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THE REVIEW

SUPERCONDUCTING MAGLEV (SCMAGLEV)

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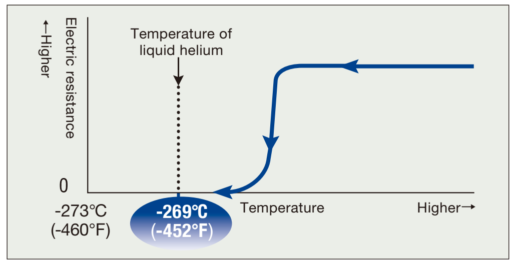
The Superconducting Maglev - Next Generation Transportation System

The Superconducting Maglev (SCMAGLEV) is an internationally acclaimed, cutting-edge technology unique to Japan. Unlike conventional railway systems that rely on adhesion between wheel and rail for movement, the Superconducting Maglev is a contactless transportation system that accelerates and decelerates by the magnetic force generated between the onboard superconducting magnets and ground coils, which enables a stable ultra-high speed operation at the speed of 311mph. Research of a totally new levitated transportation system commenced in 1962, and running tests on the Yamanashi Maglev Line began in 1997. Since then, a wide range of tests were conducted and cleared. With these test results, the Maglev Technological Practicality Evaluation Committee (MTPEC) under the Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has evaluated Superconducting Maglev technology at each stage. In July 2009, MTPEC acknowledged that the technology has been established comprehensively and systematically, which makes it possible to draw up detailed specifications and technological standards for revenue service. In December 2011, the technical standards of the Superconducting Maglev were enacted by the Japanese Minister of Land, Infrastructure, Transport and Tourism. In August 2013, the Yamanashi Maglev Line was fully renewed and extended to 42.8km (26.6miles), and is currently operating using Series L0 (L Zero).
This leading edge Japanese technology is the next generation of super fast train travel.

The Principles of the Superconducting Maglev System

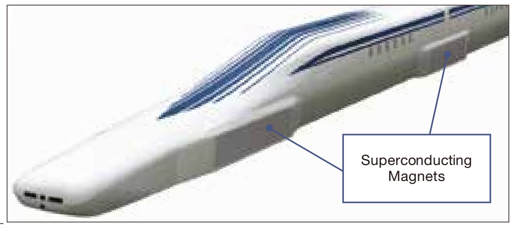
What is Superconductivity ?

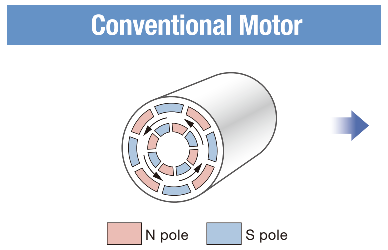
Superconductivity is the phenomenon that the electrical resistance of certain materials approaches zero at very low temperature. When an electrical current is applied to a superconducting coil (coil in a superconductive state), the current continues to flow almost indefinitely, resulting in the creation of a powerful Superconducting Magnet.
The coil in the Superconducting Magnet is made of a Niobium-titanium alloy and the superconductive state is achieved when cooling it with liquid helium to a temperature of minus 269°C (minus 452°F).

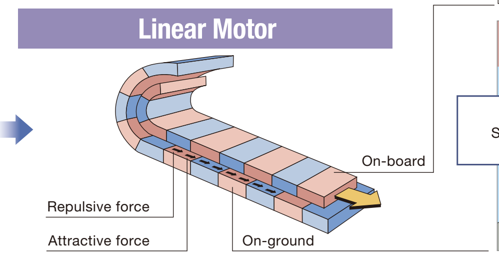


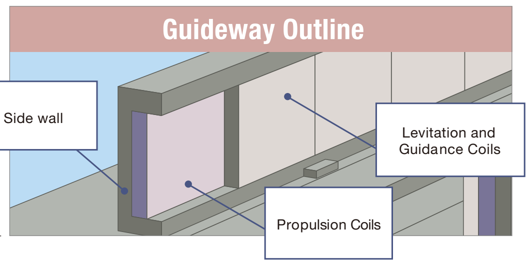
What is a linear motor ?

