SUR COESTER INTERNATIONAL

AEROMOVEL TECHNOLOGY

1989 TECHNICAL NOTES

CBD PILOT LINE

PORTO ALEGRE, BRASIL

MODEL SPECIFICATION

1990

PRESENTED BEFORE
INDONESIAN TRANSPORTATION INSTITUTE
CONFERENCE ON 21ST CENTURY ISSUES
GEDUNG SUARA PEMBARUAN
15th SEPTEMBER 1989
JAKARTA, DKI, INDONESIA

SUR COESTER INTERNATIONAL
AEROMOVEL TECHNOLOGY

1989 TECHNICAL NOTES
CBD PILOT LINE
PORTO ALEGRE, BRASIL
MODEL SPECIFICATION

PRESENTED BEFORE
INDONESIAN TRANSPORTATION INSTITUTE
CONFERENCE ON 21ST CENTURY ISSUES
GEDUNG SUARA PEMBARUAN
15th SEPTEMBER 1989
JAKARTA, DKI, INDONESIA

SUR COESTER INTERNATIONAL - AEROMOVEL TECHNOLOGY

PORTO ALEGRE - CBD PILOT LINE - MODEL SPECIFICATION

1. TRANSPORT SYSTEM

The Sur Coester Aeromovel Pilot Line is a single-track guideway designed for Phase I operation with one passenger vehicle operating between two stations. The site is along the southwestern perimeter of Porto Alegre's CBD.

The first section of the Pilot Line provided a complete full-scale installation of Aeromovel Technology by which the system could be tested, researched, operated, demonstrated, and evaluated. As such, it provides the prototype model by which future Aeromovel lines gain their certification.

As envisioned by EBTU and FINEP this Pilot Line has a strategic alignment which is to be used for launch of a CBD inner city distributor loop.

From 1989 the Pilot Line contains a guideway switch which demonstrates the high-use function and non-complex design of the system. One station demonstrated layout for single alignment methods while the second station shows the layout for double track routes.

2. STATIONS

The single-track station was built with a 25m platform having a 5m width. The other station has 35m platform and 6m width. The difference in platform length reflects the research and testing plans for operation of two vehicles - the standard single-articulated vehicle and the expanded double-articulated vehicle.

3. PROPULSION SYSTEM

The Aeromovel Pilot Line has been fitted with a multi-option power-propulsion system. This options was used to permit testing, modification, research and certification of the components and to use various types of equipment within the propulsion.

Currently, the propulsion in use contains the following.

3.1 A GMP (Ground Motor Propulsion) Unit composed of one 70,000cu m blower driving in tandem by two asynchronous electric motors. Two levels of air pressure and discharge are obtained since one motor is 100 kW at 1150rpm and the other is 256kW at 1750 rpm.

3.2 Three AV (Atmospheric Values)

a. AV1 - An atmospheric value actuated by pneumatic cylinders sited between piers P37-38 and having panel of 2.5 m length and 1.0m width.

b. AV2 - An atmospheric value actuated by pneumatic cylinders installed between piers P2-3 and having panel of 1.7m length and 1.0m width.

c. AV3 - Atmospheric value powered by pneumatic cylinder between piers P02B-P03B with 0.82m length and 1.0m width

3.3 One SIV (Section Isolation Value) located between pier P31-32. It is operated by pneumatic cylinder and has 2.5m length and 1.0m width.

3.4 Along the guideway 16 locations have been provided for fitting of values and GMP coupling, with five locations currently in use. There are 3 access ducts from the top of beam and four duct plugs inserted at the end of final guidebeam segments.

4. GUIDEWAY

The Aeromovel Guideway extends 1067m over its length with 703m tangent guideway and 364m curved guideway. Beams of various design are used;

- Level/Tangent
- Gradient
- Horizontal circular curve
- Horizontal transition curve (clothoid)
- Vertical transit curve (parabola)
- Reverse horizontal circular curve
- Curve with constant superelevation (cant)
- Curve with variable superelevation (cant)
- Curve without superelevation (flat)
- Switch (Y-curve)

Tangent segments number 28 beams of which 27 beams are 25m length and one beam is 18m length.

Curved beams comprise 15 beams with:

- 7 units of 164m radius having length of 25m each,
- 1 unit of 25m length with 194m radius
- 2 units of 9.7m length with 25m radius
- 1 unit of 10.7m length with reverse curve of 25m radius
- 1 unit of 63.0m length cast in situ with three spans with radius of 166.2m, 153m, and 123.3m
- 1 unit of 25m length with clothoid
- 1 unit of 23.9m combining clothoid horizontal curve with vertical parabolic curve and transition in super-elevation
- 1 unit of 23m with 164m radius and horizontal and vertical parabola curved combined.

Construction aspects of the guidebeams differed from procedures used in conventional LRT projects. Fabrication is done in two steps and with different design standards. The straight guidebeams are normally 25m in length and are designed to achieve optimal performance with non-excessive material quantities. A design of 1982 was used for the first 20 beams, called the first generation. Tangent beams of 1987 design are the second generation and curved beams of 1987 are the third generation. From these three evolutionary designs, a fourth was used for guidebeams in Indonesia and a fifth is being prepared for the Philippine/Pakistan projects. Static and dynamic tests have been performed on the first three generations of beams and computer analysis and simulation of loads have been made for the later generation beams.

At "insert" locations along the guideway (16 locations) the opening not in use are closed/blocked by metal plugs bolted to the concrete duct.

Sur Coaster drawings #236 and #8626 show the fitting locations for valve couplings, the beam spans, platform locations, and urban street pattern contiguous to the alignment.

The vertical gradient between P41 and P08 is 0.2% while the section between P08-P06 contains a 5% grade with end transition sections.

Between piers P18-P07 a constant superelevation of 2 degrees (3.49%) is provided with transitions at P20-P18 and P06-P07. The remaining guideway is flat.

Two guideway switches are provided. One was cast and erected for future extension of the line. The other is used for alternative entry to Station Two. Curvature within switch is 25m radius.

The trackwork for vehicle guidance is provided with twin steel rails of 45kg/m. Track fastenings are two designs. On the beams cast in 1982 the fastenings are Dorbras S-75 type; a method originally patented in France. On the 1987 beams the track fastening is DEENIK spring clip, manufactured by Industrial Artetecnica of Brasil; known as DE clips in the Netherlands.

Standard "T" rail is used with thematic welding. In the tangent guideway from P41 to P20 the rail is welded to 36m length. Between P06 and P16 the rail has 50m lengths with intermediate expansion joints. Rail welding at switches is not used. The criteria for butt-welding relates to climatic conditions and guidebeam loadings.

GUIDEWAY - SUMMARY DATA

Interior Duct - Guideway Size (Cross-section): 1.0m X 1.0m
- Duct Shape: Square

Fabrication Tolerances: 5mm
Forms used for casting: One Set (comprising 20 sections for 25m tangent beam)
Beam Erection Method: Hoisting by 2 75-ton mobile cranes
Guideway Foundation: 4 piles of 35cm2 cast in site
Note: Borepile can be used, but abutting structures and soil conditions within Porto Alegre did not require this method)
Piers: Fabricated and Cast : Off Site (Casting Yard) 20 Piers
On-Site: 4 Piers
Clearance under Guidebeam: 4.5 (Minimum)
Rail Gauge (Tangent Guideway): 1600mm

5. VEHICLE

The Aeromovel vehicle is designed as two-compartments with a single mid-articulation. Vehicle has overall length of 25.9m and external floor-width of 2.75m. Interior layout designed for line-haul, short duration usage with 48 seats and 252 standees; a capacity of 300 persons. Such vehicle would be used with headways of 120, 90, 75, and 60 seconds, dependent upon traffic demand. Such frequency would provide per-direction hourly carrying capacity of 9000-14,000 as required by the specifications of the Brasil Ministry of Transportation.

The Aeromovel vehicle is supported and guided by three trucks/bogies. The two end trucks are 1.00m wheelbase while the central truck/bogie is 1.8m wheelbase. The two end trucks are fitted with one set of pylon and propulsion plate. The central truck is fitted with smaller width twin pylons and inner-beam wheels. No cross-axles are used. Each of the 12 steel-tread wheels are independent of the others. The two passenger compartments of the vehicle are built with an aeronautical underframe using low-carbon steel members and a light-weight body of aluminum panels.

VEHICLE: SUMMARY DATE

Dead Weight: Service Ready - 8,643kg (19,000 lbs)
Trucks/Bogies: End Truck - Weight 754kg (1660 lbs) each
Central - Weight 1019kg (2240 lbs)
Compartments: Two sections
Each section: Underframe: Weight 1064kg (2340 lbs)
Body : Weight 1469kg (3232 lbs)
Electric/Pneumatic Components: 300kg (660 lbs)
Propulsion Component: One Set
Pylon, propulsion plate, accessories 225kg (495 lbs)
Propulsion Plate Dimensions
Stainless Steel Frame/Panel - 94cm X 94 cm (37"x37")
Rubber Tolerance Edge (2 sets) - 100cm X 100cm (39"x39")
Brakes: Pneumatic counter-flow & on-car disc-brakes hydraulically actuated.
Wheels: 4/truck(bogie) with 460mm (18") diameter
Passenger Capacity: Peak Load
300 patrons (48 seated, 252 standing)
Passenger Doors: Four Sets of Double Doors per Side
1.8m (5'6") width each
pneumatically operated
safety interlock
Emergency Doors: Two per vehicle - with stairway (manual)
Standee Accessories: Vertical/Horizontal Stanchions
Measurements:
Railhead to Vehicle Floor 754mm (30")
Railhead to Station Platform 754mm (30")
Maximum Vehicle Suspension Variation
Empty/Full +-15mm (5/8th")
Railhead to Roof Top 2836mm (8'9")
Curvature: Minimum 20m (62')

6. VEHICLE UTILITIES SYSTEM

Various utility systems are fitted to the passenger vehicles.

Lighting - Interior: Twin groups of fluorescent lights are placed longitudinally within the compartments. Emergency lamps with UPS are installed at each door-area and at the two emergency door positions.

Lighting - Exterior: Two halogen lamps of 60W/12VDC with white color are fitted underfloor to each vehicle end.

Signalization: Four sets of twin indicator lights are fitted to each side of each end of the vehicle. Such lamps provide real-time monitoring of on-board components. Yellow light shows direction of travel, red (if activated) show degradation within any vehicle utility including brakes, doors, emergency energy.

Electric: Energy needs are divided into AC and DC systems. The DC system is collected from the running rails (55VDC) by special small collectors attached to the outer part of wheel. The AC energy is provided in 110VAC and 14VDC for air compressors, interior lamps, and the DC system. The DC system rectifies the energy (AC to DC), filters and feeds the automatic brake control system, the emergency lighting system, the control panel, the door control and the communication system and the signalization system.

On-Vehicle Brake: The on-board braking is made with friction disc-brakes mounted inside each wheel assembly. The components are obtained from commercial road vehicle sources and tested for worst-case conditions. They activate with hydraulic pressure and are interlocked with the doors, emergency controls, and the automatic brake control system.

Service Brake - Control System: This automatically applied system permits smooth and safe deceleration of the vehicle without jerks and without wheel skidding. The system contains a microprocessor programmed for efficient deceleration within each guideway section.

Door Control: Signal is transmitted between vehicle and control center to command position of doors. An antenna is placed within guideway at each station on the side to be activated. It emits a pulse command for opening or closing the doors. Doors on applicable side can be opened only if vehicle is fully stopped, brakes set, and position is correct within the station area.

Ventilation: Ventilation within vehicle reflects the temperate nature of Porto Alegre. Without long-term extremes in temperature, natural ventilation is used. Roof openings and partial window opening are sufficient within this location. (Note: In other projects, special heating and/or air cooling may be required. No technical limitation exists that would preclude placement of HVAC components on the vehicle.)

Compressed Air: Within each compartment of the vehicle an air-compressor is fitted for door operation control. Each compressor has twin reservoir tanks. The two compressors and four tanks act as a redundant system when any one component is degraded.

Emergency Equipment: Within Porto Alegre the emergency equipment is limited to two 5kg (12 lbs) ABC fire extinguishers and information panels to passengers. (Note: Option exists for use of direct-phone links between passenger compartments and central control, but this options has not been required for Porto Alegre.)

Operation Panels - Indicators & Controls: A set of panels, locked and protected from passenger/unauthorized access, is located at mid-point of vehicle. It contains the minor devices for the utility system of electric, pneumatic, and electronic. All on-board fuses are located within the panel.

7. VEHICLE CONTROL DURING OPERATION IN GUIDEWAY SECTION

Trajectory control of the passenger vehicle is maintained by use of the various patented sub-systems:

Guideway Sensor: A sub-system of reed-switch sensors are spaced along the running surface of the guideway in redundant pairs. On tangent and non-impeded alignment sections the sensors are placed 25m (78') apart while near stations, sharp curves, and special component locations the spacing is 12.5m (39'). The guideway sensors are inter-connected and linked to station control cabins by a bus cable. Each sensor emits an individual and codified signal composed of 8 bit binary code.

All sensors are mounted by metallic fasteners to the rail fasteners of the guideway. This results in uniform gap between vehicle induction coil and trackway.

The bus cable conforms to standard industrial-grade telephone cable with 6-pairs of wires. It is laid between the outer wingwall of the guideway and the running rail. Such system if provided on each side of the track, thereby maintaining the redundancy safety factor within the sub-system. Minor degradation of the system does not result in shut-down of the service.

Actuation magnets are fitted on the central truck/bogie of the vehicle to "trip" the sensors. Two magnets are placed on both sides of the truck, with result that system monitors each side twice as the vehicle passes.

Atmospheric Valve Sensor: Three types of guideway valve sensor are used.

Valve Sensor - Status/Position: Double microswitches are installed in the SIV and AV valves to monitor valve position. They are actuated mechanically by the position of the flaps command shaft/shutter within the SIV. The sensors report status with valves closed, open, or within an incorrect position.

Pneumatic Sensor - Status Pneumatic Pressure: Pressostat sensors are installed within the pneumatic feed line to report flow direction and pressure.

Electric Sensor - Vehicle Auxiliary Services/Compressors: This device is limited to direct reading of the DC energy conditions at the control panel within the vehicle.

Guideway Switch Sensor: The GSD (Guideway Switch Device) is designed with three sensor sub-systems.

Rail Point Status - Position of Switch Rails: Double micro-switches are installed at the rail blades /points to report the rail position and confirm that this agrees with the selected position within the control program.

Hydraulic Pressure Status: A pressostat device is placed within the actuation cylinder of the hydraulic line to report the condition and pressure level.

Electric Supply Monitor: A simple electric sensor monitors current quality within the AC system at the control panel.

Control Equipment: Design drawings show the process by which the Aeromovel Vehicle is controlled and monitored during its movement within a guideway section.

Within each station the control equipment includes two independent computers including two CPUs (Central Processing Units), video monitors, a keyboard and print-out unit; two UPS power supply systems, two ATP control units, two toggle switches, and a command/control panel with racks which are enclosed and arranged ergometricly in the metallic console.

The computers required are PC-XT (or equivalent) with hard-disk/winchester, a flexible disk unit, and 640 Kbytes of RAM.

Each ATP control unit (controller) is connected to the following sub-systems:

guideway bus sensor cable
Valve & Pressure Sensor
Switch Sensor.

According to the monitored reading of all sub-systems and the changes within such information, the controller chooses a speed program for the vehicle selected from a minimum of five programs available within memory. As a result of changes in vehicle position, direction, and velocity the controller monitors and compares the actual with pre-determined limits designed and set within the program Operation Design. The ATP controller maintains real-time control on the GMP (Ground-based Motor Propulsion) Unit and all valve components so fail-safe positions are maintained.

The ATP
Manual Control Override
Automatic Vehicle Protection: The ATP control contains:
UPS-Electric Supply
CPU-Central Processing Unit
CPU Interface Circuit with Guideway Sensors
CPU Input and Output Interface

The CPU uses the processor Z80, of 8bit, and auxiliary components. Computer access is made with communication interface RS232.

Each electric supply system provides +-12VDC and +5VDC for the overall control system within the station. There is a signal monitoring circuit for the CPU (watch dog), which - in the event of failure - actuates the self-test module in the control panel.

The input interface module permits reading of 16 channels (2x8) on basis of on-off positions. These are used to check the correct position/status of guideway valves and track switch. This interface is electrically isolated by an optic coupler. The output interface modules permits the connection to 16 (2x8) channels which are electrically isolated by optic couplers. The ATP controller uses a channel to send ATP trip data to the ATP mixer.

The guideway interface sensors assist the reading/monitoring of data from vehicle movement.

The DC electric energy, at constant tension, is provided within sections controlled by individual circuit breakers for each sub-system or devise requiring very high reliability. The electric system is provided by a set of UPS batteries to feed the full control system without interruptions if fault occurs within external AC public utility supply.

From the ATP controller, each computer independently receives continual new data about vehicle position, velocity, direction; guideway status data about valves and switches. Link is made with an interface modules RS232. All information is processed and displayed on the VCR monitor:

Vehicle velocity
Programmed Maximum Speed Allowed
at each position in guideway
Number of Last Guideway Sensor actuated
Toggle Switch Positions
Distance of Vehicle from: Station Departed
Station to Reach
Track Switch, if any
Section Isolation Valve
Atmospheric Valve
Ground-based Motor Propulsion
Horizontal Curve - Beginning/End

During operation, whenever any "irregularity" is detected within any sub-system of the Aeromovel Technology, registration of the event and time will be printed-out by the computer.

Information on toggle switch positions for the GMP are transmitted to the computer via interface modules RS422.

The toggle switch has seven positions - center is neutral and three positions to each side thereof. The two sets of three positions relate to the GMP and the different profiles for pressure direction and discharge rate.

