The Development History of Superconducting Maglev

Ken Nagashima
Railway Technical Research Institute

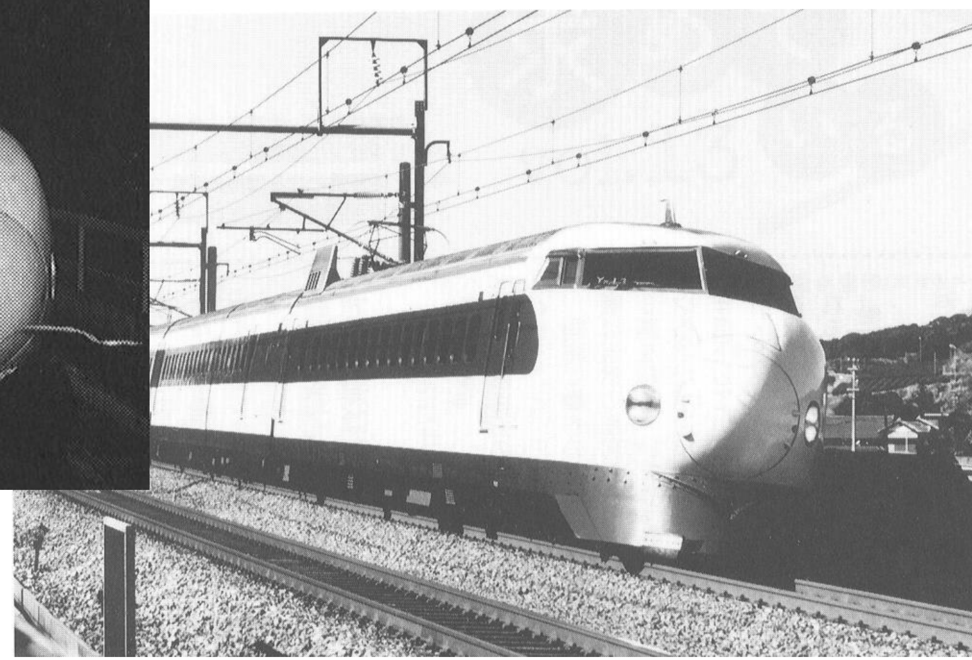
Railway Technical Research Institute (RTRI)

Address:
Hikari-cho,
Kokubunji-shi,
Tokyo

(derived from
Shinkansen
"Hikari" Express)

1907/04 Inaugurated as a section of the government (112 years ago)
1986/12 Organized as an non-profitable foundation
1987/04 Took over R&D of Japanese National Railways (JNR)
Birthplace of the Shinkansen AND Maglev high-speed systems

The Tokaido Shinkansen



1964 Sep.24

Inauguration of Tokaido Shinkansen service between Tokyo and Shin-Osaka

Tokyo - Osaka 3 hours 10 minutes (1965)

High-Speed Transport by Magnetically Suspended Trains

(J. R. Powell and G. R. Danby)

Printed in U.S.A.

66-WA/RR-5

an ASME publication

$1.50 PER COPY
75¢ TO ASME MEMBERS

High-Speed Transport by Magnetically Suspended Trains[1]

J. R. POWELL

Nuclear Engineer, Brookhaven
National Laboratory,
Upton, N. Y.

G. R. DANBY

Physicist, Brookhaven
National Laboratory,
Upton, N. Y.

A magnetic suspension suitable for 300-mph trains is described. It can suspend a 100-ft-long, 100-passenger train 6 in. above a track with no mechanical contact. The total train weight is 60,000 lb. The train is propeller driven and requires 200 hp for electrical losses and 1200 hp for air drag. The moving train carries a 300,000-amp superconducting loop which induces 5000 amp of current in aluminum track loops on the ground. The suspension is self-stabilizing, and the train always returns to its equilibrium position if displaced by external forces. The concept is technically and economically feasible with present materials.

[1] This work was performed under the auspices of the U. S. Atomic Energy Commission.

Contributed by the Railroad Division for presentation at the Winter Annual Meeting and Energy Systems Exposition, New York, N. Y., November 27-December 1, 1966, of The American Society of Mechanical Engineers. Manuscript received at ASME Headquarters, August 11, 1966.

