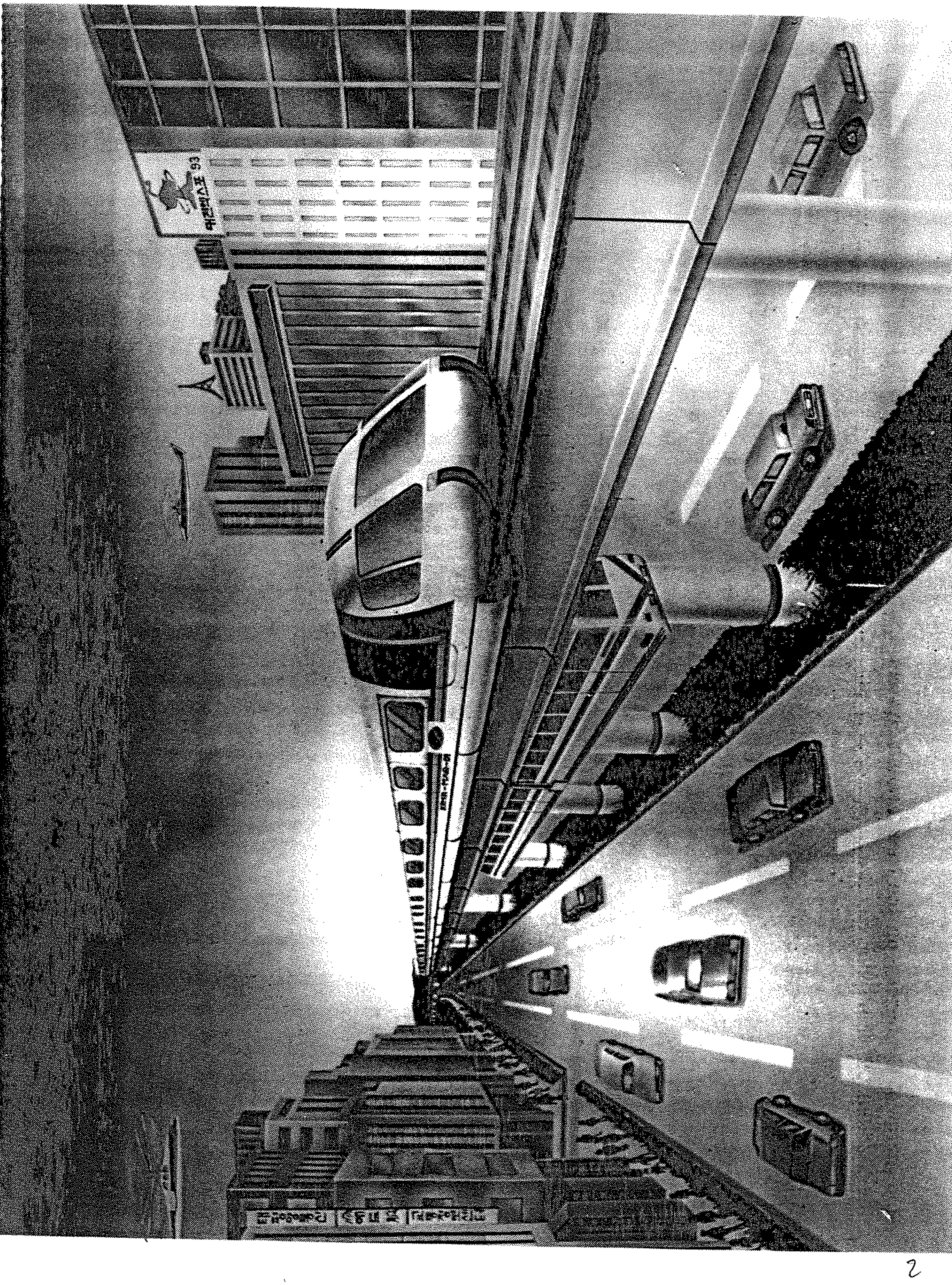
New Transit System with Environmental Compatibility !

도시형 자기부상열차 (都市型 磁氣浮上列車)

Maglev for Urban Transit

1994.10.26

한 국 기 계 연 구 원 / 자기부상열차사업단
Korea Institute of Machinery & Metals / Maglev Project

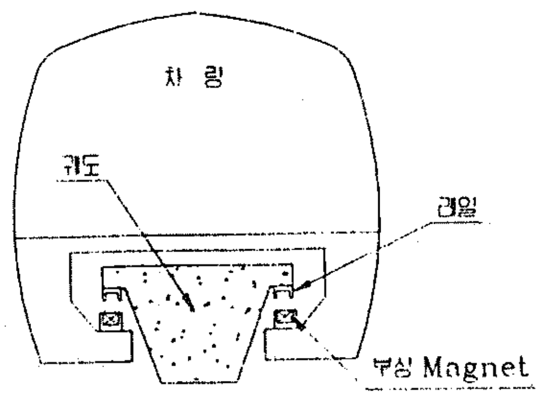


▣ 자기부상열차 의 기술방식

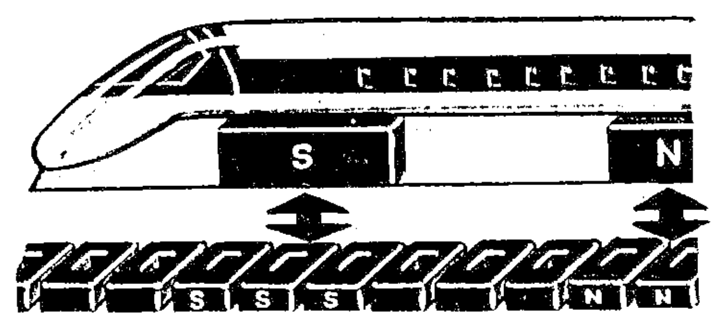
★ 부 상 : 상전도흡인식(常電導吸引式) : 일반 전자석으로 1Cm 정도 부상
초전도반발식(超電導反撥式) : 초전도 자석으로 10Cm 정도 부상

