

# Canadian Light Source – Project Budget Estimations

**Johnny Campbell, P.Geo., PMP®**

CMCF Upgrade Project Manager

LINAC and Electron Gun Replacement Project Manager

2021-11-08



# Agenda

- Resource and Procurement Estimations.
- High-level overview of CMCF Beamline Upgrade Project (9.0M budget).
- CMCF Upgrade Project estimates; tools, techniques and outcomes.
- Summary.
- Discussion

# Resource and Procurement Estimates

- **PHILOSOPHY:** The better the scope and requirements are defined in a Project at the Initiation and Planning Phases, the better the estimations will be.
- Great philosophy, however not always the case.....



[This Photo](#) by Unknown Author is licensed under [CC BY](#)



Canadian Light Source  
Centre canadien de rayonnement synchrotron

THE BRIGHTEST LIGHT IN CANADA | [lightsource.ca](http://lightsource.ca)

# Procurement Estimates

- Generally, procurement estimates fall within budget.
  - Historical data easily accessible;
  - Budgetary quotes;
  - Change Requests.
- Minor overages due to oversights, inflation, supply chain issues, etc.

# Human Resource Estimates

- Generally, under estimated and over budget.
  - Historical data not easy accessible or directly relevant;
  - Change Requests less scrutinized



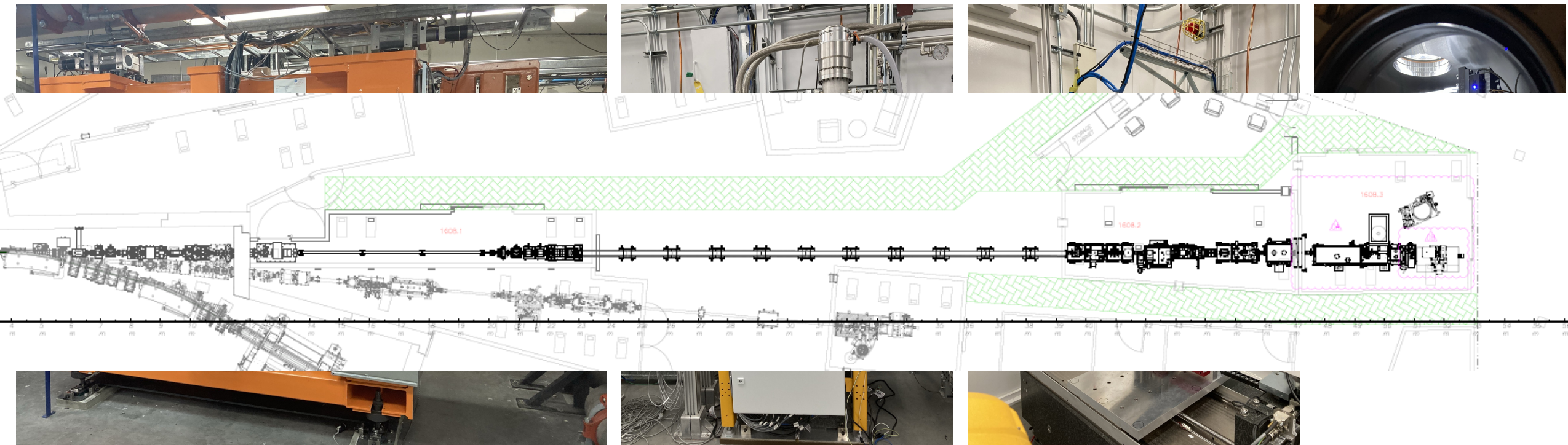
[This Photo](#) by Unknown Author is licensed under [CC BY](#)



