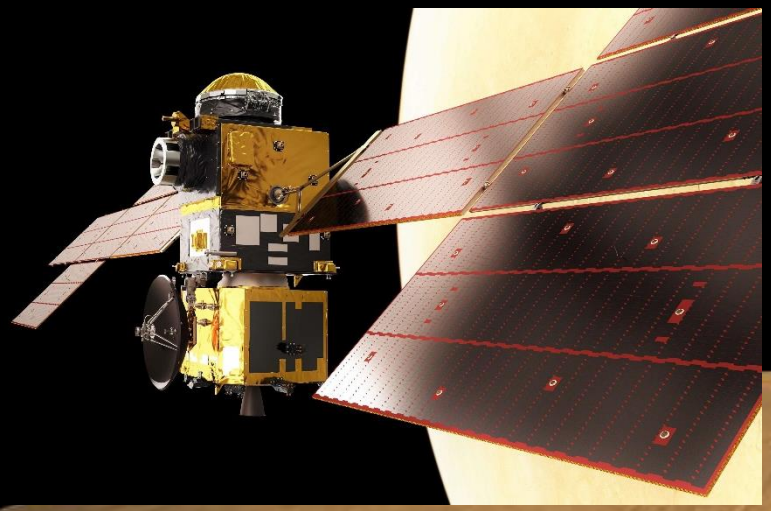
Mars Sample Return
Capture, Containment and Return System (CCRS)

CCRS Project PP&C Overview

NASA Cost & Schedule Symposium

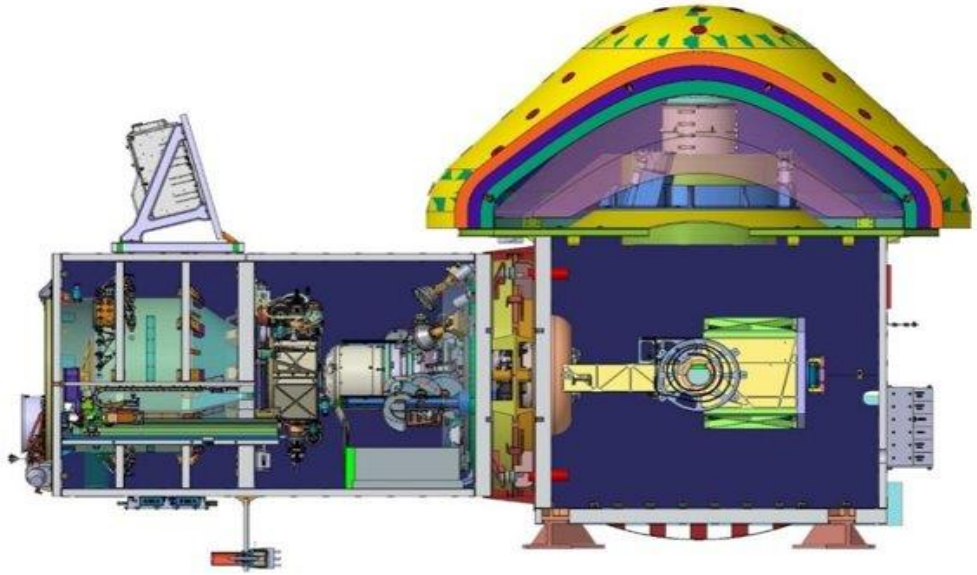
Robert Montgomery
Zac Dolch
Zach Walters
Joan Stahr
Daniel Battle

April 2024



CCRS Overview

- CCRS is the primary payload on the ESA-led Earth Return Orbiter (ERO) as part of the Mars Sample Return Program
- The payload's key functions include:
  - Capturing the Orbiting Sample (OS) container in Mars orbit after ERO rendezvous
  - Applying UV light exposure to the OS to support Backwards Planetary Protection requirements
  - In-flight assembly of the Earth Entry System including secondary containment of the samples
  - Ballistic delivery of the Earth Entry System to Earth (Utah Test and Training Range)



CCRS will deliver the first soil samples of another planet to Earth

CCRS Project Planning & Control (PP&C)

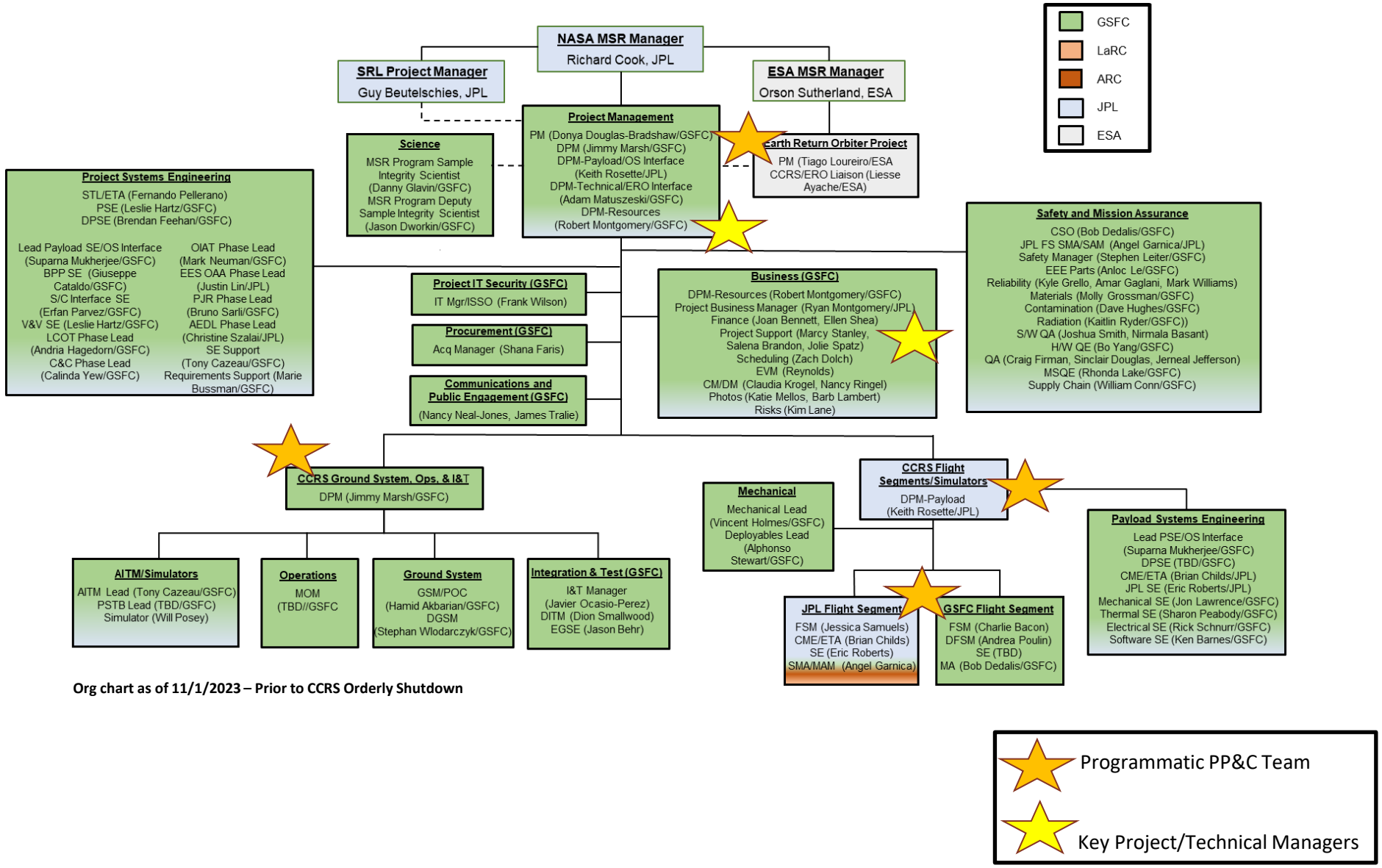
- While not the primary focus of this discussion, it is important to mention that CCRS experienced significant cost and schedule growth in Phase A/B, driven by:
  - numerous technical and programmatic constraints the project was under
  - overly optimistic early estimates inherited by the project

