The History and Future of Time-Scaled Planning

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Abstract:

The human drive to put a picture to the ephemeral aspects of planning is central to the progress of planning through the ages. It is through visualization that the human mind most easily comprehends abstract and spatial frameworks.

In order to properly deal with planning today, as it relates to activities and projects, it may be helpful to first understand how humanity visualizes time. Throughout recorded history mankind has sought to clarify, classify, and visually represent time: from early attempts to create calendars to Einstein's Theory of Relativity, man has attempted to put concrete definitions to invisible forces in the physical world. How we plan today is informed by how we planned before today and how we visualize time and calendars.

Most projects, regardless of type or size, include some sort of planning or scheduling session early in their lives. The extent of collaboration, content and scope for such a session can vary dramatically, from something as simple as one person taking a few minutes to detail a few project steps on a piece of paper to something as complex as all project stakeholders participating in a multi-day interactive process to develop a project plan in detail. The authors intend to investigate the historical and current processes used to develop early project plans and to critique current methodology in light of new technologies available now. The authors also will detail what they feel to be the future of interactive/collaborative project planning.

Humanity's Historical struggle to grasp time.

In the developed world our lives are driven every day by calendars and clocks: What time is my flight, what day should we meet, how late can you work? In the world of scheduling and time-scaled planning, start dates, end dates, and durations is the order of the day. As far as we know we are the only creatures on earth who have a concept of passing time. But how many of us have stopped to consider where time and dates come from? Who invented the calendar? Is time really relative? Time does not seem especially relative on the critical path of a networked schedule!

A retrospective look at the humanity's quest to understand dates and times may offer the reader a new perspective on the planning process and a broader understanding of the actual underpinnings of that thing we call a time-scaled plan.

> *"The calendar is intolerable to all wisdom, the horror of all astronomy, and a laughing-stock from a mathematician's point of view" - Roger Bacon, 1267*

Why was a Roman Catholic Monk raging against calendars in the mid 13th century? One might imagine an orderly, synchronized system of straight forward, almost mechanical precision, lurking just below the methodical appearance of calendars and clocks. However, as Holden Caulfield famously declared of his roommate, Stradlater, in Salinger's "Catcher in the Rye": time is a secret slob. Oh sure it looks all put together on the surface, but just peel back the top layer and one will find a messy contrivance worthy of Rube Goldberg!

Take for instance the formula below, used to calculate the day of Easter in the non-Orthodox, Christian church.

a = year%19

b = year/100

c = year%100

d = b/4

e = b%4

r = (b + 8) / 25

g = (b – f + 1) / 3

h = (19 *a + b – d – a + 15)%30

i = c/4

k = c%4

1 = (32 + 2 * e + 2 * i – h – k)%7

m = (a + 11 * h + 22 * 1)/451

Easter month = (h + 1 – 7 * m + 114/31 [3 = March, 4 = April]

p = (h + 1 – 7 * m + 114) % 31

Easter date = p + 1 (date in Easter month)

/ = division neglecting the remainder

% = division keeping *only* the remainder

* = multiply

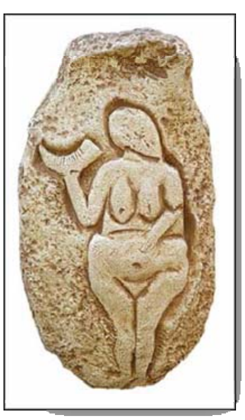
Figure 1 - Easter calculation[1]

One would typically imagine these types of mathematical machinations would have little to do with the orderly world of dates and times. But in fact at the time of Roger Bacon the calendar was an unstable mass if workarounds and shims. Today with all we know of the solar system, we still make adjustments to time, because of the gradual slowing of the rotation of the earth.

The Ancients

Creation of calendars

The Moon, the Stars, and Sun



27,000 years ago humankind was recording the passage of time through the phases of the moon. Archeologists note the 13 marks in this depiction of a moon shaped horn held skyward as a depiction of the phases of the moon. Archeologists have also discovered a moon phase calendar etched into an eagle bone from 11,000 BC. Around 3,000 BC Egyptians used a stick on the banks of the Nile (called a Nilometer) to measure the passage of time. As the waters of the Nile rose the stick would record the highpoint and thus the farmers could schedule their work towards the floods and next year's crops. Later, observation of the stars, most specifically the Dog Star Sirius, enhanced the accuracy of the Egyptian calendar.