★ 추 진 : 선형유도식(線型誘導式, LIM: Linear Induction Motor) : 차상 1차
선형동기식(線型同期式, LSM: Linear Synchronous Motor) : 지상 1차

흡인식 부상 / LIM 추진



반발식 부상 / LSM 추진



▣ 실용화 기술방식과 사례

	부 상	추 진	적 용	비 고
TYPE 1	상전도 흡인식	선형유도전동기(LIM)	중저속	일본 HSST, 영국 BPM, 한국
TYPE 2	상전도 흡인식	선형동기전동기(LSM)	고 속	독일 TR
TYPE 3	초전도 반발식	선형동기전동기(LSM)	초고속	일본 MLU
TYPE 4	--------- Hybrid ------------		중저속	독일 M-Bahn

※ HSST : High Speed Surface Transport
※ BPM : Birmingham People Mover
※ TR : Transrapid

▣ 자기부상열차 ----- 어디에 와 있는지?

독일 Transrapid : 시험 완료(31.5 Km 시험선로), 상업화 확정 (베를린-함부르크)

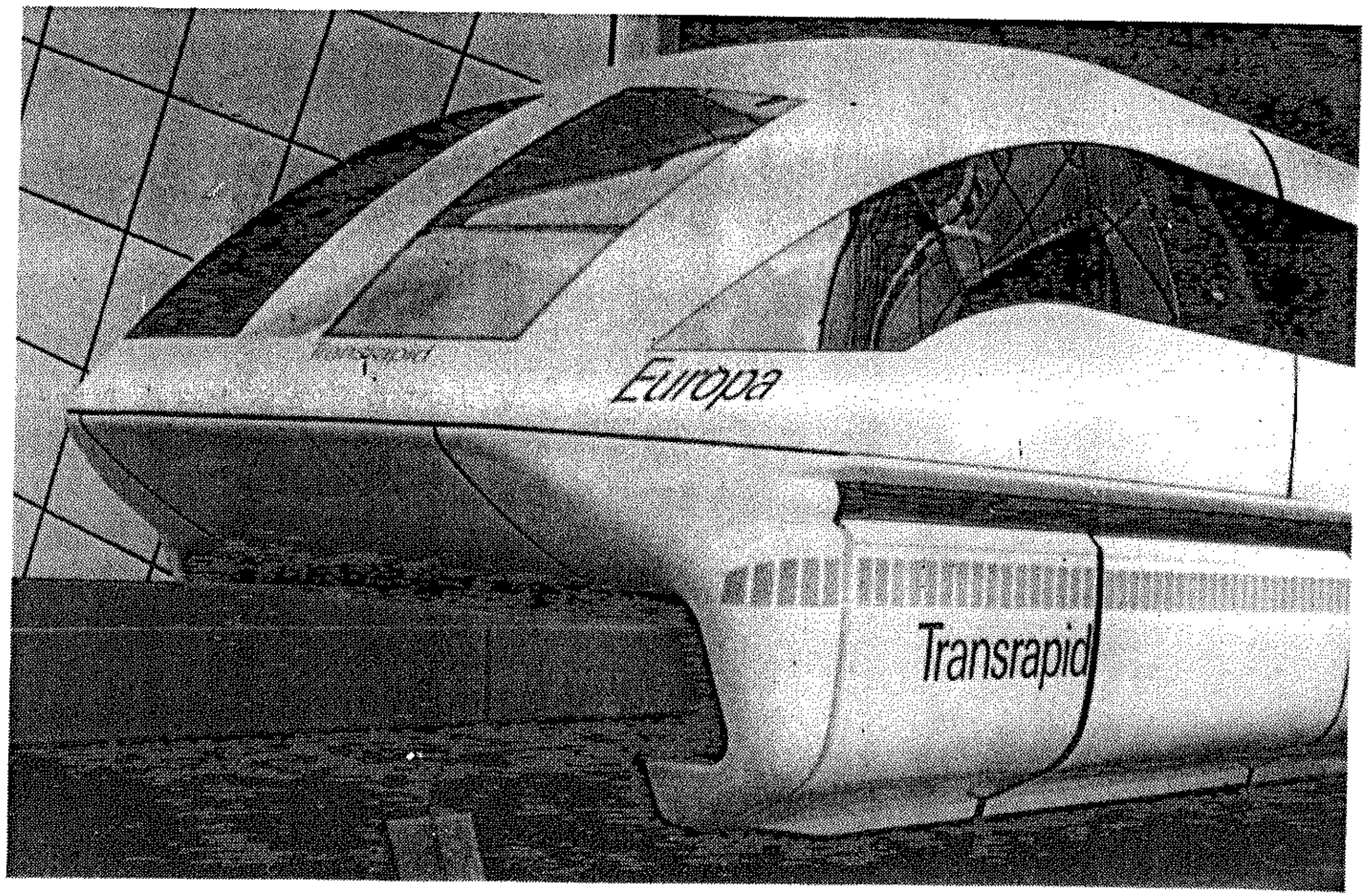
일본 HSST : 시험 완료(1.5Km 시험선로) , 상업화 추진중

일본 MLU : 시험중(7Km 시험선로) , 시험 및 상업화 선로 건설중, 상업화 추진중

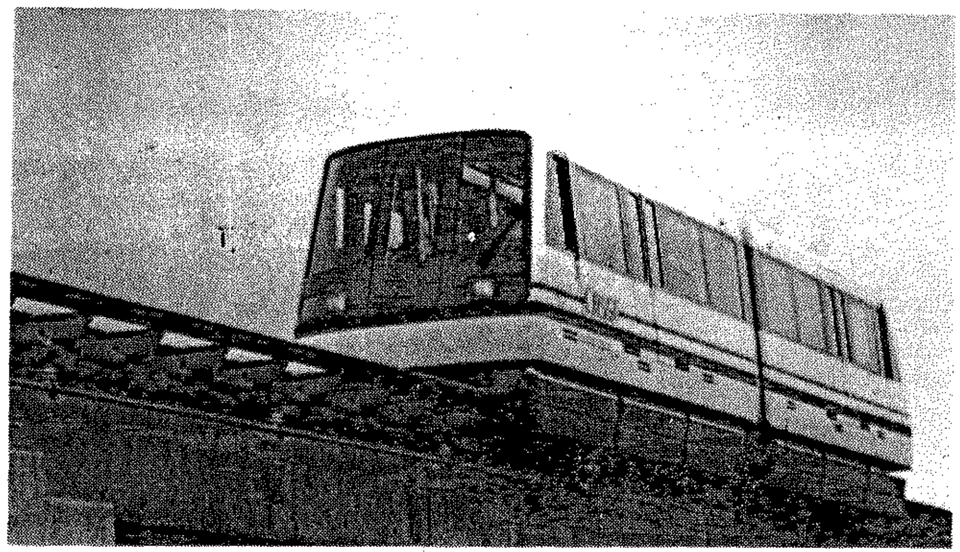
영국 BPM : Birmingham 공항과 인근 지하철역 간 600m 노선에 Shuttle 운행 ('84~)

한국 : 연구개발중, 1Km시험선로 건설중, 3~4년 후 개발 완료 예정

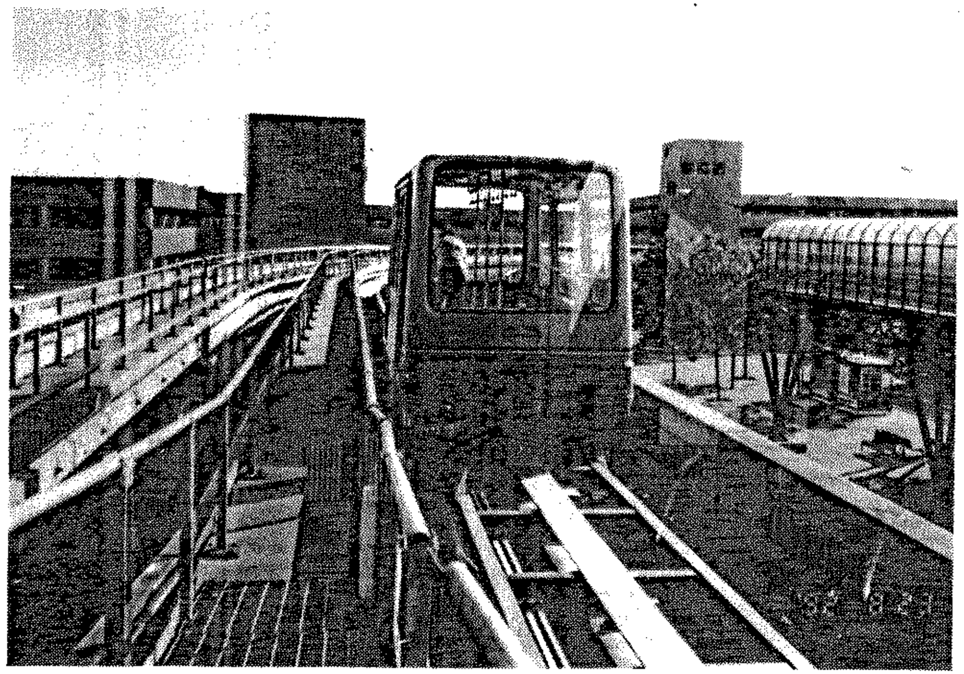
▣ 독일의 TR-07 모델(사진)