At each station the control panel had double-system for door control, disc-brake, and system self-test.

The open-close door command is conveyed by rectangular magnetic antenna transmitting signals at 3kHz. It is fed by an oscillating circuit mounted at the control panel.

Vehicle service brake is controlled by 150 mH coil placed within the guideway at 100m from each station. This activates a reed-switch sensor mounted on the central truck, thereby commencing the programmed brake application.

The self-test sub-system has three basic functions:
Activation of the System: (On-Off) (ATP Activated)
Turn-off system if "watch-dog" circuit detects CPU failure within the ATP
Option of manual operation for system with ATP Off/ Bypass.

The mixer received command "ATP TRIP" from the controller at the station. This maintains or releases the GMP commands to relays for the solenoid spring-loaded valves controlling the pneumatic propulsion.

The expansion program within the computer permits vital relays within guideway, power system, and vehicle to be continually monitored for failure or correctness. Any incorrect reading will result in return to fully fail-safe position. If vehicle is at station, such failure will preclude movement of vehicle.

Automatic Operation Control: This aspect of operation control is considered in three sections:

GMP Control
Valves Control
GSD Control

The GMP control requires direct signal emissions to the GMP valves with a monitoring feed-back component. Control is performed in either automatic(ATO) or manual method. If ATO is not used, the operator at station control uses his right hand to operate toggle switch levers.

All guideway valve controls are positioned by automatic command. Manual override is normally not used or permitted.

The GSD control, as built in Porto Alegre, is manual.

The full control requires two UPS electric supplies, two GMP controllers, and a GMP mixer. The electric supply is same as used for station controls.

The GMP controller has UPS energy supply, CPU, various communication interfaces, a solenoid interface and input modules interface.

The UPS energy feeds the GMP controller at DC current of +-12VDC and +5VDC for its internal functions

The data to CPU is interfaced at station.

The solenoid activated the GMP valves, the SIV and AV, and the GMP mixer modules.

The GMP modules comprises two GMP mixer modules, the SIV mix modules and the system selector module.

The GMP mixer contains circuit to receive command from the two GMP controllers for activation of valves. When the GMP controller sends the signal ATP TRIP to the GMP, the command drops all energy feeding vital relays, effectively and safely shutting the system down.

The SIV mixer modules is similar to the modules used on the GMP.

The system selector module establishes which station has control of the GMP valves, SIV and AV.

FOR FURTHER INFORMATION, PLEASE CONTACT:

U.S.A. & CANADA:
SUR COESTER AEROMOVEL
Suite 221, 2025 I Street NW
Washington D.C. 20006 USA
Tel: 1-202-223-3805
Fax: 1-202-223-3931

BRASIL & SOUTH AMERICA:
SUR COESTER S.A.
Rua Washington Luis 186
Porto Alegre, RS, Brasil
Tel: 55-512-261088
Fax: 55-512-271 392
or 342 661

INTERNATIONAL:
SUR COESTER
c/o Lee H Rogers
4909 St Barnabas Road
Temple Hills, Md 20748 USA
Tel/Fax 1-301-894-2037

AEROMOVEL

ADVANCED URBAN TRANSPORT TECHNOLOGIES AND APPLICATION POTENTIAL FOR INDONESIAN CITIES

BY

IR IRSAN ILYAS AND L.R. BROTO
P.T. CITRA PATENINDO NUSA PRATAMA

Presented Before
Railway Transport Conference
Faculty of Civil Engineering
University of Indonesia,
UI-Depok Campus, Jakarta
6th October 1988

ADVANCED URBAN TRANSPORT TECHNOLOGIES
AND APPLICATION POTENTIAL FOR INDONESIAN CITIES

BY
IR IRSAN ILYAS AND L.R. BROTO
P.T. CITRA PATENINDO NUSA PRATAMA

What are the parameters in which to consider the use of technologies for urban transport within Indonesian Cities? Firstly, today we are reviewing a type of transport which internationally is termed Peoplemover or Automated Guided Transport. This is a system for use within urban and regional settings. Existing systems of rail and road technology are not included within this type classification. The main characteristic of such AGT technology is that the alignment is exclusive for the operation - no other use of the actual travelway is permitted. Secondly, the operation is conducted with control that is not routinely handled by personnel or staff - in effect, the transport is operated similar to an escalator or lift/elevator. Although Metros and some LRT systems are operated with complete ATC - Automatic Train Control, their operation is still conducted with a stationary driver or attendant who has a control panel that is used continually during the operation.

There has been more than two decades of activity within such technology, but the results, until very recently, have been less than clear for success. This last statement is made with reference to OECD nations, not the global need. Our interest is the transport function and development within Indonesia. With the envisioned urban expansion of ALL cities within Indonesia, whatever type of transport projects are to be undertaken, the needs are not limited to Jabotabek and Jakarta.

As planners, we need to think of what is practical for daily operation. It is possible to have technology which functions, but which as maintenance and cost characteristics that exceed practical levels. Additionally, any type of technology which is to be used should have the potential for contributing to the national resources, not detracting from them. By this is meant that the technology should be able to be development and operated by local people, both at direct operation level and at the senior management level. Such equipment should be able to be produced within the country - or at least the majority of it should be within the country. This has been one of the primary problems found for urban transport equipment during the last decades - when purchasing buses or railway equipment, the spare parts are still required to be imported. There are many reasons for this, but in the overall, it is a drain on the direct national economy and it does not encourage the local industry for provision.

Let us look at what has been developed and built during the last decade.

Now, from the standpoint of Pelita IV and Pelita V and from the standpoint of social and economic needs within Indonesia, I have the view that none of us should be "automatically" attached to any one technology simply for the sake and sales of such equipment. Both at the government level and within the private sector levels we need to think about the urban transport sector of the city. Within Indonesia we do not have only one major city, we have ten major cities today. Within the next decade this amount will grow and within the early part of the 21st Century there will be 30-40 cities with populations of more than half a million people each. Since, as a nation, we should not look only to the needs of Jakarta, but to the whole of the nation, we should attempt to find types of technology and systems which serve the best interests of the people and the nation. It was within that philosophy that my firm, PT Citra Patenindo Nusa Pratama embarked upon an evaluation of world-technologies available for the improvement of urban mobility.

There is a difference between being a national planner and a good citizen and being a direct salesman for equipment. Also, the suppliers - especially outside Indonesia - have as their first objective the sale of their equipment, not the longer-range needs of the Indonesian nation or any one of its specific cities. Therefore, we have to be a bit cautious about "friends bearing gifts". In the past decade, there have been times when proposals for new urban equipment have not been pursued by government simply because the initial evaluation showed that to buy to the technology or equipment would create worse conditions - especially from the financial view - than the existing conditions. In this way, the "do nothing" option was used.

At conferences and conventions and within academic meetings, we can think about transport methods and procedures. We can dream about new systems. However, when hardware is placed on a specific alignment for public use, the realities of operation and maintenance and safety had better be clear. During the last 15 years there have been many cases where the international urban transport community has seen equipment display poor results due to its lack of design for day-in, day-out usage. We should all understand that given enough money, given enough maintenance equipment and given enough highly-trained personnel, anyone can operate almost any type of equipment on a daily basis. However, within daily urban transport we are looking for the realistic methods, not the exotic.

Although we could have lengthy discussion about the next few statements, for the needs of this presentation I would like to review various aspects of transport systems now available for use within the world. Firstly, I am not discussing normal city bus services because the focus is upon transport methods which can reach above bus capacities, which can be operated on an exclusive alignment, and which "psychologically" give the appearance of a more attractive condition. Secondly, we are not talking conventional railway services because there have been few locations which have been able to attract private funds and to maintain profitable multi-year operation of such systems. In the case of Jakarta, urban planners have shown many corridors for future development which are not along existing railway alignments. From the economic viewpoint, railways MIGHT be upgraded into urban/regional passenger operation within corridors which have existing alignments. However, within totally new areas, the cost of land and development for an urban railway have been shown to be very high. In two examples not far from Indonesia, the Hong Kong MTR has been organized in a manner by which land values along the alignments are captured by the agency for repayment of much of the capital costs. In Singapore, the USD$2 billion development of MRT has been outstanding for its design and its engineering. However, within the operation viewpoint, government has separated the capital costs from the needs for cash flow within the system. In effect, the agency charged with daily operation does not have to generate funds for the capital cost recovery of the project. Therefore, the fare levels are set at the amount required for full operation, maintenance, and administration of the system; but not the finance or development costs.

From the time of discussions in Bappenas and Dep Finance in 1979, there has been interest within the Indonesian Government to find a system (or systems) which can be built, operated, and maintained without direct or indirect subsidy or support from government - either at national or local level. At times this seems like a quest for an impossible object. However, with the continual development of technologies within the world, it has been necessary to monitor developments within many nations and then consider how such developments could have application within Indonesia.

Let's look at some systems. I will separate into two categories the new technologies that have been developed. Those which have been built, but which are no longer offered for sale or development. Second, I will review some of the technologies which have been built and which are now being built in various cities.

One of the hardware projects which should give us insight for future applications of technology was built in a small town, in West Virginia USA. The town happened to be the home of the State University of West Virginia, Morgantown. In the early 1970s there was much excitement that "new systems" would be the short term "magic" answer to many problems. During that time many aerospace and military firms entered the marketplace, mostly by direct purchase of primary patents. Boeing was included within such activity. It developed a system and it received a contract from the US Government to build the system at Morgantown. The result was very clear. While the system could be made to work, the costs for construction and for operation were far greater than originally envisioned. Additionally, the "minor" problems of

continuous operation - both in winter conditions and in normal summer conditions - resulted in major staff and cash commitments. By 1975, the world's most successful aircraft builder had given up the promotion of this system and had withdrawn from sale of such technology. However, the system still operates, directly under the University administration.

2. The Ford Motor Company is internationally known for its role within the world's history of mass automobile production and sales. Less known is Ford's involvement within this special urban transport market. At the same time as Boeing, the Ford Company undertook a peoplemover project near its headquarters in Dearborn (Detroit) Michigan. As a real estate development a major shopping complex and convention hotel was being built. Ford proposed and built a transport system to link the hotel with the shopping complex. This alignment was to be the forerunner of many more within the shopping complexes throughout the USA. However, Ford has no background in normal urban public transport or within this type technology. As a result, the line was built, but the failure rate of components and sub-systems resulted in very high costs and major staff time commitments for maintenance. After a few years, when Ford reviewed its corporate strategy, management concluded that they should stick with the technologies they knew the best, but attempt new fields which could not provide a reasonably quick payback. So, they withdrew from the market.

At times, people (including ourselves) talk about peoplemovers as a method which SHOULD BE the same as a conventional elevator or lift; however, horizontal rather than vertical. In the same time frame as the two firms above, Otis Elevator entered into the market. They had an idea which was "revolutionary" in the technology. They would make a system without wheels. They would produce a levitation vehicle. Otis hired a staff, purchased relevant patents, and pushed to development a product. With the expansion of the University of North Carolina Hospital at Durham, a need was found for some type of mechanical system to act as a shuttle service between the existing and the new complex. Otis agreed to supply their equipment. As in the two cases given above, they succeeded in supply the equipment. The equipment succeeded in reasonable operation, but not outstanding. However, when time came to calculate the costs for development, building, and routine operation - the experience was not considered good.

Enough of horror stories. I am not hear to tell you why such systems don't work. Rather I want to show how technologically the cities of this world may be poised for a new era within their mobility.

Within Japan, France, Canada, and USA there has been development of peoplemover systems. In the case of Lille France and Vancouver BC Canada, these applications have paralleled the normal applications of either heavy rail (metros) or light rail (LRTs). From the late 1960s there has been a slow, but determined professional interest within many nations to improve the mobility of citizens. Such efforts and interest have not been solely focused on new systems. To point out a few examples there is the Metro or rapid transit developments in places like Hong Kong and Singapore. Such technology is normally called Heavy Rail. There has been international interest in the expanded use of trams or electric urban railways, such as Tien Mun (Hong Kong) or Manila. In Europe, LRT has been used for Docklands in London and Nancy France and Torino Italy. Within the USA and Canada these systems have been newly placed in San Diego, Calgary, Portland Oregon, Sacramento, and Edmonton. We can look at such technology to see what as been achieved. In many ways the investment in Jabotabek Rail has been a mix between these two types of conventional railway technology.

Within the AGT - Automatic Guideway Transport - the oldest supplier within this market is the USA firm of Westinghouse. Much has been written about their equipment and about the potential for use. However, within an direct urban application there has been been little development. From the mid-1960s this firm designed, researched, and developed a medium-capacity technology called Skybus at a location near Pittsburgh Pennsylvania. Although envisioned for use as an urban system, the equipment found its most successful application within airport complexes. Given the "slowness" of municipal urban applications, the firm has been able to use the occasional contracts with airports as a means to exist and to maintain some presence within the market. However, the one major urban application which was contracted in Miami Florida USA has not been the type of story which would endear the technology to other city governments - either within the United States or within other nations.

An early contract for use of Westinghouse's system was made with the airport authority if Tampa, Florida USA in the first half of the 1970s. As the airport has expanded in services and in passenger volumes, the use of this equipment has also expanded. Tampa was an early advocate of designing airport passenger areas around one major terminal and having it connected to a series of satellite terminals at which the aircraft were actually positioned. Today there are four satellite terminals, each connected to the main terminal by a dual-guideway peoplemover operation. None of these guideway services have switches for interchange of cars. Each guideway was but one vehicle which shuttles back and forth between the two terminal stations. In this sense it performs like a horizontal elevator. When the vehicle needs service or the guideway needs maintenance, that portion of the operation must be closed. This is not a limitation within the type of application made for an airport, but within the urban transport environment, it would not be acceptable. Looking through the decades of urban transport development, this aspect is not dissimilar to the issues raised by the 1962 Monorail line within Seattle.

From the aviation success at Tampa, and partly from the perceived competitive Florida tourist market, the airport at Orlando (near Disneyworld) also contracted this system. It was designed and it is operated in nearly the same manner - as

separate guideways between a central major terminal and a series of outlying smaller departure buildings. The distance of the route is under 600m. With the short trip and extreme peaking of passenger demand, the vehicles are designed for standees only. Therefore, a vehicle that would normally be considered with capacity for 40 seated passengers within an urban context has the capacity to handle 160 people per car since they are standing. Passengers within this system are transported without direct payment of a fare. In effect, the expense of the service is "hidden" from the user by having the airlines and the airport tenants paying the cost in their terminal fees and leases.

Within the USA, airports at Miami, Seattle, and Atlanta have installed this system. Outside the USA, only the United Kingdom airport of Gatwick has purchased the technology and has it in operation. In 1987 the Changi Airport Authority of Singapore contracted for a 600m guideway to line the new terminal area with the existing building. This project is now under construction.

The Atlanta system comes closest to an urban application. Along two guideways there are five or more train-sets operated. At each end terminal the vehicles are switched to the return guideway so one track operates as inbound and one track as outbound - similar to a standard double-tracked railway. There are four intermediate stops in each direction. Rather than having the main terminal connected by several independent guideways, the airport was designed with the satellite terminals being in parallel. The peoplemover runs totally below ground. The aircraft are positioned above the area of its route. The operation has proven to be a very effective way to handle large numbers of airline passengers and employees within a facility catering to high amounts of transfers and transit passengers from one carrier to another and among various flights. However, with the full peoplemover being underground, it is obvious that the technology has an environmental conditions which optimizes its performance since there is not rain, snow, wind, or external dust and trash which can influence the actual operation.

Westinghouse systems
- Tampa, Florida, USA
- Orlando, Florida, USA
- Atlanta, Georgia, USA
- Miami, Florida, USA
- Singapore Changi Airport, Singapore

From the early 1970s, more than 16 years ago, a group of businesspeople, university people, and transport professionals proposed the establishment of a government-equity firm within the Province of Ontario Canada to confront the challenges within urban and regional passenger transport as they perceived it. They caused to be formed the firm of UTDC - Urban Transportation Development Corporation. From the corporate standpoint this firm tried to be in urban transport what the European Aircraft Consortium had been for air carriers. From 1973 until 1986 this firm dominated policy and investment within the province and to some degree within Canada and internationally. As was prevalent within the 70's decade, the theme permeating the activities was that the "existing" methods and equipment were obsolete and provided little value for devising new methods. This firm, with available funding from the provincial government, commenced to make and market a new transport system. The peoplemover which was developed has been built for passenger services in Toronto, Detroit, and Vancouver. While much promotional documentation has been available, the direct operational experience and the cost experience has limited the application of this technology. Toronto used UTDC for one line at Scarbourgh. This project was undertaken as the "direction" of the provincial government even though the transport agency of the city did not endorse the use of this equipment compared with a modern LRT system. As a result, there is an agency operating the system who does not believe in it. Even though it has been built and certified for full automatic operation, the transport agency maintains one full-time "driver" or seated attendant in each operating vehicle due to "tradition" of transport operation.

From 1978, the United States Department of Transportation, in the form of its UMTA - Urban Mass Transportation Administration - promoted a national competition among cities to invest in new urban transport technologies. The experience of this program is worth a whole workshop on its own. For the subject of today, I will limit this story to the fact that only two cities actually received grants of funds and authority to undertake construction. One of these cities was Detroit Michigan. Within this city the successful applicant for the technology was UTDC.

The best application of UTDC has been in Vancouver, British Columbia, Canada. In 1986 this city and province hosted a major international exposition on the theme of transportation. One requirement within the city was to develop a showcase urban transport system which could attract and handle the anticipated crowds. From 1981, with a Can$600 million loan from Ontario Government, the Government of British Columbia agreed to build UTDC for this 14km line. Much of the alignment was obtained from an freight-only railway and entry into the centre of the city was achieved by use of an existing railway tunnel - thereby minimizing capital costs.

