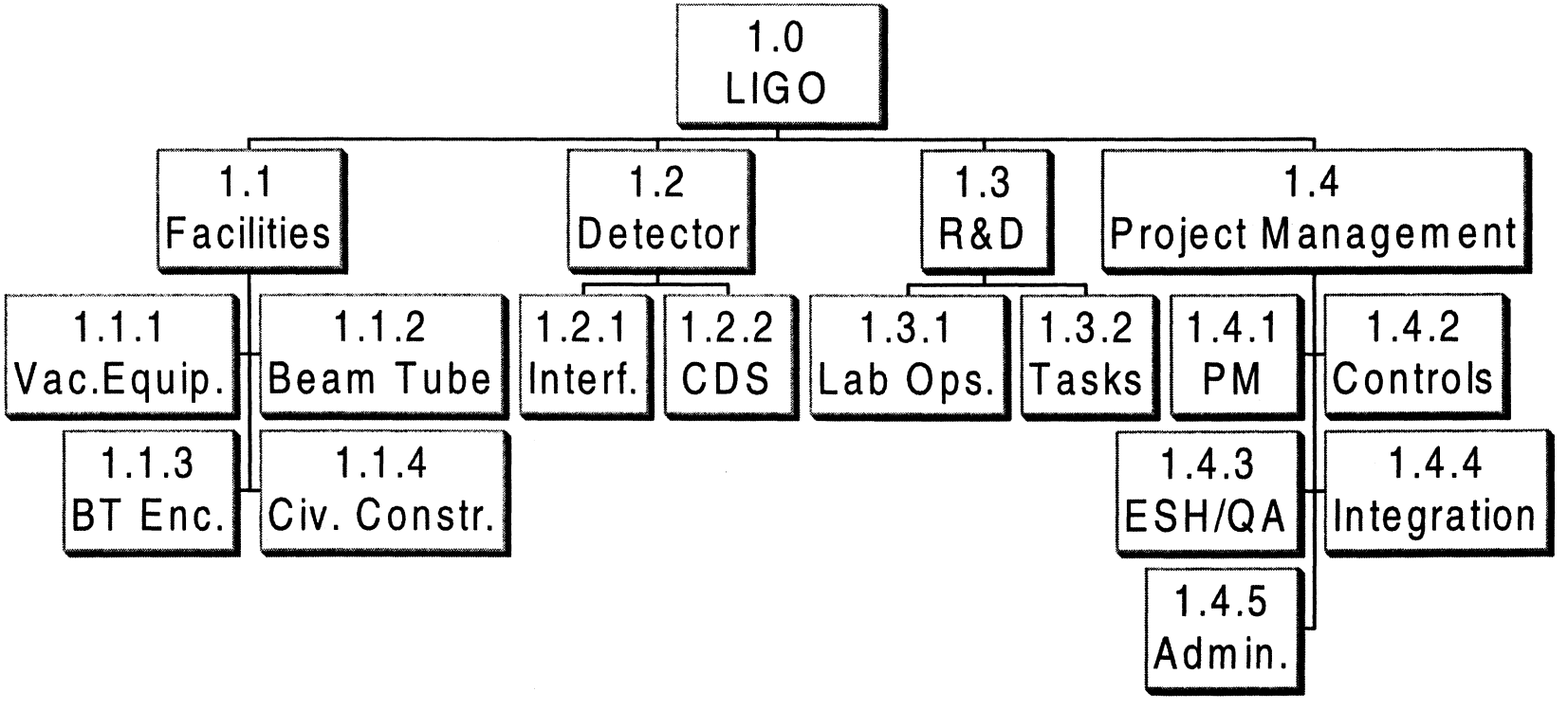
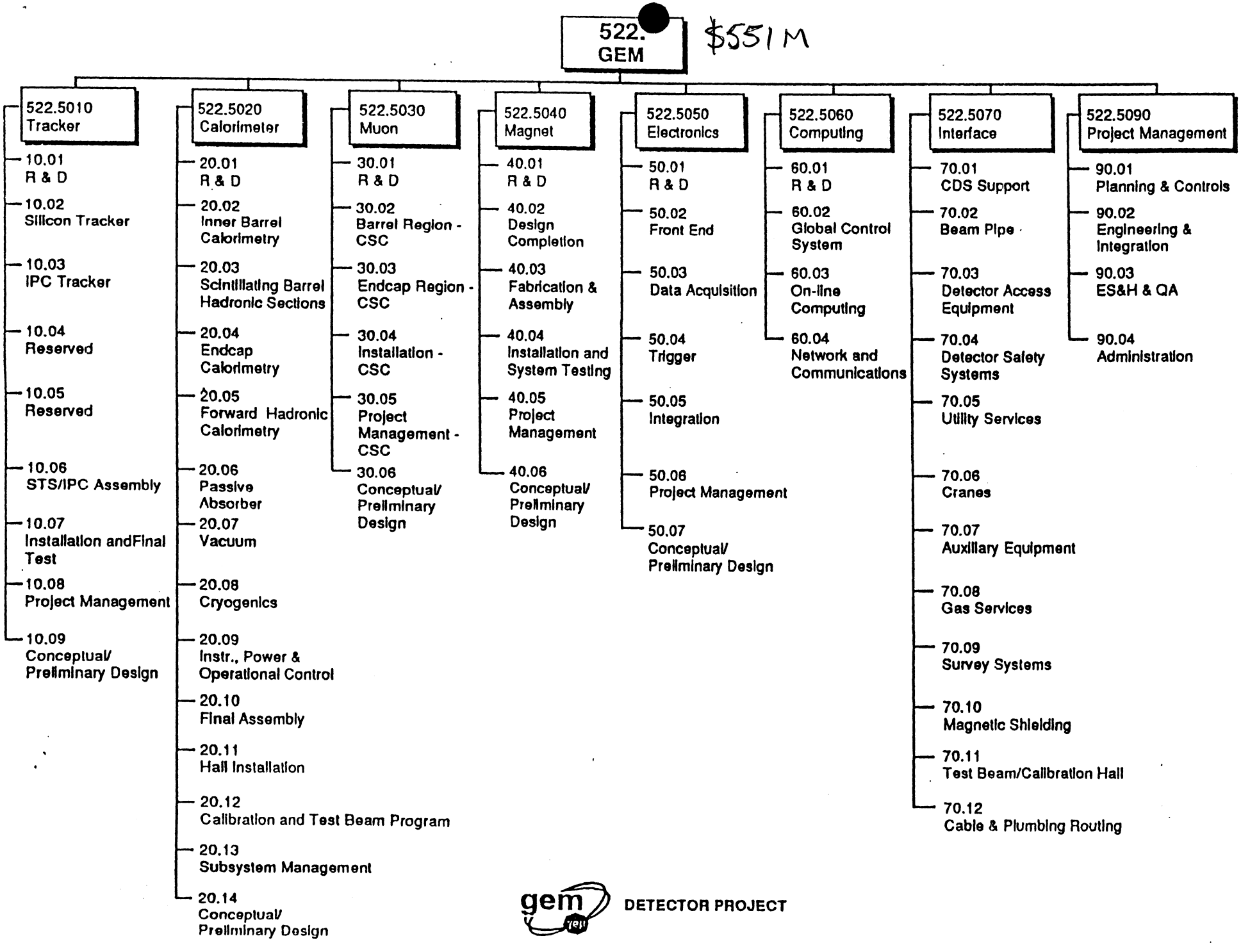
LIGO Work Breakdown Structure