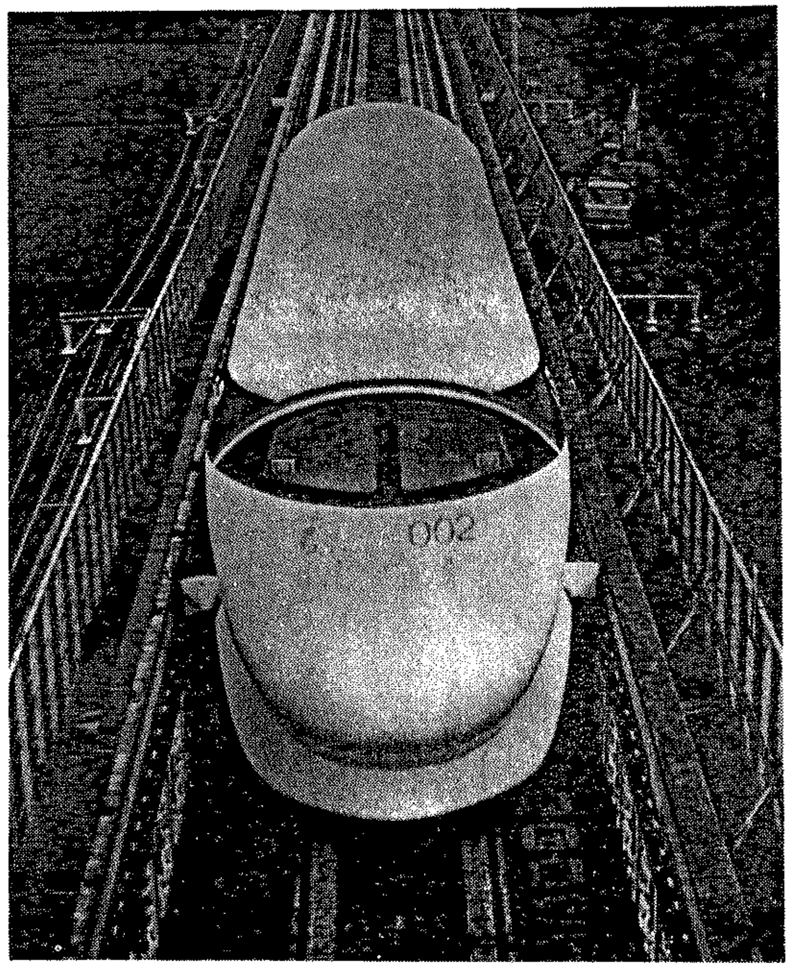
▣ 일본의 HSST-100 모델(사진)



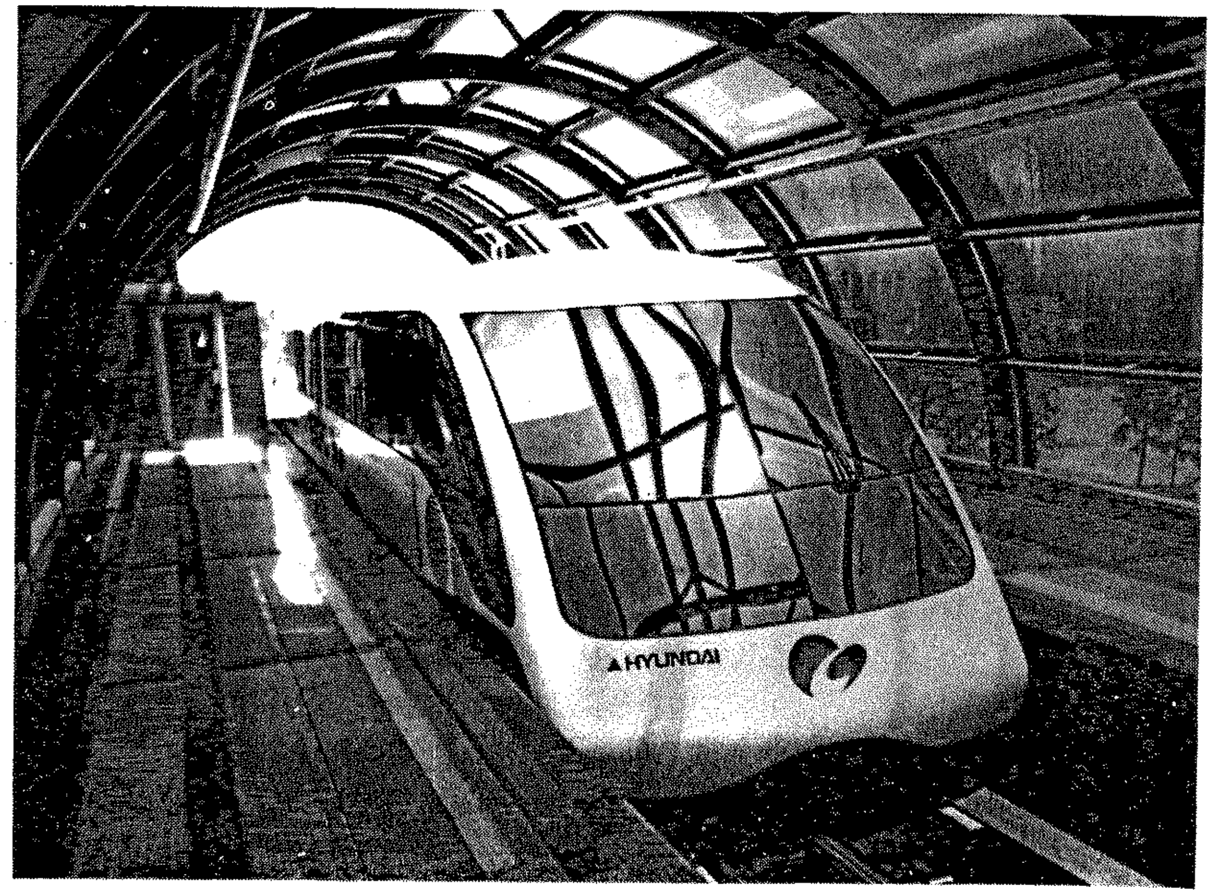
▣ 영국의 BPM 모델 (사진)



▣ 일본의 MLU 모델 (사진)

