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2nd International Workshop Towards the Giant Liquid Argon Charge Imaging Experiment (GLA 2011)

**Department of Physics, University of Jyväskylä,
Finland**

5th – 10th June 2011



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**Presentation by the
ALAN AULD GROUP LTD**

**Experience and Issues in Underground
Construction**

Alan Auld

John Elliott

Chris Thompson

Chairman and Managing Director of Alan Auld Group Ltd

Managing Director of Alan Auld Engineering Ltd

Managing Director of Alan Auld Commercial Ltd



Presentation Summary

- (1) AAG Experience in Underground Construction**
- (2) Underground Construction Issues**
- (3) Where AAG fits into the LAGUNA – LBNO Project**
- (4) Risk Management**



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AAG Experience in Underground Construction

- (1) Company History and Background**
- (2) Staff Experience**
- (3) Deep Mine Development Experience**



Company History and Background

- **Company started over 20 years ago by Alan Auld, formerly Chief Design Engineer for Cementation Mining Ltd, a deep underground mining development contractor**
- **Over the last 20 years we have steadily built the company from a 1 man band to a specialist boutique engineering company servicing the mining and civil tunnelling markets with a worldwide workload**
- **We now employ around 15 full time staff and another 10 part time specialists as required**
- **The company operates internationally in mining and civil engineering shaft sinking, tunnelling and underground construction from concept & feasibility studies through to project completion**



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Alan Auld Engineering Ltd operate in an international market and have carried out work in many parts of the world

**Finland. 2001.
(Underground
nuclear waste
repository)**

**Posiva Oy. Onkalo (Underground Rock Characterisation Facility),
Olkiluto. Feasibility Study for 5.8m ID, 500m deep shaft**

**Canada. Current.
(Potash Mines)**

**1. PCS. New Brunswick. 2 No. 5.5m ID shafts, 885m deep
currently being sunk. Shaft designers for the project**

**2. PCS. Saskatchewan. 1 No. 6.0m ID shaft, 995m deep currently
being sunk. Design review**

**3. BHP. Saskatchewan. 2 No. 6.5m ID shafts, 1030m deep
commencing construction. Shaft designers for the project**



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**Chile, South
America.
Current.
(Copper Mine)**

Codelco. 2 No. 11m ID shafts, 950m deep. Feasibility stage design

**Nevada, USA.
Current.
(Gold Mine)**

**Newmont Gold. 1 No. 8.534m ID shaft, 732m deep through
difficult, water bearing ground. Feasibility stage design.**

**Louisiana, USA.
Current. (Salt Mine)**

Inspection and design of shaft lining repairs

**Ukraine. 2007.
(Coal Mine)**

**CCI – Lubelya. Design review of 2 No. 8m ID shafts, 900m deep.
Mine currently commencing construction.**



Staff Experience

Alan Auld	13 years as Chief Design Engineer for a deep underground mining development contractor. 20 years underground construction consultancy
Brian Maskery	10 years as a Quantity Surveyor, 19 years as General and Commercial Manager of mining and tunnelling companies including 7 years running his own tunnelling company. 11 years underground construction consultancy
John Elliott	17 years contracting experience as Site Engineer, Section Engineer, Agent, Project Manager for civil engineering and tunnelling works. 11 years underground construction consultancy
Chris Thompson	27 years in contracting as a Quantity Surveyor including tunnelling works. 6 years as Commercial Manager for civil and tunnelling contractors. 3 years underground construction consultancy



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AAG Deep Mine Development Experience

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Deep Shafts Sunk from the Surface in the UK During 1977-1987 (10 year period)

Project	Client	Contractor	Diameter (m)	Depth (m)	Date
Selby Wistow No.1 and No. 2 shafts	British Coal	Cementation Mining Ltd	7.315	411 (No. 1) 383 (No. 2)	1977-81
Selby Riccall No. 1 and No. 2 shafts	British Coal	Cementation Mining Ltd	7.315	823	1977-83
Selby Stillingfleet No. 1 and No. 2 shafts	British Coal	Thyssen (GB) Ltd	7.315	708	1978-82
North Selby No. 1 and No. 2 shafts	British Coal	Cementation Mining Ltd	7.315	1043	1978-86
Selby Whitemoor No. 1 and No. 2 shafts	British Coal	Thyssen (GB) Ltd	7.315	965	1979-85
Dearne Valley shaft	British Coal	Thyssen (GB) Ltd	3.658	300	1980-82
Castlebridge shaft	British Coal	Thyssen (GB) Ltd	6.1	407	1980-83
Dodworth – Redbrook shaft	British Coal	Amalgamated Construction Co. Ltd	6.1	413	1981-83
Maltby No. 3 shaft	British Coal	Cementation Mining Ltd	8	1000	1981-87
Asfordby No. 1 and No. 2 shafts	British Coal	Cementation Mining Ltd	7.32	527	1985-1989
TOTAL = 16					



This 10 year period of deep coal mine construction in the UK saw a number of improvements in underground construction technology including the introduction of high strength, superior durability concretes and the transporting of structural quality concrete from surface to underground using small diameter pipelines.



**Deep Shafts Sunk from the Surface in the UK During 1987-2011
(24 year period)**

Project	Client	Contractor	Diameter (m)	Depth (m)	Date
	N	O	N	E	
Total = 0					



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However AAG still retain their experience and knowledge from the earlier period which is now being put to good use currently in mining development worldwide



Underground Construction Issues

- (1) Construction Requirements**
- (2) Muck Disposal Logistics**
- (3) Materials Handling Logistics**
- (4) Construction Contractual Issues**
- (5) Mine Legislation**
- (6) Health and Safety**
- (7) Risk Analysis**



1. Construction Requirements

1.1 Phyäsalmi Mine situation

1.2 Surface Works (Power, water, sewerage, data and communications)

1.3 Underground Works

1.3.1 Geotechnical and hydrological ground conditions

1.3.2 Excavation and muck removal

1.3.3 Ground stability control and temporary support

1.3.4 Ground water control

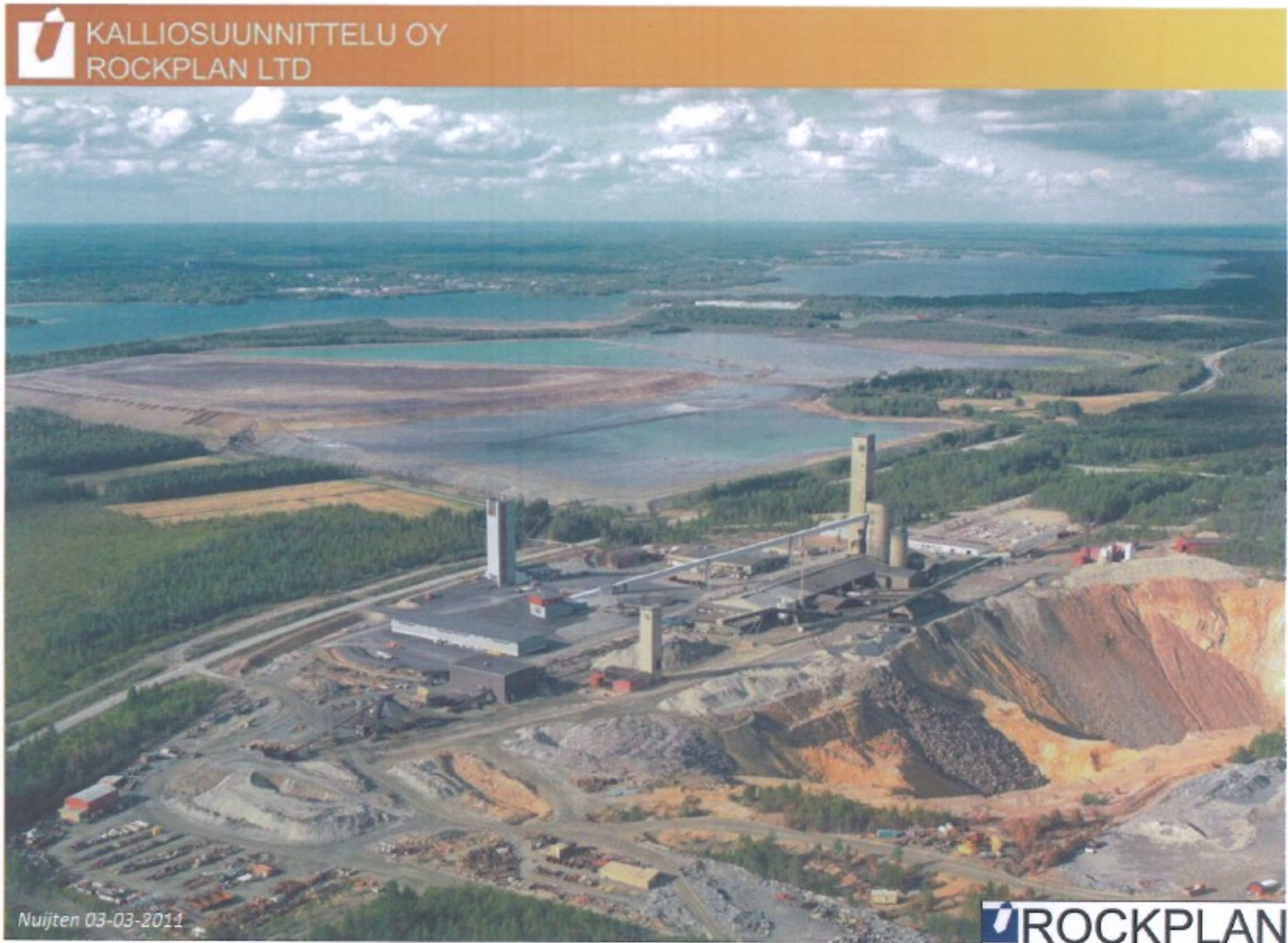
1.3.5 Lining and structural permanent works

