A photograph of a large rock cavern, likely a hydroelectric power station. The cavern walls are dark and textured. In the center, there is a large concrete structure with a large pipe extending from it. Several workers in red safety suits are standing on a platform near the structure. The lighting is dim, with some bright spots from artificial lights.

Picture from Norwegian cave

# **Current and Future Rock Cavern Projects - Collaboration between Norway and Singapore -**

**Petter Plassbak from Multiconsult AS, Norway  
Dr. Cai Jun Gang from Tritech Consultants, Singapore**

**SINTEF-TRITECH-MULTICONSULT (STM)  
CONSORTIUM**

February 2009

# Agenda

- The first challenge
- The STM Consortium
- Principles of co-operation
- Transfer of competence
- The projects – so far
- Success criteria



# The first challenge

“**Bold**” and “**innovative**” - these are just two adjectives used to describe JTC Corporation's (JTC) latest undertaking. Hitting the mark is the Jurong Rock Cavern (JRC) project, **Singapore's first** underground rock cavern facility for hydrocarbon storage.”

# The first challenge

”JTC must keep on pushing the limits of possibilities, to try out new ideas, and seek opportunities beyond known frontiers.”

# The STM Consortium

- Sintef Byggforsk Norway
  - TriTech Singapore
  - Multiconsult Norway
- 
- Leading Norwegian research institution.
  - Leading Norwegian consultant with underground competence.
  - Leading Singapore consultant with underground competence.

# STM Consortium

- Established in August 2006.
- Norwegian partners already working together in Norway.
- Sintef and TriTech working together in 2004 for geologic investigation at feasibility study stage of JRC.
- Execution of Jurong Rock Cavern project
- Feasibility study of Underground Rock Cavern Usages in Singapore

# Principles for co-operation

- Consortium agreement:
  - Steering Committee – regular meetings (half-yearly)
  - Defining split of work and responsibility
  - Shared overall responsibility for SoW
- Defined goal for long term co-operation in this region

# Transfer of competence

- Project team based on defined split of SoW
- All parties nominate resources
- Team work
- Trainee for defined positions/subjects
- Norwegian staff present in Singapore



# The first project – JRC



# Jurong Rock Cavern (JRC) Project

- The caverns are designed store a variety of products like crude oil, condensates, naphtha and gas oil.
- Overall storage capacity of 1.5 mill m3.
- There are now some 200 such caverns spread around the world, in countries like **Norway**, Sweden, Japan and China
- An alternative storage medium, caverns allow resource-scarce countries like Singapore to **free up large areas of land** for other, more value-added activities.