<https://tenor.com/view/s-how-me-the-money-tom-cruise-money-gif-15827111>

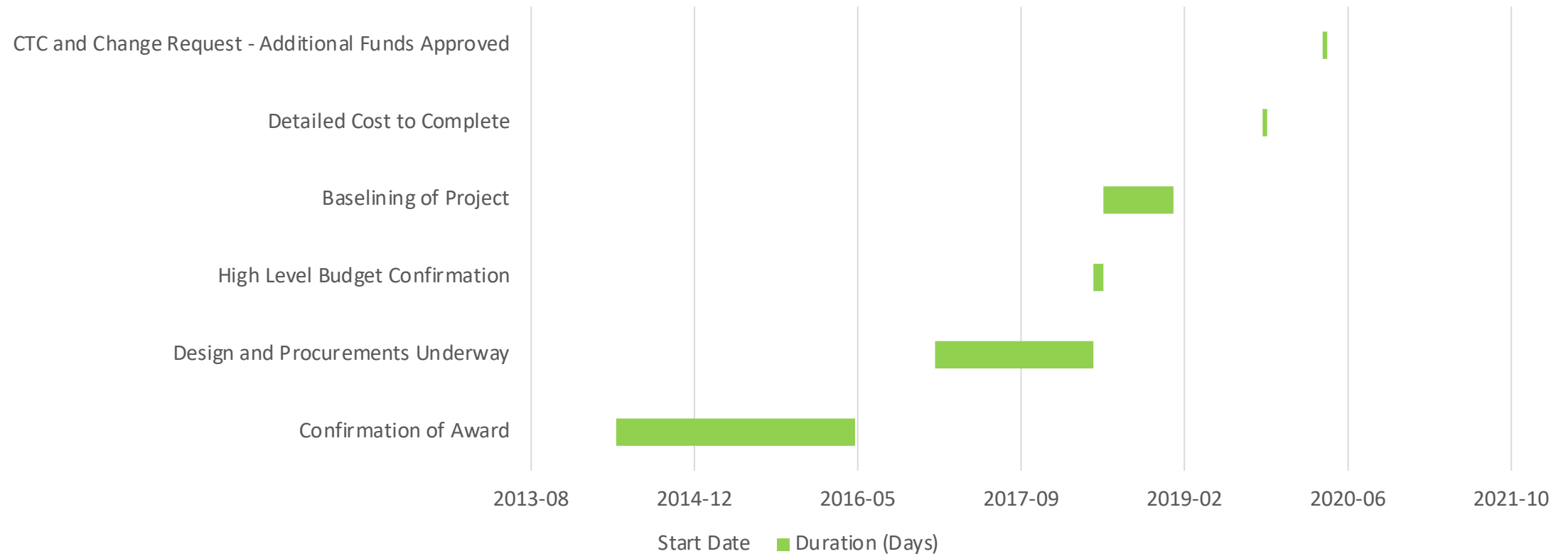


# CMCF Beamline Upgrade Project



# CMCF Upgrade Project

## CMCF Upgrade Project – Budget Development Timeline



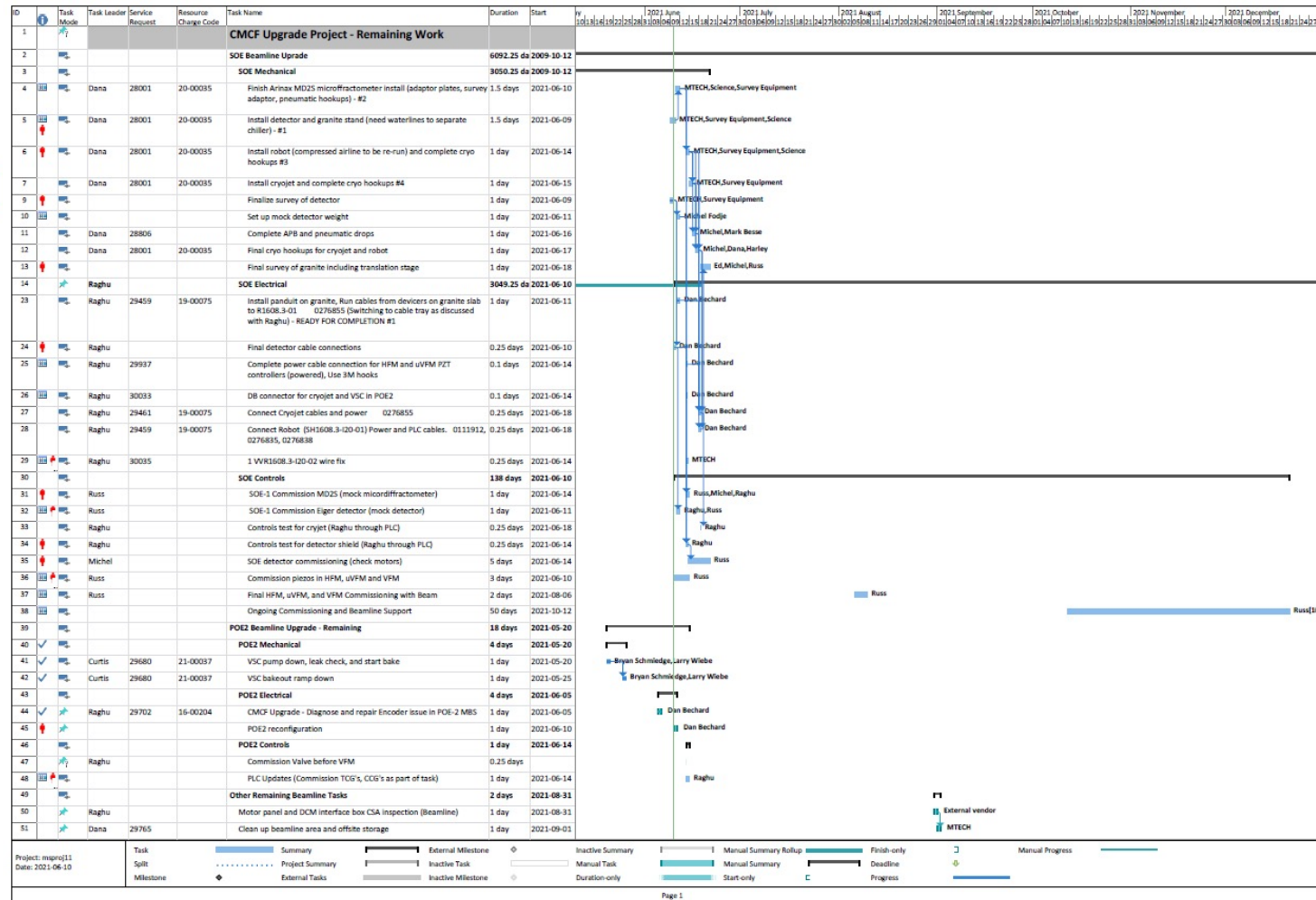
# CMCF Upgrade Project – Initiation Estimate

