GOVERNMENT OF INDIA

MINISTRY OF URBAN DEVELOPMENT






REPORT OF THE SUB-COMMITTEE
ON

ROLLING STOCK
FOR
METRO RAILWAYS

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MESSAGE

The growth story of India is to be written on the canvass of planned urbannisation and the success of planned urbanisation depends upon sustainable urban transport and transit oriented development (TOD). Efficiently designed, operationally sustainable and user friendly urban transport systems are instrumental in urban mobility.

India's urbanization process has now gained pace and as per the latest census, the growth of population in the urban areas has already exceeded that in the rural areas. As urbanization accelerates, we would need to tackle the issues of redevelopment of existing areas, creation of newly urbanised areas as well as provision of mass transit systems, modernisation and up gradation of existing urban transport systems in a manner that meets the aspirations of all classes of society. The concept would have to strategic densificastion of the urban areas, so as to optimise the land use through TOD approaches. That would invariably lead to comprehensive mobility planning for the urban areas, including the potentially urbanisable areas.

Metro railways are undoubtedly the preferred mode for mass transport on high demand corridors in big and medium cities and lead to making growing cities more liveable and sustainable. As a matter of policy, the Ministry of Urban Development (MOUD) envisages cities with 2 million plus population to plan for metro rail networks in next few years. As can be seen in Delhi, mass transport facilities such as the Metro, have been a game changer for urban transport and urban development. And that would hold good for any other large city too in the country.

With the creation of new metro facilities in several cities (tier 1 and 2), and in view of capital intensive nature of the metro rail projects, there is a need for cost optimization strategies, such as standardization and indigenization, of metro rail systems. The setting up of a committee for "Standardization and Indigenization" of metro railway systems by the MOUD an endeavour in that direction. The Committee produced a "Base Paper" wherein consensus items were indicated and also suggestions were incorporated for constitution of a number of sub-committees for in-depth study. To make rthe task more manageable, the following thematic sub-committees were constituted:

- Traction and power supply systems

- Rolling stock
- Metro railway Operation and Maintenance
- Signalling systems
- Fare collection systems
- Track structures

The initiative of MoUD to draw upon the expertise of professionals across various disciplines and also from industry has resulted in finalization of the reports of the various sub-committees. The Base Paper as well as the sub-committee reports have suggested multiple strategies for standardization and indigenization. Such evolving long term strategies for cost reduction are expected to yield significant results – in terms of both, cost optimization and high end knowledge accumulation in the country.

I encourage all cities, states, metro railway organizations and other organizations associated with metro rail systems to make full use of these reports for planning and implementation of metro rail systems in their cities as well as contribute to their further evolution in future.

I congratulate all the members of the Base Paper Committee and Sub-committees for successfully bringing out their respective reports.

(Sudhir Krishna)

New Delhi
19th November, 2013

Preface

1. Metro systems are already operational in Delhi and Bangalore and construction work is progressing at a fast pace in Chennai, Kolkata, Hyderabad, Jaipur, Kochi and Gurgaon. There are plans to have Metro Systems in cities with population more than 2 million. MOUD with a view to promote the domestic manufacturing for Metro Systems and formation of standards for such systems in India, has constituted a Group for preparing a Base paper on Standardization and Indigenization of Metro Railway Systems vide Order of F.No.K-14011/26/2012 MRTS/Coord dated 30th May 2012.

2. The Group has identified certain issues which require detailed deliberations / review cost benefit analysis / study. The Group suggested that Sub-Committees may be constituted consisting of officers/professional drawn from relevant field/ profession from Ministry of Urban Development/Railways/Metros and industries associated with rail based systems / Metro Railway Systems.

3. Accordingly following Sub-Committees for various systems were constituted by Ministry of Urban Development vide order No. K-14011/26/2012-MRTS/Coorddt. 30.05.2012/25.07.2012:
    - Traction system
    - Rolling stock
    - Signaling system
    - Fare collection system
    - Operation & Maintenance
    - Track structure
    - Simulation Tools

4. The Sub-committee on Rolling Stock has following members:

    Shri Sanchit Pandey CGM/Rolling Stock/P/DMRC.

    Shri Amit Banerjee, GM/Technology Divn. BEML, Bangaluru.

    Shri Naresh Aggarwal, Chairman CII, Railway Equipment Divn. & MD & Co-Chairman, VAE, VKN Industries Pvt. Ltd.

    Shri Raminder Singh, Siemens Ltd.

    Shri ManjeetNarwan, Resident Vice President, Texmaco Rail &Engg.Ltd.

    Shri Samir Nirula, GM, Medha Servo Drives Pvt. Ltd.

    Shri Mangal Dev, Director, Alstom Projects India Ltd.

    Shri Sriram Raju, Director, Bombardier Transportation India Ltd.

    Shri Ajay Sinha, Regional Director, EMD Locomotive Technologies Pvt,.Ltd.

    Shri R.Sathish, Director, CII.

Dr. A.K. Agarwal, CEO, Autometers Alliance Ltd.

Shri Sajal Gupta, GM/Autometers Alliance Ltd.,

Shri Sanjeev Kumar, Director, GE Transportation (GE India Industrial Pvt. Ltd)

Shri Manoj Kumar, Business Head-Transport Solution, ANSALDO STS Transportation Systems India Pvt. Ltd.,

Shri D.S.Rajora, Sr. Director, ASSOCHAM

Shri B.UmeshRai, Chief General Manager(Electrical Inspection)/CMRL

Shri S.K. Gupta, US(MRTS-I)/ MoUD

Shri ShalabhTyagi, Director/PE&Metro/RDSO

Shri Anil Kumar, System head/L&T (Hyderabad) Metro rail.

Shri Anil Jangid, Professional

Shri D.D Pahuja, Director(RSE), BMRC.

Shri Jaideep, Director Electrical(G), Railway Board.

5. The details Terms of Reference of the sub-committee on Rolling Stock is given in Annexure-10 and broadly include formulation of Standards for :

   (i) Noise and Vibration level (including RS, Track etc.)

   (ii) Emergency evacuation system

   (iii) Coupling arrangement (Automatic, semi-automatic etc.)

   (iv) Acceleration/Deceleration/Jerk Rate, Power to weight ratio/ % motorization

   (v) Eligibility/qualification criteria for procurement

   (vi) Propulsion – Single source or consortium/JV – approach.

   (vii) Control & communication protocol – common/published standard/standards for Train Control & Management System (TCMS)

   (viii) Driverless Operation

   (ix) Indigenization

6. The sub- committee had number of meetings and has since completed the assigned task. Each issue included in the TOR has been deliberated in detail in separate chapter in the report. The Key findings are given in Executive Summary.

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1.0 EXECUTIVE SUMMARY

1.1 Noise and Oscillation Level

Committee studied following Acts and Legislations:

- Environment Protection Act, 1986 and The Noise Pollution (regulation and Control) Rules, 2000 amended vide Ministry of Environment and Forests Notification dated 9th March 2009, that stipulate the norms for permissible limits for noise at various places, alongwith Noise Impact Assessment Significance criteria.

- Permissible Daily Noise exposure levels prescribed by US Environmental Protection Agency and World Health Organisation(WHO)

- "The Ancient Monuments and Archaelogical Sites and Remains (Amendment and Validation) Act 2010". Regulations regarding protection of ASI monuments (Heritage structures) from vibrations generated by metro train operations.

Committee also considered following studies on Noise and Vibrations emanating from Metro Systems:

- Study of Noise assessment inside the Greater Cairo Underground Metro - By Mostafa E Aly and Noise

- Athens Metro Extension Project to Piraeus Ground borne Noise and Vibration Assessment and Control

- RIVAS Railway Induced Vibration Abatement Solutions Collaborative project State of the art review of mitigation measures on track Project Coordinator: Bernd Asmussen International Union of Railways (UIC)

- Interim guidelines for Assessment of noise from Tail infrastructure projects-Published by Department of Environment and Climate Change NSW 59–61 Goulburn Street, Sydney

- Delhi Metro Report on Train Noise Level Study by Rupert Taylor

- Noise impact assessment of mass rapid transit systems in Delhi City – Naveen Garg, Omkar Sharma and S Maji. Acoustics, Ultrasonics, Shock and Vibration Standard, National Physical Laboratory(CSIR) New Delhi 110012

- DMRC Train Noise Level Study RS1 by GC – Report dated 7.06.2005

- METRO RAILWAY NOISE AND VIBRATION - Causes and solutions for DMRC Phase III

Environmental Noise is recognized as a major Health problem. Noise exposure is a function of two main factors:

(1) The frequency-weighted exposure level, measured in A-weighted decibels (dBA)

(2) The exposure duration

US Environmental Protection Agency (EPA) in 1974 and World Health Organization(WHO) recommends LAeq of 75 dB(A) during day time and 70 dB(A) during night time for Industrial areas as permissible noise levels. For Commuters in the Metro and at Stations also this can be considered as the upper limit and needs to be maintained.

A weighted LAeq is considered to be most suitable for predicting general annoyance and most of disturbance reactions observed. Indian Noise legislation does not permit the increase in ambient noise level by 10 dB(A) due to project noise(Noise generated by Metro operations. As per WHO and EPA Chronic exposures to 80.3 dBA for more than 160 minutes per day may be expected to produce hearing loss in some exposed individuals, and a 90.2-dBA level likewise may cause hearing loss with just 18 minutes of exposure per day.

Though most of the Metros specify measurement of internal coach noise LAeq as per ISO 3381:2011 and measurement of external noise as per ISO 3095:2010 American Public Transit Association (APTA) specifies maximum pass by airborne noise from train operationsLAmax at 85 dBA. European nations specify both maximum noise levels (Lmax) and equivalent noise levels (LAeq) for given period of the day. For example UK specifies LAmax 85dBA and LAeq 68 dBA for 06:00 Hrs to 2400 Hrs.

Noise and Vibration norms adopted by various Metros in other countries and Indian Metros, method of measurement etc were studied in detail. Valuable inputs were received from Industry and Delhi Metro in this regard. Based on the detailed study and inputs from all members of the committee, following recommendations are made:

Recommended Noise Levels

Measurement of Internal coach noiseLaeq be done as per ISO 3381:2011(or latest) and measurement of external noise as per ISO 3095:2010(or latest)

Type of Rolling Stock		Interior Noise level (ISO 3381)LAeq (dBA)		Exterior Noise level (ISO 3095)LAeq (dBA)	
		Stationary	Running	Stationary	Running 80 kmph
750 Volts Third rail	Via-duct	66	72/70	67	80
	Tunnel	70	74/72	72	82
25 KV AC Stock	Via-duct	68	72/70	67	82
	Tunnel	72	75	NA	NA

Vibrations

Ground-borne vibrations caused by the dynamic impact forces generated in the wheel-rail interaction propagate in the soil and excite the foundation walls and air borne noise caused by low frequency emissions can excite building structural components(walls etc) above ground. The key factors of the vehicle / track system which determine ground vibration are related to the track design and the maintenance of wheel and rail:

- Design of the track, more precisely the properties of the track mass/spring/damping system consisting of rail, pads, sleeper, ballast, slab, embankment

- Impact excitation from track discontinuities like switches & crossings and insulation joints

- Wheel / rail surface quality, roughness incl. corrugation, out-of-roundness, dents, flats

Intensity of ground based noise and vibrations, are primarily dependent on track structure, soil conditions and distance of such buildings from the railway track. It has to be ensured that these vibration levels do not exceed the safety limits as prescribed in ISO 14835 for which specific measures may need to be adopted while designing the track structure.

Passengers are also subjected to the vibrations for which norms have been prescribed by ISO 2631. It has been suggested by DMRC that only these norms be specified for rolling stock manufacturers. This makes sense as the rolling stock manufacturers have no control over ground vibrations emitting from Metro operations.

Recommendations

Vibrations to be measured as per ISO 2631, weighted acceleration should be less than 0.315 m/s^2

1.2 Emergency Evacuation System

Committee studied the systems adopted by various Metros worldwide for emergency Evacuation and these include

- Side Evacuation system

- Front Evacuation System

Side Evacuation

In case of side evacuation a walkway is provided along the track. People get out through normal doors and move on the walkway which takes them to the nearest station platform. The relative merits and demerits of this system are as follows:

Advantages:

1) In case of DC third rail system evacuation is faster as switching off of power to third rail is not required.
2) Evacuation from the train is faster due to large number of doors.

Disadvantages:

1) In case of sharp curves,side evacuation is not considered safe as gap between train and walkway on curve will be very large, which have to be bridged by some plate/footboard
2) Side evacuation requires side walkway and hence via-duct width is unnecessarily more and structures are heavy due to extra loading
3) Walking on raised walkway is not considered safe for children/elderly passengers. Further there are chances of stampede on walkway

Front Evacuation system

In this concept evacuation door opens upwards on hinges & ramp is deployed to tracks. Merits and demerits of this system are:

Advantages:

1) No need for extra walkway, hence size of the tunnel as well as via-duct reduces hence more economical.
2) Evacuation is from emergency doors provided at the ends and can be better regulated by motorman and stampede is prevented.
3) Walking is easier for passengers in this system as either they have to walk through the coaches or on the track

Disadvantages:

1) Power block is necessary in case of 750 Volts DC third Rail system, which may take some time
2) Exit from single emergency door may affect the faster evacuation.

Committee recommends that Indian Metros should adopt front evacuationonly with door at the center as it is the most prevalent practice world-wide.

1.3Coupling Arrangement

There are three different types of couplers used in Metro Rolling Stock

- Fully Automatic Mechanical, Pneumatic and Electrical coupler

- Automatic Mechanical and Pneumatic coupling and Jumper cables (IV couplers) for electrical connection.

- Semi-Permanent coupler for mechanical and pneumatic coupling along with electrical coupling is through jumper cables between cars.

Recommendations

1. For two ends of the train:

   Automatic Mechanical and pneumatic coupling is recommended with Electric coupling through jumper cables. Two rakes need to be coupled in the rescue mode, here time is a consideration, hence automatic mechanical and pneumatic coupling at the two end of the rakes are recommended. Electric coupling shall be using jumpers.

2. Between coaches of the same basic unit:

   Semi-permanentcoupler are recommended with Electric coupling through jumper cables between cars, as these couplings are used only in sheds during maintenance.

3. Between two basic units:

   In case frequent interchanging of basic units or changes in car formations are required, Automatic Mechanical, Pneumatic and Electrical couplermay be provided. DMRC is providing these Automatic couplers between basic units. As these couplers are most expensive (Approximately 4 times the cost of semi-permanent coupler). Hence usage should be only need based.

1.4 Percentage Motorisation, Acceleration/Deceleration/Jerk Rate, Power to weight ratio

1.4.1 Percentage Motorisation

3 Car unit

For a basic 3 -car train there is no alternative but to have 66% motorization so as to ensure that failure of one motor car does not result in immobilization of train in the section.

4 Car unit/8 Car trains

In case of 4-car/ 8 car trains, only 50% and 75% motorisation is possible. DMRC, who have sufficient experience with 50%,recommends 75% motorization both for 4 car and 8 car trains. 75% motorisation in 4 car rakes would require three different type of cars. It is thus desirable to go in for 75% motorisation in case of 8 car rakes and 50% for 4 car rakes.

6 Car/9 Car trains

In case of 6 car/9car, 66% motorization is a better option on account of following considerations:

Advantages

- Even with loss of one power car the operational performance is satisfactory, hence motor coach control can be adopted instead of bogie control.
- Smaller Traction Motor
- Higher level of acceleration and declaration is possible, subject to adhesion limits.
- Higher regeneration level is achieved resulting in lower application of friction braking and consequently less wear of pad /disc.
- Energy efficiency is better
- Chances of slip/slide even under the worst conditions are reduced due to utilization of lower adhesion factor compared to the permissible values.

Disadvantages

- Number of motor coaches will go up which will also result in increase in cost, and increase in tare weight. There will however be some reduction on account of bogie control in cost of propulsion equipment
- Number of pantographs in 25 KV AC systems will go up. This can however be reduced by having one common transformer and single panto for a 3 car basic unit. This will reduce redundancy as two motor coaches will be out in case of failures of traction transformer, hence can be permitted with only 6 car rake having two basic units of 3 car each.

The initial & maintenance cost of propulsion for 66% motorization will be higher, however there will be savings towards energy cost. World wide 66% motoring is accepted as the most appropriate.

Recommendations

Committee recommends 3 car or 6car per rake depending on the traffic projections with 66% motorization should be adopted as the standard for all future Metros. In case of 3 car rakes both motored cars should have independent propulsion equipment for complete redundancy.

Recommended Operating characteristics Acceleration, Deceleration, jerk rate etc are as given below

Characteristic	50% Powering	66% Powering
Maximum Design speed	95kmph	95 kmph
Maximum operating speed	85kmph	85kmph
Average acceleration from 0 to 40 kmph in m/s2 for fully loaded train at level track with AW3 load standees 80/m2 and seating approx. 50 p/car	0.8	1.0
Service braking rate from 80 kmph to standstill up to fully loaded train on level tangent track	1.0	1.0 m/s2
Emergency braking rate from 80 kmph to standstill up to fully loaded train on level tangent track	1.3	1.3 m/s2
Maximum jerk rate in acceleration or braking in m/s3	0.7	0.7
Minimum Adhesion level	0.20	0.20

1.5 Propulsion Equipment–Single source or Consortiums/JVs

Issue is whether bids be invited from coach manufacturers as single source with option to source propulsion equipment from sub contractors, or consortiums/JV of coach manufacturers and Propulsion equipment supplier.

Rolling stock manufacture involves four distinct requirements, namely:

i) Car body/mechanicals,
ii) train system design & integration,
iii) Propulsion system including TCMS and
iv) Interfacing, testing & commissioning with full MRTS system.

The above role is normally divided amongst two different set of firms

1. Car manufacturers
   They specialize in manufacture of car body/mechanicals and integration of propulsion system and TCMS from the specialist suppliers.
   Examples are BEML, CAF, ROTEM

2. Propulsion Equipment suppliers
   Propulsion system comprises of Traction Motor, main converter-inverters, auxiliary converters, transformers & TCMS. The propulsion system is quite crucial sub-system of the train. Responsibilities of propulsion system supplier include:

   - Supply of propulsion equipment including TCMS
   - Interfacing with other subsystems like HVAC, Lighting, Doors, ATC/ATO, Brake System, Signaling, Passenger Information system, Power supply etc.
   - Commissioning and Testing

   Examples are Toshiba, MELCO, Hitachi, SIEMENS, Bombardier etc.

There are suppliers who supply the complete rolling stock including propulsion system. Examples are Bombardier, SIEMENS, ALSTOM, Ansaldo Breda etc.

Advantages of Non consortium approach ie when propulsion equipment suppliers can be sub contractors:

- Enables competitive pricing as
  - Rolling Stock manufacture that manufacture their own propulsion equipment can offer better competitive price
  - Rolling stock manufacturers (who do not manufacture propulsion equipment) will have enough negotiating power with Propulsion equipment suppliers. This will reduce the price.
  - As the number of Propulsion equipment manufacturers are limited, consortium approach will restrict the number of bids to number of propulsion equipment manufacturers and thus competition.
  - It will promote indigenous manufacture at competitive price as indigenous capability for car manufacture is available in the country and dependence on tie up with a particular propulsion equipment vendor will reduce.

Recommendations

Committee recommends that car manufacturers can either bid as a single vendor with their own propulsion equipment in case it is manufactured by them and will have an option to source the propulsion equipment from any propulsion equipment supplier as a sub contractor. There should be no compulsion on the car manufacturer to have propulsion equipment supplier as a consortium/JV partner for bidding as consortium. Car manufacturer will have the option to bid as a single vendor or in consortium with propulsion manufacturer

1.6 Eligibility Criteria

Eligibility criteria should aim at encouraging competition, ensuring reliability and quality and indigenization. Eligibility criteria have a direct bearing on the cost. Broader criteria ensures competitive prices.

Rolling stock comprises of Car body and Propulsion equipment. As there are two distinct set of suppliers for Car body manufacturing and propulsion equipment, and Non consortium approach for propulsion equipment supplier is recommended, it is necessary to have separate eligibility/qualification criteria for these two separate set of suppliers.

Eligibility criteria for car manufacturer must ensure quality, reliability and competitive price of the rolling stock. Taking the views of Industry and Metros into consideration, following eligibility criteria for Rolling stock supplier is recommended.

Eligibility criteria for car manufacturer:

Bidder consortium or its members, individually or jointly as member of other consortium have experience and carried out vehicle design, Interface, Assembly & Supply, Testing and Commissioning and should have following credentials:

1. Minimum number of cars	300 metro (i.e. MRT,LRT, Sub-urban railway or high speed railways out of which minimum 200 cars shall be of either stain less steel or Aluminum in the last 10 years.
2. No of countries	At least one country other than the country of manufacture or in India.
3. Operation Performance	150 cars out of above must be operating satisfactorily against more than one contract in at least one country other than the country of manufacture or in India for last 5 years.

4. Projects executed through TOT arrangement with global player may be taken as experience. This will promote indigenization.
5. Indian subsidiary companies be eligible to bid on the basis of the global credentials of parent company.

Eligibility criteria for Propulsion Equipment Supplier:

Propulsion equipment supplier can be consortium member or a sub-contractor meeting the following requirements:

a) Must have cumulative experience of minimum 10 years in the Design and manufacturing of propulsion equipment (Traction converter-Inverter, Auxiliary converter/Inverter and Traction Motor rolling stock).

b) Propulsion equipment supplied must have been in satisfactory revenue operation for at least five(5) years in minimum 500 cars comprising of both powered and non-powered cars supplied against minimum five different contracts in the Metros of least one country other than the country of manufacture or in India.

c) Projects executed through TOT arrangement with global player may be taken as experience. This will promote indigenization.

d) Indian subsidiary companies be eligible to bid on the basis of the global credentials of parent company.

1.7 Control & communication protocol

Train integrated management system (TIMS) is a complete, integrated system for the control and monitoring of the train-borne equipment. TIMS provides control and monitoring, diagnostic and reporting of the train-borne equipment in a redundant manner.Train Control & Management (TCMS) is a subsystem of TIMS and controls and monitors all train equipment.

Subsystems of the train utilize microprocessor-based control. The subsystems are inter-linked via a communication data bus system for the monitoring, fault data logging and for first line diagnostics of faults on board the train. Communication is through the Train Bus (ARCNET) and Local bus (RS-485). IEC 60571 is the International standard for TIMS hardware.

All the Reputed rolling stock manufacturers have developed their own Train Integrated Management Control System (TIMS) over the years. Even though communication protocols are based on international standards but achieving interoperability with subsystems of alternative vendors is generally quite difficult. Support of the TIMS manufacturer is required for achieving integration.

Recommendations for TIMS

Conformity to IEC62280-1 (Safety related communication in closed transmission systems)

The hardware systems deployed should conform to international standards.

There should be Open protocol between TCMS & respective sub-systems.

Also Transmission data flow in the network between TCMS & sub-systems can be standardized, so that subsystem supplier of different makes can meet the requirement of monitoring & control of the various parameters through TCMS. Gradually sub-system supplier should adopt IP technology.

1.8 Driverless Train Operation

Main Features

- Automatic departure and run from station to station, including automatic turn-back
- Door re-opening on train hold command
- Remote start of stalled trains

Attendant responsibility:

- control passenger doors
- prevent person injuries between cars or between platform and train
- ensure safe starting conditions
- set in/set off operation
- supervise the status of the train

Driverless system on the Indian Metro Projects

- Driverless system is the technology, which is well proven now and is strongly recommended for use in Indian Metro system.
- Techno-Commercials considerations are in favour of driver-less system as extra capex can be recovered in 7-10 years' time.
- Driverless system needs very high reliability and hence detaileddesigns requires extra time in RAM assurance activities.
- Approval and safety certificate from CRS due to lack of technical experience, which can probably be managed.

Driver less operation is required to achieve 85 to 90 seconds frequency for full utilization of Metro infrastructure capacity. This will require communication based Train Control (CBTC) system. Driverless Train Operation can be adopted in phases with signaling up-gradation.

1.9 Indigenisation

Rolling Stock manufacture includes

- Manufacture of Carbody& Bogie frames, assembly, integration & testing. Infrastructural facilities for manufacture of car body and bogie frame and it's integration are already available in the country. Indigenous sources for certain outfitting items like GFRP panels, grab poles & rails, window glasses, glass wool insulation, electrical panels, battery box, stainless steel and aluminum fabricated items, etc are also available.

- manufacture of propulsion system including TCMS and other critical sub-systems like propulsion, brake, door, HVAC, passenger address & Passenger information system, CCTV etc.

Car manufacture

Indigenisation of Car body manufacture has already taken place as following manufacturing facilities have already been set up:

- BT coach manufacturing unit at Vadodara
- BEML Bangalore under TOT from Hyundai Rotem
- Alstom setting up unit near Chennai
- CAF setting up manufacturing unit in Haryana
- Kawasaki is also planning to set up coach production facilities.
- ICF and RCF have facilities to manufacture EMU/MEMU coaches which can be up graded to Metro coaches.

Above facilities can take care of the future Metro needs. There is however a need to protect these investments and some incentives need to be given to these units for effectively utilizing the facilities already created.

Propulsion equipment

The critical area is indigenization of manufacture of propulsion system, TCMS and other critical sub systems. Global suppliers with satisfactory performance record need to be encouraged to either set up their subsidiary in India or transfer technology to an Indian company through JV. Following steps are necessary to achieve this:

Specifications for both rolling stock and traction distribution system are standardized.This will help indigenous

Standardization will result in higher volumes. It will be possible to leaverage the bulk procurement by a single agency to achieve development of indigenous industry through TOT as has also been done by China.

Presently individual metros are procuring rolling stock in small quantities with different specifications and clause to manufacture 60 to 70% cars indigenously. This does not promote indigenisation of propulsion equipment which is mostly imported. As in case of car body manufacture, indigenous manufacture of complete propulsion equipment in the phased manner also needs to be mandated in the rolling stock tenders.

MoUD in order to promote indigenous manufacture of propulsion equipment should give development orders for small quantities to local firms who can either develop on their own or through collaboration with global suppliers. IR has adopted this approach for development of indigenous three phase propulsion equipment for locomotive and EMUs. After successful tests and trials these sources can be considered as regular sources for propulsion equipment.

Committee, thus, recommends that a system of bulk order placement may be devised preferably by MoUD by combining requirement of smaller metros. Orders should be placed with at least 70% indigenization clause for both propulsion equipment and car manufacture through TOT with indigenous manufacturers or setting up of Indian subsidiaries.

2.0 TERMS OF REFERENCE OF THE SUB COMMITTEE ON ROLLING STOCK

Item No. 1 - Noise and Vibration level (including RS, Track etc.)

Terms of Reference

- Study of the Environmental Laws in India and extracting the relevant statutory requirements.
- Study of noise and vibration criteria adopted by various metros in India in their rolling stock and trackwork specifications.
- Study of similar international regulations in other countries having vast knowledge base in this field – such as USA, Germany, Japan, Singapore etc.
- Study of regulations regarding protection of ASI monuments (heritage structures) from vibration generated by metro trains operation.
- Study of regulations in other countries regarding protection of heritage structures.
- Analysis of above and recommendations for acceptable noise & vibration criteria for rolling stock and track including suggestions for integrated responsibilities or clarity of interface.
- Report of above study.

Item No. 2 - Emergency Evacuation System

Terms of reference

- Study of the NFPA 130 and other relevant national/international standards regarding emergency evacuation system
- Study of practices adopted in various metro systems in India and elsewhere along with the underlying logic/reasons (at least 3 metros each in USA, Europe, Japan, China and South East Asia to be studied).
- Study of particular requirements of emergency evacuation with respect to elevated, underground and at-grade routes.
- Study of report by NOVA (available with DMRC)/COMET (a society of heavy metros) in this regard.
- Study of procedure adopted during emergency evacuation – such as power off, ETS activation, signaling interface etc. – particularly in systems having third rail traction.
- Analysis of data collected including structured presentation of database.
- Report covering all the above issues including summary and recommendations.

Item No. 3 - Coupling arrangement (Automatic, semi-automatic etc.)

Terms of reference

- Study of various types of couplers being used in Indian railways and various metros in India and elsewhere.
- Study of the relevant Indian and International standards in this regard.
- Study of functional advantages offered by various types of couplers (automatic viz-a-viz. semi-automatic couplers).
- Collection of data regarding various suppliers of various types of couplers – both in India and elsewhere
- Information gathering regarding regular suppliers of such items to Indian Railways, DMRC, BMRCL, Kolkata Metro.

- Preliminary cost analysis of each type of couplers including studying impact of imported components/assembly.
- Study of maintenance practices of trains being followed by Indian Railways, Kolkata Metro, DMRC and BMRC and assessment of instances of coupling and de-coupling of units and coaches – in depots as well as on lines.
- Study of an assessment report conducted by BMRCL in this regard.
- Report comprising above issues, analysis, recommendations and way forward.

