TESLA Budget Book – Dictionary Version

This tabulation is included here, not to provide any additional cost estimate data beyond what is given in the TESLA TDR, but rather to indicate the extent of the elements considered in preparing the cost estimate. This table was put into a WBS spreadsheet format to facilitate viewing the high level summaries while allowing study of the individual elements. The highest level summary is presented, followed by the expanded listing of the elements considered for each sub-system on subsequent pages.

Level 3 Elements

TESLA Budget Book - Dictionary Version (w/Fermilab WBS)
March 2001 - phg - modified 3dec01
cost estimate in M Euros units - year 2000 costs
includes only level of costs available in TESLA TDR

	# units	1. Cost roll-up	1.a cost roll-up	1.a.b cost roll-up
1 Total - TESLA Collider + XFEL Increments		3,377		
1.1 TESLA Collider - total (not including XFEL)			3,136	
1.1.1 Main Linac Modules				1,131
1.1.2 Main Linac RF System				587
1.1.3 Tunnel & Buildings				546
1.1.4 Machine Infrastructure				336
1.1.5 Damping Rings				215
1.1.6 Auxiliary Systems				124
1.1.7 Beam Delivery System				101
1.1.8 Injection System				97
1.2 XFEL Increments - total			241	
1.2.1 XFEL Increments				241

Level 4 Elements

TESLA Budget Book - Dictionary Version (w/Fermilab WBS)
March 2001 - phg - modified 3dec01
cost estimate in M Euros units - year 2000 costs
includes only level of costs available in TESLA TDR

		# units	1.a.b cost roll-up
1	Total - TESLA Collider + XFEL Increments		
1.1	TESLA Collider - total (not including XFEL)		
1.1.1	Main Linac Modules		1,131
1.1.1.1	Cavity preparation & string assembly		
1.1.1.2	Cryostat modules & sc magnets		
1.1.1.3	Cavity structure & vessel fabrication		
1.1.1.4	Niobium material RRR 300		
1.1.1.5	RF Power & HOM Coupler		
1.1.2	Main Linac RF System		587
1.1.2.1	RF Power Distribution & LLRF		
1.1.2.2	Klystrons & Interlocks		
1.1.2.3	Modulator		
1.1.2.4	Pulse transformer & predriver		
1.1.2.5	HV pulse cable & installation		
1.1.3	Tunnel & Buildings		546
1.1.3.1	Tunnels & access shafts		
1.1.3.2	Site & halls & buildings		
1.1.3.3	General Tunnel Infrastructure		
1.1.4	Machine Infrastructure		336
1.1.4.1	Cryogenic plants & supply		
1.1.4.2	Cryogenic Distribution		
1.1.4.3	Water plants & distribution		
1.1.4.4	AC Power plant & distribution		
1.1.4.5	Various supply systems		
1.1.5	Damping Rings		215
1.1.5.1	Magnets & Power System		
1.1.5.2	Vacuum system		
1.1.5.3	RF Power & cavity system		
1.1.5.4	Beam diagnostics & controls		
1.1.6	Auxiliary Systems		124
1.1.6.1	Global machine control system		
1.1.6.2	Electronic & cabling		
1.1.6.3	Vacuum RF Power coupler		
1.1.6.4	Vacuum modules - Main Linac Cryostats		
1.1.6.5	Various auxiliary systems		
1.1.7	Beam Delivery System		101
1.1.7.1	Magnets & Power System		

Level 5 Elements

TESLA Budget Book - Dictionary Version (w/Fermilab WBS)
March 2001 - phg - modified 3dec01
cost estimate in M Euros units - year 2000 costs
includes only level of costs available in TESLA TDR