Copies will be available until September 1, 1967.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS UNITED ENGINEERING CENTER, 345 EAST 47th STREET, NEW YORK, N.Y. 10017

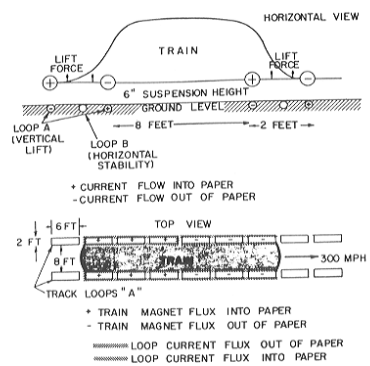


Fig. 1 Conceptual view of track and train

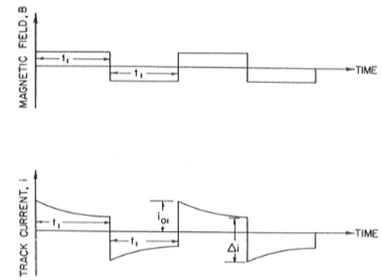


Fig. 2 Magnetic field at and current in track loops

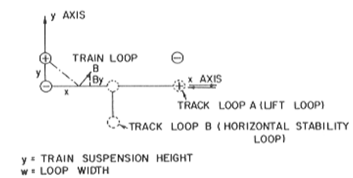


Fig. 3 Geometry of track and train loop

track separated by the width of the train (≈10 ft) to prevent any rolling of the train. The train floats 6 to 12 in. above the track loops when moving. The loops can be laid on or slightly underground. The track carries no current ahead of or behind the train. The horizontal stabilizing loops carry no current at all unless the train moves from the equilibrium plane of symmetry. The train is constrained to follow the track, since any displacement from its equilibrium position, vertically or horizontally, generates a restoring force. However, in the direction of motion the train is almost frictionless except for air drag and the small I^2R loss in the track.

In the rest of the paper we will describe the lift forces for such a suspension, its stability, frictional drag, construction of track and train, and a brief estimate of its economics.

MAGNETIC LIFT FORCE

The magnetic lift force depends on three factors: Train current, the induced track current, and the distance between them.

Turning first to the induced track current we find that the current in any loop j along the tracks is given by

$$L_j \frac{\partial i_j}{\partial t} + i_j R_j = - \frac{\partial \Phi_j}{\partial t} \qquad (1)$$

With the following assumptions, we can analytically calculate the current in the jth loop as a function of time:

1 The magnetic field in the track loop is equal to that of an infinite wire at any point under the train and zero ahead. This field has a discontinuity at the end of the train, Fig.2. This is equivalent to specifying that the suspension height is much less than the train-loop length. With the train loops that we are considering, errors of <5 percent in current and lift force are introduced by this assumption.

2 Track loops have negligible length along the track. Magnetic field and flux through them is that specified at the point position they occupy.

3 Flux through the loop is zero until the front of the train passes, and then it increases instantaneously to the full value characteristic of an infinite train loop.

4 There is no oscillation of train height.

Then, assuming all track loops are identical

Merits of LSM with EDS System

High Speed:

Linear Synchronous Motor

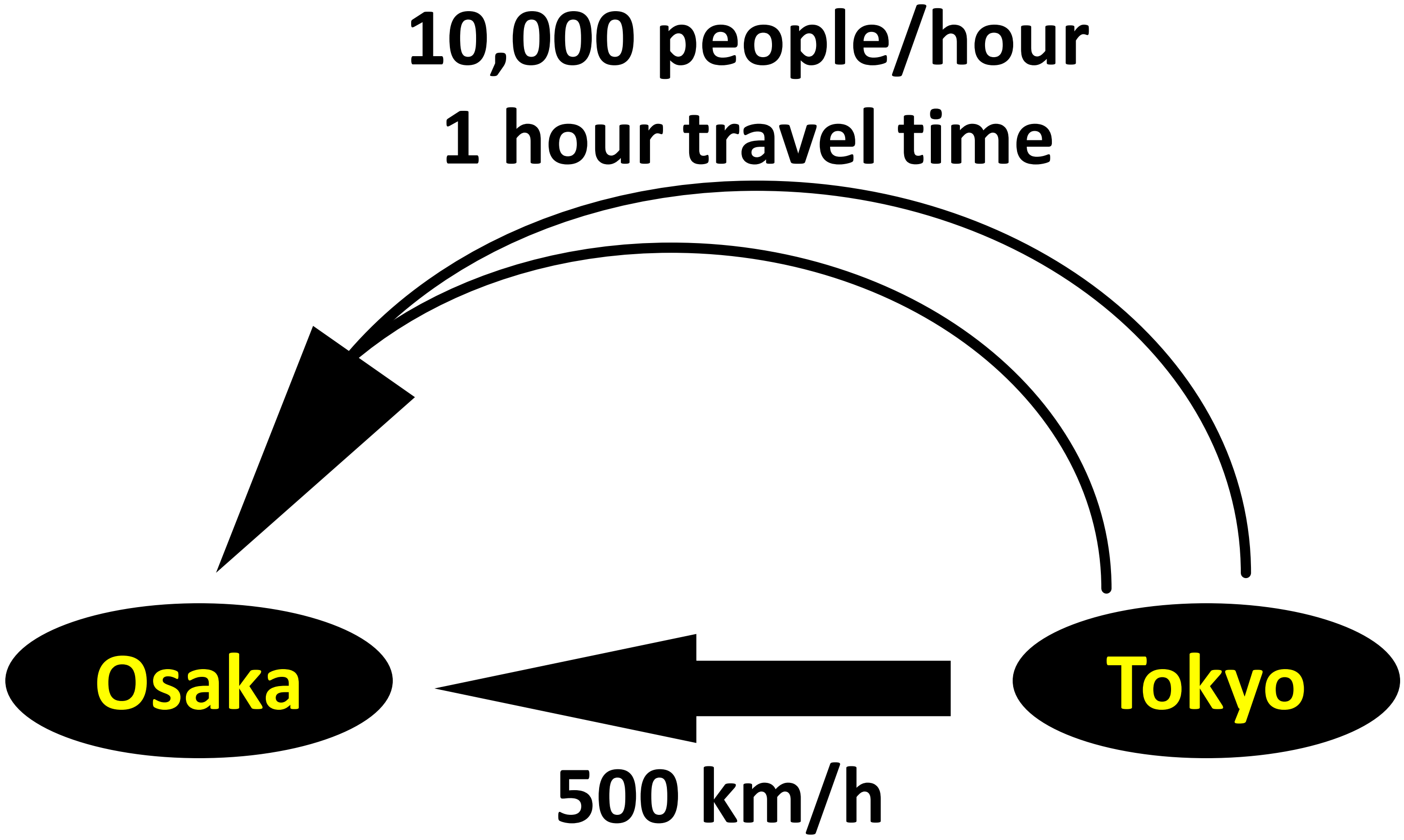
Stability and Large Air Gap:

