CFS Cost Reductions

Conventional Facilities and Siting Group

A. Enomoto, V. Kuchler, J. Osborne

Session One - Processed Water

- Current RDR Design
  - Three Loop System for Process Water
    - Shaft (Surface to Tunnel Depth}
    - Tunnel Main Distribution
    - Skid Loop
    - 20 ^{o}F ΔT
  - Two Loop System for Chilled Water
    - Shaft (Surface to Tunnel Depth)
    - Tunnel Main Distribution
- Project X Design Utilizes a Similar System with the Exception of the Shaft Loop Due to Near Surface Configuration

SPECULATION LIST

Priority		DESCRIPTIONs & "color" legend (DRAFT Dec 11 2007) (Gut-Feel) may **not** result to large savings (Gut-Feel) may result to savings. Will be evaluated? (potential cost savings TBD) MARC ROSS DEC 04, 2007 DIRECTION (*LIST TO BE EVALUATED*) Will be evaluated By Others(HLRF), not CFS, whether high cost savings impact or not (not shaded) = Items that im Not Sure	(gut-feel) Estimated Cost Savings	Hrs needed to evaluate cost impact/ (by Whom)	For items (by others) will impact CFS
Low Priority	1	Provide one high efficiency cogen power / cooling plant on site and distribute power and 33 degree F chilled water throughout the facility, remove the power generation and chilling cost from the project cost	TBD	*Free (SteveK)*	
High priority	4	Eliminate one piping system by using process water as primary rejection for chilled water system w/#1 (using refrigerated heat pump as fancoils and standalone chillers for racks)	TBD	*40 Hrs (Emil)*	
	4b	Eliminate one piping system by using process water as primary rejection for chilled water system w/#1 (using process cooled fancoils), warmer tunnel (item 6_15)	TBD	*40 Hrs (Emil)*	
High priority	5	Increase the delta T in the LCW and chilled water systems to 30 degrees, reduce flow, pipe size w/#1	TBD	*40 Hrs (Emil)*	
	6	Add a chiller on the process water side w#1	TBD	*N/A*	
	23	Lower the temperature in the tunnel to 65 or 70 degrees to increase operating efficiency, extend equipment life, and improve operating environment w/#1	TBD		
	33	Consider use of renewable energy source for use with cogen system w/#1	TBD		
	47	Provide a cost analysis for reducing the overall cooling load by 5% and 10% w/#1	TBD	*N/A*	
	2	Centralize the cooling system	TBD		
	12	Provide distributed cogen power / cryo (similar to #1 &2)	TBD		
Medium priority	9	Decentralize the 345 KV substation function w/ 18, 20, 38, & 39			
Medium priority	18	Electrically engineer the distribution system to optimize and reduce cost w/#9			
Medium priority	20	Provide connection to electrical utility sytem at all shafts (w/ #9)			
Medium priority	38	Optimize substation spacing w/#9			
Medium priority	39	Let the electrical utility construct substations and don't include that cost in the project construction cost w/#9			
Low Priority	10	Centralize the HVAC and reconfigure air flow from the ends		*Lee?*	
Low Priority	34	Pipe two chilled water coils in series, chilled water reclaim, size one for 30 degree delta T w/#10		*Lee?*	
	13	Let the temperature in the tunnel go to 104 degrees F during normal operation and local cool to 85 degrees where people are (consider increased cost for more frequent replacement)	TBD	*40 Hrs (Emil)*	
	15	Raise tunnel temperature to 103 degrees at all times (meets OSHA requirements) w/#13	TBD	*40 Hrs (Emil)*	
	17	Provide air conditioned suits for personnel working in tunnel and let the temp go higher than OSHA requirements w/#13	N/A	*N/A*	
	14	Consider oversizing electrical cables and transformers to reduce heat	TBD		
	16	Redesign the RF loads for more optimal process water flow	TBD	*by HLRF*	YES
	21	Modify top shaft HVAC to only process make up air, add blowers down shaft for recirculation	TBD	*Lee?*	
	24	Reduce lighting level to egress limits	TBD	*Tom?*	
	25	Reduce water pressure drop across components, minimize head pressure	TBD	*by HLRF*	YES