		# units	1.a.b cost roll-up
1	Total - TESLA Collider + XFEL Increments		
1.1	TESLA Collider - total (not including XFEL)		
1.1.1	Main Linac Modules		1,131
1.1.1.1	Cavity preparation & string assembly		
1.1.1.1.1	cavity preparation & assembly	20,592	
1.1.1.2	Cryostat modules & sc magnets		
1.1.1.2.1	vacuum vessel & cold mass	1,716	
	vacuum vessel		
	Cryo supports		
	GHeRP (return pipe)		
	shields 4.5 degree		
	shields 70 degree		
	Cryo pipes		
	Cold mass pre-assembly		
	intermediate transportation		
	Final transportation		
	management		
1.1.1.2.2	module intercon beam vacuum	1,716	
1.1.1.2.3	magnet package	750	
1.1.1.2.4	module instrumentation	1,716	
1.1.1.2.5	module interconnection	1,716	
1.1.1.3	Cavity structure & vessel fabrication		
1.1.1.3.1	Structure machining	20,592	
1.1.1.3.2	Tuner mechanics + gear box	20,592	
1.1.1.3.3	Titanium vessel, tubes & bellows	20,592	
1.1.1.3.4	Tuner motor & electronics	20,592	
1.1.1.3.5	Assembly & EB Welding	20,592	
1.1.1.3.6	Magnetic shielding Cryoperm	20,592	
1.1.1.3.7	Magnetic shielding fabrication	20,592	
1.1.1.3.8	Piezo tuner		
1.1.1.4	Niobium material RRR 300		
1.1.1.4.1	Niobium 300 material	20,592	
1.1.1.4.2	Niobium 30 material	20,592	
1.1.1.4.3	NbTi flange material	20,592	
1.1.1.5	RF Power & HOM Coupler		
1.1.1.5.1	RF power coupler fabrication	20,592	
1.1.1.5.2	Cavity control inside	20,592	

1.1.3	Tunnel & Buildings			546
	1.1.3.1	Tunnels & access shafts		
		1.1.3.1.1	Main Linac	33,500
		1.1.3.1.2	Damping ring	4,000
		1.1.3.1.3	Access shaft unit	19
		1.1.3.1.4	Bypass Tunnel positrons	600
		1.1.3.1.5	Engineering costs	
	1.1.3.2	Site & halls & buildings		
		1.1.3.2.1	Site ground	800,000
		1.1.3.2.2	HEP experimental Hall	61,500
		1.1.3.2.3	Site infrastructure - aux halls	8
		1.1.3.2.4	Refrigerator halls	170,520
		1.1.3.2.5	HE dump halls	20,000
		1.1.3.2.6	Cryo Module Test Facility Hall	134,460
		1.1.3.2.7	RF Modulator & Water Plant Halls	113,680
		1.1.3.2.8	Engineering costs	
	1.1.3.3	General Tunnel Infrastructure		
		1.1.3.3.1	Monorail	34,000
		1.1.3.3.2	Traffic lane	37,620
		1.1.3.3.3	Fire safety system	40,000
		1.1.3.3.4	Module supports	3,500
		1.1.3.3.5	Electronic shielding	8,237
		1.1.3.3.6	Handy lossy cable	40,000
1.1.4	Machine Infrastructure			336
	1.1.4.1	Cryogenic plants & supply		
		1.1.4.1.1	Cold boxes	
		1.1.4.1.2	Compressors	
		1.1.4.1.3	Distribution boxes 3,4,5,7	
		1.1.4.1.4	Cold compressors	
		1.1.4.1.5	Distributions boxes 1,6	
		1.1.4.1.6	Purification	
		1.1.4.1.7	Controls	
		1.1.4.1.8	Liquid Helium storage	
		1.1.4.1.9	Warm gas storage	
		1.1.4.1.10	Distribution box 2	
		1.1.4.1.11	Helium	
		1.1.4.1.12	Miscellaneous	
		1.1.4.1.13	Budget value to XFEL Incrementals	
	1.1.4.2	Cryogenic Distribution		
		1.1.4.2.1	Warm Helium gas tube (DN200)	
		1.1.4.2.2	Transfer lines	
		1.1.4.2.3	Vacuum Barriers	
		1.1.4.2.4	Feed boxes	
		1.1.4.2.5	End boxes	
		1.1.4.2.6	Injection feed boxes	
		1.1.4.2.7	Damping ring RF feed boxes	
		1.1.4.2.8	Controls	
		1.1.4.2.9	Booster	
		1.1.4.2.10	Injection distribution box	

1.1.4.3 Water plants & distribution
- 1.1.4.3.1 Water auxiliary halls
- 1.1.4.3.2 Water tunnels
- 1.1.4.3.3 Water XFEL
- 1.1.4.3.4 Water Experiments