- Despite the growth experienced, the project consistently received positive feedback on our PP&C processes.
  - CCRS SRR-SDR out brief reported that “CCRS programmatics are outstanding.”
  - PP&C team nominated for PMEA Award
  - Multiple CCRS programmatic team members have won awards associated with their contributions to the project (Agency Honor Awards, Peer Awards, C&SS, etc.)
  - Strong rapport with MSR Program Business Office and HQ throughout Phase A/B.
  - MSR IRB2 findings on inadequate programmatic management did not include the GSFC-led portion of the program
  - MSR SRB found the program’s business processes to be appropriate for SRR/MDR

- Prior to the program’s pause following the IRB report, the CCRS project was fully prepared to implement PP&C in Phase C/D, with the processes and team in place to manage a major portion of a flagship program.

CCRS Organization – PP&C focus

- The CCRS org charts puts a strong emphasis on PP&C, with the DPM-R role integrated into the PM team.
- Project managers throughout the project's organization also played a key role in managing PP&C.
- The CCRS business team was comprised of a set of individuals who had extensive experience working complex projects.
  - Many of which were in-house, planetary, or flagship missions
  - Experience base Included: ATLAS, MOMA, Europa Clipper, GEDI, Lucy/L-Ralph, JWST, JPSS, MAVEN/NGIMS, OSIRIS-REx/OVIRS, OCI, among others.



Org chart as of 11/1/2023 – Prior to CCRS Orderly Shutdown

CCRS PP&C Programmatic Approach

- The Deputy Program Manager for Resources (DPM-R)'s role is to ensure PP&C programmatic best practices are implemented and all business activities are integrated.
- The CCRS project implemented PP&C through:
  - Proactive planning
    - Complete cost basis of estimate documentation, reviewed by Project and line organizations
    - Detailed IMS inputs meeting maturity expectations for the project's phase
    - Validation of cost and schedule estimates through multiple data points
    - Early acquisition planning
    - Risk identification and mitigation plans (via TDMS, linked to Encumbrance, Lien, Threat (E/L/T) process)
    - Work Authorization Documents (cost/schedule/technical agreements) between Project and Implementing Orgs
  - Change control and performance tracking
    - Strict configuration control, including disposition of cost/schedule impacts of technical changes
    - Risk board clearly defined mitigation strategies and risk burndown plans
    - E/L/T process to disposition the release reserves of technical changes, risk mitigations, contract changes, and overruns
    - Tight tracking of cost and schedule performance metrics
  - PP&C Integration and Evaluation
    - Regular programmatic meetings with CAMs
    - Monthly Management Reviews examine performance, risks, issues and inform management decisions
    - Monthly EAC assessments conducted for both cost and schedule using multiple techniques
    - Proactive risk management including early identification of risks and mitigation options
    - Earned Value Management

PP&C Whitepaper Excerpt – 2017 (Programmatic focused)

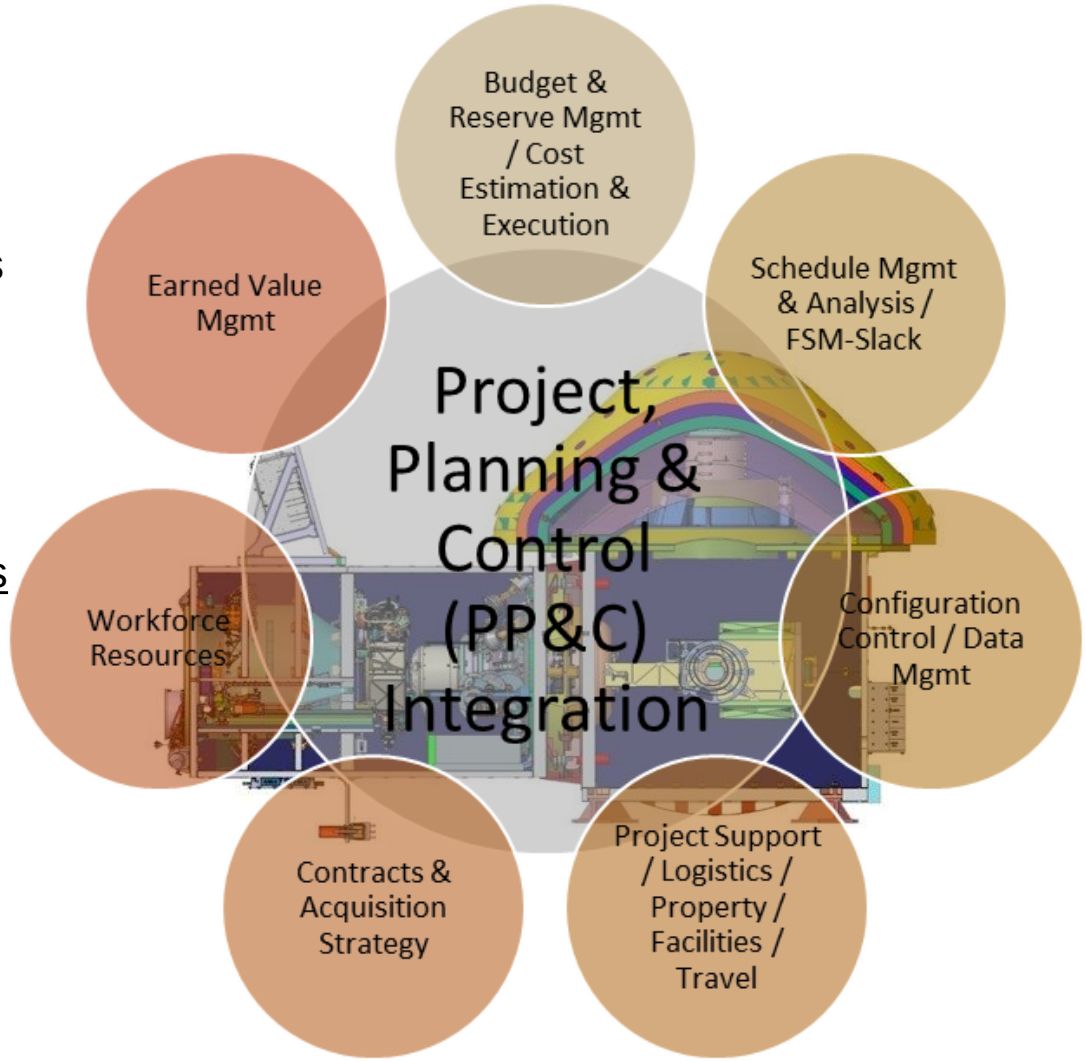
*Excerpts from Project Planning and Control Proficiencies Whitepaper NASA/SP-2017-XXXX