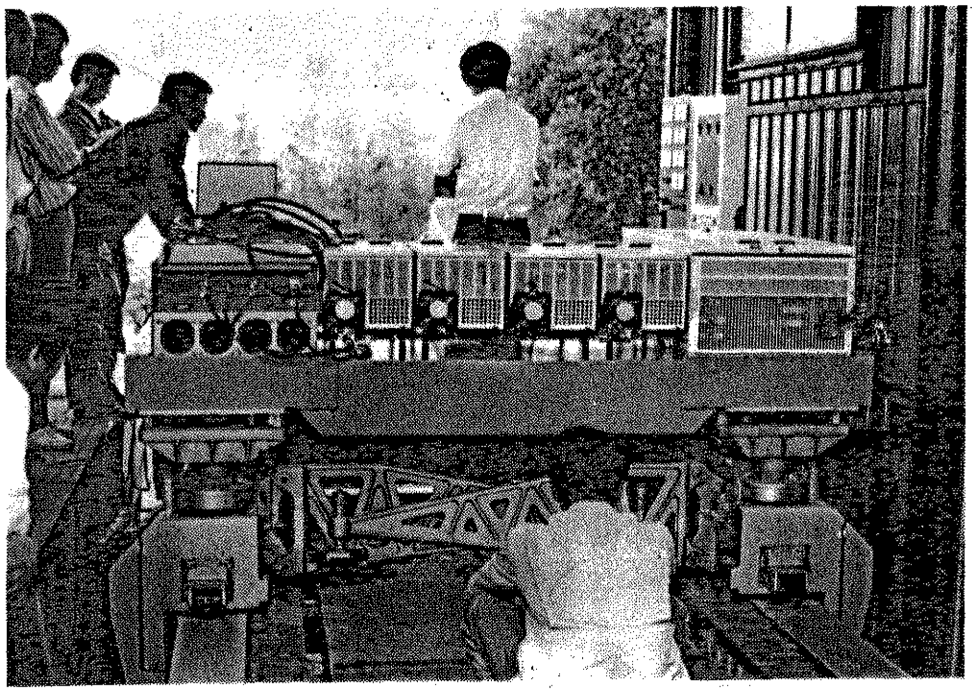


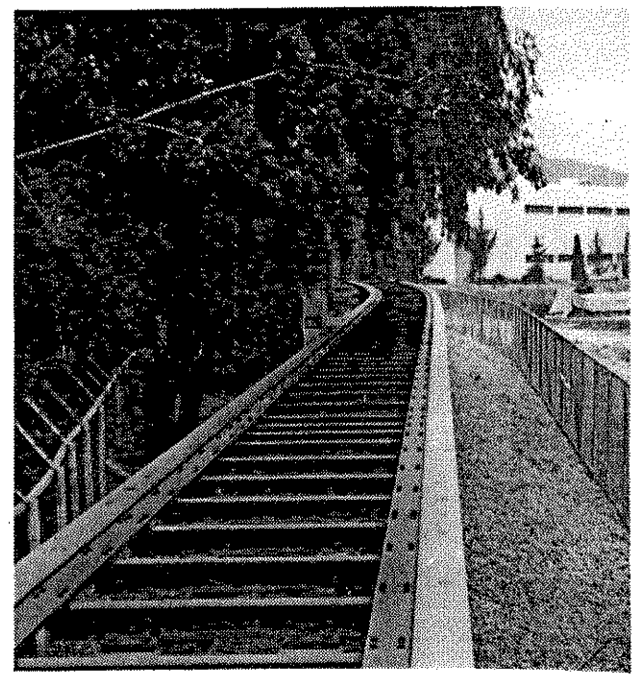
■ 현대정공 의 HML-03 모델(사진)



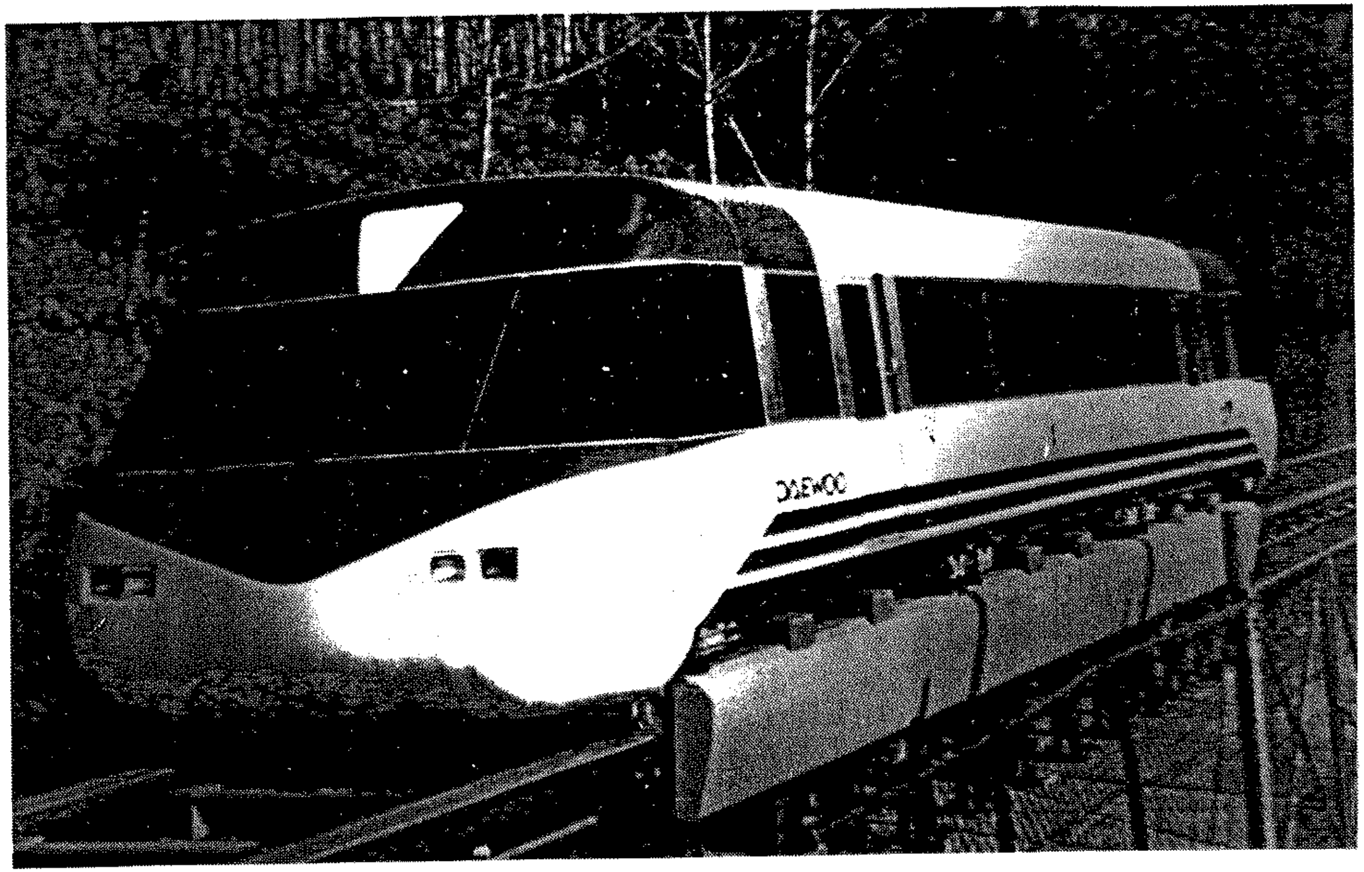
■ 현대정공의 축소시험모델 HML-02 (사진)