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SPECULATION LIST

High priority	28	Examine possibility of going to 2 condenser water loops instead of 3 as presently planned	N/A	*N/A*	
High priority	35a	Consider using low mineral content water instead of LCW w/28 (design water system for low mineral water)	TBD	*40 Hrs (use A/E)*	
High priority	31	Allow different types of pipe materials: PVC, CPVC, HDPE, carbon fiber wrapped PE, etc in lieu of stainless steel	Medium	*40 Hrs (Emil)*	
	36	Consider replacing the fan coil units with a chilled water beam (radiant cooling)			
	37	Put the water piping in the concrete slab, eliminate pipe supports			
High priority	46	Use water cooled waveguide in the accelerator tunnel in lieu of air cooling	TBD	*by HLRF*	YES
	48	Provide passive convection tunnel using cooling shafts during colder months			
	49	Provide multiple modes of operation dependent on outdoor temperature			
High priority	50	Develop loads that do not require low conductivity water	TBD	*by HLRF*	YES
High priority	54	Use the waveguide pressurization system for cooling the waveguide (flow cooled gas inside the waveguide)	TBD	*by HLRF*	YES
Low Priority	3	Pulse the power source for selected loads when not being used	N/A	*N/A*	
	7	Use pressure regulators to control the hydrostatic pressure in the collectors	N/A	*N/A*	
	8	Define the maximum hydrostatic pressure for the collectors	TBD	*by HLRF*	YES
	11	Consider expandability of systems - modular vs centralized	N/A	*N/A*	
	27	Reexamine the hot changeout of modulator power supplies	N/A	*by HLRF*	
	29	Plan for a 4 month downtime during the summer	N/A	*N/A*	
	30	Limit the operation of the system to 72 degree wet bulb	N/A	*N/A*	
	40	Use CO2/radon monitoring and limit the intake of outside air to what is necessary to maintain a safe environment		*Lee?*	
	41	Use a dessicant to dehumidify ventilation air		*Lee?*	
	51	Evaluate each load individually to determine requirements	TBD	*by HLRF*	YES
	52	Establish power budgets for the relay racks (400 W / RF + 10% of power supplies)	TBD	*by HLRF*	YES
	53	Provide power supply that will work with warm water if necessary (quasi militarized)	TBD	*by HLRF*	YES
	45	Use on site ponds for make up water	N/A	*N/A*	
	55	Consider using cooling ponds in lieu of cooling towers	N/A	*N/A*	
	22	Give or sell heat from chillers to neighboring communities	N/A	*N/A*	
	26	Increase the number of RF stations per LCW skids	N/A	*N/A*	
	32	Use vapor phase cooling on the collector and generate electricity from excess energy	N/A	*N/A*	
	42	Use the lowest KVA transformer to reduce heat load	N/A	*N/A*	
	43	Consider use of geothermal cooling	N/A	*N/A*	
	44	Use the Fox river for once thru primary cooling, eliminate the cooling towers	N/A	*N/A*	
	19	Use modular systems for all equipment	N/A	*N/A*	
	NEW1	Eliminate Rack Skid and replace with just pump	under $10M???	*40 Hrs (Emil)*	
	NEW2	*Eliminate one piping system by using chilled water only as primary rejection, eliminate process water distribution*	over $30M???	*40 Hrs (Emil)*	

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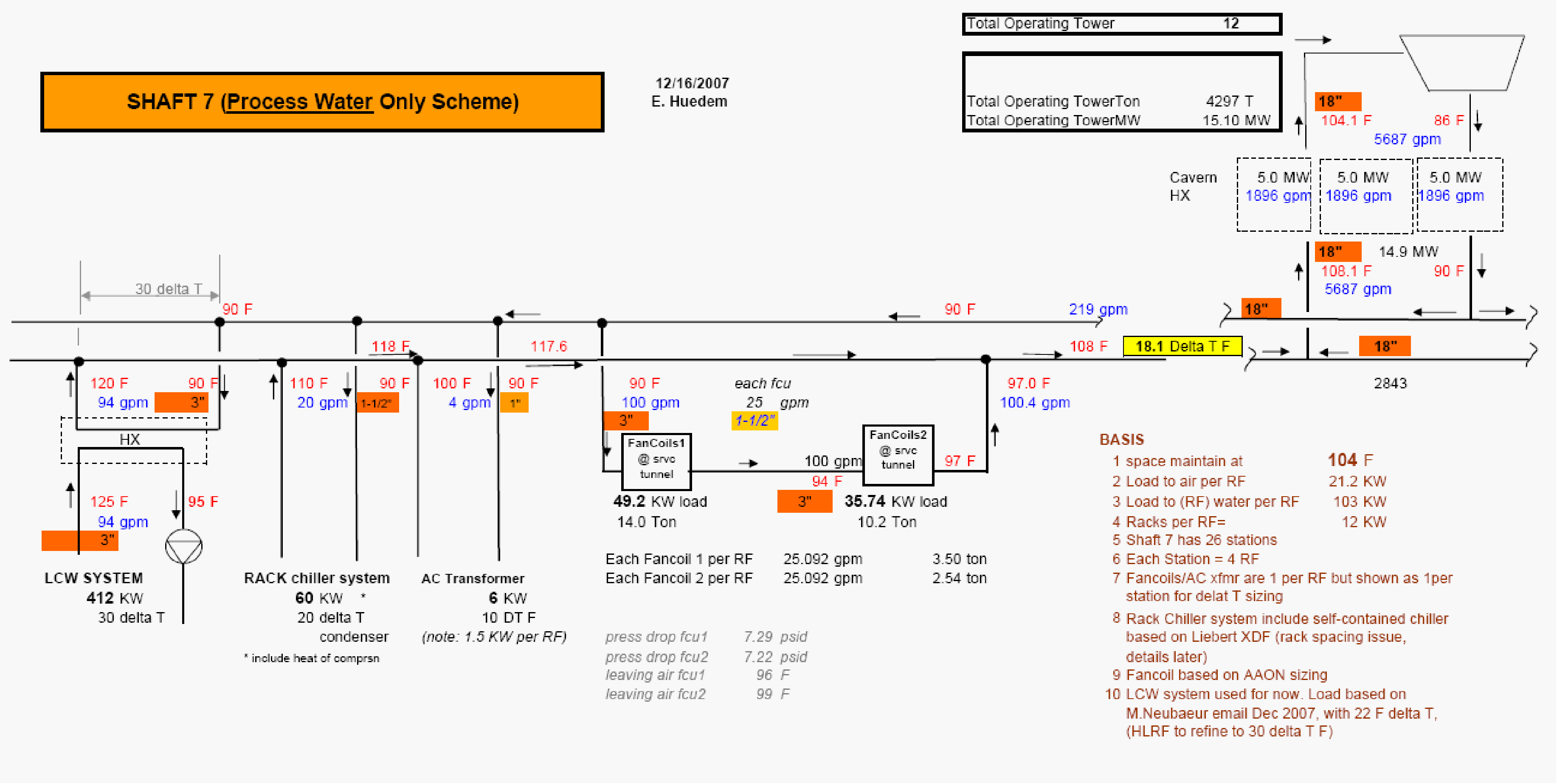
First Analysis - Eliminate Chilled Water