1.3.6 Internal permanent works



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ROCKPLAN

Feasibility Study for LAGUNA at PYHÄSALMI
Underground Infrastructures and engineering
(Deliverable 2.1)

19 (277)

12.04.2010

PART 0 INTRODUCTION



The present layout of the Pyhäsalmi Mine

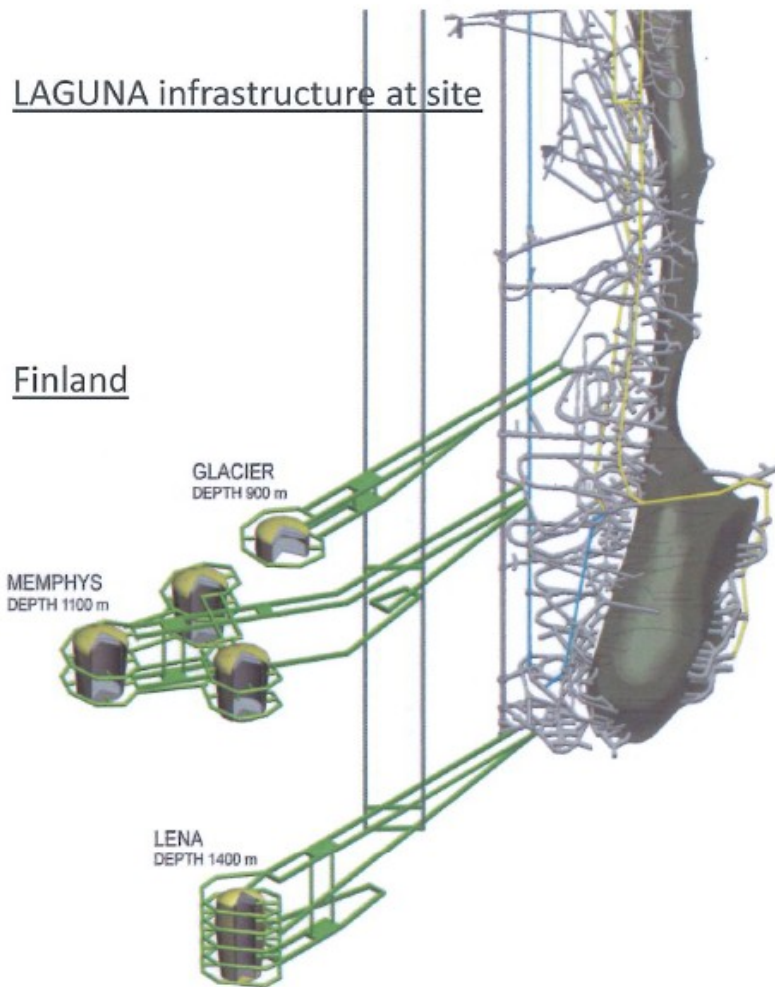
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LAGUNA infrastructure at site

Finland

Main purpose of the infrastructure

- **Sufficient** (to conduct the experiment)
- **Efficient** (cost & process effectiveness)
- **Safe** (during all phases)

Main aspects of the infrastructure

- good excavation strategy
- efficient rock disposal
- no disturbance with hosting site
- sufficient fresh air inlet
- effective outlet of return air
- safety
- supply routes for construction
- storage of material
- quality control of material at the vicinity
- supply route (pipe lines) for liquids

Nuijten 03-03-2011

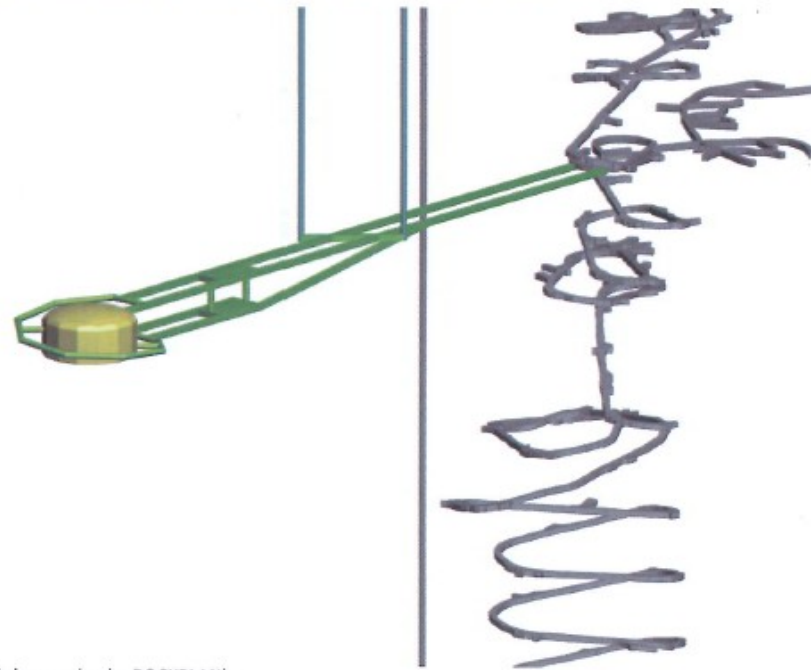
ROCKPLAN



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GLACIER at 2500 m.w.e.

GLACIER
 **ROCKPLAN**
7.10.2009



Giant Liquid Argon Charge Imaging Experiment (artistic impression by ROCKPLAN)

- yellow new cavern for tank construction
- green access tunnels and auxiliary rooms
- blue new shafts
- grey existing infrastructure at 900m

Nuijten 03-03-2011

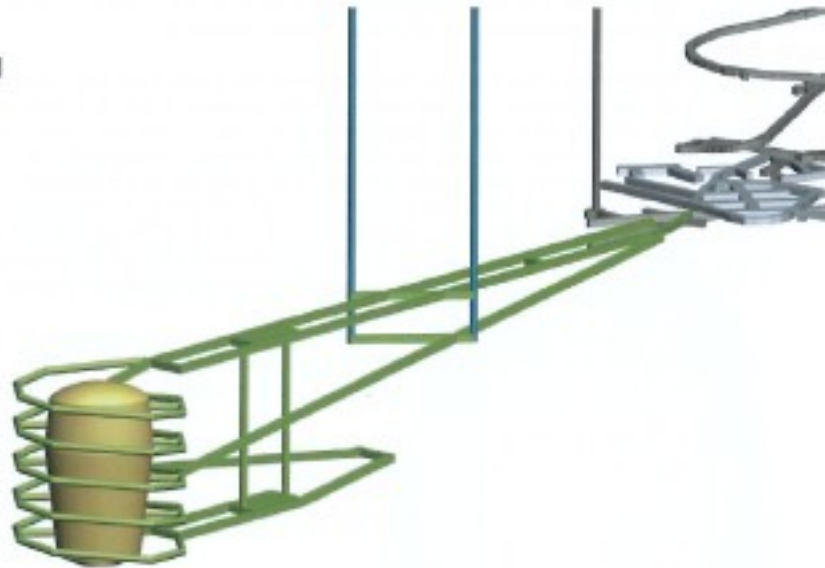
 **ROCKPLAN**



PART LLENA at 4000 m.w.e.