It has been interesting that other Canadian cities, outside Ontario Province, have not taken up the use of UTDC technology but rather opted for the LRT systems with equipment purchased from FRG-Germany. With provincial and national elections and the shift in provincial polity, the public firm of UTDC was privatized and the major equity was purchased by the consulting firm of Lavlin. This has not changed any aspects of the technology design or the equipment offered within the system. The system is still offered for use internationally, and the Bangkok Expressway and Rapid Transit Agency is actively reviewing the merits of this hardware for their long-awaited mass transit network. However, the price "offered" for the complete system is above One Billion USA Dollars for the 32 km system. (That is USD$

31.25 million per double-track km or USD$15.6 million per track km.)

UTDC/Lavlin System
Detroit, Michigan, USA
Vancouver, British Columbia, Canada
Toronto, Ontario, Canada

With the interest of USA, Canada, Japan, Germany, and UK in the development of AGT and/or Peoplemovers, various firms in France focused upon the technical potentials and the market. The most successful of these firms has been Matra with the development and installation of their VAL system. From the passenger's viewpoint (if not purse) the VAL technology would seem compatible with both Westinghouse and UTDC. However the VAL was the first to construct a peoplemover technology directly into the city centre in a manner that would permit full urban passenger services. Prior to 1984, this type of equipment was contained only within "special" areas such as airports, theme parks, and new town or new industrial park areas. VAL within the city of Lille France demonstrated what an effective peoplemover technology could do. While the capital costs and operation expenses for the technology have been high, the quality of service offered to the public resulted in much higher patronage than had been forecast. The success of the first major radial line within Lille resulted in an increase in patronage for all parts of the urban transport network within that city. Services have been operated at 16 to 19 hours per day with frequencies of 3 minutes for both peak and non-peak periods. This compares with the "standard" practice of undergrounds and LRTs to operate at 6 minute headwyuas for peak and 20 minutes headways for non-demand periods. Once the public saw the high frequency they were more willing to use the system at any time day or night. Fares were established at levels compariable to tram and bus and a network daily, weekly, and monthly pass was available. The services commence at two outlying parts of the metropolitan area and pass directly through the centre of the city - with stops at both the main railway station and the main commercial centre. The frequency permits non-peak patrons to have a seated journey while the patrons in peak periods have 50% change of having a seat for part or all of their journey. Additionally, the lower capacity of the vehicle combined with the higher frequency of service has resulted in the commuter traffic being high due to the public's feeling that the crowding is less than would be experienced on a conventional bus or tram. There has been no public protest at fully automatical operation. The technology is operated without on-board technical staff. Security and fare inspectors are combined with extensive use of CCTV to provide a demonstrated safety for the patrons of the system. In the first year, the random acts of vandalism and theft were effectively dealt with and the public quickly concluded that the system was a safe environment to use. (Compare this with the urban metro system of RATP which had more than 4200 theft cases in the year 1986).

With the public success of the first line, the central government and the local public backed the financing for a second and third commercial line within Lille. With the better corporate stability of MATRA compared with UTDC, several transport agencies have shown interest in contracting this technology. Some current locations include O'Hare Airport in Chicago, USA; Jacksonville, Florida USA, and Bordeau France. Within the French urban transport sector, this technology cannot be said to have clearly shown a superiority since various French cities are still building, planning, and evaluating other technologies, especially LRT systems.

Matra system
Lille, France
Jackeonville Florida, USA
Chicago O'Hare, Illinois, USA

Within the context of Indonesia, especially Jakarta, an additional technology should be mentioned even though it is not "technically" an automated system. There has been much comment and some consideration within private and government offices about the use of bus-related technology being promoted by Mercedes Benz. This is called the O-Bahn. A variety of benefits have been stated for this concept. However, the only full application of such equipment is to be found, not in Germany, but in Adeliade South Australia. The idea is that higher capacities can be achieved by bus with such bus is on a controlled guideway and when the steering is done without driver participation. A 14 km line has been open for two years. In the case of this city, the selection was not done on a fully technical basis. Earlier studies had proposed use of a light rail system, but this issue became politicized. When the party in power was changed through a state-wide election, the new party needed a non-rail solution to the development of the corridor. The alignment is made through an environmentally sensitive area - a flood plain which has been turned into a linear park. However, the use in Jakarta would not be in a similar area, it would be along a major arterial and through high-density settlements. In Adelaide there are only two intermediate stops within the 14 km. This is not the manner in which operation would be made for Jakarta. The cost for structures would be high due to their width and the design of the stations. The major point is that any type of single-lane busway must be used by vehicles which have very high levels of maintenance and dependability. Currently within Jakarta the 2600 buses of PPD have a daily failure rate of more than 300 units. Most of such failures are short in duration. However, ANY failure within a bus-guideway would mean that many vehicles would be quickly affected by the breakdown. If the fleet to use the busway is to be a seperate fleet, with seperate maintenance location and special maintenance equipment, then the cost to provide the service would be much higher than the current bus operations. The proprietary designed guideway has been developed ONLY for the use of specially equipped bus vehicles. Normal road vehicles cannot use the alignment and even emergency vehicles such as police, fire, and ambulance would not be able to use it. In Italy, Japan,

USA, and Brasil the special busways are used for emergency vehicles and, in some cities, for public taxi vehicles. Except for a short segment of O-Bahn in Essen, no German city has regular use of this technology and no German city has active interest in installing such system within their comprehensive transport network. One of the major savings, within European cities, comes from removal or reduction in staffing levels. However, O-Bahn still requires the driver to be sitting in the vehicle even though he is not steering. Therefore, it is an expensive new technology without major savings in direct staff costs. Productivity is improved due to the higher speed, but actual cost reduction is not found.

Now, with this summary of world development within AGT systems, I would turn to a review of the technology that we have selected for evaluation and use within Indonesia. It is very prudient for professionals to ask what the merits and the liabilities of such a system would be. It is best to evaluate the system on the needs of Indonesia, its people and its cities - not on the design or desire of the technology's inventor or marketing people.

Concomitant with the private and government efforts to make a new system within nations of North America and Europe, there was a private firm in Porto Alegre Brasil undertaking a more methodical evaluation of the needs within urban transport. Under the direction of Mr Oskar Coester, the firm of Coester Transport considered the parameters for urban passenger use of technology and the trade-offs for energy, cost, ease of operation, and safety. Without a pre-set deadline of when such equipment would have to be on-market, they were able to approach the problem in a much less stressful manner than seen in other larger firms. By the year 1980 a one-third scale operating model had been erected. By May 1983 at the edge of the CBD of Porto Alegre, a 650m pilot line was completed and placed into operation. From 1983 to date this line has logged more than 18000 hours of operation and 103 000 cycles of operation. From early 1988, with partial government funds, Sur Coester has supervised the extension of the pilot line. With this extension, with the development in Indonesia, and with the change of staff within Brasilian agencies there is more interest for funding a complete loop line within the CBD of Porto Alegre. This would result in a clock-wise operation along a 3.8km loop with seven stations.

However, our interest is not Brasil, but Indonesia. To most people familiar with the urban development of our country, there is a major issue to be addressed. Jakarta is NOT the only city within Indonesia to require improved transport infrasturcture. There are many cities which will double or triple their resident population within the next 15 years. If the need was only for one line within Jakarta or only for one network of any technology within Jakarta, it might be possible to undertaken existing methods for urban transport mobility. However, we have Medan, Bandung, Surabaya, Ujung Padang, Semarang, and other cities. Therefore, within Pelita V and Pelita VI, government must obtain the best development within the very limited funds available. It is within that context that the Aeromovel is being considered. It has many advantages not found in other options. Firstly, it has a low capital cost in regard to the capacity provided. Second, it can be installed in very short time period and with minimial disruption to the local land uses. Third, it has the best energy conservation of any urban system. Fourth, it can be installed within existing public rights of way. Fifth, it will not compete with the State Railway for goods. Sixth, Local materials can be used for erection, therefore, foreign costs are minimal. Seventh, local engineering talent and local constractors can undertake such work without participation of foreign experts. Eighth, the audio-emissions (noise pollution) is 68dB and the atmospheric pollution within the alignment is nil. An overall asset of the Aeromovel has not been stated because it permeated the overall concept of the technology. It is a safe system for the user, the worker, and for the contiguous public.

In some ways it takes "unreasonable" people to develop new approaches to old needs. This seems to be the case with Aeromovel and the construction within TMII - Jakarta. From the viewpoint of project development the Indonesian firm of PT Citra Pratenindo Nusa Pratama has agreed to the construction of the 3.2km loop line within a period of less than nine months. Ground-breaking was on 22nd August of this year and the public operation will be underway by April 1989. Further, the full cost of the project will be kept to USD$10 million or less. This is equivalent to USD$3 per km. Construction will be undertaken within an area that is already established, unlike some technologies which have been built at the same time as the development of the area to be served. TMII was opened in 1975, so we are building within an area which has already existed for 13 years. From the viewpoint of engineering the more interesting points include: The full use of Indonesian contractors; the inclusion of 10 percent gradient, the existance of a 25m radius curvature, fabrication of piers and beams off-site and maintenace of environmental integrety during the construction phase.

FOR FURTHER INFORMATION, PLEASE CONTACT:

U.S.A. & CANADA:
SUR COESTER AEROMOVEL
Suite 221, 2025 I Street NW
Washington D.C. 20006 USA
Tel: 1-202-223-3805
Fax: 1-202-223-3931

BRASIL & SOUTH AMERICA:
SUR COESTER S.A.
Rua Washington Luis 186
Porto Alegre, RS, Brasil
Tel: 55-512-261088
Fax: 55-512-271 392
or 342 661

INTERNATIONAL:
SUR COESTER
c/o Lee H Rogers
4909 St Barnabas Road
Temple Hills, Md 20748 USA
Tel/Fax 1-301-894-2037

INDONESIA:
P.T. CITRA PATENINDO
NUSA PRATAMA
23rd fl, Gedung BDN
Jl Kebon Sirih 83
Jakarta, DKI, Indonesia
Fax 62-21-380-1727

AEROMOVEL

PORTO ALEGRE'S AEROMOVEL DEVELOPMENT

Oskar H. Coester

Exhibited At

TRANSEXPO 1990 - US DOT

Sheraton Washington Hotel
Washington D.C.

PORTO ALEGRE'S AEROMOVEL DEVELOPMENT

Oskar H. Coester*

Abstract: The Aeromovel technology has operated within Porto Alegre, RS Brasil on a pilot line of 2000ft (650 m) since May 1983. While daily commercial passenger operation has not been offered, the installation has provided a full range of operation and maintenance experience which demonstrate the financial and physical merits of its use for urban transit.

1. Background of Technology:

Frequently, many cities and firms react with surprise as to the physical existence of Aeromovel Technology. The system has been developed and incrementally designed over the last two decades. Since the technology was invented by one person rather than a committee or a work group, there was a development atmosphere which lacked unrealistic time-limits for production of the hardware. As a result, the technology and its sub-systems were evolved in a comprehensive manner devoid of concern for what current product lines could be incorporated into the "new" system.

1.1. The Designer's View of Need:

During the mid-1960s, international aviation was changing from piston to jet aircraft. During work with Varig Airlines, I was struck with the anomaly that people could traverse 600 miles (1000 km) in an hour within the aircraft, but they frequently required more than an hour to cover twenty miles within urban areas to and from the airports. The question then was raised, "What can be done and how?"

After establishing a private manufacturing firm in Porto Alegre, I continued to think and sketch the issues for short-distance mobility. With an aviation background, I first viewed many existing land-transport systems as having a major flaw - excessive weight. Second I concluded that alternatives might exist to the use of direct electric propulsion of the vehicle. Third, I reasoned that whatever system evolved, it would have to be simple and rugged for the needs of urban transit. Fourth, evaluation showed that lower energy was required for vehicles using steel wheel guidance and support. Paramount to all this development was the railway and aviation philosophy that safety was not to be sacrificed in any way - there would be redundancy and there would be fail-safe methods and procedures used.

----

* Technical Director, Sur Coester SA, Porto Alegre RS Brasil

1.2. Early Tests and Research:

At a suburban plant, a short test track was built to demonstrate the basic parameters of the equipment in 1977. This was a test-bed with a single seat, propelled over very light rails with use of a 3hp blower. Even on such a modest installation, the principle was well proven. This resulted in greater interest to built an enlarged test facility. In 1978, a 2040ft (650 m) steel-duct track was built near Novo Belem, a Porto Alegre suburb. This alignment had 5% grades, 94ft (30m) radius curves, and a passenger vehicle with 8 seats. An additional test-bed with sand-bag weights was used to calibrate the amount of weight and the degree of velocity which could be gained. Throughout these tests the main consideration was full, constant and safe control of the vehicle and the operation. The results confirmed that use of large diameter cross-section ducts with low pressure pneumatic flows would permit reliable operation without major leakage.

Within Porto Alegre there was growing public awareness that a new technology was being developed. Through local government interest, a short demonstration line was placed at the State Fair Grounds. In the years 1979-1984, during the week-long annual event more than 5000 people were able to try the system, using a 12 seat vehicle. The result of these two operations was to demonstrate that larger vehicles and higher speeds could be handled.

1.3. Initial Government Participation:

From mid-1978, the Brasil Federal Government, through its agency EBTU - Brasilan Urban Transport Agency, gained interest. A detailed schedule of testing was formulated. A full-size test track was designed near Porto Alegre's CBD. Part of the earlier steel-duct trial line was shipped to Hannover Germany and exhibited as an running system in the 1980 Commercial Fair. At this location the technology was approved for use by Hannover-TUV and 18 000 visitors tried the technology.

2. Phase I - Porto Alegre Pilot Line - 1982:

In October 1982, a joint-effort started between the EBTU and Coester SA for installation of Aeromovel. The original schedule called for a 3150ft (1000m) single track section with two stations. A further extension would follow by which a multi-station circular line would result between the historic center of Porto Alegre and the new State Government Administration Headquarters. However, in early 1983, the government agency shifted priorities within its national planning and withdrew support from the construction project. Coester and the suppliers of materials completed a 650m section and equipped it with power unit, vehicle, and a single station and control center. The system's pilot line opened in May 1983. The power plant was custom made with two electric motors coupled to the industrial pneumatic blower. This permitted testing and research. The controls were for semi-automatic operation. The method of control was automated operation between stations, but manual control of the vehicle within the station. Therefore door controls were vested with the control personnel, but they were positioned within the station, not upon the vehicle. The controller and the driver were merged into one position that did not require complex electronic skill or extended years of training.

3. Interim Operation and Evolution of Design:

Although the single-station configuration of the pilot line did not permit "normal" passenger utilization of the technology, the firm operated the vehicle and system as if it were in routine public operation. Between 1983 and 1986 the vehicle "hauled" a static load which represented the equivalent of 300 passengers within the car. This load remained in the vehicle 24-hours throughout the period as a means to test the structural integrity of the vehicle. Casual visitors were permitted to ride at will. Their comments were sought. With the daily operation of more than ten hours per day, minor modifications to electronic controls and vehicle fittings were made. However, no substantive changes were required within the technology. During this five year "interim" period, it was possible to monitor the condition of components and subsystems during severe heat and near-freezing cold. Operation experience was logged for sunny days, major rainy periods, and high windy occurrences during winter and summer. During this five years operation phase there were no emergency conditions occuring and no serious failure of sub-systems or components.

By mid-1987 Coester become encouraged to join forces with a major Brasilian supplier of elevators (Sur Elevators SA). In October 1987 the joint firm of Sur Coester SA was established. With further emphasis on Aeromovel, new government funds were made available from the Ministry of Research and Technology to extend the line up to the first 3150ft (1000 m).

4. Phase II for Pilot Line - 1988:

In February 1988, construction commenced on the 1400ft (450m) length westend of the 1983 pilot line. Local contractors and domestic suppliers were used. The steel moulds for casting the beam were fabricated. The mould has been designed to permit use for both straight and curved sections. During July 1988, nine beam sections with curvature of 250 foot (85m) radius were cast. These beams were placed by late August. The city and state have plans to enlarge a parallel arterial road, so design called for a 118 feet (38m) span within the guideway. Current designs permit off-site fabrication of beams up to a length of 100feet (33m). Therefore this long, curved section was done in-site. This work provided a direct cost comparison for on-site /off-site

methods of erection. At the "Northern" station the system has a switch and a track section with 5% gradient. The horizontal curvature of the switch is 78 feet (25m) radius. A new power plant was installed using the concept of quick-replacement and backup for components and systems. The control system was designed with local hardware and proprietary software to operate the system with full automatic methods.

5. State Government Plans for CBD Loop:

Prior to the completion of the current extension, agencies of the central government and the mayor embarked on plans to continue the construction into the central historic area of the city and then extend the line to form a single-track loop operation. While the interest is evident from the government, the current problems for implementation are related to the general public finance crisis of the country.

The engineers of Sur Coester SA have shown the municipal government and the Ministry of Research that the envisioned loop infrastructure can be built within 14 months. However finance between national and local sources remains unclear. As of end-1989, the cost for the 8500ft (2.7km) additional guideway and related components was planned at USD$8.9 million.

6. Influence to Indonesia's TMII project:

The five years of operation for Porto Alegre's pilot line provides clear evidence of the maintenance and inspection needs for use of Aeromovel. As one visitor stated, "This pilot line has the significance of the the Rainhill Trials" (where English steam locomotives of 1829 showed the power advantage over animal horsepower).

When the various Indonesian planners, executives and engineers became interested in use of this technology, the pilot line provided physical proof of the Aeromovel. It was seen that this short line had been built to urban transport standards and that all sub-systems performed at or above their envisioned strength.

When the largest contingent of Indonesian professionals visited in July 1988, they observed the methods and procedures for construction of the civil works in both straight and curved locations. The design and fabrication of an improved power plant was shown and the construction of the new vehicle was inspected. Such activities within Brasil provided quicker understanding as to how implementation could be done without major time loss or disruption to others.