IF APPLICABLE		CMCF Upgrade Project - Committed Cost to Date vs CFI Approved Budget (COA)				
CFI Line #	CFI Item # (COA)	Division	Committed Costs (as of June 30, 2021)	CFI Approved Budget (COA)	Difference (+/-)	Available Budget (May 2018)
		ECAD	\$ 83,021.00	\$ 35,100.00	\$ (47,921.00)	
		MCAD	\$ 265,859.00	\$ 56,225.00	\$ (209,634.00)	
		EENG	\$ 144,800.00	\$ 49,075.00	\$ (95,725.00)	
	4	MENG	\$ 282,270.00	\$ 90,675.00	\$ (191,595.00)	
LABOUR	4	SYS Ana	\$ 112,664.00	\$ 45,500.00	\$ (67,164.00)	6500.00
LABOUR	4	HSE	\$ 1,520.00	\$ 22,750.00	\$ 21,230.00	13000.00
LABOUR	4	Sys Tech	\$ -	\$ 14,625.00	\$ 14,625.00	7150.00
LABOUR	4	Acc Phys	\$ 1.00	\$ 35,750.00	\$ 35,749.00	3575.00
LABOUR	4	Jr Phys	\$ 4,394.50	\$ 30,225.00	\$ 25,830.50	3250.00
LABOUR	4	Sr Phys	\$ 1.00	\$ 17,225.00	\$ 17,224.00	13000.00
LABOUR	4	Metrology	\$ -	\$ 6,500.00	\$ 6,500.00	5850.00
LABOUR	4	Science	\$ -	\$ -	\$ -	4875.00
LABOUR	4	EFD	\$ -	\$ 13,000.00	\$ 13,000.00	6500.00
LABOUR	4	ETECH	\$ 123,861.00	\$ 44,850.00	\$ (79,011.00)	3250.00
LABOUR	4	MTECH	\$ 246,134.00	\$ 105,625.00	\$ (140,509.00)	13000.00
LABOUR	4	PM	\$ 8,038.00	\$ 111,866.30	\$ 103,828.30	1625.00
LABOUR	4	*PM CFI	\$ 166,655.82	\$ 165,000.00	\$ (1,655.82)	19500.00
LABOUR	4	IVU	\$ 2,345,067.16	\$ 3,100,853.13	\$ 755,785.97	1625.00
LABOUR	4	BL	\$ 384,068.19	\$ 185,587.50	\$ (198,480.69)	13000.00
LABOUR	4	FE	\$ 140,020.19	\$ 406,470.75	\$ 266,450.56	3250.00
LABOUR	4	ES	\$ 2,934,020.32	\$ 2,491,908.18	\$ (442,112.15)	13000.00
LABOUR	4	Optics	\$ 1,983,286.03	\$ 1,725,820.25	\$ (257,465.78)	111866.30
		**Additional In-Kinds		\$ 268,491.00	\$ 268,491.00	269491.30
		***Resource Subtotal:	\$ 1,439,219.32	\$ 843,991.30	\$ (595,228.02)	
FE&SGU	1	****Procurement Subtotal:	\$ 7,786,461.89	\$ 8,179,130.80	\$ 392,668.91	204881.00
FE&SGU	1	<b>TOTAL:</b>	\$ 9,225,681.21	\$ 9,023,122.10	\$ (202,559.11)	4221.00
FE&SGU	1	*Additional funding approved post CFI COA. Additional funds brought into project to pay for additional PM requirements (Science). These funds cannot be reallocated.				8442.00
FE&SGU	1	**Additional in-kinds made available for project use.				5276.25
FE&SGU	1	***Subtotals include PM CFI funds not available for re-allocation.				15828.75
FE&SGU	1	****Subtotals include additional CFI in-kinds made available for project use.				15828.75
FE&SGU	1					93324.00
FE&SGU	1					26513.00