LENA

ROCKPLAN
7.10.2009



Low Energy Neutrino Astronomy (artistic impression by ROCKPLAN)

- yellow new cavern for tank construction
- green access tunnels and auxiliary rooms
- blue new shafts
- grey existing infrastructure at 1400m



ROCKPLAN

Feasibility Study for LAGUNA at PYHÄSALMI
Underground infrastructures and engineering
(Deliverable 2.1)

66 (277)

12.04.2010

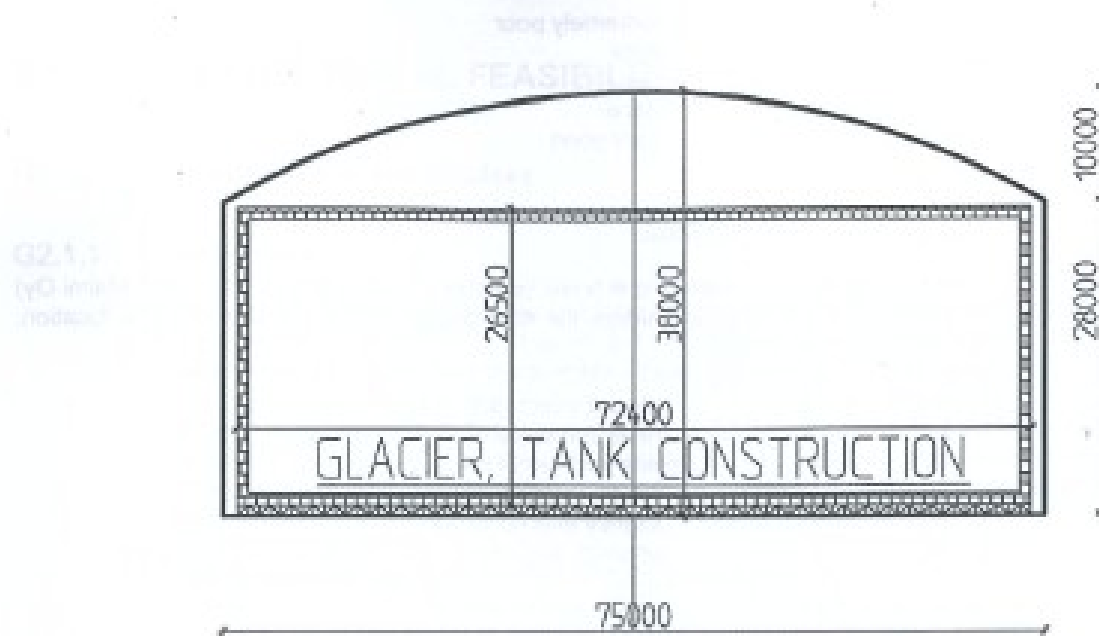


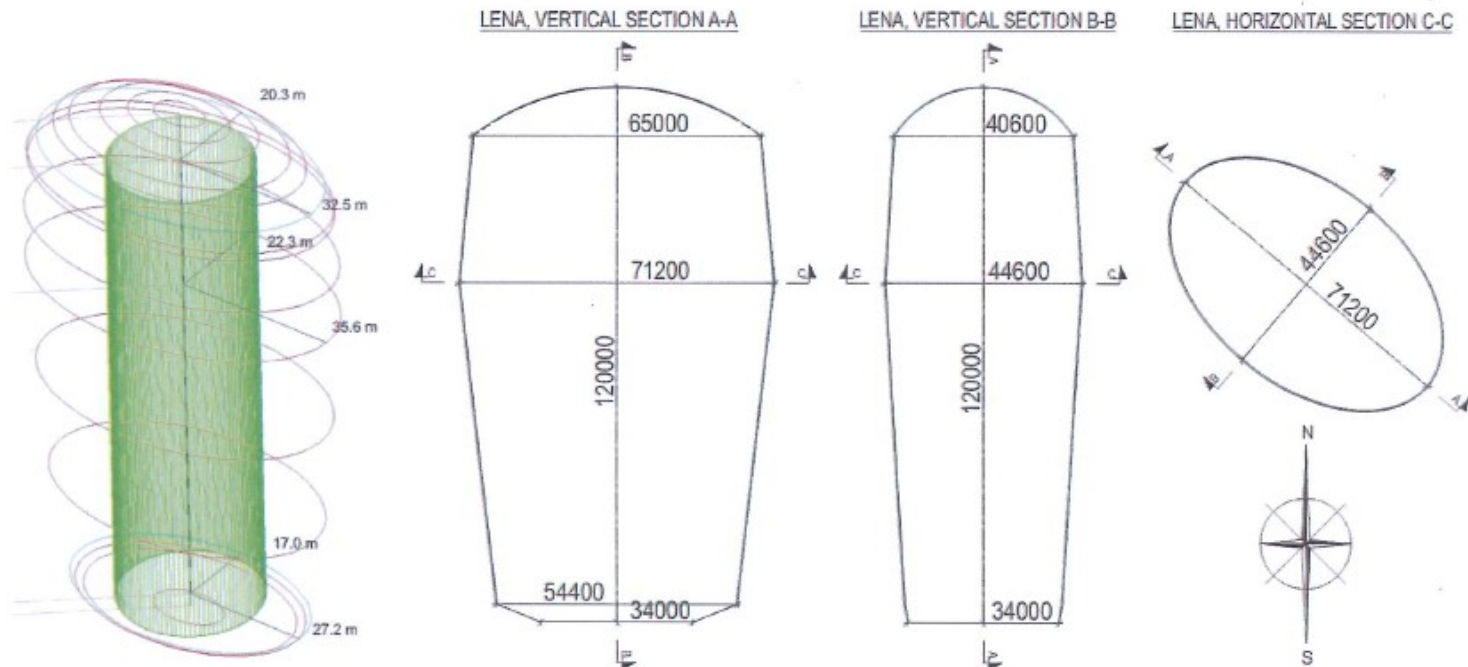
Figure G2-1. Cavern concept. Maximum height is 38m and width 75m.



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CAVERN AND TANK DIMENSIONS



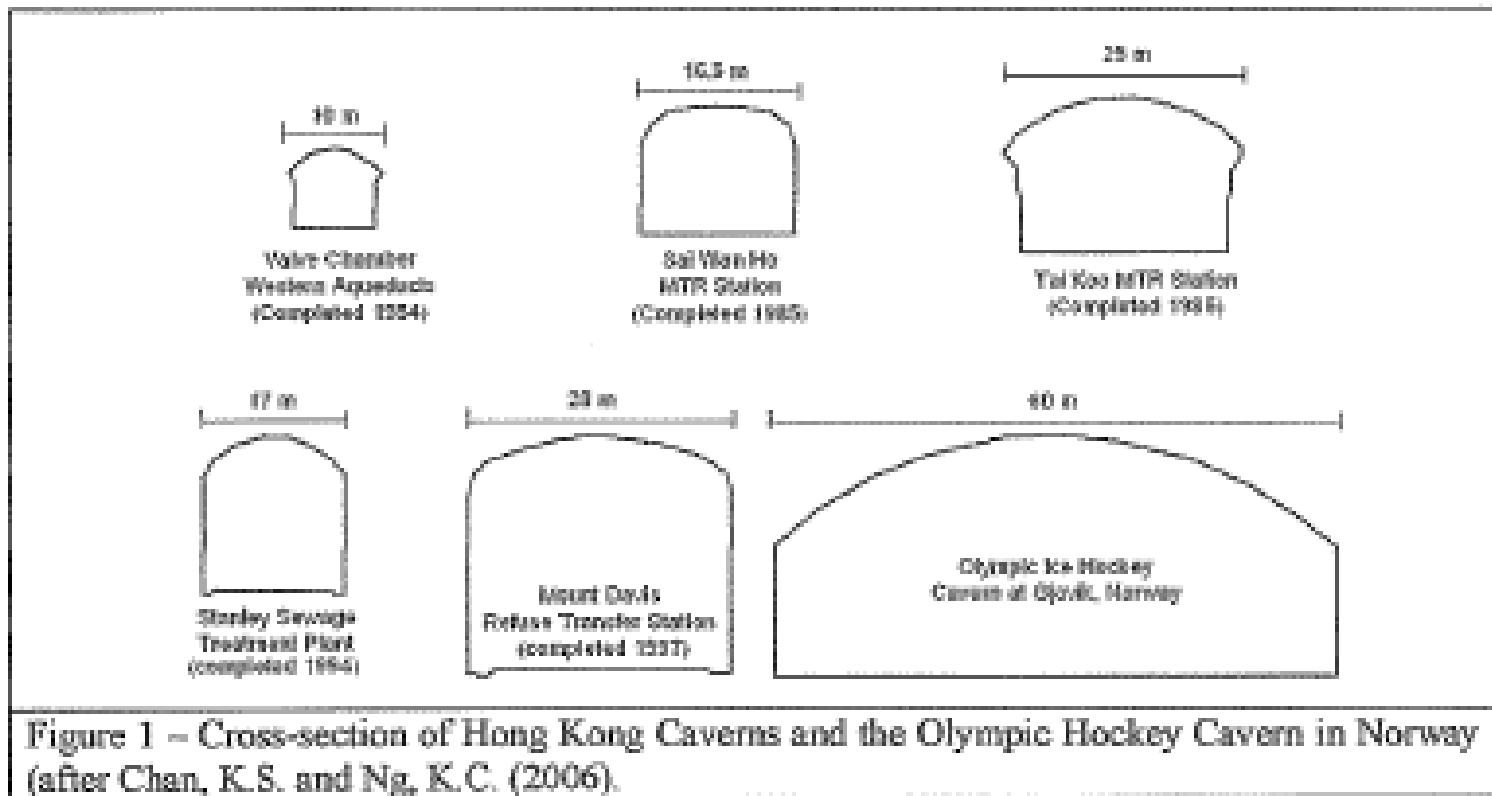
Chair for Experimental Physics
and Astroparticle Physics