- A core focus of PP&C Integration is assimilating, integrating, and assessing typically “stove-piped” information into a comprehensive picture/story and providing recommendations to assist project management in making effective, informed decisions to maintain cost and schedule performance within plans and ensure project success.

- An essential role of PP&C Integration is to keep project management focused on **affordability**. Affordability, an often discussed but little understood aspect of project management, is defined as the ability to execute a project's technical requirements within the approved cost and schedule baselines.

- In many ways, PP&C Integration is about understanding the interrelationship and alignment of the business and project scope side of a project **with the technical side**. The PP&C integration manager makes connections horizontally and vertically across multiple functions and multiple levels of information.

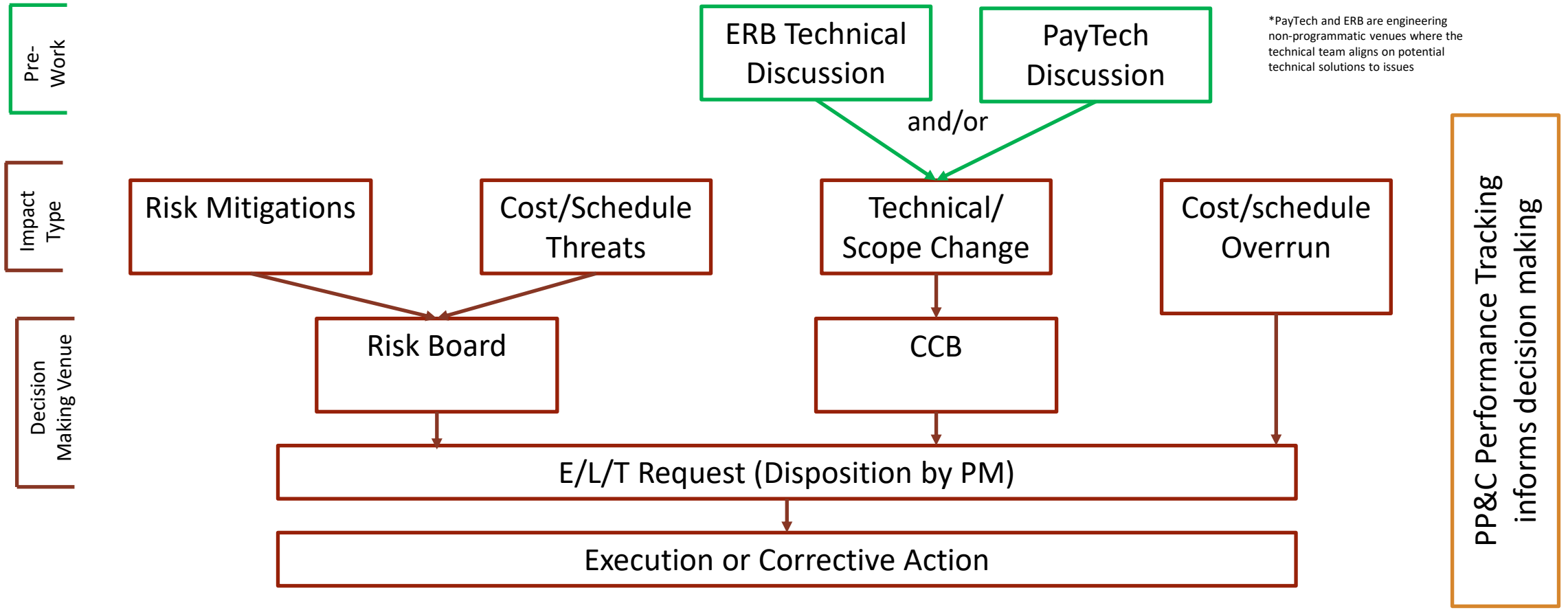
- In addition, the PP&C integration manager helps team members understand disciplines outside their own, and provides guidance, decisions, and adjustments to the other PP&C functions.