A linear motor can be compared to a conventional type of rotating motor which is cut open and extended linearly. The rotors inside the conventional motors correspond to the Superconducting Magnets in the Superconducting Maglev vehicles, while the external stators correspond to the Propulsion Coils on the ground.







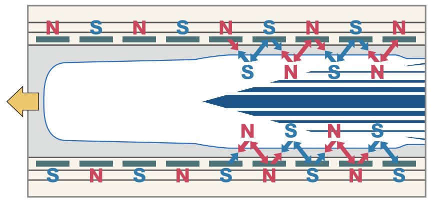


How the Superconducting Maglev runs at ultra high-speed?

In order to operate at ultra high-speed, the Superconducting Maglev levitates 10cm (about 3.9in) above ground by the magnetic force generated between the onboard Superconducting Magnets and ground coils.

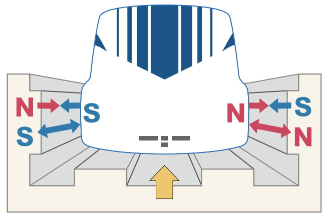
Propulsion System

By passing current through the Propulsion Coils on the ground, a magnetic field (north and south poles) is produced, thus the vehicle is propelled forward by the attractive force of opposite poles and the repulsive force of same poles acting between the ground coils and the Superconducting Magnets built into the vehicles.



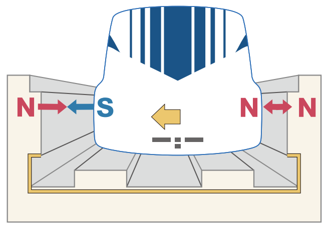
Levitation System

Levitation and Guidance Coils are installed on both sides of the guideway (track). When the onboard Superconducting Magnets passes through at high speed, an electric current is induced in the Levitation and Guidance Coils, causing them to become electromagnets.
This generates a force that both pushes and pulls up the vehicle.



Guidance System

The Levitation and Guidance Coils on both sides of the guideway keep the vehicles in the center of the guideway at all times by exerting an attractive force on the further side of the vehicle and a repulsive force on the nearer side when the vehicle moves off center to either side.