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2. Muck Disposal Logistics

2.1 Shafts

2.2 Decline

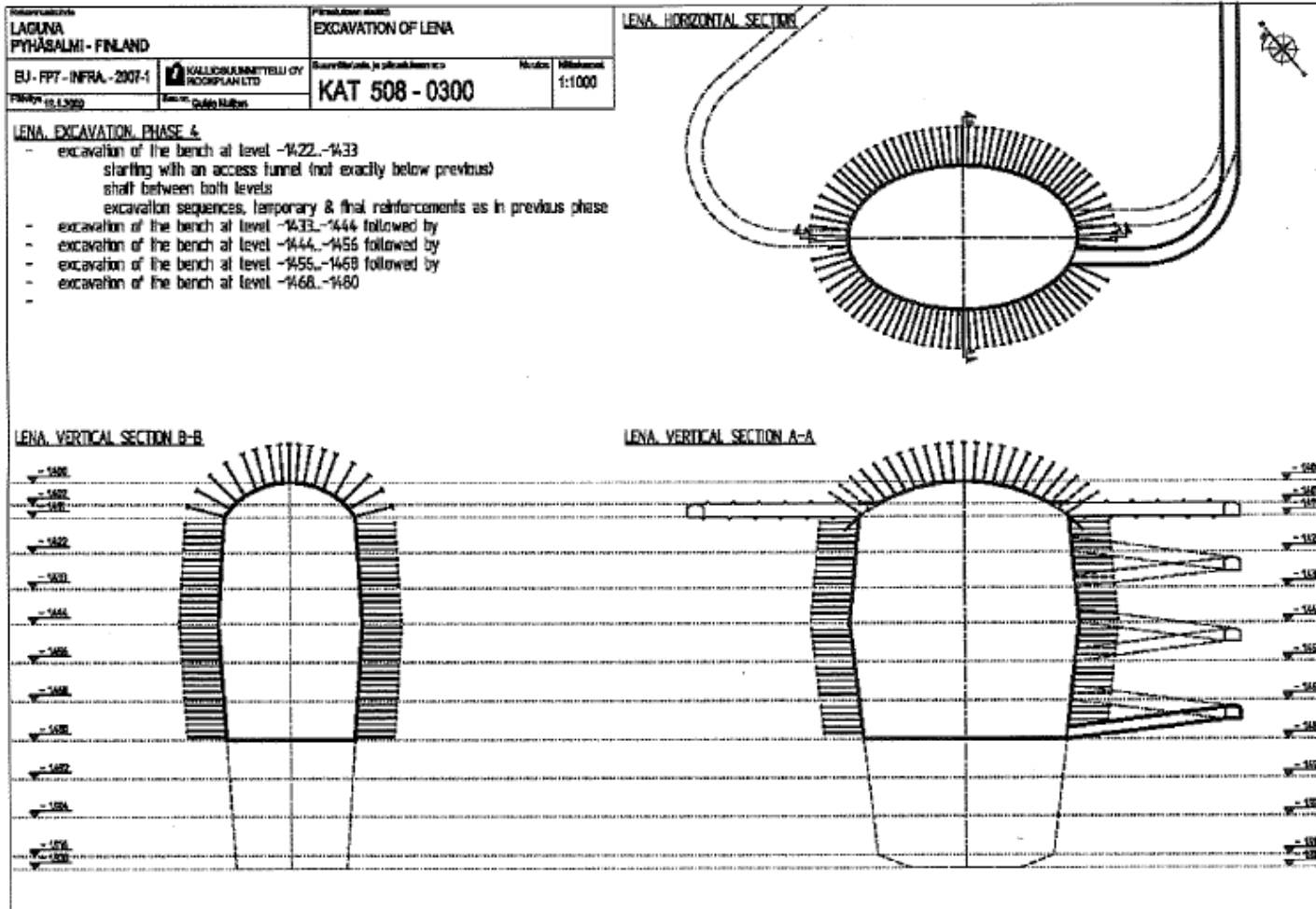
2.3 Roadways

2.4 Disposal Underground



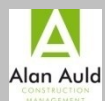
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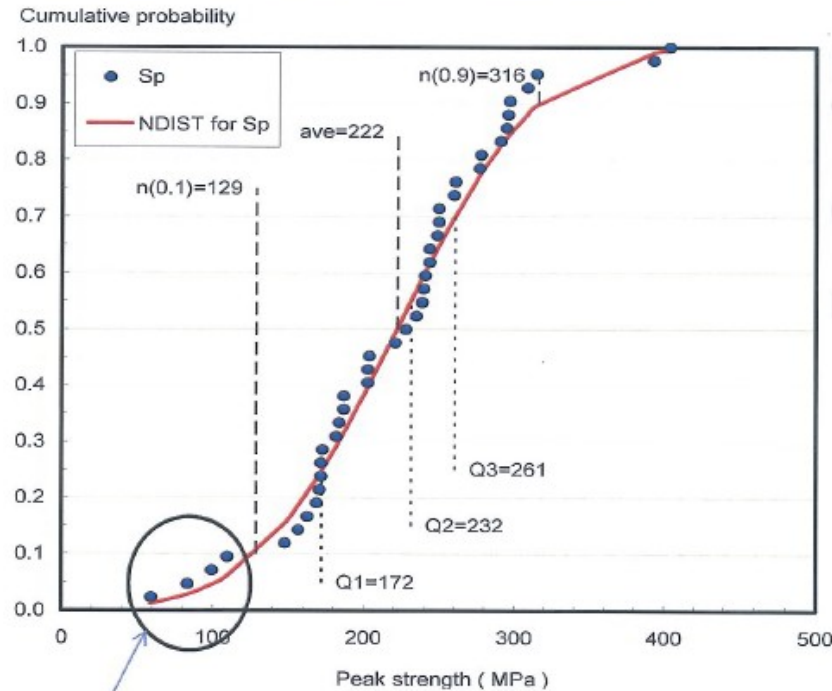
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Rock strength vs. rock stress (Finland)



Note: Pegmatite dykes (intact) $\sigma_{ci} = 110$ MPa to be avoided

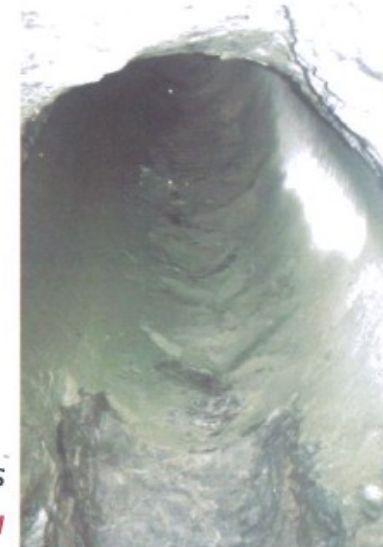
measurements and stress failure observations confirms
Rock mass strength $\sigma_{cm} = 132$ MPa

Nuijten 03-03-2011

Peak Strength of Mafic and Felsic
Volcanites (intact) $\sigma_{ci} = 232$ MPa

Geological Strength Index = 77

Rock mass strength $\sigma_{cm} = 132$ MPa



ROCKPLAN

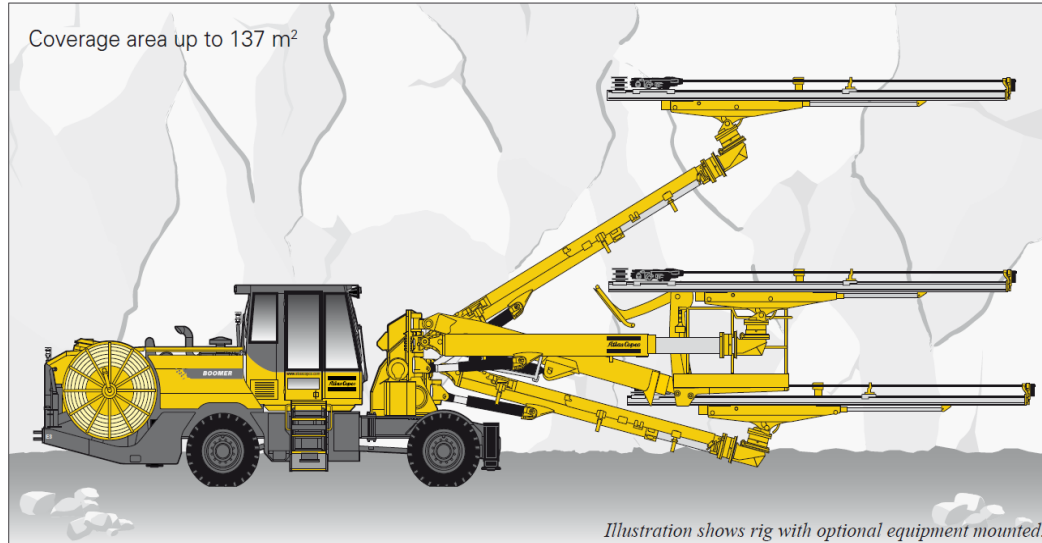


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Excavation & Support Equipment