Figure 1.1 - 25,000 BC Earth mother of Lausselle[2]

Figure 2 – Mayan calendar from 600 BC[3]

Around 1,000 BC Mesoamerican peoples developed complex pictorial representation of a, given its time in history, highly precise solar year. The development of calendars seems to be a global phenomenon throughout history regardless of race, religion, or geography. Figure 2 is an early Mayan calendar from 600 BC that depicts the months in the Mayan year. The Mayan calendar was so accurate that when Spaniards arrived the calendar they brought was less accurate than the Mayan calendar. Maya were able to calculate the cycle of Venus and would wage wars at the beginning of the cycle.

Introduction of the Julian calendar and the Gregorian correction

In 45 BC, Julius Caesar inaugurated the basic calendar we use today. However, his calendar was flawed in that it did not align precisely with the rotation of the planets. Over many years, this creates a misalignment between human seasonal celebrations and the weather. For instance, after many years of being off by a day or so, a misaligned calendar might cause a fall harvest celebration to be scheduled for the middle of the summer. Nearly 1,500 years after its debut, the Julian calendar required a 10 day correction.

Around 1,000 A.D. Ptolemy observed in a published article that the Julian calendar was off, but at this time and for hundreds of years to come, it was potentially life-threatening to question the validity of the calendar. In the 13th century, the western world's view of the universe was dictated by the Roman Catholic Church. The Roman Catholic Church did not recognize that the earth circled the sun, and in order to work out a truly precise calendar, this bit of dogma would have to adjust to match reality. So it should be no surprise that in the 1300's it was the outcaste, curmudgeonly, genius, monk with superhuman intellectual abilities and independence, Roger Bacon, in league with Pope Clement IV, who died too young, who set the stage for the Gregorian correction of the 1500s. While history does not record the reasons behind Clement the IV's interest in calendar reform it was his interest and advocacy which propelled Roger Bacon to document the failings of the Julian calendar. Shortly after Bacon's work reached the Pope, the Pope died, leaving Bacon behind with plenty of knowledge but no power to do anything about it.

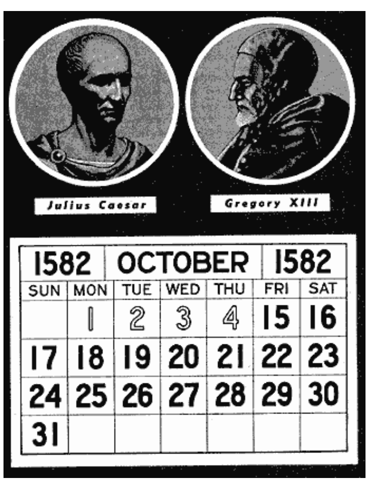


Figure 3 – Calendar showing the corrective loss of 10 days[4]

It is also important to our overall understanding of the evolution of calendars through history to bear in mind that the telescope was not invented until the 1600's. It was the telescope and minds like Galileo and Copernicus that literally reoriented the universe. This reorientation of the universe leads to a better understanding of the motion of the planets and the place of the earth in the solar system.

In the 1500's Pope Gregory XIII established a Calendar Commission to look into the, by now, widely acknowledged flaws in the Julian calendar. The commission determined that 10 days would need to be lost to make up for the accumulation of the inaccuracy over time since the introduction of the Julian calendar. Going forward, a new scheme would bring the calendar into conformance with the vernal equinox. Pope Gregory XIII issued his Papal Bull reforming the calendar on February 24, 1582. World reaction varied: some ignored it, some were grateful to have a more accurate calendar, and some in Frankfurt rioted in the streets demanding the return of their stolen 10 days.

I guess we can all be grateful that critical path method (CPM) had not yet been invented: Can you imagine dueling experts arguing over a delayed project under this unique set of circumstances? The Gregorian adjustment brings us into the modern age of calendars. It is not particularly reassuring to know that our project schedule, which we think of as precise and tangible, is completely dependent on a series of celestial orbs hurtling through space and a morass of mathematical calculations and astronomical observations.

From this point in history forward to the early 1900's not much really changes in the world of calendars and time-scaled planning has not evidenced itself in any of its modern and surviving manifestations. However, big changes are occurring in the world of science and in our understanding of time and space. Einstein's 1905 paper, "On the Electrodynamics of Moving Bodies" dismantled absolute time as an accepted concept in Physics. Ironically, this took quite a bit of time.