- Still a Three Loop Process Water System
- Requires LCW Skid to Go From 20^o ΔT to 30^o ΔT
- Fan Coil Units for Service Tunnel Temperature Control Affected:
  - Units Get Physically Larger
  - Units are Less Efficient
  - Units Operate at a Lower ΔT
  - Units Require More Water
  - Tunnel Temperature is 104 ^{o}F
  - > 104 ^{o}F Requires Electrical Equipment De-rating
  - > 86 ^{o}F Labor Restriction Becomes an Issue
- Cost Impact - Reductions
  - One Distribution System is Eliminated (Chilled Water, 2 Pipes at 8” dia)
  - Required Surface Chiller Capacity Reduced
- Cost Impact - Neutral
  - No Major Pumping Impact
  - No Major Electrical Impact
- Cost Impact - Additions
  - Process Water Pipe Size Increases from 2 @ 12” dia to 2 @ 18” dia
  - Control Racks Still Require Local Chillers for Cooling
  - Fan Coil Units get Larger

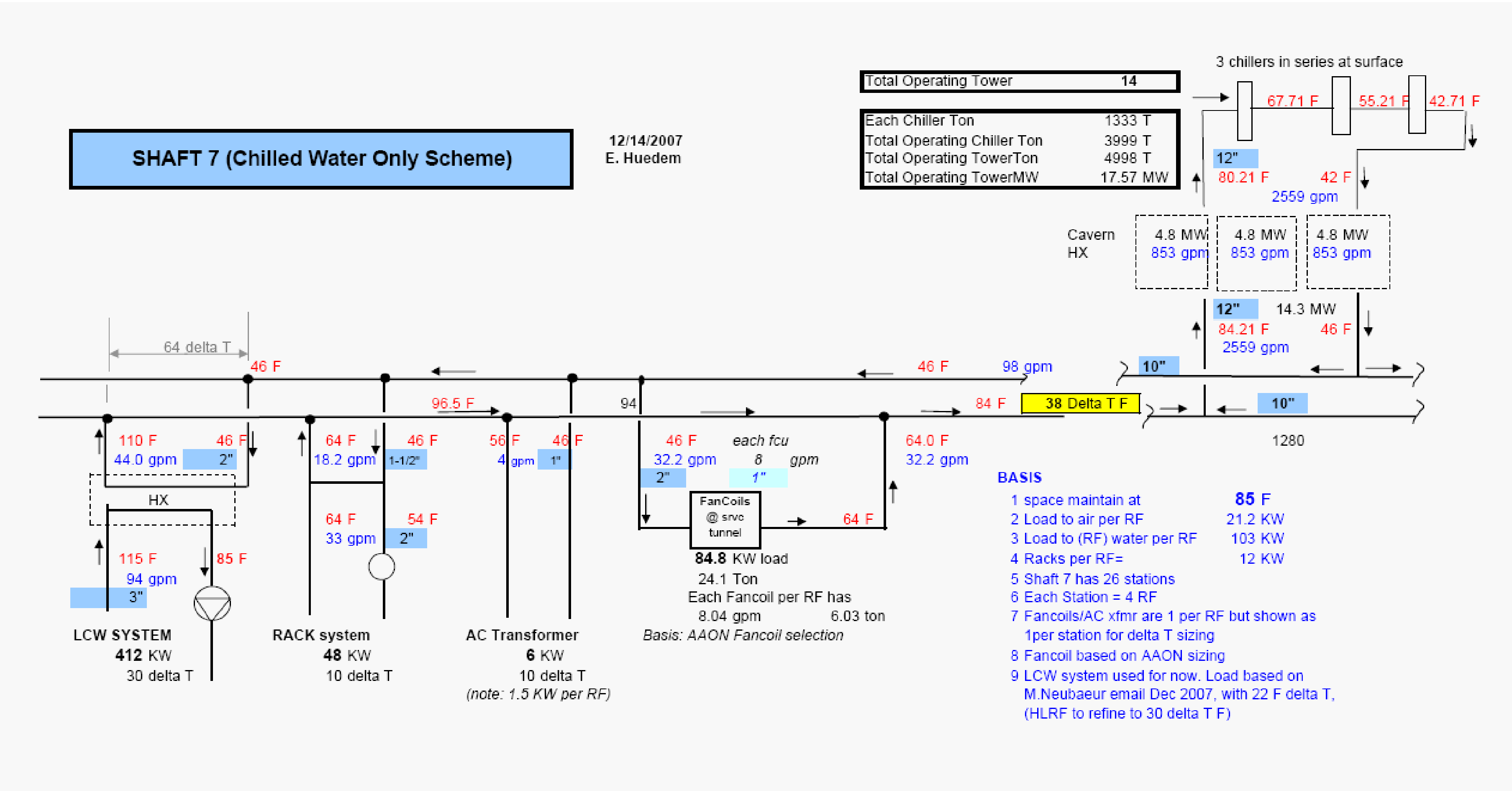


SHAFT 7 (Process Water Only Scheme)
12/16/2007
E. Huedem
Total Operating Tower 12
Total Operating TowerTon 4297 T
Total Operating TowerMW 15.10 MW
18"
104.1 F
86 F
5687 gpm
Cavern HX
5.0 MW 1896 gpm
5.0 MW 1896 gpm
5.0 MW 1896 gpm
18"
14.9 MW
108.1 F
90 F
5687 gpm
30 delta T
90 F
118 F
117.6
90 F
219 gpm
18"
108 F
18.1 Delta T F
18"
2843
120 F
90 F
94 gpm
3"
HX
125 F
95 F
94 gpm
3"
110 F
90 F
20 gpm
1-1/2"
100 F
90 F
4 gpm
1"
90 F
100 gpm
3"
each fcu
25 gpm
1-1/2"
FanCoils1 @ srvc tunnel
FanCoils2 @ srvc tunnel
100 gpm
94 F
97 F
3"
97.0 F
100.4 gpm
49.2 KW load
14.0 Ton
35.74 KW load
10.2 Ton
LCW SYSTEM
412 KW
30 delta T
RACK chiller system
60 KW *
