No.K-14011/13/2002-UT
Government of India
Ministry of Urban Development
(Urban Transport)

Nirman Bhavan, New Delhi-110011
Dated: 29th August , 2005

To

Shri Anil Baijal,
Secretary,
Ministry of Urban Development,
Nirman Bhawan,
New Delhi.

**Subject: Report on Sky Bus Metro System – Submission thereof.**

Dear Sir,

With reference to Ministry of Urban Development Office Order No.K-14011/13/2002-UT dated 10th December, 2003 constituting a Committee to examine the feasibility of establishing and operating Sky Bus Metro System in Indian Cities and the last extension given to the term of the Committee up to 31st August, 2005 through Office Order dated 2nd August, 2005, I am pleased to submit the report to you.

As you will see, the main report is of 8 pages along with 196 pages of Annexures. It has treated Sky Bus System as a technology development project rather than finished technology. It finds that the technology has been advanced well enough to deserve further development. The Committee, therefore, recommends extension of this project as technology development project not merely because of its novelty but also because of possibility of incidental technological benefits that may accrue to the nation through skills and processes developed in designing and producing the system.

The Committee places on record its appreciation of the sincere assistance provided by Shri Purnendu Kant and the advice and support given by Shri Shaleen Kabra and Shri B. S. Lalli.

With regards,

Yours sincerely

Sd/-
(Dr. P.V. Indiresan)
Chairman
Expert Committee on Sky Bus Project

# Report of the Expert Committee set up to examine the feasibility of establishing and operating Sky Bus Metro services in Indian cities

## 1. Background

A high level expert committee was appointed in December, 2003 with the direction to submit its report within two months on the feasibility of establishing and operating Sky Bus Metro Services in Indian cities. A copy of the office Order constituting the committee with its **terms of reference** is placed at **Annexure-I**. The list of members of the Committee is shown at **Annexure II.** However, the first meeting of the committee could be held only on 4th April, 2004 and the term of the committee was extended according to the exigencies till 31.8.2005. The order of last extension given to the term of the Committee is at **Annexure-III**.

## 2. Meetings of the Committee

The Expert Committee held 8 meetings to discuss the issues relating to development and feasibility of the Sky Bus. Out of which 2 meetings were held at the test track site in Goa and the rest were held in Delhi. The meetings were held on the dates indicated below and the minutes are placed at Annexures.

| Sl.No. | Meeting Date | Venue | Minutes of the meting |
|---|---|---|---|
| 1. | 5th April'04 | New Delhi | Annexure-VII |
| 2. | 7th May'04 | Goa | Annexure-IX |
| 3. | 1st Oct'04 | New Delhi | Annexure-XI |
| 4. | 10th Jan'05 | New Delhi | Annexure-XIII |
| 5. | 25th Jan'05 | Goa | Annexure-XIV |
| 6. | 20th May'05 | New Delhi | Annexure-XV |
| 7. | 16th June'05 | New Delhi | Annexure-XVI |
| 8. | 8th Aug'05 | New Delhi | Annexure-XVII |

*In the 4th meeting,* ***Action points*** *were decided and circulated to the members for their consideration before the next meeting held, on 25.01.2005 at Goa.*

## 3. Technical and Operational Aspects of Sky Bus

### 3.1 Envisaged Features

The Committee noted that the envisaged features of the sky bus system proposed by KRCL were as follows: -

