Project Scheduling Case Study:
World Outreach Expansion Project

IEOR 4405: Production Scheduling Final Presentation

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April 27th, 2017

Executive Summary

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Background Story

- A project manager of American Constructors, Inc (ACI), is working on a construction project at World Outreach Church (WOC) in Murfreesboro, Tennessee.
- The project deadline was pushed to **Dec. 14, 2009** due to unavoidable events
- Initially budgeted as a $31 million project; however, the project manager is authorized to use an additional $3 million to expedite the project if necessary

FRONT OF WOC SEPTEMBER 2009

Goals and Objectives

- Have the project completed before deadline (Dec. 14, 2009, 81 days in total) to maintain the reputation of the company, **Maximum Makespan of 81 Days**
- Reschedule or Crash tasks to meet the Maximum Makespan Requirement
- No room in timeline for errors or mistakes, need a Contingency Plan if errors occurred

Resource Requirement Overview

- The additional $3 Million Budget could be used as incentives for the subcontractors to work additional time so that the project could be finished on time or for crashing

- Workers- 10 labourers (carpenters, finishers, cleaners, and operators)
  25 different subcontractors

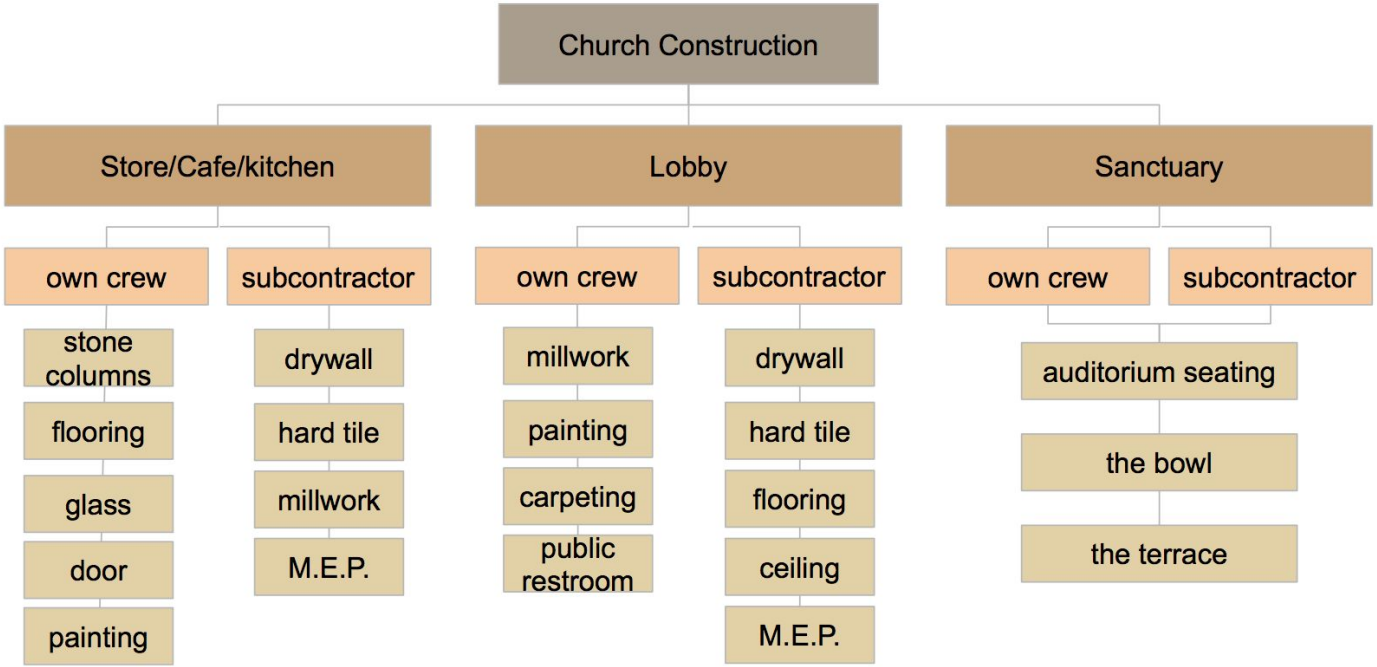
- Time- we have 81 days until Dec. 14, 2009

Remaining Constructions

As of Sep. 24, 2009, three main sections of the property were still unfinished:

Three sections can be processed in a parallel manner. After the three sections were finished, Cleaning and the Government Documentation and review could start.