20 delta T
condenser
* include heat of comprsn
AC Transformer
6 KW
10 DT F
(note: 1.5 KW per RF)
Each Fancoil 1 per RF 25.092 gpm 3.50 ton
Each Fancoil 2 per RF 25.092 gpm 2.54 ton
press drop fcu1 7.29 psid
press drop fcu2 7.22 psid
leaving air fcu1 96 F
leaving air fcu2 99 F
BASIS
1 space maintain at 104 F
2 Load to air per RF 21.2 KW
3 Load to (RF) water per RF 103 KW
4 Racks per RF= 12 KW
5 Shaft 7 has 26 stations
6 Each Station = 4 RF
7 Fancoils/AC xfmr are 1 per RF but shown as 1per station for delat T sizing
8 Rack Chiller system include self-contained chiller based on Liebert XDF (rack spacing issue, details later)
9 Fancoil based on AAON sizing
10 LCW system used for now. Load based on M.Neubaeur email Dec 2007, with 22 F delta T, (HLRF to refine to 30 delta T F)

Second Analysis - Eliminate Process Water

- *Still a Three Loop Chilled Water System*
- *Requires LCW Skid to Go From 20^o ΔT to 30^o ΔT*
- *Fan Coil Units for Service Tunnel Temperature Control*

  Remain Unchanged:
  - ***Tunnel Temperature is 86 ^{o}F***
  - ***No Requirement Electrical Equipment De-rating or Labor Restrictions***
- *Cost Impact - Reductions*
  - ***One Distribution System is Eliminated (Process Water, 2 Pipes at 12" dia)***
  - ***Pumping Configuration Reduced***
- *Cost Impact - Neutral*
  - ***Control Rack Cooling Unchanged***
  - ***Fan Coil Units Unchanged***
- *Cost Impact - Additions*
  - ***Chilled Water Pipe Size Increases from 2 @ 8" dia to 2 @ 10" dia***
  - ***Required Surface Chiller Capacity Increased***


