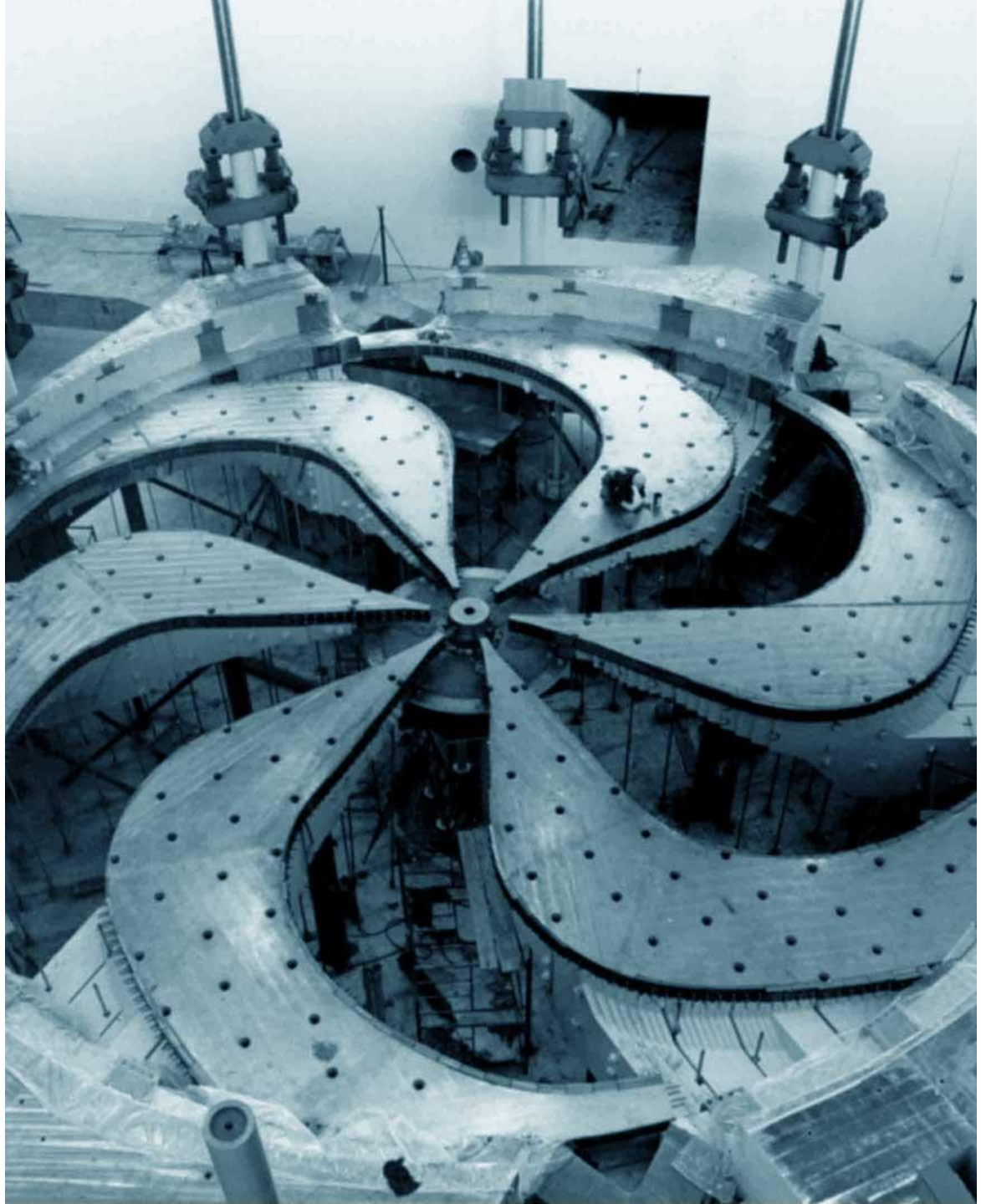
UCN Electric Dipole Moment EAC Report Feb 2020

Chris Gibson



2020-02-04

Contents

Project Objectives (Summarized from Project Plan)

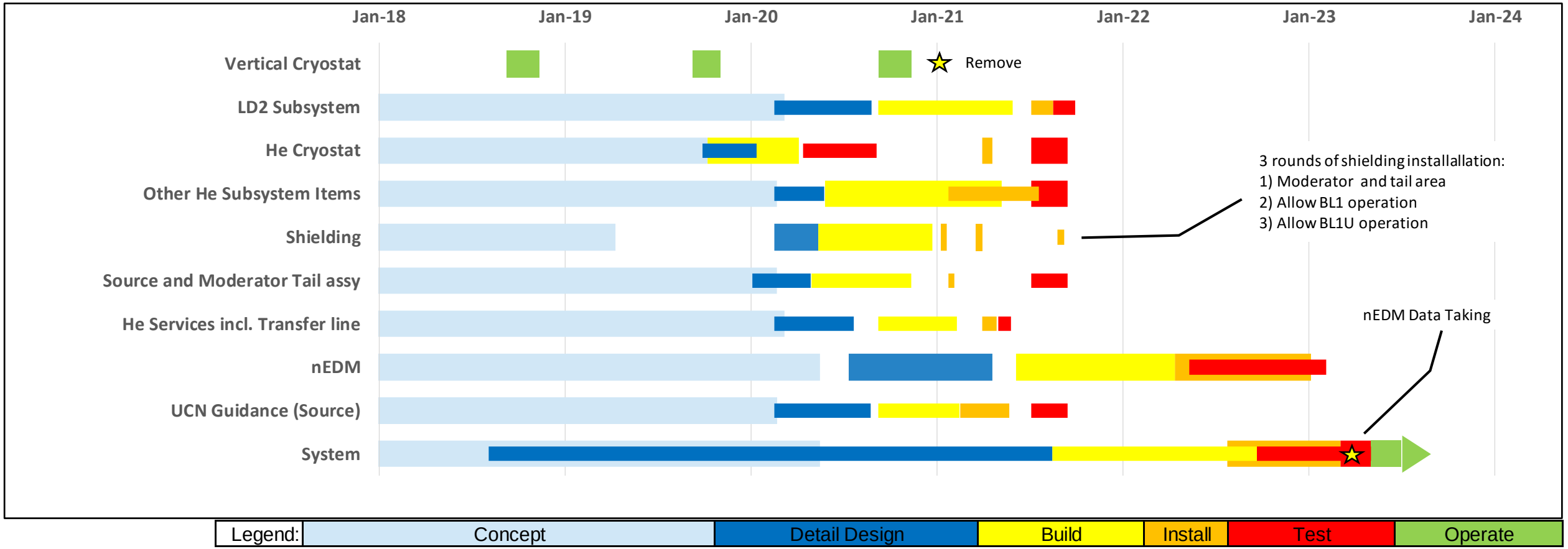
1. Commission Experiment capable of detecting a neutron Electric Dipole of magnitude 1e-27 e-cm or less within 400 beam-on days
2. Upgrade UCN source – 2 orders of magnitude improvement. Secondary & primary ports
3. Commission required facility infrastructure equipment (He liquefier out of scope)
4. Design-in the capability of the UCN source to generate Very Cold Neutrons for a future VCN experiment.

