

Executing Large EPC/EPCM Projects using Scrum Values and Principles

An Experience Paper

What started as an experiment in 2011 has resulted in the successful application of agile values, principles, and techniques in a domain usually managed with traditional techniques. Prior to starting this work, multiple conversations with the Program sponsor revealed concerns with the team's ability to focus on what's important, resolve issues quickly, and keep commitments. Many of these issues appeared to be rooted in team dynamics and a siloed approach to delivering work product; consequently we decided to experiment with applying Scrum to an Engineering Procurement Construction (EPC) project.

This paper describes how the Scrum framework was applied to this EPC project and 3 subsequent Engineering Procurement Construction Management (EPCM) projects. It is hoped that by describing how Scrum was applied, why it was applied, and the outcomes of that application that the business community at large will see that the Scrum framework is applicable and valuable outside of the software industry. The overarching message of the paper is that the Scrum framework is equipped to help organizations, teams, and people solve common problems-- regardless of the domain. The success of organizations, their products, and projects lies in their teams and how they work together.

Introduction

In 2005, a group of agilists came together to discuss how the agile manifesto applied to project management in general. They created the ['Declaration of Interdependence'](#):

“Agile and adaptive approaches for linking people, projects and value. We are a community of project leaders that are highly successful at delivering results. To achieve these results:

- We **increase return on investment** by making continuous flow of value our focus.
- We **deliver reliable results** by engaging customers in frequent interactions and shared ownership.
- We **expect uncertainty** and manage for it through iterations, anticipation, and adaptation.
- We **unleash creativity and innovation** by recognizing that individuals are the ultimate source of value, and creating an environment where they can make a difference.
- We **boost performance** through group accountability for results and shared responsibility for team effectiveness.

- We **improve effectiveness and reliability** through situationally specific strategies, processes and practices.”

This credo was an offshoot of the [Agile Manifesto](#) created specifically for software development in 2001 by some of the same people. Since 2004, I've been working with teams in different domains within the software industry applying agility (and specifically Scrum) to the execution of projects and product development.

In late 2010, a large North American energy company embarked on a large Engineering, Procurement and Construction (EPC) project to build a natural gas processing plant in northern British Columbia, Canada. The plant was to have the capacity to process 400 MCF/day and the plant was to be on-line in December 2012. The budget for the project was \$700M. In April 2011, the project manager and I started having conversations about his team's struggle to move certain activities forward, and the specific problems his team was facing:

- Unclear priorities and roles
- Lack of communication due to silo'd activities
- Lack of visible progress on what's important and why
- Lack of accountability to each other
- Lack of understanding of the true state of the project

These problems are common with many teams I've worked with in other domains. These are typical problems that can be addressed based on the 3 pillars of a Scrum mindset.

- Transparency
- Inspection
- Adaptation

We decided to experiment with applying Scrum values, principles and techniques to address these problems on the EPC project.

Change in the Context of Physical Construction

Going into this work, I had assumed that change was difficult in these types of projects because of the physical nature of the work. Once equipment or modules are fabricated, it is difficult to change them. This turns out not to be precisely the case. The construction activities of an EPC project are extremely well understood. Relative to the engineering and procurement activities, there is significantly less risk in the construction activities. Change is difficult due to all the review/approval processes necessary to finalize design, engineering, and procurement. When there are delays in reviews and approvals regarding engineering or procurement, the effect is amplified:

- Materials and equipment don't get purchased fast enough
- Which leads to those materials and equipment not arriving on time

- Which leads to less time for construction
- Which leads to missing the online date.
- Which leads to decreased revenue and therefore decreased ROI

The revenue and ROI model of a natural gas processing plant is much better understood than the analog models for software products. Therefore, it is much easier to understand the true cost of delay. The cost of delay for the initial EPC project was \$300k / day. The overall challenge within these projects is to minimize delays between dependencies to allow maximum time to deal with “the unknowns you don’t know” as well as the “unknowns you know”.

Application: Engineering, Procurement, and Construction Project

For the initial EPC project, the energy company had contracted an engineering company to provide the design and engineering, contracted a Works contractor to construct the plant, and self managed the project including the procurement. The approach to solving the initial problems exhibited by the team was to base teamwork on the **Scrum values: Focus, Courage, Openness, Respect and Commitment**.

The team needed to find a way to **focus** on what issues were the most important for the success of the project. We achieved this by implementing a backlog of issues that were iteratively prioritized by the project manager. The combination of making *project* prioritization visible (rather than discipline prioritization) and limiting Work in Progress (WIP), the team was able to continually focus on what was important for the project’s success.

The team needed to have the **courage** to face both the reality of their progress and the barriers to their effectiveness as a team. We increased this courage by implementing iterative feedback loops for both the work and the process used to achieve the work product. The retrospective sessions focused on how the team was working together. This resulted in the team taking ownership of several actions per week to improve their communication, collaboration, and work processes. Iterative planning sessions were held based on progress achieved (as demonstrated in bi-weekly schedule reviews) and roadblocks anticipated in upcoming work.

The team needed to be **open** to experimenting with different approaches to their work. They also needed to be open to the transparency that using Scrum values would create. All of the dysfunction in the team would be surfaced and would need to be addressed by the team.

The team needed to **respect** and trust each other in order to perform effectively. To this end they created basic working agreements and work processes which relied on trust.

The team needed to make and keep their **commitments** to each other. In the face of their individual discipline priorities, they had to commit to prioritizing the project’s commitments in the context of collaborative multi-discipline. Essentially they needed to regularly commit to

optimizing for the project, not their individual disciplines. Then they needed to see those commitments through.

In the context of the 3 Pillars of Scrum, the values described above were promoted through the application of Scrum Roles, Events, and Artefacts as described in the latest [Scrum Guide](#).

● Scrum Roles

○ **Product Owner**

An existing role in the energy company's organization called the **Project Manager** was responsible for regularly establishing the priorities and context for the team. That person had the overall accountability for the success of the project and was already expected to have an overall understanding of the state of the project and the progress and roadblocks to success.

○ **Scrum Master**

We created a new role we called a **Team Facilitator** who was responsible for helping the team keep an agile mindset and coordinate the transparency of goals, progress and impediments. This person facilitated the daily standups, the iterative planning meetings, and the retrospective sessions.

○ **Team**

The existing team consisted of a group of multidisciplinary specialists (Engineering, Procurement, Project Controls, Documentation, HSE, Operations, QA, Contracts) responsible for producing valuable deliverables to be consumed by the Procurement and eventually the Constructors. They were organized in a matrixed fashion, reporting to discipline leads in terms of how they performed their work but reporting to the Project Manager in terms of what they worked on.

● Scrum Events

○ **Sprint**

As illustrated in Figure 1, traditionally managed construction projects rely on monthly project schedule updates to inform a 12-week forecast, which in turn informs a 3 week forecast which sets the high level activities for the immediate 3 weeks. Progress on those activities are then reviewed once per week. We implemented a 4 week **iteration** which took priorities from the 3 week look ahead and other sources, created task plans for the priorities, and then monitored progress and roadblocks daily. Team members were instructed to keep WIP to a minimum by always working on the highest priority tasks they had taken on.