SHAFT 7 (Chilled Water Only Scheme)
12/14/2007
E. Huedem
Total Operating Tower 14
Each Chiller Ton 1333 T
Total Operating Chiller Ton 3999 T
Total Operating TowerTon 4998 T
Total Operating TowerMW 17.57 MW
3 chillers in series at surface
67.71 F
55.21 F
42.71 F
12"
80.21 F
42 F
2559 gpm
Cavern HX
4.8 MW 853 gpm
4.8 MW 853 gpm
4.8 MW 853 gpm
12"
14.3 MW
84.21 F
46 F
2559 gpm
10"
64 delta T
46 F
96.5 F
94
46 F
98 gpm
84 F
38 Delta T F
10"
1280
110 F
46 F
44.0 gpm
2"
HX
115 F
85 F
94 gpm
3"
LCW SYSTEM
412 KW
30 delta T
64 F
46 F
18.2 gpm
1-1/2"
64 F
54 F
33 gpm
2"
RACK system
48 KW
10 delta T
56 F
46 F
4 gpm
1"
AC Transformer
6 KW
10 delta T
(note: 1.5 KW per RF)
46 F
each fcu
32.2 gpm
8 gpm
2"
1"
FanCoils @ srvc tunnel
64 F
64.0 F
32.2 gpm
84.8 KW load
24.1 Ton
Each Fancoil per RF has
8.04 gpm 6.03 ton
Basis: AAON Fancoil selection
BASIS
1 space maintain at 85 F
2 Load to air per RF 21.2 KW
3 Load to (RF) water per RF 103 KW
4 Racks per RF= 12 KW
5 Shaft 7 has 26 stations
6 Each Station = 4 RF
7 Fancoils/AC xfmr are 1 per RF but shown as 1per station for delta T sizing
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Session Two - Underground Volume

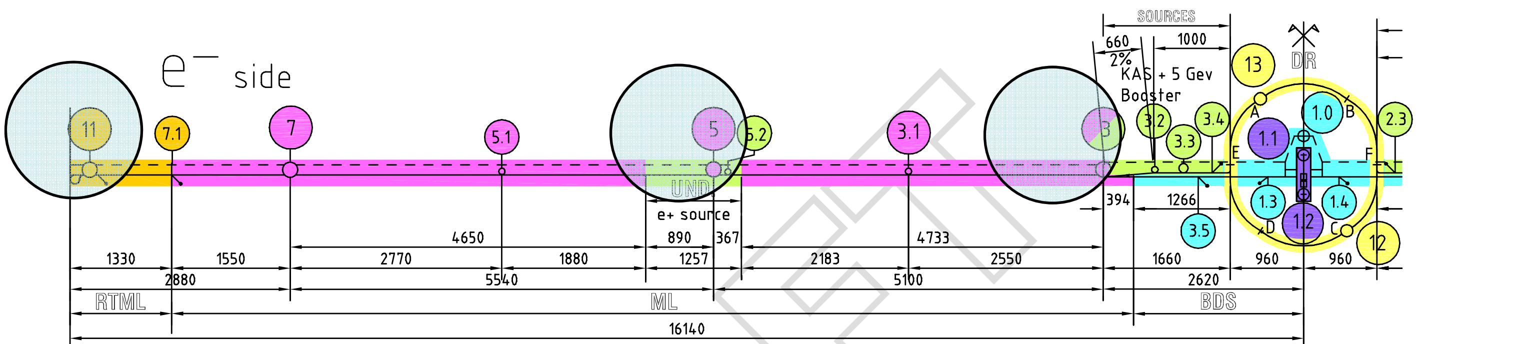
- **Currently Not Optimized for Equipment Size or Layout**
- **Primary Space Requirements Determined By:**
  - *Cryogenic Equipment*
  - *Process Water Equipment*
  - *HVAC Equipment*
  - *Installation and Material Handling Requirements*
- **Opportunities for Cost Reduction:**
  - *Revised Process Cooling Design May Result in a Reduction of Equipment Space Required*
  - *Revised HVAC Design May Result in a Reduction of Equipment Space Required*
  - *Overall Optimization of Equipment layout is Essential*
  - *Adjustment of Shaft Usage and Size will Affect Cavern Space Requirements*