522.
GEM
$551 M
522.5010
Tracker
10.01
R & D
10.02
Silicon Tracker
10.03
IPC Tracker
10.04
Reserved
10.05
Reserved
10.06
STS/IPC Assembly
10.07
Installation andFinal
Test
10.08
Project Management
10.09
Conceptual/
Preliminary Design
522.5020
Calorimeter
20.01
R & D
20.02
Inner Barrel
Calorimetry
20.03
Scintillating Barrel
Hadronic Sections
20.04
Endcap
Calorimetry
20.05
Forward Hadronic
Calorimetry
20.06
Passive
Absorber
20.07
Vacuum
20.08
Cryogenics
20.09
Instr., Power &
Operational Control
20.10
Final Assembly
20.11
Hall Installation
20.12
Calibration and Test Beam Program
20.13
Subsystem Management
20.14
Conceptual/
Preliminary Design
522.5030
Muon
30.01
R & D
30.02
Barrel Region -
CSC
30.03
Endcap Region -
CSC
30.04
Installation -
CSC
30.05
Project
Management -
CSC
30.06
Conceptual/
Preliminary
Design
522.5040
Magnet
40.01
R & D
40.02
Design
Completion
40.03
Fabrication &
Assembly
40.04
Installation and
System Testing
40.05
Project
Management
40.06
Conceptual/
Preliminary
Design
522.5050
Electronics
50.01
R & D
50.02
Front End
50.03
Data Acquisition
50.04
Trigger
50.05
Integration
50.06
Project Management
50.07
Conceptual/
Preliminary Design
522.5060
Computing
60.01
R & D
60.02
Global Control
System
60.03
On-line
Computing
60.04
Network and
Communications
522.5070
Interface
70.01
CDS Support
70.02
Beam Pipe
70.03
Detector Access
Equipment
70.04
Detector Safety
Systems
70.05
Utility Services
70.06
Cranes
70.07
Auxiliary Equipment
70.08
Gas Services
70.09
Survey Systems
70.10
Magnetic Shielding
70.11
Test Beam/Calibration Hall
70.12
Cable & Plumbing Routing
522.5090
Project Management
90.01
Planning & Controls
90.02
Engineering &
Integration
90.03
ES&H & QA
90.04
Administration
gem
DETECTOR PROJECT