# CMCF Upgrade Project Budget – Planning Phase Estimation Tools



# CMCF Upgrade Project Budget – Planning Phase Estimation Tools

Base Cost Estimates	Wt %	Total Cost	Overall Wtd Average CTC	Estimated Contingency Required	Average CTC
High Level Estimate (Johnny FTE)	10%	\$ 934,973.00	\$ 601,586.69	\$ -	\$ 100,790.11
Schedule Resource Estimate (Schedule Task Level)	65%	\$ 454,805.00		\$ 127,948.60	
Schedule Resource Estimate (HCS TECH 3-Point)	55%	\$ 886,070.25		\$ 40,905.54	
Schedule Resource Estimate (Wtd Ave TECH 3-POINT)	75%	\$ 604,036.00		\$ 95,176.35	
Schedule Resource Estimate (LCS TECH 3-POINT)	50%	\$ 409,119.75		\$ 159,935.75	
Procurements (April 2020 CTC)	100%	\$ 121,758.00	\$ 121,758.00	\$ 16,327.00	\$ 16,327.00
		<b>Subtotal AVE:</b>	<b>\$ 723,344.69</b>	<b>\$</b>	<b>117,117.11</b>
		<b>TOTAL AVE:</b>	<b>\$</b>	<b>\$</b>	<b>840,461.80</b>

# CMCF Upgrade Project Budget – FTE Estimation

		Sept	Oct	Nov	Dec
<b>Workable Days</b>	Month				
	Workable Days (100% Efficiency)	21	20	21	18
	Workable Days (90% Efficiency)	19	18	19	16
	Workable Days (80% Efficiency)	17	16	17	14
	Workable Days (75% Efficiency)	16	15	16	14
	Workable Days (70% Efficiency)	15	14	15	13
	Workable Days (65% Efficiency)	14	13	14	12
	Workable Days (60% Efficiency)	13	12	13	11
	Workable Days (55% Efficiency)	12	11	12	10
Workable Days (50% Efficiency)	11	10	11	9	
<b>Eng/CID Workable Hours</b>	Month				
	Eng/CID Workable Hours (100% Efficiency)	158	150	158	135
	Eng/CID Workable Hours (90% Efficiency)	142	135	142	122
	Eng/CID Workable Hours (80% Efficiency)	126	120	126	108
	Eng/CID Workable Hours (75% Efficiency)	118	113	118	101
	Eng/CID Workable Hours (70% Efficiency)	110	105	110	95
	Eng/CID Workable Hours (65% Efficiency)	102	98	102	88
	Eng/CID Workable Hours (60% Efficiency)	95	90	95	81
	Eng/CID Workable Hours (55% Efficiency)	87	83	87	74
	Eng/CID Workable Hours (50% Efficiency)	79	75	79	68
	Eng/CID Workable Hours (45% Efficiency)	71	68	71	61
	Eng/CID Workable Hours (40% Efficiency)	63	60	63	54
	Eng/CID Workable Hours (35% Efficiency)	55	53	55	47
	Eng/CID Workable Hours (30% Efficiency)	47	45	47	41
	Eng/CID Workable Hours (25% Efficiency)	39	38	39	34
	Eng/CID Workable Hours (20% Efficiency)	32	30	32	27
Eng/CID Workable Hours (15% Efficiency)	24	23	24	20	
Eng/CID Workable Hours (10% Efficiency)	16	15	16	14	