My view of PP&C as a practitioner

Project Decision Making and Control

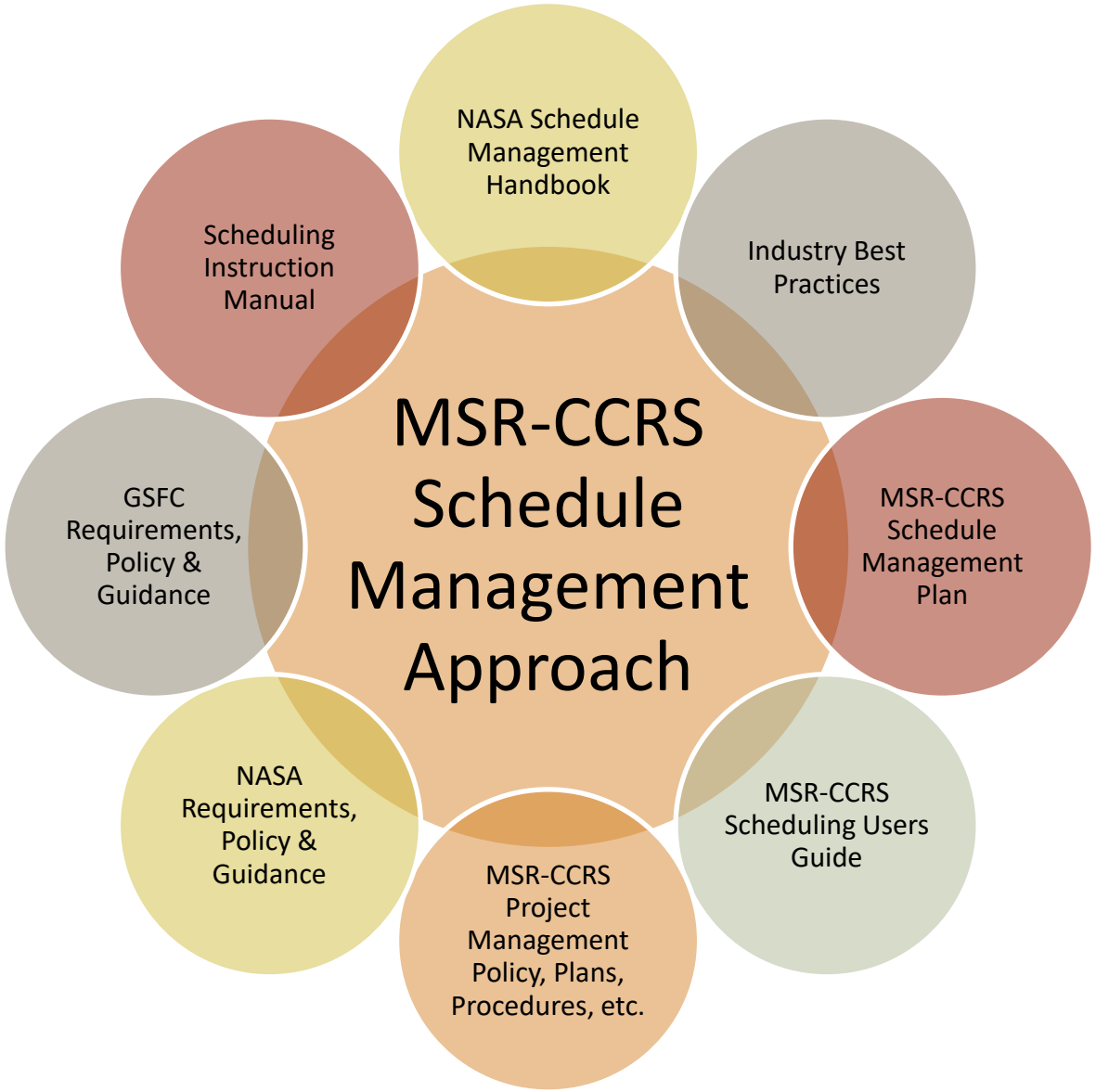
Events impacting cost and schedule, the technical baseline, or the project risk posture must flow through the appropriate decision-making venues and be dispositioned at the PM level prior to execution.



Schedule is King!

- Schedule management ensures the establishment, management, and control of baseline master schedules and derivative schedules
  - Provides the framework for time phasing and coordinating all project efforts into master plans
  - Manages and ensures objectives are accomplished within project and/or mission commitments.

- The CCRS Schedule Management Approach is a hybrid-approach to the Schedule Management Plan.
  - The plan operates within the MSR-CCRS framework , combining Agency, Institutional, Industry, and Project policy, requirements, guidance, plans, procedures, technical user's guides



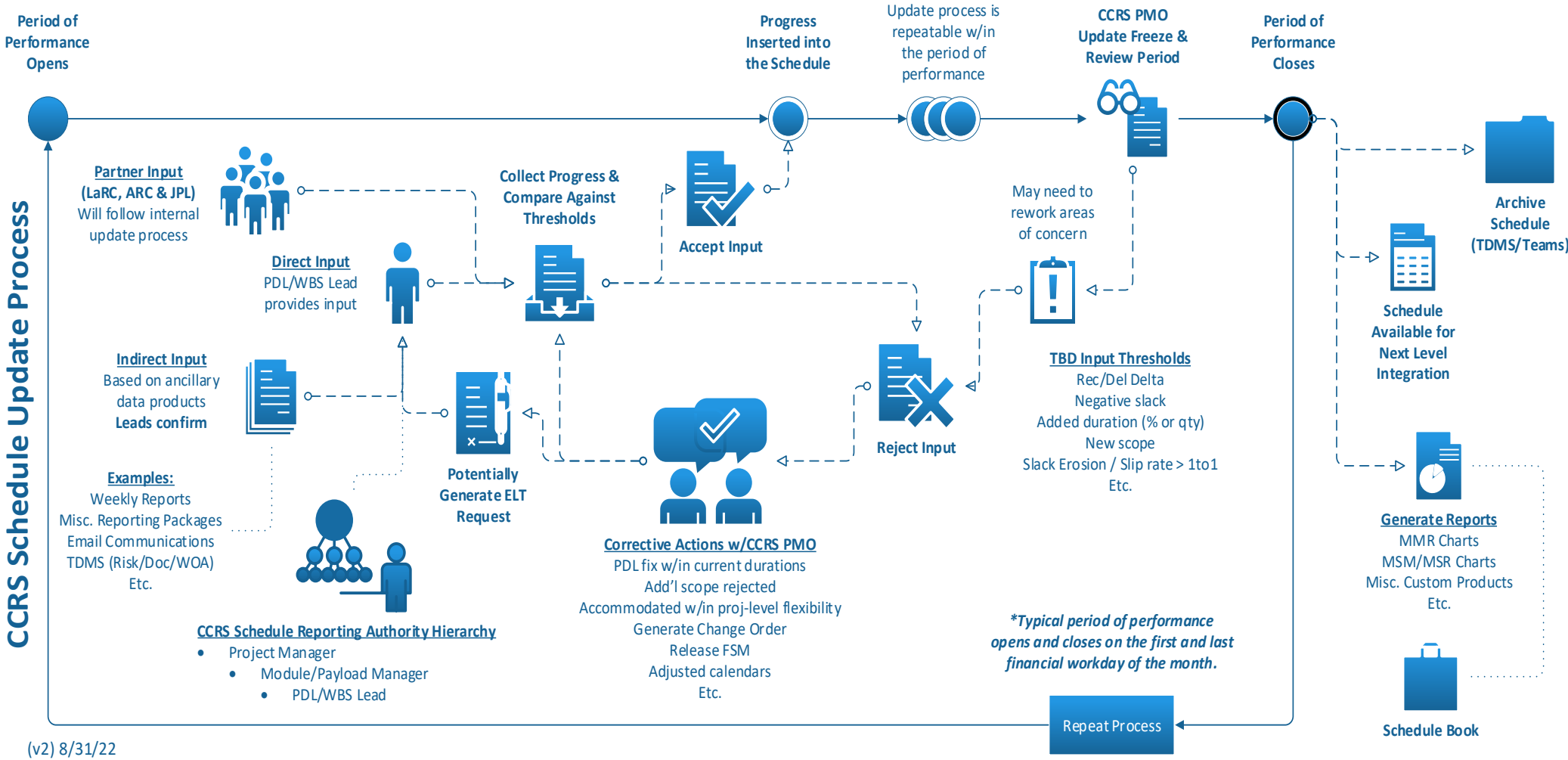
CCRS Master Schedule (ME Aug 2023)

CCRS maintained a healthy schedule to a 2028 LRD prior to its orderly shutdown in Nov 2023. Margin exceeding institutional guidelines was held both on subsystem deliverables as well as at the tail end of I&T.