1.1.4.4 AC Power plant & distribution
- 1.1.4.4.1 Low Voltage AC Power distribution
- 1.1.4.4.2 High Voltage AC Power plant
- 1.1.4.4.3 20 KV AC power switchyard stations
- 1.1.4.4.4 Wall plug power
- 1.1.4.4.5 Low Voltage AC Power stations

1.1.4.5 Various supply systems
- 1.1.4.5.1 Main LINC segment ventilation 8
- 1.1.4.5.2 Auxiliary Hall ventilation 8
- 1.1.4.5.3 Main Linac first station ventilation 2
- 1.1.4.5.4 HEP Experimental hall ventilation 1
- 1.1.4.5.5 Damping Ring Infrastructure
- 1.1.4.5.6 Cryo Test facility cryogenics
- 1.1.4.5.7 RF Power test facility
- 1.1.4.5.8 Cryo test facility operation
- 1.1.4.5.9 Cryo test RF Power System
- 1.1.4.5.10 Cryo test control system
- 1.1.4.5.11 Cryo-connection to HERA cryo-plant
- 1.1.4.5.12 Cryo test vacuum
- 1.1.4.5.13 Cryo Test vertical dewar RF

1.1.5 Damping Rings 215

- 1.1.5.1 Magnets & Power System
  - 1.1.5.1.1 Special Magnets - Wigglers
  - 1.1.5.1.2 Quadrupoles for Damping Ring
  - 1.1.5.1.3 Dipoles for Damping Ring
  - 1.1.5.1.4 Injection/Extraction Sections
  - 1.1.5.1.5 Sextupoles for Damping Ring
  - 1.1.5.1.6 Magnet assembly
  - 1.1.5.1.7 Solenoids B-line & Bunch Compressor
  - 1.1.5.1.8 Magnetic measurements
  - 1.1.5.1.9 Correctors for Damping Ring
  - 1.1.5.1.10 Quadrupoles for Beamline & B.C.
  - 1.1.5.1.11 multipole girders/supports
  - 1.1.5.1.12 Power supply system
  - 1.1.5.1.13 Dipoles for Beamline and B.C.
  - 1.1.5.1.14 Dipole stands and supports
  - 1.1.5.1.15 Correctors for Beamline & B.C.
  - 1.1.5.1.16 Sextupoles for Beamline & B.C.
- 1.1.5.2 Vacuum system
  - 1.1.5.1.1 Pumps and power supplies
  - 1.1.5.1.2 Damping Ring Vacuum Chamber
  - 1.1.5.1.3 Vacuum chamber supports
  - 1.1.5.1.4 Manual & auto valves
- 1.1.5.3 RF Power & cavity system
  - 1.1.5.3.1 RF Cryo-modules
  - 1.1.5.3.2 RF Power sources
  - 1.1.5.3.3 Waveguide network system
  - 1.1.5.3.4 Cryogenic system
  - 1.1.5.3.5 Cooling system
  - 1.1.5.3.6 Electronics, controls, interlocks, etc.
- 1.1.5.4 Beam diagnostics & controls
  - 1.1.5.4.1 BPM button/strip line monitors
  - 1.1.5.4.2 Beam diagnostics electronics
  - 1.1.5.4.3 Toroidal current transformers
  - 1.1.5.4.4 Wall current monitors
  - 1.1.5.4.5 Emittance measurement system
  - 1.1.5.4.6 Tune monitors
  - 1.1.5.4.7 Beam loss monitors
  - 1.1.5.4.8 Fluorescent screens
  - 1.1.5.4.9 Scrapers
  - 1.1.5.4.10 DC current transformers