1962 ▸ 1989

The Early Years of Superconducting Maglev Research

ML100

ML-500

MLU001

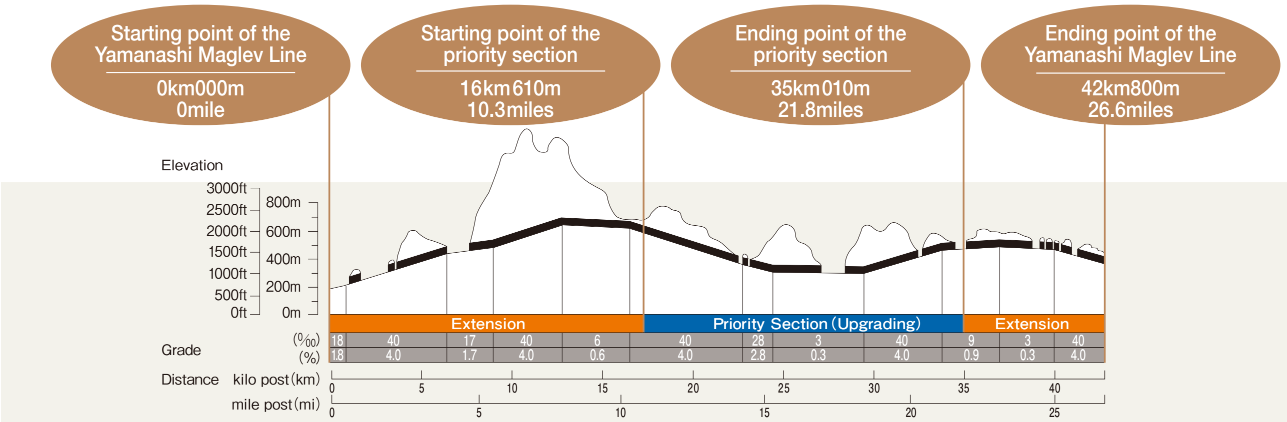
MLU002N

Research on a linear motor propulsion magnetically levitated railway system began in 1962 as the next-generation ultra-fast link between Tokyo and Osaka with a journey time of 1 hour. The first successful levitation run on the ML100 was realized at the Railway Technical Research Institute in 1972. A Maglev test track was constructed in Miyazaki in 1977, and in 1979 the first test vehicle ML-500 achieved a world speed record at the time of 517km/h (321mph). In 1980, the guideway was modified from a reversed T-type form to a U-type form, and tests continued on the MLU001 and MLU002N with manned running. Although fundamental tests on the basic performance of the Maglev were carried out on the Miyazaki Maglev Test Track, this test track was only a single track with no tunnels, steep gradients or narrow curves. A new test line with these features was required. In 1989, it was decided to construct the Yamanashi Maglev Line.

1990 ▸ 1997

Birth of the Yamanashi Maglev Line

The 42.8km (26.6miles) Yamanashi Maglev Line is located to the north of Mt. Fuji.



	Yamanashi Maglev Line (Priority section)	Miyazaki Maglev Test Track
Length	18.4km (11.4miles)	7.0km (4.3miles)
Tunnel	16.0km (9.9miles)	0km (0mile)
Aboveground	2.4km (1.5miles)	7.0km (4.3miles)
Track	Double Track	Single Track
Maximum grade	40‰ (4%)	5‰ (0.5%)
Minimum curve radius	8,000m	10,000m

The construction of the Yamanashi Maglev Line began with the groundbreaking ceremony in November 1990. The test vehicles for the Yamanashi Maglev Line, named MLX01, were completed in July 1995, and delivered to the train depot. After finishing various installation works, the 18.4km (11.4miles) priority section was completed in March 1997.

1997 ▸ 2000

Attaining Technical Prospects for Practical Application

Running tests commenced on the Yamanashi Maglev Line on April 3, 1997 with low-speed wheel-running tests. The first levitation run succeeded in the following month, confirming the stable levitation. Speed increase tests were followed, and by November of the same year, the maximum speed exceeded 500km/h (311mph), and by December-just nine months after running tests began-the maximum designed speed of 550km/h (342mph) was attained. In February 1999, running tests were carried out with a 5-car train to confirm the running stability of longer trains.
In addition, high-speed passing tests were carried out to confirm stability when passing an oncoming train, and a relative passing speed of 1,003km/h (623mph) was recorded in November of that year. Also, multiple-train control tests simulating various operations required for revenue service (including siding, passing and following) were conducted and confirmed that such operations could be performed smoothly.

▲ Ceremony for the start of running tests

▲ High-speed passing tests

▲ 5-car trainset

▲ Multiple-train control tests

MTPEC's Evaluation (March 2000)

In March 2000, the MTPEC under the Japanese Ministry of Transport (now the Japanese Ministry of Land, Infrastructure, Transport and Tourism) acknowledged that "the technology of the Superconducting Maglev has reached a stage that makes it a viable ultra-speed mass transport system."