**Table: 1- Envisioned Technical Operational Features**

| Sl. No. | Parameter | Specification |
|---|---|---|
| 1. | Gauge | Standard Gauge – 1435 mm. |
| 2. | Gradient | 1 in 60 max (but can take upto 1 in 25) |
| 3. | Curves | Minimum radius of curvature – 50 m follows roadway. |
| 4. | Platform access | Automatic turnstiles |
| 5. | Coach access | Automatic doors |
| 6. | Power supply | Three phase power supply – converted to 750 V DC - 3rd rail current collection. |
| 7. | Type of signaling | Moving Block, Auto Driving Device, Anti Collision Device developed by KRCL |
| 8. | Average Speed | 36 to 47 Kmph depending on Station intervals |
| 9. | Max. Speed | 100 Kmph |
| 10. | Capacity Maximum | 150 X 2 = 300 passengers at 5.6 persons/sqm. |
| 11. | Acceleration | 1.3 m/sec/sec (max) |
| 12. | Frequency of Service/ Headway | 40 seconds to 1 minute |
| 13. | Weight (Twin car) | Max. 48 T (loaded) |
| 14. | Distance between Sky Stations | 0.5 Km to 1.2 Km. |
| 15. | Coach | Air-conditioned (comfort) |
| 16. | Maximum passenger per hour per direction | 18,000 to 81,000 (1 sky Bus consist with 60 seconds and 3 Sky Bus consists with 40 second headway) |
| 17. | Length x Width | 9.25 m x 3.15 m. |
| 18. | Height | 2.40 m |
| 19. | Material | Steel + Poly-carbonate |
| 20. | Type of propulsion | 3 ph AC asynchronous motors |
| 21. | Motor Rating | 4 x 85 KW |
| 22. | Commuter rate of flow from Bus | 300 Nos. in 15 Seconds. |
| 23. | Differently enabled persons | Special access facility & audio-visual information. |

The Committee closely looked at the development of the Sky Bus keeping in mind the envisaged features by KRCL.

## 3.2. Assessment of the Committee

### 3.2.1 Operational Features

The KRCL had prepared the system with the original specifications shown in Table-1. After trials and in the light of practical experience KRCL has modified its expectations as shown in Table-2.

**Table: 2 – Revised Operational Features of Sky Bus**

| Sl. No. | Parameter | Specification (Revised) |
|---|---|---|
| 1 | Frequency of Service/ Headway | 2 minutes |
| 2. | Maximum carrying capacity (phpdt) | 9,000 - 1 sky Bus with 2 min headway – (to be demonstrated). |
| 3. | Curves | Radius of curvature to be kept more than proposed 50 m, to maintain reasonably high speed on curves. (The expected increase in the radius to be specified). |
| 4. | Max. Speed | 60 Kmph, (demonstrated so far) |

In the light of these modifications, which the Committee considers reasonable, the proposed system will not be suitable as high-density metro service or LRT (30,000 PHPDT). But it can still be used in medium size cities and on densely trafficked corridors.

### 3.2.2 Economic Feasibility

As for the economics of the system there has been very divergent views and it appears that the issue can be decided only after further trials and actual construction of a reasonable length and after final design. The Committee was also informed that KRCL has 1.6 km length of track within a budget of Rs.50 crore but without provision for stabling and maintenance. Other estimates as presented to the Committee is as below:-

| | Delhi Metro (elevated) | Sky Bus | |
|---|---|---|---|
| | | As estimated by DMRC | As claimed by KRCL |
| **Total Cost** | 103.22 crore/km | 84.75 crore/km | 50 crore/km |

The Committee is not in a position to certify any of these figures, which in any case will vary from location to location. KRCL has yet to demonstrate its viability with 9000 PHPDT. If KRCL Ltd. can demonstrate that they can construct a system within their cost estimates, then system is likely to be economically viable, but only, as already mentioned, for medium sized cities.

## 4. Safety Aspects of the System:

The suspended rail technology is likely to experience larger oscillations. Any systems failure in mid-air is likely to create problems of evacuation of passengers. Further there are no fail safe systems adopted to avoid rear-end collisions of sky bus. Thus suspended rail system require additional safety features in the following aspects

(i) increased propensity of oscillations.
(ii) gap between the coach and the platform.
(iii) evacuation of passengers in case of emergency.
(iv) rear-end collision.

**Speed:** KRCL has demonstrated their system upto 60Km/hr. and it seems practical that the system can be designed for acceptable safety limits at least upto this speed. KRCL will still have to demonstrate that their system will be operational and safe for higher speeds.

**Gap between Station Platform & Coaches:** KRCL has accepted this risk and has promised to install a movable bridge. The committee finds that such a system will have to be developed and will be within the capacity of Indian Engineers.