Electro Dynamic Suspension

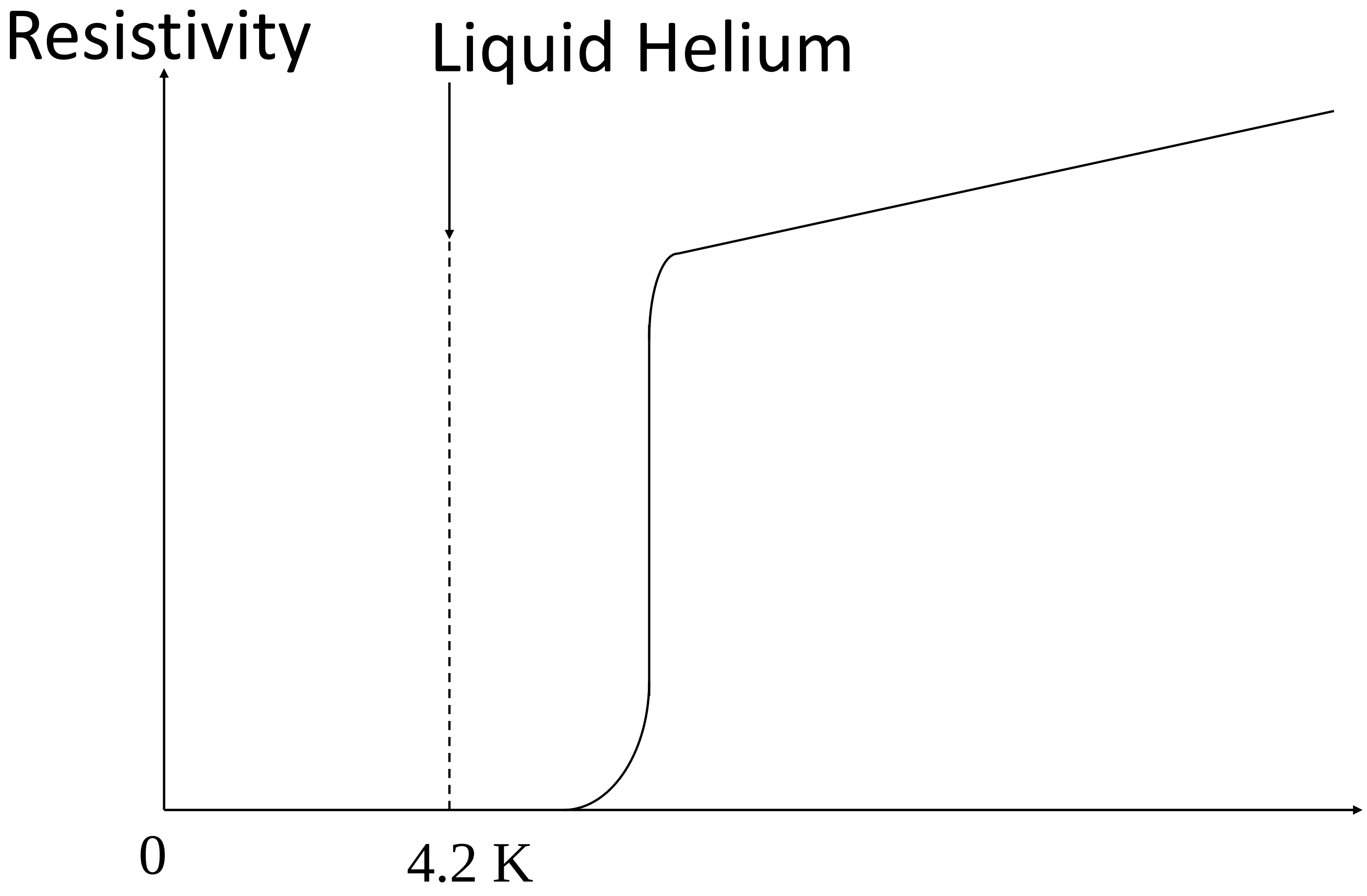
Superconducting Magnetic Levitation System

(JR Maglev)