○ **Sprint Planning**

Every 4 weeks the team participated in an **iteration planning** session. Prior to the planning session, priorities were established at a backlog refinement session by the Project Manager who considered elements from the schedule,

infrastructure requirements, and retrospective actions. At the planning session, an owner for each priority was established and a task plan (which involved the participation from multiple disciplines, complete with task owners and duration estimates) was created. That plan was then inspected and adapted on a daily basis as new information came to light. We did not focus on the concept of 'velocity' at all. Often teams need to be able to assess how much work they can accomplish in a given iteration. In our case, we knew what we had to accomplish; we needed to be able to identify and address roadblocks and risks as expeditiously as possible in order to meet our deliverable goals.

- **Daily Scrum**

On a daily basis, the team met in a **standup** format for 15 minutes to discuss the progress and roadblocks to the iteration priorities. The team met in a 'situation room' where the iteration goal, priorities, plans, progress, and roadblocks were visualized on the wall using index cards and poster paper. Figures 2 through 6 illustrate examples of those artefacts. The team members discussed progress of tasks and roadblocks to progress. The team inspected a task hour burndown as another signal of roadblocks. Those roadblocks were noted and assigned to the Team facilitator for removal.

- **Sprint Review**

The team participated in a bi-weekly schedule review of what had been actualized in the project schedule. This review gave the team and management the opportunity to review completed deliverables and informed the need for new items to be included in the backlog.

- **Sprint Retrospective**

At the end of every iteration, the team participated in a retrospective session to discuss what had gone well and what could be improved. The team used the results of their previous iteration to speak about what they should keep doing, what they should start doing and what they should stop doing. It also provided a forum for the team to discuss how they were communicating and collaborating and what they wanted to change about their working agreements.

- **Artefacts**

- **Product Backlog**

A backlog of items called the **Project Focus Backlog** was created from multiple sources of issues. Level 3 Schedule progress, roadblocks to meeting deliverables in the schedule, risks from the risk log, process infrastructure, and retrospective actions were all used as sources for backlog items. To identify new backlog items, the team used a mind mapping technique to answer questions like "What is preventing us from understanding the true state of the project?" and "What is preventing us from understanding the project Estimate At Completion

(EAC)?”. Answers to these questions allowed the team to assess root causes of existing issues and the priority for solving them.

- **Sprint Backlog**

Every three weeks the highest priority issues (as determined by the Project Manager) from the Project Focus Backlog were added to the **Iteration backlog**. That iteration backlog was then used as the focus for the team to create task plans for the completion of the issue. Further the iteration backlog was one of the central tools that the team inspected at the daily standup.

- **Product Increment**

Perhaps the most difficult aspect of Scrum is the creation of a product increment every sprint. In software this is usually defined as working tested software that provides value but may not be shipped to the customer simply because not enough value has been accrued. On an EPC project, because Construction is the least risky part of the endeavour, the product increment took several forms: a 3D model of the plant and the deliverables necessary to construct the plant. The 3D model of the plant was reviewed iteratively based on the latest design documents and engineering. Constructability analysis of the model then led to changes in design or procurement. The deliverables necessary to construct the plant were the Engineering Drawings and Procurement contracts and purchase orders necessary to get the materials and people to site. With these deliverables in place according to schedule, construction activities could proceed to meet the online date. In a pure sense, the analog to the integration testing necessary in software development to provide working, tested software is the finished plant construction.

During the ‘Turnover’ phase of construction a multi-discipline team iteratively and incrementally ‘turned the plant over’ by testing and verifying one subsystem at a time. Turnover, final testing, and commissioning constituted the ‘working, tested’ product increment. Once all sub-systems had been turned over, the plant was complete and ready for operation.

- **Artefact Transparency**

As previously mentioned, the team held all their daily standups, planning sessions, and retrospectives in a ‘Situation Room’ The project and sprint goals, along with reminders of working and communication agreements were on the walls. The iteration backlog took the form of a Kanban board composed of issues and their respective tasks on the wall. Numerous mindmaps were also up on the wall so that the team could also see their progress in meeting their goals outside the context of the project schedule. Figures x through y illustrate the use of the situation room. When it was necessary to have people attend meetings remotely, they would do so via conference telephone while looking at photos of the kanban board.

Results of Applying Scrum Values to the Project

The benefits of executing the project using Scrum values were many:

- We were able to ensure that the team regularly understood what the project priorities were that superseded their respective discipline priorities. This was evidenced by participants being able to speak about conflicts with their discipline priorities.
- We were able to gauge progress based on empirical evidence; what valuable deliverables had been completed. By developing task plans for each project priority, we were able to gauge our progress on a daily basis rather than believing “it’s on track” until the day it is late.
- Challenges, roadblocks, and issues were exposed quickly (daily) rather than remaining hidden for weeks at a time. The quicker exposure allowed more time to address each of them. Priority issue cycle time was reduced by a factor of 3.
- By encouraging the team to limit WIP, we were able to continually complete items in the backlog of issues rather than having many items in progress but none complete.
- Team composition shifted early on as some team members were uncomfortable with the openness and accountability required. As a result, we had a group of people who shared similar values and could come to agreement on how to work together. Those shared values enabled the team to iteratively improve on their communication, collaboration and work processes.
- Overall Project Cycle time reduced by 5-10% as estimated by the Project Manager.
- The project management team was able to maintain the original project schedule, complete construction on time, and stay within the Class 3 estimate. This in the face of projects of this type and over \$500M being on average 48% over budget and 18% late according to 2010 Independent Project Analysis data (see Figure 8).
- The plant was sold before it went on-line.

Application: Engineering, Procurement, and Construction Management Program of Projects

After the success of the application of Scrum values to the first project, the energy company selected a similar approach to executing a Program of three large EPCM gas plant construction projects in Northern BC. An EPCM project is one in which an EPC Contractor provides management services for all aspects of the project from design and engineering through to construction and turnover of the plant to the owner. In this scenario, the energy company is ostensibly simply in an oversight role. The Class 2 estimate for the program was ~\$3B.

In this Program there were to be several unusual aspects:

- The concept of “design one- build many” was to be employed. This meant that even though each of the plants would have different design conditions, designing components to a suitable base case and having many of those components shared amongst the plants would be economical.
- The schedule would be compressed such that there was significant overlap between projects in their respective Engineering, Procurement and Construction phases. Just enough engineering would be completed to allow procurement to start and similarly just enough engineering and procurement to allow construction to commence. This principle was being applied across three projects with EPC phases staggered only enough to accommodate the engineering and procurement design reuse.
- Finally, one of the plants would be an extension to an existing plant which meant that construction activities would be considered ‘brown field’ and occur around an already operating plant.

The major difference of this program from the initial self-managed project was that multiple / competing cultures were in play. While the initial EPC project had the owner, an engineering company, and a construction contractor involved, they were all managed by the owner. For the Program of EPCM projects, the EPC contractor managed the relationship with the construction contractor (and all other contractors) and the owner was simply in an oversight role. This proved to be the most difficult aspect of the program to manage.

Initially our approach was to use Scrum to manage oversight activities. In short order it became clear that was not going to provide the visibility the team needed. The issue was that the EPC contractor did not share many of the owner’s values and didn’t want to adopt any of their methods. In retrospect the Owner and EPC contractor cultures were quite different as illustrated by the Competing Values Framework analysis in Figure 9 . Some examples of how the cultures differed could be seen in symptoms like:

- One organization did not want posters on the walls and was reluctant to publish true status (or potentially any negative connotation) on LCD TVs-- while another was trying to make messages as visible as possible.
- One organization tried to be very mindful of how calendaring was used to coordinate meetings, while the other had an ‘accept everything and decide last minute’ approach to meetings.
- One organization was fearful of open disagreement, while the other organization thought it was necessary.

