ILC Tunnel compared with the longest Railway Tunnel experienced in Japan

Learning experience from the construction of the "Seikan Tunnel" under sea

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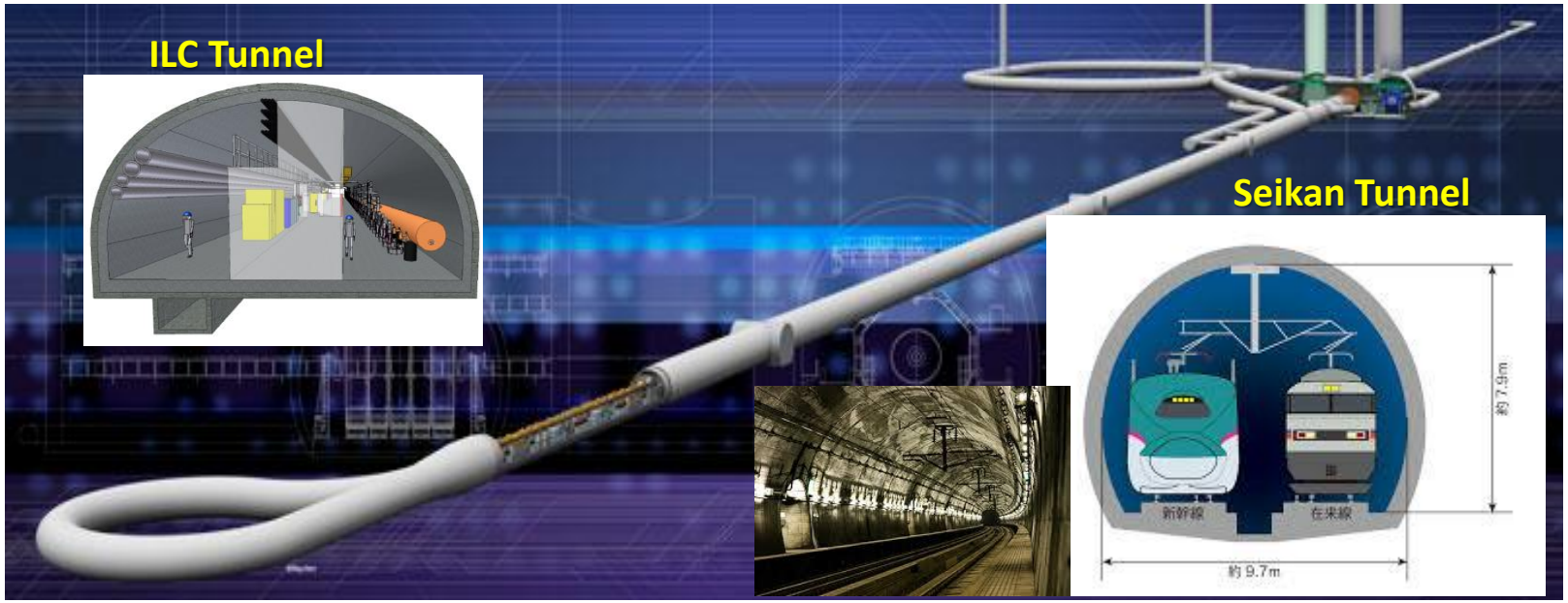
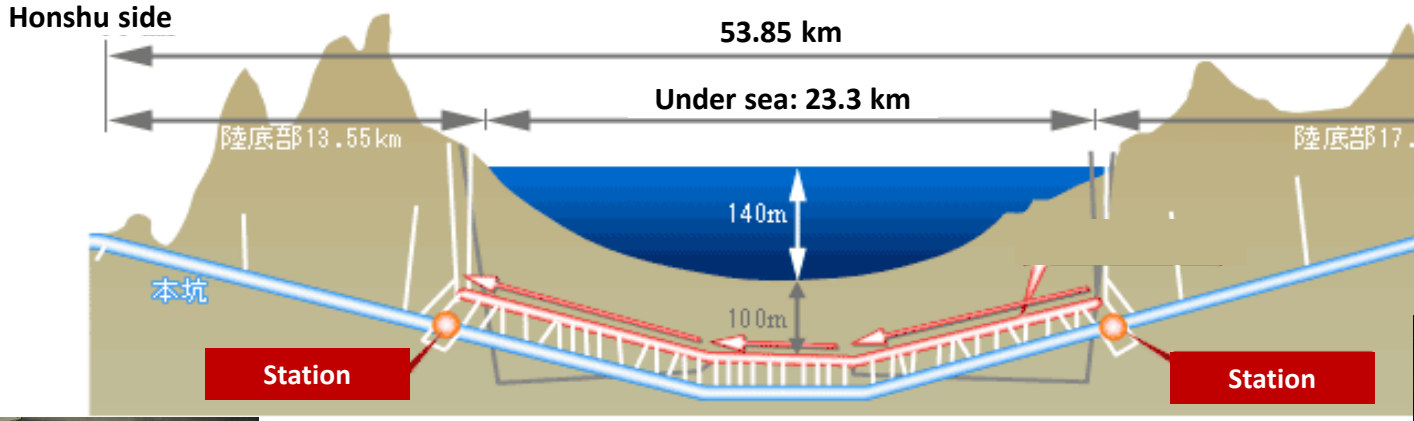
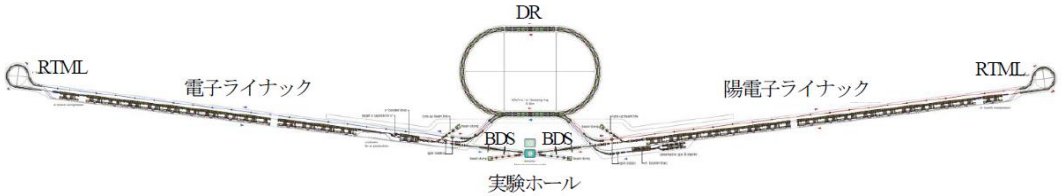
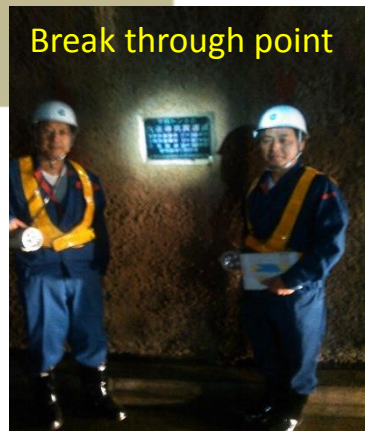


Prologue

- Akira and I visited the Seikan tunnel 240m under sea on July 7,2015.
- The main purpose:
  - to study the Construction Technology of this unique tunnel.
  - Research of the Management system after completion.