Base Cost Estimates	Resource Estimated Cost (remaining as of March 1, 2021)	Total Resource Hours Charged (as of Sept. 30, 2021)	Difference
High Level Estimate (Johnny FTE)	\$ 934,973.00		\$ 172,028.00
Schedule Resource Estimate (Schedule Task Level)	\$ 582,753.60		\$ (180,191.40)
Schedule Resource Estimate (HCS TECH 3-Point)	\$ 926,975.79	\$ 762,945.00	\$ 164,030.79
Schedule Resource Estimate (Wtd Ave TECH 3-POINT)	\$ 699,212.35		\$ (63,732.66)
Schedule Resource Estimate (LCS TECH 3-POINT)	\$ 569,055.50		\$ (193,889.50)



# CMCF Upgrade Project Budget – Schedule Task Level Estimate

ID	Location	WP Leader	WP Number	Task Name	UOM	MENG	MCAD	MTECH	EENG	ECAD	ETECH	CID - Sys. Analyst	AOD - Phys.	HSE	ST - Systems Technology	Science (n/c)	\$/UOM	TOTAL Remaining Cost to be Charged	Supplier
ID13	SR1	Shawn Carriere		ID Commissioning Studies/Commissioning Plan/Planning	hr	40	10						40	10			\$ 65.00	\$ 6,500.00	CLS
DOC1	SR1	Curtis Mullin		Detailed ray tracing (horizontal/vertical) and report	hr	80	20						20				\$ 65.00	\$ 7,800.00	CLS
DOC2	BL	Curtis Mullin		Compile BL SAT procedures and Checklists (FE, BL, Optics, End-station)	hr	60	40		60	40							\$ 65.00	\$ 13,000.00	CLS
DOC3	BL	Curtis Mullin		Compile Radiation measurements procedure document	hr	40	40							20			\$ 65.00	\$ 6,500.00	CLS
DOC4	BL	Curtis Mullin		Project Close-Out Documents (Engineering drawings, PFD's, etc.)	hr	20	60		20	60							\$ 65.00	\$ 10,400.00	CLS
DOC5	BL	Johnny Campbell		Project Close-Out Documents (Lessons learned, project sign-offs, etc.)	hr	15	10		15	10							\$ 65.00	\$ 3,250.00	CLS
DOC6	BL	Curtis Mullin		Compile BL Comm/Conditioning/Alignment Plan Document	hr	20	10		20	10							\$ 65.00	\$ 3,900.00	CLS
RCM4002	BL	Curtis Mullin		Conduct BL radiation measurements	hr	40							40	40			\$ 65.00	\$ 7,800.00	CLS
RCM4003	BL	Curtis Mullin		Conduct BL Commissioning/Conditioning/Alignment	hr	60	15	10	10	10	10	60	20	10			\$ 65.00	\$ 13,325.00	CLS
																		\$ 59,150.00	

Base Cost Estimates	Resource Estimated Cost (remaining as of March 1, 2021)	Total Resource Hours Charged (as of Sept. 30, 2021)	Difference
High Level Estimate (Johnny FTE)	\$ 934,973.00	\$ 762,945.00	\$ 172,028.00
Schedule Resource Estimate (Schedule Task Level)	\$ 582,753.60		\$ (180,191.40)
Schedule Resource Estimate (HCS TECH 3-Point)	\$ 926,975.79		\$ 164,030.79
Schedule Resource Estimate (Wtd Ave TECH 3-POINT)	\$ 699,212.35		\$ (63,732.66)
Schedule Resource Estimate (LCS TECH 3-POINT)	\$ 569,055.50		\$ (193,889.50)