Funded Schedule Margin vs Slack

- The CCRS IMS holds Funded Schedule Margin (FSM) against all major flight deliverables as well as at the back end of I&T
- Additionally, slack that exists on all non-critical deliverables is not considered freely consumable, without justification.
  - Furthermore, most of this slack is unfunded and may require the use of cost reserves to utilize.
- PDLs are entitled to use slack only if they can fund it within their budget allocation.
- If additional funds are needed due to a schedule delay, PDLs will need to make a request of PM to release reserves.
  - If delays are driven internally, FSM will be used first.
  - If delays are driven by scope changes or other external factors (BCRs), cost reserves may be requested.
  - If FSM has been exhausted but slack remains, cost reserves can be requested
  - The project's ELT request form can be used to request cost reserves (UFE) or FSM

Schedule Maintenance: Monthly Status Process

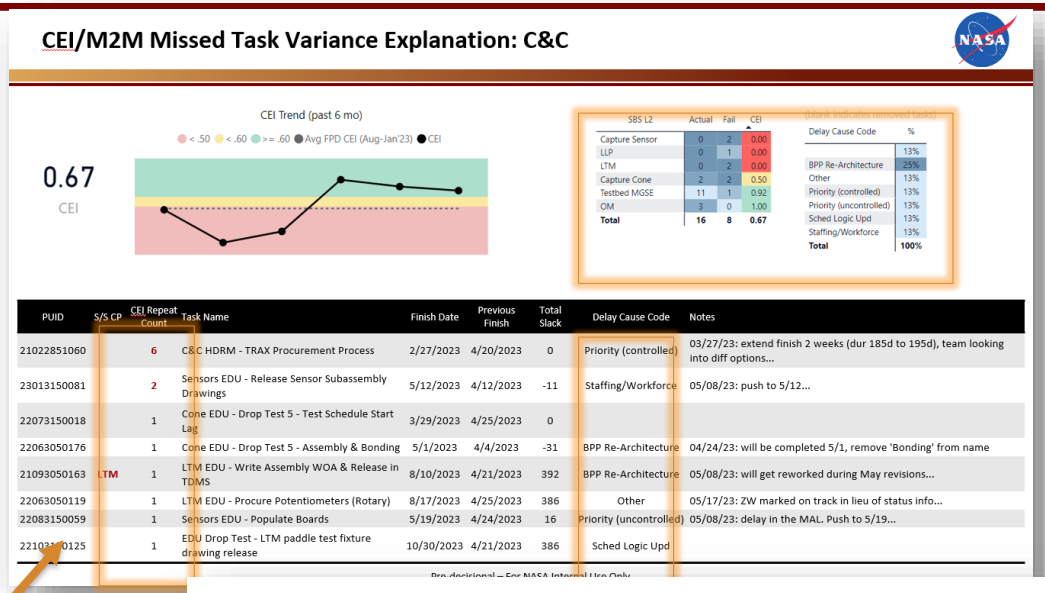


CCRS Schedule Update Process is led by CCRS Scheduling Team, with significant support from:

- Project/ Technical Management (at all levels)
- DPM-R
- Resources Team
- EVM
- Procurement

Schedule Control: Performance Metrics

- The CCRS Project has the capabilities to map additional data points at the task level to the schedule's performance metrics.
- Additional data points for mapping:
  - SBS L1 – subsystem category
  - SBS L2 – component category
  - SBS L3 – build category
  - GSFC Org Code
  - Delay Cause Codes
  - Key/Control Event Type
  - Subsystem/Project Critical Path ranking
- Some current examples:
  - Using SBS L1 and L2 to extract lower-level metrics and combining CEI with delay cause codes, subsystem critical path identification, and counting the repeat "fails".
  - Using delay cause codes to identify supply chain impacts to task durations.



The CCRSschedule management and reporting processes allowed for informed decision-making and communication across our PP&C team / business systems.

Lifecycle Cost (LCC) Management

Subsystem	Approved LCC
PM	[redacted]
SE	[redacted]
SMA	[redacted]
Flight Sys. Mgmt	[redacted]
CCS	[redacted]
S&D	[redacted]
ATES	[redacted]
RTAS	[redacted]
SEM	[redacted]
EESA	[redacted]
Vision	[redacted]
Avionics	[redacted]
Harness	[redacted]
FSW	[redacted]
WHA	[redacted]
Thermal	[redacted]
Sys. Dev Testbed	[redacted]
Simulators	[redacted]
Ground	[redacted]
I&T	[redacted]
TOTAL	[redacted]

*LCC values redacted

- CCRS manages costs against the LCC defined at each lowest level WBS.
- CAMs/WBS owners may adjust their forecast plans (EACs) within the agreed to LCC at their own discretion. CAM plans are focused on cost (not obligations).
- Adjustments to any LCC at the lowest WBS level require an E/L/T request which must be dispositioned by Project Management. E/L/T requests **shall** be agreed to prior to the execution of spending beyond plan.
- At times of significant change, the project may elect to hold a project-wide or targeted grassroots costing update. When this occurs, LCC updates should aim for the prior agreed to value, adjusted for scope changes. These exercises are anticipated to be rare once the PMB has been established.
- Work Authorization Documents are signed prior to KDP-C between implementing organizations and the project. These documents act as a contract to define an LCC, delivery date, and scope of work within each CAMs WBS'. They are managed within the project's CM tool (TDMS).