Synchronizing time over space

So as of 1905: time is relative and slows as the speed of light is approached. Calendars are a graphical representation of the passage of time based on the motion of the planets segmenting time into days, weeks, months, and years. We now enter an age where for the first time in history precision in how we keep time becomes critical. With the advent of train travel over longer distances it became important for clocks in various cities to strike the hour at the same time. Also, if you are trying to coordinate the sharing of a single track between multiple trains, prior to the invention of radio communication, synchronized time is a matter of life and death.

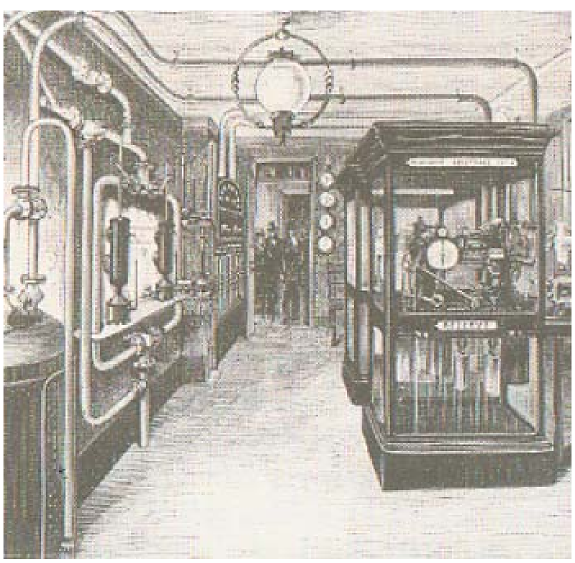


Figure 3.1 – Steam synchronization[5]

As industrialization and urbanization accelerated in the late 1800's and early 1900's the standardization and synchronization of time over distance became a critical challenge to engineers. The French genius Poincare was a driving force in this area. The first attempts at synchronizing clocks in a large urban area occurred in Paris using pressurized steam to pneumatically blast clocks all over the city into some semblance of synchronicity. An elaborate system of tunnels and steam pipes was developed throughout the City. Later as the telegraph expanded its reach the much higher speed of an electrical signal was used to synchronize clocks over large areas.

Interestingly Einstein worked in the Swiss Patent office in the late 1800's reviewing applications for patents during the hay day of clock synchronization innovation. One can only wonder if this influenced his later thinking relative to relativity.

As the twentieth century begins, so does modern planning. Likely driven by the dawn of the industrial age, formal planning tools still used today were created in the early 1900's. Gantt's innovation, the now famous Gantt chart, displays activities on a time scale and was first published in 1910 (see Figure 4). Henry Gantt was a contemporary of both Einstein and Poincare. The combination of Einstein and Poincare's thinking generated worldwide time zones, precision in global navigation, and the foundational elements of our time-scaled, modern culture. This is the period in history when we began to understand time in the same way we understand it today. Perhaps this is why many of the time-scaled planning tools invented from 1900 forward are still in use today.