# CMCF Upgrade Project Budget – Schedule Task Level Estimate with 3-Point Estimation

Task Name	Resource Names	Optimistic (Days)	Optimistic Cost (\$65/hour)	Realistic (days)	Realistic (\$65/hour)	Pessimistic (days)	Pessimistic (\$65/hour)	
<b>CMCF Upgrade Project - Beamline Schedule</b>		0 days	\$ 65.00	0 days		0 days		
<b>Spring 2020 Outage</b>		<b>0 days</b>		<b>0 days</b>		<b>0 days</b>		
<b>ID Installation (SR1)</b>		16.45	\$ 12,268.75	26.2	\$ 18,248.75	36.3	\$ 27,641.25	
Ring Access, de-energize equipment (old IVU), disconnect chicane and orbit control magnets, ETECH disconnect services for removal of old IVU out of SR1	ETECH[200%]	1	\$ 1,040.00	2	\$ 2,080.00	3	\$ 3,120.00	
Complete Wiring/Run cabling for ID (remove cables, to SR1 equip & vac interconnects)	ETECH[200%]	1	\$ 1,040.00	2	\$ 2,080.00	3	\$ 3,120.00	
Remove old CMCF ID Rack	ETECH	2	\$ 1,040.00	3	\$ 1,560.00	4	\$ 2,080.00	
Install electrical racks on top of SR1	ETECH	2	\$ 1,040.00	3	\$ 1,560.00	4	\$ 2,080.00	
Use survey to position the IVU into optimal location	MTECH[200%]	0.75	\$ 780.00	1	\$ 1,040.00	2	\$ 2,080.00	
Vacuum connect, install Upstream/Downstream absorber, new NEG pump, large roughing port/turbo Pump Down Started on IVU (Full Straight)								
LeakCheck (Full Straight)								
Final Wrap for Bake (Full Straight)								
Bakeout Started (Full Straight)								
Bakeout (10 day Bakeout, Includes weekends)								
Neg Activation and Leak Check and Cool down								
Survey alignment (final check) installation of the correctors								
Installation of new mechanical services (Final Hook								
Reinstall ACIS gate by IVU	MTECH	0.5	\$ 260.00	1	\$ 520.00	1.5	\$ 780.00	
Final Electrical Hook-ups for IVU	ETECH	0.5	\$ 260.00	1	\$ 520.00	1.5	\$ 780.00	
IVU Motion Control V&V (includes survey) including MPS V&V, Limits Verification	CID, ETECH	0		2		0		
<b>Base Cost Estimates</b>						<b>Resource Estimated Cost (remaining as of March 1, 2021)</b>	<b>Total Resource Hours Charged (as of Sept. 30, 2021)</b>	<b>Difference</b>
High Level Estimate (Johnny FTE)						\$ 934,973.00		\$ 172,028.00
Schedule Resource Estimate (Schedule Task Level)						\$ 582,753.60	\$ 762,945.00	\$ (180,191.40)
Schedule Resource Estimate (HCS TECH 3-Point)						\$ 926,975.79		\$ 164,030.79
Schedule Resource Estimate (Wtd Ave TECH 3-POINT)						\$ 699,212.35		\$ (63,732.66)
Schedule Resource Estimate (LCS TECH 3-POINT)						\$ 569,055.50		\$ (193,889.50)



# CMCF Upgrade Project Budget – 3 Point Estimation

Base Cost Estimates	Resource Estimated Cost (As of March 1, 2020)	Total Resource Charged (as of September 30, 2021)	Difference
TECH Optimistic	\$ 137,744.00	\$ 254,620.00	\$ (116,876.00)
TECH Realistic	\$ 197,284.00		\$ (57,336.00)
TECH Pessimistic	\$ 285,353.00		\$ 30,733.00

## Pert Calculation:

$(\text{Optimistic} + (4 * \text{Realistic}) + \text{Pessimistic}) / 6 =$   
 \$202, 038



# CMCF Upgrade Project Budget – Overall Status

	Current Approved Budget	Change Request Budget (Proposed)	Committed (as of Sept. 30, 2021)	% Within Initiation Budget	% Within Change Request
30-Sep-21	\$ 9,023,122.00	\$ 9,364,168.38	\$ 9,268,130.55	2.64%	1.03%

# In Summary

- A variance in budget is required from Initiation Phase to the Planning Phase (project baselining);
- Initiation to Planning Phase variance in budget needs to be understood and agreed upon by Sponsor;
- Contingencies are critical until estimations become more accurate;
- Need to establish a database for human resource estimations to be used as a reference for future projects;
- More data points required to establish usefulness of the estimation techniques;



# Discussion

- Similar or differing experiences?
- Similar or differing tools and techniques?