**Evacuation in Emergency:** KRCL proposes to have two types of systems:

- To bring a relief coach on the parallel line or in the same line and transfer passengers from one coach to the other. Such a coach will need a provision so that the passengers do not run the risk of falling down from in between the two coaches. Fire resistant materials should preferably be used to reduce the risk of fire.

- KRCL has suggested, as an alternative, bringing a relief vehicle on the road, with a glide to bring the passengers down. The committee is not convinced of its suitability mainly because, it may not be possible to bring such a vehicle quickly to rescue the passengers. However, the Committee felt that there is no novelty in bringing a relief coach on either on parallel track or on the same track to evacuate passengers.

**Collision:** As regards collision, there is no extra risk in Sky-Bus comparable to any other system and the same precaution will be in order. However, the KRCL has contended that the wheel bogie will have buffers to absorb the impact and prevent the coaches from telescoping into each other. However, no test has been performed actually experimenting with the collisions.

The Committee finds that the suspended system is likely to have wider amplitude of oscillations and yet it is feasible to design the system to operate within acceptable safety limits. KRCL has already designed ‘swing-arresters’ but their capacity to limit swings has not yet been demonstrated.

## 5. Special Features

The special feature in the KRCL's Sky Bus system are essentially the following:-

(a) Suspended Rail Coach.
(b) Traverser system.
(c) Advanced Signaling System (Not yet incorporated).
(d) Movable bridge

### Suspended Coach

The Suspended coach will have a lower center of gravity (CG) and will be fail-safe even when the coach derails. It provides a canopy that can be put to commercial use.

It will require columns, which will be significantly taller and hence subject to more vibrations and larger bending movements. Wider Doors will permit easy entry and exit to coaches but will require high standards of reliability, which is yet to be demonstrated.

### Traverser-System

The traverser-system has been demonstrated without sky-bus. However, it is not clear that the traverser will be fast enough to permit 40 seconds headway that was proposed in the original specification. Being a electro-mechanical system, it requires testing for lifetime reliability and maintainability. As the sky bus has a relatively small turning circle, it could consider, wherever feasible, a turning loop in place of traverser.

### Signalling System

1. KRCL had earlier proposed to provide 40 secs headway of Sky Bus System by developing Moving Block Technology. However they are yet to develop & demonstrate the same. In the recent meeting of the Committee held in Jan'05, KRCL stated that they will begin their services with two minutes headway by adopting Automatic Block Signalling as in use on Mumbai Suburban section and will develop Moving Block Technology to give 40 seconds headway in future.

2. Adoption of proven technology of Automatic Block Signalling with Relay (or Solid State) Interlocking as in use on Mumbai Suburban Section will be a practical step to start the Sky Bus system.

3. To ensure safety in Sky Bus operation and achieve stopping accuracy adoption of a proven technology of Automatic Train Control from the beginning of the services is considered necessary.

4. KRCL has proposed to develop Moving Block System. Whatever system they develop will require to be safety validated as per CENELEC or equivalent International Standard by an ISA (Independent Safety Accessor).

**Maintenance Problems**

Space available for maintenance between the top of the coach and rail is a matter of concern and can cause difficulties in maintenance.

**Air Conditioning System**

KRCL has not proposed any innovation in propulsion system or in air conditioning.

## 6. Critical Evaluation of the systems integration

KRCL has demonstrated within the limited scope and time it is possible to have a 1.6 km. track and system can be made operational. KRCL has explained the fatal accident that occurred and KRCL has said that additional precautions have been taken to prevent such accidents in the future. The coach and the station design require further development.

The Committee finds that in spite of the accident during trials, KRCL design holds much promise though its full capabilities are yet to be proven.

## 7. Other Observations / Recommendations

7.1. The Committee commends KRCL for bringing together large number of vendors to provide a large number of components of original design within a reasonable time-frame. The Committee would also like to place on record its appreciation of the KRCL's design-team's devotion, enthusiasm and above all courage to face unexpected problems. The Committee would also like to record their appreciation for Shri B. Rajaram, former MD, KRCL, for his leadership initiative, talent and innovation capabilities. The Committee desires that he should continue to be associated with the project.