# JRC Project

## STM Scope:

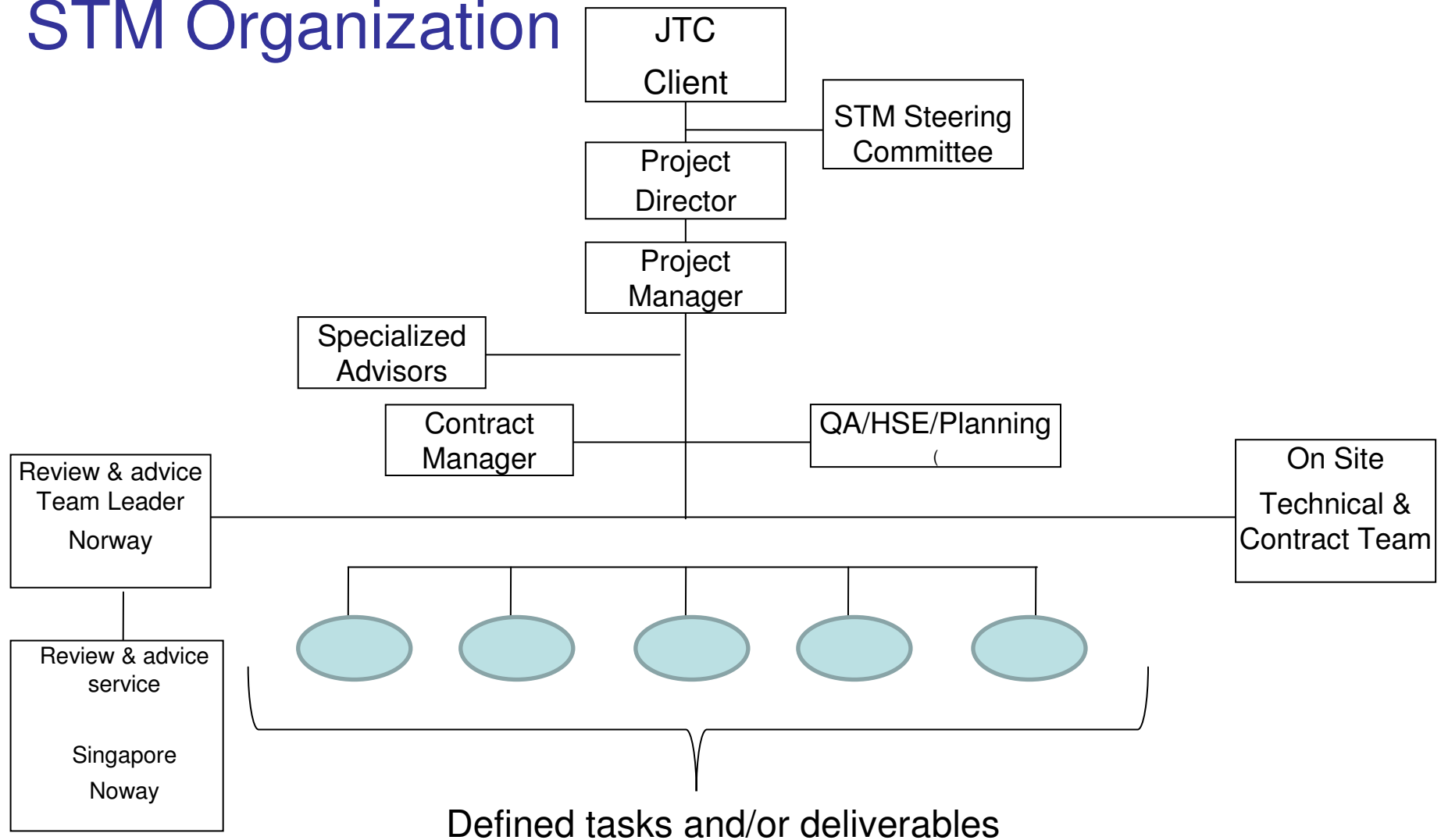
- Project Management on behalf of JTC
- Review and approval of Basic Engineering Design
- Provide technical advice through out the project