Session Three - Shallow Site Studies

- *Twin Tunnel Deep Solution is the RDR Base*
- *Cut and Cover Tunnel with Continuous Surface Gallery (Project X)*
- *Near Surface Tunnel with Surface Gallery Configuration (Dubna)*
- *Single Tunnel with Enclosed Exit Corridor (~7.5m dia)*
- *Single Tunnel with Fire Protected Alcoves*
- *Single Tunnel Only (LHC and XFEL)*
- *Twin Tunnel with Only One Equipment Access per Linac and Only Personnel Access Shafts at 5 km Intervals*
- *Single Tunnel with Only One Equipment Access per Linac and Only Personnel Access Shafts at 5 km Intervals*
- *Adjustments to Shaft Diameters with Respect to Material Handling*
- *Various Alternatives Noted May Preclude Construction in Certain Siting Locations*

Global Design Effort - CFS

reduce diameter of 14m shafts down to 9m Via lowering cryo

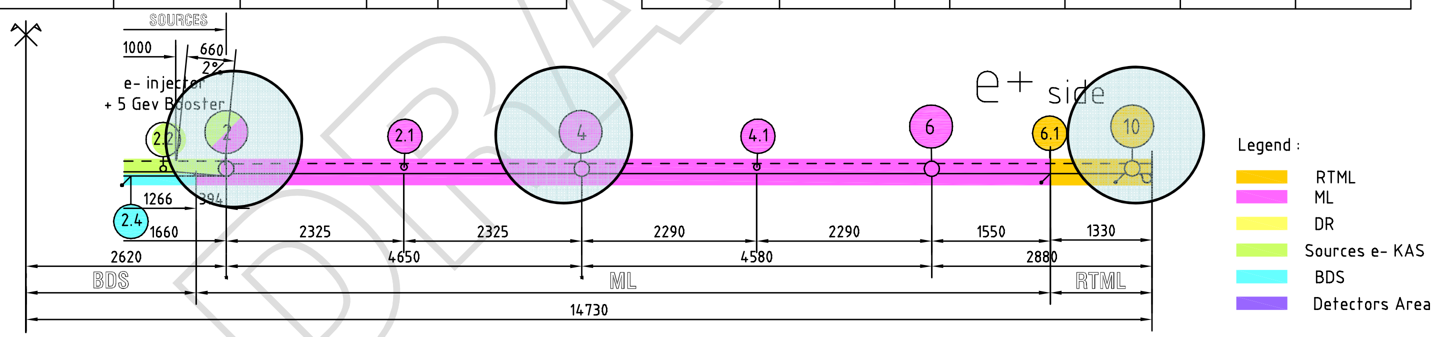


SITE / TUNNEL LENGTHS (m)

e− side + Undulator ML + RTML	e+ side ML + RTML	BDS + sources	DR	TOTAL
13 914 / 27 948	12 504 / 25 128	4452 / 12 236	0 / 6704	30 870 / 72 016

TUNNELS

Area	e− inject.,KAS beam + serv	DR	RTML beam + serv	ML beam + serv	BDS beam + serv	BDS Survey
ϕm	4.5	5.0	4.5 + 4.5	4.5 + 4.5	4.5 + 4.5	1.5 x 2.2



SHAFTS

Point	1.0	1.1	1.2	2	3	3.3	5.2	4	5	6	7	10	11	12/C	13/A
ϕm	9	16	16	14	14	4	4	14	14	9	9	14	14	9	9

BORINGS

Point	2.1, 3.1, 4.1, 5.1	2.2, 3.2	1.3, 1.4, 2.4, 3.5
ϕm	1.50		

SHAFT BASE CAVERNS

Point	2, 3, 4, 5, 6, 7, 10, 11
(LxWxH) m	49 x 16 x 18 + 3 storeys

MUON WALL WIDENINGS

Point	1.3, 1.4
(LxWxH) m	25 x7x6 +15x7x6

SOURCES CAVERNS

Point	Undulator 5.2	KAS 3.3	2.2, 3.2
(LxWxH) m	21 161m3	6 574m3	7 X 15 X 7.5

DR ALCOVES

Point	12/C, 13/A	B, D, E, F
(LxWxH) m	75 x 10 x 10 + 1 storey	16 x 8 x 8

DETECTORS HALL

Point	1.1, 1.2	1.0
(LxWxH) m	120 x 25 x 39	40 x 15 x 15

BEAM DUMPS CAVERNS (↖)

Point	SOURCES 2.3, 3.4	RTML 6.1, 7.1, 10, 11	BDS 1.3, 1.4, 2.4, 3.5
(LxWxH) m	5 x 4 x 4		20 x 9 x 15 + 1 storey

BEAM DUMP SERVICE HALLS (↖)

Point	BDS 1.3, 1.4, 2.4, 3.5
(LxWxH) m	30x20x 10

ILC - UNDERGROUND STRUCTURES SCHEMATIC LAYOUT

AREA SYSTEM DIVISION (2 mobile Detectors - Push Pull - modified CMS procedure)