1.1.6	Auxiliary Systems		124
1.1.6.1	Global machine control system		
	1.1.6.1.1	Electronics racks, etc	700
	1.1.6.1.2	Crates, front-end servers	700
	1.1.6.1.3	Control room equipment	100
	1.1.6.1.4	Network equipment	800
	1.1.6.1.5	Expendable Materials	300
	1.1.6.1.6	Network cables	500
	1.1.6.1.7	Alarm interface modules	60
	1.1.6.1.8	Servers & consoles	300
	1.1.6.1.9	Alarm line cables	60
1.1.6.2	Electronic & cabling		
	1.1.6.2.1	Data acquisition	900
	1.1.6.2.2	Monitor electronics Main Linac	800
	1.1.6.2.3	Beam loss Main Linac	800
	1.1.6.2.4	Beam monitors Main Linac	800
	1.1.6.2.5	Monitor electronics general	500
	1.1.6.2.6	Commercial electronics	100
	1.1.6.2.7	Monitor beam lines	100
	1.1.6.2.8	Miscellaneous items	
1.1.6.3	Vacuum RF Power coupler		
	1.1.6.3.1	Pump tube d=100	
	1.1.6.3.2	Sputter pump - 60 l/sec	
	1.1.6.3.3	Titanium sublimation pump	
	1.1.6.3.4	Sputter pump power supplies	
	1.1.6.3.5	TSP power supplies	
	1.1.6.3.6	Manual valve ID 35	
	1.1.6.3.7	Vacuum component electronics	
	1.1.6.3.8	Bellows	
	1.1.6.3.9	Pump pots	
1.1.6.4	Vacuum modules - Main Linac Cryostats		
	1.1.6.4.1	Penning filaments	
	1.1.6.4.2	Pump stations	
	1.1.6.4.3	Manual vacuum valve ID 100	
	1.1.6.4.4	Vacuum installation tools cryostats	
	1.1.6.4.5	Vacuum component electronics	
	1.1.6.4.6	Bridge valves	
	1.1.6.4.7	Pirani filaments	
1.1.6.5	Various auxiliary systems		
	1.1.6.5.1	DC power supplies Main Linac	
	1.1.6.5.2	Spare linac modules	
	1.1.6.5.3	Alignment & Survey	
	1.1.6.5.4	Cables from general store	
	1.1.6.5.5	Connectors from general store	
	1.1.6.5.6	Main Linac beam vacuum control	
	1.1.6.5.7	Radiation safety interlock system	

1.1.7	Beam Delivery System		101
1.1.7.1	Magnets & Power System		
	1.1.7.1.1	Magnet Supplies & Cables	
	1.1.7.1.2	Quadrupoles	180
	1.1.7.1.3	Main Dipoles	370
	1.1.7.1.4	Electrostatic Separators	32
	1.1.7.1.5	SC Doublets	2
	1.1.7.1.6	Sextupoles & Octupoles	26
	1.1.7.1.7	Movers	206
	1.1.7.1.8	Emergency extraction quads	22
	1.1.7.1.9	Emergency extraction dipoles	12
	1.1.7.1.10	Supports	624
	1.1.7.1.11	H/V correctors	400
	1.1.7.1.12	Main extraction quadrupoles	6
	1.1.7.1.13	Main extraction dipoles	4
	1.1.7.1.14	Main extraction septum	2
	1.1.7.1.15	Emergency extraction septum	2
1.1.7.2	Beam Stops & cooling		
	1.1.7.2.1	Cooling system	2
	1.1.7.2.2	Fast extraction, 30 kicker, 1 m long	2
	1.1.7.2.3	Fast sweep	4
	1.1.7.2.4	Water vessel	6
1.1.7.3	Beam diagnostic		
	1.1.7.3.1	Laser profile	2
	1.1.7.3.2	Beam electronics	370
	1.1.7.3.3	Final Focus Monitor	2
	1.1.7.3.4	BPM	200
	1.1.7.3.5	Beam loss monitor	370
	1.1.7.3.6	Wire scanner	16
	1.1.7.3.7	Cables & connectors	370
1.1.7.4	Vacuum System		
	1.1.7.4.1	Copper surfacing	1,800
	1.1.7.4.2	Vacuum tubes	3,400
	1.1.7.4.3	Pumps & valves	200
	1.1.7.4.4	Electronics	200
	1.1.7.4.5	Vacuum utilities	200
1.1.7.5	Fast Kicker & Collimator System		
	1.1.7.5.1	Spoiler	26
	1.1.7.5.2	Spoiler cooling water unit	26
	1.1.7.5.3	Absorber	12
	1.1.7.5.4	Absorber cooling water circuit	12
	1.1.7.5.5	Instrumentation	2
	1.1.7.5.6	General cables & connectors	3,400
	1.1.7.5.7	Fast Kickers	16
	1.1.7.5.8	Magnet mover electronics & cables	206
	1.1.7.5.9	BPM	10
	1.1.7.5.10	Electronics	1
	1.1.7.5.11	Miscellaneous	