7.2 **Gauge**: The Committee observes that Ministry of Railways has expressed his inability to certify safety aspects in case the system is on Standard Gauge and has instead recommended use of Broad Gauge, as the Railways has got the experience of B.G. for last over 150 years. For the purpose of trial and testing on B.G., the RDSO Wing of Railways can be utilized effectively.

7.3. Whatever progress has been made so far, is because of an informal arrangement by which KRCL had deployed a team to this specific task of development out of their normal staff. The Committee strongly recommends the constitution of an exclusive engineering team in consultation with the KRCL to continue the further development of the system in a time bound manner.

7.4. The Committee notes that KRCL has proposed an additional expenditure of Rs. 35 crore for completing the trials. The Committee finds that the amount will be inadequate to meet unexpected contingencies, or even to fully rectify the limitations identified so far. Therefore, the Committee recommends that the Government should consider to grant a sum of Rs. 60 crore spread over a period of two years. M/o Railways, who have provided Rs. 50 Crore for this project so far, has expressed its inability to fund this project further.

7.5. The Committee recommends that a Standing Technical Advisory Group (TAG) be appointed to monitor the progress of trials periodically, at least once in a quarter and the funds be released only in consultation with the Committee. For this purposes, in case extension is approved, the KRCL should be required to indicate measurable milestones for each quarter for the next two years.

7.6. The Committee recommends that a Technical Advisory Group (TAG) comprising of eminent Scientists, Researchers and Railway Engineers be established for technical support/guidance to identify the manner and the process through which, the Sky bus system may be certified for use in the public.

7.7. The Committee recommends extension of this project as a technology development project not merely because of its novelty, but also because of the possibility of incidental technology benefits that may accrue to the nation through the skills and processes developed in designing and producing the system. A dissent note of RITES is at Annexure-V.

7.8 The Committee appreciates the support provided by the Ministry of Urban Development, Ministry of Railways, Konkan Railway Corporation Ltd. and the Institute of Urban Transport (India) in making arrangements for necessary inputs, facilities and other required examination / information to facilitate the working of the Committee.

7.9 This Report has treated the Sky Bus system as a technology development project rather than as a finished technology that is advanced enough to compete with existing technologies. It looks for possible technological fallouts that may emerge from this project as being even more important than its current competitiveness. If the very strict standards that some want to apply in this case had been applied in the case of Stephenson's Rocket Engine, the world would never have seen railways at all. We would still be using horse carriages, because in those days horse carriages were definitely more advanced and offered better service than steam engines did.

7.10 We, in India, suffer from the colonial hangover and think that all innovations have to come from abroad. We are skeptical of Indian technology. This Report has tried to avoid that bias. Whether the Sky Bus fulfils all its hopes or not, this project will give a confidence to Indian engineers that the government will back up Indian innovation as far as possible. Inspiring such confidence too is important because we cannot live on borrowed technology forever, and should learn to develop our own inventions, and for that reason, learn to place confidence in Indian technology.

**(G.P. Garg)**
**Chief Commissioner of Railway Safety,**
**Member**

**(Satish Kumar)**
**Director, DMRC**
**Member**

**(Dr. P.V.Indiresan)**
**Former Director,**
**IIT, Chennai**
**Chairman**

**(Chandrika Prasad)**
**Former Additional Member (Signals),**
**Railway Board- Member**

**(S.C. Agnihotri)**
**ED (Metro Projects)**
**Railway Board**
**Member**

**(Dr. A. K. Mittal)**
**Chief Engineer**
**CPWD**
**Member**

**(Dr. T.S. Reddy)**
**Head,**
**TTP&E Division, CRRI**
**(Nominated by CSIR)**
**Member**

**(P.K. Agrawal)**
**ED(Carriage)**
**Representative of DG,**
**RDSO-Member**

**(A. K. Arora)**
**Group General Manager**
**Representative of MD,**
**RITES-Member**

**(Shaleen Kabra)**
**Deputy Secretary(UT)**
**M/o Urban Development**
**Member**

## LIST OF ANNEXURES