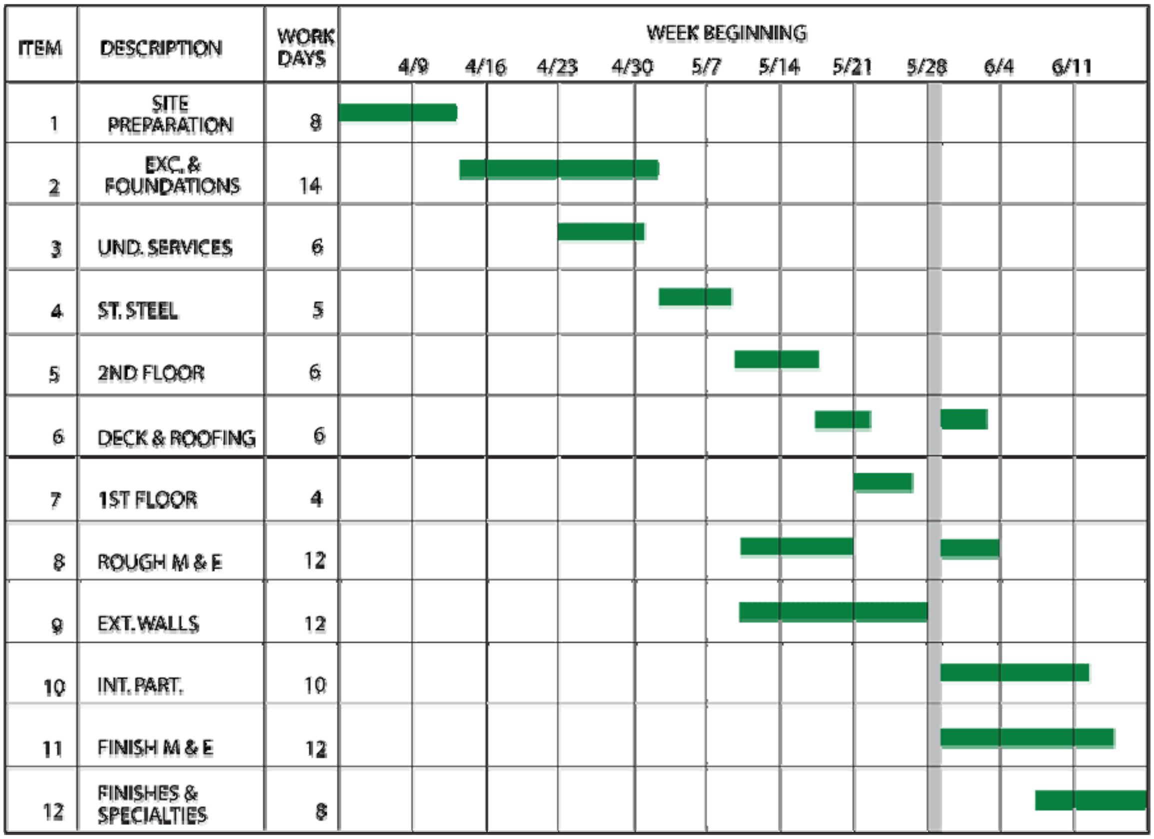


Figure 4 – Sample Gantt Chart[6]

From the invention of the Gantt Chart Jump ahead just 46 years and you will find Kelly and Walker visually representing a mathematical model with the use of arrow diagramming method (which subsequently became known as “activity diagramming method” or ADM), a sample of which is shown in Figure 5. An ADM network is something that is logically intuitive. One can “see” how activities are logically linked and how the network as a whole might be impacted by a change to one activity. Visualization is again the key to understanding the model. However there is yet another major departure from the past which coincides with Kelly and Walker, it is the advent of the computer as a tool in the production of time-scaled, logically linked schedules. For the first time in the 27,000 years of calendar and

Planning history, a machine is interposed between the plan and the planner.

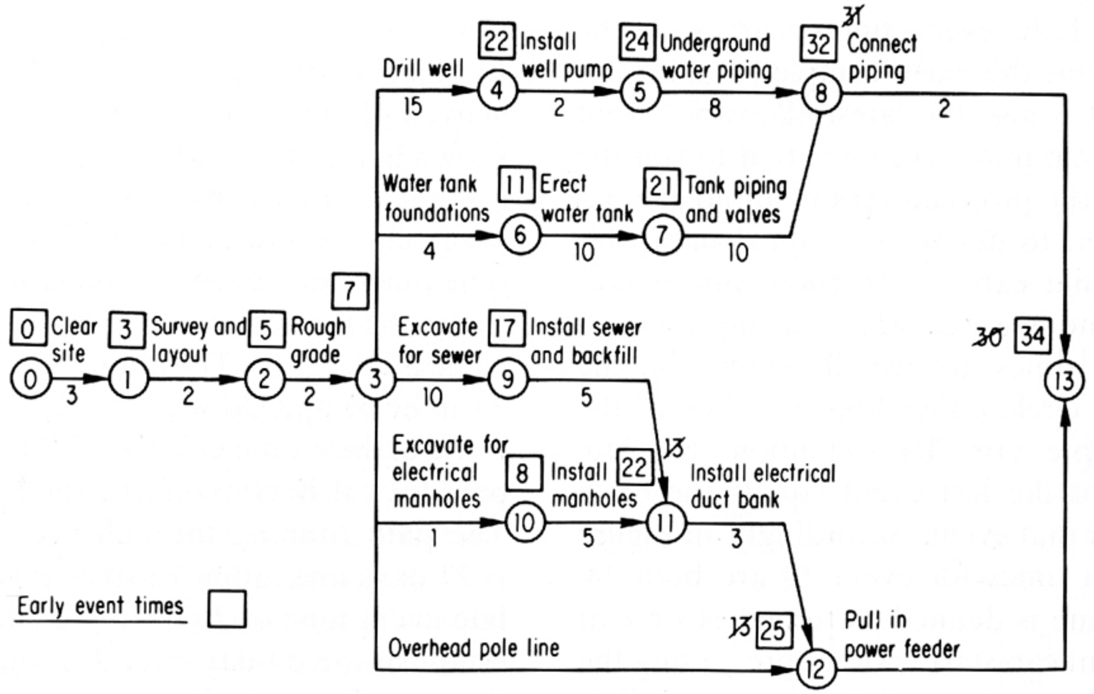


Figure 5 – Sample ADM Network[7]