Excavation will be by drill and blast using automated computer controlled drilling equipment known as a '*Drilling Jumbo*'



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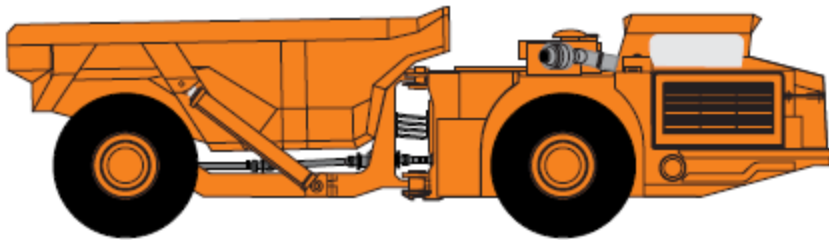
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Loading out the blasted rock will be by diesel powered front end loading equipment and load haul dump (LHD) mine trucks.



TORO 40

Main dimensions

Total length	10 217 mm (402")
Total width	2 990 mm (118")
Height	2 670 mm (105")

Standard engine

Diesel engine	Detroit S-60 DDEC IV (Euro Stage II / Tier II)
Output	354 kW / 2100 rpm (475 hp)

Capacities

Payload capacity
Box std.





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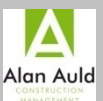
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Roof supports will be installed from the working area using mechanised drilling and installation equipment



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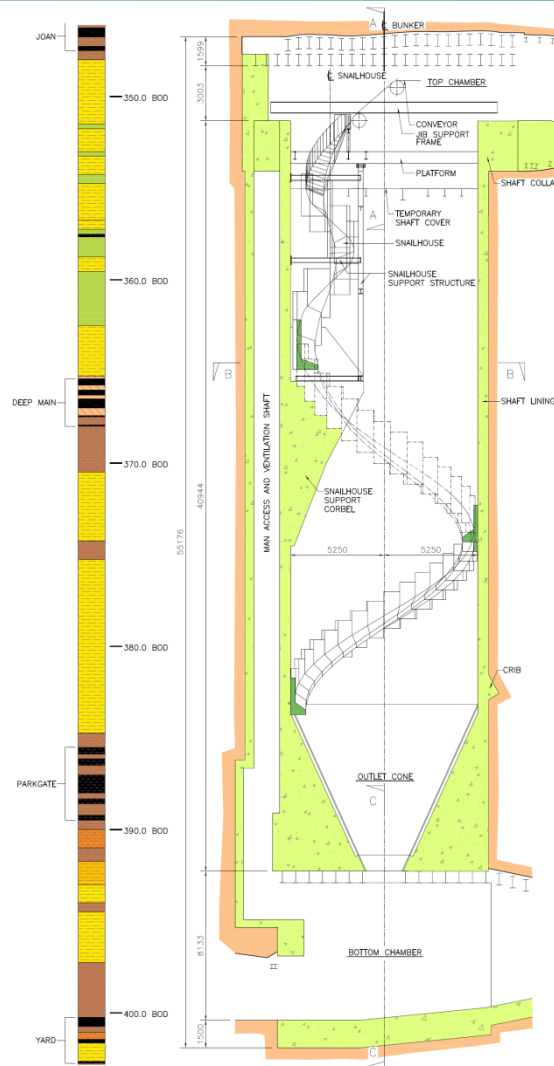
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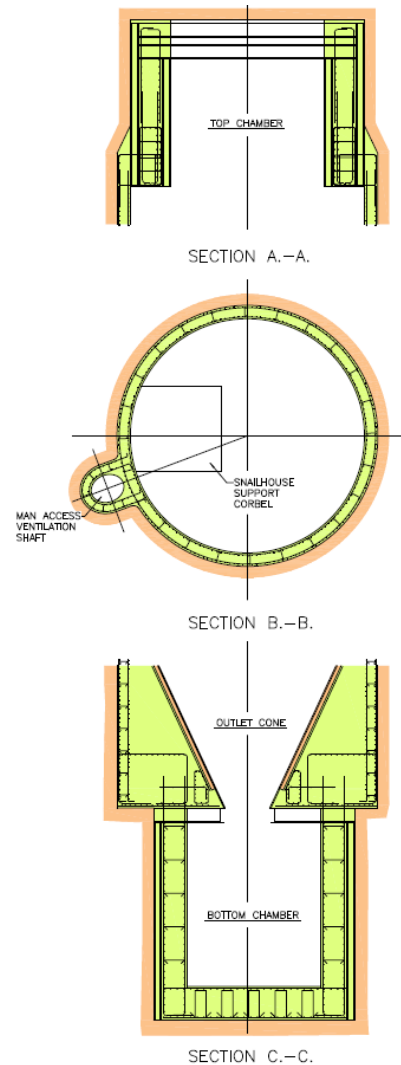
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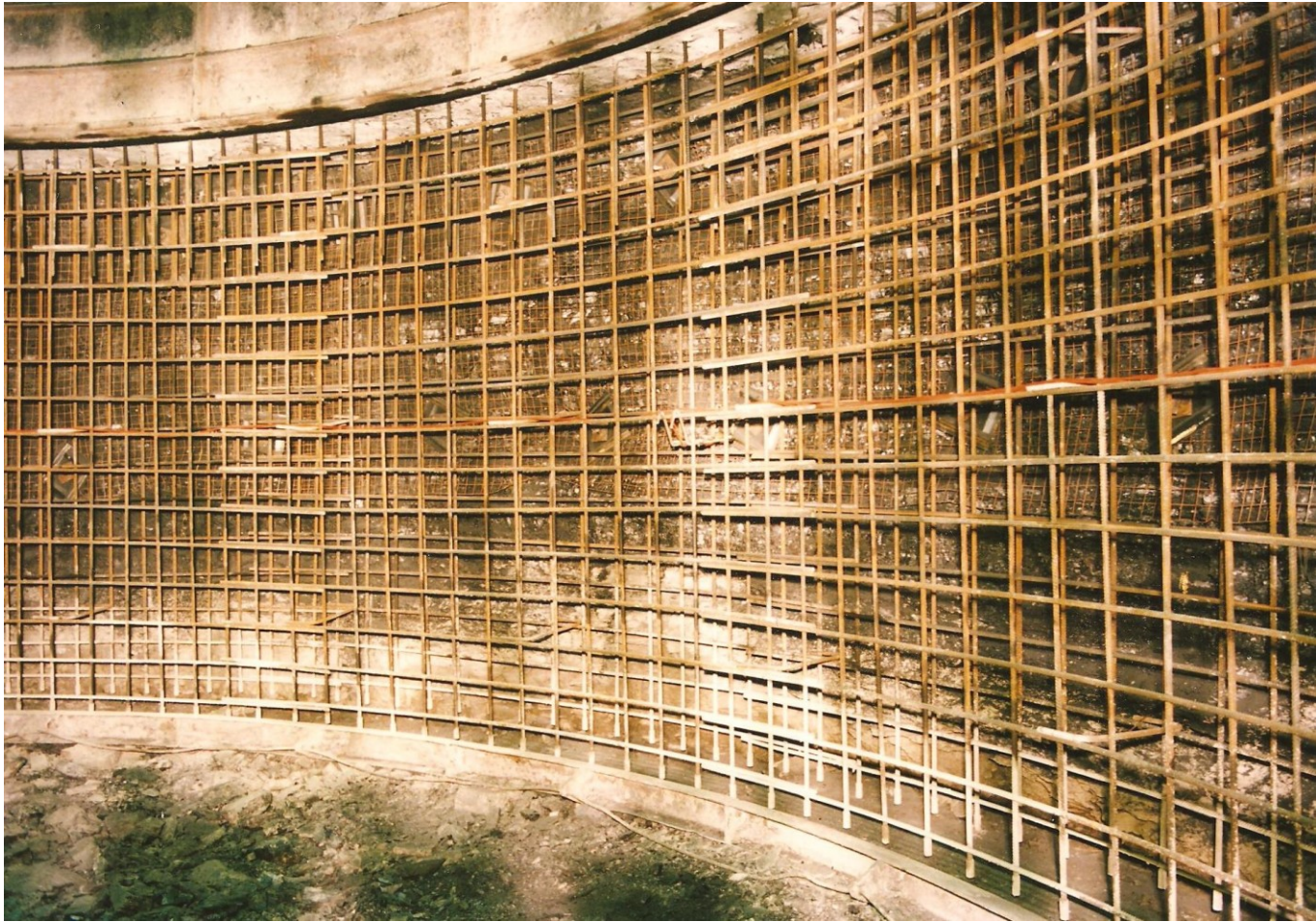
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3. Materials Handling Logistics