# JRC Project

## Organisational principles

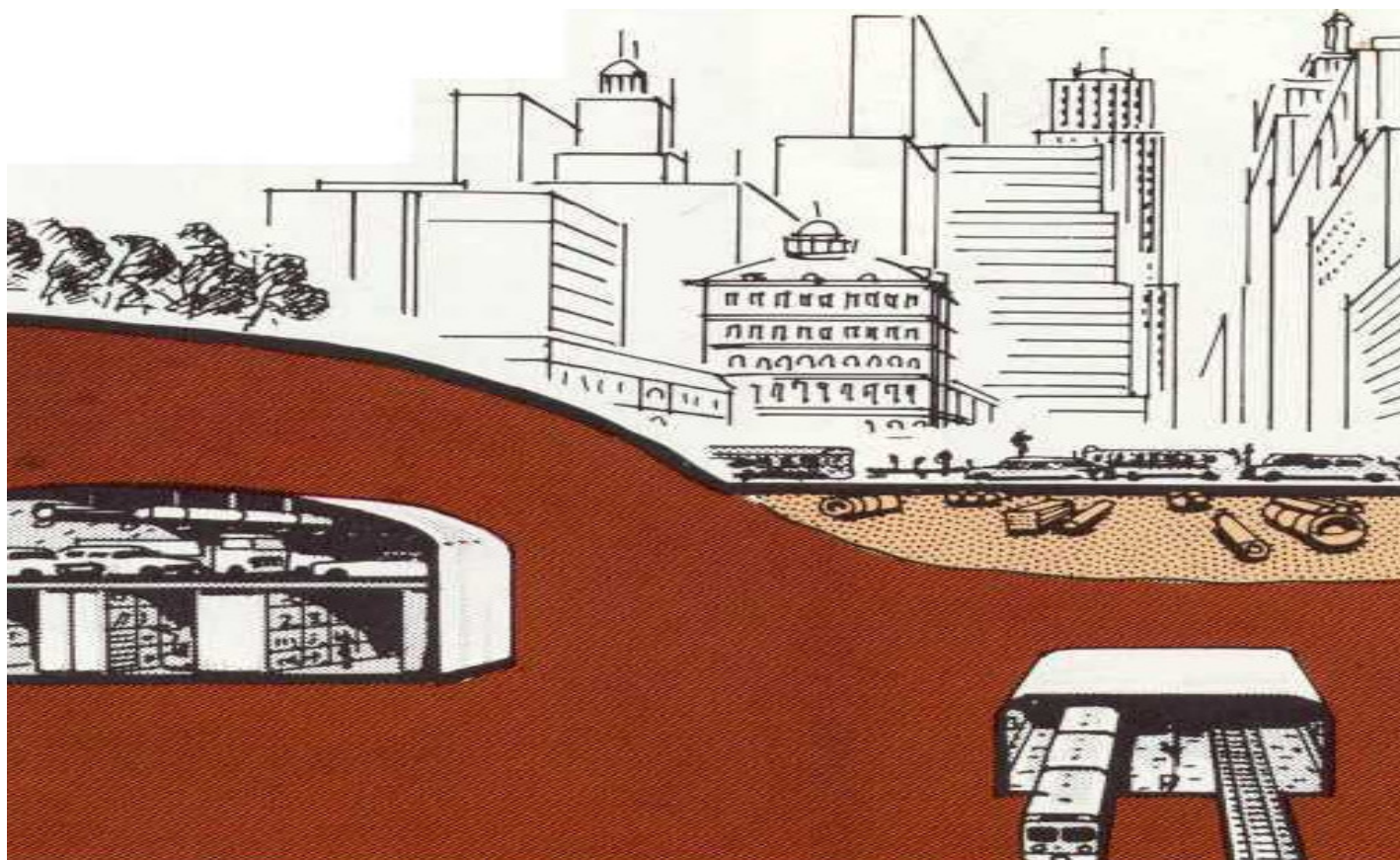
- The project team:
  - Singapore project director
  - Norwegian project manager
  - Norwegian manager technical review
  - Singapore contract manager and project engineers
  - Balance
    - technical skills – state of the art
    - Management –execution large complex project
    - Local knowledge and authority requirements

# STM Organization



# The second project – URC

from August 2008 to May 2009





# Media Report

## Down in the cavern

POTENTIAL UNDERGROUND ROCK CAVERN USES	LEAD AGENCIES
■ Power stations and electrical substations	Energy Market Authority
■ Incineration plants	National Environment Agency
■ Water reclamation plants	Public Utilities Board
■ Landfills	National Environment Agency
■ Reservoirs	Public Utilities Board
■ Warehousing and storage	JTC & Defence Science and Technology Agency (DSTA)
■ Port logistics	Maritime and Port Authority of Singapore
■ Airport logistics	Civil Aviation Authority of Singapore
■ Data centre	Infocomm Development Authority of Singapore, JTC and DSTA
■ Wafer fab plants and R&D labs	JTC

Source: JTC Tender

TODAY • Wednesday • May 14, 2008

## An underground reservoir?

### Govt tender to study feasibility of more facilities in rock caverns

ANSLEY NG

ansley@mediacorp.com.sg

LAND-SCARCE Singapore is already storing some of its military munitions in this way. And work is underway on similar storage facilities for crude oil and oil products.