1.2	XFEL Increments - total			
	1.2.1	XFEL Increments		241
	1.2.1.1	XFEL Tunnel & buildings		
		1.2.1.1	XFEL Experimental hall	150,000
		1.2.1.2	XFEL dump halls	24,000
		1.2.1.3	XFEL tunnels	8,000
		1.2.1.4	XFEL tunnel infrastructure	8,000
	1.2.1.2	XFEL Machine additives		
		1.2.2.1	Additional air conditioning	
		1.2.2.2	Radiation safety design & interlocks	
		1.2.2.3	XFEL Gun & Injector	
			1.2.2.3.1 Equipped cryostat modules	
			1.2.2.3.2 2x10 MW klystron/modulator assmbl.	
			1.2.2.3.3 Bunch compressors	
			1.2.2.3.4 Laser	
			1.2.2.3.5 3rd harmonic accel. cavity/coupler	
			1.2.2.3.6 Power supplies	
			1.2.2.3.7 Preparation chamber (mech&vac)	
			1.2.2.3.8 Vacuum & Diagnostics	
		1.2.2.4	Additional water plant & distribution	
		1.2.2.5	Compressor cavities	120
		1.2.2.6	Compressor RF power system	3
		1.2.2.7	Cryogenic distribution additives	
		1.2.2.8	Wave guide absorber adds	2,052
		1.2.2.9	Power supply RF modulator adds	57
		1.2.2.10	Substation racks & electronics	50
		1.2.2.11	Ten Degree bend for XFEL	
		1.2.2.12	XFEL Bunch compressor 2 & 3	
		1.2.2.13	Compressor cryostat module	10
	1.2.1.3	XFEL Beam switchyard		
		1.2.3.1	XFEL beam dump components	
		1.2.3.2	Dipole magnets	295
		1.2.3.3	Quadrupole magnets	537
		1.2.3.4	Sextupole Magnets	284
		1.2.3.5	Pulsed dipole magnets	6
		1.2.3.6	Correction magnets	120
		1.2.3.7	Octupole magnets	16
		1.2.3.8	Power supplies & cables	
		1.2.3.9	Beam diagnostic & feedbacks	
		1.2.3.10	Vacuum System	
		1.2.3.11	Cable, connectors & mechanics	
	1.2.1.4	Linac to XFEL Beam lines		
		1.2.4.1	Magnets	
		1.2.4.2	Power supplies & cables	
		1.2.4.3	Vacuum per meter	
		1.2.4.4	Beam position monitors	

Element Descriptions for TESLA Conventional Construction and Infrastructure

WBS Dictionary for 1.1.3 Tunnels and Buildings and 1.1.4 Machine Infrastructure

Introduction:

The following descriptions were developed based on general discussions during my visit to the DESY Laboratory. The intent is to create an understanding of the content of the TESLA Budget Book, specifically for the Conventional Facilities that will be provided as part of the TESLA project. A brief discussion of various aspects of the project scope and comments on the cost estimating process are included in the main body of this report.

Work Breakdown Structure (WBS) category numbers, corresponding to elements or entries in the TESLA Budget Book, were attached by Fermilab. This was both to more nearly match customary U.S. formats and to facilitate cross-referencing.

The buildings and tunnel enclosures are identified in **TESLA WBS 1.1.3, "Tunnel and Buildings"**. However, additional items that are considered, from the Fermilab perspective, to be part of "Conventional Facilities" are also contained in **TESLA WBS 1.1.4, "Machine Infrastructure"** and are identified by element number below.

Note that there are some inconsistencies in the sizes of the surface buildings between the TDR, the TESLA Budget Book, and the schematic table presented at Snowmass in July, 2002.

1.1.3 Tunnel & Buildings

1.1.3.1 Tunnels and Access Shafts

1.1.3.1.1 **Main Linac**- This is the Main Linac enclosure. It consists of a bored tunnel, fully lined with precast concrete "tubbings". Due to construction below sea level, the tunnel will constructed using a shielded tunnel boring machine incorporating a pressurized cutting head to eliminate water infiltration and a recycled bentonite slurry for the removal of excavated material. This enclosure is 33 km in length and has an inside finished diameter of 5.2 m. Grouting behind the precast concrete is included and will be accomplished as part of the precast liner installation. This tunnel is intended to be constructed as part of a design/build project with the design costs included in the per lineal meter unit cost. This unit cost was developed based on the actual tunnel costs incurred during the construction of the HERA project. The finished tunnel will consist of the interior surface of the precast lining with no provision for lighting,

HVAC, electrical distribution, monorail or other interior finishes. (These are included in the 1.1.4 Machine Infrastructure section.)