Item No. 4 - Acceleration/Deceleration/Jerk Rake, Power to weight ratio/ % motorization

Terms of reference

- Study and analysis of key parameters of rolling stock viz. Acceleration/Deceleration/Jerk Rate and suggest Power-to-weight ratio & % motorization and suggestion for standardization
- Above study shall be based on cost benefit analysis carried out using appropriate simulation tools as well as results of actual experience of 2MC + 1TC (of BMRCL) and 1MC+1TC (of DMRC). The study shall analyse impact on transit/round trip time with above configuration of trains.

Item No. 5 - Eligibility/qualification criteria for procurement

Item No.6 - Propulsion – Single source or consortium/JV – approach.

Item No.7 - Control & communication protocol – common/published

Terms of reference

- Study of impact of use of vendor specific(proprietary) software/protocol for TCMS on interoperability/use of subsystems of different makes as well as impact on cost of rolling stock
- Study of Control & Communication protocol – Common/published standard/standards for Train Control & Management System (TCMS) used by different metros in India and abroad and provide suggestions/recommendations.

Item No.8 - Driver less control

Terms of reference

- Collection of data regarding metros having driverless train operation and study of the same for adoption in metros in India.
- Study eligibility/qualification criteria for procurement of rolling stock being followed by different metros and Indian Railways.

Item No.9 -Indigenisation

Terms of reference

- Identifying constraints in process of indigenous development and evolving strategy for placing development orders for assemblies/systems/subsystems.
- Recommend appropriate eligibility/qualification criteria for wider competition and phased Indigenization in a planned manner without diluting quality.

3.0 Noise and Vibration Level

3.1 Environmental Laws in India and the relevant statutory requirements.

Noise Legislation in India

Environment (Protection) Act, 1986 (29 of 1986) read with rule 5 of the Environment (Protection) Rules, 1986, the Central Government has made the rules for the regulation and control of noise producing and generating sources, namely:The Noise Pollution (Regulation and Control) Rules, 2000. Rules stipulate following norms:

	Place	Limits in dB(A) Leq	
		Day time	Night Time
1	Industrial Area	75	70
2	Commercial area	65	55
3	Residential Area	55	45
4	Silence Zone	40	30

Noise and Pollution (Regulation and Control) (Amendment) Rules 2009

Noise Pollution Rules have been amended vide above notification on 9th March 2009 by Ministry of Forest and Environment. Operative para relevant to Metro is given below:

(iv) after sub-rule 3 as so amended, the following sub-rules shall be inserted, namely:-

"(4) The noise level at the boundary of the public place, where loudspeaker or public address system or any other noise source is being used shall not exceed 10 dB (A) above the ambient noise standards for the area or 75 dB (A) whichever is lower.

Implications for Metros of the above legislation:

Environmental Noise is recognized as a major Health problem. A weighted LAeq is considered to be most suitable for predicting general annoyance and most of disturbance reactions observed. Indian Noise legislation does not permit the increase in ambient noise level by 10 dB(A) due to project noise(Noise generated by Metro operations. Day time and night time values of permissible Noise levels have been specified by the Act. Act also specifies a LAeq of 75 dB(A) during day time and 70 dB(A) during night time for Indusrial areas. For Commuters in the Metro and at Stations also this can be considered as the upper limit and needs to be maintained.

3.2 International regulations in other countries having vast knowledge base in this field – such as USA, Germany, Japan, Singapore etc.

Noise exposure is a function of 2 main factors: (1) the frequency-weighted exposure level, measured in A-weighted decibels (dBA), and (2) the exposure duration. **US Environmental Protection Agency (EPA)** in 1974 and **World Health Organization(WHO)** recommended daily allowable exposure times are

SL	TIME OF EXPOSURE	LEQ DB(A)
1	24 hours	70 dBA
2	8 hours	75 dBA
3	2.7 hours	80 dBA
4	0.9 hours	85 dBA
5	0.3 hours	90 dBA

Chronic exposures that exceed these allowable combinations of duration and noise level are expected to produce Noise induced hearing loss (NIIHL) in some members of the exposed population.

Based on the WHO and EPA recommendations, chronic exposure to 80.3 dBA for more than 160 minutes per day may be expected to produce hearing loss in some exposed individuals, and a 90.2-dBA level likewise may cause hearing loss with just 18 minutes of exposure per day.

The American National Standards Institute and the US National Research Councilrecommend Day-Night average sound level (Ldn) for assessment of environmental noise as do most federal agencies and administrations. Ldn of 65 dB is the onset of a normally unacceptable noise zone. All international agencies have cognizance over use of Ldn value above 55 dB as the threshold value for defining noise impact in urban residential areas.

The Federal transit Administration (FTA), US published impact assessment procedures to be used for mass transit projects. These criteria are based upon comparison of the existing outdoor ambient noise to future outdoor sound levels from the proposed project. Unlike Indian noise regulations that permit up to 10 dBA increase in ambient noise due to project noise. Noise increase permitted by the

FTA is graded. It allows a 10 dBA increase where existing noise exposure is 42 dB(A), but only a 1 dB(A) increase where existing exposure is 70 dB(A)

American Public Transit Association (APTA) proposed noise guidelines based upon the maximum A-weighted sound level (LAmax of single vehicle pass by are given in the table below:

Area Description	Maximum Pass by sound level dB(A)		
	Single family dwellings	Multi –family dwellings	Commercial buildings
Low Density Residential	70	75	80
High Density residential	75	80	85
Commercial	80	80	85
Industrial/Highway	80	85	85

World Health Organisation(WHO) recommended a 16 hour day-time Leq of 55 dB and approximately a 45 dB nighttime Leq to prevent “serious” annoyance

US Housing and Urban Development criteria for noise for L1,L99 and LNP

L1 represents the maximum noise event which takes about 1% of measurement period L99 is the background noise, which represents the lowest level during the measurement period

L1

Normally Unacceptable 73.5<L1 <86.0 dBA

Clearly Unacceptable > 86.0 dBA

L99

Normally Unacceptable 53.0 <L99 <68.0 dBA

Clearly Unacceptable > 68.0 dBA

American Public Transit Association (APTA) guidelines for maximum pass by airborne noise from train operations are given in the table below:

Community Area	Maximum Pass by sound level dB(A)		
Description	Single family dwellings	Multi family dwellings	Commercial buildings
Low density residential	70	75	80
Average residential	75	75	80
High-density residential	75	80	85
Commercial	80	80	85
Industrial/Highway	80	85	85

According to UK “Design Manual for Roads and Bridges (DMRB) , the onset of annoyance due to a new project activity, is considerable if the change is more than 10 dB(A)

Railway Noise Impact criteria followed in various countries

Table below shows the various noise impact criteria followed by different European nations. Specific maximum noise levels (Lmax) and equivalent noise levels (LAeq) for given period of the day as related to these sensitive areas are specific**.**

Country	Period	$L_{A.max}$dBA	LAeq (dBA)
Australia	06h00-06h00	85	60
Denmark	06h00-06h00	88	60
UK	06h00-24h00	85	68
	24h00-06h00	85	63
USA	06h00-06h00		77,55
Sweden	06h00-06h00		63
Japan	07h00-22h00	70	60
	22h00-07h00	70	55
Germany	06h00-22h00		59
	22h00-06h00		49
France	06h00-22h00		60
	22h00-06h00		55

3.3 Major Noise Sources from Metro Systems

Noise radiated from train operation and track structures generally constitute the major noise sources from Metro System. Air borne noise is radiated from at grade and elevated operations, ground borne noise and vibration is of prime concern for underground operations. Following Noise need to be considered in case of Metro System Design

a) Way side Noise

Way side noise is very important for residential areas, hospitals,schoolsetcfalling in the vicinity of Metro Systems. There are four basic sources of way side air borne noise.

1. Wheel rail Noise that is directly radiated from the vibrating wheels and rails
2. Propulsion equipment including noise from traction motors, cooling fans reduction gears etc.
3. Auxiliary equipment like compressors, ventilation system, A/C units and other car mounted equipment
4. Elevated structure Noise radiated by vibrations of the via-duct components excited by train pass-by.

While all countries specify L_{Aeq}average noise levels as given in the table above, some countries specify maximum sound levels Lmax also for noise impact assessment.

b) Interior Noise inside the cars

It directly affects the daily commuters, as commuters spend up to 1 hour in the cars, while travelling from one end to the other. Average noise levels and peak noise levels both are relevant here. Sources contributing to interior noise are:

- External airborne noise transmitted through the car shell
- Structure borne noise and vibration
- Airborne noise from internal sources

Any of these noise sources can dominate the interior noise level depending upon the car design and operating conditions.

c) Noise in transit stations

There are five major sources

- Trains entering, leaving and stationary at stations
- Auxiliary equipment like air conditioning and ventilation equipment, escalators etc.
- Passenger activity
- Public address system
- Street or highway traffic noise especially on over ground stations
- Reverberant build up noise etc.

3.4 Study of Noise assessment inside the Greater Cairo Underground Metro ByMostafa E Aly

L1 ranges from 87.8 to 102.5 dBA., so it exceeds the limit by about 1.5 to 16.5 dBA. The highest value of *L*1 was noted between El-Gamaah and El-Behoos stations, this is due to the tunnel entrance and the sharp turn of 90◦, which increases the slip between the wheels and the rails, which in turn increases the noise emission.The sources of noise at the platforms are the aerodynamic and mechanical noises of the train, the train siren, the brakes when applied, the passengers themselves and the attention signal sound systems.

The noise problem is very significant especially inside the metro units. This increase of noise levels is due to the lack of air in the ventilating system of the units, which causes the passengers to open the side windows to compensate forthe required quantity of air. This situation permits the outside noise to enter the units.

The side windows are sound-proof windows, which prevent outside noise from entering the units. The closing of the side windows attenuates the noise inside the units by about 20 to 25 dBA. The noise outside the metro units is due to the mechanical and aerodynamic noise, whichincreases by reflection of sound from the tunnel walls. The tunnel has a cylindrical shapewhich reflects the sound from any source to the centre axis of the tunnel where the trains run.The noise at the station platforms is due to the application of the air sirens of the trains andthe application of the brakes. The increase of noise levels at the platforms is also due to thereflections from the side walls, which are covered with smooth ceramic tiles.

Study recommendations

- Increasing the efficiency of the ventilating system inside the metro units to avoid the opening of the side windows.
- Informing the passengers of the importance of closing the side windows
- Coating the tunnel walls with some kind of sound absorbing materials to decrease thereflection of sound into the metro units.
- Reducing the approach speed of the trains to reduce the time of application of brakes.
- Replacing the brake lining materials with other more efficient ones to reduce the timeof application of brakes
- Changing the smooth ceramic tiles of the station platforms walls by other kinds which can absorb sound to decrease the total noise level at the station platforms.

3.5 A study of Noise Levels associated with New York City's Mass Transit System by Richard Neitzel, Robyn R. M. Gershon and others

Mass Transit noise exposure has the potential to exceed limits recommended by the WHO and the US Environmental ProtectionAgency and thus cause Noise – induced hearing loss among riders given sufficient exposures. Noise measurements made are given in the tables below:

TABLE 1

Average (L_{eq}) Noise Levels in dBA, by Transit Type and Measurement Location: New York City, June and July 2007

	Combined[a] L_{eq} Levels		L_{eq} Levels Inside Vehicle		L_{eq} Levels at Platforms or Terminals		
Transit Type or System	No.[b]	Mean dBA (SD)	No.[b]	Mean dBA (SD)	No.[b]	Mean dBA (SD)	P[c]
Subway							
MTA	156	80.4 (4.3)	60	79.3 (3.1)	96	81.1 (4.7)	.01
PATH	12	79.4 (3.3)	4	79.2 (4.2)	8	79.5 (3.1)	.89
Commuter rail							
LIRR	18	74.9 (5.8)	6	71.4 (3.8)	12	76.6 (6.0)	.07
SIRR	3	76.7 (0.6)	2	76.5 (0.5)	1	77.2[d]	.43
Metro-North	11	75.1 (5.1)	4	71.9 (1.6)	7	77.0 (5.5)	.10
Bus	30	75.7 (3.7)	14	75.3 (2.6)	16	76.0 (4.4)	.62
Ferry	4	75.3 (3.1)	2	77.7 (2.1)	2	72.9 (1.1)	.09
Tram	4	77.0 (3.1)	2	77.5 (2.3)	2	76.6 (4.7)	.83

Note. L_{eq} = Equivalent continuous noise level; dBA = A-weighted decibel; MTA = Metropolitan Transportation Authority; PATH = Port Authority Trans-Hudson; LIRR = Long Island Rail Road; SIRR = Staten Island Rail Road; Metro-North = Metro-North Railroad.

[a]The number of noise measurements taken.
[b]Calculated with 1-way analysis of variance by measurement location.
[c]Single measurement.

Against 24 hour 70-dBA WHO and EPA suggested exposure limit and the National Institute for Occupational Safety and Health 8-hour 85-dBA Recommended Exposure Limit, Leq measurements exceeded 70dBA threshold at all subways. 7% subways had mean vehicle Leq levels greater than 85 dBA and 23% had mean Leq platform levels greater than 85 dBA. Mean aboveground vehicle Leq levels were 1 to 5 dBA lower than above ground platforms levels. Mean vehicle Leq levels for underground measurements were always lower than those for underground platforms. (Table 3 below)

L_{max} Levels

Table 2 below shows the associated L_{max} levels with each transit type. MTA subways had the highest maximum noise levels on average 90.4 dBA. Highest Lmax level among all platform measurement was 102.1 dBA at MTA subway station. Half the subway lines had average vehicle and platform levels that exceed 90 dBA

TABLE 2

Maximum (L_{max}) Noise Levels in dBA, by Transit Type and Measurement Location: New York City, June and July 2007

Transit Type or System	Combined[a] L_{max} Levels			L_{max} Levels Inside Vehicle			L_{max} Levels on Platforms or Terminals			
	No.[b]	Mean dBA (SD)	Highest dBA Level	No.[b]	Mean dBA (SD)	Highest dBA Level	No.[b]	Mean dBA (SD)	Highest dBA Level	*P*[c]
Subway										
MTA	156	90.4 (4.6)	102.1	60	90.5 (3.6)	97.8	96	90.3 (5.2)	102.1	.75
PATH	12	88.1 (3.8)	94.9	4	88.3 (4.5)	94.9	8	88.0 (3.7)	92.6	.91
Commuter rail										
LIRR	18	84.9 (6.0)	97.3	6	83.8 (5.2)	92.4	12	85.5 (6.5)	97.3	.59
SIRR	3	90.4 (3.2)	93.0	2	92.2 (1.2)	93.0	1	86.8[d]	86.8	.17
Metro-North	11	86.5 (6.1)	99.5	4	82.2 (1.1)	83.4	7	89.0 (6.5)	99.5	.07
Bus	30	86.8 (6.1)	101.6	14	85.6 (4.7)	96.8	16	87.8 (7.1)	101.6	.34
Ferry	4	89.9 (3.0)	92.5	2	92.5 (0.0)	92.5	2	87.4 (0.1)	87.4	<.001
Tram	4	88.7 (6.5)	93.9	2	90.9 (1.1)	91.7	2	86.6 (10.4)	93.9	.62

TABLE 3

Average (L_{eq}) Noise Levels in dBA for Subway and Commuter Rail Systems, by Measurement Location and Surroundings: New York City, June and July 2007

Transit Type or System	L_{eq} Level Inside Vehicle		L_{eq} Level at Platforms or Terminals		*P*[b]
	No.[a]	Mean dBA (SD)	No.[a]	Mean dBA (SD)	
Aboveground					
Subway					
MTA	24	77.9 (3.1)	42	77.9 (3.3)	0.98
PATH	...	...	...	...	...
Commuter rail					
LIRR	3	69.6 (3.9)	9	74.8 (5.8)	0.18
SIRR	2	76.5 (0.5)	1	77.2[c]	0.43
Metro-North	2	71.2 (1.3)	5	74.3 (3.5)	0.29
Underground					
Subway					
MTA	36	80.2 (2.8)	54	83.5 (4.3)	<.001
PATH	4	79.2 (4.2)	8	79.5 (3.1)	.88
Commuter rail					
LIRR	3	73.1 (3.4)	3	82.0 (2.3)	.02
SIRR	...	...	...	...	...
Metro-North	2	72.5 (2.0)	2	83.9 (0.4)	.02

3.6 Noise Levels specified by Various Metrosworld wide

Noise levels of AB Metros/LRV			
Metros/LRV	Internal noise	External noise	Measurement conditions
Metro Brescia 750V third rail - 3coaches	LeqAT < 68*dBA Stationary LeqAT < 72*dBA @ 60km/h * Preliminary	LeqAT < 60*dBA Stationary LeqATp < 77*dBA @ 60km/h * Preliminary	**External noise** stationary @ 7.5m from track centre running @ 7.5m from track centre **Internal noise** Stationary/running @ 1.2-1.6m above the floor – open site Track not grinded
Metro Riyadh 750V third rail - 2coaches	LeqAT < 60dBA Stationary LeqAT < 70dBA @ 60km/h	LeqAT < 66dBA Stationary LeqATp < 73dBA @ 60km/h	**External noise** stationary @ 1.5m from platform edge running @ 15m from track centre **Internal noise** Stationary/running @ 1.2-1.6m above the floor – open site Track not grinded
Metro Milano 750V third rail - 4coaches	LeqAT < 65dBA Stationary	LeqAT < 58dBA Stationary	**External noise** stationary @ 7.5m from track centre running @ 7.5m from track centre **Internal noise** Stationary/running @ 1.2-1.6m above the floor – open site Track not grinded
Tram Los Angeles Catenary 750V - 2coaches	LeqAT < 68dBA Stationary LeqAT < 73dBA @ 55mph	LeqATp < 73dBA @ 40mph	**External noise** stationary @ 7.5m from track centre running @ 7.5m from track centre **Internal noise** Stationary/running @ 1.2-1.6m above the floor – open site Track not grinded
Metro Madrid Catenary 750V - 6coaches	LeqAT < 65dBA Stationary LeqAT < 67dBA @ 60km/h	LeqAT < 64dBA Stationary LeqATp < 76dBA @ 60km/h	**External noise** stationary @ 7.5m from track centre running @ 7.5m from track centre **Internal noise** Stationary/running @ 1.2-1.6m above the floor – open site Track not grinded
Metro Roma C Catenary 1500V - 6coaches	LeqAT < 65dBA Stationary LeqAT < 71dBA @ 80km/h	LeqAT < 61dBA Stationary LeqATp < 82dBA @ 80km/h	**External noise** stationary @ 7.5m from track centre running @ 7.5m from track centre **Internal noise** Stationary/running @ 1.2-1.6m above the floor – open site Track not grinded
Tram Sirio Catenary 750V - 3coaches	LeqAT < 64dBA Stationary LeqAT < 77dBA @ 60km/h	LeqAT < 60dBA Stationary LeqATp < 74dBA @ 50km/h	**External noise** stationary @ 7.5m from track centre running @ 7.5m from track centre **Internal noise** Stationary/running @ 1.2-1.6m above the floor – open site Track not grinded
Metro Copenhagen 750V third rail - 3coaches	LeqAT < 65dBA Stationary LeqAT < 72dBA @ 80km/h	LeqAT < 50dBA Stationary LeqATp < 77dBA @ 80km/h	**External noise** stationary @ 7.5m from track centre running @ 7.5m from track centre **Internal noise** Stationary/running @ 1.2-1.6m above the floor – open site Track grinded

Noise Study on Indian Metros

Following Noise related studies have been done on Delhi Metro which were made available by DMRC

- Noise Impact Assessment of Mass Rapid Transit Systems in Delhi *byShri Naveen Garg, Omkar Sharma and S. Maji*
- Noise Control Measures for Delhi Metro *by National Physical Laboratory*.
- Train Noise Level Study *by General Consultants to Delhi Metro for Phase I*
- Metro Railway Noise and Vibration Causes and solution for DMRC Phase-III

Quoting from the above studies mainly carried out after phase-I of DMRC, observations are as follows:

At Stations

Average value of background noise levels in Metro stations was about 59$\pm$3 dB(A). Average level in underground stations was 2 dB(A) lower

Average value of exterior noise levels when trains were standing in metro stations was 76 dB(A) in all sections.

Noise level due to train entering and leaving the station near exit points in underground station was higher by 5 dB due to reverberant noise buildup of train noise in station space.

Interior Noise

DMRCs target value of 85 dB(A) fixed for interior noise level in moving trains running at 80 kmph with all auxiliary equipment in operation is on higher side by 5-10 dB(A) when compared to noise level of 75dB(A) experienced for face to face conversation elsewhere. Interior noise levels were 10 to 12 dB(A) lower in at grade sections and elevated corridor.

Average interior noise levels observed in moving trains were higher by 5 dB(A) at 90$\pm$1dB(A)
Door operation noise was also higher by 5 dB(A) vis-à-vis specified level of 72 dB(A)

Exterior Noise levels OR Way side Noise Levels

Way side noise levels were 10 dB(A) lower than specified at 60 dB(A) on at grade racks at 25 meter.

Noise specifications in various procurement tenders by Indian Metros

Internal Noise Leq in dBA

Name of Metro	Tender Number	Under Stationary condition as per ISO 3381 Saloon/Cab		Under running conditions as per ISO 3381 Saloon/Cab		Remarks
		viaduct	tunnel	viaduct	tunnel	
DMRC	RS1*	68	NA	72/70	92/90	At 80 kmph
	RS2*	68	75/72	72/70	75	At 80 kmph
	RS3**	68	75/72	72/70	75	At 85 kmph
	RS10**	64/63	68	72/68 75/70		72/68 at 50 kmph and 75/70 at 75 kmph
Mumbai	Line 1	64	NA	70/70	NA	
BMRCL	----	68/62 dBA	75/72 dBA	72/70 dBA	80/78 dBA	
CMRCL	----	70/71 dBA	NA	75/78 dBA	NA	
KMRCL	----					
L&T HMR	----	70 dBA	NA	74 dBA	NA	
RMGL	----	68	NA	72		

External Noise levels specified in various procurement tenders:

Name of Metro	Tender Number	Under Stationary condition as per ISO 3381		At 80 kmph speed as per ISO 3381		Remarks
		viaduct	Tunnel	viaduct	tunnel	
DMRC	RS1*	61 dBA	72 dBA	80 dBA	Not specified	At 80 kmph
	RS2*	67 dBA	NS	84dBA		At 80 kmph
	RS3**	67 dBA	NS	84 dBA		At 85 kmph
	RS10**	67 dBA		82 dBA		Lpa5 at 75 kmph
Mumbai	Line 1	70 dBA		80 dBA		
BMRCL	----	67 dBA		82 dBA		
CMRCL	----	65 dBA		81 to 82 dBA		Values at 15 meter
KMRCL	----					
L&T HMR	----	68dBA		85dBA		72 dBA and 78 dBA
RMGL	----	72 dBA		82 dBA		

Door operation noise levels specified in various procurement tenders:

Name of Metro	Tender Number	As per ISO 3381		Remarks
		Sliding operation	Locking/Unlocking	
DMRC	RS1*	72	NS	
	RS2*	72	78	
	RS3**	72	78	
BMRCL	----	72 dBA	78 dBA	
CMRCL	----			
KMRCL	----			
L&T HMR	----	72 dBA	78 dBA	
RMGL	----	72	78	

*All values measured are $L_{pAeq.5s}$

A–Weighted equivalent continuous sound pressure level where the measurement time interval ***T*** is five second (***T=5s).***

**All values measured are L_{pA5} -

After applying the time and frequency weighting, the sampled measurement data of 20 seconds (10000 readings sampled with 500 H_z from one microphone) is divided into classes corresponding to each level (e.g. 10 classes per dB). For each class the frequency over the measurement time is calculated. A histogram of the frequency of each L_{pAF} level over the measurement time is made. This is then converted to a graph over cumulative relative frequency. The value for 95% of the time is the L_{pA5} level, i.e. the A weighted sound pressure level exceeded for 5% of the measurement time period.

3.7 Deliberations on Noise specifications for Metro Rolling Stock

Method of Measurement

ISO 3095 is the international standard followed for measuring external noise.Track parameters described in ISO 3095 that influences the rolling stock noise are given below:

Parameter	Parameter value for minimum noise level	Parameter value for maximum noise level	Level difference for min. and maximum parameter value (dB)
Rail type	UIC 54 E1	UIC 60 E1	0,7 dB
Pad Stiffness	5 000 MN/m	100 MN/m	5,9 dB
Pad Loss Factor	0,5	0,1	2,6 dB
Sleeper type	Bi-bloc	Wooden	3,1 dB
Sleeper distance	0,4 m	0,8 m	1,2 dB
Ballast stiffness	100 MN/m	30 MN/m	0,2 dB
Ballast Loss Factor	2,0	0,5	0,2 dB
Wheel offset	0 m	0,01 m	0,2 dB
Rail offset	0 m	0,01 m	1,3 dB
Wheel Roughness	Smoothest	Roughest	8,5 dB
Roughness of uncorrugated rails	Smoothest	Roughest	0,7dB to 3,9 dB
Train Speed	80 km/h	160 km/h	9,4 dB
Axle load	25 t	10 t	1,1 dB
Air temperature	10 °C	30 °C	0,2 dB

Internal Noise in the Cars

Passengers on an average spend 40 minutes in the train. Noise level of a normal conversation is 60 to 70 dBA. A 95 dBA noise level is 10 times more intense than an 85-dBA a 95 dBA noise level and 100 times more intense than a 75-dBA noise level. Taking into consideration the limits of daily exposure for NIHL of 8 hour-85 dBA or 18 mins for 90.4 dBA and the need for reducing noise pollution inside the cars, the levels for Leq and L max need to be defined.

As can be seen from the table above Leq level of 64 to 71 dBA under stationary conditions on via-duct and 75 dBA in tunnels and 70 to 75 dBA on via-duct and 80 to 95 dBA in the tunnels at speeds around 80 kmph have been specified. In

comparison World Metros as per table given above specify Leq levels of 64 to 68 dBA under stationary conditions and 68 dBA to 77 dBA at speeds around 60 kmph. No LAmaxvalue have been specified.

Most of the Metroshavejust mentioned the values specified in their tenders. DMRC has however recommended that Maximum level of noise Lpa5 and not average noise levels Laeq, as has been done in the past, be measured.

Siemens have also recommended values as specified in RS10 with method of measurement as per ISO3381 and ISO 3095.

M/S Bombardier have proposed measurement of LpAeqt as per ISO 3095 latest version. Interior Noise at grade should be 65 dBA at standstill and 75 dBA in saloon and 70 dBA in cab at 80 kmph according to ISO 3381 latest. M/S Bombardier have proposed noise increment of +2 dBA for via-duct and +5 dBA for tunnels depending on type of tunnel.

External Noise

External Noise need to be limited taking into consideration Environment Protection Rules as mentioned above.The Noise Pollution (Regulation and Control) Rules, 2000 stipulates a maximum Leq of 75 dBA during day and 70 dBA during night under worst conditions in Industrial areas and a maximum of 55 dBA during day and 45 dB during night time in residential areas.

Metros internationally specify L_{eqAT} of 55 to 65dBA under stationary conditions and $L_{eqATp}$of 73dBA to 84 dBA at speeds varying from 40 kmph to 80 kmphat 7.5 meters from the track. 68 dBA levels of external noise as given in the table above.

Indian Metros have specified Laeqof 61 to 72 dBA under stationary conditions and 80 to 85 dBA under running conditions at speeds varying from 50 to 85 kmph. Delhi Metro has prescribed Lap5 for RS3 and RS 10 and recommends the same. M/S Siemens have recommended L_{AeqT} of 67 dBA under stationary conditions and 82 dBA at 75 kmph. M/S Bombardier have recommended average of LpAeq around the train of 68 dBA at standstill and 83 dBA at 80 kmph.

Door closing/opening noise

Metros internationally generally do not specify door closing/opening noise. M/S Siemens and M/s Bombardier have also not recommended the same. Delhi Metro have also not specified the same in RS10. This gets included in internal noise and external noise specification as it affects both L_{Amax} and $_{LeqAt}$

Though general recommendation is to specify Laeqt as per ISO 3381. DMRC is of the view that it is not possible to accurately measure LAeq level and hence proposed LpA5 instead of LpAeq. Lpa5 gives maximum noise levels against average noise levels

LpAeq. It is however mentioned that LAmax level are generally 10 to 12 dB higher than average noise levels(Laeq). Hence in that case specification will have to be different.

Recommended Noise Levels

Measurement of Internal coach noiseLaeq be done as per ISO 3381:2011(or latest) and measurement of external noise as per ISO 3095:2010(or latest)

Type of Rolling Stock		Interior Noise level (ISO 3381)LAeq (dBA)		Exterior Noise level (ISO 3095)LAeq (dBA)	
		Stationary	Running	Stationary	Running 80 kmph
750 Volts Third rail	Via-duct	66	72/70	67	80
	Tunnel	70	74/72	72	82
25 KV AC Stock	Via-duct	68	72/70	67	82
	Tunnel	72	75	NA	NA

Delhi Metro has proposed that instead of LAeq these level be specified for LpA5 (Project Noise LAmax that exceed 5% of the time measured with T=20 seconds) as has also been stipulated in RS10 be followed as there is very little ambiguity in its measurement. Committee is however of the view that the Measurements be done as stipulated in latest ISO 3381 and ISO 3095 as has been specified in all the other tenders so far and recommended by majority of the members because all the limits and norms exists in terms of Laeq only.