▣ 자기부상열차사업단의 실차형 시험모델(사진)

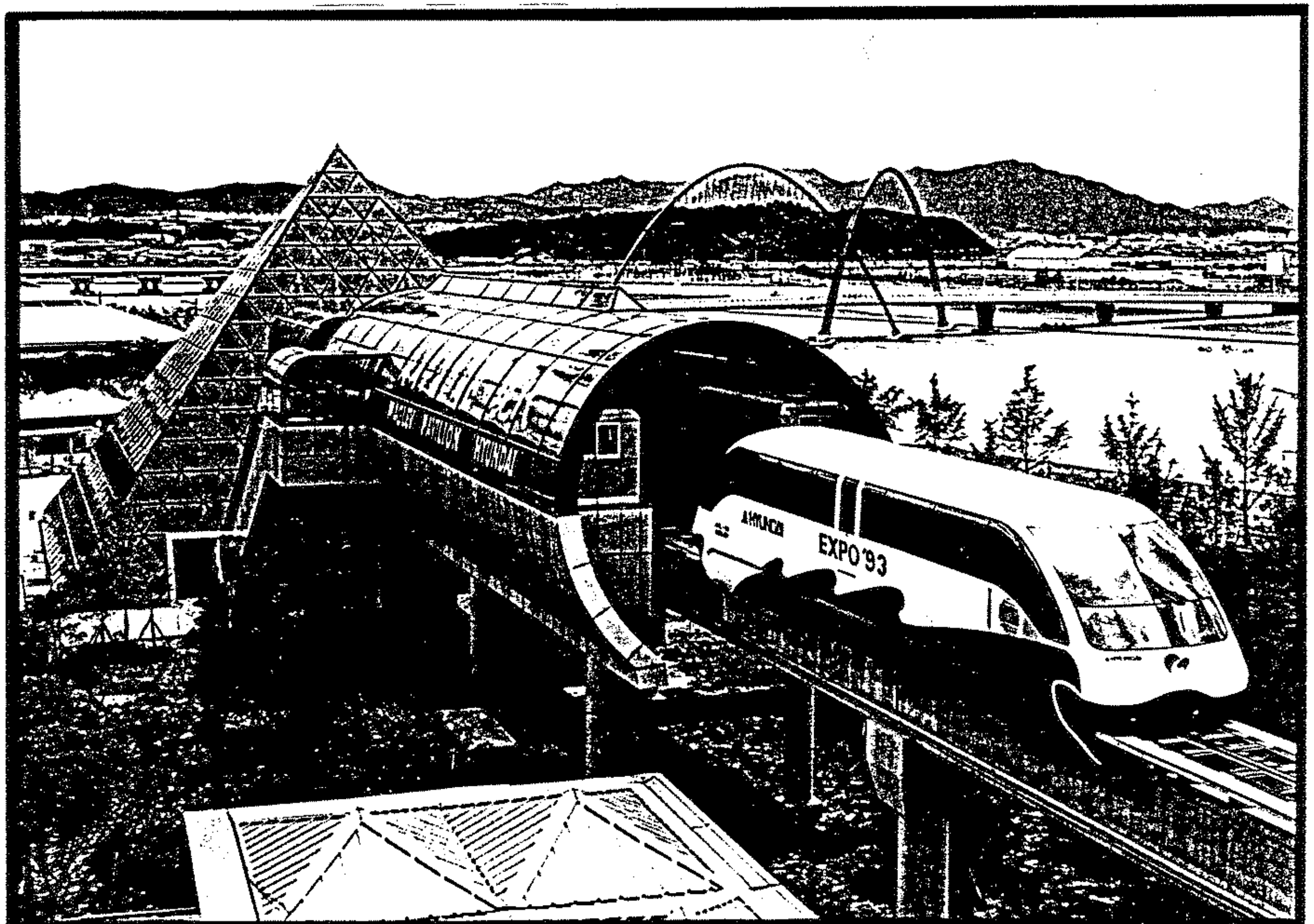




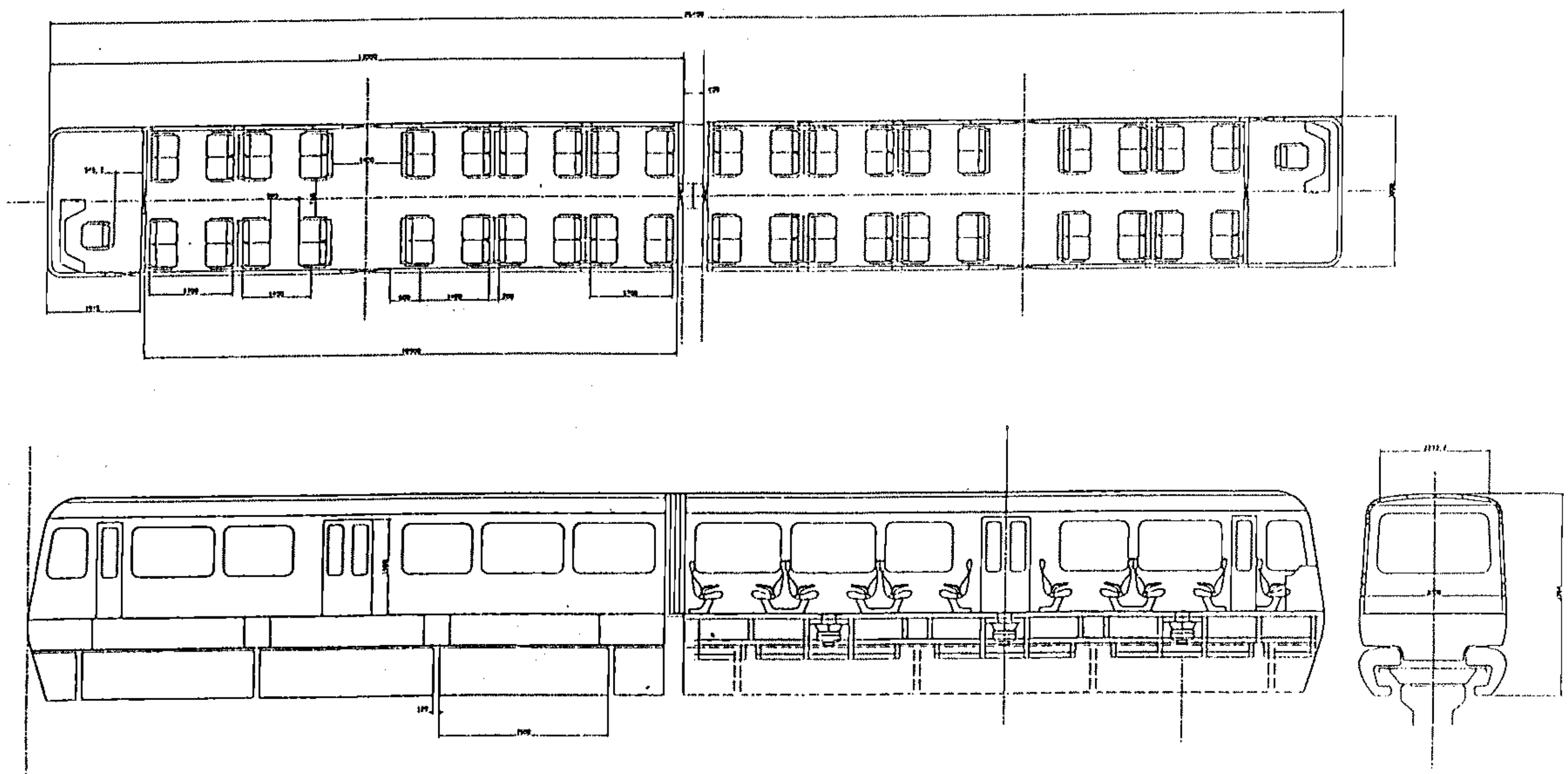