ILC Main Linac Tunnel

The cross-sectional area of the ILC tunnel is almost the same as the standard of JR Shinkansen tunnel.

RF Source

3.5m

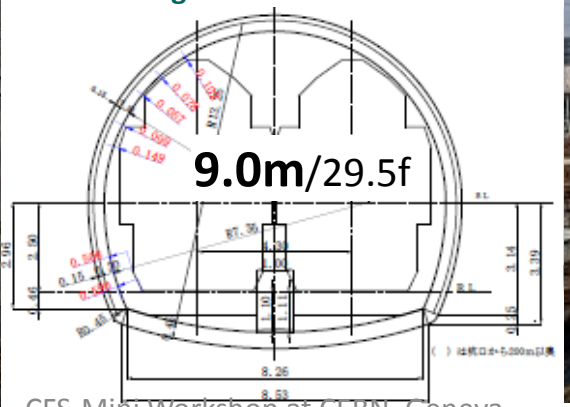
Klystron Garally

Beam Tunnel (Cryomodule)

11.0m/36ft.

JR Shinkansen Tunnel

Existing Line Standard Section



Tunnel Length - World Rankings

: Europe
: Japan

① Gotthard Base	57.1km	Europe
② Seikan(青函)	53.4km	Japan
③ Euro (Channel)	49.4km	Europe
④ Lotschberg Base	34.6km	Europe
⑤ Hakkoda(八甲田)	26.4km	Japan
⑥ Iwate（岩手一戸)	25.8km	Japan
⑦ Laerdals <road>	24.5km	Europe
⑧ Iiyama(飯山)	22.2km	Japan
⑨ Oshimizu(大清水)	22.2km	Japan
⑩ Simplon	19.8km	Europe

Tunnel


Gotthard Base Tunnel


Seikan Tunnel

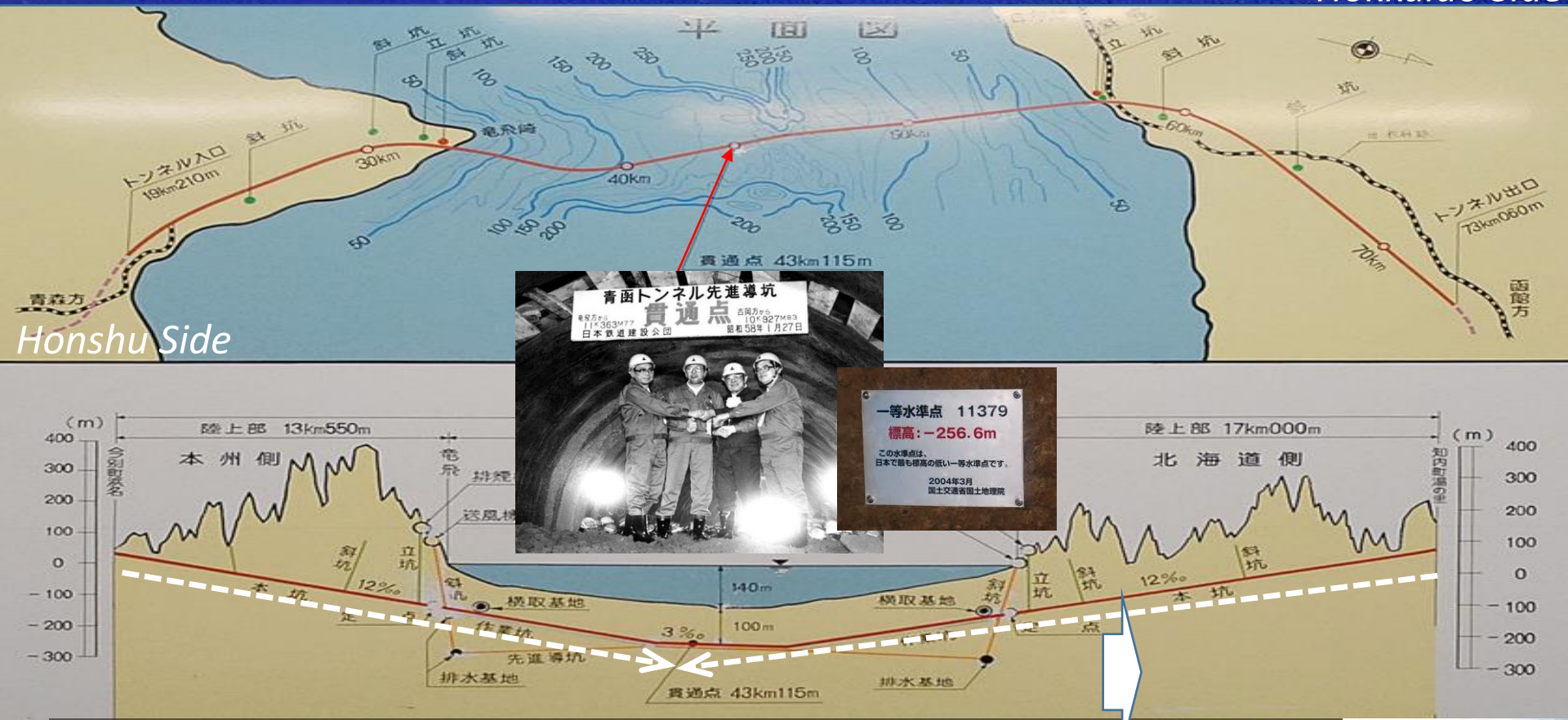
Euro Tunnel


Lotschverg Tunnel


Hakkoda Tunnel

What we have learned from the construction of the Seikan Tunnel !

Hokkaido Side



- This project needed 24 years from beginning to completion
- Accidental death under construction: 34 people.