3.8 Vibrations from Metro operations

Study of regulations regarding protection of ASI monuments (heritage structures) from vibration generated by metro trains operation.

The Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act 2010,

Act imposes restrictions in carrying out construction work within 100 meters of a protected monument. Relevant excerpts from Sec 20A of the act is reproduced below:

***[20A. Declaration of prohibited area and carrying out public work or other works in prohibited area.-** Every area, beginning at the limit of the protected area or the protected monument, as the case may be, and extending to a distance of one hundred meters in all directions shall be the prohibited area in respect of such protected area or protected monument:*

Provided that the Central Government may, on the recommendation of the Authority, by notification in the Official Gazette, specify an area more than one hundred meters to be the prohibited area having regard to the classification of any protected monument or protected area, as the case may be, under section 4A.

(2) Save as otherwise provided in section 20C, no person, other than an archaeological officer, shall carry out any construction in any prohibited area.

(3) In a case where the Central Government or the Director-General, as the case may be, is satisfied that--

(a) it is necessary or expedient for carrying out such public work or any project essential to the public; or

(b) such other work or project, in its opinion, shall not have any substantial adverse impact on the preservation, safety, security of, or, access to, the monument or its immediate surroundings, it or he may, notwithstanding anything contained in sub-section (2), in exceptional cases and having regard to the public interest, by order and for reasons to be recorded in writing, permit, such public work or project essential to the public or other constructions, to be carried out in a prohibited area:

This act is a legislative measure to ensure thatheritage buildings are not damaged during the construction stage of the project and is also protected with harmful effects of noise and vibrations on the old weak and structurally weak buildings and historical monuments

Regulations in other countries regarding protection of heritage structures.

Some countries prescribe the limits of Ground base Noise levels and vibrations reaching the buildings, emanating from Metro projects. Maximum permissible values of ground borne noise & vibration from train operations as recommended are as follows:

1) for Ground Borne Noise:
   - for all residential buildings *40 dB(A)*,
   - for other sensitive buildings (such as education i.e.Universities, schools, libraries, and also hospitals,churches theatres and archaeological sites and museums: *35 dB(A)*
   - for concert halls & TV/Radio studios: *25 dB(A)*

2) for Vibration: (max ppv at z direction):
   - *0,5 mm/sec* for buildings & relevant sensitive buildings
   - *0,2 mm/sec* for archaeological sites and museums

Study of Vibration and Noise associated with Metro Operations

An important adverse effect of Metro operation is the increased level of vibration transmitted to buildings in close proximity. Furthermore the vibration in buildings is the result of the direct transmission of ground borne vibration. Thereare two ways in which metro traffic can induce vibration in nearby buildings

- Ground-borne vibration caused by the dynamic impact forces generated in the wheel-rail inter phase due to irregularities of both wheels and tracks that can propagate in the soil and excite the foundation walls of nearby buildings, beneath ground.

- Air-borne noise, caused by low frequency emissions that can excite building structural components (walls etc.) above ground.

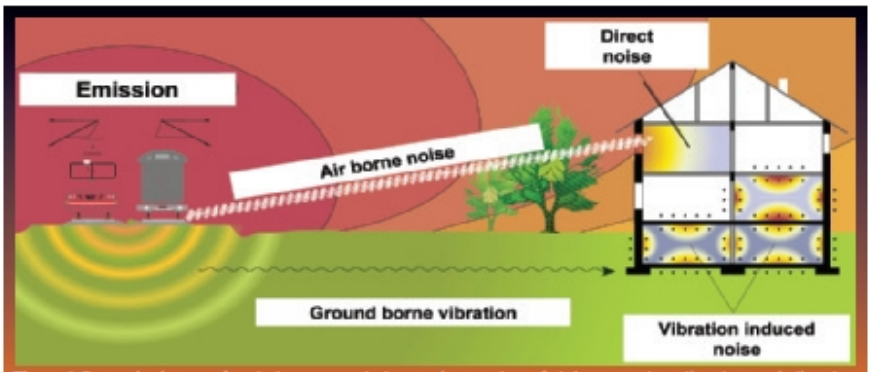
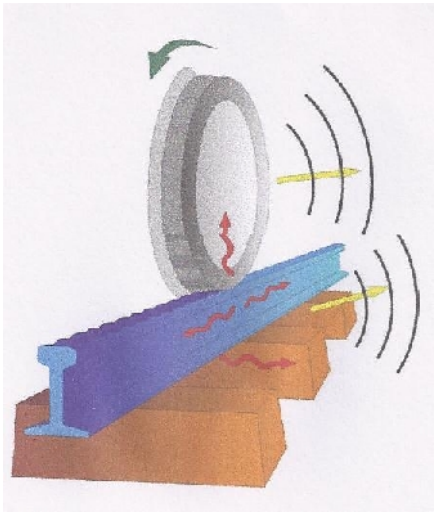


Figure 1 General scheme of emission, transmission and reception of air borne noise, vibration and vibration induced noise



Noise generated by Rail Wheel interaction

The excitation of noise and vibrations stem from the wheel-rail interaction and hence is primarily governed by the properties of the vehicle and the track. This is the case for excitation of air-borne and ground-borne noise with frequency content above 50 Hz [3]. Ground-borne vibrations however has an essential part of the energy concentrated to frequencies below 50 Hz. The excitation of these long-wavelength vibrations will be governed also by the ground properties and hence the excitation will also be site-specific. In rare cases the vibration emissions from the railway constitutes a safety risk for the railway vehicle itself. However the vibrations excited in the wheel-rail contact

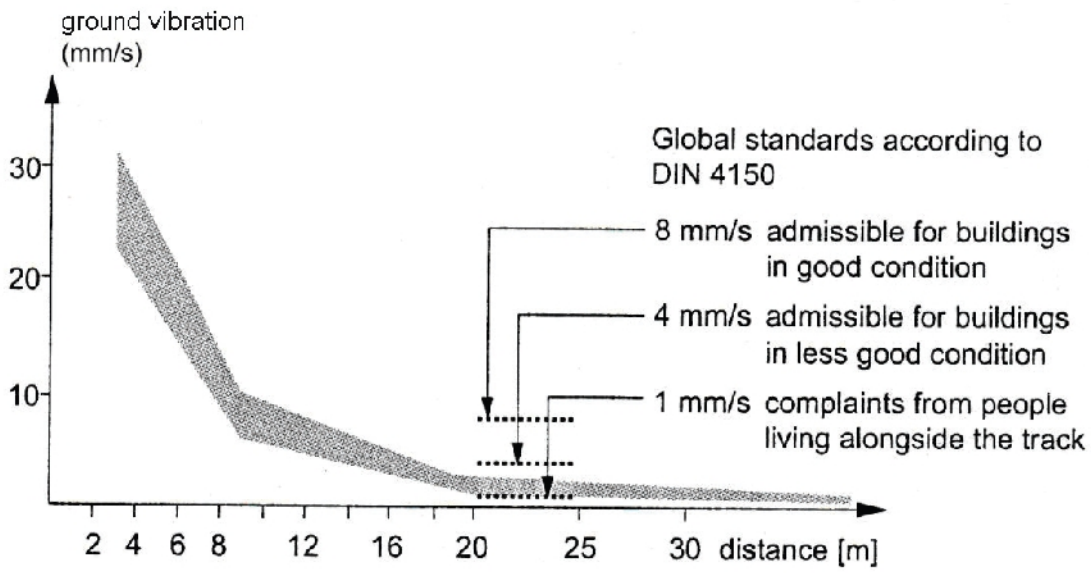
are primarily a problem for the environment adjacent to the railway lines. The vibration propagates in the ground and becomes problematic as it reaches buildings or other constructions in the vicinity of the track. The issues are primarily related to discomfort experienced by residents but can also be more severe and damage buildings or disturb sensitive equipment in e.g. hospitals and laboratories.

Seismic waves are usually called ground-borne vibration, or structure-borne vibration, when they reach buildings in the vicinity of the source and are still sufficiently strong to causeperceivable vibrations. The closer the frequencies of the seismic waves are to the building's natural frequency,the stronger the excitation and hence larger amplitudes will be transmitted through the walls andreach the floors or ceilings. These usually act as amplifiers at the point of emission and can result in clearlynoticeable vibration, usually in the range of 1–80 Hz.The occupants' perception of ground-borne vibration depends on a person's position, their activity, sensitivity,ambient influences, as well as the duration and strength of the vibration. Details can be found in theinternational norm ISO 2631 [1], which evaluates the exposure of human bodies to shock and vibration.

More specific information in regard to mechanical vibration solely as a result of rail systems is found inISO 14837-1 [2]. It explains the mechanisms of excitation and the general circumstances of interest, beforeproviding guidance on how measurements in affected rooms should be carried out.The norm approaches the issue of ground-borne noise, which is a by-product of ground-borne vibration. Ifthe vibration of ceilings, floors or walls is strong enough and excites the surrounding air at frequencies inthe hearing range, the resulting airwaves could be audible. This so-called structure-borne noise (usuallyin the range of 16 – 250 Hz) can pose an additional nuisance to the occupants, and is mostly associatedwith rail systems in tunnels or at-grade situations when rooms face away from the tracks, so that no directairborne noise is perceived. ISO 14837 states that the assessment of ground-borne noise can be carried outin the form of direct measurements using sound level meters or derived from ground-borne vibration. Theadvantage of the latter is that only one type of sensor would be needed. Only monitoring vibration levelsis less maintenance-intensive than also putting up a sound level meter, and could ease evaluation at theend. Calculating noise levels from ground-borne vibration only considers the sound radiated from walls and floors, while a microphone also records internal sources (clattering, rattling) or possible direct noise from(rail) traffic, which is not part of the ground-borne noise evaluation, Safety Evaluation of Buildings in the Vicinity of Railway Tracks.

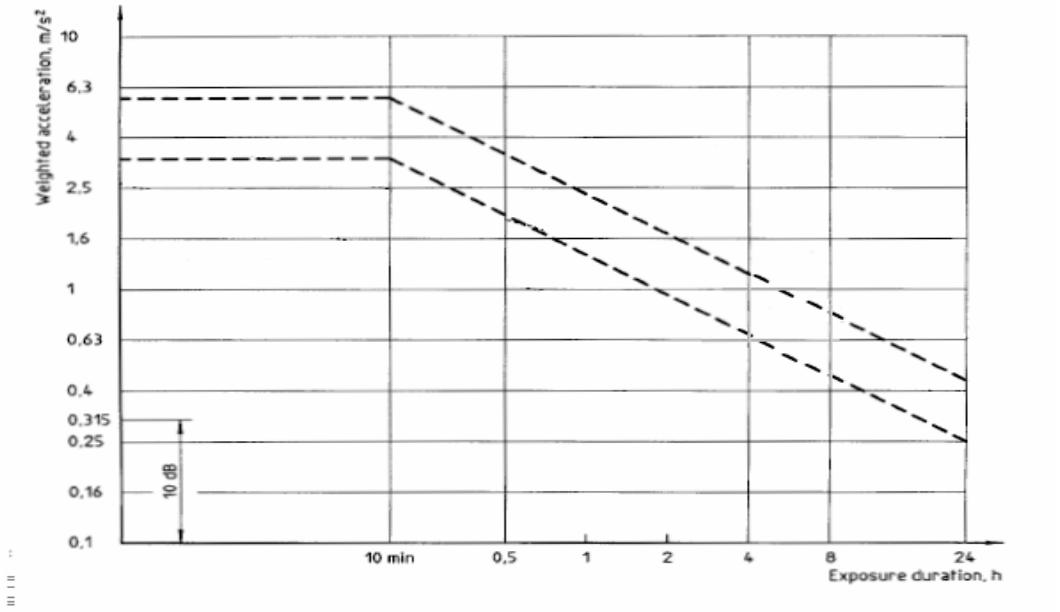
As per ISO 14837, typically, dominant frequencies are less than 100 Hz because they represent the response of building elements. The frequency range relevant to the evaluation of the risk of vibration-induced damage on building structures is 1 Hz to 500 Hz, although high strains associated with higher risk of damage are associated with low frequencies. Most building damage from manmade sources occurs in the frequency range 1 Hz to 100 Hz. This is an appropriate range for evaluating building damage and peak particle velocity. A proposed safe level for "serious" structural

damage is very high: 50 mm/s peak particle velocity. Nevertheless, much lower levels may be relevant for damage to old and historic buildings(as low as 2 mm/s), and for more "minor" damage in ordinary building ("fine plaster cracking and reopening of old cracks") [5]



Vibration norms for passengers ISO 2631

ISO-2631 (1997) provides some guidance to the health effects of vibration as it applies to people in normal health who are regularly exposed to vibration. The referenced standard provides a graph showing the recommended or preferred “zone” (See Figure 9). Vibration exposures below the zone indicate health issues that have not been clearly documented and/or objectively observed. Exposures above the zone indicate that health risks are likely.



3.9. Deliberations on Vibrations

The key factors of the vehicle / track system which determine ground vibration are related to the track design and the maintenance of wheel and rail:

- Design of the track, more precisely the properties of the track mass/spring/damping system consisting of rail, pads, sleeper, ballast, slab, embankment
- Impact excitation from track discontinuities like switches & crossings and insulation joints
- Wheel / rail surface quality, roughness incl. corrugation, out-of-roundness, dents, flats

Intensity of ground based noise and vibrations, are primarily dependent on track structure, soil conditions and distance of such buildings from the railway track. It has to be ensured that these vibration levels do not exceed the safety limits as prescribed in ISO 14835 for which specific measures may need to be adopted while designing the track structure.

Passengers are also subjected to the vibrations for which norms have been prescribed by ISO 2631. It has been suggested by DMRC that only these norms be specified for rolling stock manufacturers. This makes sense as the rolling stock manufacturers have no control over ground vibrations emitting from Metro operations.

As per ISO 2631, weighted acceleration of 0.315 m/s2 is the permissible value for passenger comfort when he is subjected to the vibrations of this intensity, continuouslyfor 24 hours.

Committee recommends

Vibrations to be measured as per ISO 2631, weighted acceleration should be less than 0.315 m/s^2

4.0 Emergency Evacuation System

4.1 Practices adopted in various metro systems in India and elsewhere along with the underlying logic/reasons (at least 3 metros each in USA, Europe, Japan, China and South East Asia to be studied).

Emergency doors are provided for evacuation during emergencies. Two types of evacuation systems are provide in Metros world wide:

- Front Evacuation System
- Side Evacuation system

For emergency egress, following 3 situations are possible -

- Sliding door concept : This allows train to train & train to track detrainment, in this concept you have a emergency door which slides sideways & ramp can be deployed to track or a passage to other train can be provided, it is mainly useful where no side passage is available
- Top opening door concept: In this concept evacuation door opens upwards on hinges & ramp is deployed to tracks, no train to train detrainment is possible with this.
- No front detrainment door: If infrastructure is provided with side walkways & train has adequate level of redundancy it is extremely unlikely that train can not be driven to next station for evacuation, that is to say it could be interesting not to provide evacuation door at all on the trains with ATO or with driver

Systems followed world-wide by different Metros

Sl.No.	Name of Metro	Evacuation system
1	London Metro	Front
2	Paris Metro	Front
3	Germany	Front
4	Washington Metro	Front
5	Singapore	Front
6	Dubai	Front
7	China	Front
8	Bangkok	Front

Singapore Metro

Front Evacuation

Travellers on the London Underground know well how cramped trains can be. So fitting a system for passenger evacuation required DCA to come up with a design that combines space saving features with fast deployment.

The detrainment system designed for Bombardier are fitted to new S-Stock trains on the Metropolitan Line. DCA says: “Human factors played an important role in the design of the escape system. Deployment has been made easy by the development of a novel strap insertion and retention detail and by maintaining a total mass of just 15kg for the ladder part of the system. A further complication that has been resolved was the need to provide a lightweight interlocking bridge plate that allows the ladder to clear the auto coupler for train-to-track egress as well as being used on its own for train-to-train evacuation.”

In pre-launch trials, deployment took under one minute and passengers escaped from the train at a rate of one every two seconds.

London Metro

Shanghai Metro Front Evacuation

New York Metro Front Evacuation

4.2 Systems adopted by different Metros in India

Sl.No.	Name of Metro	Evacuation system
1	Delhi Metro	Front
2	Bangalore Metro	Side Evacuation
3	Chennai Metro	Side evacuation
4	Kolkata Metro IR	Front
6	L&T HMR	Front

Side Evacuation system

A walkway is provided along the track. People get out through normal doors and move on the walkway which takes them to the nearest station platform. The relative merits and demerits of this system are as follows:

Advantages:

- In case of DC third rail system evacuation is faster as switching off of power to third rail is not required.
- Evacuation from the train is faster due to large number of doors.

Disadvantages:

- In case of sharp curves,side evacuation is not considered safe as gap between train and walkway on curve will be very large, which have to be bridged by some plate/footboard
- Side evacuation requires side walkway and hence via-duct width is unnecessarily more and structures are heavy due to extra loading
- Walking on raised walkway is not considered safe for children/elderly passengers

Front Evacuation system

Advantages:

- No need for extra walkway, hence size of the tunnel as well as via-duct reduces thus is more economical.
- Evacuation is from emergency doors provided at the ends and can be better regulated by motorman and stampede is prevented.
- Walking is easier for passengers in this system as either they have to walk through the coaches or on the track

Disadvantages

- Power block is necessary in case of 750 Volts DC third Rail system, which may take some time
- Exit from single emergency door may affect the faster evacuation.

4.3 Recommendations

There have been instances of emergency evacuation in Kolkata Metro in its operation during the last 25 years, but no major difficulty was faced in evacuation even though system operates on 750 volts DC third rail and power has to be switched off before opening of the emergency door.

Committee thus strongly recommends that Indian Metros should adopt front evacuation only, with door at center as is also the most prevalent practice world-wide.

5.0 Coupling arrangement (Automatic, semi-automatic etc.)

5.1 Type of Couplers

There are different types of coupler head designs available, usually the types are determined by existing fleet or rescue locomotives etc. for new metro system usually the couplers are from Schafenberg family of couplers. These are of following types:

- Automatic Mechanical, Pneumatic and Electrical coupler
- Automatic mechanical and pneumatic coupling and Jumper cables for electrical connection.
- Semi-Permanent coupler. Electrical coupling is through jumper cables between cars.

Suppliers for Indian Metros and costs

Suppliers are:

Voith Turbo, Germany	RS1,RS3 and BMRCL
Dellner, Sweden	RS2
Faiveley	Chennai Metro

Dellnerand Voithhave set up subsidiary units in India for local manufacturing. Voith couplers are of Scharfenberg (Schaku) type. The Dellner and Faiveley couplers are also of similar type. Faiveley is also manufacturing couplers in India.

The design of the couplers depends on the type of coupler head, amount of energy absorption required, coupling range, etc.

Cost Aspects

- Semi Permanent Rs 2.5 to Rs 3.0 Lakh
- Automatic mechanical & pneumatic coupler Rs 10 Lakhs
- Automatic mechanical, electrical & pneumatic coupler Rs 20 Lakhs

The coupling arrangement in the various Indian metros is brought out below:

Project	**Ends of rake / train formation**	**Between cars in basic unit**	**Between two basic units**
DMRC RS1	Automatic mechanical & pneumatic	Semi-permanent	Automatic mechanical, pneumatic & electrical
DMRC RS2	Automatic mechanical & pneumatic	Semi-permanent	Automatic mechanical, pneumatic & electrical
DMRC RS3	Automatic mechanical & pneumatic	Semi-permanent	Automatic mechanical, pneumatic & electrical
Jaipur metro	Automatic mechanical & pneumatic	Semi-permanent	Automatic mechanical, pneumatic & electrical
Bangalore metro-3 car	Automatic mechanical & pneumatic	Semi-permanent	
Hyderabad metro- 3 car	Automatic mechanical & pneumatic	Semi-permanent	
Kolkata metro E-W 6 car	Automatic mechanical & pneumatic	Semi-permanent	Automatic mechanical, pneumatic, jumper cables for electrical
DMRC RS10	Automatic mechanical & pneumatic	Semi-permanent	Automatic mechanical, pneumatic & electrical

5.2 Functional Requirement of couplers

The coupling arrangement is dependent on operating needs:

1. Full automatic front coupler with electrical & pneumatic head : These couplers are required where quick connect / disconnect is required, for example EMU trains for which one regularly couples & decouples the train to form different train configurations. On Indian Metros configuration is very rarely changed. Most of the metros run in fixed formation i.e. 4 car,6 car or 8 car. Hence is not

required for Indian Metros and in such cases even semi permanent couplers can be provided between two basic units

2. Between coaches which are not expected to be decoupled often, semi-permanent coupler are preferred design.

3. Two rakes need to be coupled in the rescue mode, here time is a consideration, hence automatic mechanical and pneumatic coupling at the two end of the rakes are recommended.

4. Besides the load key criterion for couplers is their recoverable stroke capability, and usually for metro train of fixed train configuration it should not exceed 10 km/h, that is to say coupler should not be requested to absorb collision energy in excess of 10 km/h

5.3 Recommendations for Coupling Arrangement:

1. For two ends of the train: Automatic Couplers without electric head.Electric coupling shall be through jumper cables. Two rakes need to be coupled in the rescue mode, here time is a consideration, hence automatic mechanical and pneumatic coupling at the two end of the rakes are recommended.

2. Between two basic units: In case frequent interchanging of basic units or changes in car formations are required, Automatic Mechanical, Pneumatic and Electrical coupler may be provided. DMRC is providing these Automatic couplers between basic units. As these couplers are most expensive (Approximately 4 times the cost of semi-permanent coupler). Hence usage should be only need based.

3. Between cars of the same basic unit: Semi-Permanent Couplersand jumper cables for electrical

6.0 Acceleration/Deceleration/Jerk Rake, Power to weight ratio/ % motorization

6.1 Percentage Motorisation

Effect on Run Time with varying percentage of Motorisation

Metros that have adopted 66% Motorisation are KMRCL Metro and Bangalore Metro with:

- Basic configuration 1 DTC and two MC
- TM continuous rating 180 KW
- Rake consists of 3 car, 6 cars or 9 cars
- In 6 car consist Total Traction Motors 16 Total 2880 KW

DMRC adopted 50% motorization for Phase 1 and Phase 2 with:

- TM continuous rating 240 KW
- General configuration 2 Car basic unit 1MC and 1 TC
- Rake consists of 4 cars, 6 cars or 8 cars
- In 6 car consist Total Traction Motors 12 Total2880 KW

6.2 Typical Operational parameters for a 6 car rake with 50% powering

Sl. No.	Item Description	Typical Values	Remarks
1	Tare weight of Train	246 tons	
2	Weight AW3	380 tons	380 persons per coach @ 8 persons per sq meter
3	Adhesion	0.18	Typical
4	Maximum tractive effort	342 KN	0.18*380*0.5*10 KN
5	Starting Resistance	19 KN	@500 Kg/ton on level track
6	Net starting	323 KN	

	Tractive effort		
7	Maximum starting acceleration	0.85 m/s2	305/380
8	KW rating of Motor	240 KW	Typical used by DMRC etc
9	Total Power per rake	2880 KW	240*12
10	Power with one pair motors out	2400 KW	Bogie control
11	Power with two pairs cut out	1920 KW	

With 66% Powering

Sl. No.	Item Description	Typical Values	Remarks
1	Tare weight of Train	246 tons	
2	Weight AW3	380 tons	380 persons per coach @ 8 persons per sq meter
3	Adhesion	0.18	Typical
4	Maximum tractive effort possible	451 KN	0.18*380*0.66*10 KN
5	Starting Resistance	19 KN	@500 Kg/ton on level track
6	Net starting Tractive effort	432 KN	27 KN per motor
7	Maximum starting acceleration	1.13 m/s2	432/380
8	KW rating of Motor	180 KW	Typical proposed by CAF etc
9	Total Power per rake	2880 KW	180*16
10	Power with one coach cut out	2160 KW	180*12
11	Starting Tractive effort with one coach cut out	324 KN	Starting acceleration =0.85 m/s2
12	Power with two coach cut out	1440 KW	180*8
	Starting tractive effort with two coach cut out	216 KN	Starting acceleration = 0.56 m/s2

6.3 Time Saving Calculations

Typical section KMRCL

Total Distance 14.2 Km

Loading AW4

Number of halts 11 of 30 seconds each

Coasting 8% of allout run time

Average station distance 1290 meter

Assuming level grade

Time required with 66% motoring (180 KW X16) 21.7 minutes

Time required with 50% motoring (220 KWX12) 22.1 minutes

As per actual simulation done by Mitsubishi

Time required in all out mode with 66% powering (180 KWX16) 22.9 minutes

Allout mode with 50% powering(180 KWX12) 23.6

Time savings with higher initial acceleration is very marginal around 1.5% For both 50% and 67% motorization, the schedule speed in normal mode is almost the same. The acceleration levels are higher in 67% motorization which will be helpful in routes with frequent gradients. Scheduled speed with both 50% powering and 67% powering is given in the table below:

Characteristic	**DMRC RS3 25 KV AC**	**Chennai 25 KV AC**	**Jaipur 25 KV AC**	**KMRCL 750 VDC**	**BMRCL 750 VDC**	**RMGL**
Powering	**50%**	**50%**	**50%**	**66%**	**66%**	**66%**
Average acceleration from 0 to 30 kmph in m/s2	0.8	0.8	0.8	1.0	1.0	1.0

Instantaneous deceleration from 80 to 0 kmph in m/s2	1.0	1.0	1.0	1.1	1.0	1.0
Average emergency deceleration in m/s2	1.3	1.3	1.3	1.3	1.3	1.3
Jerk rate in m/s3	0.7	0.7	0.7	0.75	0.7	0.75
Schedule speed (normal mode) in kmph	34	34	34	34	33	34

6.4 Savings in Regenerative braking

The major advantage of 67% motorization is that more amount of regenerative energy will be available, thereby reducing the net energy consumption for traction.

Normally regenerated energy is around 30% of the energy consumed during motoring. Regenerated energy with 67% motoring will go up by around 12 to 13% i.e. regenerated energy will increase from 30% to 34%.

Typical Values of Energy consumption in Motoring and Regeneration(Traction energy only) in case of 25 KV AC system with 50% powering in case of DMRC and 66 powering in case of KMRCL as per simulation studies are given below:

DMRC 4 Car train

DMRC Consumption figures of July 2010 BT rakes

KM earned 109593

Consumption motoring 1954073 KWH

Regeneration 777691 KWH

Motoring Consumption per km(4 cars@63 tons per car) 17.82 KWH or 70 watts/ton.km

Regeneration per km(4cars) 7.1 KWH or 28.9 watts/ton.km

Net energy consumption 10.72 KWH or 42.5 watts/ton.km

With 67% powering regeneration will go up by 15% ie to 33.2 watts/ton km

Net energy consumption would be 36.75 watt/ton.km ie reduction by 4.3 watts/ton.km. Presuming that there will be no increase in energy consumption during motoring on account of additional motor coach and higher acceleration.

6.5 Simulation results by Mitsubishi for KMRCL 750 Volts third rail system with 67% powering

Sl .No	Item	DMRC figures as per recorded figures of July 2010 on BT rakes	DMRC figures as per recorded figures of July 2010 on MC rakes	KMRCL 750 V Third Rail figures as per simulation by Mitsubishi with 67% powering
1	Weight of train(loaded condition)	252 tonne(4 car)	252 tonne	380 tonne (6 car)
2	Energy consumption Motoring per.tonne km	70 watts	53.88 watts	51.2 watts
3	Regeneration per tonne.km	28.9 watts (41%)	23.68 watts (43.9%)	32 watts (62.5%)
4	Net energy consumption per tonne.km	42.5 watts	30.2 watts	19.2 watts
5	Regeneration with 67% powering expected	33.2 watts (47%)	27.2 watts (50%)	32 watts (62.5%)
6	Net energy consumption with 67% powering excluding auxiliary load	36.75 watts	26.68 watts	19.2 watts

Life cycle energy cost for additional 1 watt hour per tonne.km consumption presuming a life of 35 years and 150,000 kms per year @ Rs 5 per unit works out to (5X35X150000X63/1000) Rs 16.5 lakh per car. This cost needs to be taken into consideration while deciding the mode of traction and percentage powering

Motorisation

3 Car unit

For a basic 3 -car train there is no alternative but to have 66% motorization so as to ensure that failure of one motor car does not result in immobilization of train in the section.

4 Car unit/8 car trains

In case of 4-car/ 8 car trains, only 50% and 75% motorisation is possible. DMRC who have sufficient experience with 50% recommends 75% motorization both for 4 car and 8 car trains. 75% motorisation in 4 car rakes would require three different type of cars. It is thus desirable to go in for 75% motorisation in case of 8 car rakes and 50% for 4 car rakes.