CCRS Cost Estimating Approach

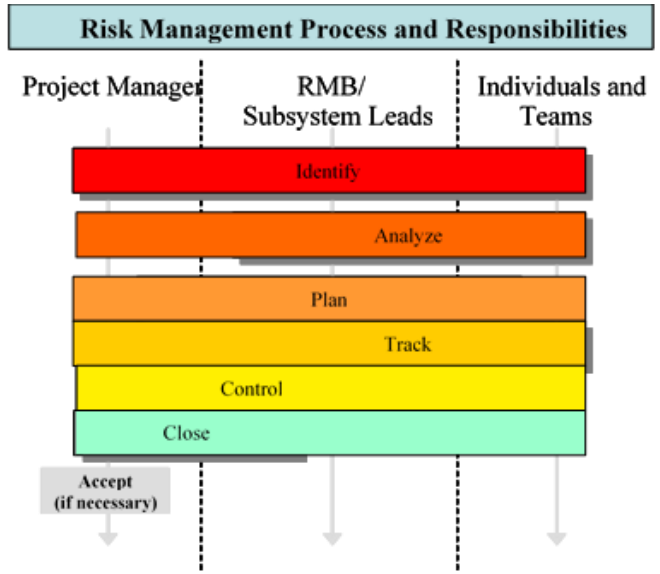
- Beginning in Phase A, the CCRS team has used a grassroots cost estimating approach including:
  - Leads for each lowest level have provided inputs tied to the latest IMS (schedule-first approach)
  - A common cost estimating template has been used across the project
  - In addition to the cost inputs, PowerPoint presentations documenting assumptions, heritage, estimating methodology and justification, risks, etc. have been created
  - Grassroots values were reviewed against parametric and analogous estimates, as appropriate
  - Project and line management reviews have assessed realism, achievability, and completeness of the estimates.

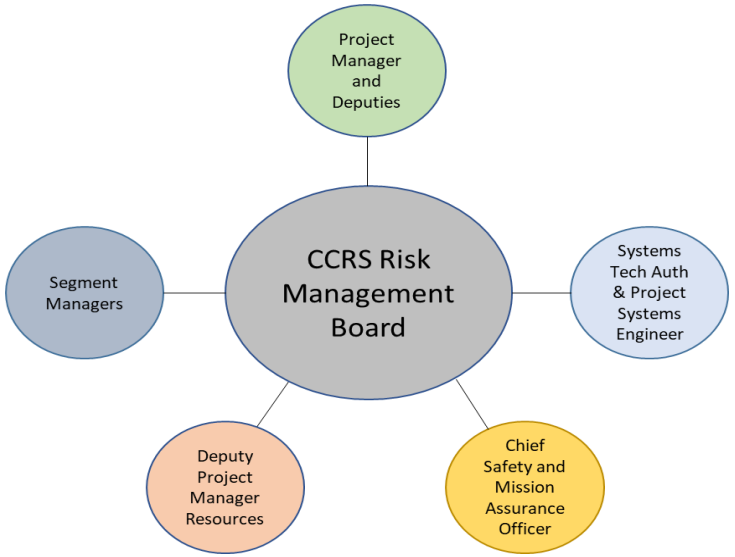
- Leading into all gate reviews, multiple rounds of independent cost and schedule analyses were conducted to assess the realism of the estimates created.

- Prior to KDP-C, the following cost/schedule analyses and reviews will be conducted:
  - Project and line management reviews
  - Project-led JCL/SRA
  - Programmatic Peer Review (including independent SRA)
  - GSRT programmatic assessment
  - Resources Analysis Office assessment
  - Program led JCL and independent JPL assessments
  - HQ Program Office sponsored independent assessments
  - GSFC CMC

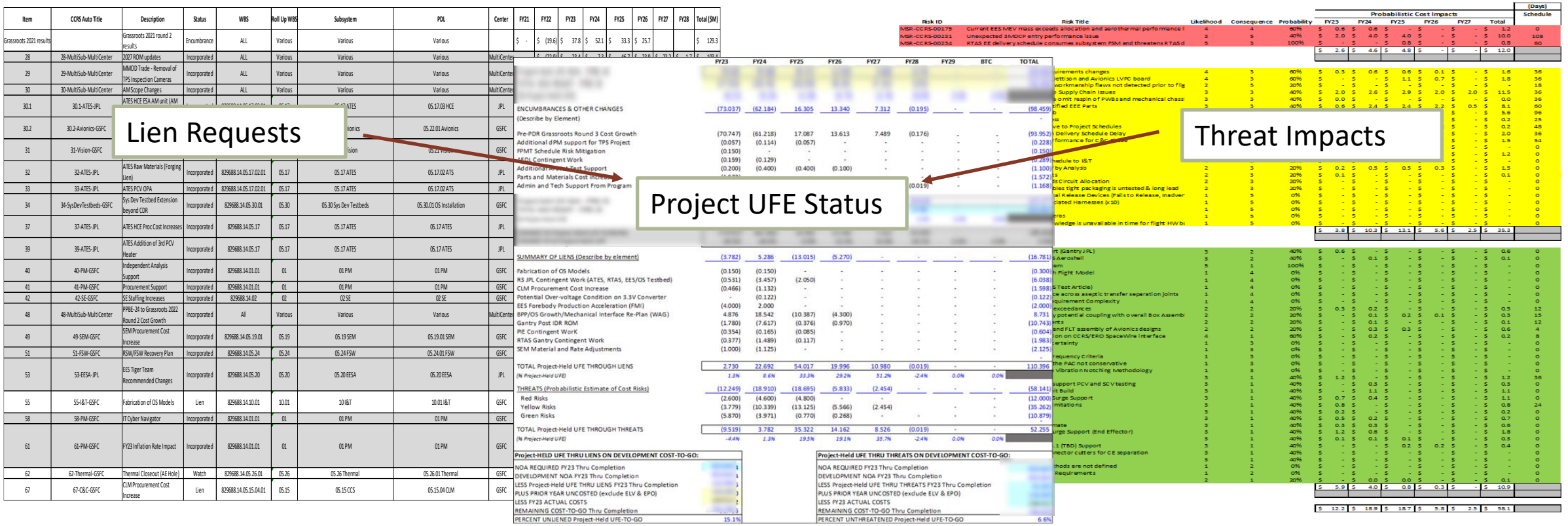
Risks/Threats

- Risk identification is a responsibility of all CCRS team members. Risks can be identified and brought forward by any individual on the team
- CCRS uses the TDMS database to process and document risk statements, status, mitigation steps, cost/schedule impacts, etc.
- The Risk Coordinator manages the risk identification, boarding, and updating process.
- All risks entered in TDMS begin in the “In Discussion” phase and dedicated meetings are used to ensure risk documentation is complete and ready to be brought forward to the Risk Board.
- All risks are required to identify cost and/or schedule impacts, per GPR 7120.4D. Estimates are generally for the mitigation of the risk and are provided by the risk owner, with support and validation from business team.
- Monthly Risk Board meetings are held to formally disposition new risks, update existing risks, and identify mitigation strategies.
- The CCRS business team will utilize risk/threat data to assess EACs, conduct SRAs/JCLs, inform stakeholders, and identify budgetary threats throughout the CCRS lifecycle.