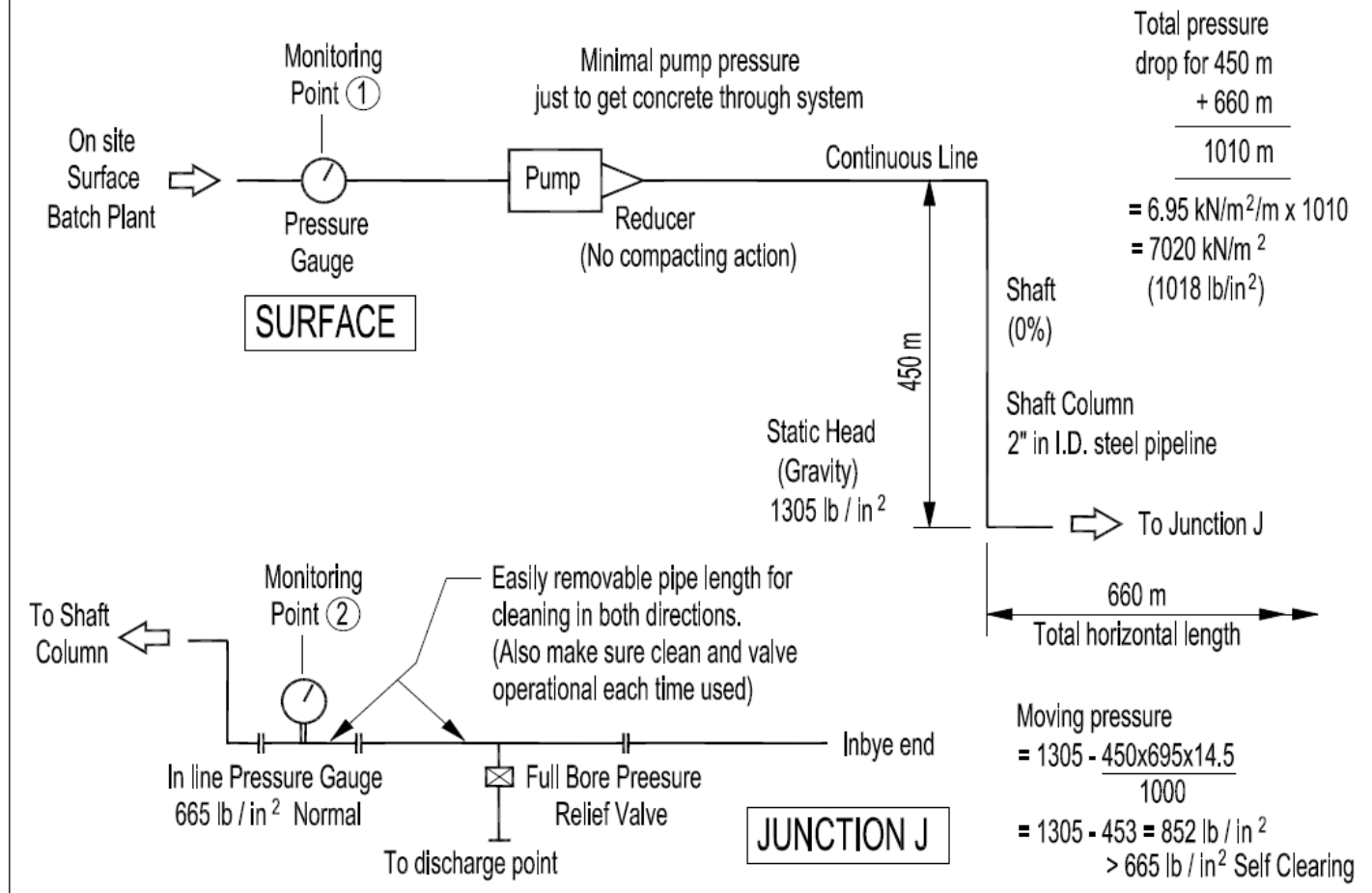
3.1 Shafts

3.2 Decline

3.3 Roadways



ASFORDBY MINE. FINE AGGREGATE CONCRETE PIPELINE.





4. Construction Contractual Issues

- 1. Tender documentation**
- 2. Appraisal of contractors' bids**
- 3. Appointment of contractor**
- 4. Monitoring of contractor's performance technically and financially**



5. Mine Legislation

5.1 Mine Manager's statutory responsibilities

5.2 Legal documentation

5.3 Mines Inspectorate



6. Health and Safety

- 6.1 Training**
- 6.2 Safety equipment**
- 6.3 Emergency procedures including egress**
- 6.4 Ventilation**
- 6.5 Fire and control**
- 6.6 Flooding and control**
- 6.7 Large volume liquid gas emergencies**
- 6.8 Production of liquid cryogenics**
- 6.9 Air quality monitoring**



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7. Risk Analysis

7.1 Identification of risks

7.2 Risk Register



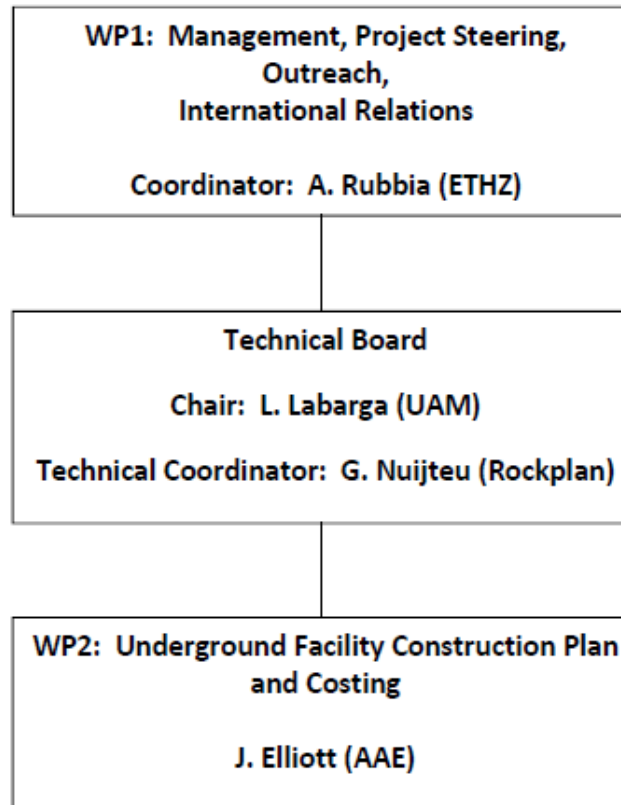
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Where AAG fits into the LAGUNA – LBNO Project

- (1) Planner and Co-ordinator for the WP2 (Deep Underground Facility and Costing) Work Package**
- (2) Risk Management Consultant for the Underground Works**