The number of deaths by an accident under

What we should learn from the project "Seikan-tunnel construction"

■ Longest & Deep under sea Tunnel

● Total Tunnel Length: 54 km

- *How to do the survey? Without GPS!*
- *How to do the Geological survey under sea?*
- *How to do the tunnel digging?*

● Under the sea level : 250 m

- *How to withstand Water Pressure?*
- *How to estimate the Cost & Schedule?*

Location of Seikan Tunnel

Red line:

Hokkaido-Shinkansen Construction

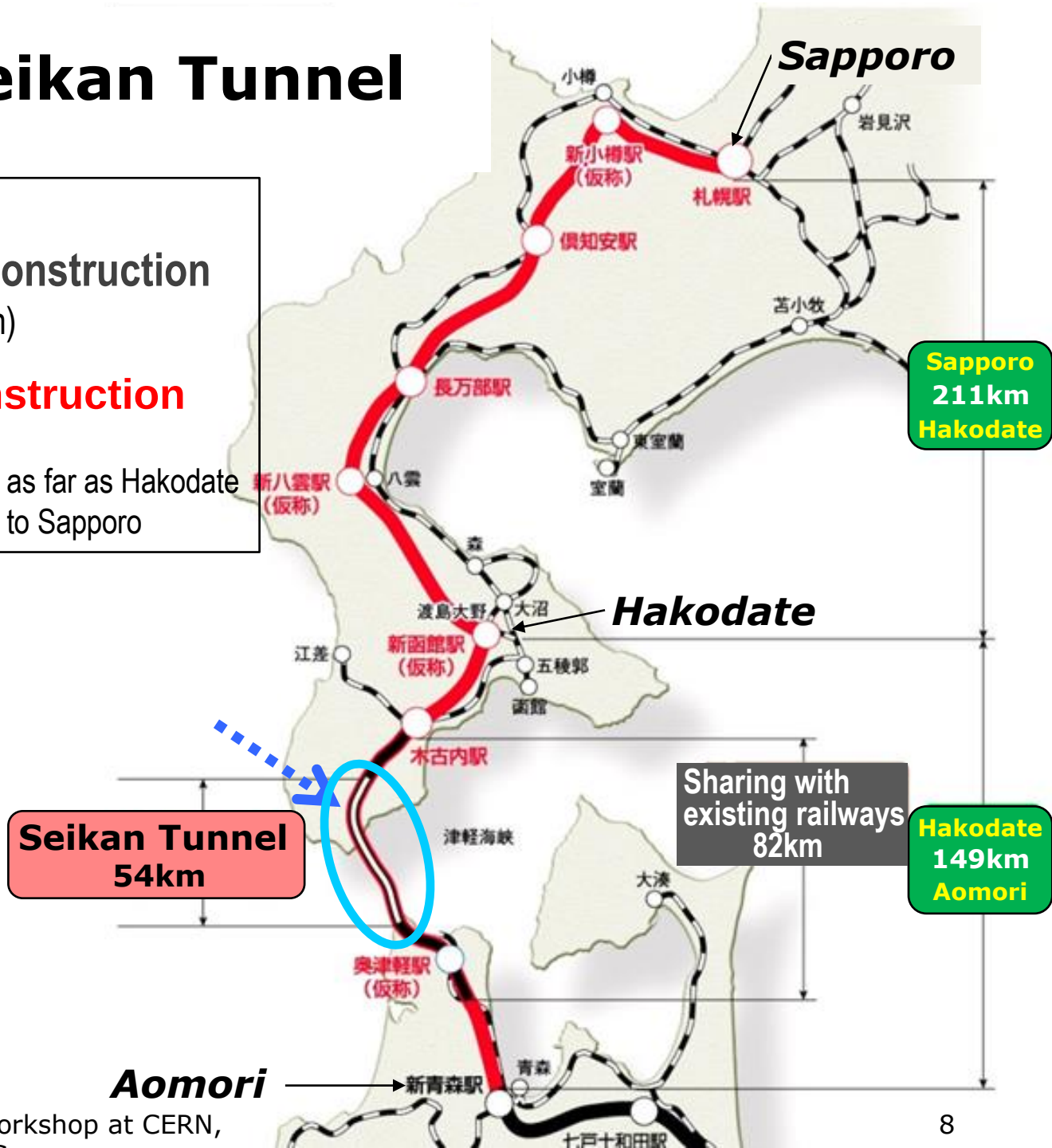
Sapporo～Shin-Aomori (360km)