6 car/9 car trains

In case of 6 car/9car 66% motorization is a better option on account of following considerations:

Advantages

- Even with loss of one power car the operational performance is satisfactory, hence motor coach control can be adopted instead of bogie control.
- Smaller Traction Motor
- Higher level of acceleration and declaration is possible, subject to adhesion limits.
- Higher regeneration level is achieved resulting in lower application of friction braking and consequently less wear of pad /disc.
- Energy efficiency is better
- Chances of slip/slide even under the worst conditions are reduced due to utilization of lower adhesion factor compared to the permissible values.

Disadvantages

- Number of motor coaches will go up which will also result in increase in cost, and increase in tare weight. There will however be some reduction on account of bogie control in cost of propulsion equipment

- Number of pantographs in 25 KV AC system will go up. This can however be reduced by having one common transformer and single panto for a 3 car basic unit. This will reduce redundancy as two motor coaches will be out in case of failures of traction transformer and is acceptable only for 6 car rake.

The initial & maintenance cost of propulsion for 67% motorization will be higher, however there will be savings towards energy cost

Recommendations

Committee recommends 3 car or 6car per rake depending on the traffic projections with 66% motorization should be adopted as the standard for all future Metros. In case of 3 car rakes both motored cars should have independent propulsion equipment for complete redundancy

6.6 Recommended Operating characteristics are as given below

Characteristic	50% Powering	66% Powering
Maximum Design speed	95kmph	95 kmph
Maximum operating speed	85kmph	85kmph
Average acceleration from 0 to 40 kmph in m/s2 for fully loaded train at level track with AW3 load standees 80/m2 and seating approx. 50 p/car	0.8	1.0
Service braking rate from 80 kmph to standstill up to fully loaded train on level tangent track	1.0	1.0 m/s2
Emergency braking rate from 80 kmph to standstill up to fully loaded train on level tangent track	1.3	1.3 m/s2
Maximum jerk rate in acceleration or braking in m/s3	0.7	0.7
Minimum Adhesion level	0.20	0.20

7.0 Propulsion – Single source or consortium/JV – approach.

7.1 Issue is whether bids be invited from Coach manufacturers as single source or consortiums/JV of coach manufacturers and Propulsion equipment supplier.

Rolling stock manufacture involves four distinct requirements, namely:

i) Car body/mechanicals,

ii) train system design & integration,

iii) Propulsion system including TCMS and

iv) Interfacing, testing & commissioning with full MRTS system.

The above role is normally divided amongst two different set of firms

1. **Car manufacturers**
   They specialize in manufacture of car body/mechanicals and integration of propulsion system and TCMS from the specialist suppliers.
   Examples are BEML, CAF, ROTEM

2. **Propulsion Equipment suppliers**
   Propulsion system comprises of Traction Motor, main converter-inverters, auxiliary converters, transformers & TCMS. The propulsion system is quite crucial sub-system of the train. Responsibilities of propulsion system supplier include:
   - Interfacing with other subsystems like HVAC, Lighting, Doors, ATC/ATO, Brake System, Signaling, Passenger Information system, Power supply etc.
   - Commissioning and Testing
   - They supply propulsion equipment including TCMS who also carry out interfacing, testing & commissioning with MRTS system.

   Examples are Toshiba, MELCO, Hitachi, SIEMENS, Bombardier etc.

There are suppliers who supply the complete rolling stock including propulsion system. Examples are Bombardier, SIEMENS, ALSTOM, Ansaldo Breda etc.

7.2 Views by the Industry representatives

ALSTOM

Bids must be invited from JVs/Consortiums, wherein suppliers of each of the four requirements must be part of the consortium, and share joint and several responsibilities.

SIEMENS

The propulsion system supplier shall be allowed to bid as consortium member and also as sub-contractor to rolling stock supplier

Bombardier

A Consortium approach is recommended as it ensures that propulsion system supplier is committed to contractual obligations. Non consortium approach may allow car manufacturers(who do not manufacture propulsion equipment) to have enough negotiating power post contract.

7.3 Views of Metros

BEML

Propulsion system supplier can be a sub-contractor or member of consortium member. Both approaches are acceptable, in case subcontractor approach is followed, the role of propulsion equipment supplier should be clearly defined.

CMRCL

Propulsion from single source is preferred.

DMRC

Propulsion equipment manufacturer can be a sub contractor or JV/consortium partner with rolling stock manufacturer. Propulsion equipment supplier itself however should be a supplier of main converter /inverter and traction motor.

Hyderabad Metro

Has Propulsion equipment supplier as sub-contractor and not a consortium member

RMGL

Propulsion system supplier need not be a consortium partner

The majority view is in favor of having propulsion equipment supplier as a sub-contractor and not as a consortium partner with rolling stock manufacturer. For example Rolling stock manufacturers BEML or Hyundai Rotem could bid as a single source with options to source propulsion equipment from any of the suppliers eg Toshiba, Siemens, Bombardier or MELCO as a subcontractor. ALSTOM is the only exception recommending consortium approach. It is mentioned here that Siemens and Bombardier also supply its propulsion equipment to other rolling stock manufacturers,

besides supplying complete rolling stock, hence their views partly reflect their business interests.

Advantages of Non consortium approach.ie when propulsion equipment suppliers can be a sub contractors.

Enables competitive pricing as

- Rolling Stock manufacture that manufacture their own propulsion equipment can offer better competitive price
- Rolling stock manufacturers (who do not manufacture propulsion equipment) will have enough negotiating power with Propulsion equipment suppliers. This will reduce the price.
- As the number of Propulsion equipment manufacturers are limited, consortium approach will restrict the number of bids to number of propulsion equipment manufacturers and thus competition.

7.4 Recommendations

Recommendations

Committee recommends that car manufacturers can either bid as a single vendor with their own propulsion equipment in case it is manufactured by them and will have an option to source the propulsion equipment from any propulsion equipment supplier as a sub contractor. There should be no compulsion on the car manufacturer to have propulsion equipment supplier as a consortium/JV partner for bidding as consortium. Car manufacturer will have the option to bid as a single vendor or in consortium with propulsion manufacturer

8.0 Eligibility/qualification criteria for procurement

Eligibility criteria should aim at encouraging competition, Ensure reliability and quality and indigenization. Eligibility criteria has a direct bearing on the cost. Broader criteria ensures more competition and competitive prices.

Rolling stock comprises of Car body and Propulsion equipment. As there are two distinct set of suppliers for Car body manufacturing and propulsion equipment, and sub-contractor approach for propulsion equipment supplier is recommended. It is necessary to have separate eligibility/qualification criteria for these two separate set of suppliers.

Car body manufacturers include

1. CAF
2. BEML
3. CNR
4. CSR
5. Hyundai Rottem
6. Bombardier
7. ALSTOM
8. SIEMENS

Propulsion equipment suppliers are

1. Bombardier
2. Siemens
3. Alstom
4. Toshiba
5. Mitsubishi
6. Hitachi
7. ABB

8.1 Views of Industry

<u>SIEMENS Views</u>

For both Car Manufacturer and Propulsion equipment supplier

Bidder/Cons members, individually or jointly as a member of other Consortia/Joint Venture or as sub-contractor to it's parent company have experience of and carried out Vehicle Design, Interface (with other designated Contractors such as signaling, Track, Traction etc.), Assembly & Supply, Testing and Commissioning of

1. Minimum of total 300 metro (i.e. MRT,LRT,Sub-urban Railways or high speed railways) cars (out of which minimum 200 cars shall be of either Stainless Steel or Aluminum).

2. Service Experience 50% of 300 must have compl;eted satisfactory revenue operations for 5 years
3. No of contracts Minimum three.
4. Country Experience Three different countries or 5 years in India

BOMBARDIER

Eligibility criteria should focus on in-house Design capability, Vehicle Integration experience and Service provenessin different environment and should specified for each of the following critical components a) carboy b) bogies c) Propulsion Systems & 4) Vehicle Integration. These capabilities be demonstrated through;

1. Country experience Minimum two to three countries
2. Period of Satisfactory service 5 years
3. Bids by 100% Indian subsidiaries be permitted.

ALSTOM

Bidders must have proven capabilities

a) Train system design &integration
b) Car body mechanicals
c) Propulsion system including TCMS
d) Interfacing, testing and commissioning with full MRTS operation.

Indian subsidiary companies who have through parent company global experience be eligible to bid on the basis of the global credentials of parent company. This will help in cutting cost and indigenization. Credentials be proved through

1. Period of Satisfactory service 10 years of the parent company
2. No. of cars supplied Parent company experience
3. Bid by consortium with propulsion equipment manufacturer.
4. Country experience Multiple countries of Parent global company

BEML

The Applicant or Consortium / JV or its members individually or jointly as member of other Consortia in their respective roles carried out design, manufacture, supply, testing, commissioning & Integration of a minimum of 200 nos of stainless steel cars with similar features including traction propulsion system,

JVs of reputed propulsion equipment manufacturer and Indian companies are allowed to ensure transfer of latest technology and indigenous manufacturer in the country. Qualification criteria should be as follows:

Minimum number of Cars	200 in last 10 years
Period of satisfactory service	50% of 200 must have completed 5 years or more
Country Experience	In India or in a country other than the country of manufacture

Projects executed through TOT arrangement with global player, be taken as experience

Views of Other Indian suppliers

1. Lead bidder must have experience in full RS integration, manufacture of trains, car shells, bogies, propulsion etc.
2. Design should be proven design and coaches manufactured with that design be in service for some time.
3. Indian subsidiaries of the main bidders who meets all the required qualification criteria should be allowed to manufacture and supply 100% of the supplies
4. For sub-systems,similarly, the Indian owned subsidiaries of the suppliers who qualify based on their references in their home country be allowed to manufacture and supply 100% of the supplies.

8.2 Views based on experience of Indian Metros

BMRCL

Manufacturer of the propulsion system and other major sub-systems should have at least 10 year experience in this field with at least 5 years outside its home country.

CMRCL

Have previously designed, manufactured, supplied, tested and commissioned for a minimum of 200 cars with comparable features and of similar complexity in the preceding 10 years. At least 50% of the 200 cars/carsets shall have been supplied and proven in service for a period of 5 years or more in India, or, in a country other than the country of manufacture

RMGL

Supplier should be necessarily a car builder and should have at least supplied 200 cars running for a period of 3years without any major problem. The Propulsion equipment

supplier need not necessarily be a Consortium partner, but should have experience of design and manufacture of minimum 200 nos. of Propulsion System with similar features which should have been proven in service for a period of 3 years in a country other than the country of origin of manufacturer

LTHMR

Propulsion supplier was decided on the basis of operational proven-ness for 10 years. At least 4 years should have been in three different countries (it may be a consortium or single source)

DMRC

Bidder consortium or its members, individually or jointly as member of other Consortia have experience and carried out vehicle design, Interface, Assembly & Supply, Testing and Commissioning and should have following credentials:

Delivery Record of Metro cars in last 10 years

1.	Minimum number of cars	300 metro (i.e. MRT,LRT, Sub-urban railway of high speed railways out of which minimum 200 cars shall be of either stain less steel or Aluminum
2.	No of Contracts	5
3.	No of countries	Three countries

Operation Performance

150 cars out of above must be operating satisfactorily against three different contracts in three countries for the last five years.

Propulsion System

Propulsion equipment supplier as a member of bidder consortium or a subcontractor to the car manufacturer must have cumulative experience of minimum 10 years in the Design and manufacturing of propulsion equipment (Traction converter-Inverter, Auxiliary converter/Inverter and Traction Motor rolling stock. Propulsion equipment supplied must have been in satisfactory revenue operation for at least five(5) years in minimum 500 cars comprising of both powered and non-powered cars supplied against minimum five different contracts in the Metros of minimum two different countries outside the country of origin.

In case of JV/Consortium lead partner must have been a lead partner in at least two rolling stock contracts against ICB in the last ten years.

8.3 Major Issues

Propulsion equipment suppliers are mainly Japanese and Europeans for example MELCO, Hitachi, Toshiba, Bombardier, Alstom, Siemens, ABB. There is no indigenous supplier of modern propulsion system. Some of the above major suppliers have started manufacturing theseequipment in India through 100 % owned subsidiaries. Some Japanese suppliers are also planning to set up joint venture companies in India with Indian partners. All the above suppliers have enough experience of system integration and have been supplying propulsion equipment to all major car manufacturers in number of countries. Indian Metros and IR have also so far obtained propulsion equipment only from above suppliers. Recently some Indian companies like Medha and BHEL are trying to develop their own propulsion equipment for Mumbai suburban system. All the above suppliers meet the following criteria for propulsion system:

No of Cars equipped	Minimum 300
Minimum Cars in last 5 years	Minimum 200
Country Experience	At least one country other than the country of manufacture or India

The above criterion has been proposed by most of the committee members representing both Industry and also the Metros. Even 100% Indian subsidiaries of the parent company and also their JV companies having majority stake with parent company can be considered eligible with guaranteed support from parent company. Barring Alstom most of the members are of the view that Propulsion equipment supplier need not be a consortium partner and can also be a sub-contractor. It will not make any difference to the Metros as most of the eligible propulsion equipment suppliers are proven sources worldwide, but will give a wider choice to the car manufacturers and likely to lead to more competitive prices.

Car Manufacturers

Present scenario

There are number of Metro car manufacturers in Europe, Korea and China. Some of these have already supplied Metro cars to IR and have also set up or are setting up car manufacturing units in India. Examples are Bombardier, Alstom, CAF Besides these some Indian manufacturers have obtained TOT for coach manufacture from reputed car manufacturers like BEML. ICF has also been manufacturing Metro coaches for Kolkata Metro but these are conventional DC Metro cars. ICF does not have technology to manufacture modern 3 phase Metros. There is a need to encourage European car manufacturers to set up manufacturing facilities in India through technology transfer to JVs with Indian coach manufacturers so that cost comes down.

8.4 Recommendations of the Committee

Eligibility criteria for car manufacturer must ensure quality, reliability and competitive price of the rolling stock. Taking the views of Industry and Metros into consideration, following eligibility criteria for Rolling stock supplier is recommended.

Eligibility criteria for car manufacturer:

Bidder consortium or its members, individually or jointly as member of other consortium have experience and carried out vehicle design, Interface, Assembly & Supply, Testing and Commissioning and should have following credentials:

1. Minimum number of cars	300 metro (i.e. MRT,LRT, Sub-urban railway or high speed railways out of which minimum 200 cars shall be of either stain less steel or Aluminum in the last 10 years.
2. No of countries	At least one country other than the country of manufacture or in India.
3. Operation Performance	150 cars out of above must be operating satisfactorily against more than one contract in at least one country other than the country of manufacture or in India for last 5 years.

4. Projects executed through TOT arrangement with global player may be taken as experience. This will promote indigenization.
5. Indian subsidiary companies be eligible to bid on the basis of the global credentials of parent company.

Eligibility criteria for Propulsion Equipment Supplier:

Propulsion equipment supplier can be consortium member or a sub-contractor meeting the following requirements:

a) Must have cumulative experience of minimum 10 years in the Design and manufacturing of propulsion equipment (Traction converter-Inverter, Auxiliary converter/Inverter and Traction Motor rolling stock).

b) Propulsion equipment supplied must have been in satisfactory revenue operation for at least five(5) years in minimum 500 cars comprising of both powered and non-powered cars supplied against minimum five different contracts in the Metros of least one country other than the country of manufacture or in India.

c) Projects executed through TOT arrangement with global player may be taken as experience. This will promote indigenization.

d) Indian subsidiary companies be eligible to bid on the basis of the global credentials of parent company.

9.0 Control & communication protocol – common/published

9.1 TIMS or Train Integrated Management

Train integrated management system (TIMS) is a complete, integrated system for the control and monitoring of the train-borne equipment. TIMS provides control and monitoring, diagnostic and reporting of the train-borne equipment in a redundant manner.

Train Control & Management (TCMS) is a subsystem of TIMS and controls and monitors all train equipment.

The TIMS is designed for ease of fault diagnosis and maintenance.

Subsystems of the train utilize microprocessor-based control. The subsystems are inter-linked via a communication data bus system for the monitoring, fault data logging and for first line diagnostics of faults on board the train.

Communication is through the Train Bus (ARCNET) and Local bus (RS-485).

IEC 60571 is the International standard for TIMS hardware.

Present Scenario

- All the Reputed rolling stock manufacturers have developed their own Train Integrated Management Control System (TIMS) over the years.
- Even though communication protocols are based on international standards but achieving interoperability with subsystems of alternative vendors is generally quite difficult
- Support of the TIMS manufacturer is required for achieving integration.

9.2 **Views of Industry**

Siemens

TCMS should be supplied by Propulsion equipment supplier only. No comments have been given on use of propriety software.

Bombardier

TCMS is critical for train operations, reliability and safety. Train builders and equipment suppliers use different solutions and protocols; normally supplier specific hardware and common network solutions and protocols such as MVB,CAN, Ethernet. Functional requirement only need to be given for providing flexibility of solution.

The common standard for the TCMS is defined by IEC 61375 series of standards.

BEML

MELCO TCMS uses ARCNET defined by ANSI / ATA 878.1.The interfacing with different sub-systems is carried out by the TMS sub-contractor and the various sub-system suppliers in co-ordination with the rolling stock contractor.

Train Control & Management system of M/s MELCO is presently based on ARCNET technology (Standardized protocol defined by ANSIIATA878.1). ARCNET is basically a Ladder type Train Bus. Advantages of ARCNET:

1. Highly reliable with stored and forward method.
2. Ensure real-time control command data both by packet division and priority control.
3. Conformity of IEC62280-1 (Safety related communication in closed transmission systems)
4. Twisted Copper cable for ARCNET is easy to use. considering maintenance cost. cost performance & Redundancy.
5. Local bus communication is RS485 / RS422 defined by EIA (Electronics Industries Association).
6. The interfacing with different sub-systems is carried out by the TMS sub-contractor and the various sub-system suppliers in co-ordination with the rolling stock contractor.

9.3 Views of Metros

LT HMR

The hardware systems deployed on modern rolling stock normally conform to international standards and can be insisted upon

BMRCL

- TCMS with ARCNET technology supplied by MELCO is using Token passing. HDLC (High Level Data link Control) frame format for Train Bus Communication between the Cars (One TMS CPU to other Car TMS CPU).
- For communication from TCMS -Subsystem it is based on RS485/RS422 protocol.
- In IP technology with Ethernet back bone communication currently CSMAlCD (Carrier Sense Multiple Access I Collision Detection) is being used.
- There is no problem to monitor different sub-systems of different sub-suppliers; however it should be possible to meet the common protocol between TCMS & respective sub-systems.

- Also Transmission data flow in the network between TCMS & sub-systems can be standardized, so that subsystem supplier of different makes can meet the requirement of monitoring & control of the various parameters through TCMS. Gradually sub-system supplier should adopt IP technology.
- As far as software is concerned, it is a vendor specific proprietary item and during the Tendering stage, concerned contractors refused to share the source code with BMRCL and subsequently this requirement was modified.

DMRC

All the Reputed rolling stock manufacturers have developed their own Train Integrated Management Control System (TIMS) over the years. Even though communication protocols are based on international standards but achieving interoperability with subsystems of alternative vendors is generally quite difficult and support of the TIMS manufacturer is required for achieving integration.

The hardware systems deployed on modern rolling stock normally conform to international standards and can be insisted upon.

CMRL

CMRL has MVB bus in both intra and inter vehicular communication. It is preferred that WTB for train communication and MVB/CanOpen for inter-vehicular be adopted for all train set.

9.4 Recommendations of the Committee

Conformity to IEC62280-1 (Safety related communication in closed transmission systems)

The hardware systems deployed should conform to international standards.

There should be common open protocol between TCMS & respective sub-systems.

Also Transmission data flow in the network between TCMS & sub-systems can be standardized, so that subsystem supplier of different makes can meet the requirement of monitoring & control of the various parameters through TCMS. Gradually sub-system supplier should adopt IP technology.

10.0 Driver less control

10.1 **Driverless Train Operation – Main Features**

- Automatic departure and run from station to station, including automatic turn-back
- Door re-opening on train hold command
- Remote start of stalled trains
- Attendant responsibility:
  - control passenger doors
  - prevent person injuries between cars or between platform and train
  - ensure safe starting conditions
  - set in/set off operation
  - supervise the status of the train

10.2 Basic technical system requirements for driverless operation

- Continuous, bi-directional communication between trackside / OCC and trains (= CBTC system).
- Platform Screen Doors, radar grid or optical obstacle detection systems for sealing the guide way in the platform areas and along the alignment in case of elevated systems.
- Highly reliable Rolling Stock sub-systems.
- Obstacle detection equipment on bogies
  - Derailment detection on bogie axles.
  - Door nip protection equipment on all train doors.
  - Complete CCTV coverage on trains and two-way passenger help points.
  - Onboard fire, smoke and temperature detection equipment in passenger compartments and inside the equipment cabinets.

<u>Views of LT HMR</u>

Hyderabad Metro evaluated about driverless system but in absence of CBTC system decision, this decision could not be taken (driverless system requires CBTC).

Hyderabad Metro operation/signaling concept is STO – Semi-automated Train Operation where

- train runs automatically from station to station
- automatic stop and door opening
- train operated by a driver supported by ATO
- driverless reversal to meet 90 seconds headway at terminal stations

<u>Views of Siemens</u>

It is recommended to have Driverless Trains as they enable shorter headways and cost benefits for the operator over the project life cycle.

BMRCL

There is a need to adopt the communication based Train control (CBTC) system as a matter of further up gradation of signalling system and subsequently “Driverless train operation can be adopted in phases”

CMRL

Present design of RS is to operate it with driver, whose responsibility is to monitor the passenger door in full ATO operation. However, Chennai may try driverless version in the next phase.

DMRC

Rolling stock being procured for Phase-III project of DMRC (for Line-7 and Line-8) against the tender ‘RS10’ will be suitable for operation in ‘GoA3’ and ‘GoA4’ modes i.e. un-attendant train operation with attendant on board and without attendant on board respectively

10.3 Recommendations

Driverless system on the Indian Metro Projects

- Driverless system is the technology, which is well proven now and is strongly recommended for use in Indian Metro system.
- Techno-Commercials considerations are in favour of driver-less system as extra capex can be recovered in 7-10 years’ time.
- Driverless system needs very high reliability and hence detailed
- designs requires extra time in RAM assurance activities.
- Approval and safety certificate from CRS due to lack of technical experience, which can probably be managed.

Driver less operation is required to achieve 90 seconds frequency for full utilization of Metro infrastructure capacity. This will require communication based Train Control (CBTC) system.“Driverless" Train Operation can be adopted in phases with signaling up-gradation.

11.0 Indigenization

11.1 Indigenization objectives

- Development of Indigenous industry for reducing dependence on imports
- Reduction in import content and easy availability of spares
- Reduction in rolling stock price.

11.2 Present Scenario

Coach manufacturing units

Standard clause in Metro Tenders mandates that the successful bidder will set up car manufacturing unit in India and at least 70% of the quantity be produced indigenously. This has led to setting up of following manufacturing units

- BTcoach manufacturing unit at Vadodara
- BEML Bangalore Development of facilities for Metro car production under TOT from Hyundai Rotem
- Alstom setting up unit near Chennai
- CAF setting up manufacturing unit in Haryana
- Kawasaki is also planning to set up coach production facilities in the country

These units are also sourcing their sub assembles from local industry example HVAC units, transformers, Pantograph, internal furnishing material etc.

Private developers like GMRL, Reliance Metro,Mumbai, Airport Express and LTHMRL have not imposed any condition for indigenous development and entire stock has been procured from Hyundai-Rotem, South Korea and CSR, China.

11.3 Views of Industry

BT

This needs detailed discussions with a view to ensure long-term Spare Parts & Service availability during the lifetime of rolling stock. Unfortunately the indigenization requirement is not very stringent in metro Tenders in India except a few tenders. Other countries have utilized the mandatory localization concept effectively to develop the local industry in terms of technology and quality through mandatory indigenization criteria.

ALSTOM

Tender evaluation should consider landed cost at MRTS depot so that after considering custom duties including countervailing duty (CVD), Cess on CVD and the Special Additional duty (SAD) - to arrive at the total landed cost of the Rolling Stock at the MRTS Depot. Landed cost of indigenous manufacture will then be cheaper, which would act as incentive to indigenous manufacture. Lower cost of indigenous maintenance spare would life cycle costs. This in turn will push many Global Companies to set up local manufacturing facility under a separate locally incorporated company in order to reduce costs.

A large number of reputed major train builders have set up manufacturing in India. In the next phase, the emphasis should be on indigenization of propulsion system &TCMS which, so far, has been trailing behind the localization curve.It would therefore, be prudent to aggressively push for and support moves towards 100% indigenization and indigenous procurement of the entire Rolling Stock, including Propulsion Systems.

This would also encourage more FDI to come in to India. The Government must must initiate steps to ensure that investment of those manufacturers, who have invested heavily in India in the form of manufacturing facilities, are well protected.

To promote indigenization it is proposed that:

I. A central Rolling Stock Procurement Agency that procures on behalf of all Metros Authorities in the country be set up.
II. Big tenders of more than 250 cars should be contracted to more than one supplier. Currently, many of the manufacturing facilities that were set up in anticipation of obtaining orders are challenged with low off-take.
III. Similarly, awarding contracts on the existing supplier on single bid basis also hampers competition & competitiveness and increase the cost. For example in Jaipur Metro whereRS was awarded on single bid basis to BEML.
IV. There is a need to correct this situation by incentivizing procurement from firms that have an installed manufacturing base in India. Tender Evaluation should be based on the landed cost, inclusive of Taxes & Duties.

BEML

The specification requirement of metro cars is very stringent and based on established international standards. The major constraintsrestrictingindigenizationare:

- Technical know- how and know -why
- Infrastructural facilities
- Type and routine test facilities
- Skilled trained manpower

- Maintaining Quality to ensure high reliability & availability

Normally, Global Metro Manufacturers establish in-house infrastructure/ facilities for manufacture of Carbody& Bogie frames, assembly, integration & testing. Major aggregates are sourced from established limited global suppliers who have already supplied to other Metros with satisfactory performance record.

Infrastructural facilities for manufacture of carbody and bogie frame and it's integration are already available in the country. Indigenous sources for certain outfitting items like GFRP panels, grab poles & rails, window glasses, glass wool insulation, electrical panels, battery box, stainless steel and aluminum fabricated items, etc are also available.

For critical sub-systems like propulsion, brake, door, HVAC, passenger address & Passenger information system, CCTV, gangway, bogie suspension, gearbox, etc there are few established global suppliers with satisfactory performance record and they should be encouraged to either set up their subsidiary in India or transfer technology to an Indian company through JV. Certain items like wheel and axle may have to be imported as present Indian manufacturers are having capacity constraints.

The specifications need to be standardized to increase the volumes. Presently, the specifications are drafted on project to project basis. The major specifications which require standardization are axle capacity, train formation including basic unit composition, kinematic envelope, track parameters including minimum radius of curvature, operating voltage, overhead or third rail current collection, etc. Standardization will result in higher volumes, more vendors will show interest and the cost will come down. Also, the cost towards design and type test can be amortised over large number of cars.

DMRC

DMRC has followed the policy of encouraging indigenisation on consistent basis with notable achievements by involving Indian contractors and manufacturers having adequate experience to deliver quality products. Emphasis is made to promote transfer of technology and suitable clauses have been included in the tender. This provides the necessary stimulus and mandates the Rolling Stock (RS) contractors to associate with suitable Indian companies for not only providing support during execution and the warranty period but also for taking up manufacture of major sub-assemblies within India. For procurement of high value Rolling Stock, specific provisions have been made in the tender documents for manufacturing of a minimum specified number of train sets in India with progressively increased indigenisation content by establishing the manufacturing facilities either independently by the contractor or with an Indian partner. Further, to facilitate ease in maintenance and availability of spares, the contractor is

bound by the contract conditions to ensure that the indigenisation of the specified items is achieved either by setting up of the manufacturing facilities by the Principal foreign supplier(s) of such items or by choosing a suitable Indian partner.

For achieving indigenisation of sub-systems, the rolling stock contractors can be mandated with a contract condition to ensure that the indigenisation of the specified items is achieved either by setting up the manufacturing facilities by the Principal foreign supplier(s) or by choosing a suitable Indian partner. This would help in ensuring that these firms remain abreast with the technological developments.

BMRCL

The quality of indigenized item must be of the same level as available internationally.

New product developed indigenously takes about 3 to 4 years for conducting field trials undergoing cycles of failures and subsequent modifications before getting stabilized in terms of performance and reliability for large scale adoption. This approach may be feasible with IR having its own dedicated Design & development wing at RDSO but may not be feasible for small Metros.

Metros have given the responsibility of development of local vendors to global suppliers who have the responsibility of meeting global standards.