Now, the Government wants to look at building power stations, warehouses, incineration plants, airport logistics centres and reservoirs – all below ground.

Industrial landlord Jurong Town Corporation (JTC) last Friday called a tender for a “underground rock cavern usage feasibility study” to see how subterranean grottos could be used to maximise land use. Among other things, the winning consultant will have to study the costs and the use of underground caverns in other countries. It will also advise JTC on the possible environmental and health issues, such as pollution, radiation and damage to existing buildings and infrastructure.

Last July, TODAY broke the story of how government agencies including the JTC were exploring the feasibility of creating caverns for living.

Professor Zhao Jian, who led early feasibility studies on cavern development in Singapore, had said then that the potential for space underground was “almost limitless” and was “particularly useful for any facilities that are not desirable at surface level, for example, sewage treatment plants”.

The study now up for tender will look merely at feasibility and not sites, a JTC spokeswoman told the *Business Times*.

However, potential sites could be areas with deposits of igneous rock, such as granite, in the central, northern and northeastern areas of the island.

A 1995 paper by Nanyang Technological University researchers including Prof Zhao, in the *Quarterly Journal of Engineering Geology*, concluded that the Bukit Timah granite – which forms one-third of the surface area of Singapore – had good potential for underground cavern construction.

The tender closes June 6, and the consultant is expected to work with the Civil Aviation Authority of Singapore and the Energy Market Authority, among others.

#### OTHER CAVERN PROJECTS:

- In March, the Ministry of Defence opened caverns under the disused Mandai Quarry to store ammunition such as bullets, bombs and missiles. The warehouse caverns – each about the size of six basketball courts – were blasted out of solid granite underneath the quarry, freeing up surface land the size of Pasir Ris town.
- The JTC is constructing the \$2-billion Jurong Rock Cavern beneath Jurong Island, for use by petrochemical companies. The first caverns under Phase 1 should begin operations in 2010.
- A plan in the late 1990s to construct a Science City, a mixed-use commercial project, under Science Park 2 was derailed by cost factors.

# Parties Involved

Project Drivers – JTC & URA

Lead Agencies for Specific Usages

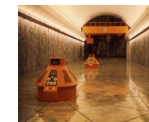
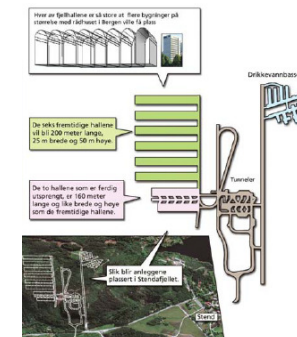
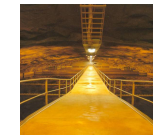
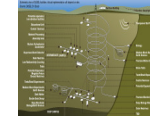
Regulatory Agencies (Acts & Regulations)

Consultant – STM Consortium

Feedback from Local Industries - leading Consultants &  
Operators for Aboveground Facilities  
(Codes, Standards & Local Practices)

# Potential Ten Rock Cavern Usages

1. Wafer fab plants – Lead Agency JTC
2. Generic R&D facilities – Lead Agency JTC
3. Warehousing and storage & port logistics – Lead Agency JTC & DSTA
4. Water reclamation plants – Lead Agency PUB
5. Reservoirs – Lead Agency PUB
6. Incineration plants – Lead Agency NEA
7. Landfills – Lead Agency NEA
8. Power station and electrical substations – Lead Agency EMA
9. Airport logistics – Lead Agency CAAS
10. Data centre – Lead Agency IDA, JTC & DSTA