Seikan Tunnel Re-construction

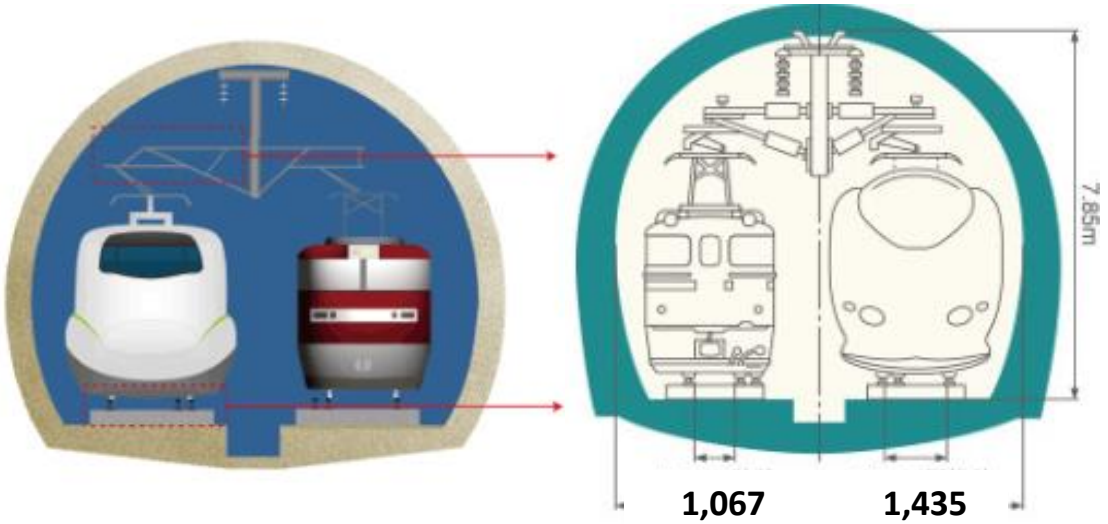
2005.4 Project started

2016.3 Scheduled to be completed as far as Hakodate

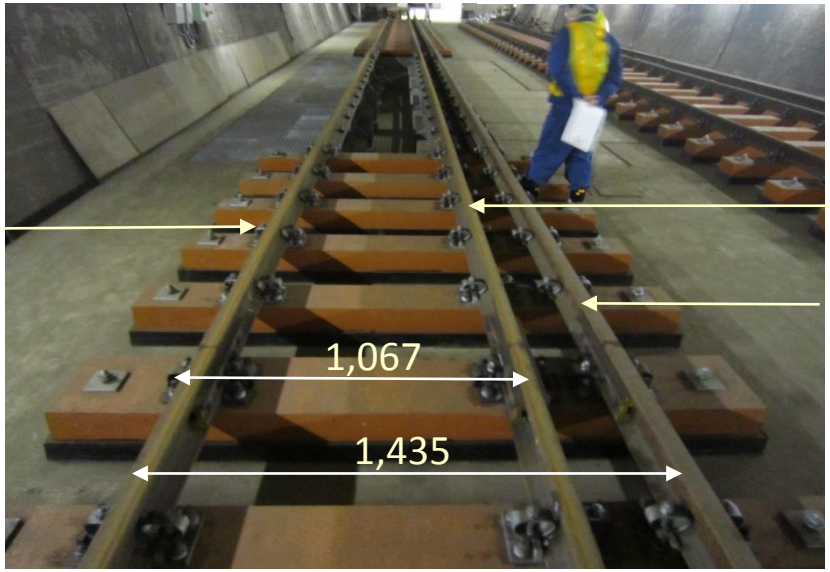
? Scheduled to be completed to Sapporo



Shared construction of Shinkansen and the conventional line : 3 line tracks



New rail (shared).



Old rail
(existing railway use).

New rail
(exclusive use).

Almost finished


News: 2014.12.07
The Shinkansen (Bullet train)
exits the SEIKAN Tunnel .
This is a test run.
Will be open in spring next year.
Seikan Tunnel Entrance (Honshu side)

Project: Seikan Tunnel

Tsugaru Strait

Seikan-tunnel
Undersea section

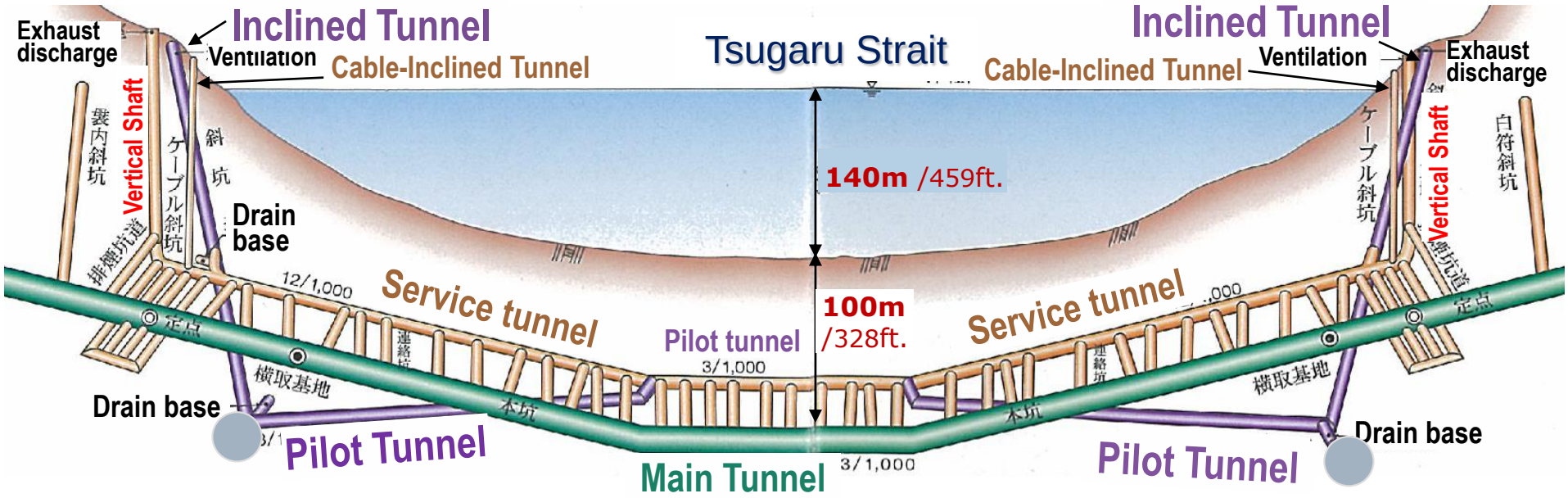
青森県津軽国定公園竜飛岬から北海道を望む。

History of Seikan tunnel construction:

- 1964 **Groundbreaking**
- 1983 **Completion of Pilot tunnel**
- 1985 **Completion of Main tunnel**
- 1987 **Total Completion**

Functions of each Tunnel (Current condition)

Honshu side **Hokkaido side**



■ Inclined tunnel

- Access & Installation
  Maintenance machine & materials
- Power Supply
- Air Ventilation
- Groundwater Drainage
- Passenger Evacuation