Unbeknownst to Kelly and Walker, the combination of a mathematical model for a network schedule and computer power to drive the model would result in the bifurcation of planning and scheduling. Entering data in to tables became a new way to visualize schedules, but a series of numbers is not the natural way to see time and time-scaled plans. Over the subsequent decades a byzantine intellectual structure has calcified around the original CPM thinking: to the point where some earlier practitioners are now in a state of rebellion against the malformed manifestations of their original conceptual framework.

The evolution of critical path scheduling software and the revolution of computing technology from the 1970's, along with the inability of ADM to model start-to-start and finish-to-finish relationships, sped the demise of ADM in favor of PDM and the dominance of scheduling over collaborative planning. Progress, such as it is, has continued in juggernaut fashion, over the last three decades, to the point where some will openly brag about having a 50,000 activity schedule!

While many still hold collaborative planning sessions, the last major technology introduced into the process was by 3M, yes: the sticky note. Until recently use of technology has not evolved much beyond sticky notes and butcher block paper.

Current Time-Scaled Planning Methods

Most construction projects, regardless of type or size, include some sort of planning or scheduling session early in their lives and potentially later in the project as well. The frequency, extent of collaboration, content and scope for such sessions can vary dramatically from project to project and from firm to firm. Ranging from Gilbane Building Company's "card trick" scheduling and planning session[8] to PMA's "full-wall" scheduling sessions[9], these time-scaled planning sessions can take various shapes, but the goal is the same - to engage a collaborative group of project stakeholders to collectively create the roadmap to a successful project. For the purposes of this paper, we will refer to these planning sessions generically as 'full-wall planning sessions'.

Typical Full-Wall Process

The name full-wall originates from the large sheets of paper which are placed on the walls of the room during the session to document the plan. PMA has facilitated in or participated in over a hundred full-wall scheduling sessions for various project types. Although the exact process can vary, a typical full-wall scheduling session may include the following steps:

1. A time scale is drawn on large sheets of paper and hung on the wall (i.e., full wall). The time scale may be either ordinal or calendar-based and may be either hand drawn on butcher block paper or plotted on a long roll of paper.

2. A meeting of all project stakeholders is held. The exact makeup of the stakeholders will vary depending on the specific project and intent of the session, but it may typically include: owner, architect, program manager, construction manager, subcontractors, etc.

3. One of the project stakeholders or a third-party is designated as the moderator and facilitator of the session.

4. Sticky notes are used to represent activities and milestones. Various colors typically signify different trades or responsibility for the task. Activity descriptions are hand-written onto the sticky notes and the group discusses each activity in detail and decides when the activity will likely occur or what the predecessors for the activity are. Once a consensus is reached, the sticky note is placed on the timescale in the appropriate location. Additionally, a list of issues, assumptions, and interfaces inherent to each activity is created.

5. If logic ties are identified during the session, they are drawn on the full-wall sheets appropriately connecting linked activities. This particular step can vary significantly. Some sessions drive the activities primarily on dates and other sessions yield a lot of logic ties.

6. The session may either be done in forward or backward pass fashion, depending on the specific parameters and constraints. However, a typical process is to identify the major milestones, and then fill in the blanks, in somewhat of a forward pass fashion.

7. The process continues until all activities are represented on the full-wall sheets.

8. Following the meeting, the full wall product is manually input into the scheduling software of choice. As mentioned, the activities on the full-wall sheets are often times not clearly driven by logical relationships. At that point, the scheduler must choose whether to input the activities and logic into the schedule and allow the dates to calculate, or use a series of constraints and logic ties to force the schedule to mimic the full-wall dates. It typically is the latter, which can jeopardize the integrity of the resultant schedule.