Work Breakdown Structure



PERT Method Overview

Assume processing times are deterministic

- Processing time of j random with mean m_j and variance s_j^2.
- We want to determine the **expected makespan**
- Assume we have
- p_j^a = most optimistic processing time
- p_j^m = most likely processing time (mode)
- p_j^b = most pessimistic processing time

Assume we have:

- p_j^a = most optimistic processing time
- p_j^m = most likely processing time (mode)
- p_j^b = most pessimistic processing time

Estimate expected processing time:

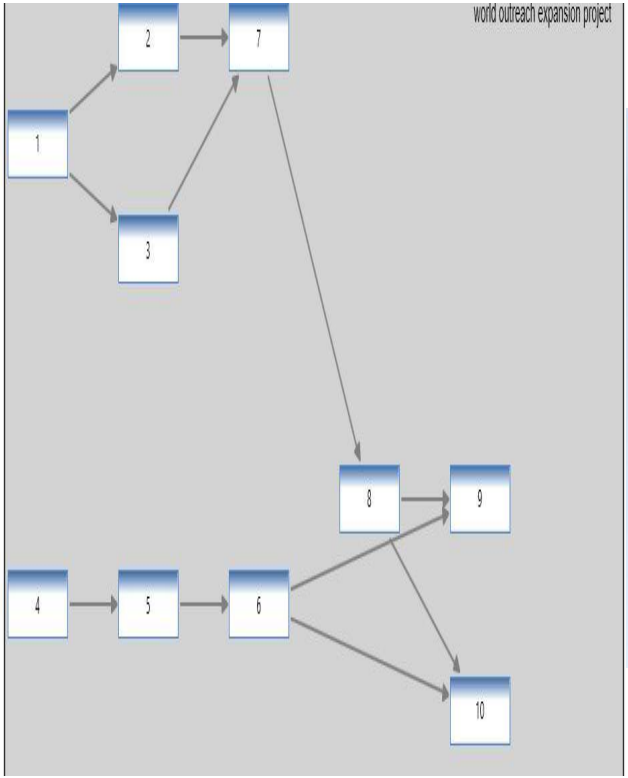
$$\mu_j = \frac{p_j^a + 4p_j^m + p_j^b}{6}$$

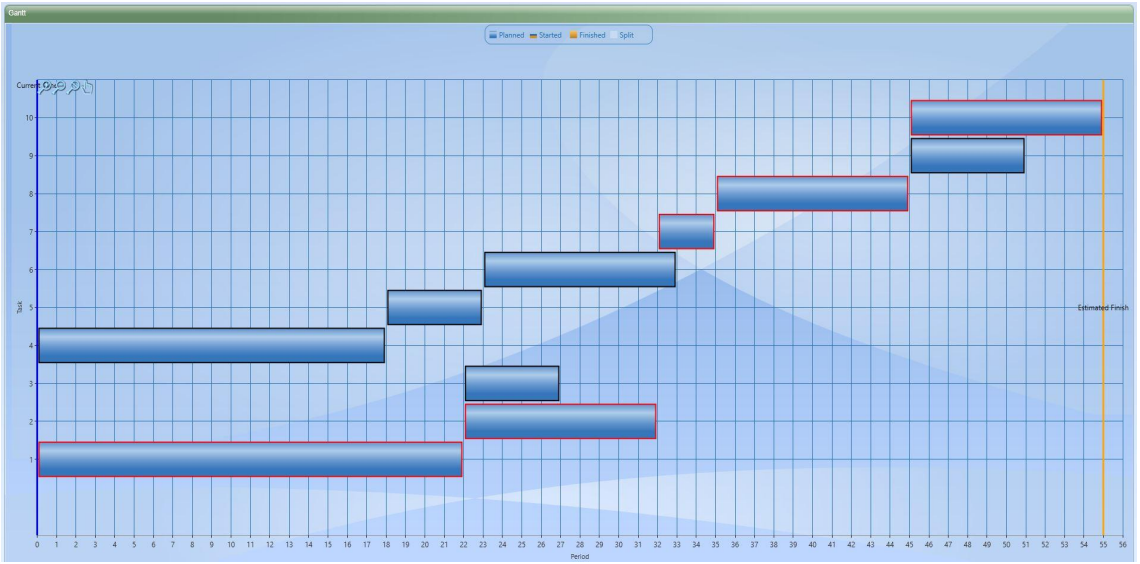
- Apply CPM with expected processing times