7. Experience Within Aeromovel Technology/Philosophy:

From the early 1980s, greater numbers of Brasilian professionals have been brought into the design and operation of Aeromovel Technology. Since 1985 there has been an increasing international awareness of Aeromovel and its non-OECD origins. A number of factors have been demonstrated by its development and the Porto Alegre operation.

7.1. Operations Needs:
Effective urban public transport requires the operation of technologies which can fulfill the needs of all citizens - frequent and occasional users, young and old, workers and tourists. Such transport needs to have an attractiveness - in routing and in physical appearance - that encourages both the high-income and the captive rider to use the service. To be effective it must be frequent and it must have a cost of operation which is low. In such regards, the Porto Alegre Pilot Line has demonstrated that frequencies of 30 to 45 trains per hour can be routinely managed. The operation has shown the merits of fixed-site propulsion and computer-dominated control.

7.2. Safety Parameters:
With any evolution within technology, the public demands that performance, operation, and design must rigorously provide maximum prudent safety for all members of the community - the passengers, the staff, and all others. While many types of standard "proven" technology are considered safe; events such as the Kingscross Fire of 1987 clearly show that all technologies must continuously guard against unsafe conditions whether they are sudden or inherent over time.

7.2.1. Passengers:
Based on daily operations within rapid transit and LRT systems, the safety needs are divided into two main groupings - firstly, the aspects related to the technology and secondly, the aspects related to human behavior. This review is limited to the first grouping since the issues of human behavior are endemic to all transport methods.

Hazards from fire, sudden jolts in operation, changes in floor level, poor vehicle design and poor lighting are the main factors in passenger related safety. With a vehicle that appears to the riding public similar to existing systems of LRT, the Aeromovel technology has a level of safety within the same parameters. However, where Aeromovel differs is that power and brake related power equipment is located OFF the vehicle. In the event that such equipment fails, short-circuits or burns, the event will not occur within the vehicle or within the station waiting areas.

Interior materials conform to the safety standards for public transport vehicles in Brasil and Indonesia. If more rigorous standards are desired or legally required for other nations, modification can be made. Such option also reflects the "ability" of Aeromovel to utilize local materials rather than to force users to import goods and materials.

The issue of smoking upon the vehicle is left to local policy and does not incur a hazardous condition more severe within Aeromovel than within other technologies.

Unlike existing electric urban railway technologies, the Aeromovel does not require third-rail or overhead catenary systems containing very high voltage and electro-magnetic interference. The duo-rails of Aeromovel are used for 52v energy. At this low voltage and with the 5'6" (1600mm) gauge of the track, there is no injurious potential to people even if they enter the prohibited track area.

The external areas of the vehicle are designed on aeronautic principles and with the fundamental understanding that NO area or component can be placed or built in such a manner that people can ride or mount on the outside of the vehicle. Such problem is found worldwide, but within cities of emerging nations there is frequent experience with undisciplined crowds riding on roofs or between vehicles. In part, this phenomenon occurs due to low frequency of service. As shown in the high-frequency Manila LRT operation, a traveling public that is aware of the high frequency service is less prone to do such "misconduct". In OECD nations the problem is more with pranksters and vandals. Such individuals may or may not be under the influence of drugs or alcohol.

Existing electrically powered railway vehicles have tendency to jerk the patrons at the moment of acceleration. Such occurrence is normal with mechanical transmission of the power to the wheels. Since the propulsion of Aeromovel is obtained by pneumatic methods, the instant of acceleration is smooth. As a result there is no perceptible jerk rate. Therefore children and elderly have less risk of falling (or instability) than has been achievable with other technologies.

The most frequent passenger injuries are falls. Since the riding public is composed of people in varying degrees of physical health, the conditions must minimizes the potential for falls. The Aeromovel operation has flat-level points of entry and exit between the station platform and the vehicle's interior floor. The interior of the vehicle has one floor level without any variation or tapering of angle.

Within the Brasil and Indonesia, there is no legal requirement for mechanical access to the station-vehicle interchange area. In existing locations no elevators or escalators are used. Like the LRT of Manila, such design is desired to limit the capital costs and the annual operating and maintenance costs. The Aeromovel technology has no inherent design factor which would prohibit wheelchair access.

The vehicle design reflects the heights, weights, and dimensions of the general public. Therefore windows, stanchions, doors, floor, and other fixtures are installed in a manner that will NOT cause potential injury or discomfort to users. Such design takes cognizance of the both the general public and the individuals having interest to search out and exploit hazards.

The specifications require vehicles to have internal illumination which will function under ALL conditions. Each vehicle is equipped with batteries and backup powerpacks for lighting. The amount of lumens required conform to the regulations of VOV - Germany for public transport vehicles.

7.2.2. Staff:
All Aeromovel operation and security staff are require to complete a training course that enlightens them to the principles of the technology and the occupational aspects of safety within their specific tasks and responsibilities. The focus on staff safety is directed to the hardware and the operation, not the limited potential for contact with the revenue passengers.

Aeromovel has a track structure which is unincumbered with cross-ties, high-voltage electric, or loose gravel and oily surfaces. The permanent-way is built in a manner not requiring frequent maintenance. No staff are required to work upon the guideway during revenue operations.

Therefore, the main hazard area to be considered for staff is within the workshop. Since vehicles are not equipped with heavy propulsion equipment and subsystems, the safety environment is equal or better than existing urban rail systems.

7.2.3. Others:
While any transport infrastructure can be occupied by unauthorized persons, reasonable design standards are taken to preclude "unintentional" or unmalicious entry into non-passenger areas. On railways, the major problem arises from contiguous land users and residents. In both railways and highways the pedestrian frequently uses portions of the alignment which have not been designed or considered for their use.

In the case of Aeromovel, a fully grade-separated guideway is provided. Generally, it is a dual-track elevated alignment which has access for passengers at designated stations and access (or egress) for staff at "secured" points. Therefore, trespassers on such alignment would not be a frequent or "accidental" occurrence. Rather, such individual would have demonstrated their overriding purpose to penetrate into non-public areas. Stations are the most frequent area for such occurrence. In addition to the security and control person at the station, there is CCTV and emergency procedures to counter hazards induced by unauthorized personnel. This means, at the minimum, the Aeromovel will have safety equal to Kobe, Lille, Vancouver or Miami. From Morgantown to Tokyo and Paris, system experience has shown that some individuals will

seek to be present in non-public areas. The security staff and other personnel are trained for such cases.

7.3. Maintenance:
Whether in aviation, railways, or road transport there is an underlying need for varying degrees of maintenance to vehicles and guideways. Many types of APMs have shown that they can operate within a public environment. However, like the early years of both Morgantown and Dallas-Fort Worth International Airport, the maintenance needs placed a very, very heavy burden on the budget and staffing of the operator. Urban transport is renown for its potential to minimize maintenance. Therefore, rather than to make problems in regard to maintenance and repair, an innovative technology should attempt to make a system which possesses little need for complex testing or difficult repairs. Aeromovel Technology does require maintenance, but its frequency is lower and its complexity is minor. General electrical, electronic, and mechanical tasks dominate the maintenance function. Infrequency is incurred, with the result that reliability of operation is improved. Components require weekly and/or daily inspection, but such task is not complex. The motor for the power propulsion unit is built with a sensor to automatically close-down if the armature exceeds a specified internal temperature. Power units, vehicles, electronic sensors are designed and installed in a manner that permits short-time replacement of the unit. The full power unit can be replaced in less than five hours. The maintenance experience of steel track is known. However, within the Aeromovel the axle weights, under fully loaded conditions, is below four metric tons rather than the 17 metric tons permitted on many national railways. With use of 85 lb/yd (42kg) rail, the wear on the head is low and the impact of the vehicle is not detrimental to the alignment of the track. The track width of 5'6" (1600mm) also permits better riding qualities. The beams and piers are made from concrete and re-bar. Within the conditions of Porto Alegre, such structures have a projected life of 40 years.

7.4. Construction Costs 1983 and 1988:
Prior to construction, proponents can "estimate" capital costs at optimistic or pessimistic levels. However, after the actual construction, within various nations, the capital cost parameters are more clear and documented. Prior to 1988 the building costs were based on the 1983 contracting costs for the components within the Pilot Line. In 1989, the costs were derived from work in Porto Alegre and Jakarta. The Aeromovel installation within Porto Alegre can be considered higher than normal due to the short length of alignment and the overall cost for molds, fabrication yard, mobilization, and contracting. In effect, many costs related to such projects are lump-sum whether the project is a mile in length or 20 miles in length. A steel mould for the beams has a higher price when ordering only one, rather than five or six. The cost of use of such mould likewise has variation depending on

casting of ten beams or a hundred. The 1989 Porto Alegre capital costs, including all items required for public operation, are equivalent to USD$5.4 million per track-mile (USD$3.4 million per track km). If a single pier, twin-guideway were built, it would be USD$9.6million per route-mile. Because the Jakarta TMII project was built over a two mile (3.2km) route, the per-track-km costs are lower even though the time constraints on the project increased the direct costs.

Construction costs have been reviewed for various countries based on high wage rates and lower wage rates for construction personnel. Since 71% of the capital cost is related to the civil works, the price of concrete and re-bar have more significance than has been found in conventional LRT systems such as Calgary. Two cost areas have been omitted from this work - 1) the commercial purchase cost of land, if required for the project and 2) the relocation costs of major public utilities. In Porto Alegre the alignment was provided under authorization by the government parallel to a public road. The relocation of individual minor public utility lines and lighting were included, but no major water, gas, or sewerage pipes were encountered.

7.5. Annualized Costs of Commercial Operation:

Within the context of this paper, Aeromovel operation is considered for public line-haul urban passenger transport. In such application there would be high utilization of the vehicles and high-volumes of passenger use. Within Porto Alegre Brasil and Jakarta Indonesia the fare collection is done manually due to the low wages and the social need for creation of employment. The overall operation costs of the Aeromovel are low, based on a capacity-unit value. However, secondary systems - such as escalators, station air-conditioning, and automated fare collection system - could significantly increase the costs of the transport function. If station-platform double-doors were installed, the maintenance needs of the system would be higher than currently experienced.

8. Conclusion:

The decade of pre-operation Aeromovel development coupled with the five years of physical research and operation within Porto Alegre Brasil has shown the merit of this technology. Since the innovation has double-track capital costs of USD$9.4million per route mile and operating costs of USD$2.10 per vehicle-mile, there appears potential for provision of improved urban transport within many cites at a much lower cost level than experienced currently. The merits of Aeromovel have generated interest in Indonesia, USA, France, Malaysia, Philippines and Pakistan for consideration of this technology.

FOR FURTHER INFORMATION, PLEASE CONTACT:

U.S.A. & CANADA:
SUR COESTER AEROMOVEL
Suite 221, 2025 I Street NW
Washington D.C. 20006 USA
Tel: 1-202-223-3805
Fax: 1-202-223-3931

BRASIL & SOUTH AMERICA:
SUR COESTER S.A.
Rua Washington Luis 186
Porto Alegre, RS, Brasil
Tel: 55-512-261088
Fax: 55-512-271 392
or 342 661

INTERNATIONAL:
SUR COESTER
c/o Lee H Rogers
4909 St Barnabas Road
Temple Hills, Md 20748 USA
Tel/Fax 1-301-894-2037

AEROMOVEL

URBAN TRANSPORT WITHIN JAKARTA AND POTENTIAL FOR NEW TECHNOLOGIES

LEE H ROGERS

PRESENTED BEFORE
INDONESIAN-U.K. BUSINESS ASSOCIATION
14TH SEPTEMBER 1989,
MANDARIN HOTEL, JAKARTA
INDONESIA

URBAN TRANSPORT WITHIN JAKARTA AND POTENTIAL FOR NEW TECHNOLOGIES

LEE H ROGERS - JAKARTA

Urban transport is a subject dear to the hearts of everyone. The views and feelings of each of us on issues of transport and mobility change from day to day - generally for the worst. Whether our attempts at movement are made on foot, in public transport, or with self-owned motorcycles and automobiles, each of these types of equipment and services have conflict with the other and with the adjacent land-use. In Jakarta most of us feel that the condition is the worst possible. However, people who have visited and worked in Bangkok would consider Jakarta's traffic problem mild compared to their own. Then there is Lagos, Nigeria which has a transport reputation stronger than even New York City. The fact is that urban mobility is an issue in all major cities of the world - from London and Moscow to Cairo and Surabaya. Let's just focus on Indonesia today, with emphasis on Jakarta.

As a transport planner, one of the early ambiguities seen is the "name" of a city - whether London or Jakarta. Why do I say this? Because, when we say London or Jakarta, people think of one physical location. Everyone knows that Jakarta is over 460 years old and London can trace its history back to Roman times. However, the London of 1830, the London of 1900, the London of 1950, and the London of 1989 are much different places. The same is true for Jakarta. In 1950 the "satellite city" of Kebayoran was thought to be too far to go. Many government officers refused to move their families to such remote area. In 1970, the areas of Cilandak and Bangka were remote. In 1975 a trip to Country Wood Estates was a half day adventure. Today Jakarta sees thousands of daily commuting people from Tanggerang, Bekasi, and Bogor. Depok and Serpong are not considered so far any more. Ps Minggu is an "inner" city shopping area, as is Blok M. Prior to 1950 Jatinegara and Tanah Abang were not really considered as "inner" city. What this reflects is a continuing growth in both population and land area in urban use. In 1945 Jakarta contained 600,000 people. By 1950 this had increase to 1.5 million. By 1975 it was above five million and now within the city boundaries the total is 7.5 million. However, that is not the whole story - because we have what is locally called Jabotabek, something like Greater London. This covers 2000 sq km and now supports 13 million citizens. The planners envision more than half a million additional people per year - by natural birth and

migration. So, by Year 2005, the forecast is for 22 million people in Jabotabek, of which 13 million will be within actual city. Now we could talk about all the needs - housing, water, employment, food, education, health - but today I will limit comments to transportation. The challenge is not a type which is served by pessimism. When we reflect on how much has been done in the past 24 years, there is a good basis for future success in provision of effective transport. As with Tokyo and London, regardless of what measure are taken there will still be points of congestion, and conflicting public needs for mobility.

There is no one urban transport technology that can satisfy all needs - either for goods or passengers. Governments have found passenger or citizen mobility to be the most difficult and costly. New roads are required. New railways - or at least upgrading of existing alignments - are required. Better bus services certainly help. But even with such projects there is always more needs and more demands for capital funding. In Indonesia, like UK, or India, or China, the options of urban transport improvement must be considered from the social, economic, and political view. Whatever is done in Jakarta, will be demanded by Surabaya, Medan, Ujung Padang, and Bandung. An example is the national allocation of double-deck buses from Medan to Sulawesi. For government that means money. From the national finance this is a commodity which has many uses; but which could be totally consumed by just the urban transport needs of Jakarta. The PJKA urban railway services have budgeted nearly 2000 million USD$ for improvement up to 1992. The major new highways have a similar budget figure. It is fine to say it is not enough, but for Jakarta it is more than now found in other million-plus cities of Indonesia.

What this means is that a search has been made to obtain improved urban transport, but without extreme burden on national or local government funding or on items which could be used in only the largest city.

Since 1965, many firms and nations have tried to develop new answers to the "century-old" problems of urban mobility. Some answers of earlier times - like LRT and railways - seemed attractive, until the current price tag was determined. In Jakarta, from Manggarai to Kota Station the elevated railway has a budgeted cost of USD$42 million per km. In Washington DC and Tokyo the construction of underground railways costs more than USD$65 million per km. What is "feasible" from an engineering viewpoint may seem a "disaster" from the financial viewpoint. Such case has been made for both the metro of Rio de Janiero, Brasil and the metro of Santiago, Chile.

After preliminary data and evaluation, a private firm within Indonesia sent a small team to Brasil in October 1987 to assess a new type of transport. From this first contact, a license was arranged, various routes within Jakarta and

Bandung were considered, and agreement was reached to build a demonstration line in TMII. The technology used is called Aeromovel in Brasil.

Frankly, on an urban transport basis, there are many things unique with this project. First, it is not conventional in its method of operation. All previous systems of fixed guideway urban transport - whether on rubber or steel wheels - had propulsion from electric motors fixed to the running vehicle. That has been the standard for more than 100 years. A recent variation has been linear motors, but this still has major heavy equipment on the vehicle. Within Aeromovel, the vehicle and the propulsion are separated. The guideway becomes the propulsion area, not the vehicle. Such movement control is made with air pressure. One major advantage of this is that the basic weight of the vehicle can be drastically reduced. A normal railway metro carriage or an LRT vehicle has a weight of 38 to 42 tons (empty). An Aeromovel vehicle has an empty weight of 9 tons. Both types of vehicles have the same capacity. Energy required for movement is a direct physics relationship between mass and velocity. So, 300 passengers weight 19.5 tons. If they are moved in metro their weight is but a third of the moving mass. That means that a metro car - at best - is always moving 66% of its own weight, not the payload. In Aeromovel the full passenger weight would be 68% of the total. To put it another way, for every passenger of a full metro the dead weight of the vehicle averages 135kg, but on Aeromovel the dead weight is only 34kg.

The principle of Aeromovel has been known for nearly 150 years, but the application has awaited the Brasilian design as made and patented by Mr Oskar Coester. Actually, in the 1840s I.K.Brunel built the South Devon railway line with use of this propulsion idea, but for a number of reasons it was not commercially viable. My view is that there are many things different between these two projects. First is 150 years of development. That means advancement in metallurgy; advancement in engineering; advancement in rubber and plastics, and especially advancement in control systems and electronics.