One Page Status Summary

Category		Status	Comments
Confidence in Achieving Project Objectives (see previous slide)	1. <400 beam-on days		Fall 2018 tests provided useful data. Analysis and optimization is ongoing. See performance risk on next slide.
	2. Source upgrade		Finalization of LD2 Cryostat concept configuration behind schedule. He Cryostat concept review now done. (target March 2020 for rest of source).
	3. Infrastructure		Needs further planning
	4. VCN		Radiation simulations done, but detailed 3D models do not currently include this feature
Schedule and Budget	Schedule vs baseline		*Not much slack left in plan regarding 2021 installations. Will re-baseline soon based on upcoming MOU finalization.*
	Budget <CAD15.7M		Significant budget reduction in last month, primarily due to scope reductions (without compromising objectives)

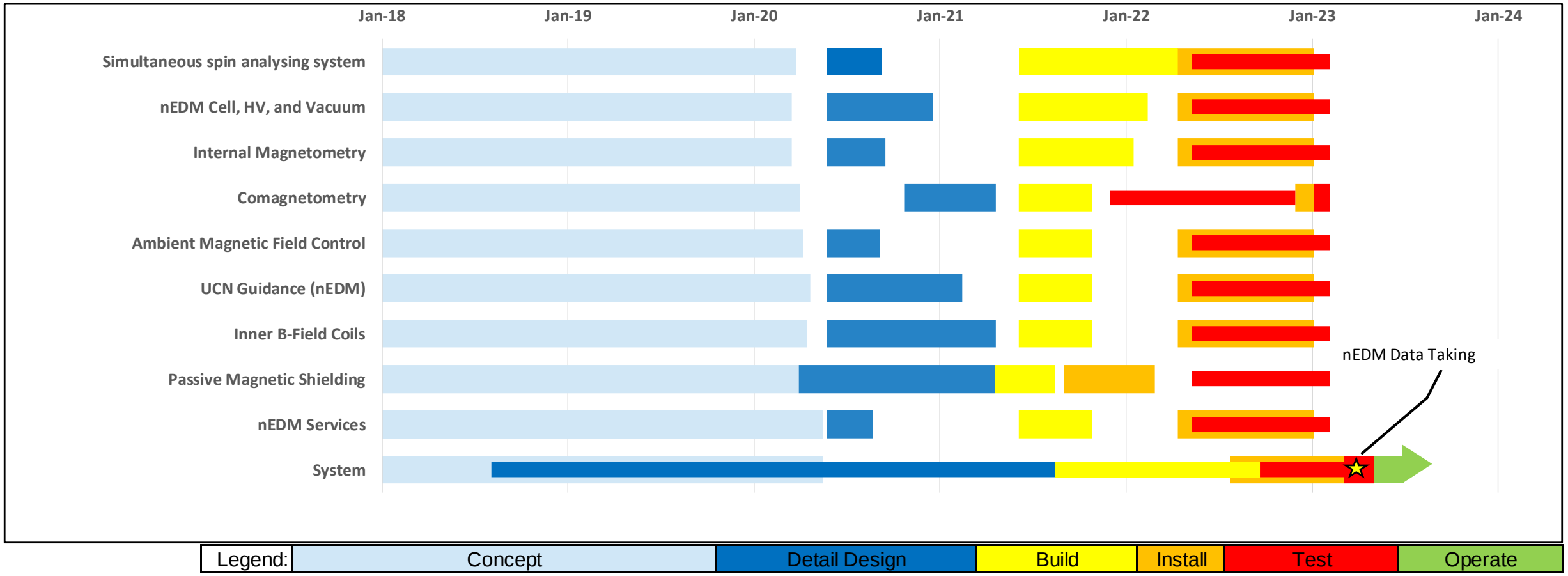
Legend	
	On track
	Off track, with plan to fix
	Off track, no identified path to fix
blue text	Highlight of recent updates

High-Level Schedule (Subsystem-Centric)



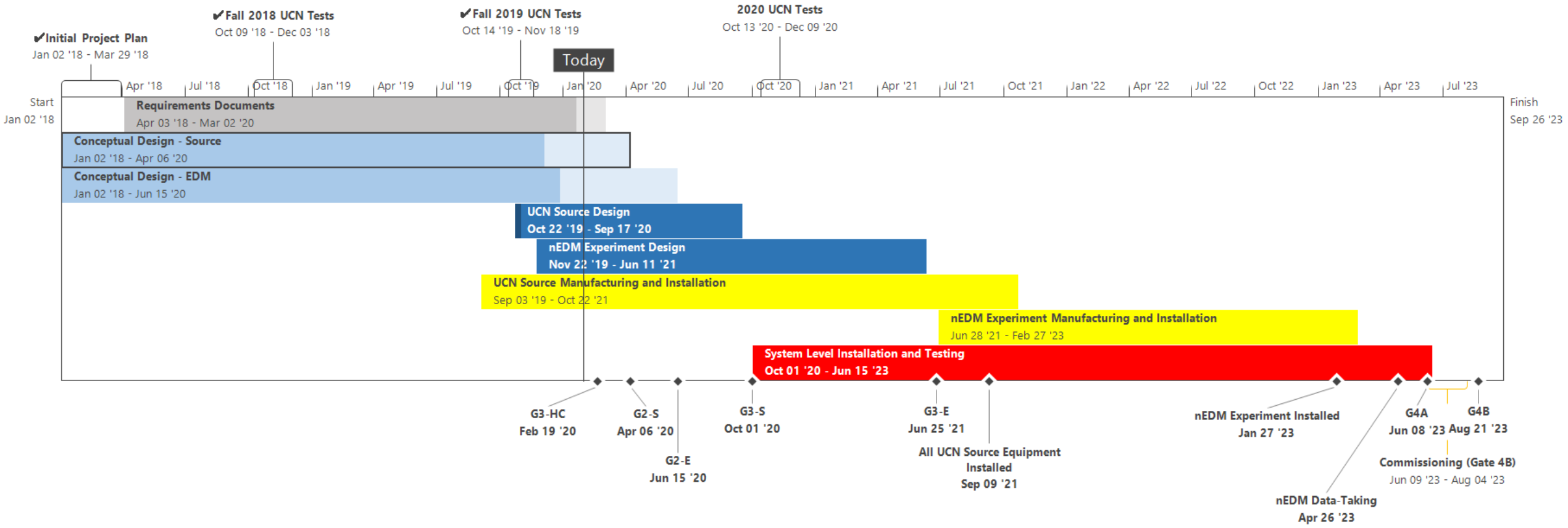
- Complete Source Concept by March 2020. Some detailed design work starts before this.
- Moderator and tail section need to be installed in Jan-Apr 2021 shutdown (need to add shielding by end April to allow other experiments to run)
- Goal to make UCNs before start of shutdown in December 2021 (completed source installation)
- Still refining Installation and Test sequence

High-Level Schedule (nEDM Subsystem-Centric)



- Build, Install, Test sequence for nEDM not yet determined (very preliminary sequence shown here)

High-Level Schedule (Gate-Centric)