Activities from Original Statement- Store/Cafe/Kitchen

Tasks	Duration	Predecessors	Optimistic	Most likely	Pessimistic	Notes
1: Framing, hanging & finish drywall	21-23	None	21	22	23	
2: Hard tile installation	10	1	8	10	12	1 to 2
3: Complete stone columns	5	1	4	5	6	1 to 3
4: Millwork	15-21	None	15	18	21	happening at the same time with 1,2,3
5: Casework	5	4	4	5	6	4 to 5
6: Flooring installation SCK	10	5	8	10	12	5 to 6
7: Glass installation SCK	3	2, 3	3	3	3	could be less than 3// 2,3 to 7
8: Painting SCK	10	7	8	10	12	7 to 8
9: Doors installation & matching hardware SCK	5- 8	6, 8	5	6	8	6,8 to 9
10: M.E.P. SCK	10	6, 8	10	10	10	6,8 to 10

Node Network and Critical Path for Store/Cafe/Kitchen



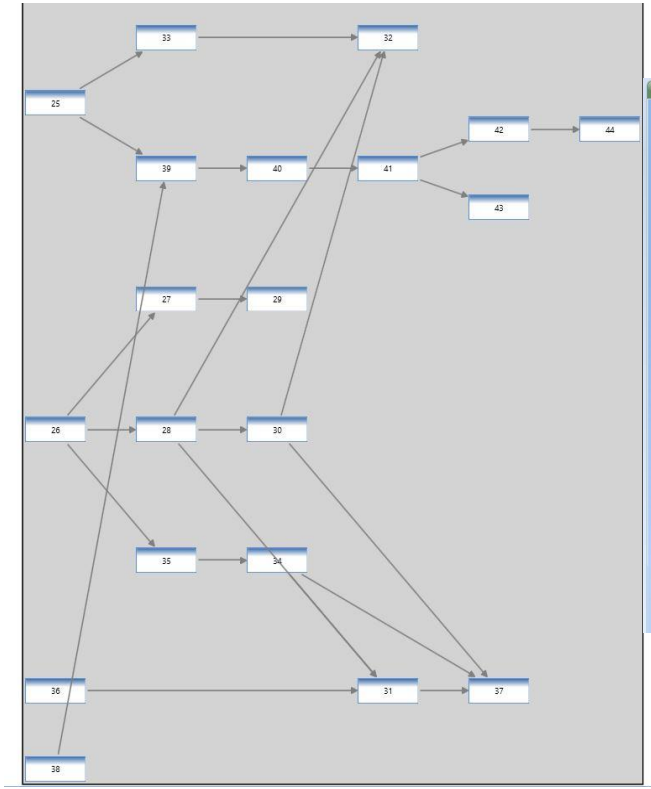


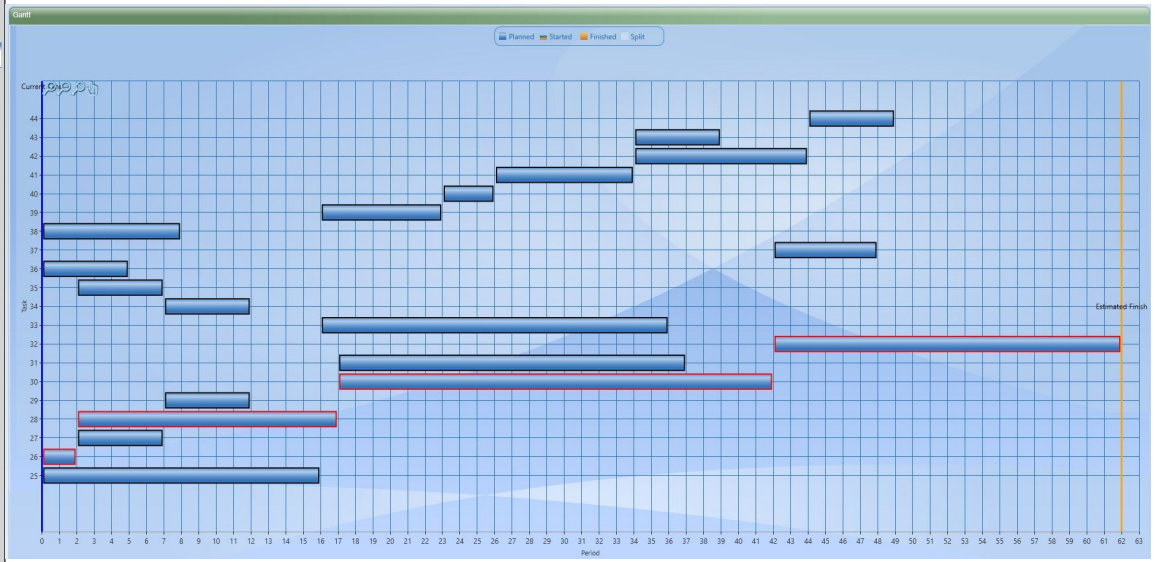
Makespan: 22+10+3+10+10=55 Days

Activities from Original Statement-Sanctuary