The Aeromovel Technology uses a completely separated right of way or guideway, generally placed 5.5 m above surrounding land use. The guideway is normally made from cable-stressed concrete beams with a hollow center of 1 sq meter. The vehicle operates on the top of such beam with support and guidance by twin steel rails and flanged steel wheels. From the underside of each bogie there is a mast or steel pylon which travels along a slot within the top of the guidebeam. This mast is attached to a rigid metal plate which seals the cross section of the duct. At selected points along the right of way, a small container-size power unit is placed. This contains a blower which can push a volume of air into or out of the duct. As the air pressure in front of the vehicle or behind the vehicle changes, the car can be moved - accelerated or decelerated.

I could explain much more about how the technology works. But the important thing is that it does work. This means that we have a situation somewhat like the period when electric lights were proposed to augment (not replace) paraffin/kerosene illumination. It is like the first years of the telephone - when most educated people "knew" that the human voice could not be made to pass through a tiny copper wire. Today, few people question the feasibility of either electric lights or telephonic communication. Today we select types, models, and brands for such needs. In technology awareness, this is the point at which Aeromovel is now placed. For that reason the Indonesian Licensee, PT Citra Patenindo Nusa Pratama, agreed to construct the demonstration line. The 550 ha complex of TMII has sought a type of internal distribution system for more than 10 years. As a result, an agreement was made that served the interests of both parties.

Firstly, a 3.2 km single track loop was designed with six stations. Second, it would permit people to view the park and its attractions from a good vantagepoint. Third it would show technology merits for future placement in urban areas. In this last grouping, the parameters that have been set include: Rapid construction, Reliance on domestic skills and firms, private funding of the project, and use of an alignment which caters to the park conditions, not to the technology wishes.

On 22nd August 1988, Ibu Tien Soeharto led the ground-breaking. Eight months later, President Soeharto opened the line. During that eight months all civil and mechanical works were done. There was no "vacant" alignment or pre-project assembly of equipment. Everything of a physical nature for this project started with mid-August 1988.

After the start of the project we found one piece of knowledge that had not been known earlier. In other major parks - worldwide - such major transport projects have always been erected at the time of first construction of the park, not retrofitted later. Of course we could not close the park for our civil engineering. We could not leave major areas in open and dirty condition. Further, we had to blend the guideway to the layout of the park and finally we had to give consideration to environment and stress problems for the major collection of tropical birds housed near the project.

The line as built for public operation in a counter-clockwise pattern. Along the southern area of the park a speed of 70 kph is operated. Between the Komodo and the Bird Park a speed of 55 kph is done with the remaining route being operated at a leisurely 20 kph to permit patrons to see the main attractions. So, we have demonstrated the speed which can be used in an urban line.

Additionally, curvatures have been built to as tight as 25 m radius. For most metros, anything under 200 m in modern design is rejected. That is part of the reason that such metros, like the new one in Singapore, have such great capital cost. Also, metros seldom have gradients of more than 5% since adhesion - especially in wet conditions - is very difficult on rail. Since Aeromovel does not use the rail for power, braking, or adhesion, we have built a 10% gradient to show the ability of our system.

Most important to Indonesia, is that the project has been accomplished with full reliance on local engineering firms, contractors, and workers. There have been three Brasilian engineers visiting for short term to advise about various aspects. But the prime responsibility for success has been placed with the Indonesian Licensee. This was done to show how such technology can be used in other nations actively working on their own economic development. There are aspects within the civil and mechanical work which will be changed and which required repeated improvement, but in the overall, a project of this magnitude was accomplished by Indonesians in Indonesia in a period of only eight months. A similar size project with conventional equipment was done in Miami USA, but required more than four years. The Canadian project done in Detroit was also 3.2 km, but work consumed nearly five years.

The most unique aspect is not the physical materials or the engineering. It is the finance and the economic merit. THII has been done for less than USD$12 million (complete) - all foundations, cars, piers, beams, stations and landscaping. That is for 3.2 km. As comparison, in Jacksonville Fla USA, an 800 m line was just opened for a "modest" USD$34 million. What this means is that Aeromovel has a capital cost need which permits non-government sources to consider the full equity of urban transport development. Without heavy running equipment, the operating and maintenance costs are also very low, meaning about USD0.03 per passenger-km. As a result, offer has been made to GOI and DKI that a concession-type arrangement can be made similar to what has been done with new major highway projects.

In this later option what is proposed is to make a 20 year agreement. During the first ten years the firm would install a full network of 12-15 lines within DKI Jakarta (estimated at 300 km) averaging 30 km of route per year. Then in the remaining ten years the investment would be returned. This would be done with a fare for daily passengers which is Rp500 per trip.

During September, we should complete the full training of operating staff. During the next months we will be making further refinements within the operation. the Titihan Samirono is open for public use. Come. Ride it. Then, you can fulfill one of my strongest statements - "Seeing is believing"

FOR FURTHER INFORMATION, PLEASE CONTACT:

U.S.A. & CANADA:
SUR COESTER AEROMOVEL
Suite 221, 2025 I Street NW
Washington D.C. 20006 USA
Tel: 1-202-223-3805
Fax: 1-202-223-3931

BRASIL & SOUTH AMERICA:
SUR COESTER S.A.
Rua Washington Luis 186
Porto Alegre, RS, Brasil
Tel: 55-512-261088
Fax: 55-512-271 392
or 342 661

INTERNATIONAL:
SUR COESTER
c/o Lee H Rogers
4909 St Barnabas Road
Temple Hills, Md 20748 USA
Tel/Fax 1-301-894-2037

AEROMOVEL TECHNOLOGY

SUR COESTER S.A.

PROJECT ISSUES
WITHIN
U.S.A. URBAN TRANSIT

By

Lee H Rogers
Transportation Planner

Exhibited At

TRANSEXPO 1990 - US DOT

Sheraton Washington Hotel

Washington D.C., USA

JANUARY 1990

AEROMOVEL TECHNOLOGY

CONTENTS

This report is sponsored by:

SUR COESTER S.A.
P.T. CITRA PATENINDO NUSA PRATAMA
ARNOLD MCKEE & ASSOCIATES

AEROMOVEL TECHNOLOGY

Worldwide, vast amounts of research and development work have been done with the goal to improve urban transit. With 3500 cities of more than 100,000 population and with the thousands of agencies holding part-responsibility for urban transit tasks, much information does not circulate within the transportation profession. Within the 300+ SMSA metropolitan areas of USA and Canada there is growing demand for new projects in urban transit.

Sur Coester S.A. provides this short report as a means to introduce engineers, planners, and government staff to an urban transit technology now in operation in Brasil and Indonesia. An overview of Aeromovel is given. Aeromovel is an option with potential to reduce capital funding costs, raise service quality, and permit rapid installation when demand capacities are below 15,000 persons per direction per hour.

I OVERVIEW

Since the mid-20th Century, two trends in urban mobility have flooded the planning and projects for transportation. Following 1945, there was a "manifest-destiny" that all persons and all cities would solve their transit needs with total dependence on private automobiles and public expressways. By the end of the 1960s this view had been altered. Even before the 1973 energy events, the urban planners and community officials were gaining the belief that public transit needed to be installed. However, such beliefs were split between the group advocating return to "proven" technologies of rail and road and the group advocating wholesale investment in new-technologies. During the 1980s both groups have been compromised by a series of adverse issues.

The first issue is cost - both capital and operation. The public envisions an urban transit system which is useful and with reasonable cost. However, metro, LRT, busway, APM, TSM have all demonstrated an experience in which the capital costs are frequently 50-100% more than the first estimates. The provision of peak-hour capacities have been gained at a unit-cost of USD$2300 to USD$5600 per space. Such cost levels generate public opposition in large part due to competing demands for public funds and the lack of "attractiveness" for local citizens to actually use the service.

The second issue is time-frame for implementation of technology. The USA, especially at the city and regional level, does not take readily to embarking on projects which require decades to complete. As Washington DC shows with a metro which started active planning in 1963 and Atlanta with a rapid rail network started in 1965, many rail solutions take longer to implement than many people spend in their direct employment span.

Revived Interest in Urban Transit:

However, during the 1980s, the leaner budgets of federal and state governments have tempered the projects and the expectations while local demand for mobility has continued to increase. Concomitant with this is the urban sprawl which has resulted in many medium-size cities having commute trips of 20 miles one-way (Orlando to Sanford, Florida) and large-size cities having one-way worktrips of more than 40 miles (Washington DC to Frederick Md). What is seen is a need for a package of options in urban transit and transportation, not single reliance on any one item. Additionally, any options which require the full consumption of available public funds only for themselves, look less attractive to the electorate than options which have more modest capital needs. Finally there is growing frustration with "services" which cannot cover their own budgets.

Aeromovel's Advantages:

Many attributes of Aeromovel are similar to LRT but without the same capital cost levels and without extended time periods for development. There is the use for special locations within the community and for development of a network within the metropolitan area. There is a flexibility in alignment or right-of-way requirements.

Aeromovel provides an intermediate capacity technology which can function cost-effectively in a range from a few-hundred patrons per hour to 15,000 patrons per-direction per hour. It has strongest advantage compared with other options when no service alignment exists. Based on projects in two cities, the infrastructure can be installed without major distruption to existing city activities. It can be placed within existing urban layouts.

Even though long installation time is not required, the permanence of the alignment serves to enhance land values contiguous to the route.

Construction costs are one-half to one-fifth comparable project costs for LRT and/or heavy rail. As a result, existing budget levels can be used to provide a greater amount of benefit by providing a larger network within the same budget limits.

Operation costs reflect the automated factors of Aeromovel. Reduced expense permits higher levels of service and greater ability to cover direct expenditures. Based on existing Aeromovel projects, financial conditions suggest that private equity can be attracted to the full implementation of this technology when legally permitted by government agencies.

Environmentally, Aeromovel surpasses LRT in quality since electric energy is conserved by use of permanent site power units and the vehicle generates less audible emissions. With a lighter vehicle (Empty=10 tons vs. 35 tons), the Aeromovel incurs less ground vibration, thereby permitting use into existing buildings and close to residential districts.

CHARACTERISTICS OF STEEL RAIL TRANSIT MODES

	LRT	AEROMOVEL	HEAVY METRO
FIXED FACILITIES			
Guideway - Exclusive(%)	60	100	100
Width (ft)	30'	21'	24'
Placement Time *	15	8	30
Propulsion System			
Complexity	Yes	No	Yes
Location	On Car	Off Car	On Car
Operation Control	CTC	Computer	CTC
Fare Collection	On Car	At Station	Pre-Use
Station Layout			
Length	150'	90'	350'
Complexity	Medium	Simple	Complex
Entry Height	Low/High	Cross-Platform	Cross-Platform
VEHICLE/TRAIN PARAMETERS			
Train Composition (# Units)	1-4	1	3-10
Vehicle Length (ft)	75-90	60	49-80
Vehicle Capacity (Seats)**	32/58	48/104	36/84
Vehicle Capacity (Total)**	180/80	300/235	300/100
OPERATIONAL PARAMETERS			
Operating Speeds - Max (MPH)	50	50	65
Avg (MPH)	25	30	33
Headways - Peak Hour	12-20	20-40	6-20
Non-Peak Hour	2-6	10-20	3-10
SYSTEM ASPECTS			
Network Pattern	Fair	Good	Limited
Stop Interval	1000-4000	500-2000	1500-7000
User's Trip Length	Main Commute	Mixed	Main Commute
Ability for Coordination	Good	Very Good	Very Good
FINANCE			
Capital Requirement (US$10^6)	25	11	40-65
Operation Requirement	High	Low	Very High
Potential for Repayment	Low	High	Very Low

* Months per double-track mile installed
** High Density/Low Density (# of seats)

Historical Perspective:

In re-assessment of early LRT development within cities of USA, planners found that the pre-auto transit conditions were similar to current methods of exclusive rights-of-way for transit. The merit if LRT was not the actual hardware, but the use of a dedicated alignment which did not have disruption from other land use activities or other transportation activities. It is in this context that Aeromovel contains the same potential. However, with use of an exclusive alignment, there is further merit in that totally automatic control can be used. The merit of pre-1940 streetcars was not their actual equipment capacity or their electric energy usage, but rather the fact that much of their right-of-way was fully or semi-exclusive. After that period, too many corridors were converted to full private auto usage and priority for public transit was not continued. Now, entering the 1990s, it is difficult for public officials to support return of portions of ground level public roads to be used for transit. The transit option requires an alignment totally separate from other uses. Within the family of conventional urban railroad equipment - albeit metro or LRT - the capital cost has been found to be extremely high. While short routes or a single prestigious line can be built, public funds are not sufficient to support the development of a comprehensive network within any one city. [Washington D.C. provides clear evidence of this between 1963 and 1989].

Existing Aeromovel Operations: From May 1983, Aeromovel has operated in Porto Alegre, RS, Brasil. In October 1989, this line was extended further into the CBD of the city. On 20th April 1989 a two mile line was opened in Jakarta Indonesia as a distributor system within a major activity complex.

These projects demonstrate that Aeromovel Technology is suited to urban transit needs.

It is an affordable option in development of new urban transit corridors.

It can be installed within a city in a much shorter time and with much less disruption than alternative technologies

Its modest width is 10' for one-way guideway or 21' for a two-way guideway. This compares with 26' for standard double track railroad and 30' for conventional two-lane city street. The ground-print for piers is 27"x34" for single guideway and 32"x52" for twin guideway. Therefore, existing road medians and non-used railroad lines and minor water courses have ability to serve transit needs.

Environmentally, medium-capacity urban transit can be provided with sacrifice to surrounding land area quality. Landscaping permits high service levels and positive neighborhood aestectic qualities.

The two decades of "new technology" quest and the professional interest in LRT have combined in new interest for Aeromovel due to its use in Indonesia and Brasil.

Aeromovel is now being designed for Manaus, Amazonas, Brasil and planned for Vitoria, ES, Brasil for mixed-equity agencies.

Construction design is being made for one district in Manila, Philippines, using private equity for comprehensive development.

Project design for Jakarta, Surabaya, and Bandung Indonesia using private concessionary finance.

Financial Study for Airport Usage with private equity in Sydney NSW Australia

Financial and Engineering Study for Lahore and Rawalpindi, Punjab, Pakistan.

Engineering Study for Pattaya, Thailand, by hotel owner.

Engineering Study for Galeão International Airport in Rio de Janiero, Brasil for public operation.

II TECHNOLOGY COMPONENTS

All urban transit technology requires reasonable understanding of its potentials and limitations. The mundane standards are more important than the exceptions. Ability of technology to adapt to local needs and to accommodate financial requirements needs evaluation. The hardware components are vehicle, guideway, controls, propulsion, maintenance support and stations.

Vehicle: The vehicle has less importance within the overall project, based on budget, than observed with LRT or APM. In Jakarta Indonesia and Porto Alegre Brasil, the passenger vehicles reflect the local policy that good appearance, non-frill equipment is sought. Reflective of existing public transit and the policy to maintain the lowest adult fare, vehicles are designed with major floor area for standees. In outward appearance the vehicle looks similar to a single-articulated LRV with a length of 80'. Doors are positioned at four points on each side of the car. Seating for 48 patrons is provided. Like LRVs in FRG-Germany this permits off-peakhour users to sit, but retains vehicle capacity for handling major peak-hour volumes. With the short stop, limited duration service neither operation uses air-conditioning or heating within the vehicle. Service efficiency is maintained by use of level-platform entry and exit from vehicle. This also permits wheelchair patrons direct access at any door area rather than being restricted to one door only.

The basic car is designed as a simple, safe carriage for passengers. Interior can be outfitted for high-seating or high-standing demands. Double Doors are furnished on both sides, but if all stations are to one side only, the vehicle can be built with doors on one side only. Passenger-activated door control is provided as option. Hotel services are placed in panels at the articulation area and underfloor. Since the vehicle is passive, with all control at station and CCC (Central Computer Center), there is no special area for driver, attendant, or staff and no operation controls within the vehicle. Such vehicle can operate in bi-direction method, so pinched-loop or stub-end terminals can be used. The current vehicle has a single articulation; two body sections joined by a swivel design which permits passenger movement between the compartments and permits the vehicle to negotiate curvatures as sharp as 75' and vertical gradients of 10%. For corridors with higher passenger demands, a double-articulated vehicle has been designed.

Compared with metro and LRT vehicles offered in USA and internationally, the Aeromovel vehicle has the ability to be built locally due to reliance on standard materials and a non-complex design. This permits local project to consider local manufacturer OR purchase for regional, national, or international sources.

Guideway: Aeromovel utilizes a fully dedicated alignment which is totally restricted from any other use or incursion. However, such alignment is not limited to one style of design. It can be placed at ground level, near ground level, or below ground in addition to its normal pattern of above ground position. The only requirement is that no contiguous planned or unplanned activity will enter into the alignment cross-section.

In Brasil and Indonesia the placement of Aeromovel has been on a narrow above-ground structure with sufficient height to permit normal highway vehicles to pass underneath at crossing points. Such height is normally 15' to 17' (5m). Since gradient is not a limitation in placement of the Aeromovel, transition from one elevation to another can be made in short distance and in conformity to the local urban needs. Use of elevated structures within any urban area must be carefully considered. The heritage of such structures has resulted in major reluctance by much of the public to approval of their use. However, a modern design structure used by vehicles without on-board motors for carriage of many thousands per hour is preferable to alteration of the urban fabric by placement of wide elevated highways. [This would compare SW Freeway in Washington DC with Harbour-View APM of Tampa or Dan Ryan Expressway in Chicago with Boston's Green Line.]