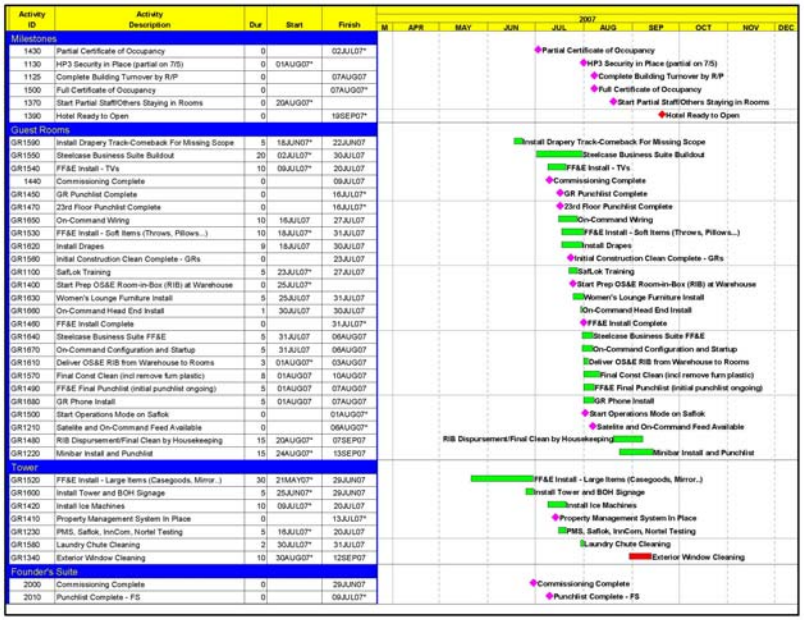
9. The scheduler sends the schedule out to the meeting participants for review and comment. Frequently, the full-wall participants are upper-level management and not necessarily inclined to spend the time to review a hardcopy of a schedule in much detail and are very unlikely to trace the logic in any detail to confirm that the logic is appropriate. This can be a drawback of the full-wall method, depending on the extent of project complexity.

Example of the Full-Wall Process

As an example, the authors facilitated and participated in a full-wall scheduling session for the completion and pre-opening activities of a high-rise hotel for which PMA was the program manager. This session involved the owner, operator, PM, CM and architect. The half-day session generally followed the steps listed above. Figure 6 shows pictures of the resultant full wall sheets.

Figure 6 - Results from a full-wall session

Following the session, the activities were input into Primavera. However, as is evident in Figure 6, there was limited logic identified during the meeting. In fact, of the 147 activities identified, 78 of them were constrained within Primavera so that they would fall on the identified dates. Also, there were a large number of open-ends. As such, the network was really a bar chart rather than a CPM network with calculated dates. Obviously, float values of the activities in Primavera were mostly useless. Figure 7 shows an excerpt of the actual Primavera schedule.



Activity ID	Activity Description	Dur	Start	Finish
Milestones				
1430	Partial Certificate of Occupancy	0		02JUL07*
1130	HP3 Security in Place (partial on 7/5)	0	01AUG07*	
1125	Complete Building Turnover by R/P	0		07AUG07
1500	Full Certificate of Occupancy	0		07AUG07*
1370	Start Partial Staff/Others Staying in Rooms	0	20AUG07*	
1390	Hotel Ready to Open	0		19SEP07*
Guest Rooms				
GR1590	Install Drapery Track-Comeback For Missing Scope	5	18JUN07*	22JUN07
GR1550	Steelcase Business Suite Buildout	20	02JUL07*	30JUL07
GR1540	FF&E Install - TVs	10	09JUL07*	20JUL07
1440	Commissioning Complete	0		09JUL07
GR1450	GR Punchlist Complete	0		16JUL07*
GR1470	23rd Floor Punchlist Complete	0		16JUL07*
GR1650	On-Command Wiring	10	16JUL07	27JUL07
GR1530	FF&E Install - Soft Items (Throws, Pillows...)	10	18JUL07*	31JUL07
GR1620	Install Drapes	9	18JUL07	30JUL07
GR1560	Initial Construction Clean Complete - GRs	0		23JUL07
GR1100	SafLok Training	5	23JUL07*	27JUL07
GR1400	Start Prep OS&E Room-in-Box (RIB) at Warehouse	0	25JUL07*	
GR1630	Women's Lounge Furniture Install	5	25JUL07	31JUL07
GR1660	On-Command Head End Install	1	30JUL07	30JUL07
GR1460	FF&E Install Complete	0		31JUL07*
GR1640	Steelcase Business Suite FF&E	5	31JUL07	06AUG07
GR1670	On-Command Configuration and Startup	5	31JUL07	06AUG07
GR1610	Deliver OS&E RIB from Warehouse to Rooms	3	01AUG07*	03AUG07
GR1570	Final Const Clean (incl remove furn plastic)	8	01AUG07	10AUG07
GR1490	FF&E Final Punchlist (initial punchlist ongoing)	5	01AUG07	07AUG07
GR1680	GR Phone Install	5	01AUG07	07AUG07
GR1500	Start Operations Mode on Saflok	0		01AUG07*
GR1210	Satelite and On-Command Feed Available	0		06AUG07*
GR1480	RIB Dispursement/Final Clean by Housekeeping	15	20AUG07*	07SEP07
GR1220	Minibar Install and Punchlist	15	24AUG07*	13SEP07
Tower				
GR1520	FF&E Install - Large Items (Casegoods, Mirror..)	30	21MAY07*	29JUN07
GR1600	Install Tower and BOH Signage	5	25JUN07*	29JUN07
GR1420	Install Ice Machines	10	09JUL07*	20JUL07
GR1410	Property Management System In Place	0		13JUL07*
GR1230	PMS, Saflok, InnCom, Nortel Testing	5	16JUL07*	20JUL07
GR1580	Laundry Chute Cleaning	2	30JUL07*	31JUL07
GR1340	Exterior Window Cleaning	10	30AUG07*	12SEP07
Founder's Suite				
2000	Commissioning Complete	0		29JUN07
2010	Punchlist Complete - FS	0		09JUL07*