Management Structure





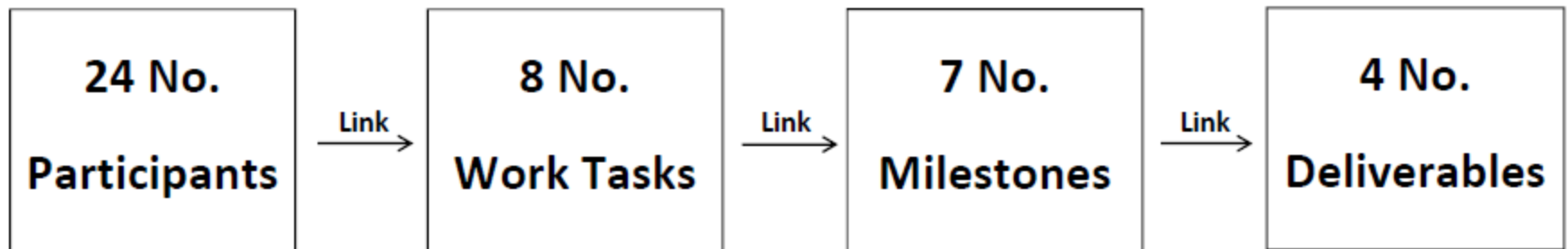
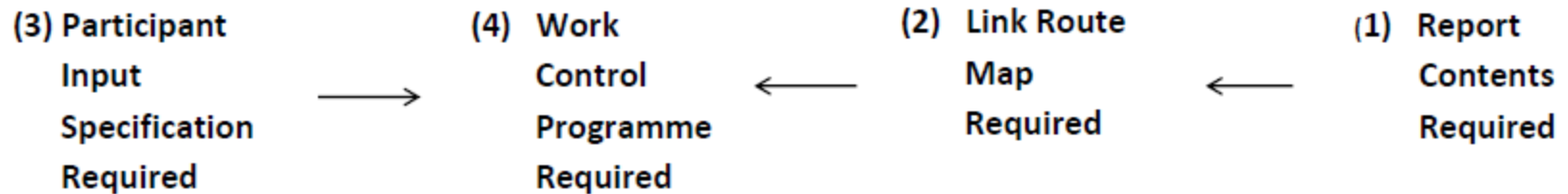
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Deliverables (4 No.)	Delivery Date
<u>D2.1</u> Draft report on risk identification with risk register for underground construction	
Alan Auld Group Ltd.	12
<u>D2.2</u> Report on updated reference tank and underground layout options	
Technodyne International Ltd.	18
<u>D2.3</u> Interim report ancillary facility and liquid transfer infrastructure and costs, liquid risk analysis	
Alan Auld Group Ltd.	24
<u>D2.4</u> Final report feasibility of underground construction, cost and risks	
Alan Auld Group Ltd.	36



LAGUNA – LBNO – Design of a Pan – European Infrastructure for Large Apparatus Studying Grand Unification, Neutrino Astrophysics and Long Baseline Neutrino Oscillations

WP2 – Deep Underground Facility Plan and Costing





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Risk Management



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What Is Risk?

‘Anything that poses a threat to the achievement of a department’s objectives, programmes, or service delivery for citizens’.

(National Audit Office)



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Why Take Risks?

‘Nothing will ever be attempted, if all possible objections must first be overcome.’

(Dr Samuel Johnson)



What Makes Risk Management Important?

‘No construction project is risk free. Risk can be managed, minimised, shared or accepted. It cannot be ignored.’

(Sir Michael Latham)



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What Makes Risk Management Important?

Failure to identify and/or manage risk is often a contributory factor in the failure to deliver construction projects on time and within budget.



Attitudes to Risk

At one time risk was frequently not considered until the end of the design process.

Good practice and in some areas legislation now dictate that it is considered from the beginning.

An international standard ISO 31000 was introduced in 2009 to set out guidelines for Risk management.



The Process

Risk management seeks to:

- **Identify risks**
- **Assess the potential impact**
- **Identify mitigation/elimination measures**
- **Assess the residual impact**
- **Quantify**
- **Continually monitor the process**



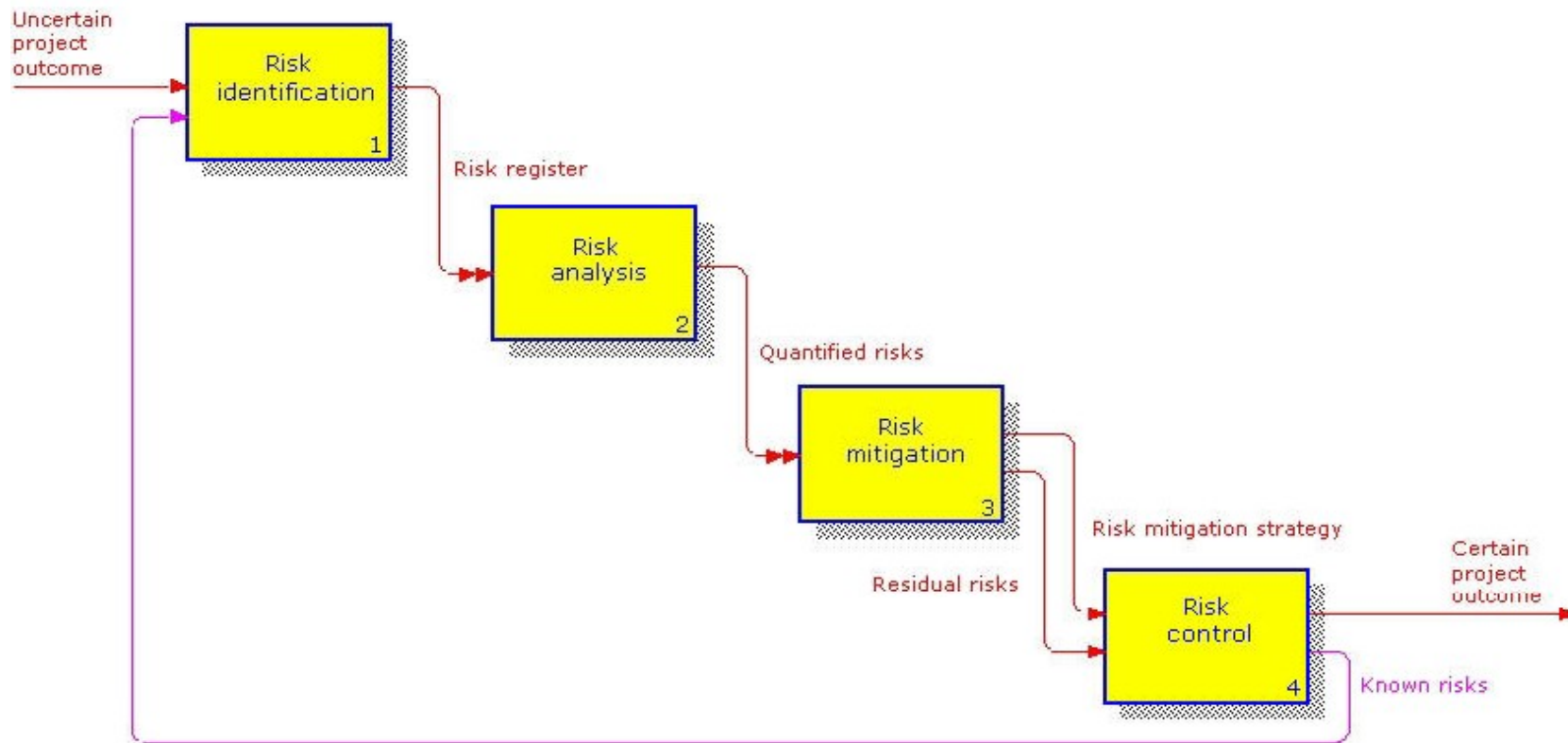
The Process

- Should be workshop based
- Usually works better with a facilitator
- Should be continuous
- Output must be uniform
- One person should “own” the Risk

Register



The Process





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The Process

Some considerations for LAGUNA:

- **Scientific**
- **Construction**
- **Logistics**
- **Social**
- **Financial**
- **Political**



The Process

The assessment of risk involves both quantitative and qualitative analysis. It is therefore vital that the process involves people with the appropriate skills to make the necessary judgements.