Tasks	Duration	Predecessors	Optimistic	Most likely	Pessimistic	Notes
25: Hanging drywall	16	None	14	16	18	
26: Core drill for the rails	2	None	2	2	2	
27: Rails installation	5	26	4	5	6	
28: Carpeting at seats	15	26	13	15	17	
29: Carpeting at rails	5	27	4	5	6	
30: Wood Panelling, trim and stage work	25	28	22	25	28	
31: Painting	20	36	18	20	22	
32: Seats at Audi	20	33	18	20	22	
33: Seats at Bowl	20	25	18	20	22	
34: Stain floor	5	35	4	5	6	35 to 34
35: Wood stage steps	5	26	4	5	6	26 to 35
36: Carpeting at Bowl	5	None	4	5	6	
37: Doors installation & matching hardware	5- 8	31	5	6	8	30,31,34 to 37
38: Window installation	8	None	7	8	9	
39: Waterproofing	7	25	6	7	8	
40: Insulation	3	39	3	3	3	39 to 40
41: Deck completion	5- 10	40	5	8	10	40 to 41 //speed depends on weather
42: Stairs	10	41	8	10	12	41 to 42// easy to reduce time
43: Aluminum rails installation	5	41	4	5	6	
44: Masonry on the stairs	10	42	4	5	6	42 to 44