It has been possible to achieve about 31% indigenization on BMRCL project in rolling stock. Details are as follows:

- Car body manufacture fully indigenized
- About 12 out-fitting items are outsourced from local vendors
- Factory Acceptance test of the coaches, depot testing and commissioning is done by BEML Engineers under the supervision of expatriate experts from Korea and Japan.

Government can act as a catalyst by prescribing a certain level of indigenization in the contract as mandatory. We can begin with 45 to 50% of contract value initially, which can be later on increased with passage of time.

Indian railways

Car manufacture, integration and testing is done by ICF. Propulsion equipment is procured through global bid and IR is also dependent on imports as there are no indigenous sources for propulsion equipment including TCMS.For development of Indigenous sources for 3 phase propulsion equipment, development orders have been given to indigenous sources. Initiative can be taken by MOUD as is done by Ministry of

Railways for IR. This will help Indian firms acquire technology thorough collaborations or indigenous development on their own.

11.4 Recommendations of the committee.

Rolling Stock manufacture includes

- Manufacture of Car body& Bogie frames, assembly, integration & testing. Infrastructural facilities for manufacture of car body and bogie frame and it's integration are already available in the country. Indigenous sources for certain outfitting items like GFRP panels, grab poles & rails, window glasses, glass wool insulation, electrical panels, battery box, stainless steel and aluminum fabricated items, etc are also available.
- manufacture of propulsion system including TCMS and other critical sub-systems like propulsion, brake, door, HVAC, passenger address & Passenger information system, CCTV etc.

Car manufacture

Indigenisation of Car body manufacture has already taken place as following manufacturing facilities have already been set up:

- BT coach manufacturing unit at Vadodara
- BEML Bangalore under TOT from Hyundai Rotem
- Alstom setting up unit near Chennai
- CAF setting up manufacturing unit in Haryana
- Kawasaki is also planning to set up coach production facilities.
- ICF and RCF have facilities to manufacture EMU/MEMU coaches which can be up graded to Metro coaches.

Above facilities can take care of the future Metro needs. There is however a need to protect these investments and some incentives need to be given to these units for effectively utilizing the facilities already created.

Propulsion equipment

The critical area is indigenization of manufacture of propulsion system, TCMS and other critical sub systems. Global suppliers with satisfactory performance record need to be encouraged to either set up their subsidiary in India or transfer technology to an Indian company through JV. Following steps are necessary to achieve this:

Specifications for both rolling stock and traction distribution system are standardized. Standardization will result in higher volumes. It will be possible to leverage the bulk procurement by a single agency to achieve development of indigenous industry through TOT as has also been done by China.

Presently individual metros are procuring rolling stock in small quantities with different specifications and clause to manufacture 60 to 70% cars indigenously. This does not promote indigenisation of propulsion equipment which is mostly imported. As in case of

car body manufacture, indigenous manufacture of complete propulsion equipment in the phased manner also needs to be mandated in the rolling stock tenders.

MOUD in order to promote indigenous manufacture of propulsion equipment should give development orders for small quantities to local firms who can either develop on their own or through collaboration with global suppliers. IR has adopted this approach for development of indigenous three phase propulsion equipment for locomotive and EMUs. After successful tests and trials these sources can be considered as regular sources for propulsion equipment.

Committee, thus, recommends that a system of bulk order placement may be devised preferably by MoUD by combining requirement of smaller metros. Orders should be placed with at least 70% indigenization clause for both propulsion equipment and car manufacture through TOT with indigenous manufacturers or setting up of Indian subsidiary.

12.0 BIBLIOGRAPHY

Sl No.	Details
1	Study of Noise assessment inside the Greater Cairo Underground Metro ByMostafa E Aly
2	A study of Noise Levels associated with New York City's Mass Transit System by Richard Neitzel, Robyn R. M. Gershon and others
3	Athens Metro Extension Project to PiraeusGround borne Noise and Vibration Assessmentand Control byKonstantinos E. Vogiatzis
4	Noise impact assessment of mass rapid transit systems in Delhi City – Naveen Garg, Omkar Sharma and S Maji. Acoustics, Ultrasonics, Shock and Vibration Standard, National Physical Laboratory(CSIR) New Delhi 110012
5	Ministry of Environment and Forests Notification, New Delhi,the 9th March 2009
6	METRO RAILWAY NOISE AND VIBRATION Causes and solutions for DMRC Phase III
7	'Guidance on the provision of equipment and arrangements for evacuation and escape from trains in an emergency' London Metro
8	**RIVAS**Railway Induced Vibration Abatement Solutions Collaborative project State of the art review of mitigation measures on track Project Coordinator: Bernd Asmussen International Union of Railways (UIC)
9	Being a good neighbour– reducing vibrations near railway lines Bernd AsmussenEnnoWiebe RIVAS Project Coordinator, UIC Manager Research Programmes and Projects, UIC
10	Article EuropeanRailwayReview_Vol.17issue6_2011
11	MD, Bangalore Metro Rail Corporation Ltd. letter No. BMRCL/MD/PS/12-13/038 dated 09.06.2012 to Secretary to Govt. of India
12	DMRC Train Noise Level Study RS1 by GC – Report dated 7.06.2005
13	Interim guidelines for Assessment of noise from Tail infrastructure projects-Published by Department of Environment and Climate Change NSW 59–61 Goulburn Street, Sydney

D.D. PAHUJA, B Tech IRSEE
Director (R.S.E.)

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No:BMRCL/DRSE/PS/2012-13/1485 Date:18th December 2012

Shri. R.K. Bhatnagar,
Advisor Electrical, Railway Board,
Ministry of Railways,
111, Rail Bhavan, New Delhi-110001,,

Subject : Draft Report of the Sub-Committee on Rolling Stock for Metros

Reference : Your email dated 13/12/2012

With reference to the email quoted above, item-wise details required for the finalization of **Report of the Sub-Committee on Rolling Stock for Metros** are given below:

Item No.1:

Specified Noise level for BMRCL Rolling Stock (Interior & Exterior) and Noise & Vibration remarks :

	Conditions	BMRCL Specified
Interior noise	**Stationary** **In Free field** **In tunnel**	Saloon/Cab 68dBA/68dBA 75dBA/72dBA
	Running **In Free field** **On At-grade** **On Elevated** **In Tunnel**	Saloon/Cab 72dBA/70dBA 72dBA/70dBA 80dBA/78dBA
Exterior noise	**Stationary** **On At-grade** **On Elevated**	 67dBA 67dBA
	Running **On At-grade** **On Elevated**	 82dBA 82dBA
Door Operation noise	**Sliding operation Locking/ Unlocking**	72dBA 78dBA
Vibration	**Stationary**	2.0mm peak-to-peak amplitude for the frequency range from 1.4Hz to 20Hz, and in excess of 0.8mm per second peak vibration velocity for the frequency range above 20Hz.

Remarks : Since grinding of Rails is required before conducting Noise/Vibration test, this has not been conducted formally on Reach-1. However, random test was conducted without grinding of rails on Reach-1. The results are erratic. The Rolling Stock manufacturer has advised that the Preliminary Noise/Vibration test will be conducted during April'2013 and Complete Noise/Vibration test will be conducted after the commissioning of the full Corridor.

Item No.2:

Emergency Evacuation System:

- In BMRCL Trains, each door has been provided with "Emergency Egress Device" (EED) which are used in case of Emergency evacuation.
- In each Car, two nos. of Emergency ramp on either side of the car provided for bridging the gap between coach floor and walkway during emergency evacuation.
- Doors selected for Emergency evacuation are shown to Passenger by means of LCD monitors (Passenger Information Boards (PIBs)) provided in the saloon interior.
- The detail procedure of Emergency evacuation is explained in BMRCL's General Rules Chapter-7, clause no.49(3A,3B,3C) & 50.

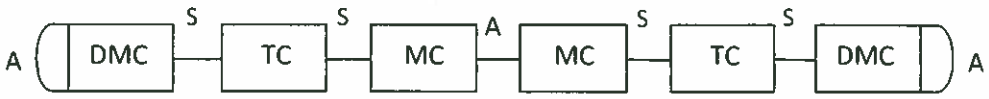
Item No.3:

Details of coupling arrangement and formation of Trains prescribed by BMRCL:

Basic units are:

- 3 Car unit :

- 6 Car unit :



A : Automatic Coupler
S : Semi permanent Coupler

Item No.4:

Acceleration/Deceleration/Jerk rate/Power to Weight ratio and percentage motorization::

- Average acceleration rate from 0 to 30 km/h : 1 $m/s^2 \pm 5\%$
- Average service deceleration from 80 to 0 km/h : 0.95 $m/s^2 \pm 5\%$
- Maximum jerk rate : 0.7 $m/s^3 \pm 0.05$
- Power to Weight ratio : 13.58 kw/ton
- Percentage motorization : 66.66%

Item No.5 & 6:

Eligibility/Qualification Criteria adopted by Bangalore Metro:

- While prescribing the eligibility criteria of procurement, BMRCL has introduced the clause that Manufacturer of the propulsion system and other major sub-systems should have at least 10 years experience in this field with at least 5 years outside its home country.
- Criteria of 10 year experience will ensure the provenness of the Propulsion system in different climatic conditions
- Criteria of 5 year experience outside its home country will ensure that the manufacturer have sufficient experience of interfacing with other sub-system suppliers of different make.
- For ATO operation, realization of Traction effort & Braking effort is required to be correctly interfaced with corresponding Traction & Braking demand from ATO side. The Propulsion manufacturers having a wide experience in interface with ATC/ATO system can only achieve the requirement of Traction & Braking demand from ATO side and hence such criterion is needed.

View of BMRCL on advantages/disadvantages of sourcing propulsion equipment from Single source vis-a-vis consortium/JV:

- Advantages:
  - Propulsion supplier is sub-contractor or member of the Consortium, their role in the design, interfacing and testing is required to be clearly defined in the Contract itself.
  - Propulsion supplier should be made responsible for interfacing with other sub-system supplier like ATC/ATO, Brake system, signaling, Telecom, power supply etc..
  - In case of single source, interface with other sub-system supplier is the responsibility of Main contractor.
- Disadvantages:
  - In the Sub-contract system, the role of propulsion supplier with respect to interface is not made clear and this is on the mercy of Main contractor and in this process interface work will suffer.

Item no. 7:

Control and Communication Protocol (TCMS) used in Bangalore Metro:

- Train Control & Management system of M/s MELCO is presently based on ARCNET technology (Standardized protocol defined by ANSI/ATA878.1).
- ARCNET is basically a Ladder type Train Bus.
- Advantages of ARCNET:

- Highly reliable with stored and forward method.
- Ensure real-time control command data both by packet division and priority control.
- Conformity of IEC62280-1 (Safety related communication in closed transmission systems)
- Twisted Copper cable for ARCNET is easy to use, considering maintenance cost, cost performance & Redundancy.

- Suggestions and recommendations of Bangalore Metro:

  - TCMS with ARCNET technology supplied by MELCO is using Token passing, HDLC (High Level Data link Control) frame format for Train Bus Communication between the Cars (One TMS CPU to other Car TMS CPU).
  - For communication from TCMS –Subsystem it is based on RS485/RS422 protocol.
  - In IP technology with Ethernet back bone communication currently CSMA/CD (Carrier Sense Multiple Access / Collision Detection) is being used.
  - There is no problem to monitor different sub-systems of different sub-suppliers; however it should be possible to meet the common protocol between TCMS & respective sub-systems.
  - Also Transmission data flow in the network between TCMS & sub-systems can be standardized, so that subsystem supplier of different makes can meet the requirement of monitoring & control of the various parameters through TCMS. Gradually sub-system supplier should adopt IP technology.
  - As far as software is concerned, it is a vendor specific proprietary item and during the Tendering stage, concerned contractors refused to share the source code with BMRCL and subsequently this requirement was modified.

Item No.8:

Suggestions of Bangalore Metro on Driverless Train operation in Indian Context:

In the opinion of Bangalore Metro, there is need to adopt the communication based Train Control (CBTC) system as a matter of further upgradation of signaling system and subsequently "Driverless" Train Operation can be adopted in phases.

Item no.9:

Strategy for Indigenous development adopted by Bangalore Metro along with Constraints:

45 trains of BMRCL are being manufactured at BEML factory, where approximately 35% indigenization has been achieved.

A detailed note on indigenization sent from BMRCL to MOUD/GoI is attached.

Yours sincerely,

DPahuja
18/12/2012

(D.D.Pahuja)
Director(RSE)/BMRCL

Copy enclosed as referred.

Rolling Stock details of CMRL

Item No.	Subject	Value specified

1 Noise level

a. Interior Noise Levels

Condition – Stationary Car	**Average Noise Level**
Driver's cab, car stationary	70 dBA
Saloon	71 dBA
Condition – Car Traveling at Full Speed	
Driver's Cab - Rake operating in the open on dry, level, tangent track at any speed up to 80 km/h in any normal mode of acceleration, coasting, or braking, with all auxiliaries operating under normal conditions.	75 dBA
Saloon - Rake operating in the open on dry, level, tangent track at any speed up to 80 km/h in any normal mode of acceleration, coasting, or braking, with all auxiliaries operating under normal conditions.	78 dBA

b. Wayside Noise Levels

Condition	**Avg. Noise Level**
All systems operating simultaneously, including air conditioning and propulsion cooling system, rake stationary	65 dBA at 15 m
Each auxiliary system operating alone, car stationary.	68 dBA at 5 m
Rake at any speed up to 30 km/h, maximum acceleration or maximum full service brake with all auxiliaries operating under normal conditions.	81 dBA at 15 m
Rake between 30 km/h and 80 kmh, maximum acceleration or maximum full service brake with all auxiliaries operating under normal conditions.	82 dBA at 15 m

Reference specification

All measurements shall be made in accordance with the following:

i. ISO 1683: "Acoustics – Preferred reference quantities for acoustic levels";

ii. EN ISO 3381 (2005): "Acoustics – Measurement of noise inside railbound Vehicles" and

iii. EN ISO 3095 (2005): "Acoustics – Measurement of noise emitted by rail bound Vehicles".

Vibration — Stationary car: 2.0mm peak-to-peak amplitude for the frequency range from 1.4Hz to 20Hz, and 0.8mm per second peak vibration velocity for the frequency range above 20Hz.

Ground borne Vibration: To limit car introduced groundborne vibration induced in structures neighboring the rail alignment to 70 dB

Vibration velocity levels are referenced to 1.0 mm/s^2

2 Emergency evacuation system

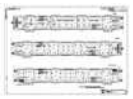
Passengers alarm - One location on each side of the coach

Internal Emergency Egress Device - One passenger doorway on each side of each car

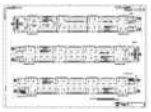
External Emergency Passenger door Release Device - One passenger doorway on each side of the car

Emergency ramp - procedure shall be displayed in the passenger compartment

Controlled evacuation



Un controlled evacuation



3 Coupling arrangement

The minimum operational unit shall be a 4-car rake, with semi-automatic (between trains) and semi-permanent (within the train) couplings to form a single rake with driver cars at each end of the rake.

4 Acceleration/ deceleration, rake powering

Item	Metro Corridor
Maximum Design Speed	90 km/h
Maximum Operating Speed	80 km/h
Round Trip Schedule Speed w/ 30sec station stop & 8% coasting excluding terminal station turn around time	34 km/h
Acceleration from 0 to 30 km/h for fully loaded train on level tangent track	0.82 m/s^2 + 5%
Service braking rate from 80 kmph to standstill up to fully loaded train on level tangent track	1.0 m/s^2
Emergency braking rate from 80 kmph to standstill up to fully loaded train on level tangent track	1.3 m/s^2
Maximum jerk rate in acceleration or braking	0.70 + 0.05 m/s^3

Coefficient of adhesion (min.) but not limited to	0.18
Rake Powering	50%

5	Qualification criteria	Service proven: In general, “service proven” shall mean the system, subsystem, equipment or components, etc. which have previously been designed, manufactured, supplied, testing and commissioned for a minimum of 200 cars/carsets with comparable features and of similar complexity in the preceding 10 years, At least 50% of the 200 cars/carsets shall have been supplied and proven in service for a period of 5 years or more in India, or, in a country other than the country of manufacture Car-body structure, bogie structure, seat frames, and equipment boxes shall be designed for a service life of 30 years minimum in the Chennai environment, based on an average annual operating distance of 150,000 km per rake without requiring structural repair or replacement
6	Propulsion equipment	Propulsion equipment from single source could be preferred if it doesn't result in cost escalation.
7	TCMS	CMRL has MVB bus in both intra and inter vehicular communication. It is preferred that WTB for train communication and MVB/CanOpen for inter-vehicuar be adopted for all train set.
8	Driverless train	Present design of RS is to operate it with driver, whose responsibility is to monitor the passenger door in full ATO operation. However, Chennai may try driverless version in the next phase.
9	Indigenization	The present contract allows the supplier to indigenize the train production. Hence the supplier has set up a factory in a location close to Chennai. Indigenization is promoted in non critical areas and 35-40% of the items manufactured in the new factory is expected to be indigenous. Constraints in indigenization are, i. Difficulty in ensuring full transfer of technology ii. Trained labor for specific skills iii. New machinery and plant which will take time to give consistent quality iv. Ancillary units experienced in stainless steel / aluminium metal work for car building to required standards. v. Non-availability of material / car level advanced test facilities in private sector in India vi. Unavailability of metro traction propulsion manufacturers in India

Date: 13th February, 2013

NOTE

Sub: DMRC's comments on TOR for Sub-Committee on Rolling Stock

1. Item No. 1 – Noise and Vibration Level (including RS, Track etc):

1.1 Recommended interior and exterior noise levels:

a. Interior and Exterior level, specified under stationery and running conditions on via-duct as well as in tunnel for the existing rolling stock contracts (RS1, RS2 and RS3) is indicated in the attached ***Annexure-I***.

b. The specified interior and exterior noise levels in 'RS10' tender for procurement on rolling stock for Phase-III Project of DMRC is also indicated in the ***Annexure-I***.

1.2 It is clarified that for the rolling stock proposed to be procured for Phase-III Project of DMRC, measurement of specified noise levels shall be in $L_{PA5.}$

2. Item No. 2 – Emergency Evacuation System:

2.1 Front evacuation directly on the track bed has been adopted in broad-gauge network of DMRC (RS1 and RS2 stock)

2.2 Side evacuation through saloon doors to the side walk way has been adopted in Line-5 & Line-6 of DMRC network (RS3 stock)

2.3 For the stock proposed to be procured for new lines under Phase-III project of DMRC (L7 & L8), front evacuation has been planned.

3. Coupling arrangement (Automatic, Semi-automatic) etc.

3.1 Automatic couplers (with pneumatic head but without electrical head) has been adopted on both ends.

3.2 Automatic couplers with electrical and pneumatic head is used between the units.

3.3 Semi-permanent couplers are used in a unit.

4. Acceleration/Deceleration/Jerk Rake, Power to weight ratio/% motorisation

4.1 Performance parameters for rolling stock procured for Contract 'RS!', 'RS2' and 'RS3' is adopted as per ***Annexure-II***.

5. Eligibility/Qualification criteria for procurement:

5.1 The criteria for procurement depend on the type of rolling stock and the quantity of procurement. The qualification criteria for procurement for 'RS10' tender is given in the enclosed ***Annexure-III***.

6. Propulsion – Single Source or consortium/JV – approach:

6.1 For the rolling stock, proposed to be procured against 'RS10' tender to meet the requirement of Phase-III project of DMRC, propulsion manufacturer can be either a member of the JV/ Consortium or a sub-contractor.

6.2 It is DMRC's considered view that single source/vendor for propulsion equipment (consisting of main converter inverter and traction motor) is beneficial for realizing high reliability rolling stock. It has been our experience that procurement of these items from different vendors results in integration issues, thereby the lowering the reliability of the stock.

7. Control & Communication protocol – Common/Published:

7.1 All the Reputed rolling stock manufacturers have developed their own Train Integrated Management Control System (TIMS) over the years. Even though communication protocols are based on international standards but achieving interoperability with subsystems of alternative vendors is generally quite difficult and support of the TIMS manufacturer is required for achieving integration.

7.2 The hardware systems deployed on modern rolling stock normally conform to international standards and can be insisted upon.

8. Driverless Control:

8.1 Rolling stock being procured for Phase-III project of DMRC (for Line-7 and Line-8) against the tender 'RS10' will be suitable for operation in 'GoA3' and 'GoA4' modes i.e. un-attendant train operation with attendant on board and without attendant on board respectively.

9. Indigenisation:

9.1 DMRC has followed the policy of encouraging indigenisation on consistent basis with notable achievements by involving Indian contractors and manufacturers having adequate experience to deliver quality products. Emphasis is made to promote transfer of technology and suitable clauses have been included in the tender. This provides the necessary stimulus and mandates the Rolling Stock (RS) contractors to associate with suitable Indian companies for not only providing support during execution and the warranty period but also for taking up manufacture of major sub-assemblies within India. For procurement of high value Rolling Stock, specific provisions have been made in the tender documents for manufacturing of a minimum specified number of train sets in India with progressively increased indigenisation content by establishing the manufacturing facilities either independently by the contractor or with an Indian partner. Further, to facilitate ease in maintenance and availability of spares, the contractor is bound by the contract conditions to ensure that the indigenisation of the specified items is achieved

either by setting up of the manufacturing facilities by the Principal foreign supplier(s) of such items or by choosing a suitable Indian partner.

9.2 For achieving indigenisation of sub-systems, the rolling stock contractors can be mandated with a contract condition to ensure that the indigenisation of the specified items is achieved either by setting up the manufacturing facilities by the Principal foreign supplier(s) or by choosing a suitable Indian partner. This would help in ensuring that these firms remain abreast with the technological developments.

(H.S. Anand)
DRS

Annexure – I

Interior Noise Levels

Name of Metro	Tender No.		Under Stationary Condition		Under running condition (RS1 at 80 kmph, RS2 & RS3 at 85 kmph		Remarks
			Viaduct	Tunnel	Viaduct	Tunnel	
DMRC	RS1*	Saloon	68dBA	Not specified	72dBA	92dBA	
		Cab	68dBA	Not specified	70dBA	92dBA	
	RS2**	Saloon	68dBA	75dBA	72dBA	Not specified	
		Cab	68dBA	72dBA	70dBA	Not specified	
	RS3**	Saloon	68dBA	75dBA	72dBA	Not specified	
		Cab	68dBA	72dBA	70dBA	Not specified	

Exterior Noise Levels

Name of Metro	Tender No.		Under Stationary Condition		Under running condition (RS1 at 80 kmph, RS2 & RS3 at 85 kmph		Remarks
			Viaduct	Tunnel	Viaduct	Tunnel	
DMRC	RS1*		61dBA	72dBA	80dBA	Not specified	
	RS2**		67dBA	Not specified	84dBA	Not specified	
	RS3**		67dBA	Not specified	84dBA	Not specified	

Door Operation Noise Level

Name of Metro	Tender No.		Under Stationary Condition		Under running condition (RS1 at 80 kmph, RS2 & RS3 at 85 kmph		Remarks
			Viaduct	Tunnel	Viaduct	Tunnel	
DMRC	RS1*	Opening/ Closing	72dBA	Not specified	Not applicable	Not applicable	
		Unlocking/ locking	Not specified	Not specified	Not applicable	Not applicable	
	RS2**	Opening/ Closing	72dBA	Not specified	Not applicable	Not applicable	
		Unlocking/ locking	78dBA	Not specified	Not applicable	Not applicable	
	RS3**	Opening/ Closing	72dBA	Not specified	Not applicable	Not applicable	
		Unlocking/ locking	78dBA	Not specified	Not applicable	Not applicable	

* All values measured are $L_{pAeq.5s}$ A – Weighted equivalent continuous sound pressure level where the measurement time interval ***T*** is five second (***T=5s).***

** All values measured are L_{pA5} After applying the time and frequency weighting, the sampled measurement data of 20 seconds (10000 readings sampled with 500 H_z from one microphone) is divided into classes corresponding to each level (e.g. 10 classes per dB). For each class the frequency over the measurement time is calculated. A histogram of the frequency of each L_{pAF} level over the measurement time is

made. This is then converted to a graph over cumulative relative frequency. The value for 95% of the time is the L_{pA5} level, i.e. the A weighted sound pressure level exceeded for 5% of the measurement time period.

RS10

(a) Interior

Interior Noise Level (L_{pA5})

Location (Section)	Interior Noise Measurements in dBA			
	Stationary		Running	
	Elevated	Tunnel at platform	50 Kmph	75 Kmph
Saloon	64	68	72	75
Driving Cab	63	68	68	70

(b) Exterior

Exterior Noise Level (L_{pA5})

Maximum Level of Exterior Noise in dBA	
Elevated (measured in two track section) and at-grade sections	
Stationary	Running at 75Kmph
67	82

Annexure – II

Acceleration/Deceleration/Jerk Rate/Power to Weight Ratio/% Motorisation

Item	RS1	RS2	RS3
Max. Speed	90 kmph (Design) 80 kmph (Operational)	95 kmph (Design) 85 kmph (Operational	95 kmph (Design) 85 kmph (Operational)
Starting Acceleration/ Speed Range	0.82 m/s^2 ± 5% (Metro Corridor) 0.78 m/s^2 ± 5% (Rail Corridor) (0-30 kmph)	0.82 m/s^2 ± 5% (0-30 kmph)	0.80 m/s^2 ± 5% (0-30 kmph)
Service Braking/ Deceleration/Speed Range	1m/s^2 ± 5%	1m/s^2 ± 5%	1m/s^2 ± 5%
Emergency Braking Rate	1.3m/s^2	1.3m/s^2	1.3m/s^2
Maximum Jerk Rate in acceleration or braking	0.7 ± 0.05m/s^3	0.7 ± 0.05m/s^3	0.7 ± 0.05m/s^3
Co-efficient of Adhesion	0.18	0.18	0.18
Rake Powering	50%	50%	50%
Average speed	Schedule Speed: 32 kmph (Metro corridor) 35 kmph (Rail corridor)	Schedule Speed: 35 kmph	Schedule Speed: 34 kmph
Power/Weight Ratio	Tare: 149KN/Train Full load: 234 KN/Train (Above for 4-car train)	Full load:250KN/Train (Above for 4-car train)	Tare: 149 KN/Train Full load: 227 KN/Train (Above for 4-car train)
Average Inter Station distances	1.12 km(Line#3/Line#4) 1.28 km(Line#2)	1.12km(Line#3/Line#4) 1.28 km(Line#2)	1.291km (Line#6)

Coupling arrangement adopted by various Metros

Metro	For two ends of rake	Between two basic units	Between coaches of same basic unit	Remarks
DMRC-RS1	Automatic without electrical head	Automatic with electric head	Semi-permanent	
DMRC-RS2	Automatic without electrical head	Automatic with electric head	Semi-permanent	
DMRC-RS3	Automatic without electrical head	Automatic with electric head	Semi-permanent	

Annexure –III

Eligibility/Qualification criteria for procurement:

1. Delivery Record

Has the Bidder/Consortium/Joint Venture or its members, individually or jointly as a member of other Consortia/Joint Venture have experience of and carried out Vehicle Design, Interface (with other designated Contractors such as signaling, Track, Traction etc.) Assembly & Supply, Testing and Commissioning of minimum of total 300 metro (i.e. MRT, LRT, Sub-urban Railways or high speed railways) cars (out of which minimum 200 cars shall be of either Stainless Steel or Aluminium)

EITHER outside the country of origin in at least five(5) different contracts in MRT, LRT, Sub-urban Railways or high speed railways of at least three(3) different countries

OR in India

In the last ten(10) years.

2. Operation Performance:

Out of 300 or more cars commissioned in accordance with above (1), have minimum of total 150 metro (i.e. MRT, LRT, Sub-urban Railways or high speed railways) cars completed satisfactory revenue operation:

EITHER outside the country of origin in at least three(3) different contracts in MRT, LRT, Sub-urban Railways or high speed railways of at least three(3) different countries

OR in India

for more than five(5) years.

3. Propulsion System

Does any Member of the Consortium/Joint Venture individually or its Parent company or its group companies have cumulative experience of minimum ten(10) years in the Design and Manufacturing of Propulsion Equipments (Traction Converter-Inverter, Auxiliary Converter Inverter and Traction Motor) for Metro rolling stock AND do the propulsion equipments supplied have been in satisfactory revenue operation for at least five(5) years in minimum aggregate 500 cars comprising of both powered and non-powered cars, supplied against minimum five(5) different contracts in the Metros (i.e. MRT, LRT, Sub-urban Railways or high speed railways) of minimum two(2) different countries outside the country of origin.

OR

Does the manufacturer of the Propulsion Equipment (Traction Converter Inverter, Auxiliary Converter-Inverter and Traction Motor) proposed by the tenderer as a sub-contractor for supply of the Propulsion Equipments against this tender, has minimum ten(10) years experience in the field of Design and Manufacturing of the Propulsion Equipment AND do the Propulsion Equipment Designed, Manufactured and Supplied by the said manufacturer have been in satisfactory revenue operation for at least five(5) years in minimum aggregate 500 cars comprising of both powered and non-powered cars, supplied against minimum five(5) different contracts in the Metros (i.e. MRT, LRT, Sub-urban Railways and high speed railways) of minimum two(2) different countries outside his country of origin.