Target of JR Maglev



Superconductivity

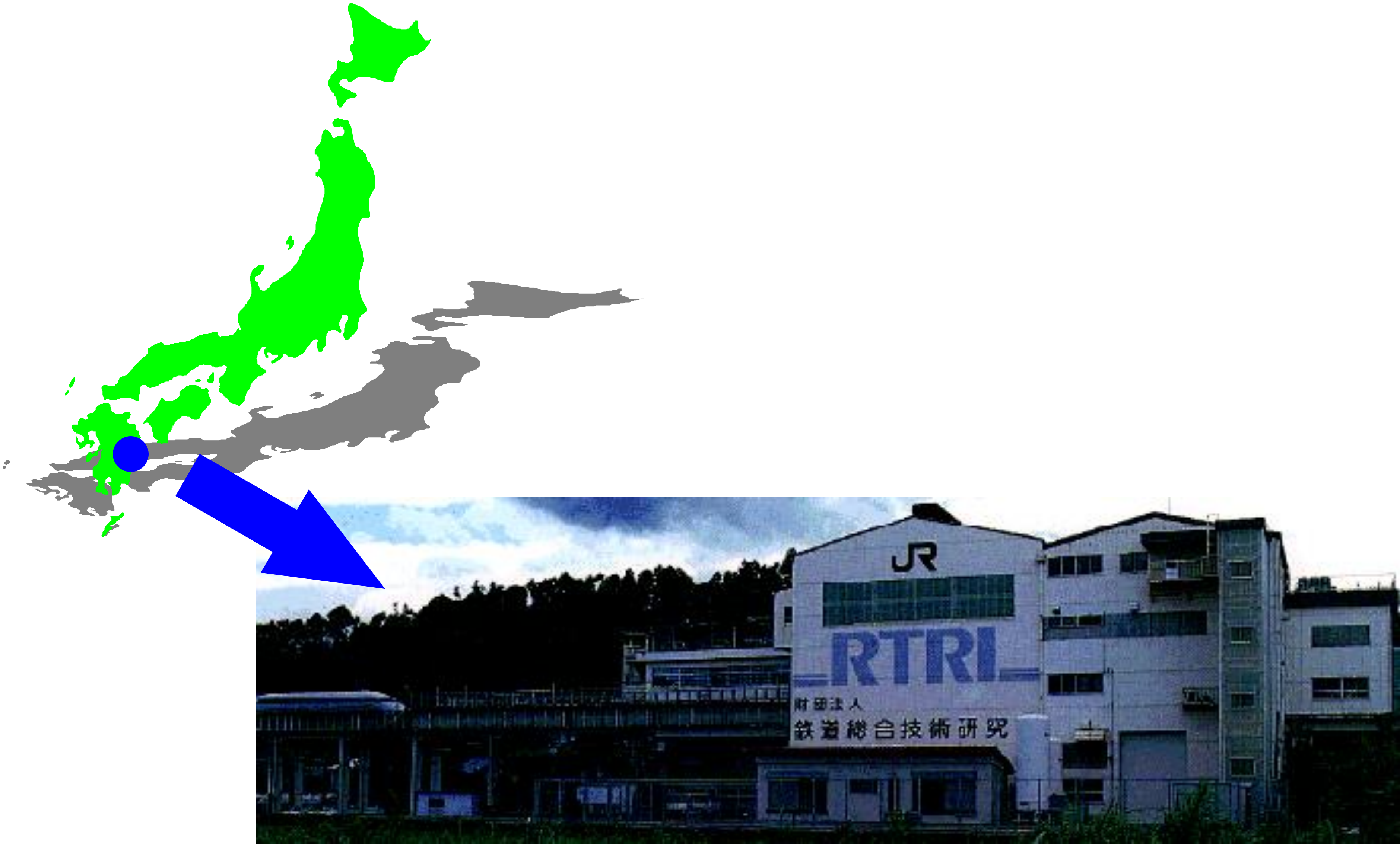


RTRI Kunitachi Headquarters

ML-100

ML-100 October 1972

Miyazaki Maglev Test Center



ML-500

ML-500 December 1979

MLU001 (1980)

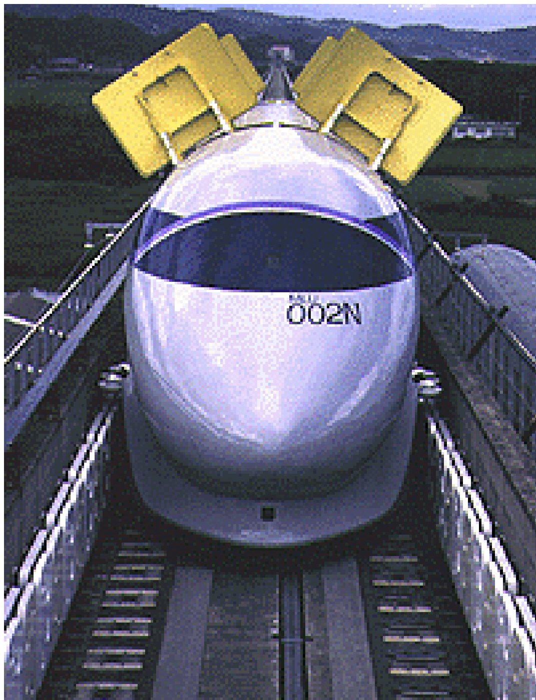
Max. speed

405km/h
(2-car train)

352km/h
(3-car train)

MLU002N（1993）

Aerodynamic brakes



Max. speed

431km/h
(unmanned)

411km/h
(manned)

Thank you for your kind attention