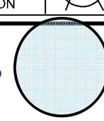
EUROPEAN REGION

CERN

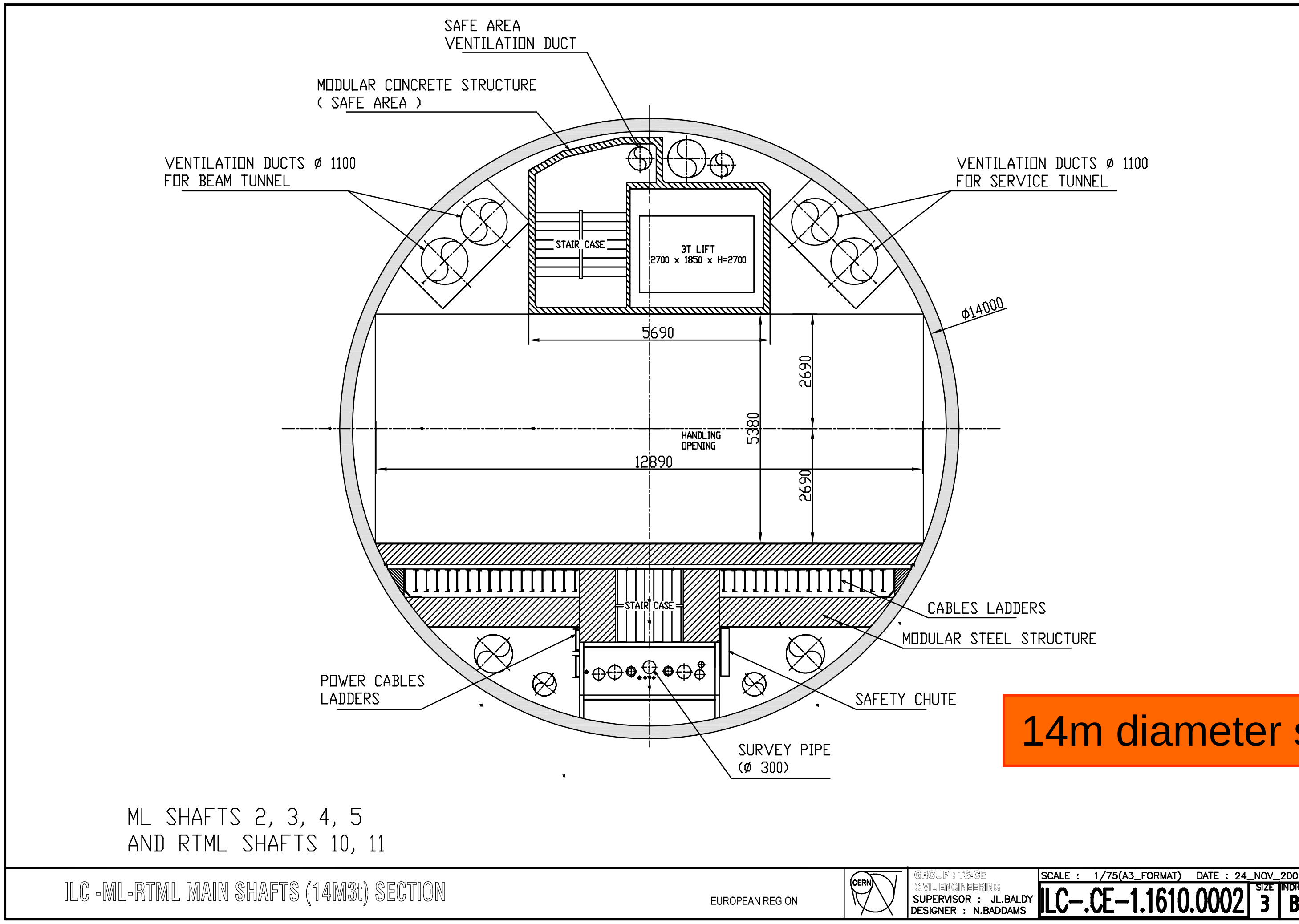
GROUP : TS-CE
CIVIL ENGINEERING
SUPERVISOR : JL.BALDY
DESIGNER : N.BADDAMS

SCALE : 1/50000(A3_FORMAT) DATE : 05_DEC_2006

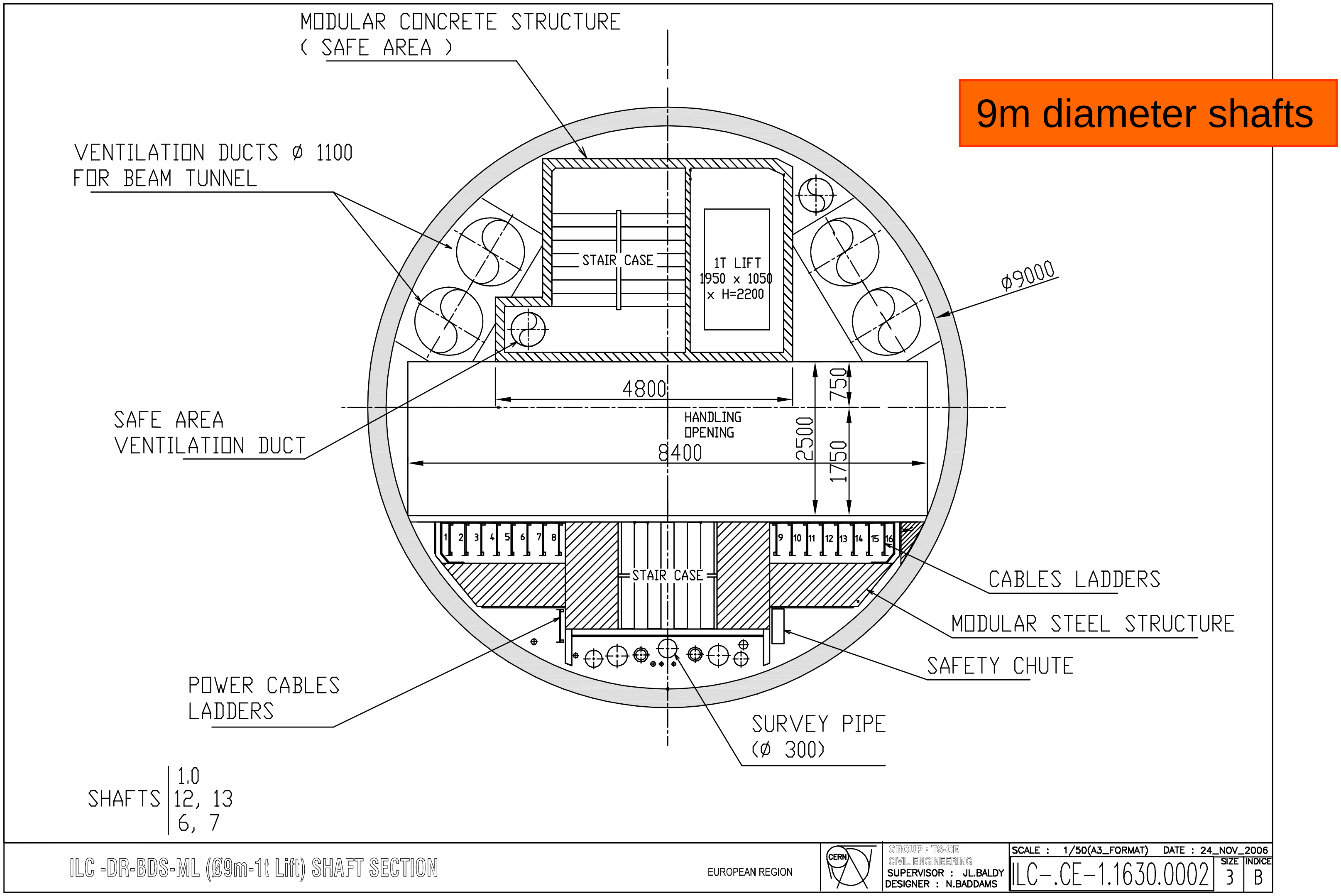
ILC−.CE−1.1649.0016 | SIZE 3 | INDICE G



= 14m diameter shafts



14m diameter shafts


MODULAR CONCRETE STRUCTURE
(SAFE AREA)
VENTILATION DUCTS Ø 1100
FOR BEAM TUNNEL
STAIR CASE
1T LIFT
1950 x 1050
x H=2200
Ø9000
4800
HANDLING
OPENING
8400
750
2500
1750
SAFE AREA
VENTILATION DUCT
CABLES LADDERS
MODULAR STEEL STRUCTURE
SAFETY CHUTE
POWER CABLES
LADDERS
SURVEY PIPE
(Ø 300)
SHAFTS
1.0
12, 13
6, 7
ILC -DR-BDS-ML (Ø9m-1t Lift) SHAFT SECTION
EUROPEAN REGION
CERN
GROUP : TS-CE
CIVIL ENGINEERING
SUPERVISOR : JL.BALDY
DESIGNER : N.BADDAMS
SCALE : 1/50(A3_FORMAT) DATE : 24_NOV_2006
ILC-.CE-1.1630.0002
SIZE 3
INDICE B
9m diameter shafts

Cost Study : reduce diameter of 14m shafts down to 9m

- *Saving from civil engineering to reduce diameter for all six shafts would be in the region of 2Million Euros per shaft. This is only valid for the CERN deep tunnel site.*
- *This is not the case for Asia where tunnel access is via inclined tunnels rather than shafts.*
- *Extra costs due to lowering cryo magnets inclined needs to be assessed*