Cost Estimate - Source of Estimate

- Clearly identify the type of the source of the estimate
  - » Engineering Estimate (EE) - least reliable
  - » Vendor Quotation (VQ) - better, but likely to increase
  - » Placed Order (PO) - even better
  - » Actual Costs (AC) - best
  - » Other methods include Parametric, Trends, Specific Analogy
- For every material subsystem, work to increase the fraction of the estimate based upon industrial vendor quotations

GEM COST ESTIMATE SUMMARY

4/26/93

EM DETECTOR SYSTEM

FY93 U.S. Dollars

BS Code	Description	WBS Level	Material, k$	ManHours	Labor, k$	M + L, k$	Markup, k$	%	Contingency, k$	%	TOTAL, k$
	-GEM DETECTOR SYSTEM	00	274,531	3,657,544	167,306	441,837	6,029	1%	103,362	23%	551,228
	-CENTRAL TRACKER	01	12,168	190,275	9,786	21,954	0	0%	5,369	25%	27,324
	-CALORIMETER	01	68,570	1,012,430	37,976	106,546	0	0%	28,870	27%	135,415
	-MUON	01	40,631	891,791	36,819	77,449	0	0%	20,897	27%	98,347
	-MAGNET	01	64,787	348,234	33,232	98,019	6,029	6%	21,277	21%	125,325
	-ELECTRONICS	01	52,619	465,971	22,552	75,171	0	0%	17,100	23%	92,272
	-COMPUTER & CONTROLS	01	10,390	168,299	5,478	15,869	0	0%	3,591	23%	19,460
	-INTERFACE SYSTEMS	01	21,814	122,305	3,567	25,381	0	0%	4,433	18%	29,813
	-PROJECT MANAGEMENT	01	3,551	458,239	17,897	21,448	0	0%	1,825	9%	23,274

0.03.1.2.3 VESSEL SUPPORT STRUCTURES FAB/ASSY

						MATERIAL		LABOR						TOTALS
NE EM	ITEM CODE	ITEM DESCRIPTION	QUANTITY	UNIT MEAS	COST BASIS	UNIT COST	TOTAL MAT'L,$	CRAFT/ TEAM	HOURLY RATE	MH/ UNIT	TOTAL HOURS	UNIT COST	TOTAL LABOR,$	MAT'L+ LABOR,$
1	I&A	Coordinator Suppt During Const	3.00	MM	BU			INSPAD	60	147	441	8,859	26,578	26,578
2	M&S	Weld Inspec Qa Time	0.50	MY	BU	97,610	48,805							48,805
3	P/F	Saddles 304l Ss W/ 8% Waste	262.00	TON	BU	4,154	1,088,243							1,088,243
4	P/F	Support Blocks 304l Ss	80.00	TONS	BU	4,154	332,288							332,288
5	P/F	Transportation	20.00	LOADS	BU	2,596	51,920							51,920
6	P/F	Plate Section Burning	120.00	SECTION	BU	623	74,765							74,765
7	P/F	Web Section Burning	8.00	WLDMNTS	BU	1,817	14,538							14,538
8	P/F	Weld Fixturing & Alignmnet	1.00	LS	BU	41,536	41,536							41,536
9	P/F	Welding	8.00	WLDMNTS	BU	10,384	83,072							83,072
10	P/F	Blasting	16.00	WLDMNTS	BU	2,596	41,536							41,536
11	P/F	Rigging	1.00	LS	BU	103,840	103,840							103,840
12	P/F	Hydraulic Jacking System	1.00	LS	BU	207,680	207,680							207,680
13	P/F	Transporter Grease Pads	24.00	EA	BU	8,650	207,597							207,597
14	I&A	On/off Site Inspections	2.00	MM	BU			INSPAD	60	147	294	8,859	17,719	17,719
SUBTOTAL -		40.03.1.2.3 VESSEL SUPPORT STRUCTURES FAB/ASSY					$2,295,819				735		$44,297	$2,340,117

PRIME CONTRACTOR MARKUP	7.71%	$180,373
		$2,520,490
CONTINGENCY	22.00%	$554,508
COST PLUS CONTINGENCY		**$3,074,998**

COST MATRIX

	ENG/DES	M&S	INSP/ADM	PROC/FAB	ASSBLY	INSTALL
LABOR	0		44,297		0	0
MATERIAL	0	48,805	0	2,247,015	0	0
TOTAL, $	0	48,805	44,297	2,247,015	0	0
MANHOURS	0		735		0	0