Rather than shift the cultures one way or the other, we needed to help create a culture for the program that both parties wanted to live and respect. The owner had engaged me as a member of a small group of 3 specialists in Communications and Leadership coaching. This support group decided to utilize an approach from Patrick Lencioni’s ‘The Advantage’ to start that process of growing a new culture.

This support group focused on helping the owner and EPC management jointly create a guiding framework based on a Mission, Vision and Values for the Program. The process of creating that guiding framework led to an agreement to working as a singular team, which included joint participation in the Scrum activities. Further, a Scrum of Scrums approach was taken for the Program. The owner, EPC Project managers, and functional managers held their own Scrum activities based on a Program backlog containing program-wide priorities and roadblocks. Both the Project and Program activities were initially facilitated by the owner.

While the owner was substantially co-located inside the EPC contractors' offices, the overlapping nature of the projects and the overlapping phases of each project led to the need to apply techniques for distributed Scrum activities. A situation room was no longer feasible (for cultural reasons) and the artefacts for Scrum activities needed to be visible remotely (from other offices, the Module Yard, and site) using screen sharing applications during standups, planning and retrospectives.

Breaking Through - “Necessity is the mother of invention”

In December 2015, the owner and EPC contractor leadership gathered to discuss the current state of the Program and its future. The Leadership agreed that the projects making up the Program were very likely going to be 10% over budget and 2-3 months late if the Program continued to function as it had over the past year. These predictions were in-line with average performance by the industry in western Canada. At that time, Leadership made a commitment to each other to perform well above this industry average; to be part of something extraordinary. This level of performance would both solidify the relationship between the EPC contractor and the owner, but also likely bring further investment to the Program from 3rd parties attracted by that performance. To measure this performance, Leadership set themselves the following targets for the Program:

- Meet Plant design standards
- Safety Total Recordable Incident Frequency (TRIF) < 0.1
- Plant A - 1 month early & 10% lower Total Installed Cost (TIC)
- Plant B - 1.5 months early and 15% lower TIC
- Plant C - 2.5 months early and 15% lower TIC

In order to achieve these targets, the leadership team recognized that the way the entire Program worked towards goals was going to have to change. They committed to the following principles which are the foundation of supporting extraordinary performance:

- We challenge the status quo
- We focus on outcomes
- We make commitments mindfully and honour them
- We consider these 4 key factors first
 - safety

- schedule
- quality
- cost

Average performance is characterized by being predictable based on what we know. Innovation and extraordinary performance arises when we allow ourselves to commit to outcomes that aren't part of what we think of as predictable. We don't know how we're going to achieve the outcome, but we believe the outcome is possible, and we are committing to finding out how it is possible and executing on that discovery.

"If you solve one problem, and then the next one ... if you solve enough problems, you get to come home." - The Martian

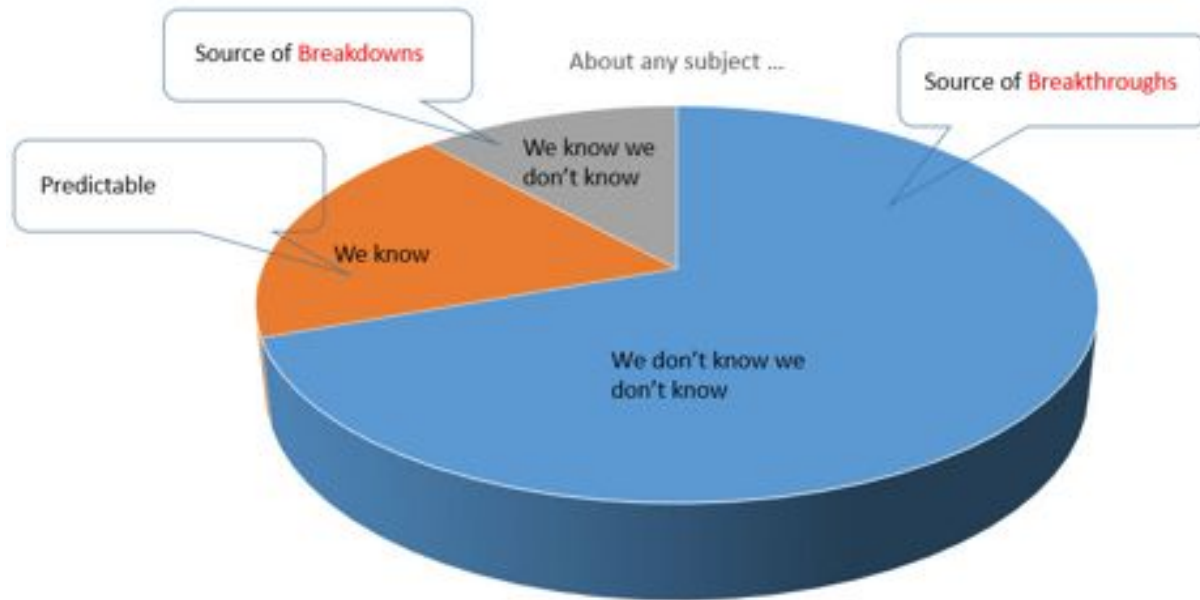
Achieving extraordinary performance involves the following steps:

- Set a vision
- Enlist in the vision
- Identify breakdowns
- Manage the breakdowns to create breakthroughs

The next few sections of this paper describe the process by which we helped the team members reach extraordinary performance.

For the Program, the overall vision had been set by Leadership. They had committed to enabling the Program to meet the extraordinary goals. To do so, they had also committed to focusing on true 'leadership' rather than 'management'--- where 'management' is defined as minimizing risk and maximizing predictability, and 'leadership' is defined as enabling the creation of something currently unpredictable. It is the role of Leadership to continually enlist recommitment in the vision. Leaders speak in declarations of what is possible and what will be. This is fundamentally different from the language of Management which is the assertion of what is predictable based on historical evidence.

'Breakdowns' are defined as any gap that exists between what has been committed to and what is currently predictable. Breakdowns should be embraced as opportunities for innovation and extraordinary performance. 'De-committing' is the act of allowing a set of circumstances to distract the team from honouring their commitment. A 'Breakthrough' is the result of managing a Breakdown (avoiding de-commitment) so that the gap between what is predictable and what is committed to is eliminated.



Enlisting Team Members in the Vision

While the Program Leadership had voluntarily committed to meeting their extraordinary performance targets, Leadership needed to continue to garner voluntary and personal commitment to those goals from all team members. Voluntary personal commitment is only possible if team members are free NOT to commit. Assessing levels of commitment and garnering personal commitment involves the continuous application of the most powerful medium of leadership; conversation. Leaders must take every opportunity to engage in conversation (most effectively face-to-face) with their team members in order to provide them with the guidance, safety, and a model for making and meeting commitments. Those who have not yet committed can prove useful during the management of breakdowns, as they can provide necessary balance during conversations. In the interim, it may be enough for Team members to simply believe that the Program goals are possible. Helping the team come up with their specific version of the vision will aid greatly in garnering commitment from the team.