4. Leader of the JV/Consortium

In case of a Joint Venture/Consortium, has the proposed leader of the Joint Venture/ Consortium for his project been a leader of any of the Joint Venture/Consortium in at least two(2) Rolling Stock contracts awarded against ICB in the last ten(10) years.

Hyderabad Metro - Submissions for Metro Railway Standardization

Sl. No	Description	LTMRHL's Response	Remarks
1.	**Noise levels specified** Under stationary conditions – ~~under the tunnel and~~ on wire duct.	**Inside Car & Cab**: - 70 dB (A) as per international standard ISO 3381. **Outside the train**:-68 dB (A) as per international standard ISO 3095. **Door Operation Noise**: - 72dBA during the sliding operation and 78 dBA for the locking/unlocking	
	Under moving conditions ~~both inside the tunnel and~~ on wire duct.	**Inside Car & Cab:-**74 dB (A) as per international standard ISO 3381. **Outside the train:-**85 dB (A) as per international standard ISO 3095.	
2.	**Emergency evacuation system:** System adopted by Hyderabad Metro Rail for emergency evacuation along with underlined logic reason. Study by HMR in this regard vis-a-vis elevated, underground corridors may also be given.	For emergency evacuation in Hyderabad Metro network, we have provided front end emergency door, which shall be able to detrain 2000 passengers in 30 minutes. The main reasons for this are as under as proposed by Consultants: a. 25KV traction system and hence front evacuation is safe. b. sharp curves of 120m and hence side evacuation is not considered safe as gap between train and walkway on curve will be very large, which have to be bridged by some plate/footboard. c. side evacuation requires side walkway and hence viaduct width is un-necessarily more and structures are heavy due to extra loading. d. walking on raised walkway is not considered safe for	

		children/elderly passengers.	
3.	Details of coupling arrangement prescribed by LTMRHL		
	For two ends of the rake	For two end, Automatic coupler having mechanical and pneumatic connection is provided.	
	Between two basic units	Between Two basic units, Automatic coupler having mechanical and pneumatic connection is provided.	
	Between the coaches of the same basic unit	Between the coach of the same basic unit, Semi-permanent coupler is provided.	
	Implication of various coupling arrangement	Design implication shall be such that coupling shall be achieved with the most adverse mismatch of car heights, caused by wheel wear, passenger loading, air spring deflection, and service tolerances. The gathering range of the mechanical coupler shall be suitable for up to horizontal curves of 100m radius and vertical curves of 1500m radius.	
4.	Acceleration from 0 kmph to 30 kmph for AW4 loaded train on level tangent track.	1.0 m/s^2 ± 5%	
	Deceleration from 80 kmph to standstill for AW4 loaded train on level tangent track	1.0 m/s^2 ± 10 % as per EN 13452-2:2003	
	Jerk rate	0.70 m/s^2	

	Power to weight ratio	<table><tr><th>Train Formation</th><th>Load Condition</th><th>Acceleration Rate (m/s^2)</th></tr><tr><td rowspan="2">2M1T</td><td>AW0</td><td>1.0</td></tr><tr><td>AW4</td><td>1.0</td></tr></table>
	Percentage motorization may be given for rakes planned on LTMRHL.	66 %
	Simulation report for merits of 66% power over 50% powering.	Decision for 66 % traction power per rake was made on the basis of following: a. higher acceleration requirement considering, Hyderabad metro alignment (which have sharp curves/gradients) b. average speed requirement (30kmph and above) c. higher regeneration with 66% powering d. train clearing section and going upto terminal in degraded mode with one motor coach failure
5 & 6.	Advantages/disadvantages of sourcing propulsion equipment from single source vis-à-vis consortium/JV	Propulsion supplier of LTMRHL trains will be M/s Mitsubishi Electric, Japan, who is sub-contractor of Hyundai Rotem (not a consortium member). Our selection criteria for propulsion supplier was decided on the basis of operationalproven-ness for 10 years of which at least 4 years should have been in three different countries (it may be a consortium or single source)

7.	Control and communication protocol (TCMS) prescribed and used in rakes running on Hyderabad Metro. Suggestions and recommendations of Hyderabad Metro in this regard.	Train integrated management system (TIMS) is a complete, integrated system for the control and monitoring of the train-borne equipment. TIMS provides control and monitoring, diagnostic and reporting of the train-borne equipment in a redundant manner through the Train Bus (ARCNET) and Local bus (RS-485). The TIMS is designed for ease of fault diagnosis and maintenance. TIMS controls and monitors all non-safety critical systems and shall monitor vital or safety critical systems. Subsystems of the train utilize microprocessor-based control. The subsystems are inter-linked via a communication data bus system for the monitoring, fault data logging and for first line diagnostics of faults on board the train. TIMS hardware system shall conform to International standard IEC 60571.	
8.	Suggestions of Hyderabad Metro on driverless train operation in Indian context. Data available with Hyderabad Metro regarding Metros having driverless train operation.	Hyderabad Metro operation/signaling concept is **STO – Semi-automated Train Operation where** - train runs automatically from station to station - automatic stop and door opening - train operated by a driver supported by ATO - driverless reversal to meet 90 seconds headway at terminal stations	

		Driverless Train Operation – Main Features Driverless operation - Automatic departure and run from station to station, including automatic turn-back - Door re-opening on train hold command - Remote start of stalled trains Attendant responsibility: - control passenger doors - prevent person injuries between cars or between platform and train - ensure safe starting conditions - set in/set off operation - supervise the status of the train **Basic technical system requirements for driverless operation** - Continuous, bi-directional communication between trackside / OCC and trains (= CBTC system). - Platform Screen Doors, radar grid or optical obstacle detection systems for sealing the guideway in the platform areas and along the alignment in case of elevated systems. - Highly reliable Rolling Stock sub-systems. - Obstacle detection equipment on bogies. - Derailment detection on	

		bogie axles. - Door nip protection equipment on all train doors. - Complete CCTV coverage on trains and two-way passenger help points. - Onboard fire, smoke and temperature detection equipment in passenger compartments and inside the equipment cabinets. **Driverless system on the Indian Metro Projects** - Driverless system is the technology, which is well proven now and is strongly recommended for use in Indian Metro system. - Hyderabad Metro evaluated about driverless system but in absence of CBTC system decision, this decision could not be taken (driverless system requires CBTC) - Techno-Commercials considerations are in favour of driver-less system as extra capex can be recovered in 7-10 years' time. - Driverless system very high reliability and hence detailed designs requires extra time in RAM assurance activities. - Approval and safety certificate from CRS due to lack of technical experience, which can probably be managed. -	

9.	Strategy for indigenous development adopted by Hyderabad Metro along with constraints	For LTMRHL, presently there is no indigenous development imposed on Vendors for rolling stock as the entire coaches are procured from Hyundai-Rotem, South Korea. However, the indigenous equip can be used provided proven-ness and RAM requirements are met. The Agreement with Govt calls for stringent Key Performance Indicator (KPI) and there are associated penalties. This to some extent restricts usage of newly developed indigenous equipment on the Project.	

Submissions by RMGL on TOR Items

Item No. 1

Noise levels specified:

i) Under stationary conditions – on via duct

ii) Under moving conditions on via duct.

The above values may be given for noise inside the coach as well as external noise for rakes procured by RMGL. Remarks may also be given for Noise and Vibration level (including RS, track etc.) as per TOR.

Noise levels specified:

i) Under stationary conditions – on via duct:

Internal Noise: 68dBA External Noise: 67dBA

During Door Operation: 72dBA, during Door Locking /Unlocking: 78dBA

ii) Under moving conditions on via duct.

Internal Noise: 72dBA External Noise: 82dBA

Vibration:

- 2.00mm Peak to peak amplitude for the frequency range from 1.4Hz to 20 Hz
- 0.8mmper second peak vibration velocity for the frequency range above 20Hz

Item no.2:

Emergency Evacuation System:

System adopted by RMGL for emergency evacuation along with underlined logic reason. Experiences of BMRC in this regard vis-a-vis elevated, underground corridors may also be given:

1. Energy evacuation on RMGL system is through the side door of the car nearest to the driver.
2. The emergency evacuation of passengers in a metro train should meet the following requirements:

a) As far as possible evacuation should be avoided in between the stations and trains should be taken to the next station, if possible, where the evacuation is safe and faster.
b) Passengers should be evacuated under the supervision and guidance of metro staff to avoid stampede and injury to passengers.
c) The rate of evacuation should be fast as large no. of passenger in a train, which may be high as high 2700 passengers in an 8-car train, are required be evacuated in less than 60 min.
d) There should be no harm/injury to passenger while coming out of train on to the walkway.

3. Generally there are two methods of evacuation: one through the ramp door at the front end of each cab and the other from the side doors of the car. In the first method, front ramp door is opened by the train operator, which on opening rests on the track. In this method the passengers have to move on the track structure upto the next station. The track design should be such as to provide a safe and smooth passage to the passengers. The main advantage of this method is that evacuation is carried out in orderly fashion with the assistance of driver and other helping staff. The main drawbacks of this system are as follow:

   a) The width of the ramp door is limited and rate of discharge of passengers is rather slow. In case of 8-car train, with a fully loaded train, it will be a challenge to disembark all the passengers in less than 60min.
   b) The provision a ramp door in a centre of the cab implies that driver's seat would be provided on the left hand side of the cab and provision of a wide glass on the front of the cab, will not be possible, which certain metro authorities, prefer for aesthetic reasons.

4. The second method is through a side door nearest to the driver's cab which can be opened by the driver sitting in the cab in emergency situation. As the door is sufficiently wide the evacuation rate is faster. In this case the passengers need to be evacuated on a walkway on the viaduct/underground tunnel for movement upto the next station. As the evacuation is permitted through only one door it is possible to regulate the flow of passengers by the driver or assisting metro staff. However, this method suffers from the following problems:

   a) The width of the walkway may vary between 750-950 mm. There is a possibility that the passengers may fall from the walkway due to pushing by the fellow passengers in panic mode.
   b) The gap between the door of the train and the walkway has to meet the K.E. /Structure Gauge requirements. K.E. in-between sections has to be designed for max. speed of the train along with other train movements due to various factors. The gap between the car body and walkway in between the station, on a tangent track is expected to be approx 275mm. On curves the gap will become wider to take care of the mid/end throw of cars. With such a wide gap there is every

possibility that passenger may fall in-between the gap between the carbody and walkway. In such a situation, it is required that a bridging device is fixed between the carbody and walkway before the passengers are permitted to come out. This device will be kept under the seat and will have to fixed by the railways staff before the evacuation starts.

c) Walking on the walkway of limited width at the car floor level on the elevated corridor, may be more difficult for the passengers than on the railway track in first method.

5. DMRC uses both methods of evacuation through a front ramp door in (RS-1 and RS-2 Contract) and side door in (RS-3 Contract). A comparative evaluation of both methods of evacuation can be made through the mock drills in DMRC under controlled conditions and safer of the two alternatives may be adopted for future metro railways.

Item No.3:

Coupling Arrangement :

Details of coupling arrangement prescribed by RMGL :

(i) For two ends of the rake.

(ii) Between two basic units

(iii) Between the coaches of the same basic unit

Costs implications for various coupling arrangements may also be given:

Following type of coupler are used in RMGL trains.

1. For two ends of the train: Automatic Couplers without electric head.
2. Between two basic units: In RMGL system only one basic unit of 3 cars will be operated. However automatic couplers need to be provided between the two basic units. Automatic couplers are preferred in lieu of semi-permanent couplers as coupling and coupling of the basic units during corrective/preventive maintenance can be achieved automatically without manual operation.
3. Between cars of the same basic unit: Semi-Permanent Couplers.

Note: Automatic couplers at the ends of the trains may be slightly different from those in between the basic units in respect of electric head of the coupler. The requirement of electrical contacts on electric head on the automatic couplers at the end of the train is significantly lower than those in between the basic units, resulting in cost reduction.

Costs implications for various coupling arrangements is not available currently with RMGL

Item No.4:

Acceleration/ Deceleration:

Values of acceleration/deceleration and jerk rate, power to weight ratio and percentage motorization may be given for rakes procured by RMGL
Any analysis or simulation report for merits of 50% power over 66% powering.

- Average acceleration from 0 to 30km/h : 1 m/s2 (± 5%)
- Maximum Jerk : 0,7m/s³ (± 0, 05)
- Adhesion limit : 16 %
- Average service deceleration from 80 to 0 km/h : - 0.95 m/s2 (± 5%)
- Instantaneous full service deceleration : 1.1 m/s2
- Full service deceleration: 1.3m/s2
- Maximum Jerk : 0,7m/s³ (± 0, 05)
- Percentage motorization: 66% (1C2M configuration)
- Power weight ratio: 14.59 W/Kg (AW0 condition)

Based on the traffic forecast there is no requirement of increase in no. of cars/basic units in future on RMGL system. No simulation analysis was carried out for 50% powering v/s 66% powering. Further following comments are made:

- For a basic 3 -car train there is no alternative but to have 66% motorization so as to ensure that failure of one motor car does not result in immobilization of train in the section.
- In case, a basic 2-car train is required to be operated as a unit, 100% motorization is required.
- In case of 4-car train with 2 basic 2-cars units, 50% motorization appears to be a preferred choice.

A 3-car unit with 66% motorization is a better option on account of following considerations:

a. Even with loss of one power car the operational performance is satisfactory.
b. Higher level of acceleration and declaration is possible, subject to adhesion limits.
c. Higher regeneration level is achieved resulting in lower application of friction braking and consequently less wear of pad /disc.
d. Changes of slip/slide even under the worst conditions are reduced due to utilization of lower adhesion factor compared to the permissible values.

However, in this configuration the train composition of 8-cars is not possible.

Item No. 5 and 6:

Eligibility/qualification criteria adopted by RMGL. Views of RMGL on advantages/disadvantages of sourcing propulsion equipment from single source vis-à-vis consortium/JV:

The eligibility/qualification criteria adopted by RMGL was as follows:

- The Rolling Stock supplier should be a car builder.
- The requirement of cars for RMGL project was 15 cars only. Initially there was no response from the established Rolling Stock manufactures for supply of these cars. Finally Consortium of Siemens AG, Germany and Siemens Limited, India offered cars manufactured in the factory of Zhuzhou Electric Locomotive Company Limited (ZELC), China to a design almost identical to the cars running on Guangzhou Line-3 (GZL-3) in China. These cars were originally manufactured to Siemens design in the Year 2005 under a technology transfer agreement. The propulsion equipment was also of Siemens design.
  However RMGL's views are that RS supplier should be necessarily a car builder and should have at least supplied 200 cars running for a period of 3years without any major problem. The Propulsion equipments supplier need not necessarily be a Consortium partner, but should have experience of design and manufacture of minimum 200 nos. of Propulsion System with similar features which should have been proven in service for a period of 3 years in a country other than the country of origin of manufacturer.

- Propulsion equipments need not be generally procured from a single source but the supplier must have sufficient experience and the equipment should have proven record of satisfactory service in revenue operation as stated above. However, it would be positively preferable if Propulsion equipment is procured from the same manufacturer on a particular metro railway to reduce the spare inventory and avoid training of staff in different designs of propulsion systems.

Item No. 07:

Control and communication protocol (TCMS) prescribed and used in rakes running on Bangalore Metro. Suggestions and recommendations of Bangalore Metro in this regard.

This query is not related to RMGL.

Item No. 08 :

Suggestions of RMGL on driverless train operation in Indian context. Data available with RMGL regarding Metros having driverless train operation.

RMGL presently doesn't have its own experience of Driverless Train Operation (DTO) or Unattended Train Operation (UTO).

- In general, employment of DTO/ATO, technically, would require higher level of redundancy, suitable means for remote monitoring, CCTV surveillance and rescue operations, and provision of Platform Screen Doors/Gates at station platforms. At the same time, DTO/UTO operation can provide more regular and predictable

runs, more uniform ride quality, flexible timetables, lower turnover times and lower life cycle costs and this is also equally applicable in the Indian context.

- Further, DMRC has planned DTO/UTO on Lines 7 and Line 8 in their Phase-3, and their views on the subject would be useful.

- **Unattended train operations on metro line, with no person aboard (UTO) were in Kobe (Japan) in 1982, Lille (France) in 1983 and Vancouver (Canada) in 1985. The Kobe and Lille systems were based on fixed-block technology whereas the Vancouver system utilized CBTC technology. Other examples of UTO utilizing CBTC technology would include, for example, Lyon Line D(1992), Paris Meteor Line (1998), Kuala Lumpur (1998) and Singapore North-East Line (2003). Examples of UTO based on fixed block technology would include Osaka (1982) and Copenhagen Metro (2002).

***Based on reference IRSE NEWS | ISSUE 150 | NOVEMBER 2009*

Item No. 09:

Strategy for indigenous development adopted by RMGL along with constraints. :

The holding of metro cars in RMGL system is rather small i.e.15 nos. in Phase-I. Even after completion of Phase-II the holding is not likely to exceed 36 cars. With such a small holding, there is no significant incentive to go in for indigenous development of equipments/components in a big way. The local industry will undertake indigenous development of equipments/spares only when the quantities are significant. In view of above, it is considered that Major Metro Railways with sufficient experience in operation and maintenance will be in a better position to frame a suitable policy in this regard.

The reliability standards of the metro railways are, by necessity, very high as any dislocation of services would cause adverse public reaction. The quality of the indigenous products should therefore be as good as that of imported product. To ensure this, it is essential that proper specifications of the products and testing procedures are established before initiating the development process. It should also be ensured that the proper manufacturing and testing facilities are available with the supplier. The locally developed product will also need to be proved for satisfactory performance in service for a specified period before clearance is given for bulk application. The prospective suppliers should therefore be identified through a rigorous process of inspection of the design and production facilities of their works.

The main problem in this respect is that the Rolling Stock suppliers do not furnish detailed technical specifications of the spares/equipments without a technology transfer agreement with the local industry. The local industry would obviously not invest money in local development of spare/equipments or go in for a technology transfer arrangement unless there is a sizable order and there is a guarantee for supply of the developed product for a certain period by the metro railway. There will be only a few items which will have very large consumption to justify local

development. Summarizing indigenous development should be taken with caution and after considering the various aspects, some of which have been stated above.

BT COMMENTS ITEMWISE

Item No. 1 Noise and Vibration level (including RS, Track etc.)

Terms of Reference

- Study of the Environmental Laws in India and extracting the relevant statutory requirements.
- Study of noise and vibration criteria adopted by various metros in India in their rolling stock and trackwork specifications.
- Study of similar international regulations in other countries having vast knowledge base in this field – such as USA, Germany, Japan, Singapore etc.
- Study of regulations regarding protection of ASI monuments (heritage structures) from vibration generated by metro trains operation.
- Study of regulations in other countries regarding protection of heritage structures.
- Analysis of above and recommendations for acceptable noise & vibration criteria for rolling stock and track including suggestions for integrated responsibilities or clarity of interface.
- Report of above study.

For measurements we should always make reference to standard ISO 3095 indicating always the last version (pr EN ISO 3095:2010). In that standard you will find details of the track acoustics characteristics like rail roughness and track decay rates.

For interior noise we should use the standard ISO 3381 (which is in phase of rewriting it).

For typical values that we could propose:

- Exterior noise
    - Constant speed 80 km/h -> 83 db(A) measured according to pr EN ISO 3095 (LpAeqTp)
    - Standstill -> 68 dB(A) measured according to pr EN ISO 3095 (average of LpAeq around the train)
- Interior noise

- Constant speed 80 km/h -> 75 dB(A) measured according to ISO 3381 in passengers area. 70 dB(A) in driver's cab. LpAeq according to ISO 3381

- Standstill -> 65 dB(A) according to ISO 3381

1. In viaducts, based on our experience, the noise increment to the above values is : + 4 dB would be more suitable for exterior noise and +2 for interior noise.

2. For tunnels the differences could be too much different depending on the type of tunnel and the its section, etc. So it is difficult to provide a suitable value. However for one project, where we measured the values in tunnels the noise increment for a tunnel of double track, ballasted was around +5 dB(A).

Item 2 Emergency Evacuation System

Terms of reference

- Study of the NFPA 130 and other relevant national/international standards regarding emergency evacuation system
- Study of practices adopted in various metro systems in India and elsewhere along with the underlying logic/reasons (at least 3 metros each in USA, Europe, Japan, China and South East Asia to be studied).
- Study of particular requirements of emergency evacuation with respect to elevated, underground and at-grade routes.
- Study of report by NOVA (available with DMRC)/COMET (a society of heavy metros) in this regard.
- Study of procedure adopted during emergency evacuation – such as power off, ETS activation, signaling interface etc. – particularly in systems having third rail traction.
- Analysis of data collected including structured presentation of database.
- Report covering all the above issues including summary and recommendations.

Item No. 3 Coupling arrangement (Automatic, semi-automatic etc.)

Terms of reference

- Study of various types of couplers being used in Indian railways and various metros in India and elsewhere.
- Study of the relevant Indian and International standards in this regard.
- Study of functional advantages offered by various types of couplers (automatic viz-a-viz. semi-automatic couplers).
- Collection of data regarding various suppliers of various types of couplers – both in India and elsewhere
- Information gathering regarding regular suppliers of such items to Indian Railways, DMRC, BMRCL, Kolkata Metro.
- Preliminary cost analysis of each type of couplers including studying impact of imported components/assembly.
- Study of maintenance practices of trains being followed by Indian Railways, Kolkata Metro, DMRC and BMRC and assessment of instances of coupling and de-coupling of units and coaches – in depots as well as on lines.
- Study of an assessment report conducted by BMRCL in this regard.
- Report comprising above issues, analysis, recommendations and way forward.

Item 4 Acceleration/Deceleration/Jerk Rake, Power to weight ratio/ % motorization

Terms of reference

- Study and analysis of key parameters of rolling stock viz. Acceleration/Deceleration/Jerk Rate and suggest Power-to-weight ratio & % motorization and suggestion for standardization
- Above study shall be based on cost benefit analysis carried out using appropriate simulation tools as well as results of actual experience of 2MC + 1TC (of BMRCL) and 1MC+1TC (of DMRC). The study shall analyse impact on transit/round trip time with above configuration of trains.

BT Comments:
Acceleration with 50% motorisation is around 0.8 m/s² maximum between 0 to 30 kmph
Acceleration with 67% motorisation is around 1.1 m/² maximum between 0 to 30 kmph.

Service Deceleration Rate - same level as acceleration rate to ensure max. use of regeneration
Emergency Deceleration Rate (DR) - Specify braking distance instead of deceleration rate - normally maximum DR is 1.2 m/s². Higher rate shall complicate brake pad design due to high thermal requirements.

Average interstation distance - 1 to 1.2 kms

Motorisation - Most of the Metros around the world are above 50% motorisation either 60%, 67% , 75% or even 100%. Motorisation of 50% is suboptimal as it leads to low acceleration, lesser scheduled speeds, maximum usage of brake pads and less regeneration energy. See attached power point slides.

Scheduled speed - around 34 kmph (depends on alignment and curves)

Minimum adhesion levels- Normal - 16%. Worst - 8% (criteria for safe braking distances)

These performance values are outcome of system design, there is no generic recommendations about these. It depends on overall railway system being planned

Acceleration with 50% motorisation is around 0.8 m/s² maximum between 0 to 30 kmph

Acceleration with 67% motorisation is around 1.1 m/² maximum between 0 to 30 kmph.

Service Deceleration Rate - same level as acceleration rate to ensure max. use of regeneration

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Scheduled speed - around 34 kmph (depends on alignment and curves)

Minimum adhesion levels- Normal - 16%. Worst - 8% (criteria for safe braking distances)

Item No. 5 Eligibility/qualification criteria for procurement

Views and system adopted by various Metros

Eligibility criteria should focus on in-house Design capability, Vehicle Integration experience and Service proveness for minimum 5 years in different environment and should specified for each of the following

critical components a) carbody b) bogies c) Propulsion Systems & 4) Vehicle Integration

Design Capability - No metro product is off the shelf and needs to be modified to the specific needs of customer and the environment. Design capability ensures that the bidder has the capability to design to the new environment as well as has the capability to find quick design solutions when failures occur in service. For this reasons certain eligibility criteria to test the design capability of bidders in at least two to three countries could be introduced.

Vehicle Integration Capability -
Metro projects are greenfield projects and hence all the systems like Signaling, communication, tracks are new. Vehicle Integration capability highlights the ability of the bidder to integrate his rolling stock with other contractors and find suitable solutions to integration issues that will arise during the Testing & commissioning phase.

Service Proveness in different countries is required to test the capability of the Design to adapt to different environment and also to check the reliability of the system offered.

Item No.6 Propulsion – Single source or consortium/JV – approach.

Views and system adopted by various Metros

- BT Comments:
- A consortium approach ensures that the Propulsion supplier is part of the consortium and is committed to delivering his commitment as per the contractual obligations.Else normally the suppliers may have a separate arrangement on warranty clauses/ reliability clauses with the Rolling Stock bidders which may not be aligned with Contractual requirements. This may create contractual issues during execution.
- On the other side a non- consortium approach may allow certain bidders (who do not manufacture propulsion equipment) to have enough negotiating power post contract. However, this seems to have little effect on bidding price as the same is decided by competition.

IR Query
Control and communication protocol
Details of Common/published standard/standards for Train Control & Management System (TCMS). Views may be given taking terms of reference into consideration.

BT Comments:
TCMS is critical for train operation, reliability and safety. Train builders and equipment suppliers use different solutions and protocols; normally supplier specific hardware and common network solutions and protocols, such as MVB, CAN, Ethernet. Requirements need to be of functional type while flexibility is provided for type of solutions.

IR Query
Indigenization
Your views on indigenous development and constraints in the process and strategy required to be adopted for the same.

BT Comments - This needs detailed discussions with a view to ensure long-term Spare Parts & Service availability during the lifetime of rolling stock. Unfortunately the indigenization requirement is not very stringent in metro Tenders in India except a few tenders. Other countries have utilized the mandatory localization concept effectively to develop the local industry in terms of technology and quality through mandatory indigenization criteria.

BT Comments
Additional points to be considered:

The price of the rolling stock depends not only on Technical features but also on delivery conditions, contractual conditions, ordered quantity, Design Cost (closeness to standard product)
Some areas which can be looked into are the following:

1. Technical features -Every specification has two features a) "Nice to Have" and b) "Must Have" features. It has been observed that several of the "Nice to Have" featrures get introduced in the specification through earlier base specification sources. We recommend to have discussion with suppliers well before bidding stage in an effort to remove cost drivers (“nice to have” features) which are not performance oriented. There is a trend in recent specifications in Europe

to separate "Nice to Have" requirements clearly from mandatory "Must Have" features. This provides a better insight for the Employer in the quality of the train builders offers.

2. Bidding Time - Provide suitable bid time - Atleast 3 months from the date of release of final addendum after discussions with suppliers

3. Design & delivery time - Provide sufficient Design time to improve reliability and avoid retrofits (Final Design Completion – 90 weeks). Delivery of prototype to around 22-24 months from NTP + 3 months commissioning time

4. Arbitration Clause (Selection of Arbitration Panel) - Provide equitable clause for selection of Arbitration panel in line with Indian Arbitration and Reconciliation Act -1996

5. Warranty - Restrict warranty to 2 years maximum from delivery of each trainset

6. Supplier Approval process - Allow bidders to provide a Supplier list during Tender submission qualifying certain service experience norms on supply for 5 years etc as specified in the Tender (for major components like - bogies, propulsion, HVAC, Doors, TCMS etc). Once the supplier's qualify these norms the suppliers should be allowed to choose his Supplier from the list during contarct execution. Rejection of suppliers from the list or addition of new suppliers during contract execution adds risk cost to the bid price.

7. Order Quantity - Ensure Order quantity is large to enable bidders leverage economy of scale and spread the Design Cost. As far as possible include only positive Optional Quantity Clause. Negative optional Quantity Clause will not get the best price.

8. Standardization & Ordered Quantity - At this stage most of the major cities requiring huge volumes of Rolling Stock have (Delhi, Chennai, Kolkata , partly Mumbai)already completed their procurement process. We would now see a trend of only Tier II cities going in for procurement of Rolling Stock henceforth, where the requirement shall be only of the order of 60 -80 cars. Unless the specification across Tier II cities are standardized this will result in high cost of metro cars. Standardization shall also help in pooling of Rolling Stock requirement across metros to get the best price.

8. Risk Provisions - Tender documents should minimize ambiguity in clauses - both technical & commercial to enable bidders to appropriately

quantify risks. Too much ambiguity in the Tender documents may lead to high risk provisioning. This can be mitigated by having sufficient interaction time with bidders before the bid.

BEML DRAFT VIEWS ON TERMS OF REFERENCE FOR STANDARDISATION OF METRO ROLLING STOCK

Noise level:

The permissible noise levels specified in some of the Indian metros are brought out below.