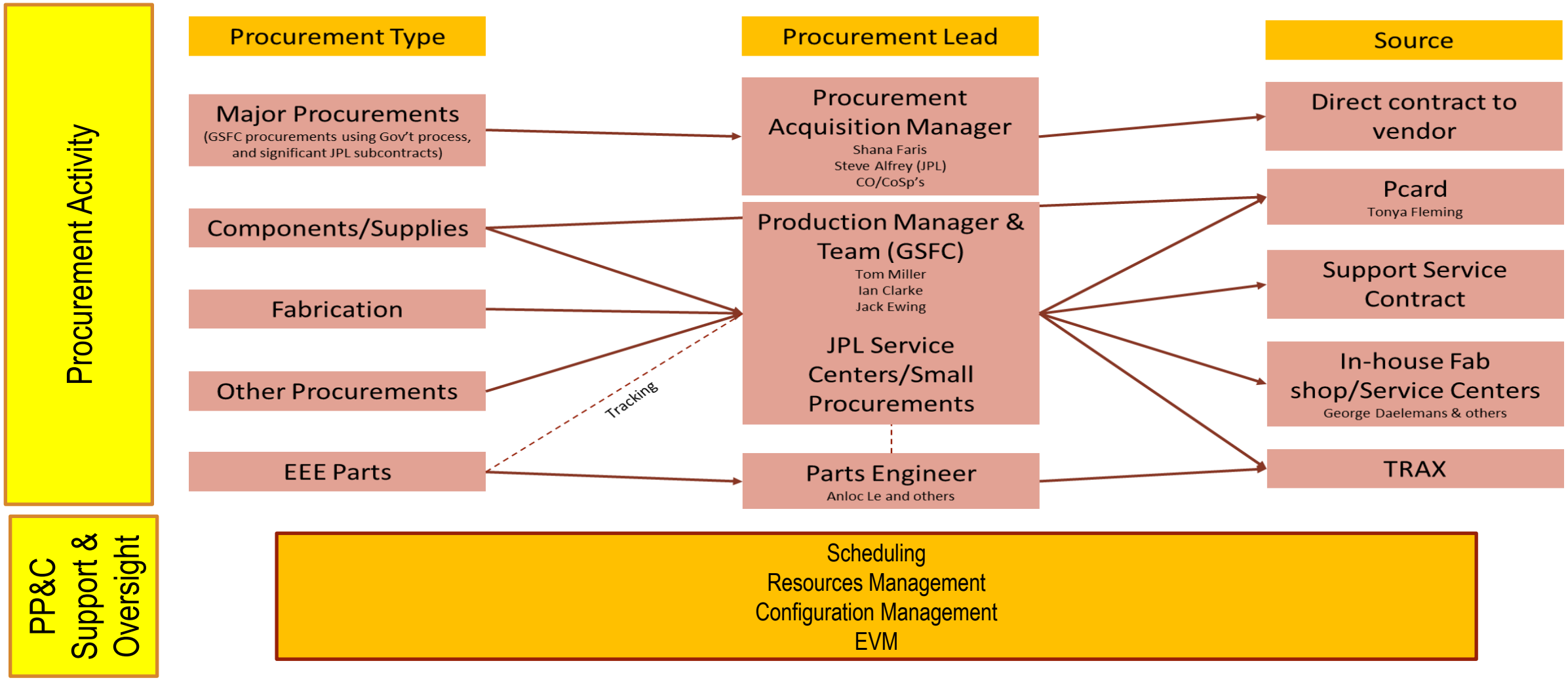
CCRS Examples of E/L/T Tracking



- CCRS meticulously tracks the cost reserve available to the project both on an LCC and FY basis. These values are tracked as NOA guidelines available to the project against the captured encumbrances, liens, and threats.
- Risk data is also used for EAC assessments and other programmatic models required for regular business reporting and gate reviews.

CCRS LCC and reserve management processes are integrated tightly with all PP&C disciplines as well as the Project Management decision making process

Procurement Management



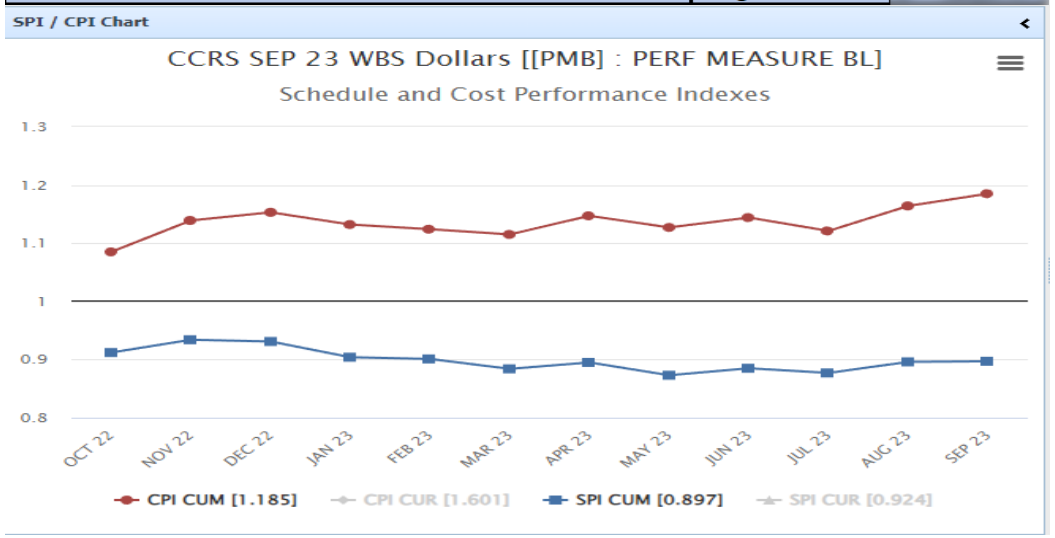
CCRS procurements run through the Procurement Acquisition Manager and Production Manager. The PP&C team supports and provides oversight of the execution and tracking of all procurements.