Identifying Breakdowns within the Program

In order to execute on this model effectively, Breakdowns needed to be identified and managed iteratively. While the horizon for the commitment of the program was 18 months in the future, the ability to meet those commitments was contingent on keeping commitments with

nearer time horizons. Inspecting for Breakdowns (and managing them) early and often was the key to successfully achieving extraordinary performance.

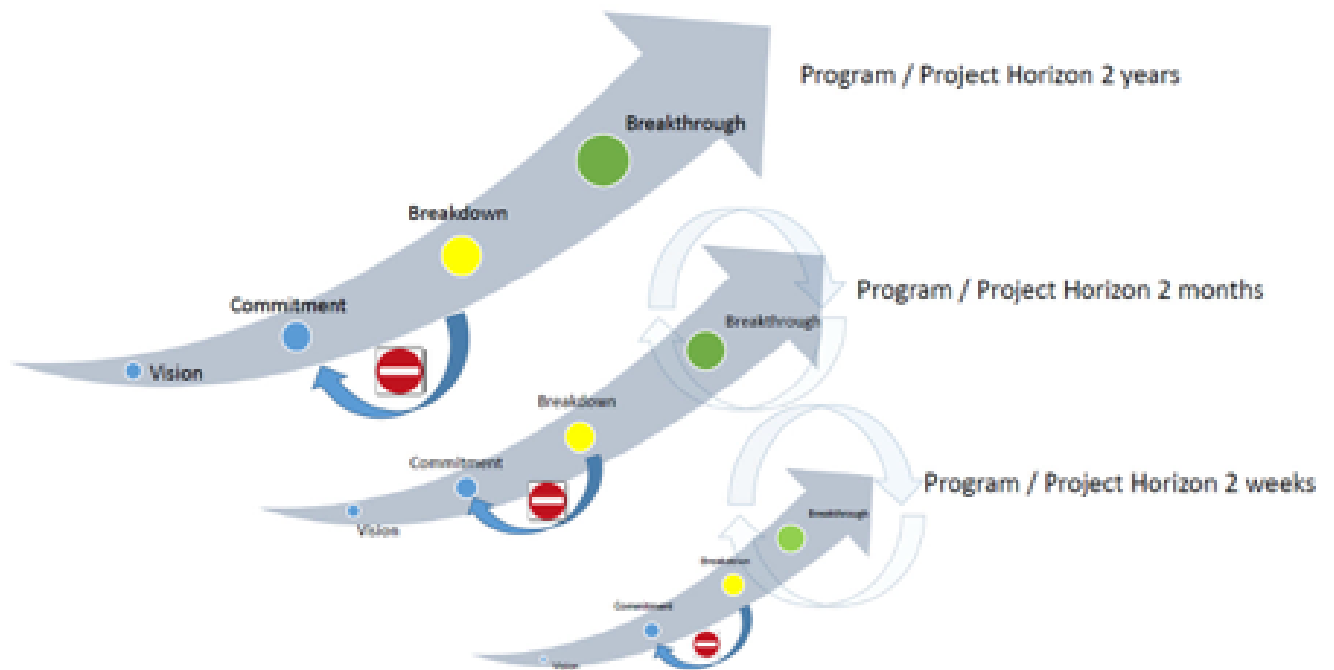
For the Program, that iterative Breakdown identification process involved decomposing longer term milestones down into nearer term outcomes. Goal X could only be achieved in 18 months if interim goals A and B were completed in 6 months, and goal A could only be achieved if goal K was achieved in 1 month. Breakdowns could have occurred at any or all of these horizons.

Project managers, functional managers and team members needed to inspect the L2, L3 and L4 schedules at least monthly to identify those schedule-based outcomes where there was uncertainty as to how they will be achieved. Any team member could declare a Breakdown. These Breakdowns were compiled and prioritized by their respective Project Manager. Breakdowns deemed to be applicable to multiple projects or unworkable at the Project level were identified as Program Breakdowns.

Creating an Environment to Surface Breakdowns

The base mechanics of identifying Breakdowns were already in place within the Program. Nominally the agile framework of Scrum was in place. This framework involved each Project team iteratively identifying their priorities, planning the work necessary to commit to achieving those priorities, inspecting and adapting those plans daily based on progress and roadblocks, and then reviewing their work process/culture for improvements before repeating the cycle.

Nothing about this framework needed to change except the rigour by which outcomes are identified, prioritized and planned. If teams had not been using 14 day, 30 day, and 60 day look aheads as well as L2, L3 (and eventually L4) schedules as inputs into their priority identification, they were now required to do so. Project Managers were expected to manage the 'backlog' of these priorities (now containing Breakdowns) and teams needed to spend more time planning their upcoming work activities to meet the outcomes. Teams decided for themselves how much time to spend in planning, but 5-10% was not unreasonable. Some teams found this iterative process more amenable every 2 weeks, while others preferred every 4 weeks.



However the Breakdowns were identified, their widespread dissemination, communication, and visibility was crucial to ensure that all people who might have ideas on how to challenge the status quo are aware of the Breakdown.

Creating an Environment to Manage Breakdowns

Focus, Courage, Openness, Commitment, and Respect

A Breakdown is a gap between what has been committed to and what is predictable. Once a Breakdown has been identified and prioritized as being significant enough to work immediately a person must be identified as the Breakdown leader. That person took ownership of the coordination of the planning and activities that needed to occur for the breakdown to be managed to a Breakthrough. Usually this involved coordinating multiple discussions with multiple team members who have experience with the intricacies of the breakdown gap. These discussions focused on challenging the status quo, but took many forms/combinations including but not limited to:

- Business process workflow value analysis
- The 5 Whys
- Socratic Method

These conversations were time-consuming, and that time was prioritized according to the outcomes' importance for the Project or Program to meet their extraordinary targets.

The success of these Breakdown conversations relied primarily on three factors:

- having the right people involved in the conversation
- having enough time to resolve the breakdown before it materially affects the Project/Program
- the perseverance of the participants to solve the Breakdown.

Conversations were limited to 6 people and a facilitator. We made it clear that titles were not an indicator of the suitability to work a particular Breakdown. While it was sometimes useful to include people directly involved in the work process that was untenable, it was also useful to invite those who were completely unfamiliar with the process. These people were able to ask questions that others closer to the matter sometimes weren't capable of seeing in the moment .

The faster a Breakdown was identified and prioritized high enough to work immediately, the longer the team had to transform the Breakdown into a Breakthrough. There is an inverse relationship between the frequency with which Breakdowns are identified and the time available to work the Breakdown. For example, if Breakdowns are only identified monthly, it is possible that an entire month will be lost to the effort of solving that Breakdown. The use of the '24 hr rule' helped maximize the time available to think about and solve Breakdowns.

There was no guarantee that a Breakdown would lead to a Breakthrough. Honouring a commitment mindfully simply means that either the commitment is met, or that the team is notified as quickly as possible that the commitment will not be met. This notification allowed those who are depending on it to adjust as best as possible. Judgement was required to assess diminishing returns on efforts spent looking for a resolution, but we wanted the team to exhaust challenges to status quo before considering de-commitment.

Avoiding De-Commitment

The most difficult part of managing Breakdowns is avoiding de-commitment. There are many organizational, cultural, and personal mechanisms that we allow ourselves to be impeded by. Part of challenging the status quo involved challenging those mechanisms which have become normal work and communication practices. Some examples included:

- treating the sending of an email as a transfer of ownership
- allowing the apparently urgent to distract from the important
- notifying people of a missed commitment the day the commitment was due
- communicating apparent commitments without due diligence
- responding to challenges to status quo with "That's not how we work"

In any team member's toolbox, maybe the most important tool to deal with de-commitment is courage; the courage to speak out when seeing other team members de-committing. Part of modelling leadership is the ability to speak with honesty and respect about our propensity to de-commit. Modelling this behaviour at the highest levels encourages and enables others to adopt this behaviour.