Project	Internal Noise			
	Stationary (elevated & at grade)	Stationary (tunnel)	Running (elevated & at grade)	Running (tunnel)
DMRC RS3 Saloon / cab	68 / 68	75 / 72	72 / 70	-
BMRCL Saloon / cab	68 / 68	75 / 72	72 / 70	88 / 82
Chennai Saloon / cab	71 / 70	-	78 / 75	-

Project	External Noise	
	Stationary	Running
DMRC RS3 (at 7.5 m)	67	84
BMRCL (at 7.5 m)	67	84
Chennai (at 15 m)	65	82

The external noise is to be measured in accordance with ISO 3095 and internal noise as per ISO 3381.

Achieving the interior and exterior noise limits on elevated track in running condition are the main constraints. As train noise running on the elevated track is highly influenced by the vibro-acoustic characteristics of infrastructure, giving guaranteed noise performance of train on the elevated track is difficult. Sound and vibration will not be properly absorbed on elevated track as compared to at-grade track. Also, rail and wheel roughness should be maintained within acceptable limits of the standards before taking measurements.

To recommend the acceptable noise performance vis a vis track specifications for Indian metros, it is opined that experts in the field may be required to carry out a study.

Emergency evacuation system

All rail vehicles should have sufficient evacuation facilities to ensure that people may make a rapid and safe exit. Where the vehicles are to be used on routes which have restricted clearances, due to significant operation in tunnels, end emergency egress facilities are provided. For other routes, side egress leading to side walkway is provided. Vehicles shall be designed to ensure that evacuation & escape can be performed safely under reasonably foreseeable emergency conditions.

BS 6853:1999, Code of practice for fire precautions in the design and construction of passenger carrying trains, classifies rail vehicle into two categories; Category I as underground and category II as surface. Category I is further subdivided into category Ia and Ib. Category Ia refers to vehicles having substantial operating periods in a single track tunnel with no side exits to a walkway. Category Ib refers to vehicles having substantial operating periods in a multi track tunnel or a tunnel with side exits to a walkway. Category II refers to surface stock with no substantial operating period

in tunnels. The fire test requirements brought out in the standard are different for the above category of vehicles with category Ia having the most stringent values.

The emergency egress system provided in the Indian metros is as follows:

- Kolkata metro (North – South) – end evacuation
- Delhi metro RS1 & RS2 – end evacuation
- Delhi metro RS3 – side evacuation
- Bangalore metro – side evacuation
- Chennai metro – side evacuation
- Jaipur metro – side evacuation

Specification requirements of the following metros are also listed

- Kolkata metro (East – West) – side evacuation
- Hyderabad metro – end evacuation
- Delhi metro RS10 – end evacuation & side evacuation in acute emergency.

In view of the above, it is opined that the choice of end egress or side egress is dependent on the operating environment and the decision needs to be taken based on the proposed metro system. Either of the systems can be provided by the rolling stock supplier.

Coupling arrangement:

The type of coupling arrangement depends on the train configuration. The various combinations in the Indian metros are as follows:

- Two car basic unit with 4 / 6 / 8 car train formation.
- Three car basic unit with 3 / 6 car train formation.

In the 2 car basic unit type, the coupling arrangement is as follows:

- Automatic mechanical & pneumatic coupler at either end of train formation / rake

- ❖ Semi-permanent coupler between coaches in the same basic unit. Electrical coupling is through jumper cables between cars.
- ❖ Automatic mechanical, pneumatic and electrical coupler between two basic units.

In the 3 car basic unit type, the coupling arrangement is as follows:

- ❖ Automatic mechanical & pneumatic coupler at either end of train formation / rake
- ❖ Semi-permanent coupler between coaches in the same basic unit. Electrical coupling is through jumper cables between cars.
- ❖ Automatic mechanical, pneumatic and electrical coupler between two basic units for a 6 car train formation.

The coupling arrangement in the various Indian metros is brought out below:

Project	**Ends of rake / train formation**	**Between cars in basic unit**	**Between two basic units**
DMRC RS1	Automatic mechanical & pneumatic	Semi-permanent	Automatic mechanical, pneumatic & electrical
DMRC RS2	Automatic mechanical & pneumatic	Semi-permanent	Automatic mechanical, pneumatic & electrical
DMRC RS3	Automatic mechanical & pneumatic	Semi-permanent	Automatic mechanical, pneumatic & electrical
Jaipur metro	Automatic mechanical & pneumatic	Semi-permanent	Automatic mechanical, pneumatic & electrical
Bangalore metro-3 car	Automatic mechanical & pneumatic	Semi-permanent	
Hyderabad metro- 3 car	Automatic mechanical & pneumatic	Semi-permanent	
Kolkata metro – E-W	Automatic mechanical & pneumatic	Semi-permanent	Automatic mechanical & pneumatic, jumper

– 6 car			cables for electrical
DMRC RS10 – 6 car	Automatic mechanical & pneumatic	Semi-permanent	Automatic mechanical, pneumatic & electrical

The couplers for the Indian metros are mainly being supplied by Voith Turbo, Germany and Dellner, Sweden. Voith Turbo has supplied for DMRC RS1 and RS3 & BMRCL projects. Dellner has supplied for DMRC RS2 project. Both the firms have set up subsidiary units in India for local manufacturing. Faiveley also manufactures couplers & their make couplers are proposed for Chennai metro. Voith couplers are of Scharfenberg (Schaku) type. The Dellner and Faiveley couplers are also of similar type. The design of the couplers depends on the type of coupler head, amount of energy absorption required, coupling range, etc.

Semi-permanent coupler is the cheapest, costing around 2.5 to 3.0 lakhs INR. Automatic mechanical & pneumatic coupler costs around 3 to 4 times of semi-permanent. Automatic mechanical, electrical & pneumatic coupler costs almost two times the cost of automatic mechanical & pneumatic coupler. In view of this, to reduce the cost of car, automatic electrical coupling may be avoided or kept to the bare minimum.

Operating Characteristics

The typical values of acceleration, deceleration, jerk rate, etc adopted by Indian metros for Standard Gauge track are as follows:

50% motorization:

Characteristic	DMRC RS3 25 KV AC	Chennai 25 KV AC	Jaipur 25 KV AC
Average acceleration from 0	0.8	0.8	0.8

to 30 kmph in m/s2			
Instantaneous deceleration from 80 to 0 kmph in m/s2	1.0	1.0	1.0
Average emergency deceleration in m/s2	1.3	1.3	1.3
Jerk rate in m/s3	0.7	0.7	0.7
Schedule speed (normal mode) in kmph	34	34	34

67% motorization:

Characteristic	BMRCL 750 VDC	Kolkata E-W 750 VDC	Hyderabad 25 KV AC	DMRC RS10 25 KV AC
Average acceleration from 0 to 30 kmph in m/s2	1.0	1.0	1.0	1.0
Instantaneous deceleration from 80 to 0 kmph in m/s2	1.1	1.0	1.0	1.0
Average emergency deceleration in m/s2	1.3	1.3	1.3	1.3
Jerk rate in m/s3	0.7	0.7	0.7	1.0

Schedule speed (normal mode) in kmph	34	33	-	-

For both 50% and 67% motorization, the schedule speed in normal mode is almost the same. The acceleration levels are higher in 67% motorization which will be helpful in routes with frequent gradients. The major advantage of 67% motorization is that more amount of regenerative energy will be available, thereby reducing the net energy consumption for traction. However, whether the regenerated energy can be utilized in a 750 VDC third rail system, needs to be studied. For 25 KV AC system, the regenerated energy can be utilized fully. This kind of system is being adopted for Hyderabad and DMRC RS10 projects. The initial & maintenance cost of propulsion for 67% motorization will be higher, however there will be savings towards energy cost. The net savings and performance of 67% motorization in 25 KV AC system in Indian conditions can be evaluated after Hyderabad metro is operational.

Eligibility / qualification criteria for procurement of Rolling stock

At present, Metro corporations float Global Tenders for sourcing Rolling Stock with typical eligibility criteria as follows.

- The bidder should have experience in Design, manufacture, Testing & commissioning of Metro cars/Electrical Multiple Units
- The Applicant or Consortium / JV or its members individually or jointly as member of other Consortia in their respective roles carried out design, manufacture, supply, testing, commissioning & Integration of a minimum of 200 nos of stainless steel cars with similar features including traction propulsion system, ATP/ ATO systems etc. in the preceding 10 years. At least 50% of the above 200 cars should have been supplied and proven in service for a period of 5 years or more in India or in a country other than the country of manufacture

- The rolling stock, including all sub-systems and equipment shall be of proven design. Sub-systems and equipment of similar design philosophy shall have been in use and have established their performance reliability on a mass rapid transit system or suburban EMU's in revenue service over a period of five years or more. Where similar equipment or sub-systems of a different rating are already proven in service, then the design shall be based on such equipments.
- For certain subsystems like Propulsion, at least 200 cars of the proposed assembly/sub assembly should have been proven in service in metro cars in the last 10 years; Out of the 200 cars, 100 cars should have been proven in service for at least 5 years in a country other than the country of origin of manufacture

The eligibility and qualification criteria may include the following provisions for Indian manufacturers:

- The bidder should have metro car manufacturing facility in India
- Should have manufactured/assembled/supplied minimum 300 nos. metro cars in India and supplied to Indian Metro corporations either through consortium route or independently
- The bidder should have executed projects in India based on Transfer of Technology arrangement with reputed global players

Procurement of propulsion equipment:

In the Indian metros under revenue service, the responsibility of propulsion equipment & train management system is with a single source. For the DMRC RS2 project it is Bombardier and for DMRC RS1, RS3 and BMRCL it is MELCO. MELCO is also the consortium partner in the respective projects. The advantage of the propulsion supplier being in the consortium is that they are also equally responsible for successful execution of the project. In the case of DMRC RS2, the main contractor,

Bombardier, is responsible for the propulsion. However, certain items may be procured by the propulsion contractor from other sources. The qualification criteria specified by the Indian metro Corporations for propulsion system is very stringent and only established global players will qualify.

It is opined that the propulsion may be procured from a single source so that the responsibility for the integration of the complete system is with a single party. Also, JV of reputed foreign & Indian companies may be allowed to ensure transfer of latest technology & indigenous manufacture in the country.

Control and communication protocol

DMRC RS3 and BMRCL projects are having MELCO supplied TMS. The train bus communication in these systems is ARCNET defined by ANSI / ATA 878.1. Local bus communication is RS485 / RS422 defined by EIA (Electronics Industries Association). The interfacing with different sub-systems is carried out by the TMS sub-contractor and the various sub-system suppliers in co-ordination with the rolling stock contractor.

Indigenisation:

The specification requirement of metro cars is very stringent and based on established international standards. This is required in view of the need for safety of the passengers, high reliability and availability of the rolling stock.

The major needs / constraints for indigenous development are:

- Technical know- how and know -why
- Infrastructural facilities
- Type and routine test facilities
- Skilled trained manpower
- Maintaining Quality to ensure high reliability & availability

Normally, Global Metro Manufacturers establish in-house infrastructure/ facilities for manufacture of Carbody & Bogie frames, assembly, integration & testing. Major aggregates are sourced from established limited global suppliers who have already supplied to other Metros with satisfactory performance record.

Infrastructural facilities for manufacture of carbody and bogie frame and it's integration are already available in the country. Indigenous sources for certain outfitting items like GFRP panels, grab poles & rails, window glasses, glass wool insulation, electrical panels, battery box, stainless steel and aluminium fabricated items, etc are also available. For critical sub-systems like propulsion, brake, door, HVAC, passenger address & Passenger information system, CCTV, gangway, bogie suspension, gearbox, etc there are few established global suppliers with satisfactory performance record and they should be encouraged to either set up their subsidiary in India or transfer technology to an Indian company through JV. Certain items like wheel and axle may have to be imported as present Indian manufacturers are having capacity constraints.

The specifications need to be standardized to increase the volumes. Presently, the specifications are drafted on project to project basis. The major specifications which require standardization are axle capacity, train formation including basic unit composition, kinematic envelope, track parameters including minimum radius of curvature, operating voltage, overhead or third rail current collection, etc. Standardization will result in higher volumes, more vendors will show interest and the cost will come down. Also, the cost towards design and type test can be amortised over large number of cars.

Infrastructure & Cities

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Your letter
Our reference
Date

Advisor Electrical (G),
Ministry of Railways,
New Delhi

Kind Attention :Mr. R. K. Bhattnagar

Sub: Comments on Agenda of Sub-Committee on Rolling Stock

Ref: Meeting on 3rd Dec'2012 to discuss the Agenda of Sub-Committee on Rolling Stock

Dear Sir,

With reference to the agenda for Sub-committee on Rolling Stock and subsequent meeting, we are pleased to submit our comments as under :

1. **Noise**

Siemens's comments :

Recommended values are

Motorization (%)	Interior					Exterior			
	Tunnel		Elevated		Cab	Tunnel		Elevated	
	Stationary	Running	Stationary	Running	Running	Stationary	Running	Stationary	Running
67	68 dBA	NA	64 dBA	72 dBA (50 KmpH) 75 dBA (75 Kmph)	68 dBA (50 kmph) 70 dBA (75 KmpH)	NA	NA	67 dBA	82 dBA (at 75 kmph)

Standard for measurement shall be ISO 3381 and ISO 3095 for inside and outside measurements respectively.

2. **Vibration**

As discussed in sub-committee's meeting, the study under this topic is beyond the scope sub-committee.

3. **Emergency Evacuation System**

Siemens's comments:

Emergency Evacuation System should be at the Front centre in Driving cars of the train.

With our experience, most of the rolling stock operating different parts of the world have evacuation by Front Centre including the rolling stock supplied by Siemens.

4. <u>Coupling Arrangement</u>

Siemens's comments:

Considering the operation, maintenance and costs aspects we recommend to use as under :

- Automatic coupler without electrical head at the two ends of the train.
- Automatic couplers without electrical head between the basic units with electrical connection via jumper cables **<u>OR</u>** Semi permanent couplers between the basic units.
- Semi-permanent couplers between the cars within the basic unit.
- ***Gangways :*** Split type of gangways for all interconnection between the coaches.

We would like to share that the automatic couplers without electrical heads are cheaper by nearly 20% than the automatic couplers with electrical heads. Further the Semi-permanent couplers are cheaper by nearly 20% than the automatic couplers without electrical heads.

5. <u>Acceleration</u>

Siemens's comments:

Minimum Design Average Acceleration rate for fully loaded (AW3) train on level tangent track shall be as under:
0 kmph to 40 kmph : 1.0 m/s2
0 to 60Kmph : 0.6 m/s2
0 to 80Kmph : 0.3 m/s2
Minimum Operational Average Acceleration rate for AW2 loaded train on level tangent track shall be as under:
0 kmph to 35 kmph : 1.20 m/s2
0 to 60Kmph : 0.65 m/s2
0 to 80Kmph : 0.35 m/s2

Please note that for Metro Lines between 15 to 20 Kms, higher acceleration is more suitable as with higher schedule speeds fleet size can be optimized.
This is more so important as Tier 2 & 3 cities in India would have such line lengths.

6. **Deaccelaration**

Siemens's comments:

Service braking rate from 85 kmph to standstill for fully loaded (AW3) train on level tangent track : 1.0 m/s2
Service braking rate from 85 kmph to standstill for AW2 train on level tangent track : 1.1 m/s2

7. **Jerk Rate**

Siemens's comments: 0.75 m/s3

8. **Motorization rate**

Siemens's comments:

We would like to share that the motorization rate and the train size are related topics and should be decided together for all new metro projects.
Therefore, We should first finalize the optimum "train size in terms of number of cars" and then based on evaluation of suitable motorization rate, appropriate "Basic Unit" configuration should be finalized.

Step - 1 : Optimum Train Size

In order to work out a optimum train size, we would like to evaluate the optimum requirement with respect to the PHPDT (Peak Hour Peak Direction Traffic) Demand. Following table highlights the "utilization rate" of different train sizes w.r.t PHPDT demand :

Train Size ↓		PHPDT demand									
		10000	20000	25000	30000	35000	40000	50000	60000	70000	80000
3 Car	PHPDT Capacity	45600	45600	45600	45600	45600	45600				
	Utilization rate	21.93%	43.86%	54.82%	65.79%	76.75%	87.72%				
4 Car	PHPDT Capacity	60800	60800	60800	60800	60800	60800	60800			
	Utilization rate	16.45%	32.89%	41.12%	49.34%	57.57%	65.79%	82.24%			
6 Car	PHPDT Capacity	91200	91200	91200	91200	91200	91200	91200	91200	91200	91200
	Utilization rate	10.96%	21.93%	27.41%	32.89%	38.38%	43.86%	54.82%	65.79%	76.75%	87.72%
8 Car	PHPDT Capacity	121600	121600	121600	121600	121600	121600	121600	121600	121600	121600
	Utilization rate	8.22%	16.45%	20.56%	24.67%	28.78%	32.89%	41.12%	49.34%	57.57%	65.79%
9 Car	PHPDT Capacity	136800	136800	136800	136800	136800	136800	136800	136800	136800	136800
	Utilization rate	7.31%	14.62%	18.27%	21.93%	25.58%	29.24%	36.55%	43.86%	51.17%	58.48%

Table – 1

Note :

- The PHPDT capacity for different train sizes, is based on passenger capacity of 380 numbers per coach with a headway of 90seconds from "System Design perspective" i.e maximum 40 trains of each train size could be operated in one hour.
- The headway of 90 seconds is achievable with modern Signalling systems.
- The above data does not reflect the "Fleet Size" which will depend upon other factors like line Length, schedule speed etc..

Following conclusions can be drawn from Table - 1 :

a) For PHPDT Demand between 10000 to 40000, 3 car train is the most optimum as the utilization rate is the best.

b) For PHPDT Demand between 40000 to 80000, 6 car train is the most optimum as the utilization rate is the best.

Step - 2 : Possible Motorization rates for different Train Sizes

Based on the conclusions from "Step - 1", in order to finalize the motorization rate and the basic unit configuration, please refer to different possibilities as depicted in Table – 2 below :

Train Size ↓	Motorization rate			
	50%	67%	75%	100%
3 Car	X	√ **with 3 car basic unit**	X	√
4 Car	√	X	√ **Basic unit configuration will be lost, 3 types of cars**	√
6 Car	√ **with 2 car basic unit**	√ **with 3 car basic unit**	√ **Basic unit configuration will be lost, 3 types of cars**	√
8 Car	√ **with 2 car basic unit**	X	√ **Basic unit configuration will be lost, 3 types of cars**	√
9 Car	√ **Basic unit configuration will be lost**	√ **with 3 car basic unit**	√ **Basic unit configuration will be lost, 3 types of cars**	√

Table - 2

Following conclusions can be drawn from Table – 2 :

a) Corresponding to the Train size of 3 cars, motorization rate of 67% and 100% is possible.

b) Corresponding to the Train size of 6 cars, motorization rate of 50%, 67% and 100% is possible.

c) For both Train sizes of 3 car and 6 car, though Motorization rate of 75% is possible, it is not viable as "Basic Unit configuration" is lost which poses challenges for running and maintenance operations.

Step – 3 : Optimum Motorization rate for 3 car basic unit

In order to arrive at optimum motorization rate, a comparison among the motorization rates of 50%, 67% and 100% is shown as under in terms of performance and the resultant costs.

Following are possible train configurations corresponding to 50%, 67% and 100%.

Legend:
- DMC Driving Motor Car
- DTC Driving Trailer Car
- MC Motor Car
- TC Trailer Car
- \+ Automatic coupler
- = Semi-permanent coupler

- **Train formations with 50% Motorization rate :**
  6-car formation
  +DMC=TC+MC=TC+TC=DMC+ or +DTC=MC+MC=TC+MC=DTC+
  Capacity: 2250 passengers in W3 load (seats + 8 standees per sqm)
  Note : Each 2-car unit is equipped with 1 transformer and 1 pantograph, means in total there are 3 transformer/ pantograph sets per 6-car train.
- **Train formations with 67% Motorization rate :**
  3-car formation :
  +DMC=TC=DMC+
  Capacity: 1106 passengers in W3 load (seats + 8 standees per sqm)
  6-car formation
  +DMC=TC=DMC+DMC=TC=DMC+ or +DMC=TC=MC+MC=TC=DMC+
  Capacity: 2252 passengers in W3 load (seats + 8 standees per sqm)
  Note : 3-car unit is equipped with only 1 transformer and 1 pantograph, means in total there are 2 transformer/pantograph sets per 6-car train.

- **Train formations with 100% Motorization rate :**
  There is possibility of 2 car basic unit as it is difficult to pack a set of Transformer, Traction Converter and auxiliary converter in one coach.

A. Train Performance : <u>Adhesion & Acceleration</u>

The possible acceleration rates for different motorization rates at normally available adhesion limits is as under :

Acceleration* with 50% Traction	Acceleration* with 67% Traction	Acceleration* with 100% Traction	Adhesion Limits
For normal operation (100% power is available) :			
0.8 m/s2	1.065 m/s2	1.603 m/s2	16.3%
0.88 m/s2	1.175 m/s2	1.762 m/s2	18.0%
With 25% loss of Power (Design Criteria) :			
0.601 m/s2	0.798 m/s2	1.202 m/s2	16.3%
0.661 m/s2	0.883 m/s2	1.327 m/s2	18.0%

Table – 3

* The above values of acceleration are calculated with following basis :

- Level tangent track. (With gradients, higher adhesion would be required).

- Rotational mass is not considered.

Please refer to Annexure -1 which depicts the calculation of adhesion limits for the desired accelerations.

Following conclusions can be drawn from Table – 3 :

a) From above it can be seen that it is possible to accelerate at > 0.85 m/s^2 within the adhesion limit of 18% in case of 25% loss of power with 67% traction and 100% traction as compared to 50% traction wherein a maximum acceleration of 0.66 m/s^2 is ONLY possible which will not be sufficient to meet the "Time Table" of the metro service.

b) Higher acceleration helps to increase the schedule speeds upto 38 kmph as compared to 31kmph in recent metros. This is very critical in projects wherein the lines are 15 to 20 Kms long as fleet size of rolling stock can be optimized.

– ***c) Acceleration more than 1.0 m/s2 would not be necessary in a metro system as the inter-station distances are small. Therefore 67% traction would be more than sufficient.***

B. Cost Impact on 6 car train with50% , 67% and 100% motorization rates

- **Capital Costs :**
  Possible indicator for capital cost is the number of main equipments in both types of traction systems. A comparison of number of equipments is as under :

	6 car train (50% motorization)	6 car train (67% Motorization)	6 car train (100% Motorization)
Basic Unit Configuration	2 car	3-car	1 car/ 2 car
No. of Traction Transformers	3	2	6/ 3
No. of Traction Converters	6 (Bogie Control is necessary for redundancy)	4 (Coach Control is acceptable ensuring redundancy)	6 (Coach Control is acceptable ensuring redundancy)
No. of Aux. Converters	3	2	6/3
Sets of Pantograph, VCBs & HV components	3 sets	2 sets	6/3
No. of Automatic couplers without electrical head	2	2	2
No. of Automatic Couplers with electrical heads	4	2	10/4
Sets. Of Semi-permanent Couplers	2 sets	4 sets	0/2 sets
Brakes	Disc Brakes	TBUs (as costly disc brakes can be avoided due to higher available electrical braking power)	TBUs (as costly disc brakes can be avoided due to higher available electrical braking power)

Table - 4

Following conclusions can be drawn from Table – 4 :

a) The number of main costly equipments like transformers, converters etc. is least with 67% motorization rate as compared with 50% & 100% motorization rate.

b) Since the number of equipments are fewer with 67% motorization rate, not only the cost of equipments but also the installation & commissioning costs per train would be less.

c) 67% motorization rate provides right balance between the redundancy and reliability& availability.

d) Therefore it can be clearly concluded that the capital cost of complete rolling stock with 67% motorization rate shall be lower in comparison with 50% & 100% motorization rate.

- **Maintenance Costs :**

– Maintenance costs with 67% motorization rate shall be lower as compared to maintenance costs with 50% & 100% motorization rate. Main reasons being :

a. Use of "Fewer number of equipments per train" which has following advantages :
   - Less wear and tear on Overhead Catenary Line due to less no. of pantographs km.
   - Maintenance cost of tracks shall be lower. This can be substantiated from the summary of achievable adhesions limits with both systems as under :

	For normal operation	With 25% loss of Power (Design Criteria)
For acceleration of 0.8 m/s^2		
With 50% Motorization	**16.3 %**	**21.8 %**
With 67% Motorization	**12.2 %**	**16.3 %**
With 100% Motorization	**8.2%**	**10.9%**
For acceleration of 1.0 m/s2		
With 50% Motorization	**20.4 %**	**27.2 %**
With 67% Motorization	**15.3 %**	**20.4 %**
With 100% Motorization	**10.2%**	**13.6%**

b. As use of mechanical brakes is minimized due to higher available electrical braking, the wear & tear of mechanical brakes is less.

- **Energy Costs :**
  - With 67% traction, there is 17% extra regeneration of electrical power during braking w.r.t 50% motorization rate.
  - However, energy saving for 100% motorization over 67% motorization is practically zero as electrical brakes would be sufficient to brake the train at the given deceleration rates without use of mechanical brakes and hence the energy savings would be comparable to 100% motorization.

C. Recommendation for Train sizes and motorization rate :

1. Optimum Train Size : 3 Car/ 6 Car

i. For PHPDT Demand between 10000 to 40000, 3 car train is the most optimum as the utilization rate is the best.

ii. For PHPDT Demand between 40000 to 80000, 6 car train is the most optimum as the utilization rate is the best.

2. Motorization rate : 67% motorization rate should be standardized due to following reasons :

- ✓ Higher acceleration of 1.1 m/s2 is possible with adhesion of 18%. Higher acceleration with 100% motorization rate is not necessary for Metro systems.
- ✓ During emergency condition of 25% motorization cut out, higher acceleration of 0.88 m/s2 is possible with adhesion of 18%.
- ✓ As explained in conclusion under point A, the operational advantages of higher acceleration rate and adhesion go a long way in optimizing the fleet size and thereby reducing the cost of a Metro system especially with line lengths of 10 to 15 Kms. E.g. considering a cost of Rs.10 Crores per car to an operator, a reduction of 10 number of cars would save Rs.100 Crores for a project. <u>This advantage is substantial for cities having lower PHPDT during the start of the project and wherein cost is a major concern.</u>
- ✓ Regeneration of energy is better with 67% traction over 50% traction as 17% extra re-generation is possible. However, difference of energy savings between 67% motorization and 100% motorization is practically zero.
- ✓ Capital & Maintenance cost is lower with 67% traction.

3. 3 Car formation with 67% and 6 car formation with 67% motorization rate should be standardized.

It can be noted that all latest projects in India – Hyderabad, Kolkata (E-W), Bangalore, Gurgaon and Delhi Ph III have adopted the concept of 3 car basic unit with 67% motorization. This is also a trend in global market.

4. Following dimensions are recommended for rolling stock :

width : 2.9 mtrs to 3.2 mtrs
length : maximum 22 mtrs (including end fairings).

9. <u>Eligibility Criteria</u>

Siemens's comments:

We would like to share that almost all components of rolling stock are manufactured by local companies including subsidiaries of multinational companies in our country. This has been possible with the projects coming from Indian Railways and Metros projects mainly Delhi, Bangalore and Chennai.

These investments are in the interest of our nation considering the employment opportunities and availability of technology locally. In view of this, items like Car body, Bogies and Propulsion equipment like Traction Transformer, Traction converter, auxiliary converter and Traction Motors "MUST" be localized.

Please note that cost economics of localization would be highly favorable with the progress of standardization.

Kindly refer the Annexure - 2 for the proposed eligibility criteria.

10. **Propulsion single source/ consortium approach**

Siemens's comments:

It is recommended to have "Single source" for full propulsion chain i.e transformers, traction converter, auxiliary converter and Traction Motors considering the interface and integration aspects of the system.

The recommended eligibility criteria for a propulsion supplier shall be as per Annexure 2.

Further regarding the Consortium or sub-supplier approach, the issue primarily depends upon the strengths of the mechanical partner in terms of system integration and interface management.
For an experienced car manufacturer, propulsion supplier could be a sub-supplier however for a lesser experienced mechanical partner who is also leader of the project, it would be better to have propulsion supplier as consortium partner.

11. **TCMS : TCMS should be from the propulsion supplier same as in point 10 above**

Siemens's comments:

TCMS should be from the propulsion supplier for better integration of the complete propulsion system and controls to avoid any technical glitches due to interface management issuesin case of different suppliers for TCMS and propulsion supplier.

This will enable single party liability during the DLP and post DLP period and also lower cost of inventory of spares.

12. **Driverless trains**

Siemens's comments:

It is recommended to have Driverless Trains as Driverless trains enable shorter headways and cost benefits for the operator over the project life cycle.

This is for your kind reference and perusal. Please feel free to contact us for any additional information.
Yours truly,

Raminder Singh
Chief Manager – Metros & Coaches, South Asia
Siemens Ltd.