Earned Value Management (EVM)

- CCRS was successful in implementing Phase B EVM
  - Preliminary EV performance measurement was in place on the GSFC portion of the CCRS project from June 2022 until the orderly shutdown of the project in Nov 2023.
  - Formal EVM baselined reporting will be established after completion of the CCRS Preliminary Design Review (PDR)
  - The PDR gate will allow the project to establish the Performance Measurement Baseline (PMB) maintained under configuration control
  - Coordination efforts between GSFC, other NASA centers, and subcontractors have been made ensuring cost and schedule integration between all areas and scopes of work

- Using the Phase B EVM data to track performance was challenging due to the changing nature of the CCRS technical baseline.
  - However, the early focus on EVM allowed the project to align its processes and products in a manner to provide valuable programmatic insight to management moving forward

CCRS Responsibility Assignment Matrix (RAM)		
WBS	**CAM**	**BAC ($K)**
829688.14.01 - CCRS Project Management	Montgomery	
829688.14.02 - CCRS Systems Engineering	Feehan	
829688.14.03 - CCRS Safety & Mission Assurance	Duncan	
829688.14.05.01-.04 - CCRS Payload WBS Pre-Partial Jettison	CLOSED	
829688.14.05.11 - CCRS Flight System Management	Bacon	
829688.14.05.15 - CCRS Capture and Configuration System	Dear	
829688.14.05.16 - CCRS Structure and Deployables	Ngo	
829688.14.05.17 - CCRS Aseptic Transfer and Encapsulation System	Nayeri	
829688.14.05.18 - CCRS Robotic Transfer Arm System (RTAS)	Roberts	
829688.14.05.19 - CCRS Spin Eject Mechanism	Stein	
829688.14.05.20 - CCRS Earth Entry System Aeroshell	Roberts	
829688.14.05.21 - CCRS Vision System	Bos	
829688.14.05.22 - CCRS Avionics	Ramirez	
829688.14.05.23 - CCRS Harness	Kim	
829688.14.05.24 - CCRS Flight Software	Ferrer	
829688.14.05.25 - CCRS Workhorse Actuators	Schepis	
829688.14.05.26 - CCRS Thermal	Otero	
829688.14.05.30 - CCRS System Developmental Testbeds	Kimvilakani	
829688.14.05.31 - GSFC-CCRS Simulators	Geist	
829688.14.09 - CCRS Ground Systems	Akbarian	
829688.14.10 - CCRS Flight Systems I&T	Ocasio-Perez	
Total CCRS	**Douglas-Bradshaw**	



*BAC values redacted

CCRS EAC Assessment Process

- CCRS will maintain an up-to-date project Estimate at Complete (EAC) at all times.
  - The primary EAC will be based on the project's baseline cost including all liens and encumbrances.
  - EACs will be available at the project-level, subsystem-level, and down to the component WBS.

- Routinely, the project will assess its EAC utilizing schedule, resource, earned value, and risk management analysis activities including
  - Budgetary discussion with leads
  - Critical path analysis combined with WBS burn rate
  - Earned value TCPI and iEAC calculations
  - Earned schedule analysis
  - Risk / threat analysis
  - MMR reporting and review
  - Grassroots updates, as needed

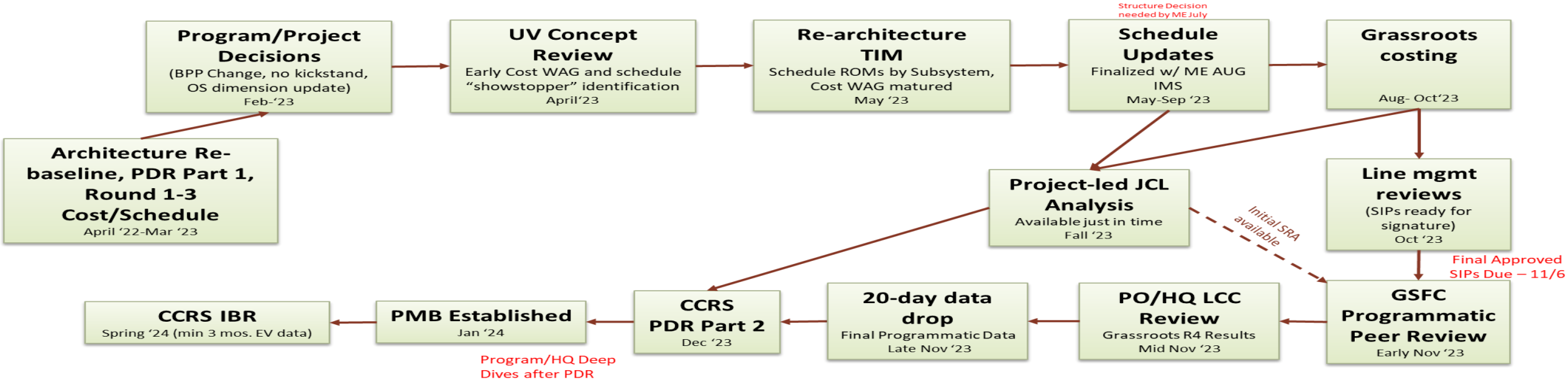
- These analysis activities will be imbedded within the CCRS ELT process to provide the most up-to-date and accurate estimate at completion.

Project MMR

- CCRS holds a Monthly Management Review as the primary venue where CAMs are reviewed for performance. This includes a tracking of:
  - Schedule performance
    - CEI was primary performance metric used in Phase A/B, transitioning to BEI in Phase C/D (with HMI also tracked)
      - Missed tasks and delay cause codes tracked and reported against
    - Slack and delivery date history, Rec/Dels, and Milestone tracking
  - Financial performance
    - Monthly and cumulative plan v actual including variance explanation
    - Subsystem EAC trends including liens/encumbrances and threats
    - Workforce performance to plan
  - Procurement tracking
    - Procurement dashboard assessing vendor status on cost/schedule/technical
  - EVM
    - Preliminary Phase B EVM data was not effective for tracking performance due to changing technical baseline
    - Phase C/D reporting to utilize EVM metrics to a greater degree
  - Summary dashboards used for managers over multiple subsystems with stoplight reporting on cost, schedule, technical, workforce, procurement, and other

A Well Practiced Replanning Process

Sample CCRS Replanning flow



The CCRS team conducted multiple rounds of replanning in Phase B as the technical baseline was updated.

- The flow initiates with allowing the technical design to mature sufficiently
- A schedule update is next, allowing sufficient time for iteration
- A grassroots cost update follows the schedule, with a recognition that resource constraints could drive further schedule updates
- Line management and external reviews proceed finalization of programmatic inputs for PDR
- Independent assessments conducted at the Program level for MSR (pre-IRB 2)

Conclusion

- CCRS is a highly complex development payload that represents a significant PP&C challenge

- Prior to the project's pause, CCRS had implemented a proactive, integrated PP&C approach leveraging agency best practices, the team's experience, and lessons learned from prior missions

- The CCRS PP&C framework is a model that could be applied on all NASA-led missions

BACKUP

Contact Info

Robert Montgomery

GSFC RMO Deputy Chief
CCRS DPM-R

Cell – 301-377-2475

Robert.t.Montgomery@nasa.gov