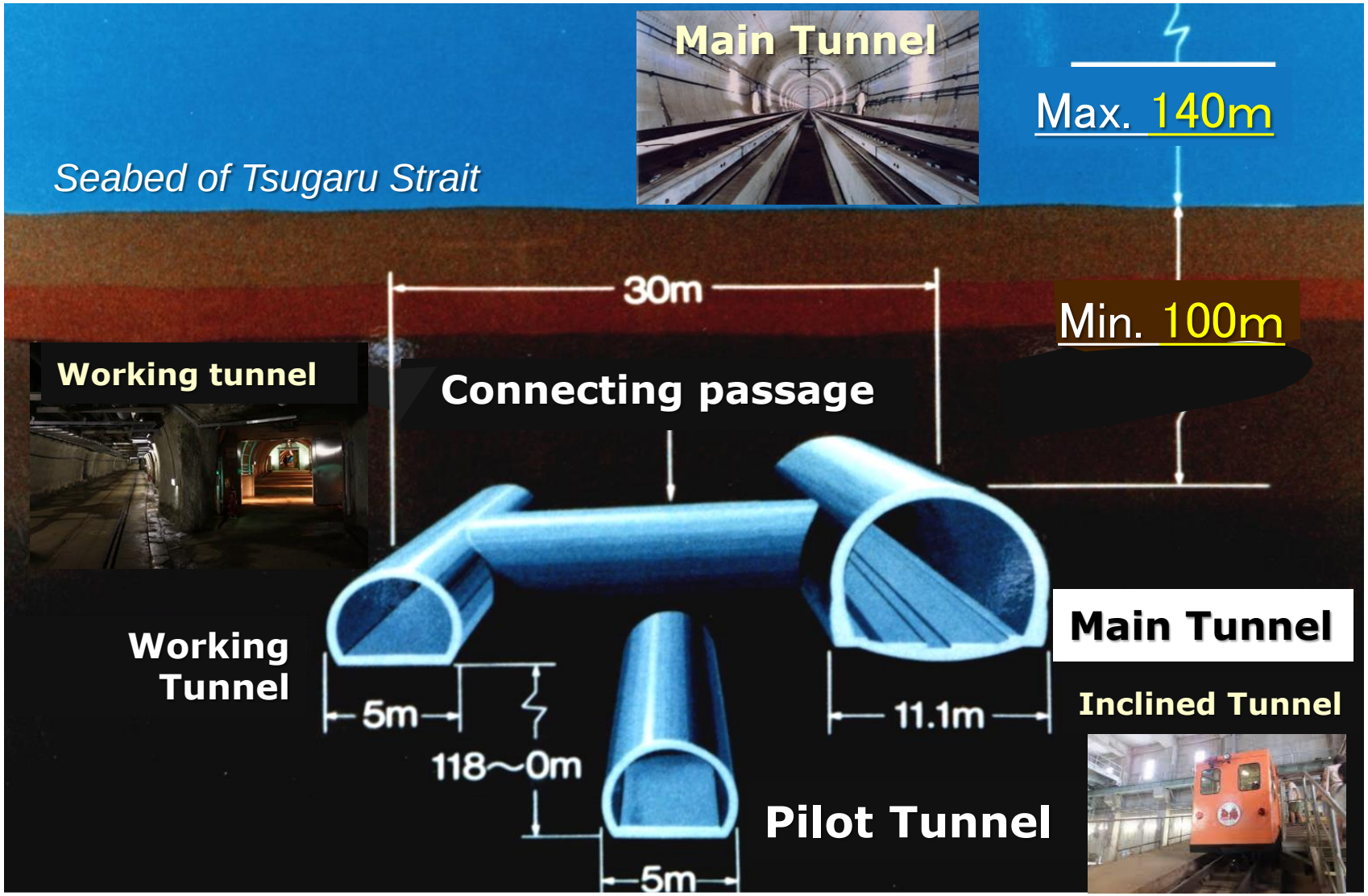
■ Pilot & Service tunnel

- Maintenance passage (Working Vehicle)
- Air Ventilation
- Groundwater Drainage
- Passenger Evacuation

■ Main tunnel = Railway

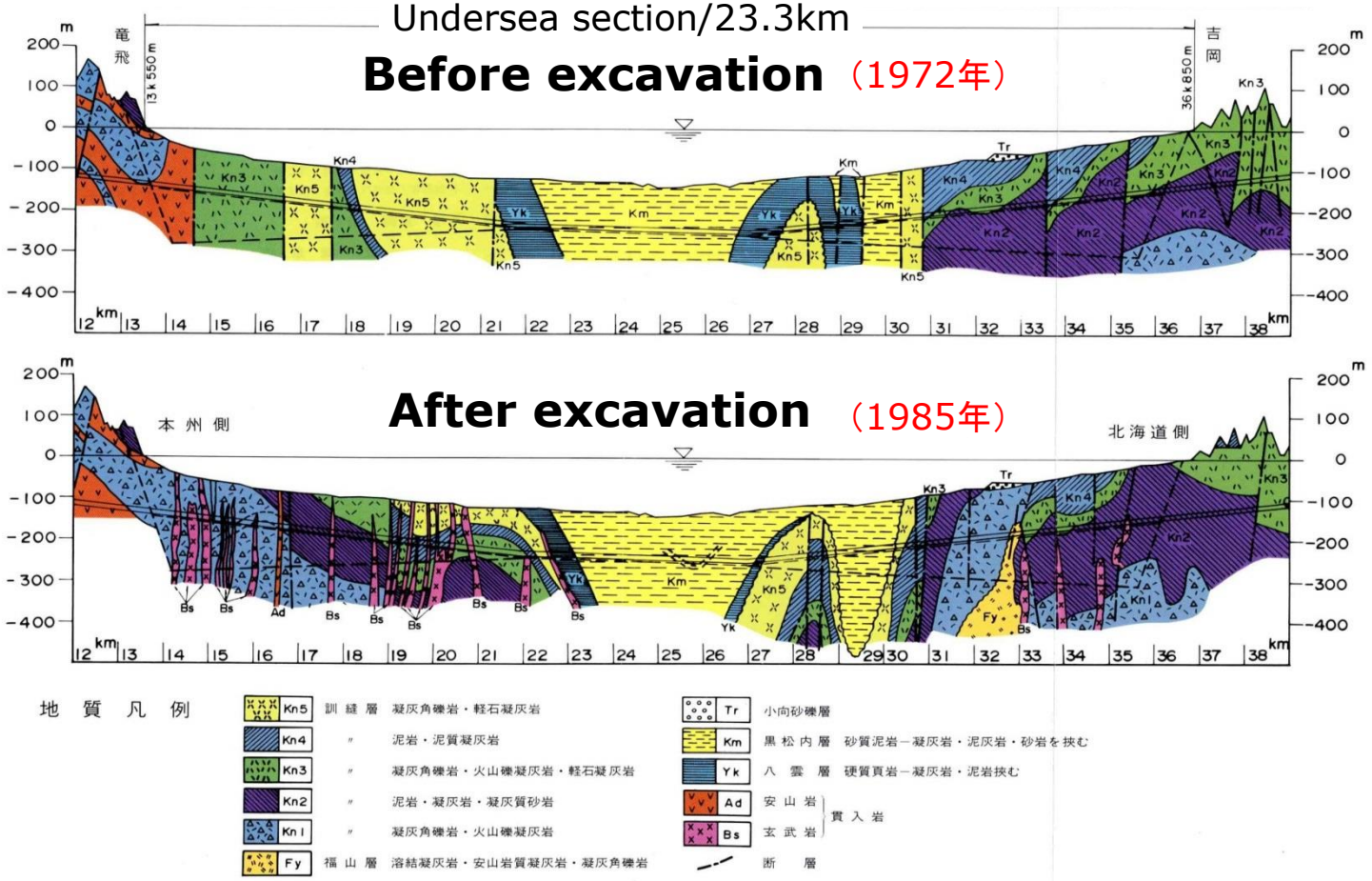
- Existing line & Freight line + Shinkansen line