Median and Side of Existing Arterial Highways
Grade Separation with Single and Double Guideway
Underground Alignments
Shared Use of Non-Road Alignment.
Entry into major Buildings and Shopping Malls

Track Structure:

Aeromovel Technology has endorsed steel rail and flanged-wheel guidance. Such component reduces operation costs and maintenance demands while providing low-friction means to guide and support the vehicle. While track gauge could be varied, the two operation lines have a 5'6" (1600mm) gauge which augments stability and operating speed. With the 66 inch gauge and the 39 inch inner-duct sail, riding quality is maintained. Aeromovel is built for passenger mobility within the city and region, not for interchange with conventional rail services. Since equipment is very light weight, civil works for alignment are built without the standard requirements of railroads using 120 ton locomotives and

2000 ton freight trains. For that reason there is no requirement to have the same track gauge. Aeromovel uses railroad track components, but otherwise its operation and design varies as compared with standard railroads.

Steel rail is welded, but support is placed directly into the guideway beam. Wooden or concrete ties are not used. Rail expansion joints are designed differently than railroads. Fastening of rail to beam is done with DE Clips; an elastic clamp which provides firm anchorage for welded sections. Between baseplate and rail a neopreme/rubber dampening pad is fitted. Between the under-rail rubber pad, the guidebeam resting pad, and the non-rigid link between beams, train vibration is dampened. Railroad ballast material is not used. As a result, the track structure does not encumber the upper surface of the guidebeam with hazardous conditions if it is required for pedestrian or staff occupation.

In most Aeromovel installations a double-track design would be used with each track dedicated to a single service direction. Single-track design with bi-directional use is possible, but productivity of technology would be incurred if high passenger demands are to be handled. In selected urban corridors a mixture of double and single track design would be used when frequency of service is 3 minute or greater.

Switching of trains between routes and/or tracks is done with conventional railroad-type steel switch components. A double-point system is used; as found on Swiss Railways' cog sections and the Stuttgart (FRG-Germany) incline rack.

Propulsion:

Whereas LRT routes have requirement for continual use of overhead wire to provide electricity for operation, Aeromovel locates its power needs at a few permanent sites along the alignment. As a result, the latent hazard of high-voltage electric wire is eliminated. This enhances the aestectics of the public transit route.

Aeromovel's vehicles are moved by control of low-pressure pneumatic flows within a hollow duct of the guidebeam. While the vehicle and guideway suggest the appearance of LRT or standard rail, the actual structure is lighter and audible emissions are reduced. Since the propulsion is planned for each section of the route, less energy is required. Why? In a bus or LRV the motor must have enough power - at all times - to surmount any grade with any loaded and within any climatic conditions. As a result the vehicle's power on-board is excessive for "normal" use. In Aeromovel, the level sections would have sufficient power for the operation while the grades would have power which reflects the added energy required in that one section.

The SPU - Stationery Power Unit - has the dimension of a 20' Container. It is positioned under the guideway at selected points, normally near a station. Within this unit are two compartments - one for electric panel and linkage with commercial power supply and one for the primary motor, blower and value sets.

The pneumatic blower is used to push air into the duct or extract air from the duct. If singularly used, this permits the vehicle to be pushed from the rear by positive pressure or pulled from the front by vacuum (negative) pressure. Since a very large diameter duct is used with low pneumatic pressure, there is no high-dBa audible emissions along the alignment. If the power unit is used jointed with another, then the vehicle can be operated with one pushing and the other pulling. This permits retention of smaller energy units at sections with heavy gradient or need for higher speeds. Various options exist for matching the transit needs, the energy needs, and the urban structure need.

To the public, the only evidence of the power system along the right-of-way is the rubber-capped slot parallel to the running rails. No moving parts are seen. No latent hazards are present in the alignment. The result is use of transit technology which does not emit atmospheric pollution along the alignment. This technology has low dBa propagation, an alignment which is not above human perception of reasonable height, and which provides high quality service.

At option of contracting agency, this equipment can be operated with non-electric primary power. However, within USA and Canada all cities have sufficient electric resources that such option would be used for full-time power. Some cities might select to outfit power units with UIS generators as a means to keep the system running under all conditions.

Unlike LRT, the sudden loss of primary energy does not result in immediate stoppage of the equipment. The blowers have sufficient momentum to be able to move vehicles to the next station, where patrons could be discharged. This reflects fail-safe philosophy - passengers should be handled at stations under all conditions which retain safety. Exit of passengers at stations is normally more prudent than other options during a time of unscheduled degradation of the system's operation. While the guideway is design for safe passage of walking pedestrians along it, it is an option/feature which should not be used if other alternatives exist to have passengers de-train at stations.

Stations:

Aeromovel functions with high-frequency services with use of single-vehicle trains. Vehicles are not coupled to increase train capacity. Rather route capacity is satisfied by provision of medium to high frequency services. Since all trains are uniform length (85') the platform required for such train is much shorter than observed in other APMs or LRT projects. It is fundamental that the longer the train, the longer will be the station platform. Within urban areas this means that locations which require service are frequently not served because the technology

of standard rail options cannot place a station without physically destroying the area or requiring a very high cost for construction. Within Aeromovel the station requirement is 85' in length. The depth can be limited to platform width plus track width. Examples of the potential for such stations are seen in the World Trade Center Station in CBD Miami and the office building station of the Detroit APM near Renaissance Center. However, in both those cases the building was built at the same time as the APM. As Aeromovel demonstrated in Jakarta, it can be inserted into an existing structure. With combination of sharp curvature, responsive gradient, and low ground vibration, Aeromovel permits direct entry into major activity areas and existing CBD areas.

Stations can be designed as free standing or directly incorporated into existing structures. With high frequency service and short trains, the stations do not require massive investment. Patrons will not wait excessively for the service. Stations permit integration with bus and rail operations and joint-use of smaller stations with convenience stores and professional offices. The actual design of stations is a function of local social requirement, fare collection method, security needs, climate to be provided in addition to the headway of trains and the volume of demand. While underground stations are not required nor encouraged, such stations would have lower cost due to the more modest dimensions.

Maintenance Facilities

All technologies require maintenance. However, the issue is how much and with use of what support facilities. LRT and heavy rapid transit demands huge maintenance facilities and frequent, detailed inspection and maintenance procedures. Due to vehicle complexity and tradition, nightly service suspension is achieved with stabling of all equipment in depots or yards. Aeromovel does not require this extensive method of support. Firstly, the power units are permanently sited along the right-of-way rather than within the vehicle. Therefore the vehicle is much more simple in its characteristics. Wheel wear is reduced due to separation of power transmission from the wheel and truck components. Doors, hotel services, and parking brake components need periodic inspection and preventive maintenance, but in a system using 30 vehicles, the maintenance facility can be provided with capacity for ten vehicles, or less. At the option of the operating agency, the nightly service suspension of Aeromovel would be accomplished with parking of most vehicles at wayside stations. All stations have 24-hour, 7-day security using electronic and patrol methods. Cleaning and minor servicing of vehicles can be done by staff also responsible for cleaning of the station.

With the sub-system and/or component aspects of Aeromovel, much of the maintenance can be contracted to local suppliers and service firms, especially for operations with less than 20 vehicles.

Operation Control:

With the benefits of high-speed electronic data processing and industrial computer process controls, Aeromovel achieves complete safety within operation but without the heavy, costly railway type components. Firstly, the train operation is directly related to the pneumatic flow within the duct. Since this flow propels the train, only one train can be passed through a section at a time. Controls on the power unit preclude more than one train entering a section (of block). When the propulsion system also serves as the train control system, the technology has achieved direct full-time train protection within the operation. This compares with CTC on metro and railroads. CTC is a proven safe technology for monitoring and controlling trains, however it is actually an elaborate "secondary" system rather than a direct primary system of control.

In fully automatic operation, Aeromovel functions in a manner similar to elevators. All safety components within train protection and operation are made in a redundant manner, so failure of any one component will not cause failure or danger within the operations. Dual sensors along the alignment monitor the direction, speed, and movement of trains. This is related to the computers via two independent circuits. The two computers within the section and the two central computers compare the updated information with the program-logic. In this way velocity is controlled and deceleration for stations is activated in a manner permitting exact stopping at the platform. When the train is stopped at the station, the computer intregates the data to confirm location, brake condition, and power unit condition prior to opening the doors. Conversely, the doors are closed, and brakes released with computer verifies safe condition for movement. Passengers or objects no outside the area of the doors, will cause the doors to recycle 2-3 times before message for control inspection is sent.

All trains have voice-link phone communication with the control center. This is activitated in either compartment and without continual holding of the emergency signal plunger. Any passenger can activate this communication at any time during the vehicle operation. However, the result will be immediate link with control, not emergency braking of the vehicle. If the train is in a station and passenger activates emergency phone link, then door interlock will be maintained until overriden by control staff. This ensures that no one is caught in the doors during operation. With CCTV and video documentation, little problem of prankster or vandalism will occur.

III SERVICE CHARACTERISTICS

Having reviewed the hardware and equipment, interest now turns to the method by which the technology is used.

Frequency:

During the 1980s within cities of the USA the peak hour bus and LRT services have been provided on frequencies of only 6-10 vehicles per hour compared with the need for higher frequencies to attract users. The frequency or headway is the amount of service given for the dominate direction of demand. The first current-decade awareness of the need for high frequency was shown in Lille, France with the Line 1 of VAL. Patronage was 25% higher than envisioned due to the high frequency of service offered (3-5 minute headways). Aeromovel provides this type of attraction. Without direct linkage of each vehicle with an operating staff member, it is possible to run five trips or 40 trips with the same amount of on-duty operation staff. Within line-haul application Aeromovel would provide 30-55 services per hour in peak periods and 15-20 services in non-peak hour periods. From the passengers viewpoint it is better to provide many services per hour rather than trying to cram the maximum number of people in a few trains per hour. That may be the fundamental difference in urban transit between the early 20th and late 20th Century.

TABLE
LEVELS OF SERVICE (FREQUENCY PER DIRECTION)

	LRT	Bus	Aeromovel
Peak Hour	6-15	5-20	30-55
Base Day	5-10	1-6	20-45
Evening	2-5	1-4	15-20

Speed:

As observed with introduction of PCC on older street railways, the top speed of the transit vehicle is not as important as the efficent acceleration and braking of the vehicle. The attainable maximum velocity for multi-stop urban services lies within a range of 40-75mph. Acceleration curves lie in the area of 3.0-3.5 $mphps^2$. Aeromovel accelerates at 3.2 $mphps^2$ with loads up to 70% and has top speed of 50 mph with existing power design. Commercial speed reflects the end-to-end time for distance inclusive of station stops. Dwell time at stations can range from 15s to 60s with the average between 15-30s. When services are provided on unobstructed, exclusive alignments, the clear path operation compensates for lower top velocity. Aeromovel would provide commercial speeds comparable to metro and LRT with the same station spacing, but with lower energy costs and lower capital costs.

System Capacity:

American urban corridors desiring new technology for passenger demand require peak-hour volumes of 2500-8500 pphpd. During feasibility studies, LRT and APM are frequently "graced" with top of the range capacities. Once daily operation starts the peak-hour movements are below 5000 pphpd. Capacity offered has been limited by the employee-input to capacity provided ratio. Constaints in labor usage preclude cost efficency in offering high capacity. Without high capacity offering many potential patrons do not come forward.

Aeromovel's single articulated vehicle has the same capacity as a single-articulated LRV. Therefore, interior layout partly determines the hourly per direction system capacity. Within USA, such vehicle would have capacity for 225 persons with probable desired peak load of only 180 persons. If 90s headways were used, this would provide a capacity of 8100-10,000 pphpd. Such capacity, when provided at modest cost, can be seen by public as more attractive for frequent or occassional use.

In non-peak hours the capacity offered seems very high, but the short wait times at stops further encourages patrons due to diminished security anxiety.

Express Services:

Within Aeromovel the option exists to offer services which reflect heavy loadings and heavy demands for selected stations. This can be provided with design for local, limited and express operation, or it can be done with restricted service to light-demand intermediate stations. The need for such options must be determined in the feasibility and design phase of the Aeromovel project.

Intermodal Interface:

Aeromovel provides a community is an option to divert private automobile flows from selected portions of the city. This is done by providing off-street parking within the station area and combining the parking charge with the Aeromovel usage charge. Effective station design can enhance inter-change between urban modes - bus, LRT, taxi, rail, and Aeromovel. Additionally, the ability of Aeromovel to pass directly through major office and shopping complexes would permit public transit users an improved access to such destinations.

Safety:

With cognizance of avaiation and railroad policies for maximum passenger safety, Aeromovel has achaived a type of service security which at least equals LRT and conventional metros. Safety must be considered in the two groups of technology related and human related. The later grouping is a problem to any type of technology - as seen in public preception of subway use within New York City.

For Aeromovel, the technology-related safety has been provided. Vehicles are designed so that patrons can only use the service when properly positioned inside the equipment. Station-car interface is provide at common floor level. Platform-car gap is reduced to under 3". Doors and interior fittings are fabricated

with safety requirements held paramount. Train design precludes derailment under all conditions. Train propulsion system offers an operation which precludes two-units colliding or hitting. With the guideway fully protected from other contiguous activities, no disruption or accident can occur to local residents or public street users. Power loss and degraded service are handled with methods to have all "on-board" patrons reach a station before exiting the vehicle. As back-up each vehicle has emergency exit doors and stairs which permit entry to the upper surface of the guideway. The guideway surface is smooth, width and without overt hazard. No high-electric voltage is required or positioned along the guideway.

At local option, Aeromovel can be installed with double-door platforms which block station-users from direct access to track. While this design is not common within urban transit, it has merit (at additional expense) of eliminating accidental or malacious entry onto running guideway by non-staff. As Hong Kong MTR and Singapore MRT and Vancouver UTDC demonstrate, such station door link with the vehicle door reduces suicide attempts, but does not eliminate them totally.

IV. PLANNING AND IMPLEMENTATION ASPECTS

Within the planning and implementation of Aeromovel a number of issues are to be addressed. These include the level of service, the capital costs, the operation expenses, the time required for installation, social impact of the project and the environmental aspects.

Planning Criteria:

Placement of Aeromovel will seldom take place in a city which lacks public demand for improved transit and/or growth in urban mobility flows.

Urban areas are not only in change but various corridors and districts within each city are also in change. Some are entering new development while others are faced with decline or transition in activities. As the community identifies each of these areas, methods of transit are considered for strengthening the community. Within this issue there is evaluation of the intensity of demand and the medium and longer-term growth for such mobility. Such question faces the issue of the joint-role between public transit and private mobility. With the agreement to undertake a new project, alignments must be considered. In some projects the existance of under-used railroad lines or placement within medians of older arterial streets may be considered. In other projects there will be need for totally new alignment. The selection of the alignment will reflect the ability of the city and the technology to blend the new service into the actual fabric of the community. Stations will be designed with a frequency and location required for best-use of the Aeromovel route.

Applications:

There are a number of application types for Aeromovel. Given the modest capital costs, Aeromovel can be used for a network of urban radial lines or as an individual line-haul. It has the ability to be a single or multi- loop distribution within the CBD. It can be used as a short or longer feeder into existing rail metro operations(as proposed in Manila). Without the need for high volumes of daily traffic, it can be placed between major suburban areas. A number of special transport functions have merit; for airports, major shopping complex, stadiums, and very large industries.

Implementation:

Within North America the project time for installing new transit has caused much problem. Once officials and public begin to believe in the merit for LRT or metro or other option, they frequently return to an opposition view of the project after determining the time required for construction. Business leaders seldom endorse such projects due to disruption along the alignment which can last for months and years. Even when we determine the long-term merit for a project, the current small-scale merchant cannot support the interium of customer loss. Aeromovel, as demonstrated in Jakarta, overcomes this issue. Firstly, the system can be installed without major physical disturbance and without multi-month occupancy of the ground under the alignment. Secondly, the Aeromovel can be rapidly installed. A single-track loop of two miles was installed in Jakarta in only eight months. With greater committment to a project, an average rate of 1.5 miles can be installed per month. This is a breakthrough for cities when compared with LRT projects which have required years from design to final public opening.

Environmental:

When compared with other urban transit options, Aeromovel equals the values of LRT for physical presence, noise intrusion, and atmospheric contamination. For values of ground vibration, construction disruption, and latent hazards the Aeromovel excels LRT and APM systems. Since energy requirements per vehicle-mile are lower than incurred by other transit options, Aeromovel causes less demand for greater electric power generation.

Social:

Studies maintained in Brasil and Indonesia are compiling data on the social impact of Aeromovel for users and non-users. Given the physcial seperation from ground-based activities, Aeromovel does not have a negative impact on existing land-use patterns. With stations of less length than conventional metros, Aeromovel is able to serve the passenger demand in the locations people desire rather than locations large enough for the equipment need. Lack of wayside noise, lack of high-current exposed electric

cables, and provision of high frequency service suggest Aeromovel can contribute to community enhancement in a manner not gained by other options.

V. FINANCIAL AND ECONOMIC

Within urban transit, there are few projects which could not be undertaken due to engineering, design, and equipment. However, many projects fail implementation due to a variety of financial and economic parameters. The business leader has interest in the commercial (financial) merit of a project while planners and officials have interest in the projects true economic benefit to the nation and/or community.

Capital Costs:

Aeromovel demonstrates an ability to require capital costs in a more modest amount than witnessed by LRT or metro. Prior to more Aeromovel projects, there is discussion regarding the capital costs on a per double-track guideway mile. Capital costs in Brasil and Indonesia were generated in employment areas having labor intensive methods and low hourly wages. However, in USA and Europe the improved productivity by mechanization suggests the costs would be of similar magnitude. However, compared with other transit options with like peak-hour capacities, Aeromovel appears to be one-half to one-fifth the per-mile cost. As of early 1990, preliminary project cost evaluations are USD$9-11 million per mile compared with USD$25-40 million for LRT and surface metro.