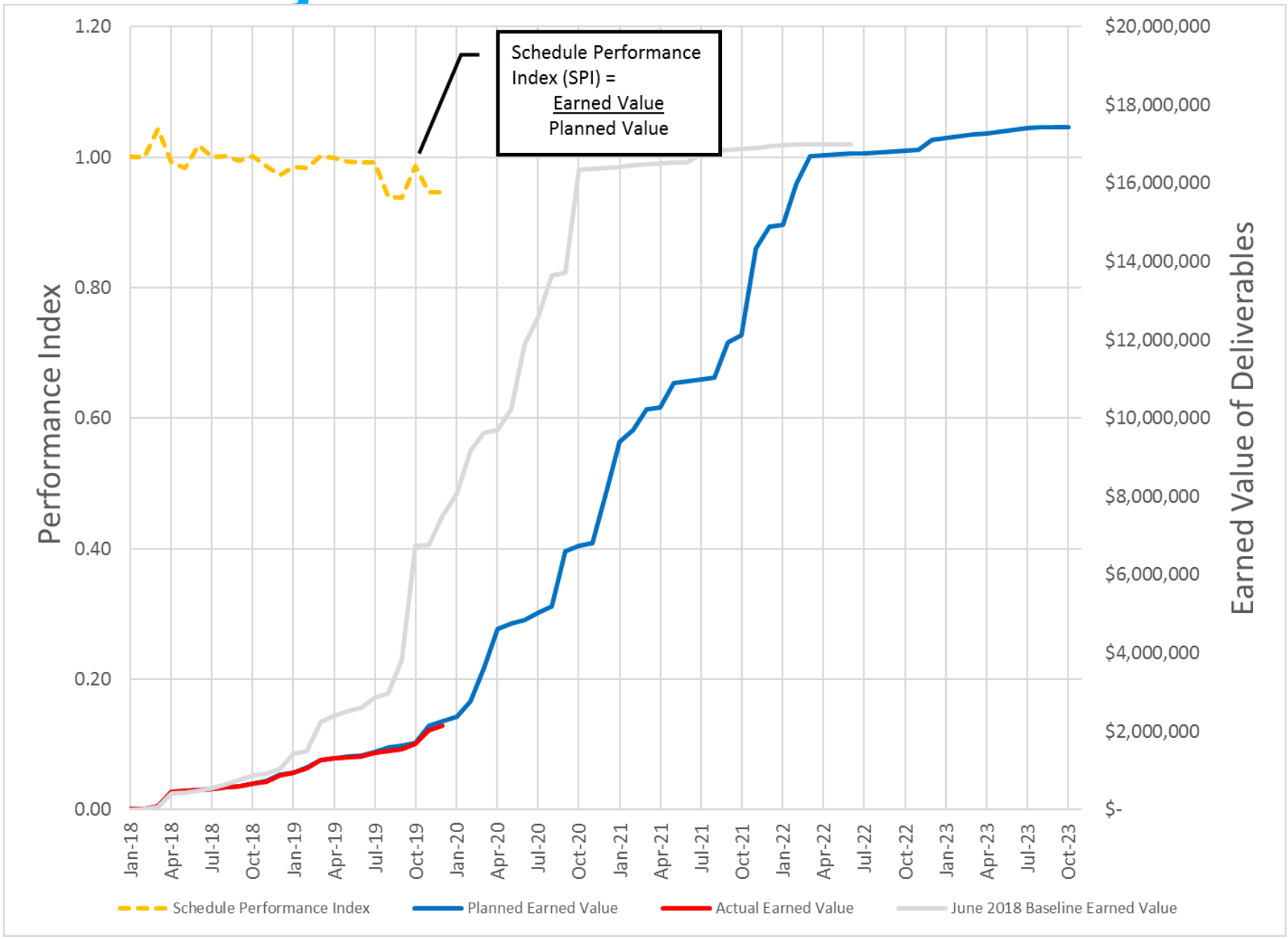


- Gate 2: Concept complete (high confidence design will meet requirements), ready to proceed with detailed design
- Gate 3: Detailed design (drawings, quotations) complete, ready to build and install
- Gate 4a: Ready to start formal commissioning (prove to TRIUMF that new system is ready to hand over for routine operations and maintenance)

Top Risks

Category	Risk Description	Plan / Status	Target Close
Schedule	Source and nEDM concept design slower than scheduled	Risk register initial version completed for Source and nEDM. Mitigating actions documented in risk register, including several actions specifically for this schedule risk. (Mitigating but not stopping delays!)	Gate 2 (Feb 2020 for source, May 2020 for nEDM)
Budget	Current Estimate higher than CFI budget	Gather more detailed quotations and estimates over time, examine need for all scope elements & reduce scope where it does not contribute to project objectives. Actions completed.	Dec 2019 to re-baseline budget with lowered scope. Completed January
nEDM Experiment Performance	Design may not meet requirements (too many unknowns)	Advance conceptual design with team members. Create a CDR Report and conduct review with external experts (as done for UCN Source).	Review February

Project Metrics*



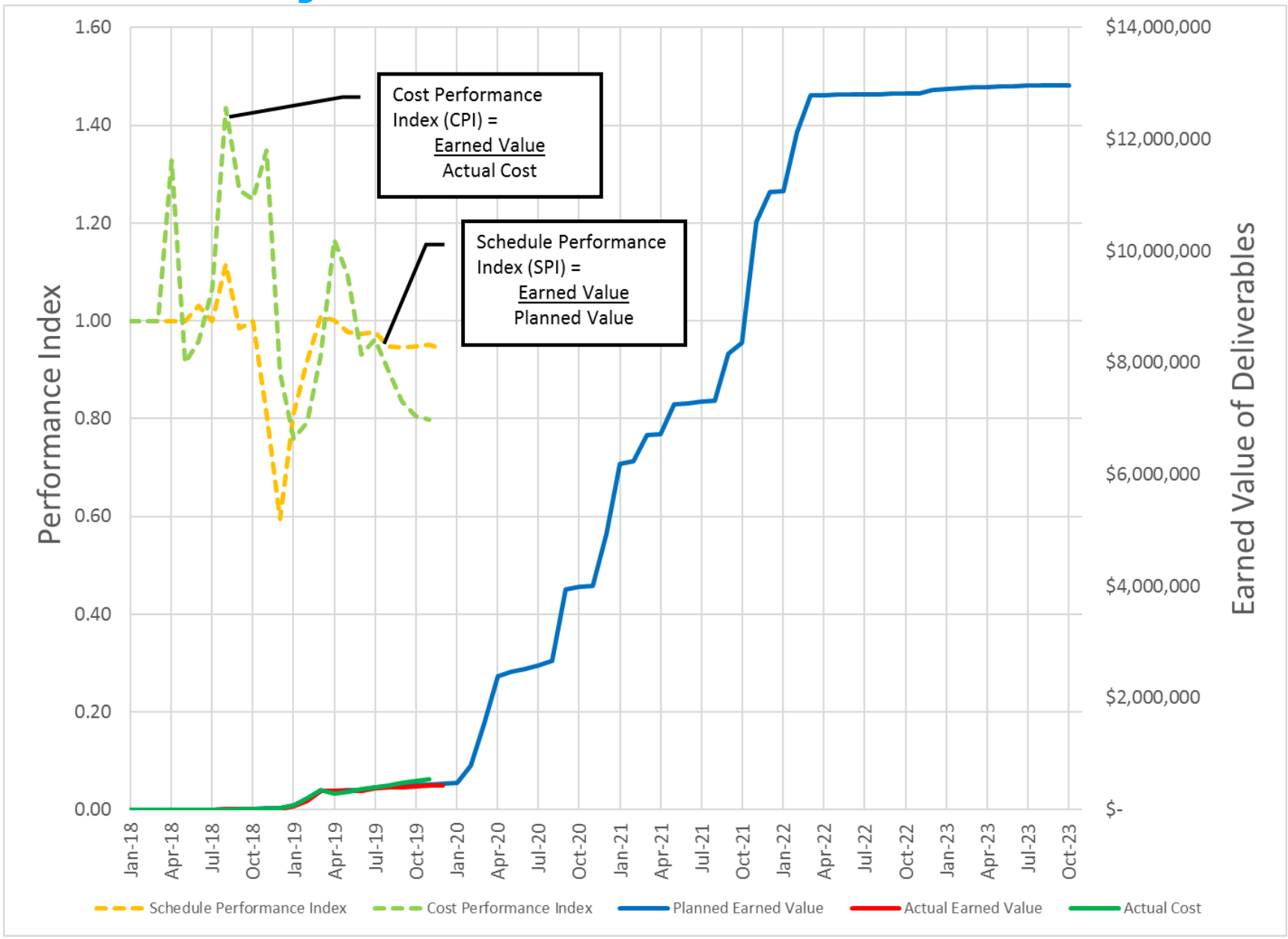
* Includes non-CFI labour and expenses (e.g. physicist labour costs).

Contingencies not included.

Now showing June 2018 Baseline (dotted) and updated plan (solid)

SPI is against updated plan

Project Metrics – CFI *



* New Report

Contingencies not included.