Cross-Section Image



Geological Structure

Geological feature constitution of the Seikan Tunnel

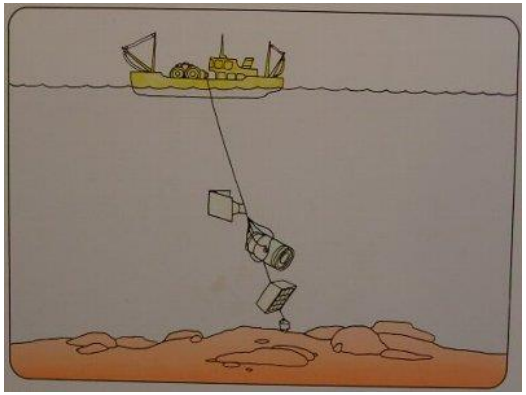


A prior prediction of the geological feature constitution is successful

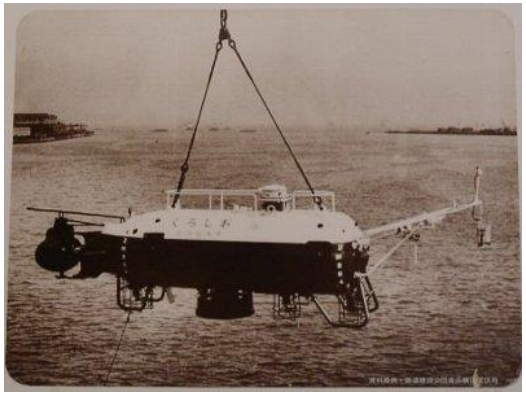
Geological Structure

- Investigation with various technologies

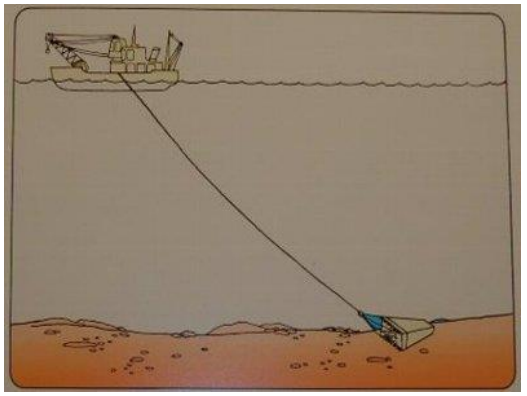
Submarine photography



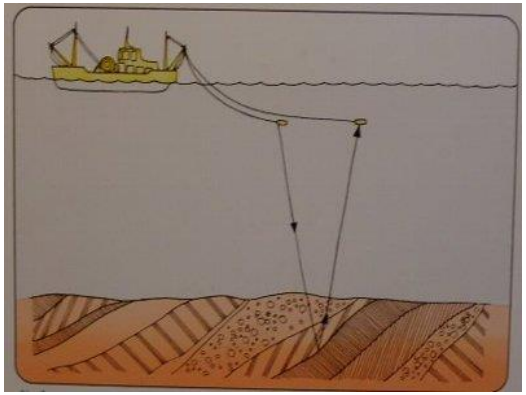
Survey by submarine



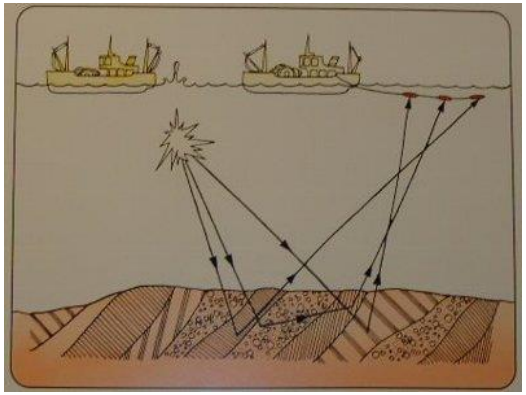
Dredging



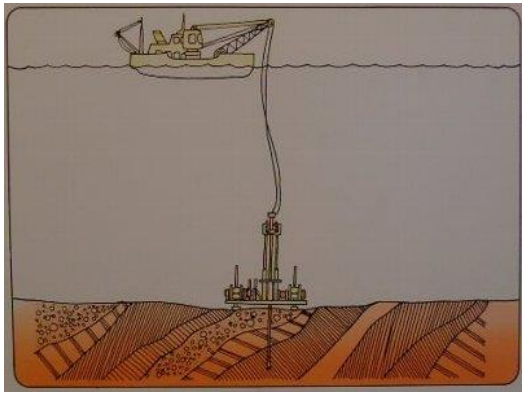
Acoustic detection



Seismic exploration



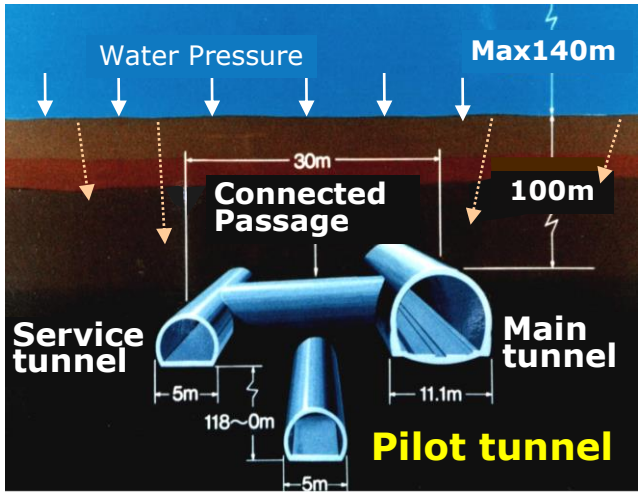
Submerging boring



Construction Method

■Three major Innovations by Seikan-tunnel

1. **Grouting** (Watertight technology by pre-grouting)
2. **Pilot Boring** (Long scale horizontal boring before excavation)
3. **Shotcrete** (Lining technology by Concrete splaying)