■ 대우중공업 의 실차형 시험모델 (사진)



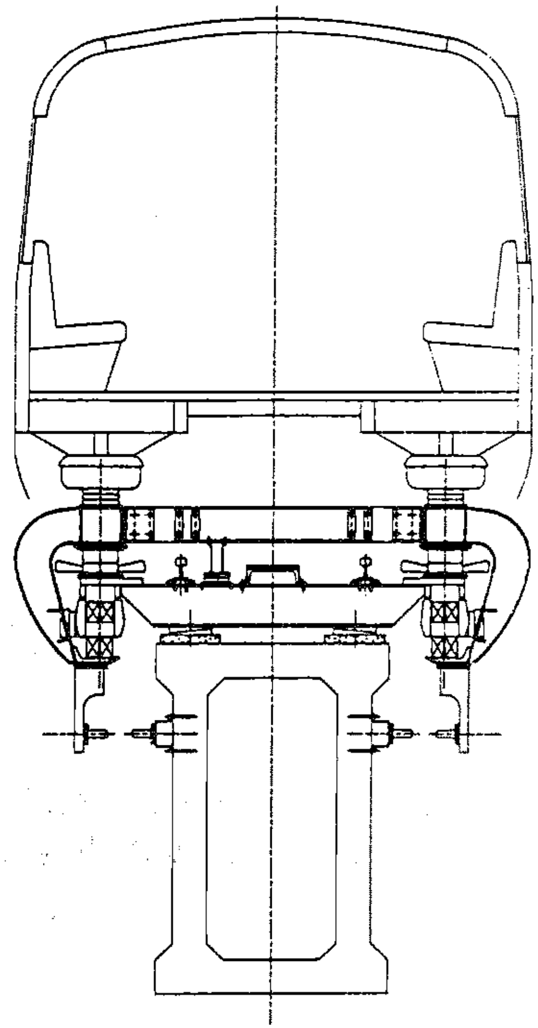
▣ 대전 EXPO'93 전시운행 모델 (: 현대정공 HML-03 모델) 사진