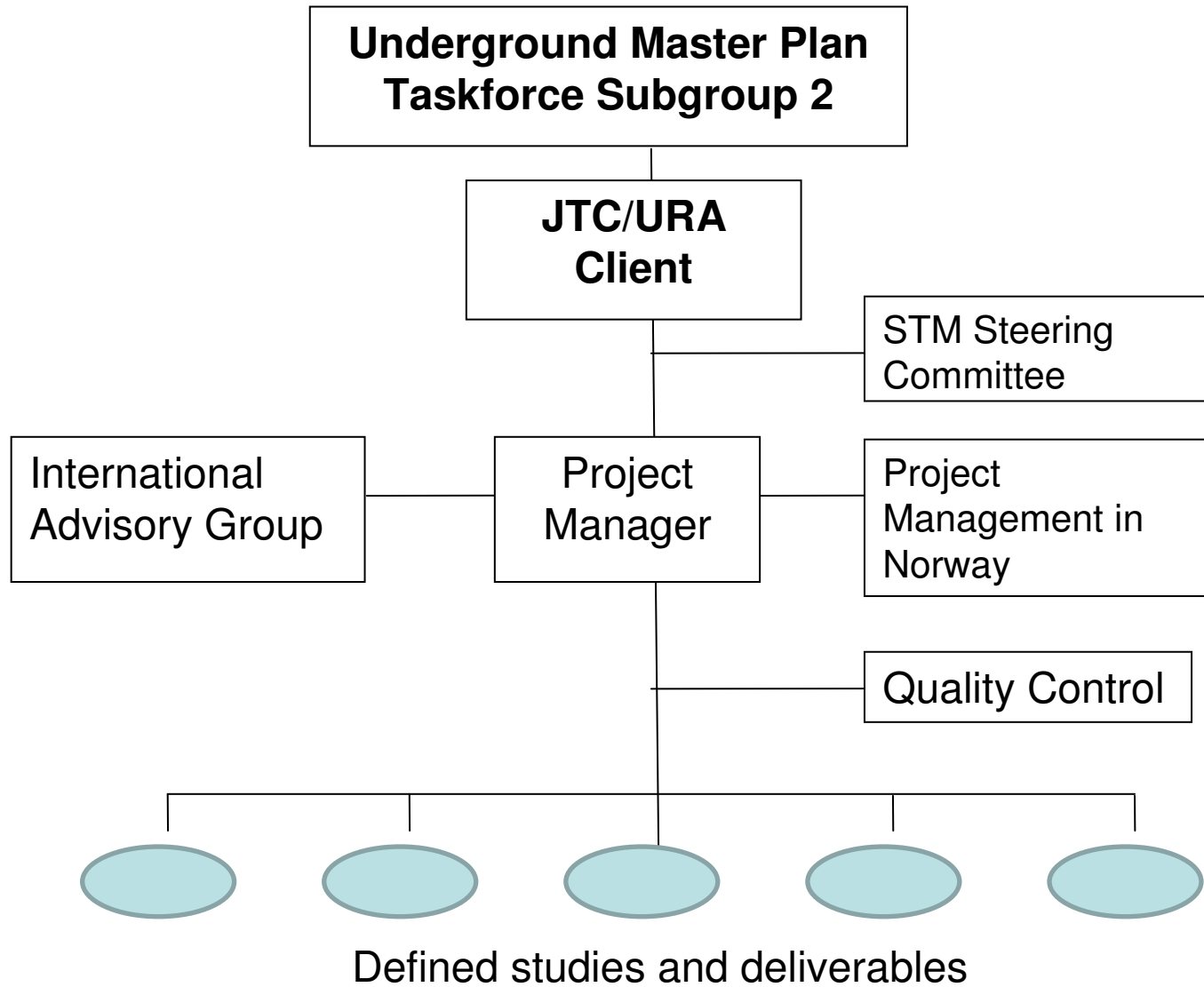


# URC Project

## STM Scope:

- Technical feasibility for 10 industrial usages to go underground
- Limitations, issues of concerns and mitigation measures
- Conceptual layout design
- Cost estimate, construction timeline and comparison with aboveground facilities
- Land saving

# STM Organization - URC





# Sucess criteria of STM Consortium

- Top management commitment
- Respect
- Integrated team work
- Benefit from cultural differences
- Long term perspective



# STM Consortium

- **Thank you for your time !**

**STM are prepared for the next project !**