HISTORY

- 1962: Research on linear motor propulsion magnetically levitated railway system begins
- '72: First magnetically levitated run successfully accomplished
- '77: Opening of the Miyazaki Maglev Test Center
- '79: The ML-500 achieves a world record of 517km/h (321mph)
- '87: 400.8km/h (249mph) is attained with manned MLU001
- '89: Decision made to construct the Yamanashi Maglev Line
- '90 6: "Ministerial Memorandum to Promote smoothly Technological Development of the Superconducting Magnetically Levitated Train"notified by the Minister of Transport. "Master Plan for Technological Development for the Yamanashi Maglev Line" and "Construction Plan" is approved by the Minister of Transport
- '90 11: Groundbreaking ceremony for construction of the Yamanashi Maglev Line
- '94: 431km/h (268mph) is attained with MLU002N
- '95 7: First maglev vehicles for the Yamanashi Maglev Line (MLX01) delivered to the train depot
- '96 1: Running tests end on the Miyazaki Maglev Test Track
- '96 7: Opening of the Yamanashi Maglev Center
- '97 1: "Maglev Technological Practicality Evaluation Committee (MTPEC)" is established under the Ministry of Transport
- '97 4/3: Running tests begin on the Yamanashi Maglev Line priority section 18.4km (11.4miles)
- '97 5/30: First levitation run on the Yamanashi Maglev Line successfully accomplished
- '97 11/28: 500km/h (311mph) is attained
- '97 12/24: Unmanned world speed record of 550km/h (342mph) is attained
- '98 6/11: Start of high-speed passing tests and multiple-train control tests
- '99 2/3: Start of 5-car trainset runnig tests
- '99 4/14: Manned world speed record of 552km/h (343mph) is attained
- '99 11/16: Passing at a relative speed of 1,003km/h (623mph)
- '00 3/9: The MTPEC acknowledges "the technology has reached a stage that makes it a viable ultra-speed mass transpotation system"

2000 ▶ 2005

Establishing Fundamental Technology for Practical Application

With the aim of establishing all necessary fundamental technologies for practical application, technological development and running tests had been promoted with a focus on verification of reliability and long-term durability of the system, cost reduction and improvement of the aerodynamics of vehicles. With these issues in mind, a new vehicle MLX01-901, which employed many trial elements in its nose shape, body cross-section and body structure, was introduced on the Yamanashi Maglev Line.

Running tests started in July 2002, and verified reduction of vehicle vibration and running resistance, as well as improvements in the cabin environment and along the line.

In addition, a series of higher level performance tests on safety, reliability and durability were conducted from 2003 in order to attain an optimal design.

In November 2003, a continuous running test was conducted and achieved a cumulative distance of 2,876km (1,787miles) in a single day (89 round trips on the priority section).

This distance is equivalent to twice the average distance of the 1,400km (870miles) traveled daily by JR Central Shinkansen trainsets.

Then on December 2003, a speed of 581km/h (361mph) was achieved, exceeding the previous world record by about 30km/h (18mph). Moreover, a passing test at a relative speed of 1,026km/h (638mph) was carried out in November 2004 that also set a new world record.

▲ Experimental vehicle (MLX01-901)

▲ The vehicle with a world record of high speed 581km/h (361mph)

MTPEC's Evaluation (March 2005)

In March 2005, the MTPEC acknowledged that "all necessary technologies of the Superconducting Maglev for the future revenue service are established."

2006 ▶ 2012

Comprehensive and Systematic Readiness for Revenue Service

With the aim of completing all technologies necessary for practical application as a ultra-high speed mass-transportation system, further technological development and running tests were conducted with a focus on verification of the long-term durability, cost reduction and verification of the specifications for revenue service.

From April 2009, running tests were performed using a modified experimental vehicle closer to revenue service design. The nose section was shortened and the sides of the car roof were angular rather than rounded. Based on the experimental data, the outline design of the new vehicle, Series L0 (L Zero) was determined in 2010 and its manufacturing started. In September 2011, the MTPEC acknowledged that "the technologies of the inductive power collection for on-board power supply have been established to the practical level". In December 2011, the technological standards of the Superconducting Maglev were enacted by the Japanese Minister of Land, Infrastructure, Transport and Tourism.