Escalating Breakdowns

Escalation of Breakdowns occurred as a normal part of the Breakdown management process. As potential solutions involving new ways of working were surfaced, it was normal for team members (and specifically the Breakdown lead) to want to gain 'permission' from their management and/or Leadership. It was important for Leadership to sanction these potential solutions as soon as practical so that the team could move forward with their solution toward the realization of their Breakthrough.

During the identification and prioritization process, Project Managers escalated Breakdowns to Program Leadership when they saw that the Breakdown impacted multiple projects. This escalation required the coordination of the Project Managers and the Functional Managers. Iteratively, Program Leadership prioritized the Program Breakdowns, assigned Breakdown leaders, and managed the Breakdowns towards Breakthroughs.

In order to help carry momentum of this process forward, we encouraged team members to widely communicate and disseminate the results of extraordinary efforts to achieve Breakthroughs. Doing this as quickly as possible (within 1 day of a Breakthrough) helped others who were struggling to avoid de-commitment to see what was possible.

Results of Applying Scrum Values to the Program

- Owner's Program Director has stated that the overall Program cycle time has been compressed by 10-15% compared to original schedule resulting in savings of between \$200 million and \$300 million.
- Currently on pace to deliver ahead of schedule and under budget in a domain where 30% over Class 3 budget and schedule is the norm.
- From a team survey:
 - "When there are challenges, the team is encumbered by processes and procedures and linear thinking. The result of applying agile and breakdowns is the realization that challenging the status quo and using non-linear thinking is required for success. This doesn't show up in a Gantt chart."
 - "I used to come to work facing problems that looked insurmountable, now we are on the precipice of something extraordinary and the problems look solvable."

- Owner's Deputy Program Director stated in his Lessons Learned about the Program:
 - Only work with an EPCM contractor who uses an agile approach
 - Provide support for agile and breakthrough approach

Lessons Learned

- Shifting from using Scrum for the Owner's oversight activities to using Scrum for the joint/execution should have happened sooner. This delay occurred because it took so long to create a trusting relationship and culture, which ultimately was about placing the right people in the right roles. If that had taken place, the transition of ownership of the Scrum approach to the EPCM contractor would have occurred sooner.
- Eventually, it became clear that the ownership of the Scrum activities needed to be assumed by the EPC contractor to be truly effective. This transition relied heavily on the personality and training of the team facilitator from the EPC contractor. We knew the transition had occurred successfully when the Scrum activities were occurring without the requirement for Owner instigation and changes were being made based on the needs of the team.
- The final transition of the Scrum activities occurred when the centre of gravity shifted from the EPC contractor offices to site. Once again, a key part of this transition was finding the right people to champion the Scrum activities and the training of all involved.
- The inability to make use of a central 'situation room' degraded the communication at Scrum activities. The use of Excel, Webex, Skype, and telephone allowed for the distributed participation during those activities, but the interactions were not as rich as in a room.
- Task duration estimates were deemed not relevant in this context. What was more important was the regular visibility of what needed to be done and why to help with prioritization and capacity discussions.
- The Scrum of Scrums approach to the Program standup effectively exposed Program-wide issues and concerns that affected multiple projects. It also exposed when it was taking too long to deal with those issues. Finally, it promoted the transfer of knowledge from one project to the next as the progressed through similar phases of execution.
- Use of the '24 hr rule' was critical to exposing issues and roadblocks as quickly as possible and led to increased time for the team to solve them.
- Applying the concept of 'Just Enough' to Model reviews was effective. Because engineering overlapped with Procurement which overlapped with Construction, model reviews which are usually done once a certain percentage of engineering is complete, were instead performed once enough information was available to make Procurement and Construction decisions. Model reviews became more iterative, smaller, and more frequent. Fewer drawings were required in order to

meet the goal of the reviews- just enough data for the purpose of the Model Review. For instance, in order to facilitate the early works activities, only weights and placements for piling were necessary to be part of a model review. This allowed procurement to order earlier than normal, and thus construction could start earlier than normal

- Despite the existence of a detailed schedule, it is not used the way we are led to believe. It suffers exactly the same flaws as trying to use a schedule in software development, with the exception that it outlines a greater percentage of the activities that need to be completed for success. It is created by people not familiar enough with the execution of the work to vet the logic and estimations. Because it is so complex (4000 lines), it is unwieldy to update regularly with the latest information.

The Future of Agility in EPC/M Projects

The Agile Manifesto, originally created in the context of software development, is easily modified to apply to any domain. Similarly, the 12 Principles behind the manifesto can be easily adapted and applied outside of the software industry. Finally, the goals and approach put forth by the Declaration of Interdependence has proven applicable in the field of EPC/M projects. Our experience with these large natural gas processing plant construction projects has corroborated these assertions.

To fully realize the value of using agile frameworks like Scrum, the industry needs to shift from a static mindset to one that values continual learning and challenging the status quo. While implementing the mechanics of Scrum provides increases in effectiveness and efficiency, it is an agile mindset adopted by more and more members of the teams that will lead to more significant benefits.

In the application of agile values and principles in software development, one of the core tenets is to use working/tested functionality as the true measure of progress. With this measure of progress, the business is able to routinely make functionality vs schedule decisions.

While building gas plants, EPCM organizations use completed engineering and procurement deliverables as the measure of progress. Comparing that actual progress against the estimated progress articulated in a project schedule provides the business with an indication of how they are performing against their time and budget goals. In these projects, functionality is not the main lever of course correction; schedule and cost are the main levers.

In agile software teams, emphasis is placed on always knowing the current state of the software; what valuable functionality could we ship to customers if we necessary. To know this, agile teams use continuous integration, automated builds, and automated testing to minimize the time it takes to understand the state of the software. Agile teams often start with a substantial amount of manual testing which can take days or weeks to execute in order to

understand the software state, however, as agile teams mature they strive to have a much more frequent (daily) view of the software state through the implementation of automation. This more frequent view is also used to uncover problems (as well as progress) which can then be prioritized and addressed in the context of value. At the very least, truly agile software teams KNOW the true current state of the software every 2 weeks.