SPI and CPI are against updated plan

Need to monitor and be able to explain why Actual Cost is tracking higher than Planned Cost

Upcoming Work to Improve Plan

- Add detail to Source Installation and Test sequencing based on an integration and test plans
- Do the same exercise for the nEDM Experimental equipment and full system integration
- Do Monte-Carlo-based schedule risk analysis and add schedule contingencies?
- Constant “rolling wave” plan improvements based on subsystem owner and team feedback

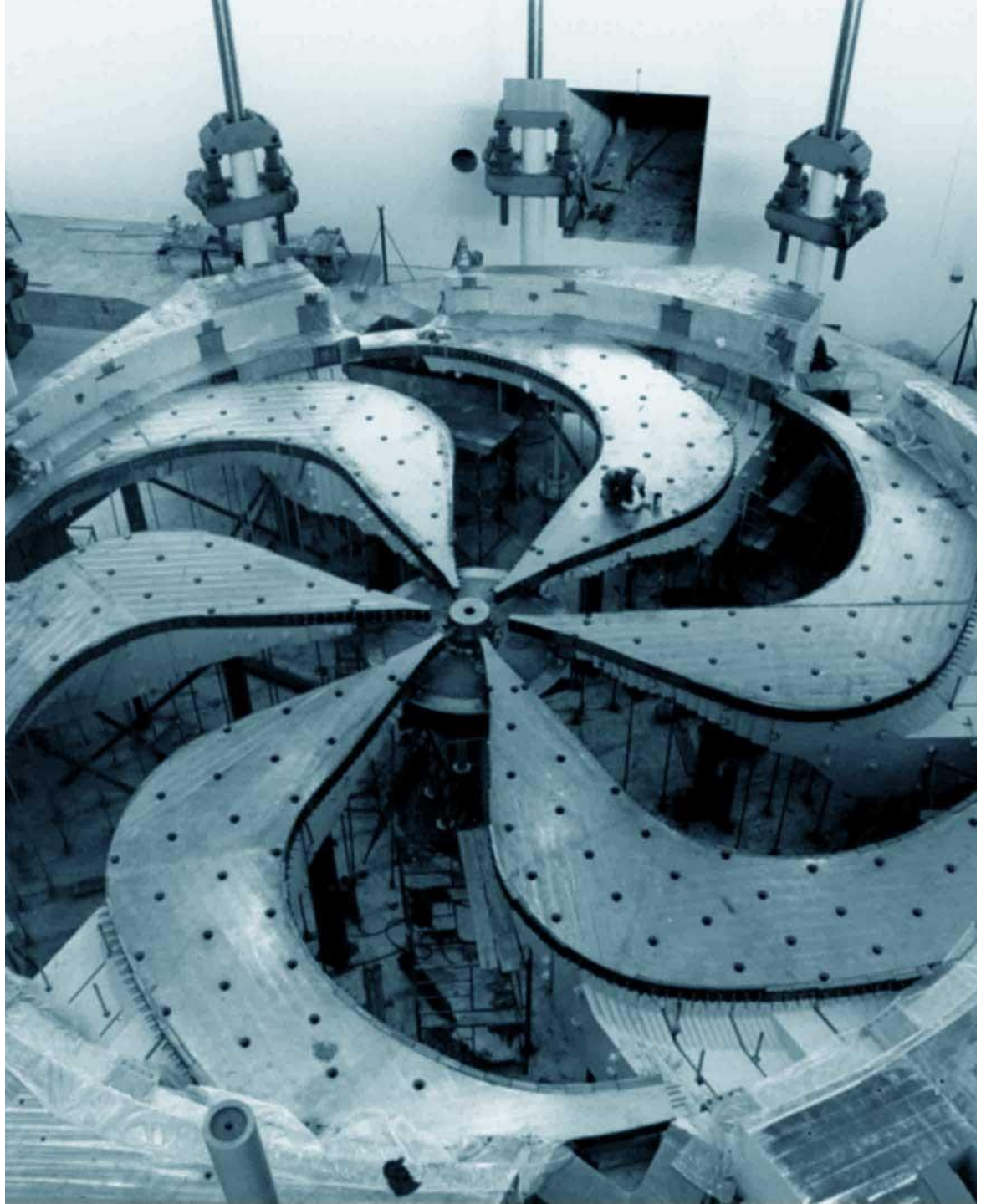
Summary From a Project Management Process Perspective

- Project Management Achievements:
  - Good visibility to TRIUMF senior management
  - Big picture status visible to all
  - Ready to get into “meat” of project monitoring and control (steep part of S-curve)
  - Well organized, bottom-up structured budget helped to identify where we were going over-budget and helped make the campaign to rationalize (reduce) the budget more straightforward

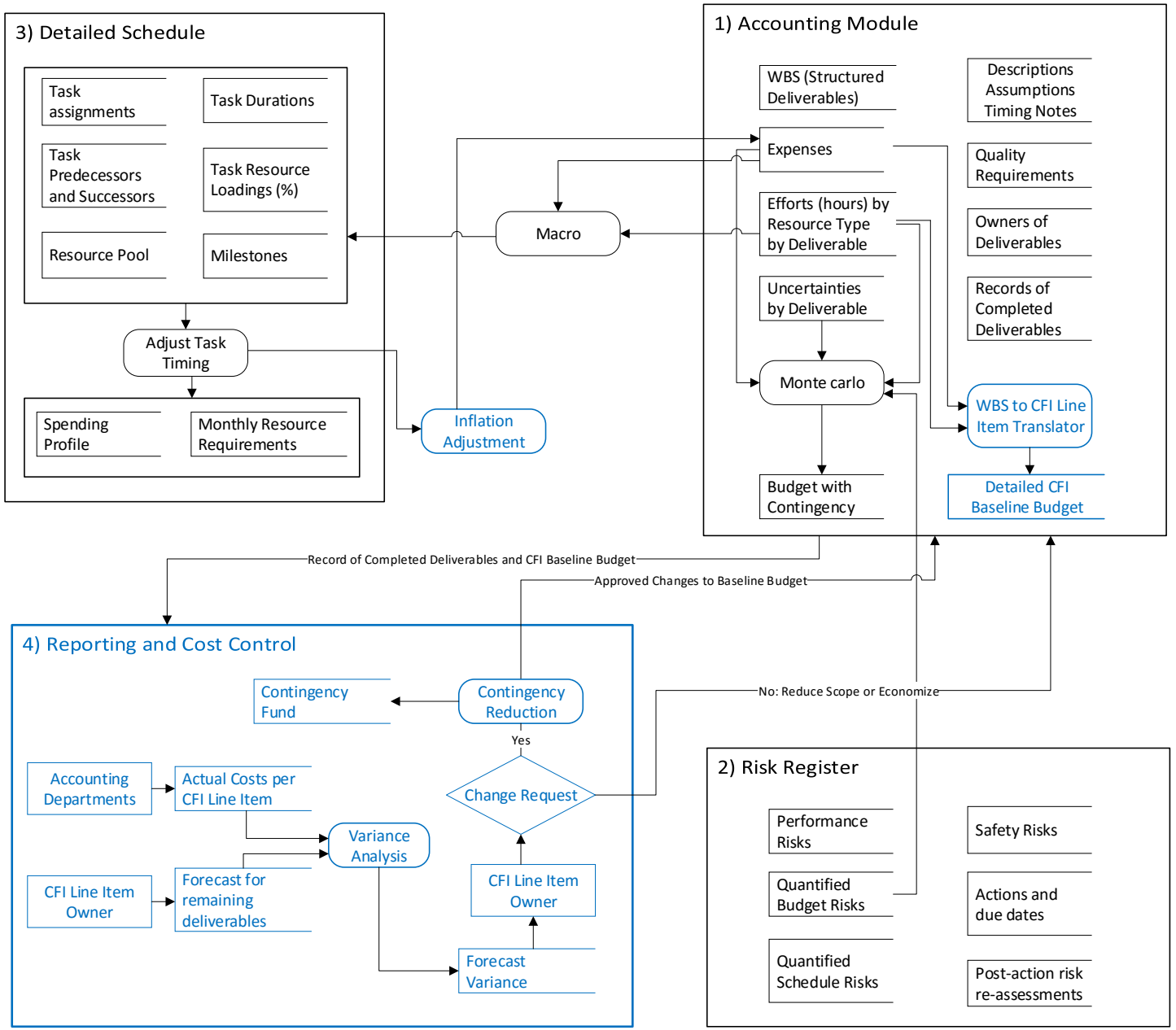
Summary From a Project Management Process Perspective (cont'd)

- Decisions and Improvements Needed (help and recommendations welcome):
  - Have to decide at what level to monitor and control budget (by institution? by sub CFI line item? Hybrid approach?)
  - Need to assign owners for each controlled budget line item: Responsible for managing budget and schedule.
  - Buy-in on usefulness of PM tools and methods: It is overhead but will be net positive if everyone participates:
    - Work with Project Manager to refine plan – make effort estimates and task duration estimates more realistic and think carefully about the sequencing
    - Speak up about uncertainties – they can go into the risk register or can be incorporated directly into the plan to enable better decision making
  - Systems Engineering methods new to many in the collaboration
    - When used well, it minimizes risk and reduces number of design changes needed; carefully chosen and defined interfaces allow subsystem owners to progress at their own pace
    - The source alone is quite complicated; we have been iterating all subsystems, creating rework on the more mature subsystem designs (on the positive side, we are getting a well-optimized source).
    - More buy-in and/or some training could pay off in future