▲ Series L0 (L Zero)

MTPEC's Evaluation (July 2009)

In July 2009, the MTPEC acknowledged that "the technologies of the Superconducting Maglev have been established comprehensively and systematically, which makes it possible to draw up detailed specifications and technological standards for revenue service."

2013 ▶

The Yamanashi Maglev Line after the renewal and extension

	Yamanashi Maglev Line	Yamanashi Maglev Line (Priority section)	Miyazaki Maglev Test Track
Length	42.8km (26.6miles)	18.4km (11.4miles)	7.0km (4.3miles)
Tunnel	35.1km (21.8miles)	16.0km (9.9miles)	0km (0mile)
Aboveground	7.7km (4.8miles)	2.4km (1.5miles)	7.0km (4.3miles)
Track	Double Track	Double Track	Single Track
Maximum grade	40‰ (4%)	40‰ (4%)	5‰ (0.5%)
Minimum curve radius	8,000m	8,000m	10,000m

The Yamanashi Maglev Line was fully renewed and extended to 42.8km (26.6miles), and is currently operating using Series L0 (L Zero). In April 2015, a continuous running test was conducted and recorded 4,064km (2,525miles) in a single day. Also, a high speed running test was conducted and achieved the current world speed record of 603km/h (375mph). This record was recognized by the GUINNESS WORLD RECORDS® in June 2015 as the world's fastest maglev train. In preparation for the opening of the Chuo Shinkansen, JR Central will continue to brush up the technologies of the Superconducting Maglev and further reduce costs of construction, operation, and maintenance.

MTPEC's Evaluation (February 2017)

In February 2017, the MTPEC acknowledged that "the Superconducting Maglev technological developments necessary for the revenue service line have been completed."

HISTORY

- '02 6/18 — Experimental vehicle (MLX01-901) is introduced
- '03 11/7 — Running distance of 2,876km (1,787miles) in a single day is achieved
- 12/2 — Manned world speed record of 581km/h (361mph) is attained (replacing the previous world speed record)
- '04 11/16 — Passing test at a relative speed of 1,026km/h (638mph) is conducted
- '05 3/11 — The MTPEC acknowledged that "all necessary technologies of the SCMAGLEV for the future revenue service are established"
- '06 9/25 — Investment plan of the renewal and extension of the Yamanashi Maglev Line is made
- '07 1/23 — Minister of Land, Infrastructure, Transport and Tourism approved the modification of "Master Plan for Technological Development" and "Construction Plan" of the Yamanashi Maglev Line, for its renewal and extension
- '08 5/30 — Renovation and Extension works begin on the Yamanashi Maglev Line
- '09 4/3 — Improved vehicle (MLX01-901A) is introduced
- 7/28 — The MTPEC acknowledged that "the technologies of the SCMAGLEV have been established comprehensively and systematically, which makes it possible to draw up detailed specifications and technological standards for revenue service"
- '10 10/26 — The outline design of the new vehicle Series L0 (L Zero) was determined
- '11 9/13 — The MTPEC acknowledged that "the technology of the inductive power collection for on-board power supply has been established to the practical level"
- 9/30 — Running tests end on the Yamanashi Maglev Line priority section. The cumulative travel distance exceeded 878,000km (545,000miles)
- 12/1 — The technological standards of the SCMAGLEV are enacted by the Japanese Minister of Land, Infrastructure, Transport and Tourism
- '13 8/29 — Operation using Series L0 (L Zero) began on the renewed and extended Yamanashi Maglev Line 42.8km (26.6miles)
- '14 4/21 — The cumulative travel distance exceeded1,000,000km (621,000miles)
- '15 4/14 — Running distance of 4,064km (2,525miles) in a single day is achieved
- 4/21 — The current world speed record of 603km/h (375mph) is attained (replacing the previous world speed record)
- '17 2/17 — The MTPEC acknowledged that "the SCMAGLEV technological developments necessary for the revenue service line have been completed."