1.1.3.1.2 **Damping Ring** - These are four "loops" connected to the Main Linac enclosure. Like the Main Linac, these "loops" consist of a bored tunnel, fully lined with precast concrete "tubbings". Due to construction below sea level, the tunnel will constructed using a shielded tunnel boring machine incorporating a pressurized cutting head to eliminate water infiltration and a recycled bentonite slurry for the removal of excavated material. These enclosures total 4 km in length and have an inside finished diameter of 3 m. Grouting behind the precast concrete is included and will be accomplished as part of the precast liner installation. This tunnel is intended to be constructed as part of a design/build project with the design costs included in the per meter unit cost. This unit cost was developed based on the actual tunnel costs incurred during the construction of the HERA project. The finished tunnel will consist of the interior surface of the precast lining with no provision for lighting, HVAC, electrical distribution, monorail or other interior finishes. (These are included in the 1.1.4 Machine Infrastructure section.)

1.1.3.1.3 **Access Shafts** – There are nineteen access shafts included in the TESLA conventional construction of which eleven are permanent shafts and eight are considered temporary for the facilitation of construction activities and will be filled in with no surface access at the completion of construction. These shafts are nominally 15 m in finished diameter, and range from 20 m to 30 m in depth. They are to be concrete structures, either cast-in-place or precast lined depending on the final contracted design. In the estimate, a single average unit cost per shaft has been assigned. These shafts are intended to be constructed as part of a design/build project with the design costs included in the unit cost per shaft. The shafts were sized at 15 meters, but new cryomodules are planned to be 17 meters long, requiring larger access shafts to prevent having to tip the cryomodules during installation.

1.1.3.1.4 **Positron By-pass Tunnel** - This is the enclosure that allows the positron beam to by-pass the interaction region and be transported into the positron Main Linac tunnel. It consists of a bored tunnel, fully lined with precast concrete "tubbings". Due to construction below sea level, the tunnel will constructed using a shielded tunnel boring machine incorporating a pressurized cutting head to eliminate water infiltration and a recycled bentonite slurry for the removal of excavated material. This enclosure is 600 m in length and has an inside finished diameter of 3 m. Grouting behind the precast concrete is included and will be accomplished as part of the precast liner installation. This tunnel is intended to be constructed as part of a design/build project with the design costs included in the per meter unit cost. This unit cost was

developed based on the actual tunnel costs incurred during the construction of the HERA project. The finished tunnel will consist of the interior surface of the precast lining with no provision for lighting, HVAC, electrical distribution, monorail or other interior finishes. (These are included in the 1.1.4 Machine Infrastructure section.)

1.1.3.1.5 **Engineering Costs** – This element includes the costs for contracted A/E and Construction Management support of 1.1.3.1, Tunnels and Buildings, that is not included in the design/build descriptions indicated above and specifically excludes any additional operational or engineering support from existing DESY personnel.

1.1.3.2 Site and Halls and Buildings

1.1.3.2.1 **Site Ground** – This element provides for the acquisition of surface land required for the construction of the TESLA project beyond the existing DESY site. Specifically it provides land for the construction of the permanent access shafts and surface buildings at the six cryogenic plant sites distributed along the length of the TESLA tunnel beyond the existing DESY site. Each of these six sites requires approximately 40,000 m^2 (10 acres). This element also includes the land needed for the central area, which includes the interaction hall and beam dumps as well as the land required for the XFEL. The central site requires approximately 540,000 m^2 (135 acres). The value assigned to this element is based on a prevailing land cost per m^2. This per m^2 cost includes a nominal provision for connecting to local natural gas, domestic water and sanitary sewer service if available. If these utilities are not locally available, propane, local water wells and sanitary holding tanks or portable toilet facilities will be considered.