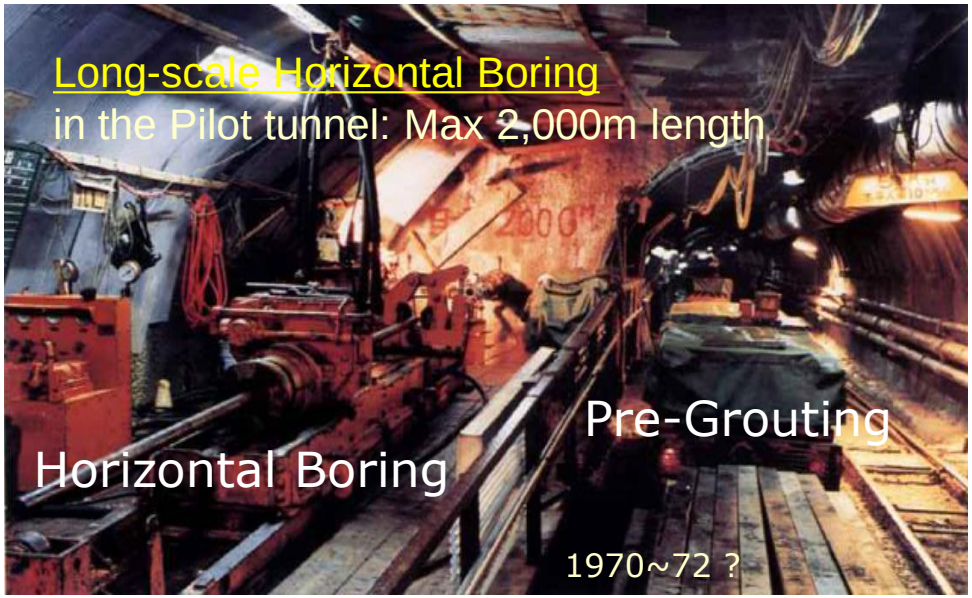


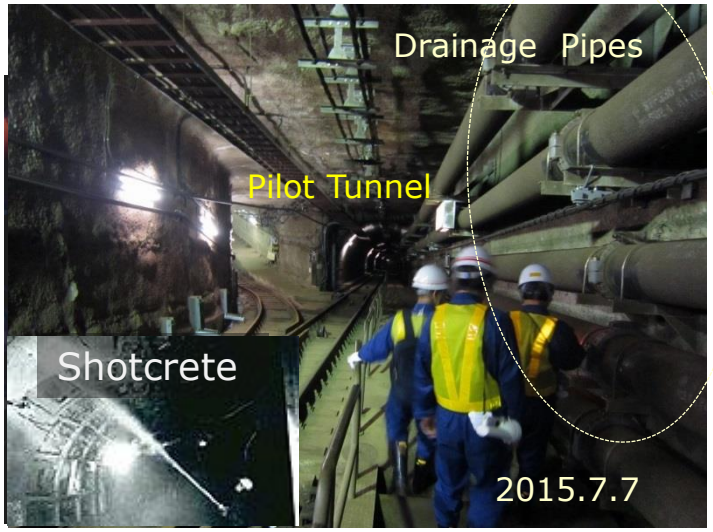
Construction Method -Pilot Tunnel

- The purpose of Pilot tunnel :

1. Exploration of geological structure
   (Fault & Fractured zone)
2. Research of construction technology
   (Spring water measures)
3. Estimates of the total Construction cost & schedule

Abandon
the **TBM** method





ILC Tunnel compared with Seikan Tunnel

Common Points : mainly Civil Engineering

- Project Scale: Tunnel Length & Cross-section
- Tunneling Method: Mountain Tunneling Method (NATM)
- Alignment precision: Special Survey
- Maintenance after completion: Service life more than 50 years

Different Points : mainly Incident Facilities

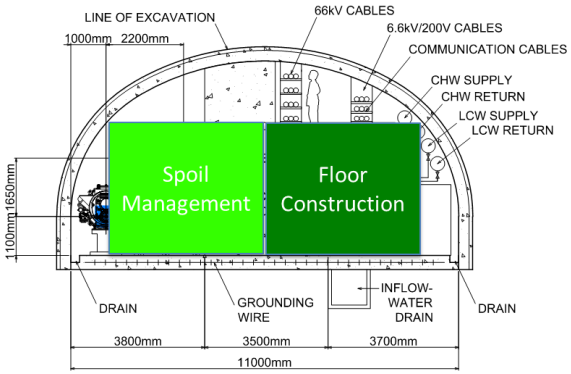
- Tunnel Linearity: ILC tunnel needs strict linear geometry.
- Infrastructures & Incidental Facilities for ILC:
  - High Power Supply
  - Cooling water system
  - HVAC system
  - Radiation Control
  - Cryogenics system