In order for an EPCM organization to have a true state of progress, they would have to consider changes such as:

- Automation of the deliverable progress update process to minimize the time it takes to understand progress against the schedule. Currently many manual updates are made which provide a progress view every 2 weeks but with data at least 1 week old. This improvement would be akin to the continuous integration/testing required on an agile software team; knowing as often as possible the true state of progress.
- Iteratively reviewing and updating the schedule logic to ensure it reflects the latest reality. In combination with using a floating and fluctuating project end date (which makes effects of changes visible immediately) this would be akin to the iterative release planning an agile software team performs.
- Using this information to rigorously and continuously look ahead to identify and innovate around the issues that need resolving in order to maintain the construction schedule.
- Experimentation with measuring the cycle time from Engineering through Construction for discrete activities starting with Early Works activities (civil, roadworks, fencing, piling). By looking at that cycle time, it may become easier to expose and address unnecessary additions to that time which can then be measure on future activities

Appendix

Figure 1: Agile Construction diagram

Agile Construction Project Approach

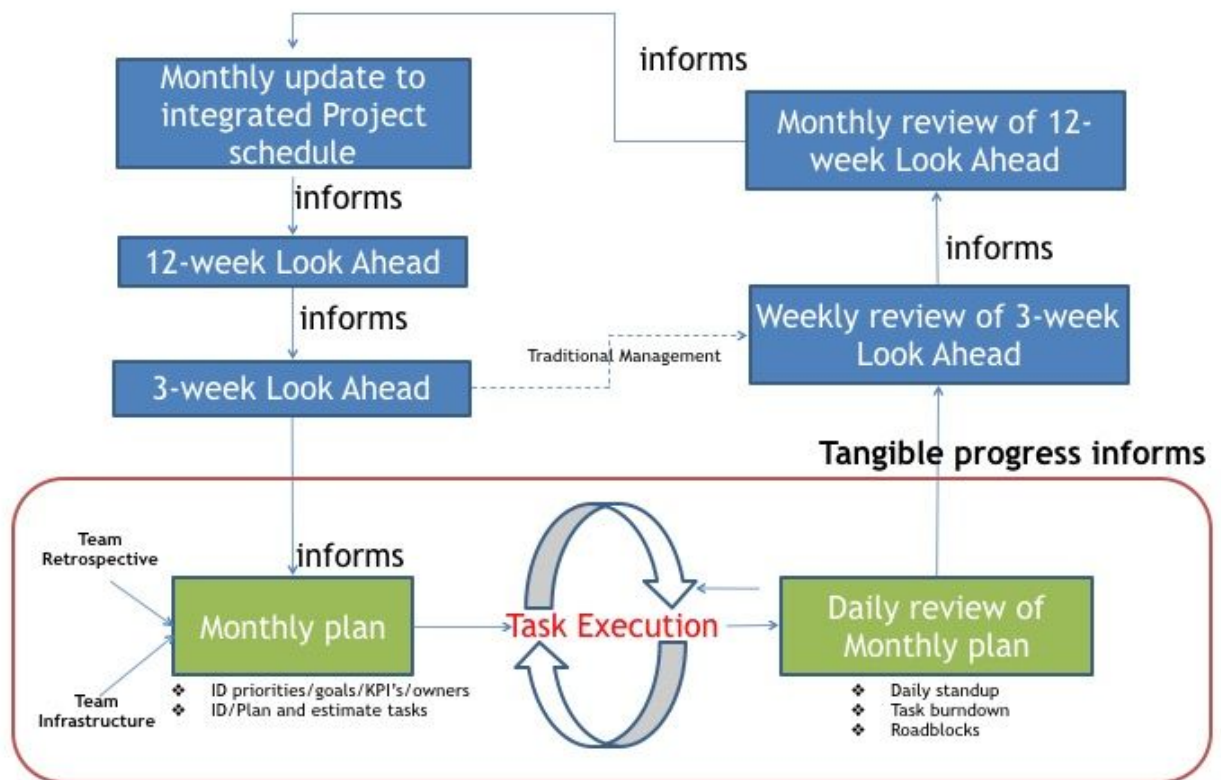


Figure 2: Communication Agreements

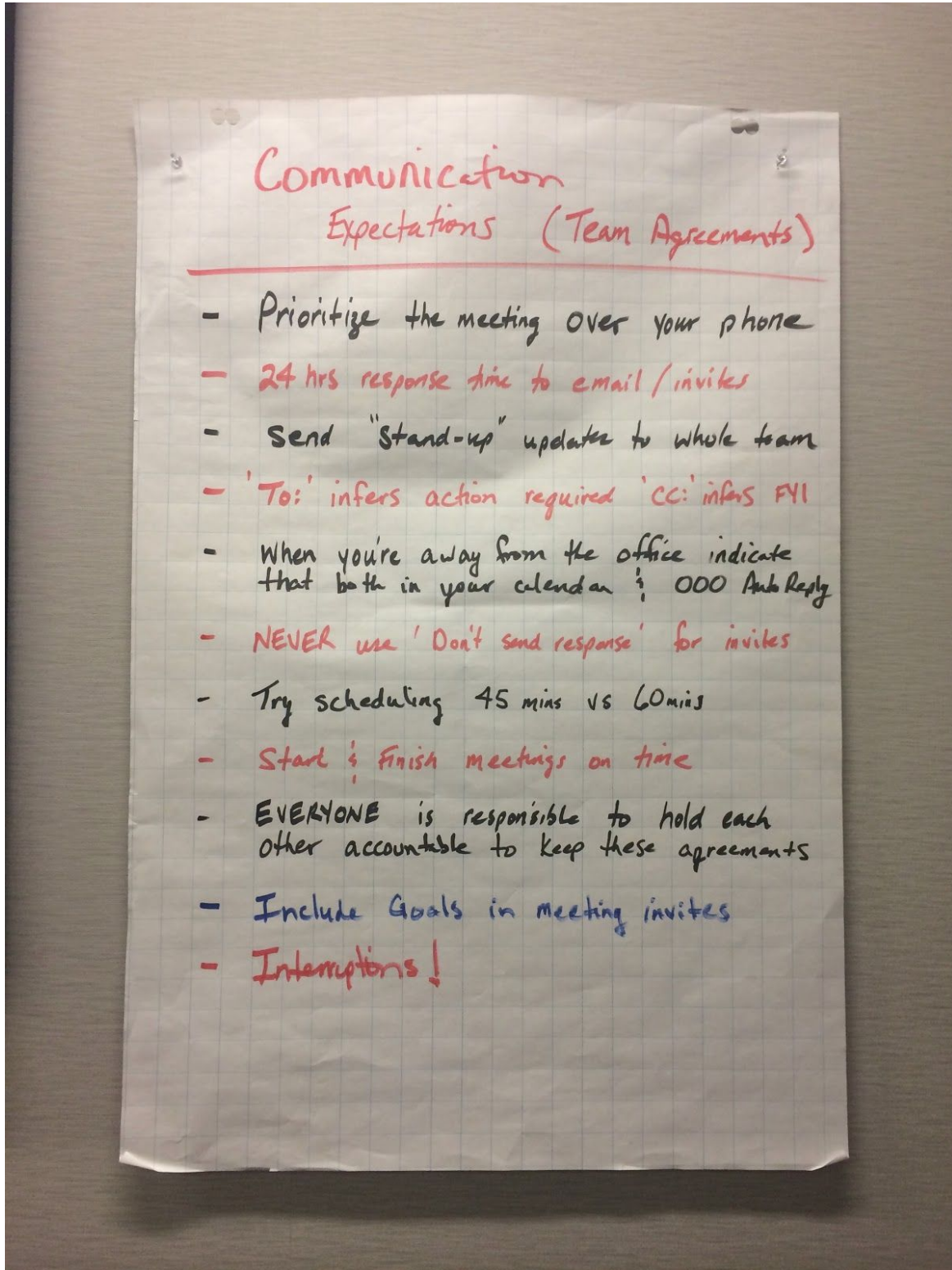


Figure 3: Retrospective Actions

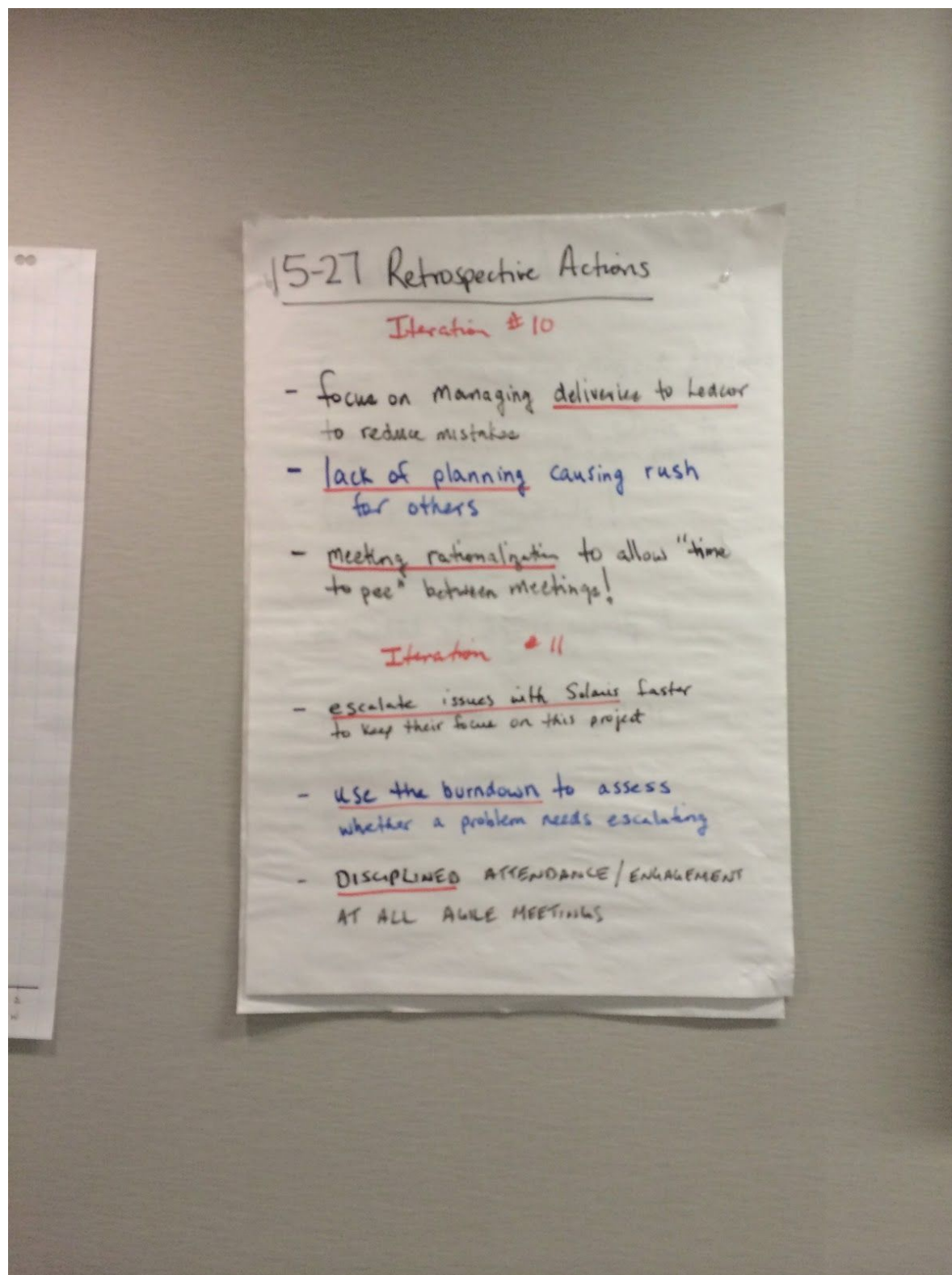


Figure 4: Kanban and Burndown



Figure 5: impediments

Road blocks

<u>When</u>	<u>What</u>	<u>Owner</u>
12/2	We need an Admin <small>Temp. access included</small>	Dan
12/10	Shared folder name structure <small>(file names for Aug 1) (May disappear when Linkin implemented)</small>	Dan
12/15	Corporate WBS	Kirk
12/17	Potential Enbridge conflicts	Gord
12/17	Jan. 16 Out for surgery (5 days?)	Gord
01/06	PHO Numbering	Pam will follow up (Rhannon)
01/10	Move furniture OUT! OR GET NEW SPACE	Simon 35-145
01/10	4-26/15-27 overlap logistics of team not yet sorted	Dan/Simon/Andy Additional PE support being recruited
01/20	Pete has higher priorities through 01/21	Pete
01/21	Ken/Jen needs space with team	Dan RESTACK
01/22	Gday attended to WBS for 2-days	Kirk
01/23	What are Rhannon's priorities?	Rhannon
01/28	While Doc Control in flux, need to ensure priorities are indicated/followed by Solaris (Rhannon, Jen, Simon) and Squad Chief	Rhannon Atvis

AWAY:

Mark
Row
Sherri → Jan 31, Feb 3

Jan 31
Jan 29- Fluor

@ Solaris:
Sherri - Jan 30

Figure 6: Situation Room

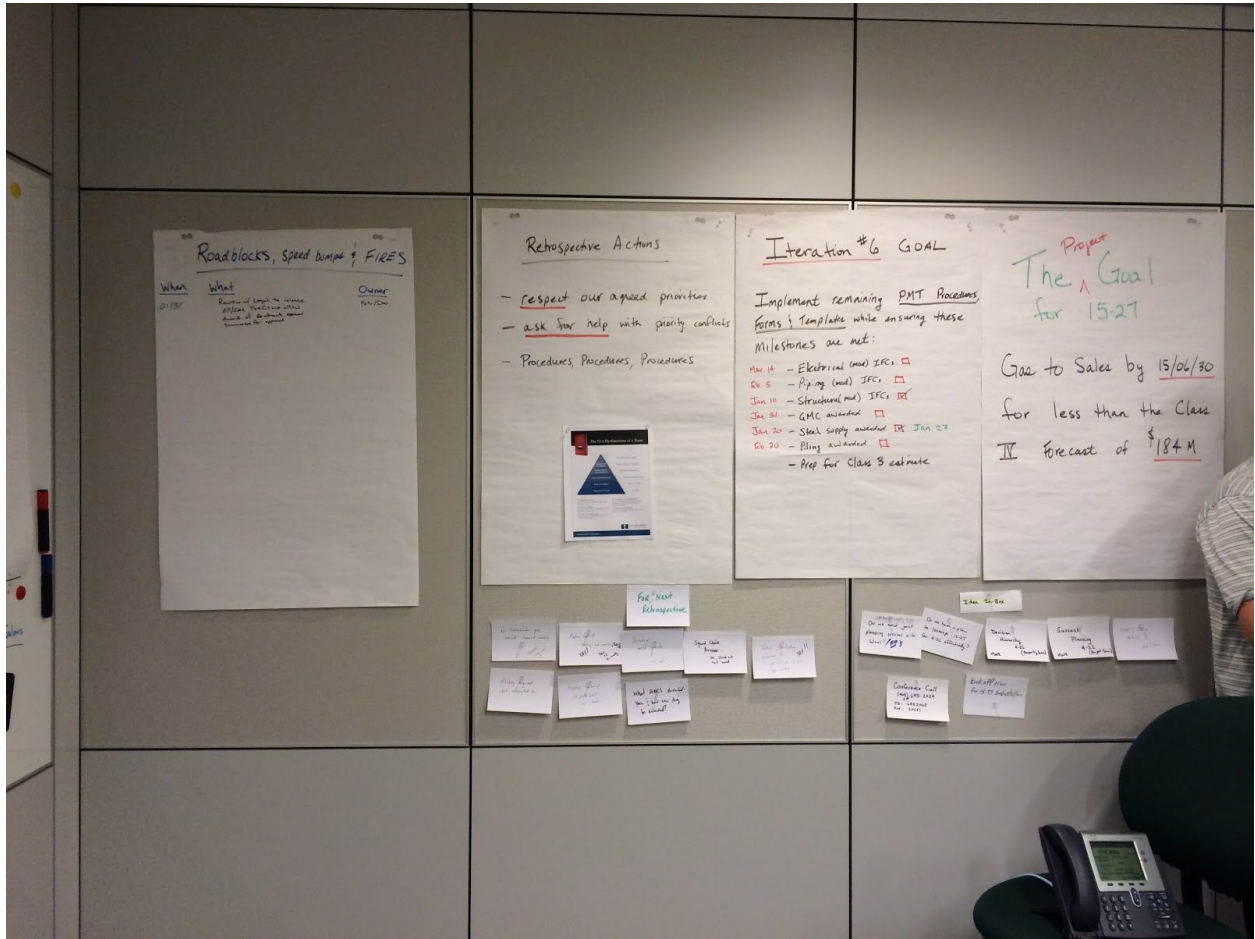


Figure 7: Mind Mapping

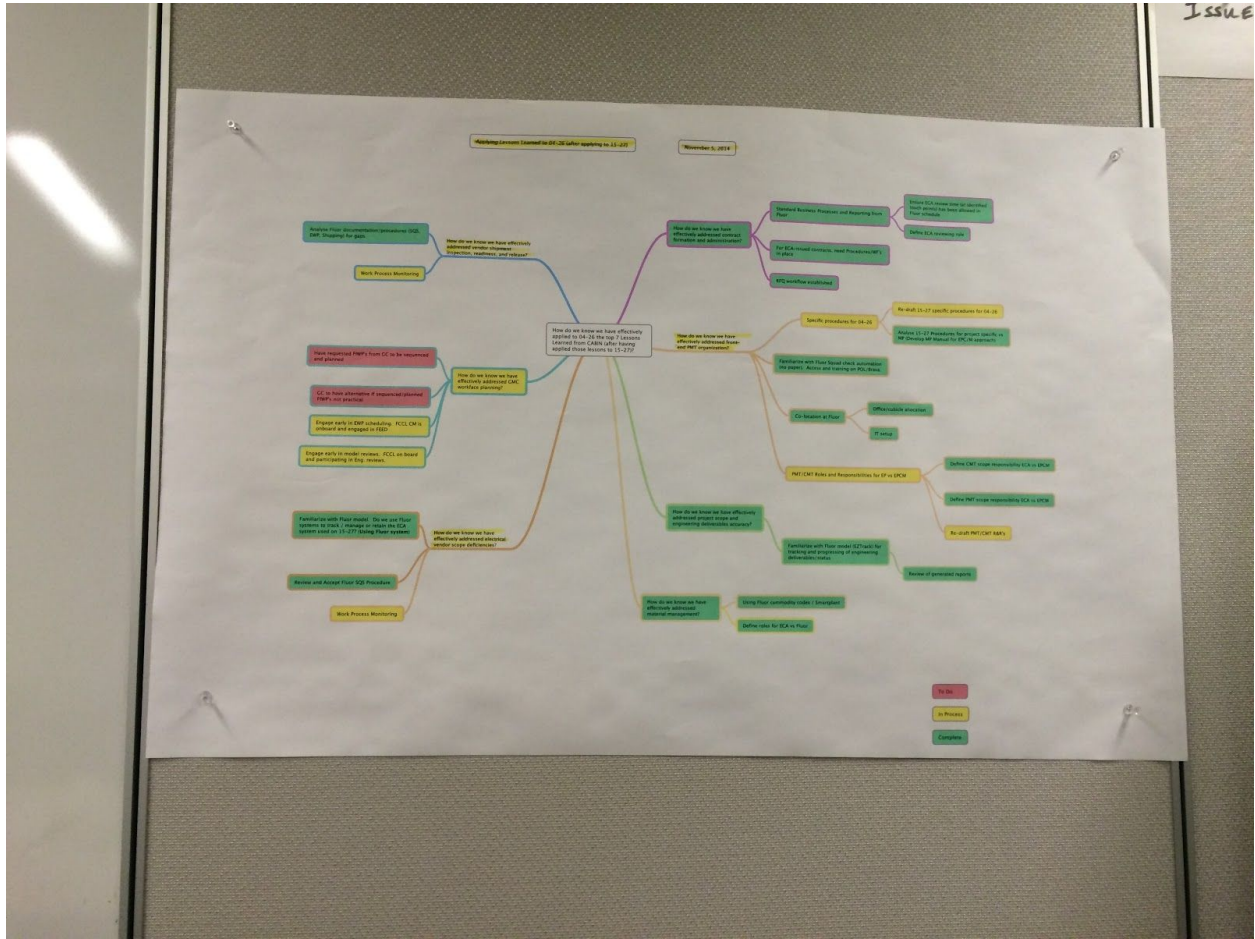


Figure 8: Independent Project Analysis chart



The Large Projects Took the Biggest Hit

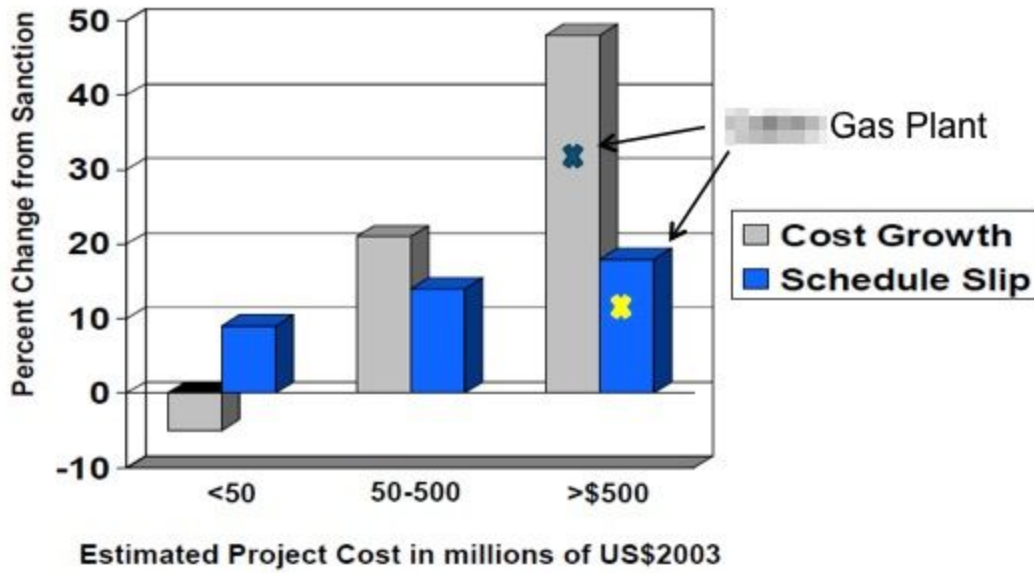


Figure 9: Competing Values Framework Analysis