LABOR

TOUCH LABOR =	$0
EDIA LABOR =	$44,297

RISK

Technical Risk	6%
Cost Risk	8%
Schedule Risk	8%

ESTIMATOR: G. DEIS/J. BOWERS
DATE OF ESTIMATE: 06/15/92

Magnet
Basis of Estimate

WBS: 40.03.1.2.3 Item: Vessel Support Structures
Date: 6/15/92 Rev: 0C By: G. Deis/J. Bowers

Element Scope: This element includes all of the hardware required to physically support the coil, vessel, and muon sector assemblies in the underground hall. This will include the saddles to support the outer vessel as well as any jacking hardware provided to align the magnet, to compensate for ground motion, or to move the magnet assemblies. This does not include any concrete structures, such as piers or support beams, which are assumed to be parts of the hall facility.

Technical design description:
The saddle support structures are low carbon steel weldments consisting of large flat plate sections. Four saddle weldments are provided to support each vessel assembly, including the magnet and all internal detectors. Total weight supported by four saddle supports is conservatively 3000 tons.

It is assumed that all four saddles see equal dead loads and horizontal loads.

All saddles can be hydraulically jacked to transport the vessel system and for alignment. The jacking system is part of the transporter, and will be capable of lifting the weight of the vessel system plus the saddles, and have sufficient control to enable pitch, roll and elevation positioning.

Interface to the building foundation is through shim blocks mounted to the floor.

Total weight of four saddle support weldments is 121 tons

Two sets of four are required, one set for each vessel.

Inspection/Admin
Basis:

coordinator support during construction	3 mm
off-site/on-site inspections	2 mm

EDIA/QA Material&Services
Basis: Quality Assurance weld inspection time .5my

Procurement/Fabrication
Basis: each vessel
raw materials
saddles:
121 tons 304L stainless steel in finished structures
add 8% waste giving 131 tons of raw material
mill rate = $2.00/ lb yielding $524K

support blocks:
40 tons 304L stainless steel in finished structures
mill rate = $2.00/ lb yielding $160k

weld material cost is included in welding cost

transportation $2500/load x 10 loads = $25k

plate section burning 0.5 days/ section, $600/ section x 60 sections = $36k

machine base plate 2 days/ weldment x 4 weldments = 8 days = $7k

weld fixturing and alignment $20k

welding $10k per weldment x 4 weldments = $40k

blasting $2.5k per weldment x 8 weldments = $20k

rigging $50k

total cost per vessel= $882k

total cost for two vessels = $1764k

Cost of hydraulic jacking system $200k

Cost of 24 transporter grease pads $200k

Installation/Ass'y
Material ($k): 0
Basis:
This is covered in WBS 40.02.9.2.1, 40.04.1.1 - Magnet Installation

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Unit type: ea Number of units: 2
Estimate Type: BU

Risk Factors:

Technical:	2	Basis: Fabrication techniques are standard. Simple shapes and interfaces. Loose tolerances. Common materials.
Cost:	4	Basis: Vendor quotes on hydraulics and bottom up construction factors for structural assemblies. Mill costs for steel will vary based on the state of the national economy at the time of construction.
Schedule:	8	Basis: If built in sections off site, will have minimal inpact on vessel installation schedule.

Misc Comments:

Current assumptions of floor movement vary up to 15 cm up and down.

Cost Estimate - Labor Rates

- Define all generic labor categories for labor charged to the Project (manager, engineer, scientist, technician, secretary, construction worker,...)
  - » Use appropriate level of detail for maturity of Project
- Establish a standard labor rate for each category based upon market survey in base currency year
- Use labor "crew" mixes if appropriate for an operation
- Replace standardized rates with specific rates only when actual labor source is certain
- Consider vacation/sick time factors

E	RATE	
RATE TABLE: MGMT	[MANAGEMENT]	
01DEC91	54.2400	
RATE TABLE: MM	[Manmonths mm = HOURS / MM]	
01DEC91	.0068	
RATE TABLE: OVERHEAD	[OVERHEAD RATES]	
01DEC91	.5800	
RATE TABLE: PROF_FAC	[PROFESSIONAL FACULTY]	
01DEC91	85.0000	
RATE TABLE: SCI	[SCIENTISTS]	
01DEC91	33.9400	
RATE TABLE: TECH	[TECHNICIAN]	
01DEC91	22.0000	
'E TABLE: UNDERGRAD	[UNDERGRADUATE STUDENTS]	
01DEC91	9.3500	