Appendices

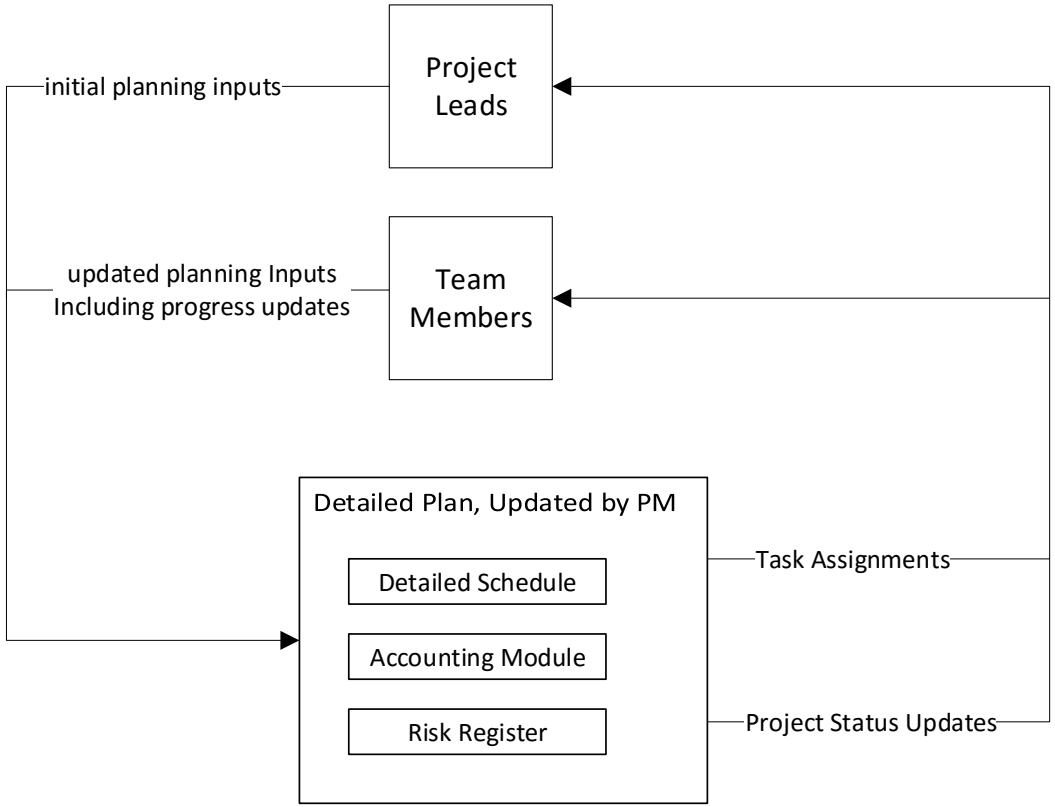


Detailed Plan – Under the Hood



(Blue items are new or proposed)

Adjusting the Plan as We Go



- We need everybody's help to identify where the plan doesn't make sense, so we can adjust / re-plan
- This can be done early. with a project review, or whenever you are asked to perform a task
  - "it's more work than this"
  - "in order to do this, I need…"
  - "supplier lead time is wrong", "cost is wrong"
  - "I just ran into this new problem" AND
  - "This part of the plan needs to be outlined in greater detail" (iterative planning)

Budget Status

Total CFI Budget Without Contingency

		Cash $			In-Kind $			Total $		
Item #	Item Description	CFI Sept 2019	Current	Change	CFI Sept 2019	Current	Change	CFI Sept 2019	Current	Change
1	UCN Source Upgrade	$ 1.430	$ 2.346	$ 0.916	$ 1.590	$ 0.942	$ (0.648)	$ 3.020	$ 3.287	$ 0.267
1a	LD2 moderator upgrade	$ 0.900	$ 0.625	$ (0.275)	$ -	$ -	$ -	$ 0.900	$ 0.625	$ (0.275)
1b	Superfluid helium cryostat upgrade	$ -	$ 0.198	$ 0.198	$ 1.000	$ 0.689	$ (0.311)	$ 1.000	$ 0.887	$ (0.113)
1c	Testing at KEK	$ -	$ -	$ -	$ 0.350	$ 0.252	$ (0.098)	$ 0.350	$ 0.252	$ (0.098)
1d	3He	$ 0.300	$ 0.226	$ (0.074)	$ -	$ -	$ -	$ 0.300	$ 0.226	$ (0.074)
1e	Final moderator and rad safety	$ 0.230	$ -	$ (0.230)	$ 0.240	$ -	$ (0.240)	$ 0.470	$ -	$ (0.470)
1	UCN Source Upgrade, Other	$ -	$ 1.297	$ 1.297	$ -	$ -	$	$ -	$ 1.297	$ 1.297
2	UCN transport and detectors	$ 1.450	$ 0.950	$ (0.500)	$ 0.230	$ 0.097	$ (0.133)	$ 1.680	$ 1.047	$ (0.633)
2a	Guide, coupler, and coating materials	$ 0.300	$ 0.199	$ (0.101)	$ 0.060	$ 0.043	$ (0.017)	$ 0.360	$ 0.243	$ (0.117)
2b	Switches and valves	$ 0.250	$ 0.083	$ (0.167)	$ 0.030	$ -	$ (0.030)	$ 0.280	$ 0.083	$ (0.197)
2c	SSA system	$ 0.300	$ 0.379	$ 0.079	$ 0.040	$ 0.046	$ 0.006	$ 0.340	$ 0.425	$ 0.085
2d	EDM cell valve system	$ 0.100	$ 0.119	$ 0.019	$ -	$ -	$ -	$ 0.100	$ 0.119	$ 0.019
2e	Guide coating facility at UW	$ 0.500	$ 0.133	$ (0.367)	$ 0.100	$ -	$ (0.100)	$ 0.600	$ 0.133	$ (0.467)
2	UCN transport and detectors, Other	$ -	$ 0.036	$ 0.036	$ -	$ 0.007	$ 0.007	$ -	$ 0.043	$ 0.043
3	Environment and services	$ 1.100	$ 0.643	$ (0.457)	$ 0.050	$ 0.008	$ (0.042)	$ 1.150	$ 0.651	$ (0.499)
3a	Vacuum systems and controls	$ 0.200	$ 0.135	$ (0.065)	$ 0.040	$ 0.002	$ (0.038)	$ 0.240	$ 0.138	$ (0.102)
3b	Mechanical support	$ 0.200	$ -	$ (0.200)	$ -	$ -	$ -	$ 0.200	$ -	$ (0.200)
3c	Thermal and vibration control	$ 0.300	$ 0.095	$ (0.205)	$ 0.010	$ 0.006	$ (0.004)	$ 0.310	$ 0.101	$ (0.209)
3d	Power, water, air services	$ 0.400	$ 0.409	$ 0.009	$ -	$ -	$ -	$ 0.400	$ 0.409	$ 0.009
3	Environment and services, Other	$ -	$ 0.004	$ 0.004	$ -	$ -	$ -	$ -	$ 0.004	$ 0.004
4	Data acquisition and controls	$ 0.550	$ 0.383	$ (0.167)	$ 0.090	$ 0.007	$ (0.083)	$ 0.640	$ 0.390	$ (0.250)
4a	Beamline control upgrades	$ 0.100	$ -	$ (0.100)	$ -	$ -	$ -	$ 0.100	$ -	$ (0.100)