… Construction Process of NATM …

Blast& Drilling

Macking

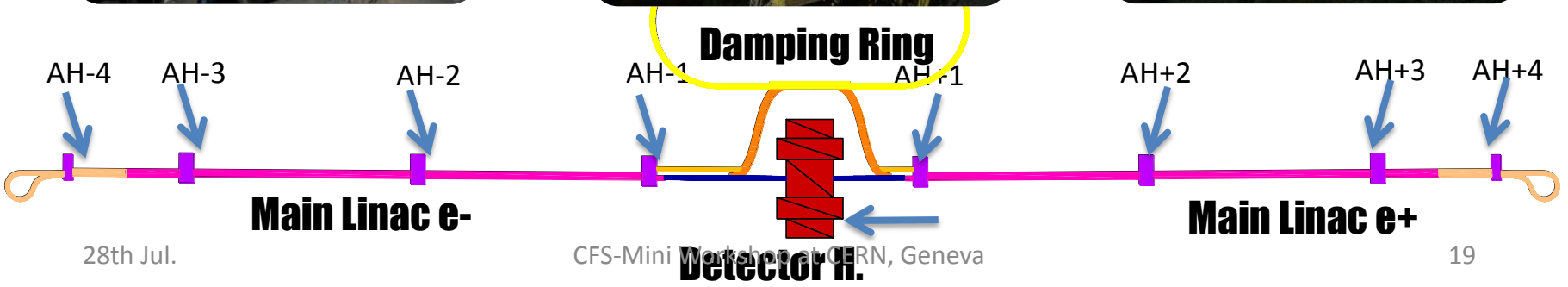
ILC ML



Shotcrete

Rock-bolt

Steel-supporting

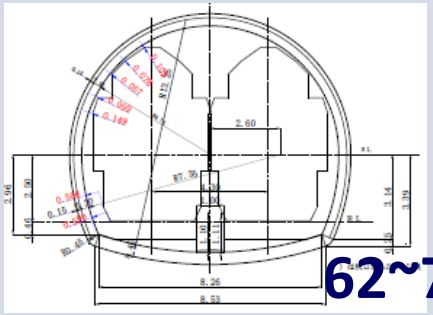
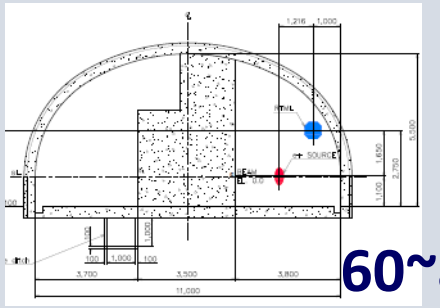


Characteristics of the construction site

Seikan Tunnel	Comparison Topics	ILC Tunnel
Feature	**Subject**	**Feature**
- Under sea	Topography	- Mountain
- Volcanic rocks - Mad stone, Sand	Geology	- Granite (very hard)
- NATM (Drilling) （Horseshoe-shape）	Construction Method	- NATM (Blasting) （KAMABOKO-shape)
- 100m ～ 120m	Depth	- 40m ～ 400m
- Inclined Tunnel (slope:1/4)	Installation & Access	- Horizontal Tunnel - Vertical shaft (Detector)
- Inclined Tunnel	Evacuation	- Horizontal Tunnel

Characteristic of the Tunnel

Comparison of ILC Tunnel and Railway Tunnel

Item	Railway Tunnel	ILC Tunnel
Cross Section	 62~74㎡	 60~80㎡
Linearity	Flexible: Depending of Terrain	- Laser straight (BDS) - Parallel to Geoid (ML)
Slope Limit	Max; 0.3%	Flat as possible
Air Condition	not necessary	Advanced HVAC systems
Ventilation	- Blower - Exhaust fan	Advanced Ventilation system

Seikan-tunnel judged by details

ILC Project by KEK-CFS

	Seikan	ILC
Main Tunnel Length	54 km	35 km
Other tunnels (Pilot & service, & Access tunnel,etc.)	80 km	10 km
Total excavation volume (m^3)	6,300,000	3,500,000
Grouting (Cement & Water glass)	850,000 m^3	?
Cement	850,000 ton	?
Construction Period	24 years	7 years
Number of the total workers	14,000,000	?
Total construction cost	¥ 690 billion	?

Summary

- We selected the potential site with the best geological conditions in ILC project.
  So, expected no difficulties on the Seikan tunnel construction.

  However,
- Tunneling work needs to prepare for unexpected conditions.
- Therefore we should often learn from experience of the Seikan Tunnel over much failure.

End

Appendix

Appendix

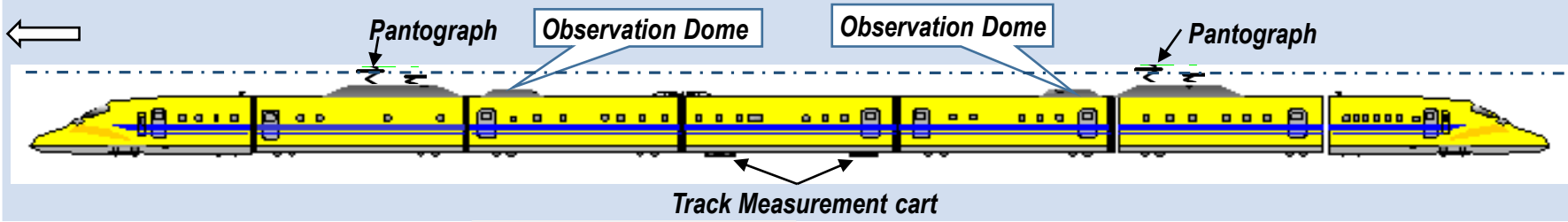
Unique train in JR: Doctor Yellow: for the Inspection of the Rail Track stability & Contract wire

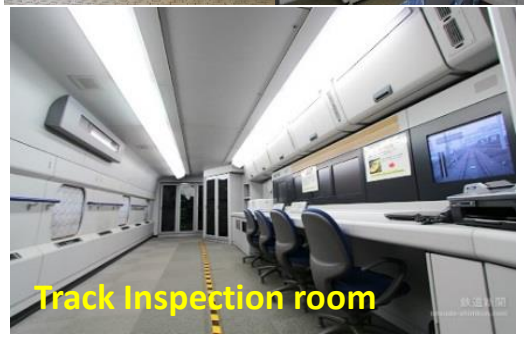
Doctor Yellow:

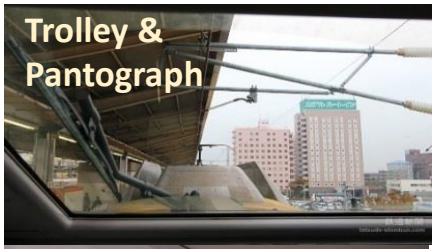
High-speed Test Train for Shinkansen (Bullet train)

Inspection Density:
● Rail track : @ 25 cm ● Trolley line: @ 5 cm

1	2	3	4	5	6	7
Signal condition, Communication	Contact wire & Pantograph	Electric Power monitoring	Track-relation Inspection	Electric Power monitoring	Contact wire & Pantograph	Signal condition, Operators Room







Rail and Contact Wire Inspection Technology

Inspection by Doctor Yellow:

● **Whole Shinkasen line: Measuring by the Running Test every 10 days**

	Rail track Inspection	Contact Wire Inspection
Measurement Item	(1) Track Gauge (2) Cross Level (3) Height (4) Flatness (5) Axial displacement	(1) Abrasion (2) Deviation (3) Height (4) Watching by Observation Dome
Measurement Interval	25 cm	5 cm

Management Value			
Track Gauge	2 mm	Height	4 mm
Cross Level	3 mm	Flatness	3 mm
		Axial Displace.	3 mm