Non-local Costs:

From the late 1970s, the USA has seen a growing dependence on non-local and non-national sources for equipment. UMTA and several state agencies have shown interest to have a type of transit technology which can be fabricated and installed with the bulk of the capital costs being contained within the recipient community. Aeromovel Technology, as demonstrated in Indonesia, has the ability to rely on local firms, engineering groups, and contractors for most equipment and work. Even the vehicle can be produced within the region of the project.

Operation Costs:

Aeromovel differs from LRT in that staffing is maintained off the vehicle. LRT advocates frequently cite the LRT ability to incur lower operation costs than heavy metro rail and to have lower labor costs per vehicle mile than found for bus. However, the issue is raised regarding how the costs will be covered. A growing view is observed that direct fares and contiguous beneficiaries should cover the budgets.

Labor Costs:

The labor needs must be based on a type of efficiency which combines the safety of patrons/staff with the tasks to operate the technology. Both bus and LRT require one person within the operating train or vehicle for mechanical functions. Aeromovel is more like an elevator with the train in safe operation with control from a central point, not by on-board staff. This has potential for improvement of services without a linear relation to the employees required.

Financing Impact - Short Implementation

Metros and LRTs and APMs have not attracted direct private equity for urban transit application due in part to the very long lead-time for implementation of such projects. Commercially there is cost to money. When investors cannot start a strong cash flow until 4-8 years from the time money is committed, the burden for support of the project becomes unacceptable. Aeromovel does not have this problem. As a result, banks and major firms have shown interest in direct financial participation for projects. The Indonesia project was financed and is operated by private firm.

Options in Project Finance due to Duration

With lower capital costs than previously available, some major developers are evaluating Aeromovel for inclusion into their current real estate complex. When the transit link to a new service area is only 5-10% of the total infrastructure cost of the complex, it is more feasible to include it in the package. A USD$500 million development with a USD$20 million Aeromovel is more palatable than a building of USD$480 million with a USD$125 APM of comparative length. The issue of "value-capture" is more directly applied since the developer requires less "sweetening" to contribute for the transit portion of a complex.

SUMMARY

This document is provided to review selected issues which currently impact the urban transit activity within many cities of the United States. It shows the merit which might be gained by use of a new urban transit technology, Aeromovel. While no one technology provides the answer to all mobility needs, Aeromovel does exhibit quality which many communities are seeking. With the existence of two operating routes (one in Brasil and one in Indonesia) and the active design and planning for building Aeromovel in three new locations; officials, business leaders, and planners may have interest in this pneumatic transit option.

FOR FURTHER INFORMATION, PLEASE CONTACT:

U.S.A. & CANADA:
SUR COESTER AEROMOVEL
Suite 221, 2025 I Street NW
Washington D.C. 20006 USA
Tel: 1-202-223-3805
Fax: 1-202-223-3931

BRASIL & SOUTH AMERICA:
SUR COESTER S.A.
Rua Washington Luis 186
Porto Alegre, RS, Brasil
Tel: 55-512-261088
Fax: 55-512-271 392
or 342 661

INTERNATIONAL:
SUR COESTER
c/o Lee H Rogers
4909 St Barnabas Road
Temple Hills, Md 20748 USA
Tel/Fax 1-301-894-2037

AEROMOVEL

THE AEROMOVEL OPERATION IN JAKARTA FINANCIAL AND ECONOMIC

Ir Irsan Ilyas

Exhibited At

TRANSEXPO 1990 - US DOT

Sheraton Washington Hotel
Washington D.C.

THE AEROMOVEL OPERATION IN JAKARTA FINANCIAL AND ECONOMIC

Ir Irsan Ilyas*

Abstract: The non-engineering parameters for selection of Aeromovel within Jakarta, Indonesia, provide awareness of the priorities and requirements for new transit within major world cities. The need is for technology which can provide whole networks, not showy single lines at excessive prices. Successful technology must satisfy the financial and economic demands without resort to subsidies.

Background: As the author, my interest was not derived from long-term association with one type of transit hardware. Rather, I consider the commercial and management merits of projects. From this vantage point I herein review the events which lead private firms within Indonesia to underwrite the construction of the first Aeromovel Technology outside Brasil and to consider financial support of such system in other nations.

Since 1966 there has been a very good rate of economic and social development within Indonesia. It is seen in the performance of agriculture, industry, education, and the improvement of health. It has also be seen in the rapid physical growth of cities. The effect of such development shows within the daily life of Indonesian citizens. Farmers have improved income with increased high-yield crop production. Youth have increased skills from increased attendance in public and private schools and universities. Families have an improved condition due to improved nutrition, adoption of family planning, and improved housing. Conditions are not perfect or enchanting, but they are significantly better for the majority of Indonesian people. The government, at both the central and regional levels, has encouraged multi-sector development through four phases of five-year plans. In 1989 Indonesia embarked on its Fifth National Plan. The plan will have greater impact upon the urban needs of the nation.

----

* Executive Director, PT Citra Patenindo Nusa Pratama, Jakarta

Urbanization: In a manner similar to the United States, Indonesia is a nation with many major cities. Jakarta, the national capital, is the largest, but it shares the urban activities with Surabaya, Medan, Bandung, Palembang, and Ujung Padang. The growth in urban importance is seen throughout Indonesia. As a nation with 172 million people living on 3,500 islands spread over an east-west distance of more than 3000 miles (5000 km), the role of provincial and district cities is greater than might be incurred if the nation were one contiguous land-mass. The major thrust of urbanization is starting. Whereas over 80% of the USA population is urban, the percentage within Indonesia is the reverse. Over 65% of the people still reside in village or rural areas. Since we already have cities with populations of more than five million, the aspects of major urban migration present major challenge within the next decade of development.

Future Trends: There are 26 provincial capitals and 257 district cities with major administrative responsibility. While the metropolitan area of Jakarta, locally termed Jabotabek, supported a 1989 population of 13.5 million, the forecast for the year 2005 indicates a 60% growth in this figure. There will be 22-23 million citizens within Jabotabek at that time. Each year the component of increase in Jakarta's population is larger than the total existing population of Austin, Texas or Gothenburg, Sweden. Additionally, the other primary cities are envisioned to have a doubling or tripling of population growth also. With Surabaya now having five million, Bandung having 3 million, Medan having 2.5 million, and Palembang, Ujung Padang, Semarang, and Malang each having one million; the future can only be termed a very great challenge for providing all services required to support this magnitude of people. As it is, each of these cities has already experienced unparalleled growth during the last 40 years with increases of six to ten times. With the existing past growth and the future projects for growth, the amount of public infrastructure existing in serviceable condition has fallen behind the direct needs of the communities. As traffic engineers we may be focused on the transport needs, but the government's focus for urbanization must be directed to a number of different sectors within such communities. There are water, sewerage, waste disposal, education, health care, housing, telecommunication, residential electricity, and employment creation to be considered in addition to just urban transit.

Existing and Future Demands for Urban Transit: While few people or government agencies feel that the current conditions of urban transit are good within the cities of Indonesia, it must be stated that during the last 20 years there has been a relentless attempt to match the capacity supplied with the demands being created. The problems of congestion, pollution, and cost are not desired; but they are viewed from the direction that they represent some indication of the success of the overall economic development within the nation. New roads have been built. Within Jakarta there is major investment in railway capacity. Private funds have been used to augment the bus and road transport services. Government firms operate nearly 3000 buses in Jakarta and several hundred in each of the other major cities. However, the growth in demand continues at 5 to 8 percent per annum. Even this growth understates the needs, since there is strong demand for private vehicles. Unlike Europe and USA, the majority of citizens are looking to ownership of motorcycles or scooters rather than private automobiles. Jakarta has more than one million powered two-wheel vehicles. On the expanding periphery of the city there are thousands of hectares of farm land being converted into residential areas and industrial areas. In 1989, the public transport of Jakarta carried 98% of the passenger trips with road-based technology. This volume accounted for 8.7 million trips per workday. In the Year 2005 the daily passenger demand will be more than 15 million. Such growth will also occur in other cities. Even with greater private vehicle ownership there will be growth market for public urban transport operation.

Existing and Future Demands on Public Funding: Up to the early 1980s, the conventional wisdom of urban transport stated that all capital funding and, frequently the budget for the operation agency, had to be taken from the public sector. Therefore, public transport is found to compete with other national transport needs and with other sectors of the economy to obtain funding. In cities of under 500 000 population, the daily transport function may be handled in ways that require a minimum of capital resource. However when cities reach over one million inhabitants, the demands for capital funding of transport become very large. Today within Jakarta there is multi-year commitment for USD$2 billion for intra-urban expressways. There is long-term commitment for more than USD$2 billion in railway improvement to transform four corridors into rail dominated travel. There is public equity of $200 000 000 investment in city buses. Each year within Jakarta the direct needs are USD$250 000 000 for the transport services. However, even this budget is below the actual needs. Therefore the city is falling increasing behind the needs. If we take the 20 largest cities of the nation, the annual urban transport capital requirement is more than USD$550 million. Where would such level of funding be obtained? The full national annual development budget for 1989 was but USD$1,225.6 million. As has been done with some of the road transport services, there is a genuine need for encouragement of private equity within this activity. However, private equity source demand one fundamental feature for their help - They want a proper return on their investment. In some nations "proper" might be 2 or 3 percent, but within commercial rates of Indonesia, there would be no private investor having interest at annual rates below 15 percent. Whether such condition is liked is not relevant. The relevance is that private equity will not be encouraged to help without such levels of return. Within most Indonesian cities, private

equity has been encouraged to own and operate medium size buses on both exclusive and competing routes. All owners complain of their lack of return, but we note that each city received a annual increase in the number of vehicles and private funding is always available for each route. Therefore, pragmatically the owners still sense a reasonable return on the capital. The question within DPM and AGT systems is whether the traffic forecasts and the capital costs will be such as to encourage private participation in the direct technology, not just the periphery real estate activities.

Types of Equipment Available: From the above "parameters" of Indonesia, there has been an awareness that even within such constraints something should be attempted to permit better urban transport. It was in this manner that existing technologies were evaluated by members and advisors to the Indonesian firm of PT Citra Patenindo Nusa Pratama. Within its staff there existed awareness of the developments in standard and new technologies from many nations - including Japan, USA, France, Canada, Germany, Australia, and Great Britain.

Criteria Used in Selection: The review of technologies was made from two points for private business interests - first that technology could be obtained and built on contract basis for government and second that some new technologies "might" offer potential for partial or full funding from private sources. The review was done on capacity, performance, reliability, capital costs, staffing requirements, foreign material requirements, construction complexity, project time requirements, and employment training needs.

Types of Application Desired: Although new technology systems of Canada, USA, France, Germany, and Japan have been built in special test conditions or even within one or two city corridors, there was a general view within Indonesia that any system would have to be demonstrated on a pilot line before it could seriously be viewed as a candidate for extensive use. Conditions within Indonesia have been open for any firm to provide and self-finance such a prototype operation in Jakarta or other city. However, all the offers for equipment were provided with the view that government would totally finance such construction. Additionally, by the time financial review was made for use of various AGT equipment it was concluded that the project cost levels were of a magnitude that would not permit private funds to be recovered within a reasonable period. The exception was found to be Aeromovel of Porto Alegre Brasil. The full per-km capital costs of this system indicated that full private funding could be used for the introductory line and that most materials could be obtained from domestic sources.

Local Parameters for Aeromovel: Following two professional visits by Indonesians to Brasil and one visit of the Brasilians to Indonesia, it was concluded that the Aeromovel Technology had a strong potential for improvement of the urban transit within the cities of Indonesia. Politically there has been increasing demand for providing projects within Jakarta. However, with the need to undertake only an introductory line, a location was required which had urban-type passenger demand but which was not in the direct arterial road pattern or within the centre of the historic city. As a result, PT Harapan Kita, the private corporation owning and operating the 500 ha theme recreation area, TMII - Taman Mini Indonesia Indah was seen to be good candidate for the first operating site.

Aeromovel Pilot Line of TMII: In 1975, a private foundation opened a major theme park and recreation area within southeastern Jakarta. Since that time, TMII has become the point for citizens and foreign tourists to visit. The basic theme is one of the diversity and richness of culture and economy within the Indonesian Nation. Gradually, the complex expanded to include not only 27 buildings representing each province and five buildings for each major religion, but many other areas for diverse interests - such as tropical birds, stamps, transport, military science, fantasy and handicrafts. Sunday and holidays are the peak demand for entry. With the growth of visitors there has been an improved skylift system installed for transport east-west. A railway of narrow gauge is used for a non-stop tour of the outer edge of the complex. Minibus vehicles are operated on demand and for charter. Private vehicles are permitted to enter into the center of the complex. With the lack of adequate parking at each pavilion there is severe conflict between the pedestrians and the vehicles. This reduces the charm and secure feeling within the complex. The administration has tried to find transport methods which could return the conditions of the park to the intended charm, but the capital cost has been prohibitively high. In this way, a joint-interest was generated for installation of Aeromovel within Taman Mini II.

Design Characteristics Intentionally Used: While the park officials desired a slow sightseeing service connecting various points, the firm with local license had interest to show the ability of the Aeromovel Technology. Therefore the design is a blend of the two criteria.

Length of Installation: An operation of less than one km length could be made for the needs of the park, but the merit of Aeromovel as an urban system would not be clearly shown on such short line. Therefore, within TMII the single-track loop has a length of 1.9 miles (3200m).

Multi-Station Operation: A point to point operation, like the airport services in Tampa and Orlando, would not reflect the normal requirements for urban high-frequency service within many parts of a city. Therefore within TMII, the route was designed with six stations and option for one additional station. All stations are above ground, with prepayment for entry. No mechanical equipment is used in the stations. This

reduces the energy requirement, reduces the maintenance needs and reduces the capital costs. Public acceptance of this design is being made. A "future" station has been planned as a manner to show the ease by which Aeromovel routes can be altered to serve changes in demand and changes in land use.

Extreme horizontal curvature: Urban planners are frequently cool to the placement of new guideway systems due to their excessive engineering dimensions. Curvatures on public routes for standard LRT are seldom permitted at radius of less than 300 feet (90m). Aeromovel has taken cognizance of the previous experience with streetcars. Therefore, three special curves have been designed with sharp radius. Two have only 100 feet (30m) while the third has 80 feet (25 m) radius. This demonstrates the ability of Aeromovel to pass through confined areas of the city. Such curves are studied for passenger comfort and behavior.

Extreme vertical gradient: While bus systems can routinely climb or descend gradients of one in eight (12%), modern design urban railways seldom permit gradients of more than 2.5% (one in forty). Such gradual inclines result in very expensive construction. Within the TMII Aeromovel route, one section was built with a gradient of 10% (one in ten). This demonstrates the ability of track vehicle to operate either up or down such gradient without impairment to operation since propulsion is not passed through the wheels.

Minimized power requirement: Single LRT vehicles and urban electric railcars frequently have on-board electric power of more than 400 kW. Such equipment is operated in trains of from two to eight vehicles, meaning that per train power needs of 800 to 3200 kW are generated. Within the TMII Aeromovel the propulsion is fixed in location. Since the power/energy needs are known within each section, the power need is much reduced. As a result within the six sections of TMII loop there will be total power installed of only 500 kW. This power will permit speeds of 43mph (70 k/h) and operation of six trains along the system. Such parameter clearly demonstrated the modest power needs of the system - at full load a vehicle consumes 32 watt-hours of energy per passenger-km.

Speed of Installation: The bane of public acceptance for urban transport alignments is frequently directed to the multi-year disturbance of the alignment when installing the technology. Within Aeromovel it was shown how fast the civil works could be done and how it had very limited disturbance to contiguous land uses. As a result, the project of 3.2 km has been planned for full and total construction and testing within a period of only 240 days - about eight months. Based on the experience of Miami and Detroit, the Jakarta system should have required more than 2.5 years for construction. The first construction commenced on 22nd August 1988 and the public dedication and operation was provided 20 April 1989.

Environmental Qualities: Like all major cities of Indonesia, the TMII complex already exists. It has a layout and activity pattern which has evolved over more than one decade. Therefore the Aeromovel was inserted into such environment. Being a public recreation centre, the normal construction conditions of urban transport could not be permitted; dirt and debris had to be contained or removed in a manner not seriously detracting from the character of the park. Additionally, trees, shrubs and public furniture had to be protected to a maximum extent. Trees were cut, but the majority were only trimmed or temporarily tied back during placement of the piers and beams. The lake centerpiece of the park could not be violated with debris. Additionally the water area abutting the piers between stations five and six could not be drained, even temporarily. Therefore the technology had to permit low cost installation with strict awareness of the green and sensitive locations. In the area of the tropical bird center the foundations were made with bore systems to mitigate the noise of conventional pile driving. Also near buildings with modest foundations, the bore pile system was used.

Two of the stations were made from modification of existing structures within TMII. This was done to show the ability of the Aeromovel technology to pass THROUGH existing structures. This could be done because the vibration is reduced to very low levels since the vehicle-weight is low, the propulsion is not on the vehicle, and the wheels are only for guidance.

Reliance on Domestic Materials: With enough money and/or external assistance, nearly any type of technology could have been obtained for the TMII route. However, for demonstration of the future impact that Aeromovel Technology will have on Indonesia, major reliance was an made on existing domestic suppliers of materials and equipments. Due to the time limitations in construction and the newness of the technology, a limited amount of materials - including one vehicle - were purchased in Brasil. However, 71% of the costs related to the civil works - all of which are obtained from Indonesian sources. For the opening period three vehicles are used. Two of these vehicles were built within Indonesia, using the facilities of bus body builders, not traditional rail coach builders. The Aeromovel showed that both the construction phase and the operation phase could be done without continual purchase of equipment and maintenance spares from foreign sources. The major savings of foreign exchange further enhance the technology to the government.