Figure 7 - Excerpted results from the full-wall session after input into P3

This schedule proved to be a useful tracking tool and work list, but it was not particularly helpful to demonstrating the effects of delaying the start of an activity or extending or crashing an activity duration.

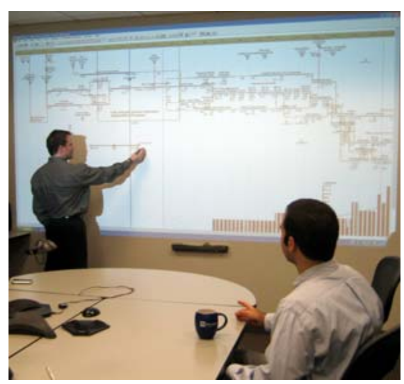
Alternative Methods

With the current state of technology, intuition says that there may be a better solution to creating the framework of the schedule collaboratively (i.e., the planning phase) and then separately entering the schedule into CPM software (i.e., the scheduling phase). Indeed, not only is the process two steps, but the second step (review, comment, and revise) is practically never accomplished in a collaborative fashion, so some of the benefits of a fully collaborative session are not realized.

Until very recently, the two-step process was mostly not avoidable. However, the authors have been able to accomplish a virtual, real-time, full-wall planning session utilizing the Graphical Planning Method®[10] (GPM). GPM is a graphical, interactive, real-time planning method anchored on object-oriented principles and network based math rules

Example of a Virtual Full-Wall Planning Session

The authors facilitated a virtual full-wall planning session for the pre-construction and construction activities of an eight-story, mixed-use building. The session involved the owner, the program manager, the contractor and a portion of the design team. NetPoint™ was used as the scheduling software of choice. To start the process, a blank timescale was projected on the wall. Throughout the four-hour meeting, the team added all of the activities and logic as shown in Figure 8.