1.1.3.2.2 **HEP Experimental Hall** – This is the single, below ground interaction region hall. The hall will be constructed of cast-in-place concrete and is modeled after the experimental halls provided for the HERA project. The experimental hall measures 82 m x 32 m in plan with a ceiling height of 23 m. This provides a total estimated volume of 61,500 m^3. The price for this element is based on a unit cost per m^3 and is primarily based on the construction experience gained from the HERA project. This hall is intended to be constructed as part of a design/build project with the design costs included in the per m^3 unit cost. The finished hall will consist of the interior surface of the cast-in-place concrete with no provision for lighting, HVAC, electrical distribution or other interior finishes.

1.1.3.2.3 **Site Infrastructure Auxiliary Halls** – This element provides additional local infrastructure support for the seven cryogenic halls and access shafts as well as the single access hall and shaft at the far end of the

positron Main Linac at Westerhorn. The cost for this element is applied as a lump sum per hall.

1.1.3.2.4 **Refrigerator Halls** – This element describes the seven surface buildings that enclose the cryogenic equipment and access shafts to the tunnel enclosure below. Each building measures 85 m x 32 m in plan with a ceiling height of 10 m. This provides a total estimated volume of 24,360 m^3 per building. While general lighting and power distribution is included in this cost, there is no provision for HVAC with respect to comfort cooling or heating in the base cost. It is intended that rejected heat will be utilized to meet winter heating needs. These buildings are intended to be constructed as part of a design/build project with the design costs included in the per m^3 unit cost.

1.1.3.2.5 **High Energy Dump Halls** – These are the two below ground halls that will enclose the electron and positron dumps adjacent to the experimental hall. They will be constructed of cast-in-place concrete and is modeled after the experimental halls provided for the HERA project. Each dump enclosure measures 30 m x 25 m in plan with a ceiling height of 15 m. This provides a total estimated volume of 11,250 m^3 for each enclosure. The price for this element is based on a unit cost per m^3 and is primarily based on the construction experience gained from the HERA project. These enclosures are intended to be constructed as part of a design/build project with the design costs included in the per m^3 unit cost. The finished hall will consist of the interior surface of the cast-in-place concrete with no provision for lighting, HVAC, electrical distribution or other interior finishes.

1.1.3.2.6 **Cryo Module Test Facility Hall** – This is a single surface building which will house the equipment needed to test the completed cryogenic modules prior to final installation. It measures 135 m x 85 m with a ceiling height of 12 m. This provides a total estimated volume of 137,700 m^3. While general lighting and power distribution is included in this cost, there is no provision for HVAC with respect to comfort cooling or heating in the base cost. It is intended that rejected heat will be utilized to meet winter heating needs. These buildings are intended to be constructed as part of a design/build project with the design costs included in the per m^3 unit cost.

1.1.3.2.7 **RF Modulator and Water Plant Halls** - This element describes the even surface buildings that enclose equipment required for the cooling needs of the non-cryogenic portions of the TESLA machine. These buildings will be constructed in conjunction with the Refrigerator Halls described above and measure 35 m x 35 m in plan with a ceiling height of 5 m. This provides a total estimated volume of 6,125 m^3 per building. While general lighting and power distribution is included in this cost,

there is no provision for HVAC with respect to comfort cooling or heating in the base cost. It is intended that rejected heat will be utilized to meet winter heating needs. These buildings are intended to be constructed as part of a design/build project with the design costs included in the per m^3 unit cost. (Note added, May, 2002: the RF modulator requirements per location are for three floors, each of 1,480 m^2 area. This is to be added to the 232 m^2 requirement for the water plant as in the TDR.)

1.1.3.2.8 **Engineering Cost -** This element includes the costs for contracted A/E and Construction Management support of 1.1.3.2, Site and Halls and Buildings, that is not included in the design/build descriptions indicated above and specifically excludes any additional operational or engineering support from existing DESY personnel.

1.1.3.3 General Tunnel Infrastructure

1.1.3.3.1 **Monorail** – This monorail system runs the entire length of the machine enclosure. It provides the means for personnel and material transport as well as consideration for emergency use. The cost is based on a unit amount per lineal meter of tunnel enclosure including installation and was developed directly by the monorail manufacturer.