Use of Local Professionals & Workers: While many projects have been granted for the transfer-of-technology between foreign experts and local specialists, it is frequently seen that this process requires a duration of years and a continual perseverance within the recipient nation. The Aeromovel is a technology utilizing existing engineering methods - both for

civil and mechanic aspects. Therefore, it permited the use of low-skilled day-workers as a means to stimulate local employment and improve the purchase power of local low-income households. Secondly, the project was designed and supervised by local persons. In this first Aeromovel project in Indonesia, there was no permanent on-site Brasilian engineer or counterpart. Therefore an additional source of foreign exchange outflow was reduced. The public has pride in a technology which they have seen built by their own national engineering profession. The professionals have encouragement for further use of the technology.

Future Lines within Jakarta: Following the April 1989 opening of Aeromovel in Jakarta, continued work is being done for the development of a comprehensive system of lines linking all sub-districts within the conurbation. The 84 cities with metros and the 220 cities with Light Rail and/or tram operation demonstrate that greater effectiveness in use of public transport can be achieved when the technology is provided on a multi-route network. In the past the provision of such network has been hampered by the extreme high capital cost of providing such technologies.

Physical Layout of System: Within discussions at municipal government level, the view has been taken by both the public and private participants that a system of 12 to 15 lines would be required. Each line would be interlinked with other lines. Such a development would be done incrementally, probably over a decade. If the approval for such project is received, it will permit more rational planning for the urban mobility. This can be accomplished because contracts for equipment and supplies can be issued on a multi-year basis, thereby giving the manufacturer or supplier an extended production run for his equipment. As example, the supplier of vehicles would be required to make 40 units per annum, even though the specific assignment of the equipment had not been determined. Since all components are standardized, the previous lock between planning and contracting is opened - hopefully with benefit to all parties including the general public.

Financial Potential for System: Too frequently what is forgotten in the halls of transport technology is that the local public and the nation are required to cover the costs of construction and operation. Excluding times of earthquake, volcanic eruption, or major floods there are few cases in which equipment and technology have been given "gratis" to a nation or a city. Soft loans may be offered to permit construction of a specific technology, but such loans still have to be repaid by the country or by the city. Repayment obviously comes from the funding sources of the city and/or the nation. Such funding sources are obtained from taxation of various types - the majority of which is either a property tax or an income tax or a value-added-tax. Each of these taxes are generated (or taken) from the local populous.

Projected Lines within Other Major Cities: Aeromovel's development within Indonesia is a project looking beyound Jakarta. It is within that context that preliminary study has been done for four cities. The case is made that Surabaya, Medan, and Bandung have a deficiency within urban transport even more severe than Jakarta, since they have less developed bus networks and more modest road patterns. Therefore a technology which can be inserted into the urban fabric in a manner that will serve the demand but that will not destroy the existing land use pattern, is the type of system sought by both private and government groups. Within Bandung there is continued growth of enrollment for higher education in the north and east districts. There is expansion within the labor-intensive industries in the west and east. There is increasing residential settlement in the south. All these patterns suggest the need for improved transport without direct reliance on existing roads and streets.

Conclusion: With the April 1989 dedication of the Jakarta Aeromovel Line and the current public operation, public agencies and private firms are evaluating new transit projects for major route within Jakarta and other Indonesia cities. The best way to understand the potential of this new technology option is to visit Indonesia and see it and ride it yourself.

FOR FURTHER INFORMATION, PLEASE CONTACT:

U.S.A. & CANADA:
SUR COESTER AEROMOVEL
Suite 221, 2025 I Street NW
Washington D.C. 20006 USA
Tel: 1-202-223-3805
Fax: 1-202-223-3931

BRASIL & SOUTH AMERICA:
SUR COESTER S.A.
Rua Washington Luis 186
Porto Alegre, RS, Brasil
Tel: 55-512-261088
Fax: 55-512-271 392
or 342 661

INTERNATIONAL:
SUR COESTER
c/o Lee H Rogers
4909 St Barnabas Road
Temple Hills, Md 20748 USA
Tel/Fax 1-301-894-2037

INDONESIA:
P.T. CITRA PATENINDO
NUSA PRATAMA
23rd fl, Gedung BDN
Jl Kebon Sirih 83
Jakarta, DKI, Indonesia
Fax 62-21-380-1727

AEROMOVEL

SUR COESTER S.A.

AEROMOVEL

QUALITIES

AND

CHARACTERISTICS

BY

Mr Claudio Pinto
and
Mr Marcelo Nery

URBAN TRANSPORT CONFERENCE
MUNICIPAL PLANNING COMMITTEE
MANAUS, AMAZONAS, BRASIL
NOVEMBER 1989

SUR COESTER S.A.

QUALITIES AND CHARACTERISTICS OF AEROMOVEL

1.1. Background

The Aeromovel Technology is a medium capacity transport system demonstrating modern concepts to improve mobility and safety within urban routes.

a. By elevating the guideway the technology can obtain maximum utilization with low capital costs, minimal energy usage, and light-weight rolling stock and alignment.
b. Provide high comfort and safety
c. The exclusive elevated guideway permits use of automatic computer-based operation without interference from other traffic or land uses.
d. Total absence of pollution along the guideway, since pneumatic pressures are induced by electric or natural gas prime movers.
e. Simplified design with emphasis on users/passenger needs.

The Sur Coester Aeromovel Pneumatic Propulsion is divided into five principle parts:

* Permanent Way
* Vehicles
* Motor-Propulsion Units
* Command and Control System
* Passenger Stations

1.2. Permanent Way - Qualities and Implantation

The permanent way is divided into four sub-groups:

* Sub-structure/infrastructure
* Mid-structure
* Super-structure
* Accessories

With except of two accessory items, all components within the guidebeam are constructed from reinforced concrete with embedded tension cables that are post-stressed. This permits the lowest capital cost concomitant with long-term durability and low maintenance requirements over the service life.

The Sub-structure/infrastructure comprises the foundation; which is made based on local soil conditions and height of guideway. Such foundations are prepared for the footings and pier of the alignment. Direct occupancy of land is limited to the time required for placing the foundation, shaping the footing, and casting the plug receptacle in which the pier is positioned.

All items and elements required for the mid-structure and superstructure can be built in pre-fabrication procedure at a site away from the alignment. This permits higher construction rate and dramatically reduces the interference formerly experienced with LRT and other urban transport technologies during the construction of the guideway.

The mid-structure constitutes the piers and their mounting pads which are used to support the single or double guidebeam, maintain the elevated level.

The super-structure consists of the guidebeam for each alignment with tangent beams having length of 25m. Lengths vary with vertical and horizontal curvature reflecting technical conditions and practical aspects of the implantation.

The guidebeams are pre-cast off site and fully prepared in the work yard prior to movement to the alignment.

The permanent way accessories are installed after the beam is positioned. These consist of the steel rails for the track, related rail fastenings, and rubber seals between beam ends and along the slot-seal.

1.2.1. Permanent Way Accessories

Rails
The vehicle operates with guidance and support derived from steel rail trackage, generally of S-41 or TR-45 design. Rail is fastened to the guidebeam with elastic DE-type clips. Between the baseplate and the rail and clip there is inserted nylon and/or rubber pads to isolate the rails from the guideway.

Slot Seal
Along the longitude of the guidebeam two strips of laminated rubber (mine conveyer belt/industrial quality) are fixed to enclose the slot during positive or negative pneumatic pressures.

Section Valves
Within selected parts of the guideway, control valves are mounted within the beam to control the flow and security of the pneumatic pressure. These are activated by either pneumatic methods of hydraulic methods.

1.2.2. Mandatory Items

In the evolutionary development and implementation of Aeromovel Technology awareness has been maintained about the dimensions of physical components and the volume of pneumatic flow required for operation within the system. This permits design of an optimal system that does not over-stress any of its components and does not incur capital costs of high levels.

The items mentioned herein are found on the Pilot Line of Aeromovel operated in Porto Alegre; which has been in operation since 1983.

Pneumatic duct within permanent way = 1m^2
Length of tangent guidebeam: 25 m
Width of beam at ends: Lower portion = 1.70m
Upper portion = 2.46m

Width of beam in middle: (22m of length)
Lower portion: 1.40m
Upper portion: 2.46m

Height of beam at ends: 1.82m
Height of beam in middle: 1.66m (22m of the length)

Track gauge: 1600mm
Clearance below guideway (Average) 4.5-5.5m

Minimum distance between track centers - double track
3.78m for tangent sections
4.48m for tight curve of 25m radius

Maximum Superelevation in curves = 10% (5'50")
Dimensions of pier: single track = 0.9m x 0.65m
double track = 1.7m x 0.65m

Dimension from top of rail to underside of beam = 1.52m
Average distance between piers 25m

Dimension of air intake/exhaust (each) 2.0m x 2.65m
Number of intakes per section = 4

1.3. Vehicle

1.3.1. General Characteristics

The vehicle is designed with two or more passenger compartments with articulated linkage between them. When the vehicle is a single articulated vehicle with two compartments there are four double doors on each side having width of 180cm and a height of 190cm. With level car floor to platform, this permits rapid entry and exit of patrons between the station and the vehicle. The vehicle contains a public address system which can (at option of operating authority) provide music as well as public announcements.

The body of the vehicle is fabricated from aluminum with a monoquoce design. The floor has special construction to suppress noise from the underside and track area.

Ventilation is provided in Brasil and Indonesia by use of circulation fans and eight open roof hatches. The upper quarter of side windows can be opened to permit entry of air without danger of occupants reaching out from such opening.

Such vehicle has crush load capacity for 300 persons at an average of 7 persons per sq. meter or 264 persons if an average of 6 persons/m^2 are used. For urban applications with high demand

and short distance, seats are placed for 24 people within each compartment; giving 48 seats for each vehicle.

The interior is formed from fire-resistant and vandal resistant materials with fiber-glass panels. All materials are easy to clean.

Illumination is design for 500 lux intensity at one meter above the floor. It is provide by a two parallel fluorescent groupings.

Disk-brakes are used with actuation by hydraulic-pneumatic components. Such brake is separated into four independent circuits to insure fail-safe quality.

The compartments are suspended on air-bellows that dampen vibration and noise.

1.3.2. On-Board Electric Requirements

Electrical requirements of vehicle subsystems are supplied by a dual arrangement of batteries and low-current voltage passed through the running rails with 55 Vac. Wiring is design with two independent systems to insure reliability under all conditions during public operation. The systems include:

- Internal Lighting
- External Signals
- Compressors for door operation
- Battery UPS backup - double
- Control of Door Security
- Control of communications

If the 55 Vac current is interrupted, there is automatic changeover to the battery reserve within the vehicles.

1.3.3. Pneumatic System of Vehicle

The vehicle is built with a dual system of compressors and air tanks. Such system operates both the doors and the "stop" brake/ position brake.

1.3.4. Braking and Safety Systems of Vehicle

The following methods have been designed for safety within the vehicles, its operation and the security of patrons and staff.

At each end of the vehicle there is an emergency door, with steps, permitting egress along the wide guideway. This will permit rapid exit, if required, for all ambulatory patrons.

Emergency brakes are built into the vehicle to permit stopping in the event of power failure.

A secondary security system of retaining wheels are mounted from the articulated portion of the vehicle into the upper portion of the pneumatic duct. As a result there is no technical or operation condition that can be made in which the vehicle would be derailed or separated from the guideway.

Fire extinguishers for type A, B, and C fires are mounted in each compartment.

A permanent telecommunication link is maintained with the vehicle and the control center. Each compartment has a speaker for passenger emergency use.

1.3.5. Dimensions and Special Aspects

Dimensions:

Length of Vehicle (2 compartments)	= 25m
Width - External	2.75m
Internal	2.60m
Height - External	2.86m
Internal	2.12m
Door Width	1.80m

Weight of Vehicle:

Single Articulated	- empty	8700 kg
	gross	28200 kg

Passenger Capacity

7 passenger/m^2	= 300	48 seated, 252 stand
6 passenger/m^2	= 264	48 seated, 216 stand

1.4. Power Units

1.4.1. General

The building containing the motor-propulsion equipment has the size of an ISO TEU container. Since the propulsion equipment is land-based, the control and monitoring of the equipment is much more simple. The oversize of the air intake results in no external noise.

The container for power propulsion is placed at required points directly below the guideway (similar to DC substations on new elevated metros). The unit can be mounted at ground level or elevated to fit into the guidebeam.

Location of such units is dependent upon the power needs of each alignment. Given the standard design, replacement and maintenance are more easy and less prone to cause disruption to commercial operation.

1.4.2. Motor-Propulsion Group

Within the motor-propulsion unit, the basic power unit is an industrial-grade centrifugal blower with rating between 36,000 to 120,000 m^3/hr. It is balanced and directly linked to electric motor. In most applications such blower would be powered by electric energy, but option does exist to use gas-powered turbines. This options is attractive to cities near surplus NPG supplies.

Above the blower is placed a four-position value which controls the direction of air flow and the pressure.

Such motor-propulsion units are located near stations, but outside the area in which public has access.

The structure containing this equipment is secure from vandals and abuse. Except in very hostile environments, it does not require chain-link fence perimeter. Rather, sensor are placed within the unit to automatically inform central control of intruders touching the external sides or doors of the unit.

The ventilation and silencer equipment within this unit preclude major noise emissions from the unit. Hydraulic and electric panels are separated from the motor and blower by a fire-resistant wall.

1.4.3. Energy Requirements

The electric energy is obtained from commercial sources and brought into the unit in industrial rates.

A substation transformer converts the high current into what can be used for the pneumatic units and for the 55 Vdc track energy system.

1.5. Command and Control System

The system of command and control has the following components:

- Panel of command at each station for monitoring and semi-automatic operation.
- Electric circuits for command of PPUs
- Pneumatic or hydraulic system for valve positions for both the power unit and the guideway
- Velocity sensors upon the guideway, spaced each 25m, with redundancy system
- Communication system between station-central control station - vehicle, station to power unit, station to station.
- Circuits to monitor operation and condition within local power unit.

1.6. Passenger Stations

The stations permit the access and egress from the vehicle for passengers in a safe, orderly, and high capacity manner. The station is divided into the lower area - for fare collection and sundries, the upper platform for access to the vehicle, the control cabin, utility rooms, and other features as required by each system.

The stations are design with consideration of local

architectural values and desires and can be done locally. Size of installation can reflect the small dimensions required for Aeromovel or enlargement for additional uses.

The technology permits placement of the alignment into existing major structures; either to permit stations within such buildings or simply to pass through them.

General Dimensions:
Width of Platform - 5.0m
Length of platform - 25.0m
Platform level
(above rail head) - 70cm
Platform edge to track center - 1.3m
Variation in car floor
and station platform - 2.5cm
Control Cabin 2.5m x 1.8m
Control Cabin floor level
above passenger platform 1.10m (minimum)
System of pneumatic values for guideway.

1.7. Workshop and Stabling Requirements

The following is the minimum required for a fleet of 10 vehicles within $1000m^2$.

1.8. Isolation Values within the Guideway

1.8.1. General

The guideway values are installed in the lower part of the guidebeam and are controlled by the command center during vehicle operation.

The location of such values is based on the needs of each project prior to implementation. The maximum space required below the guideway is 1.1m, with the normal being 40cm.

1.9. Restrictions

1.9.1. General

Considering the degree of flexibility within the Aeromovel Technology, measure are taken to gain optimum and rational design for each project. Trade-offs between the capital costs and the long-term operation and maintenance costs are considered.

1.9.2. Restrictions and Basic Conditions

Vertical Gradients:
Ideal 5%
Feasible 12% *

* Note: Standing passengers have difficulty in position when gradient of more than 9% is traversed.

Horizontal Curvature
Ideal 80m
Feasible 24m*

* Note: Velocity limited to 12 kph, therefore should be done near to entry or exit from station rather than within tangent section.

Dimension along the alignment to permit transport of beams, piers, and accessories to the point of use.

1.10. Factors for Cost Optimization, Construction Time, and Operation of System

The basic factors enumerated are required to maintain the rational and optimal costs, speed in construction, and quality within the permanent way.

Design a route or line with the minimal number of different beams.
Design smooth transitions in curves
Minimize the curves required
Attempt to have stations spaced at least 500 to 700m apart. System can function with station spacing a short as 250m, but the operation costs increase
Compensate for curve and gradient in a manner to permit good velocity.

1.11. Vehicle Operation

1.11.1. Principle of Operation

To determine the profile for location and vehicle operation between stations, the speed and total travel time is measured. This considered the various loadings (or weight) that the vehicle can carry. This ranges from 90.000N to 285.000N. Vehicle performance is measured as 0-30%, 31-50%, 51-70%, and 71-100% total weight. Variation in travel time between stations for any vehicle is limited to a maximum of 5%.

1.11.2. Automatic Operation

With the fully automatic operation of the vehicles, a series of pre-programmed computer commands are used. The programs contain the profile and characteristics of the way. The computer monitors and evaluates the speed, position, and weight of the vehicle and ensures that its operation conforms to the programs.

1.11.3. Semi-Automatic Operation with Operator

Option exists for the Aeromovel Technology to be operated in semi-automatic method with a command operator placed at each station within the control cabin. They control the procedures within the station, the acceleration of the vehicle, and the guideway values. The operator decelerates the vehicle with reverse air-pressure.

FOR FURTHER INFORMATION, PLEASE CONTACT:

U.S.A. & CANADA:
SUR COESTER AEROMOVEL
Suite 221, 2025 I Street NW
Washington D.C. 20006 USA
Tel: 1-202-223-3805
Fax: 1-202-223-3931

BRASIL & SOUTH AMERICA:
SUR COESTER S.A.
Rua Washington Luis 186
Porto Alegre, RS, Brasil
Tel: 55-512-261088
Fax: 55-512-271 392
or 342 661

INTERNATIONAL:
SUR COESTER
c/o Lee H Rogers
4909 St Barnabas Road
Temple Hills, Md 20748 USA
Tel/Fax 1-301-894-2037