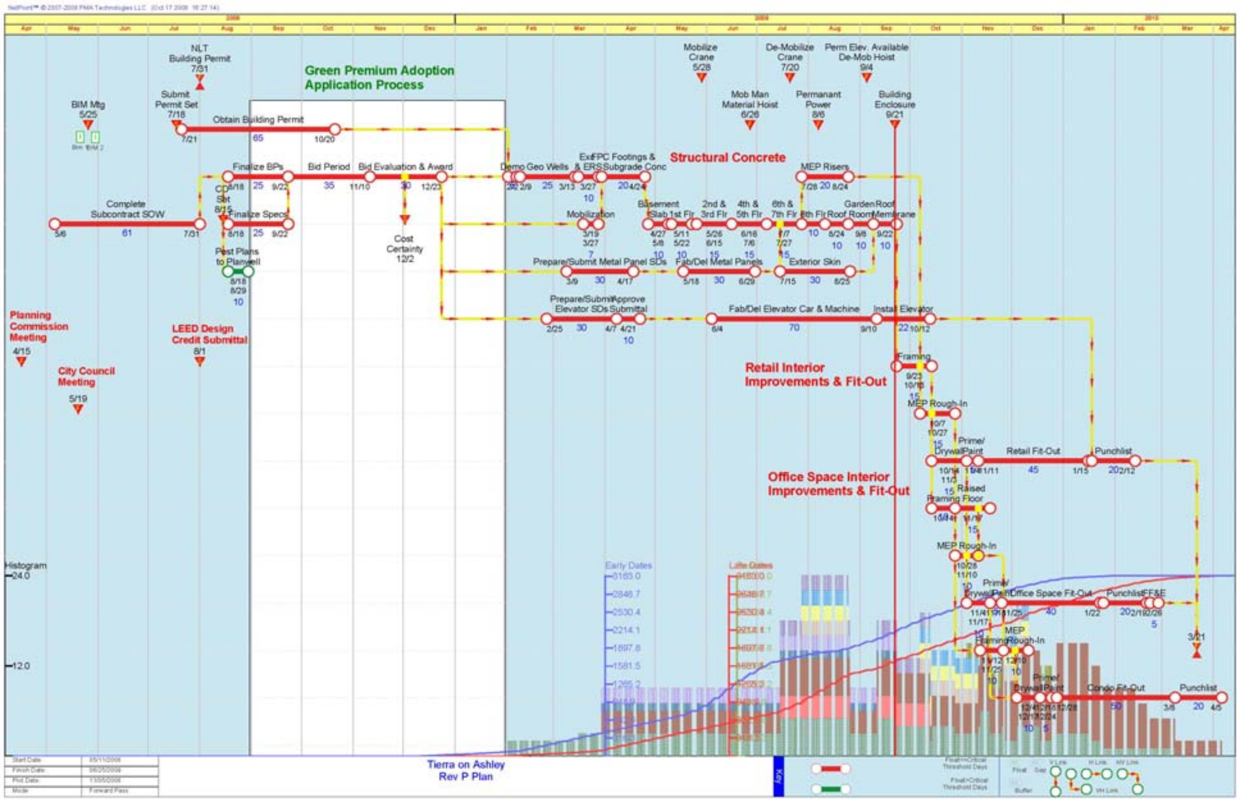


Figure 8 – Full wall session and results

The areas of specialty and background for the stakeholders in attendance for the session were wide-ranging and the collaborative nature of the session fed off the varied backgrounds of the participants. Additionally, the graphical nature of GPM allowed the participants (many who did not have any scheduling background) to easily follow the logic and the sequences developed. Several 'what-if' scenarios were run during the meeting to determine the impact of various changes to the plan. There were not any non-collaborative changes to the schedule after the meeting, rather, the group left with a consensus-driven plan.

An alternative method that the authors have used is to project Primavera and build a 'live' schedule during a full-wall session within Primavera. However, this method seems to work best when the stakeholders are familiar and comfortable with Primavera and how it works. Inexperienced stakeholders can sometimes have difficulty tracing logic and understanding calculations within Primavera.

Concluding Remarks

The way we understand and track time has evolved over the last several thousand years and will likely continue to do so. Likewise, the way we plan and schedule our construction projects will continue to evolve. The authors challenge all project management teams to reflect on their current full-wall scheduling methods and work to optimize them. They feel that a more collaborative, real-time, non-iterative planning session is preferred. Using GPM® is one way to optimize the value of full-wall scheduling sessions.

Notes

1. Calendar, Humanity's Epic Struggle to Determine a True and Accurate Year, David Ewing Duncan
2. Historical Impressions.com
3. Calendar, Humanity's Epic Struggle to Determine a True and Accurate Year, David Ewing Duncan
4. GodKind.org
5. Einstein's Clocks, Poincare's Maps, Empires of Time, Peter Galison
6. Ponce de Leon, Gui (1973). *Critical Path Methods.* CE 536 Lecture Pack. The University of Michigan, Ann Arbor, MI.
7. O'Brien, James J.(1969). *Scheduling Handbook*, NY, NY. McGraw Hill, p 39.
8. From Gilbane Bulletin, Volume 23/Issue 2 – Summer 2003.
9. From PMA 'Full-Wall Scheduling Session: An Overview' Rev 1, August 27, 1998
10. Ponce de Leon, Dr. Gui (2008). *Graphical Planning Method™ (A Network-Based Planning/Scheduling Paradigm),* Presented at PMICOS 2008 Annual Conference.

*Mesoamerican calendar research by Spencer Philip Mather