Encls .:
Annexure – 1
Annexure – 2

Item No. 5 Eligibility/qualification criteria for procurement

Eligibility criteria has a direct bearing on the cost. Broader the criteria, more the competition and lesser the cost

Eligibility criteria shouldEncourage competition. Ensure reliability and quality of the rolling stock

Rolling stock comprises of Car body and Propulsion equipment. Car body manufacturing and propulsion equipment is supplied by two separate set of suppliers

Alstom Comment: Rolling stock (train) firstly involves a system level design for train configuration and integration of various RS sub-systems such as mechanicals (car body), propulsions, TCMS, bogies & brakes, HVAC, electrical equipment (pantographetc), couplers, interiors, seating etc. and testing & commissioning and full Mass Rail Transit Systems(MRTS) site-integration in terms of interfacing with other MRTS systems. There are, in summary, broadly four distinct requirements, namely:

(i) train system design & integration,
(ii) Car body/mechanicals,
(iii) Propulsion system including TCMS and
(iv) Interfacing, testing & commissioning with full MRTS system.

Propulsion System is the core of the train in as much as a diesel engine is of the diesel electric locomotive. Therefore, the reliability and quality of the propulsion system is central to the overall performance and energy efficiency of the train.

As on date, three sets of firms are operating in this space.
Set 1: These firms perform the full design and manufacture of the trains. These include Bombardier, Siemens, Alstom, Ansaldo Breda, Hitachi, etc.
Set 2: These firms do not perform full train design and manufacture but specialize in manufacture of car body/mechanicals and integration of propulsion system and TCMS from the specialist suppliers. These include firms such as BEML.
Set 3: These firms are specialist suppliers of propulsion and TCMS namely Bombardier, Siemens, Alstom, MELCO, Toshiba, Hitachi etc. Some of these specialist suppliers also have the capability of complete train design, manufacture and integration (Set 1) and therefore have capability to integrate;

(a) their own design of propulsion systemand TCMS on different type of trains as well as
(b) with Set 3 type of firms who are specialist manufacturers of the car-body & mechanicals.

It must be noted that the average life of a MRTS Train is about 30 to 40 years. The quality and performance of the train over its life period will be severely impacted if a patchwork approach rather than an integrated and optimized design and manufacturing approachare adopted. While the patchwork approach of procuring the propulsion systems for one supplier, the bogie and mechanicals from another and the car body from yet another may reduce the capital cost in the

short run, in terms of the life cycle costs, this approach may not be the most optimal one. It will also imply relegating the risk associated with the reliability and quality of a core system like the propulsion system, to a sub-contractor, who is not liable for non-performance or sub optimal performance of the train.

Therefore, we strongly recommend that in order to ensure international quality, safety and reliability and performance standards during the entire life cycle, bidders for Indian MRTS Projects must be jointly and severally responsible for the four critical systems viz:
(i) train system design & integration,
(ii) car body/mechanicals,
(iii) propulsion system including TCMS and
(iv) interfacing, testing & commissioning with full MRTS system

In other words, manufacturers/suppliers of these four components must bid at the JV level rather than as subcontractors to the main bidder. This is the practice followed internationally for Mass Rail Transit Systems (MRTS) wherein suppliers of each of the four requirements must be part of the consortium, and share joint and several responsibilities for RAMS during the life of the trains.

The details of the qualification in terms of ;

(a) number of successfully executed MRTS projects/trains (calculated in number of cars)
(b) experience in terms of years of supply/manufacture,
(c) number of cars in service at a point of time,
(d) differentenvironments in terms of type of countries/climates/environment conditions could be defined as the eligibility criteria.

Car body

The specifications of the material, coach parameters and inspection and testing can ensure the quality of the rolling stock. Some of the reputed Car manufacturers are:

1. CAF
2. BEML
3. CNR
4. CSR
5. ROTTEM
6. Bombardier
7. ALSTOM
8. SIEMENS

Propulsion equipment

Propulsion equipment include Transformer, Motors, Traction Converters and Inverters and TCMS. The reliability performance of the Rolling stock largely depends on Propulsion equipment whichneed to be sourced from a proven source. Known propulsion equipment suppliers include:

1. Bombardier
2. Siemens
3. Alstom
4. Toshiba
5. Mitsubishi
6. Hitachi
7. ABB

Eligibility criteria adopted by various Metros

Sl.No.	Manufacturing Experience	Operational experience
BMRCL	Manufacturer of the propulsion system and other major sub-systems should have at least 10 years experience in this field	with at least 5 years outside its home country.
CMRCL	Have previously designed, manufactured, supplied, testing and commissioned for a minimum of 200 cars/carsets with comparable features and of similar complexity in the preceding 10 years	At least 50% of the 200 cars/carsets shall have been supplied and proven inservice for a period of 5 years or more in India, or, in a country other than the country of manufacture
KMRCL		
DMRC RS1		
RS2		
RS10		
LTHMR	Propulsion supplier was decided on the basis of operationalproven-ness for 10 years	At least 4 years should have been in three different countries (it may be a consortium or single source)
RMGL	Supplier should be necessarily a car builder and should have at least supplied 200 cars running for a period of 3years without any major problem.	The Propulsion equipments supplier need not necessarily be a Consortium partner, but should have experience of design and manufactureof minimum 200 nos. of Propulsion System with similar features which should have been proven in service for a period of 3 years in a country other than the country of origin of manufacturer
Kolkata Metro		
IR	IR sources propulsion equipment from reputed OEMs who are suppliers of TCMS, IGBT based Traction	Sub vendors are permitted for other equipment from reliable sources with proven experience**.**

	converter/Inverters and Traction motors and those who have successfully supplied… nos. in the past 5 years and out of which … numbers have been working satisfactorily for past 2 years without any country restriction	For Car body and Bogie, Material and performance criteria is specified which is verified before acceptance. Supplier is also bound by performance warranty.

Suggestions of Vendors:

Sl No.	Manufacturing Experience	Operational experience
BEML views for other vendors	The Applicant or Consortium / JV or its members individually or jointly as member of other Consortia in their respective roles carried out design, manufacture, supply, testing, commissioning & Integration of a minimum of 200 nos of stainless steel cars with similar features including traction propulsion system, ATP/ ATO systems etc. in the preceding 10 years	At least 50% of the above 200 cars should have been supplied and proven in service for a period of 5 years or more in India or in a country other than the country of manufacture Where similar equipment or sub-systems of a different rating are already proven in service, then the design shall be based on such equipment.
BEML views for Indian Manufacturer	The bidder should have metro car manufacturing facility in India and should have manufactured, assembled and supplied minimum 300 nos. metro car to Indian Metro corporations either through consortium route or independently	The bidder should have executed projects in India based on Transfer of Technology arrangement with reputed global players
Siemens Views	Has the Bidder/Cons members, individually or jointly as a member of other Consortia/Joint Venture or as sub-contractor to it's parent company have experience of and carried out Vehicle Design, Interface (with other designated Contractors such as signaling, Track, Traction etc.), Assembly & Supply, Testing and Commissioning of minimum of total 300 metro (i.e. MRT,LRT,Sub-urban Railways	Out of 300 minimum of total 150 cars completed satisfactory revenue operation: EITHER outside the country of origin in at least three(3) different contracts in MRT,LRT,Sub-urban Railways or high speed railways of at least three(3) different countries OR in India for more than five(5) years.

	or high speed railways) cars (out of which minimum 200 cars shall be of either Stainless Steel or Aluminum)	
BTs Views	Eligibility criteria should focus on in-house Design capability, Vehicle Integration experience and Service proveness for minimum 5 years in different environment and should specified for each of the following critical components a) carbody b) bogies c) Propulsion Systems & 4) Vehicle Integration	Design Capability - No metro product is off the shelf and needs to be modified to the specific needs of customer and the environment. Design capability ensures that the bidder has the capability to design to the new environment as well as has the capability to find quick design solutions when failures occur in service. For this reasons certain eligibility criteria to test the design capability of bidders in at least two to three countries could be introduced. Vehicle Integration Capability - Metro projects are greenfield projects and hence all the systems like Signaling, communication, tracks are new. Vehicle Integration capability highlights the ability of the bidder to integrate his rolling stock with other contractors and find suitable solutions to integration issues that will arise during the Testing & commissioning phase. Service Proveness in different countries is required to test the capability of the Design to adapt to different environment and also to check the reliability of the system offered.
BT	100% Indian subsidiaries be permitted	
Views of Indian	Lead bidder must have experience in full RS integration,	For sub-systems Similarly, the Indian owned subsidiaries of the

Manufacturers	manufacture of trains, car shells, bogies, propulsion etc. Additionally, there are requirements of proven design and manufacturing sites that have supplied such proven design. Indian subsidiaries of the main bidders who meets all the required qualification criteria should be allowed to manufacture and supply 100% of the supplies.	suppliers who qualify based on their references in their home country be allowed to manufacture and supply 100% of the supplies.
ALSTOM Comments	Bidders who have invested in the country in setting up a manufacturing unit must be incentivized with workload to sustain their factories. Afterall, Government of India has been pursing and coaxing global firms to bring FDI into India. Hence, bidders who have invested in the country must be recognized for having contributed through employment generation, technology transfer and a fundamental belief in Indian Economy. Putting eligibility conditions that require local Indian subsidiaries (like Alstom Transport India) to have supplied a minimum number of Metro trains/cars in India will completely discourage, dissuade and jeopardize any FDI and any incentive to set up factories in India. Therefore, Indian Subsidiary Companies, who through their Parent Group Company have supplied metro trains/cars globally, should be given the benefit of global experience and hence permitted to meet the eligibility criteria based on global	

	credentials. One way to incentivize such Local Indian firms could be through an evaluation process in which firms with an installed capacity in India are given preferential weightage. The other way is to ensure that tender evaluation is based on the landed cost inclusive of taxes and duties. This point has been further explained in Item No 9 - Indigenization	

Major Issues

1. Bidder should be car manufacturer or Propulsion equipment manufacturer having system integration capabilities or one having both the capabilities?

   If the Cars are to be procured from sources that manufacture cars and are also OEMs of propulsion equipment including TCMS, the number of suppliers will get restricted to very few European suppliers. Car body and propulsion equipment require completely different kind of manufacturing facilities. Car manufacturers mostly procure 3 phase propulsion equipment from different vendors like Hitachi, Mitsubishi, Bombardier, Siemens, Toshiba etc. Hence if car manufacturers are permitted to outsource 3 phase propulsion equipment from reputed and experienced OEMs with full responsibility with the OEM for system integration, failure reliability and punctuality performance, competition will be wider and costs will reduce.

   Alstom Comments: There is a significant benefit in having the Bidders who have the experience and capability to design and integrate a full train. There are already a total of more than six such RS suppliers – Japanese, European, Asian/Korean& Indian firms - as was witnessed in the recent tenders for Indian Metro Projects. It is felt that competition is already wide enough. Hence, the benefit of additional competition by allowing suppliers/manufacturers of propulsion systems, without having joint and several responsibility of integrating at the train level is likely to be marginal. On the contrary, this may jeopardize the quality of Rolling Stock/trains supplied in Indian market, given that these MRTS Rolling stock/trains must operate for a lifecycle of 30 to 40 years.

2. Different country experience

   The rationale given by various members of the committee is the presumption that the environmental conditions in different countries are different, hence eligible supplier should have supplied similar coaches in different countries. This clause as is being presently applied is restrictive and favour mainly European suppliers. Even indigenous suppliers like BEML, who have not supplied to other countries does not get qualified on its own. Similarly it will restrict supplierswhose main market has been the country of

origin. It is also seen that private Metros RMGL and Reliance Metro Mumbai have procured Metro Cars without imposing this restriction

Alstom Comments: The RAMS and field service performance of the entire train system is what ultimatelymatters. The reliability of individual sub-systems is of little consequence. Ultimately, the responsibility of system integrity rests with the Joint Venture and hencethe proposal to have the supplier of the Propulsion system as a sub-contractor goes against the basic philosophy of seeking an integrated metro rolling stock system, particularly when the RAMS& field service performancedepends to a large extent on the Propulsion System. This approach of permitting the propulsion system supplier as a sub contractoris akin to allowing a sub-contractor to provide the diesel engine of a diesel- electric locomotive and appears to be contrived to suit vested interests.

For RMGL there was only one bid i.e. from Siemens who took full responsibility of the rolling stock/trains, signaling system and the 750vDC traction electrification. Reliance Metro will be a very different and new experience and needs to be contrasted from procurement by a Public Authority. *Inthe former case, the private player is willing to take a calculated risk which cannot be taken in case of procurement by a Public Authority. In any case, private MRTS are a new experience and* we should wait for their successful operations, before validating that approach.

Introduction of this clause pushes up the cost. IR also has never imposed the country condition in any of its global tenders, except where Ministry of external affairs restrict dealings with any country

Rolling stock has to be seen as Car body plus propulsion equipment. As far as car body is concerned, the performance will not be affected by the environment, performance of metro cars will however be greatly impacted by the performance of propulsion equipment. Responsibility of commissioning, system integration rests with the propulsion equipment supplier. Hence eligibility criteria for the 3 phase propulsion equipment supplier need to be stringent for ensuring the quality of the rolling stock.

It is thus proposed that more than one country restriction should not be imposed for qualifying as coach manufacturer. As far as propulsion equipment is concerned, coach manufacturer who will be the lead partner/bidder should be allowed to source propulsion equipment from reputed vendorswho have supplied propulsion equipment to more than one country.

3. <u>Number of years</u>

Some Metro tenders specify that bidder should have at least ten year experience in the field of system integration and supply of Metro cars and must have supplied 200 to 300 cars in last 10 years, out of which 50% in last 5 years. This clause is very restrictive and will discourage indigenization. BEML who have been supplying Stainless steel coaches successfully cannot independently bid for Metros.

10 years is a long period. Further current performance is more important. So 5 years performance thus should be seen. It is all the more necessary as there are rapid advances in the technology and past performance alone should not be the criteria for qualifying as otherwise we may end up with obsolete technology.

Alstom Comments: The average life of a Metro Rolling Stock/Train is in the vicinity of 30 to 40 years and hence the ten years performance track record seems to be realistic. Ten years is also a good period to determine whether the trains being supplied by the Bidder are capable of providing flawless service for the entire life. Given the long gestation period of infrastructure projects, a prior experience of at least ten years helps to develop a better assessment of the capability & capacity of the bidder.

Key Recommendations

Bidder must be a coach manufacturer with sufficient experience in supplying Metro cars during the last 5 years. Bidder can procure propulsion equipment from any vendor meeting following criteria.

- ***Propulsion equipment supplier must be OEM having experience of supplying IGBT based propulsion equipment including (TCMS, traction converters/Inverters and Traction motors) and must have carried out system integration and commissioning of rakes during last 5 years, which must have been working satisfactorily for the last 3 years on more than one country or in India.***

ALSTOM Comments: It is proposed that for purposes of evaluating eligibility, the experience of the Bidder must include the Parent Company experiencethat has set up the factory(ies) in India through its Subsidiary(ies). Thus, if Global Firms set up a local subsidiary company that manufactures Metro Rolling Stock/Trains, its global credentials and experience must be considered, rather than the number of MRTSTrains/Cars that the local plant has supplied. If that restrictive condition is imposed, it will dissuade any FDI and employment generation and serve as a disincentive for global firms to set up design and manufacturing facility in India.

Item No.6 Propulsion – Single source or consortium/JV – approach.

Issue is whether bids be invited from consortiums of coach manufacturers with Propulsion equipment supplier as consortium partners or fromcoach manufacturers, with an option to have propulsion equipment supplier as a sub contractor

Propulsion system comprises of Traction Motor, main converter-inverters, auxiliary converters, transformers & TCMS. The propulsion system is quite crucial sub-system of the train. Responsibilities of propulsion system supplier include:

Interfacing with other subsystems like ATC/ATO, Brake System, Signaling, Passenger Information system, Power supply etc.

Commissioning and Testing

Propulsion system must comply with:

operating characteristics like acceleration/deceleration,

Energy efficiency,

System Reliability.

Safety
Availability

Advantages in sourcing from consortium

- A consortium approach ensures that the Propulsion supplier is part of the consortium and is committed to delivering his commitment as per the contractual obligations.Else normally the suppliers may have a separate arrangement on warranty clauses/ reliability clauses with the Rolling Stock bidders which may not be aligned with Contractual requirements. This may create contractual issues during execution.

Advantages Non consortium approach

- On the other side a non- consortium approach may allow certain bidders (who do not manufacture propulsion equipment) to have enough negotiating power post contract. This will reduce the price.

  Non consortium approach will help Metros in getting more competitive prices, without compromising with quality. Tender conditions will be required to clearly spell out the responsibility of Propulsion supplier. In such cases entire responsibility for choosing sub vendors etc will rest with the propulsion equipment supplier. For example BEML, the coach manufacturer should have the option to go with Mitsubishi, Siemens or Toshiba. Consortium approach will restrict the bids to number of Propulsion equipment manufacturers.

  Role of Propulsion supplier in the design, interfacing and testing is required to be clearly defined in the Contract itself.

  Committee recommends sub-contractor approach i.e. Non consortium approach for reduction in price.

  Alstom view: There are two critical issues that need to be considered by the Committee:

a) It has been witnessed in the recent tenders that there is one leading propulsion system manufacturer, who, by virtue of the restrictive criteria (e.g. past experience in 25

kVACMRTS), is in effect, driving the entire MRTSmarket. In such a scenario, there is every possibility of this manufacturer extracting monopoly rent from all metro train builder/manufacturers and driving costs upwards.

b) It is reiterated that propulsion system, like the diesel engine of a diesel electric locomotive, is central to the longevity, reliability and performance of the train. In case the propulsion system supplier is a subcontractor, he will have no responsibility to deliver the performance and RAMS over the life of the train.

In order to correct this situation, it is recommended that the propulsion system supplier should be in the ***Joint Venture where the parties are responsible, jointly and severally, overall train system performance.***The emphasis should be to promote a number of Propulsion suppliers through a more relaxed eligibility criteria for Propulsion System Suppliers so that there are more firms who can form Joint Venture with different RS builders. Also, ***given that the Propulsion System is at the heart of the Rolling Stock/Trains, it is for consideration whether the three years should not be increased to at least 5 years.***

Item No.7 Control & communication protocol – common/published

Terms of reference

- Study of impact of use of vendor specific(proprietary) software/protocol for TCMS on interoperability/use of subsystems of different makes as well as impact on cost of rolling stock

- Study of Control & Communication protocol – Common/published standard/standards for Train Control & Management System (TCMS) used by different metros in India and abroad and provide suggestions/recommendations.

System used by Different Metros

Hyderabad Metro

- Train integrated management system (TIMS) is a complete, integrated system for the control and monitoring of the train-borne equipment. TIMS provides control and monitoring, diagnostic and reporting of the train-borne equipment in a redundant manner through the Train Bus (ARCNET) and Local bus (RS-485). The TIMS is designed for ease of fault diagnosis and maintenance.
- TIMS controls and monitors all non-safety critical systems and shall monitor vital or safety critical systems.
- Subsystems of the train utilize microprocessor-based control. The subsystems are inter-linked via a communication data bus system for the monitoring, fault data logging and for first line diagnostics of faults on board the train.
- TIMS hardware system shall conform to International standard IEC 60571.

Bangalore Metro:

- Train Control & Management system of M/s MELCO is presently based on ARCNET technology (Standardized protocol defined by ANSIIATA878.1).
- ARCNET is basically a Ladder type Train Bus.
- Advantages of ARCNET:
  1. Highly reliable with stored and forward method.
  2. Ensure real-time control command data both by packet division and priority control.
  3. Conformity of IEC62280-1 (Safety related communication in closed transmission systems)
  4. Twisted Copper cable for ARCNET is easy to use. considering maintenance cost. cost performance & Redundancy.

Suggestions and recommendations of Bangalore Metro:

- TCMS with ARCNET technology supplied by MELCO is using Token passing. HDLC (High Level Data link Control) frame format for Train Bus Communication between the Cars (One TMS CPU to other Car TMS CPU).
- For communication from TCMS -Subsystem it is based on RS485/RS422 protocol.
- In IP technology with Ethernet back bone communication currently CSMAlCD (Carrier Sense Multiple Access I Collision Detection) is being used.
- There is no problem to monitor different sub-systems of different sub-suppliers; however it should be possible to meet the common protocol between TCMS & respective sub-systems.
- Also Transmission data flow in the network between TCMS & sub-systems can be standardized, so that subsystem supplier of different makes can meet the requirement of monitoring & control of the various parameters through TCMS. Gradually sub-system supplier should adopt IP technology.
- As far as software is concerned, it is a vendor specific proprietary item and during the Tendering stage, concerned contractors refused to share the source code with BMRCL and subsequently this requirement was modified.

BT Comments:

TCMS is critical for train operation, reliability and safety. Train builders and equipment suppliers use different solutions and protocols; normally supplier specific hardware and common network solutions and protocols, such as MVB, CAN, Ethernet. Requirements need to be of functional type while flexibility is provided for type of solutions.

The common standard for the TCMS is defined by IEC 61375 series of standards.

Alstom Comments: It is important that there is adherence to globally accepted standards like IEC. The Standards must be based on functionality rather than specific protocols. All protocols that adhere to the International Standard should be permitted and should not be restricted to standards employed by limited manufacturers as this would limit competition.

Item No.8 Driver less control

Terms of reference

Collection of data regarding metros having driverless train operation and study of the same for adoption in metros in India.

Driverless Train Operation – Main Features

Driverless operation

- Automatic departure and run from station to station, including automatic turn-back
- Door re-opening on train hold command
- Remote start of stalled trains

Attendant responsibility:

- control passenger doors
- prevent person injuries between cars or between platform and train
- ensure safe starting conditions
- set in/set off operation
- supervise the status of the train

Basic technical system requirements for driverless operation

- Continuous, bi-directional communication between trackside / OCC and trains (= CBTC system).
- Platform Screen Doors, radar grid or optical obstacle detection systems for sealing the guide way in the platform areas and along the alignment in case of elevated systems.
- Highly reliable Rolling Stock sub-systems.

Obstacle detection equipment on bogies

- Derailment detection on bogie axles.
- Door nip protection equipment on all train doors.
- Complete CCTV coverage on trains and two-way passenger help points.
- Onboard fire, smoke and temperature detection equipment in passenger compartments and inside the equipment cabinets.

LT HMR

Hyderabad Metro evaluated about driverless system but in absence of CBTC system decision, this decision could not be taken (driverless system requires CBTC) Hyderabad Metro operation/signaling concept is

STO – Semi-automated Train Operation where

- train runs automatically from station to station
- automatic stop and door opening
- train operated by a driver supported by ATO
- driverless reversal to meet 90 seconds headway at terminal stations

Recommendations

Driverless system on the Indian Metro Projects

- Driverless system is the technology, which is well proven now and is strongly recommended for use in Indian Metro system.
- Techno-Commercials considerations are in favour of driver-less system as extra capex can be recovered in 7-10 years' time.
- Driverless system needs very high reliability and hence detailed designs requires extra time in RAM assurance activities.
- Approval and safety certificate from CRS due to lack of technical experience, which can probably be managed.

Driver less operation is required to achieve 90 seconds frequency for full utilization of Metro infrastructure capacity. This will require communication based Train Control (CBTC) system.

"Driverless" Train Operation can be adopted in phases with signaling up-gradation.

Alstom Comments: The RS supplier must have proven experience in having successfully supplied and commissioned Driverless Trains in at least 2 countries and the Driverless Trains must be successfully running for at least 3 years in these two references.

Item No.9 Indigenization

Terms of reference

- Identifying constraints in process of indigenous development and evolving strategy for placing development orders for assemblies/systems/subsystems.

- Recommend appropriate eligibility/qualification criteria for wider competition and phased Indigenization in a planned manner without diluting quality.

Indigenous Development: Present Approach being adopted by Metros in India

Standard clause in Metro Tenders mandates that the successful bidder will set up car manufacturing unit in India and at least 70% of the quantity be produced indigenously. This has led to BEML developing facilities for Metro car production and BT and Alstom setting up their manufacturing units in India. M/S CAF is also likely to set up a manufacturing unit in India.

Merits and demerits of this arrangement

- Cost of procurement of rolling stock goes up
- IPR is retained by global bidder only the manufacturing base is shifted
- No reduction in bid price even in subsequent bids, example is BMRCL procurement, KMRCL and CMRCL procurement all have gone to new bidders.
- No development of Indigenous Industry.
- Simple components, are only procured from local industry.

Private developers like GMRL, Reliance Metro,Mumbai, Airport Express and LTHMRL have not imposed any condition for indigenous development and entire stock has been procured from Hyundai-Rotem, South Korea and CSR, China.

For true development of Indigenous sources for 3 phase Metro cars, it is necessary that some development orders be given to indigenous sources for complete propulsion equipment, with stringent performance requirements. IR has successfully adopted this approach for indigenous development of 3 phase propulsion equipment for locos for production at CLW. Initiative can be taken by MOUD as is done by Ministry of Railways for IR. This will help in Indian firms acquiring technology thorough collaborations or indigenous development on their own.

Air conditioned Metro rakes for Kolkata(though with conventional DC Motors) were produced completely indigenously with support from Indian Industry, with number of advanced features.

Further for development of Indian Industry, it is necessary that eligibility criteria enables sourcing from Indigenous manufacturers without imposing conditions like proven-ness in two or three countries as indigenous industry will never qualify with those conditions.

Alstom Comments: It would be incorrect to state that indigenous manufacture of Metro Rolling Stock/Trains would automatically lead to higher cost of production. This situation arises when tender evaluation of rolling stock is undertaken without including taxes and duties.However, the moment the evaluation is based on landed cost to the customer, the situation completely changes with indigenous rolling stock/trains having a lower in landed cost at the customer level.

It is felt that the correct approach of tender evaluation should be to include the entire taxes and duties - basic custom duty (BCD), countervailing duty (CVD), Cess on CVD and the Special Additional duty (SAD) - to arrive at the total landed cost of the Rolling Stock at the MRTS Depot. From the standpoint of the customer, the cash outflow would be lower for indigenously manufactured trains. Going forward, as more localization happens, the landed cost of manufacturing of trains and their sub-systems/components, including domestically manufactured spares will reduce drastically over the life of the train, thus giving a clear benefit on the lift cycle cost. In summary, Public Authority must evaluate tenders based on landed costs and this in itself, will promote reduction in costs as a result of localization of design and manufacturing. This in turn will push many Global Companies to set up set up local manufacturing facility under a separate locally incorporated company in order to reduce costs.

With the clear support of Public Metros Authorities such as DMRC, BMRCL, CMRL and Metro Kolkata (Indian Railways), a large number of reputed major train builders have set up manufacturing in India. In the next phase, the emphasis should be on indigenization of propulsion system & TCMS which, so far, has been trailing behind the localization curve. As a result, there is heavy dependence on foreign imports and this has a long term detrimental impact of the foreign exchange reserves. The situation gets further aggravated in a scenario where there is only one dominant supplier of propulsion system. There is also a view that the current arrangement for calling tenders (RFQ and RFP) in which suppliers of propulsion system are kept out of the consortium, is adversely affecting the level of competition as explained in our comments in Item no.6, above. It would therefore, be prudent to aggressively push for and support moves towards 100% indigenization and indigenous procurement of the entire Rolling Stock, including Propulsion Systems. This would also encourage more FDI to come in to India.

Further, it respect of Rolling Stock for Metro, it is felt that all bidders who have invested heavily in India in the form of manufacturing facilities have in effect, brought in FDI, generated employment, and helped train local manpower in cutting edge technology. The Government must ensure that these investments are well protected. As India urbanises and more metros are added, Government of India must initiate steps to ensure that these manufacturing facilities have a steady stream of order intake.Such a step will encourage further FDI through expansion of existing factories and introduction of new manufacturing units. Over time, this will also result in cost reduction through improved localization. It will also reduce cost of spares and maintenance of the Metro Trains over their economic life cycle.

It is therefore proposed that:

I. **A central Rolling Stock Procurement Agency that procures on behalf of all Metros Authorities in the country be set up. This will ensure that there is a clear visibility of requirements and allow global companies to plan their long term strategy better.**

II. **Currently, many of the manufacturing facilities that were set up in anticipation of obtaining orders are challenged with low off-take, and with a "winner takes it all" approach especially in very big tenders of more than 250 cars, in which bulk orders end up with a single supplier. This is what was witnessed in the recent RS10 tender of DMRC Phase III.Such big tenders of more than 250 cars should be contracted to more than one supplier.**

III. **Similarly, awarding contracts on the existing supplier on single bid basis also hampers competition & competitiveness and increase the cost. For example in Jaipur Metro where RS was awarded on single bid basis to BEML whereas for Signaling there was an open tender.**

IV. **There is a need to correct this situation by incentivizing procurement from firmsthat have an installed manufacturing base in India.**

V. **Tender Evaluation should be based on the landed cost, inclusive of Taxes & Duties.**


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