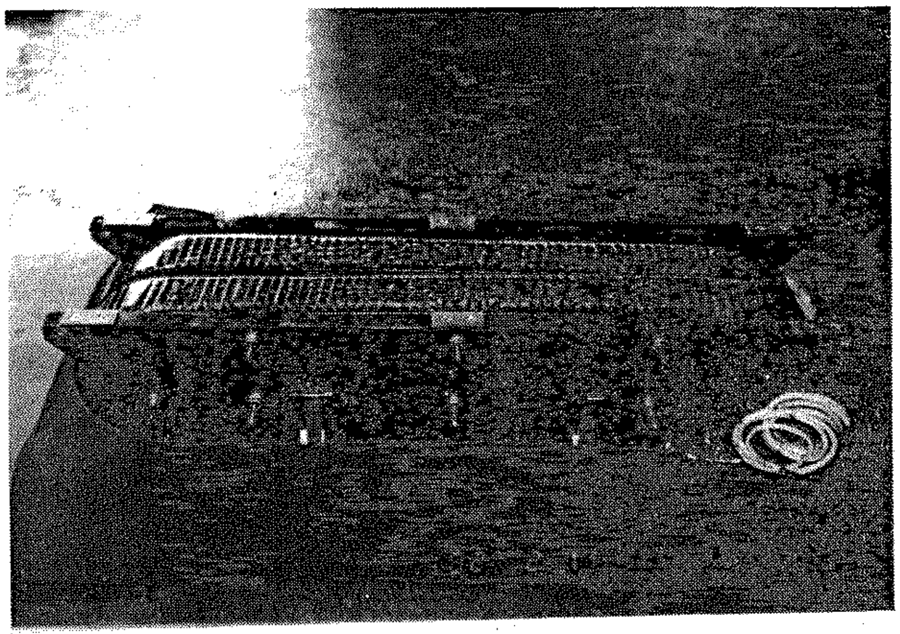
■ 도시형 자기부상열차 실용화 모델의 평면도 / 측면도 / 단면도



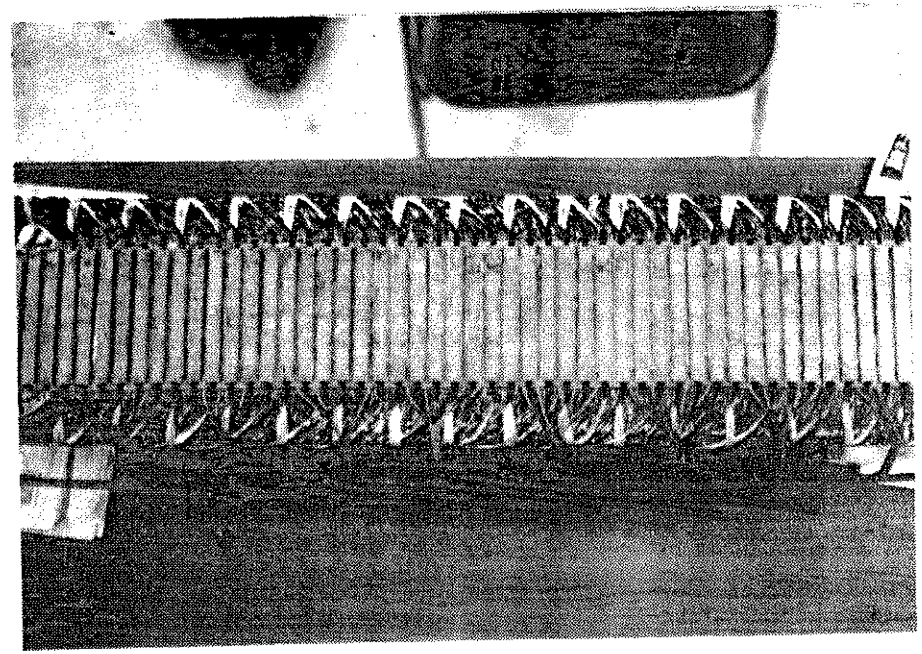
■ 실용화 모델과 레일의 세부 단면도



▣ Magnet / LIM 사진



– Magnet –



– L I M –

▣ 도시형 자기부상열차 실용화 추진계획 (안) : 부산~김해 권 경전철

◆ 검 토 조 건 : 1) 영업구간: 김해-사상 간 25.6Km (중간정차역 16 개)
2) 2011년 기준 첨두시 수송 수요 : 13,332 명/ 시간.방향
3) 승차 인원 : 선두차(MC) 105 명 , 중간차(M) 114명

◆ 검 토 결 과

편성 방식	수송인원/편성	시 격	총수요인원/시간.방향	주행소요시간	비 고
4량편성(MC+2M+MC)	438 명	2.5 분	10,512 명	38.4분/ 편도	중간역 정차 시간 각 30초
6량편성(MC+4M+MC)	666 명	2.5 분	15,984 명	38.4분/ 편도	
6량편성(MC+4M+MC)	666 명	3.0 분	13,320 명	38.4분/ 편도	

주. 1) 6량 편성 3분 시격시 차량 소요량: 총 34편성 (운행 29편성, 예비 5편성)
2) 종착역에서의 회차 소요시간 : 4 분