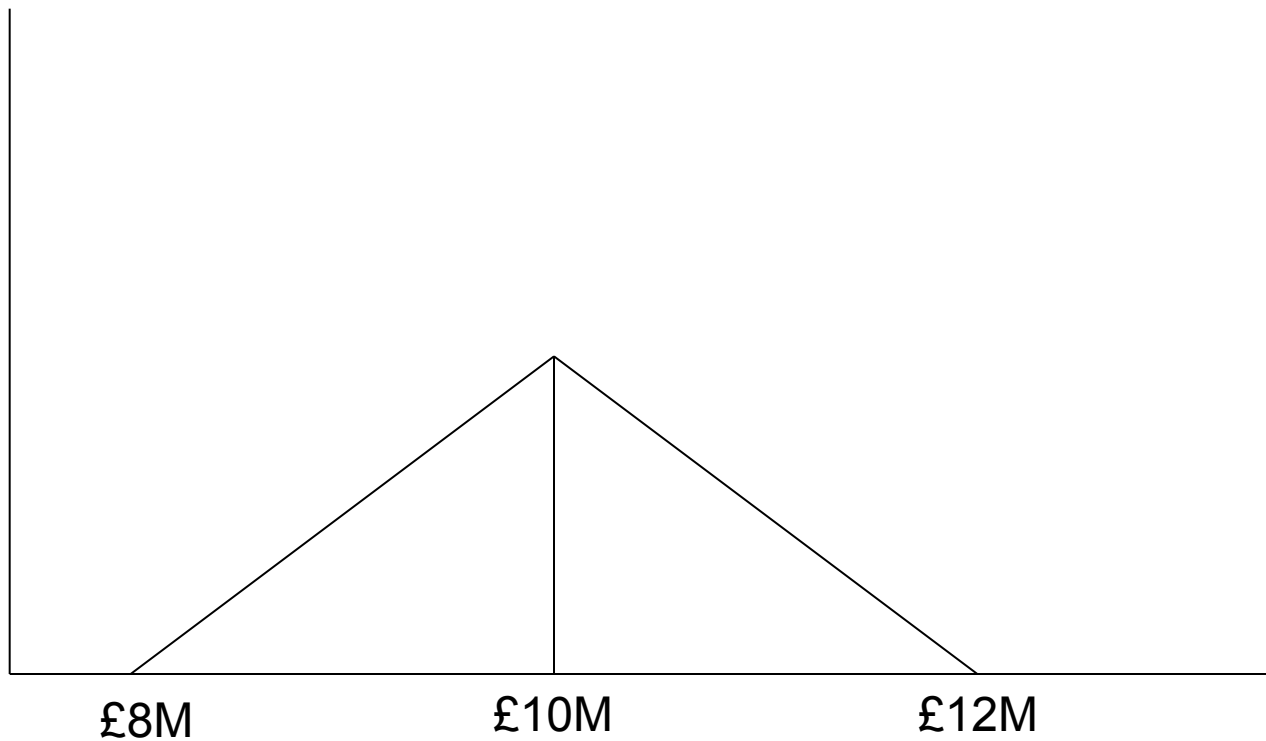
Simplified Workshop Output

PROJECT		Example		Date	June 2011		
Ref	Risk	Minimum £	Likely £	Maximum £	Action	Remedial	Residual
A	Groundwater inflow	10K	100K	200K	Pumping/Grouting	50K	25K
B	Adverse ground conditions	50K	250K	750K	Site Investigation	150K	50K
C	Equipment breakdowns	20K	100K	300K	On site plant workshop	100K	10K
	Total	80K	450K	1250K		300K	85K



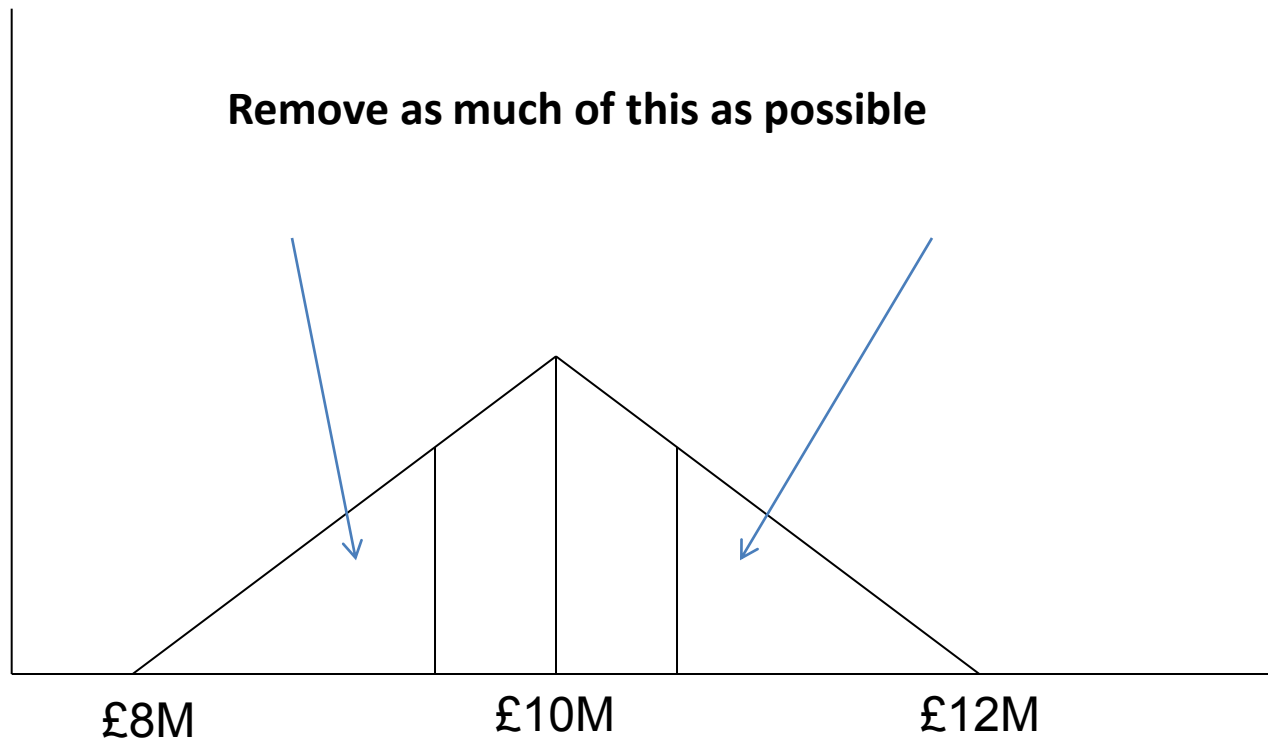
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Simplified Risk Profile





Risk Manager's View



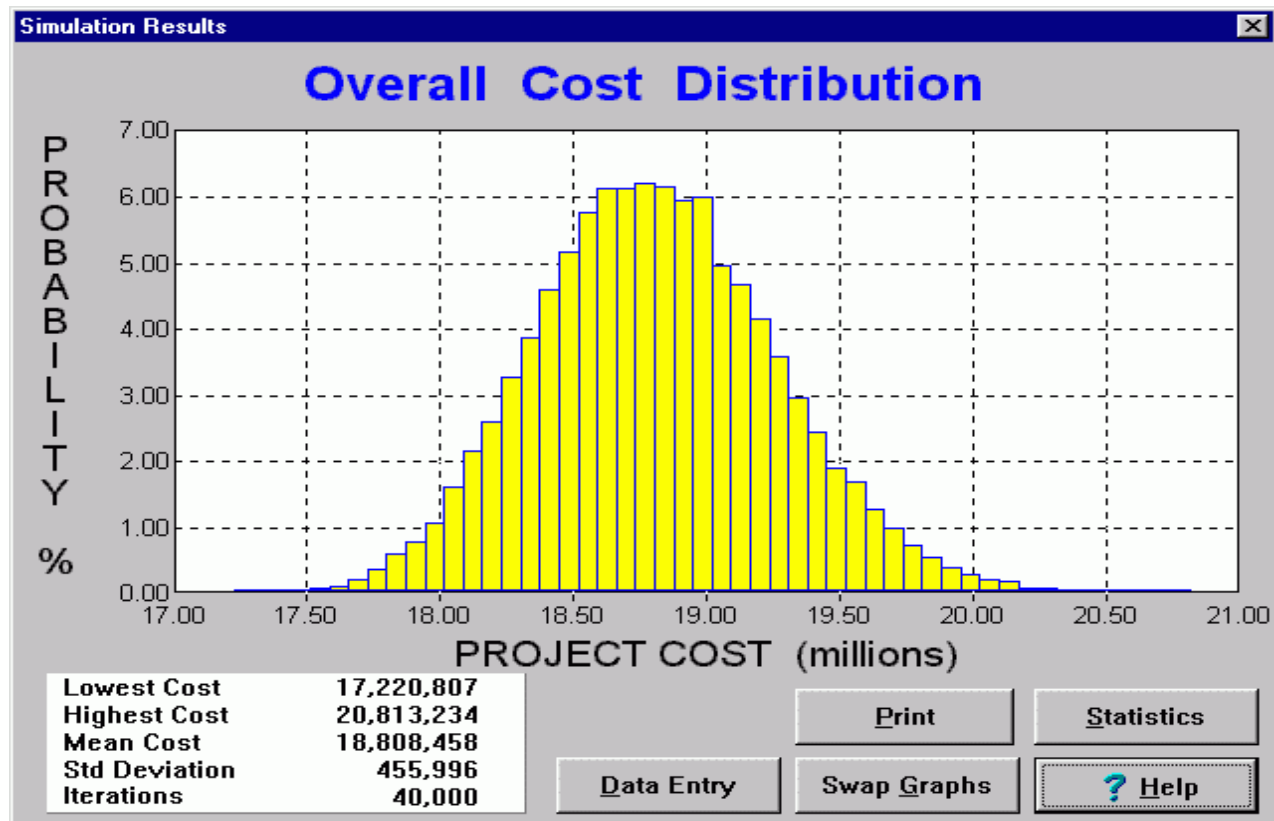


Simplified Workshop Output

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	Total	80K	450K	1250K		300K	85K



Typical 'Monte Carlo' Output





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Further Considerations

- **Software Systems**
- **Organisation**
- **Audit Trail**
- **Procurement Strategy**