4b	UCN source and valve slow controls	$ 0.100	$ 0.140	$ 0.040	$ 0.020	$ -	$ (0.020)	$ 0.120	$ 0.140	$ 0.020
4c	SSA, comagnetometer, and nEDM DAQ	$ 0.300	$ 0.172	$ (0.128)	$ 0.060	$ 0.007	$ (0.053)	$ 0.360	$ 0.179	$ (0.181)
4d	Counting room infrastructure	$ 0.050	$ -	$ (0.050)	$ 0.010	$ -	$ (0.010)	$ 0.060	$ -	$ (0.060)
4	Data acquisition and controls, Other	$ -	$ 0.071	$ 0.071	$ -	$ -	$ -	$ -	$ 0.071	$ 0.071
5	Magnetic fields	$ 4.245	$ 3.708	$ (0.537)	$ 1.717	$ 0.340	$ (1.377)	$ 5.962	$ 4.048	$ (1.913)
5a	Ambient magnetic field compensation	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
5b	Precision internal coils and supplies	$ 0.250	$ 0.274	$ 0.024	$ 0.050	$ 0.050	$ 0.000	$ 0.300	$ 0.324	$ 0.024
5c	Shielding and coil design BEM/FEA	$ 0.300	$ -	$ (0.300)	$ 0.100	$ -	$ (0.100)	$ 0.400	$ -	$ (0.400)
5d	Internal Cs magnetometers	$ 0.757	$ 0.596	$ (0.161)	$ 0.189	$ 0.119	$ (0.070)	$ 0.947	$ 0.715	$ (0.231)
5e	SQUID sensor	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
5f	magnetically shielded room	$ 2.738	$ 2.428	$ (0.310)	$ 0.548	$ -	$ (0.548)	$ 3.285	$ 2.428	$ (0.857)
5g	degaussing system + SQUID sensor	$ 0.200	$ 0.282	$ 0.082	$ 0.050	$ 0.023	$ (0.027)	$ 0.250	$ 0.305	$ 0.055
5h	SCM + external compensation	$ -	$ -	$ -	$ 0.780	$ 0.147	$ (0.633)	$ 0.780	$ 0.147	$ (0.633)
5	Magnetic fields, Other	$ -	$ 0.128	$ 0.128	$ -	$ -		$ -	$ 0.128	$ 0.128
6	Comagnetometer	$ 1.270	$ 1.713	$ 0.443	$ 0.202	$ 0.335	$ 0.133	$ 1.472	$ 2.049	$ 0.577
6a	Laser systems (2 x Hg)	$ 0.130	$ 0.421	$ 0.291	$ 0.010	$ 0.105	$ 0.095	$ 0.140	$ 0.526	$ 0.386
6b	sensors, optics, electronics, vacuum	$ 0.260	$ 0.377	$ 0.117	$ 0.052	$ 0.094	$ 0.042	$ 0.312	$ 0.471	$ 0.159
6c	laser tables, transport, and safety	$ 0.200	$ 0.114	$ (0.086)	$ 0.040	$ -	$ (0.040)	$ 0.240	$ 0.114	$ (0.126)
6d	Xe/Hg R&D lab at UBC incl. Xe-EDM	$ 0.680	$ 0.433	$ (0.247)	$ 0.100	$ 0.084	$ (0.016)	$ 0.780	$ 0.517	$ (0.263)
6	Comagnetometer, Other	$ -	$ 0.369	$ 0.369	$ -	$ 0.052	$ 0.052	$ -	$ 0.421	$ 0.421
7	Electric field system and EDM cell	$ 0.310	$ 0.406	$ 0.096	$ 0.050	$ 0.076	$ 0.026	$ 0.360	$ 0.482	$ 0.122
7a	Cell, electrodes, and coatings	$ 0.050	$ 0.044	$ (0.006)	$ -	$ 0.001	$ 0.001	$ 0.050	$ 0.045	$ (0.005)
7b	Power supply, switches, and feedthrou	$ 0.250	$ 0.246	$ (0.004)	$ 0.050	$ 0.063	$ 0.013	$ 0.300	$ 0.310	$ 0.010
7c	Leakage current monitor	$ 0.010	$ -	$ (0.010)		$ -	$ -	$ 0.010	$ -	$ (0.010)
7	Electric field system and EDM cell, Othe	$ -	$ 0.116	$ 0.116	$ -	$ 0.012	$ 0.012	$ -	$ 0.127	$ 0.127
8	Engineering and Technical Support	$ 1.550	$ 1.013	$ (0.537)	$ -	$ -	$ -	$ 1.550	$ 1.013	$ (0.537)
8	Eng & Technical Support - Expenses	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
8	Eng and Technical Support - Labour	$ 1.550	$ 1.013	$ (0.537)	$ -	$ -	$ -	$ 1.550	$ 1.013	$ (0.537)
	TOTAL	**$ 11.905**	**$ 11.163**	**$ (0.742)**	**$ 3.929**	**$ 1.805**	**$ (2.124)**	**$ 15.834**	**$ 12.968**	**$ (2.866)**