1.1.3.3.2 **Traffic Lane** – This element provides the traffic lane structure within the Main Linac and damping ring enclosures. It consists of a steel platform built over the distribution cables installed for high voltage and pulse power. It provides for personnel access along the length of the enclosures. The cost is based on a unit amount per lineal meter of tunnel enclosure.

1.1.3.3.3 **Fire Safety System** – A unit amount per lineal meter of tunnel in included in the estimate to address fire safety issues. It is intended that this system will include a full detection system with only localized suppression and some consideration for remote fire fighting capability with the monorail trains.

1.1.3.3.4 **Module Supports** – This element provides the support stands for the fully assembled machine modules. They are considered structural supports and therefore part of the conventional construction. The cost is based on a per unit amount that includes both manufacture and installation.

1.1.3.3.5 **Electronic Shielding** – This element provides for localized radiation shielding of sensitive electronic equipment at various locations along the length of the tunnel. Its cost is based on a unit amount per lineal meter of tunnel enclosure as required.

1.1.3.3.6 **Handy Lossy Cable** – This element provides for basic communication needs throughout the underground enclosures. The cost is based on a unit amount per lineal meter of tunnel enclosure.

1.1.4 Machine Infrastructure

1.1.4.3 Water Plants and Distribution

1.1.4.3.1 **Water in Auxiliary Halls** – This element provides the equipment and water source needed at each surface Refrigerator Hall for the cooling water system. It includes required chillers, pumping equipment and piping as well as the drilling of a water well if local domestic water is not available.

1.1.4.3.2 **Water in Tunnels** – This element provides the equipment needed with the tunnel enclosures for the cooling water system.

1.1.4.3.3 **Water at XFEL** – This element provided the equipment needed for the XFEL facility requirements for cooling water.

1.1.4.3.4 **Water at Experimental Area** – This element provides the equipment and water source needed specifically for the cooling water system required at the interaction region. It includes the required chillers, pumping equipment and piping as well as the drilling of a water well if local domestic water is not available.

Elements 1.1.4.3.1 through 1.1.4.3.4 were discussed as a single system and only a total estimated cost for the entire system was indicated.

1.1.4.4 AC Power Plant and Distribution

1.1.4.4.1 **Low Voltage AC Power Distribution** – This element provides for the installation of all material and equipment needed for power distribution at the 400 V level for all structures and enclosures both above and below ground.

1.1.4.4.2 **High Voltage AC Power Plant** – This element provides for the installation of all material and equipment needed for the eight individual connections to local main power distribution supply lines located at each of the cryogenic Refrigerator Halls.

1.1.4.4.3 **20 KV AC Power Switchyard Stations** – This element provides for the installation of all material and equipment needed for the eight individual substations required to transform available local line power to distribution at the 20 KV level.

1.1.4.4.4 **Wall Plug Power** - This element provides for the installation of all material and equipment needed for wall plug power distribution in all structures and enclosures both above and below ground.

1.1.4.4.5 **Low Voltage Power Stations** - This element provides for the installation of all material and equipment needed at the eight individual substations required to transform secondary power from the 20 KV level to the 400 V level.

Elements 1.1.4.4.1 through 1.1.4.4.5 were discussed as a single system and only a total estimated cost for the entire system was indicated.

1.1.4.5 Various Supply Systems

1.1.4.5.1 **Main Linac Segment Ventilation** – This element provides for the installation of all material and equipment needed to meet the ventilation requirements of the Main Linac enclosures with equipment located at each of the cryogenic Refrigerator Halls.

1.1.4.5.2 **Auxiliary Hall Ventilation** - This element provides for the installation of all material and equipment needed to meet the ventilation requirements of the surface level cryogenic Refrigerator Halls.

1.1.4.5.3 **Main Linac First Station Ventilation** - This element provides for the installation of all material and equipment needed to meet the ventilation requirements at the start of each Main Linac enclosure with equipment located at each respective access shaft.

1.1.4.5.4 **HEP Experimental Hall Ventilation** - This element provides for the installation of all material and equipment needed to meet the ventilation requirements at the interaction region.

1.1.4.5.5 **Damping Ring Infrastructure** - This element provides for the installation of all material and equipment needed to meet the ventilation requirements at the damping ring enclosures with equipment located at each respective access shaft.

Elements 1.1.4.5.1 through 1.1.4.5.5 were discussed as a single system and only a total estimated cost for the entire system was indicated.