Japan Deliverables

Industry In-Kind

Budget Status

Canadian CFI Budget Without Contingency

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1a	LD2 moderator upgrade	$ 0.900	$ 0.625	$ (0.275)	$ -	$ -	$ -	$ 0.900	$ 0.625	$ (0.275)
1b	Superfluid helium cryostat upgrade	$ -	$ 0.198	$ 0.198	$ -	$ -	$ -	$ -	$ 0.198	$ 0.198
1c	Testing at KEK	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
1d	3He	$ 0.300	$ 0.226	$ (0.074)	$ -	$ -	$ -	$ 0.300	$ 0.226	$ (0.074)
1e	Final moderator and rad safety	$ 0.230	$ -	$ (0.230)	$ 0.240	$ -	$ (0.240)	$ 0.470	$ -	$ (0.470)
1	UCN Source Upgrade, Other	$ -	$ 1.297	$ 1.297	$ -	$ -	$ -	$ -	$ 1.297	$ 1.297
2	UCN transport and detectors	$ 1.450	$ 0.950	$ (0.500)	$ 0.230	$ 0.097	$ (0.133)	$ 1.680	$ 1.047	$ (0.633)
2a	Guide, coupler, and coating materials	$ 0.300	$ 0.199	$ (0.101)	$ 0.060	$ 0.043	$ (0.017)	$ 0.360	$ 0.243	$ (0.117)
2b	Switches and valves	$ 0.250	$ 0.083	$ (0.167)	$ 0.030	$ -	$ (0.030)	$ 0.280	$ 0.083	$ (0.197)
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4a	Beamline control upgrades	$ 0.100	$ -	$ (0.100)	$ -	$ -	$ -	$ 0.100	$ -	$ (0.100)
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4	Data acquisition and controls, Other	$ -	$ 0.071	$ 0.071	$ -	$ -	$ -	$ -	$ 0.071	$ 0.071
5	Magnetic fields	$ 4.245	$ 3.708	$ (0.537)	$ 0.937	$ 0.193	$ (0.744)	$ 5.182	$ 3.901	$ (1.281)
5a	Ambient magnetic field compensation	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
5b	Precision internal coils and supplies	$ 0.250	$ 0.274	$ 0.024	$ 0.050	$ 0.050	$ 0.000	$ 0.300	$ 0.324	$ 0.024
5c	Shielding and coil design BEM/FEA	$ 0.300	$ -	$ (0.300)	$ 0.100	$ -	$ (0.100)	$ 0.400	$ -	$ (0.400)
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5e	SQUID sensor	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
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5h	SCM + external compensation	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
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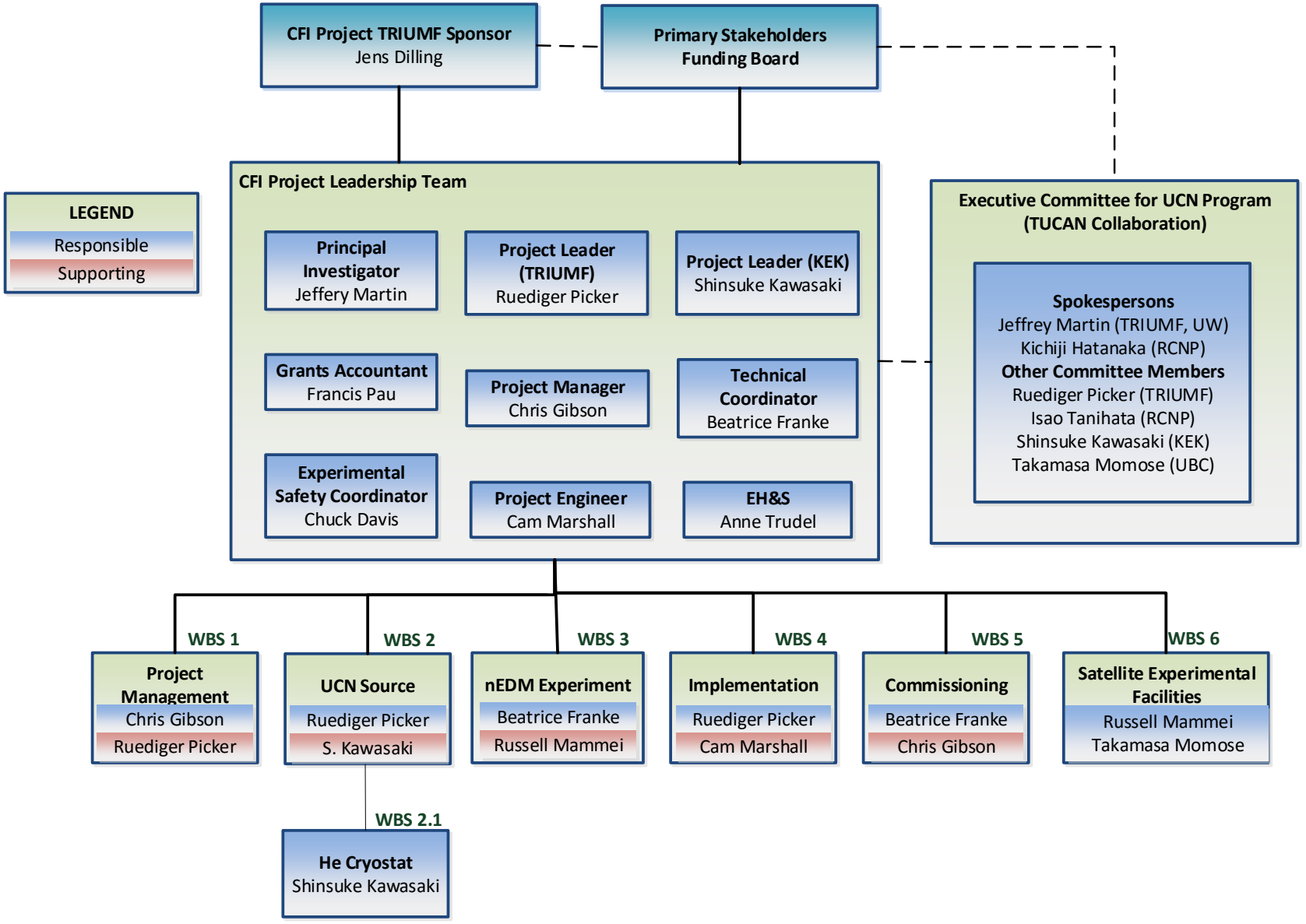
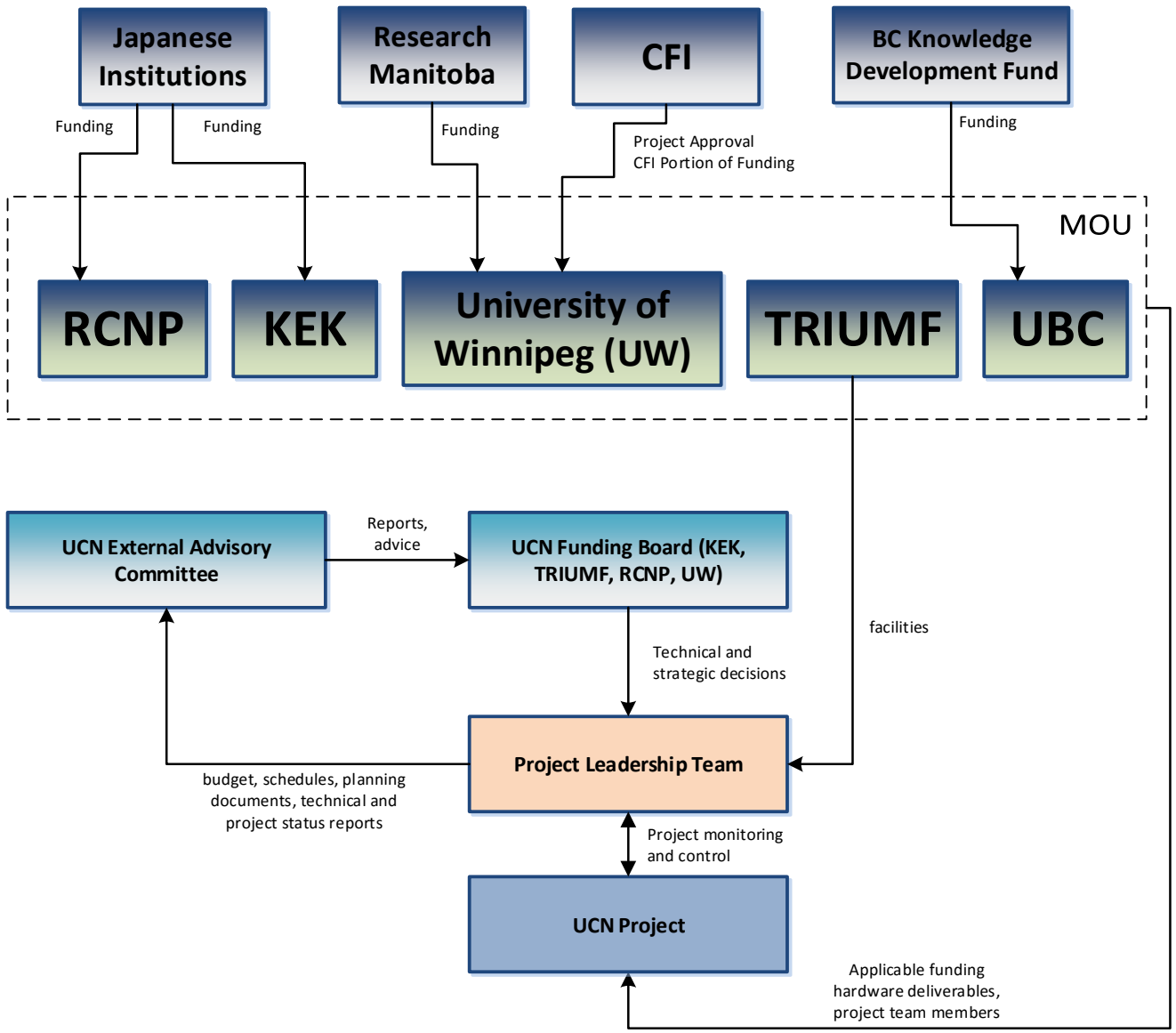
7c	Leakage current monitor	$ 0.010	$ -	$ (0.010)	$ -	$ -	$ -	$ 0.010	$ -	$ (0.010)
7	Electric field system and EDM cell, Other	$ -	$ 0.116	$ 0.116	$ -	$ 0.012	$ 0.012	$ -	$ 0.127	$ 0.127
8	Engineering and Technical Support	$ 1.550	$ 1.013	$ (0.537)	$ -	$ -	$ -	$ 1.550	$ 1.013	$ (0.537)
8	Eng & Technical Support - Expenses	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
8	Eng and Technical Support - Labour	$ 1.550	$ 1.013	$ (0.537)	$ -	$ -	$ -	$ 1.550	$ 1.013	$ (0.537)
	TOTAL	**$ 11.905**	**$ 11.163**	**$ (0.742)**	**$ 1.799**	**$ 0.716**	**$ (1.083)**	**$ 13.704**	**$ 11.879**	**$ (1.825)**

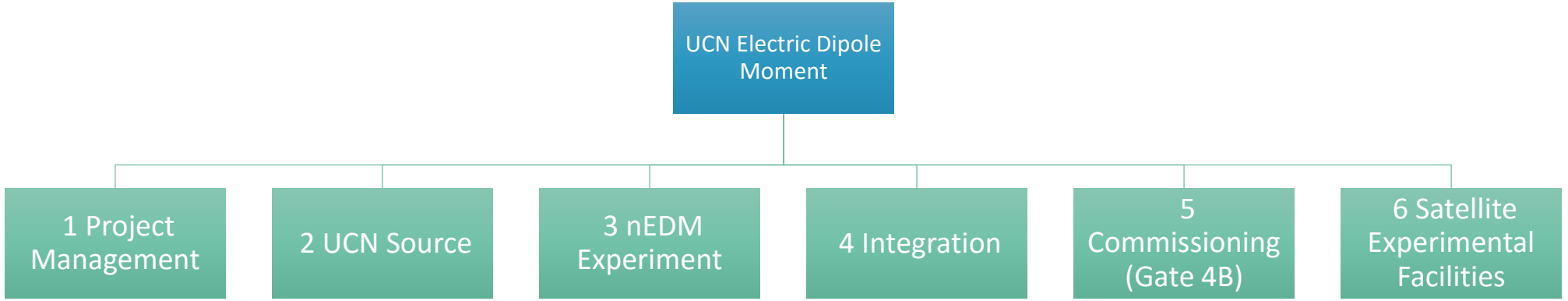
Project Org Chart



CFI Governance



Navigating the Plan – Work Breakdown (WBS)



- Project Plan
- Project monitoring
- EAC reports & Gate reviews
- Systems Engineering incl. test plan and verification reports
- Ongoing physics simulations
- Conceptual Design
- Detailed specifications for services

- Detailed Design of source subsystems and parts
- Fabrication
- Assembly to subsystem level & initial tests
- If applicable. ship to TRIUMF
- Includes some controls deliverables

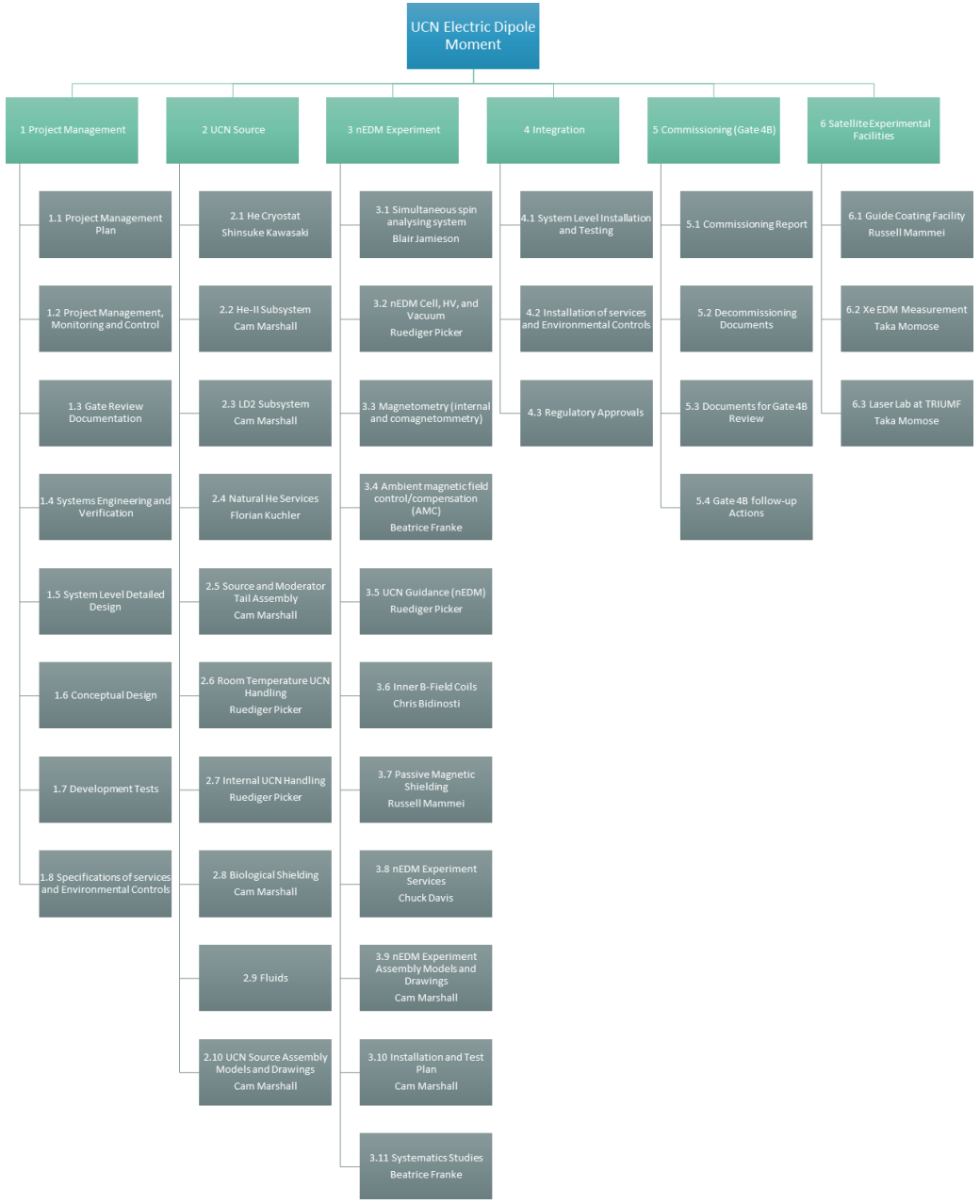
- Detailed Design of nEDM subsystems and parts
- Fabrication
- Assembly to subsystem level & initial tests
- If applicable. Ship to TRIUMF
- Includes some controls deliverables

- TSBC inspections and approvals
- CNSC license
- Installation
- Post-installation testing
- Integration (connect subsystems and test in a defined sequence)
- Some controls deliverables

- Maintenance and operating manuals
- Hand-over to operations where applicable

- Guide coating facility
- Xe EDM Measurement
- Laser Lab at TRIUMF

WBS to 2nd Level



Task tracking (embedded Excel File)

Active Tasks | **Date:** | **8-Jan-20**

Task Name	unique ID	WBS	Part of:	Start	Due	Completed? (Y,Blank)	Owner	Total Est. Hours	Status and Issues
Training Gap Analysis	7	1.1.4.1	Project Management Plan	11/25/19	1/15/20		CG?	60	
Release Facility Commissioning Plan	73	1.1.5.2	Project Management Plan	12/9/19	1/14/20		RP?	88	Dec 6: Discussed scope of this versus scope of verfication and test plan (WBS 1.4.3)
MOU	1290	1.1.6	Project Management Plan	5/6/19	11/29/19		JM	116	Dec 2: Jeff: - U of W is going through their legal process for last 3 months. JWM will check today. There was supposed to have been a revision sent ot U of W lawyer last Wednesday. UBC seems ready to sign it. Anne Fong at TRIUMF is being helpful. BF will ask Reiner to call Jino D at U of W.
2019 EAC Report	1274	1.2.12.2	Project Management, Monitoring an	1/3/20	1/16/20		CG	14	Dec 2: CG has started started a powerpoint update - need to update PM portion of EDM CDR to call this completed. Will go towards February EAC review. Will also use nEDM cdr as input into EAC review. Ruediger will create a source update for that review. Need to provide materials by mid-January. Change due date to mid-January?
Passive Magnetic Shielding Subsystem Requirements	1445	1.4.2.14	Systems Engineering and Verificatior	9/16/19	1/9/20	Y	RM	24	Dec 2: CM asked for some kind of drawing - RP asked SH to put stairs etc into full source model - RP could create a few views from that & should be sent to JWM ASAP. Then JWM will ask CG to send document out for release.

- Approximately every month, a team meeting is held with active task owners invited. The active task information is extracted from the MS Project File and Accounting module.
- Upcoming and overdue deadlines are shown
- Roadblocks, issues, and actions are recorded in the file. Actions may include updating schedule or budget.

Communication Plan

Report → Stakeholder ↓	Monthly updates on schedule progress by the Project Manager (start after Gate 2)	Monthly EVM updates by the Project Manager and Grants Accountant	Monthly updates on top project issues and risks by the Project Manager
EAC	Changing to Annual	Changing to Annual	Changing to Annual
TRIUMF Director	Y	Y	Y
TRIUMF Sponsor	Y	Y	Y
Other TRIUMF managers*	Y	N	N
Project Leadership Team	Y	Y	Y
WBS Leaders	Y	Y	Y
Team members**	Y	Y	Y

**Primary document depositories are Plone and Docushare

System Block Diagram