Node Network and Critical Path for Sanctuary



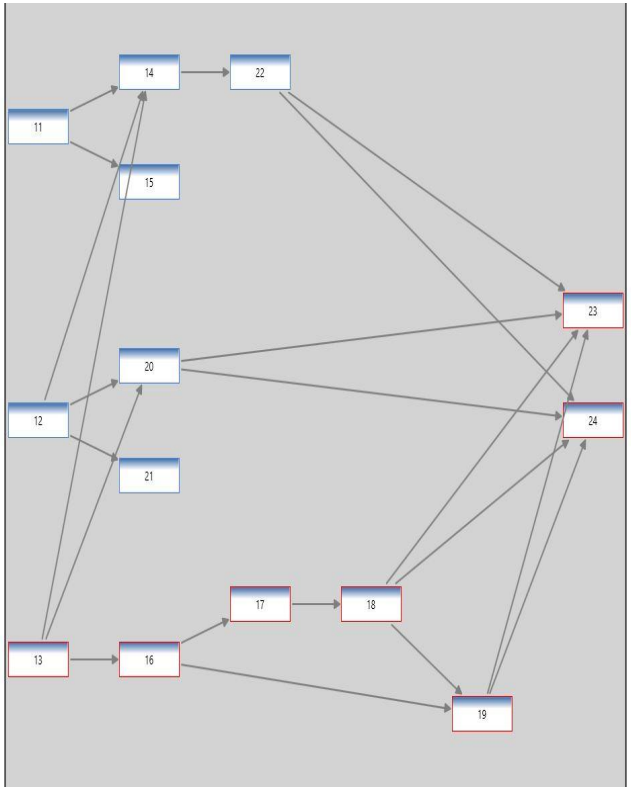


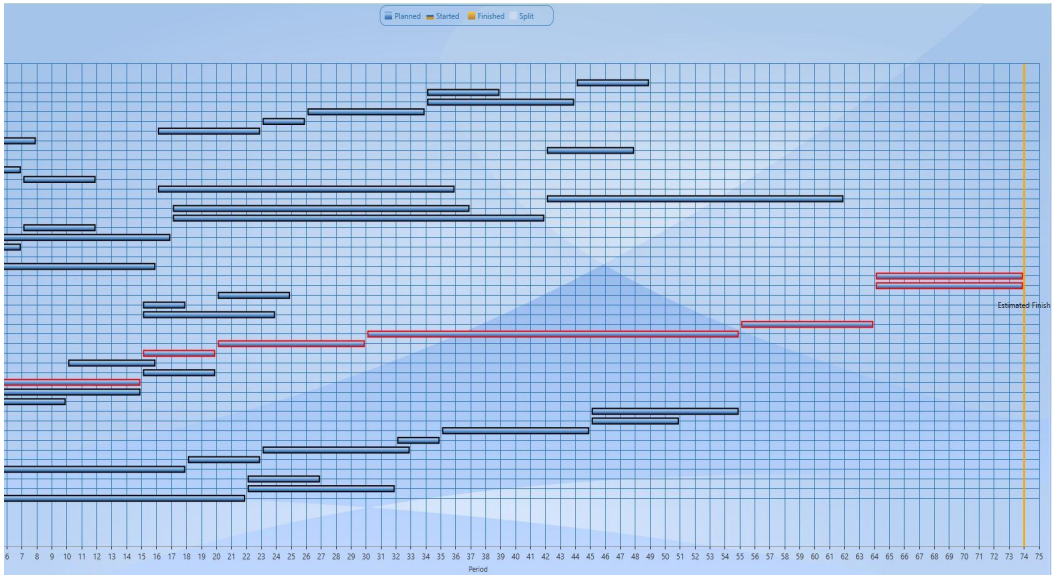
Makespan: 2+15+25+20=62 Days

Activities from Original Statement-Lobby

Tasks	Duration	Predecessors	Optimistic	Most likely	Pessimistic	Notes
11: Reception area	10	None	8	10	12	happening together with other millwork, counter only 3 days
12: Hard Ceiling	15	None	13	15	17	
13: Drywall installation	15	None	15	15	15	Cage Drywall
14: Painting for 1/F & 2/F LOBBY	5	11	5	5	5	11,12,13 to 14
15: Put a thin concrete layer	5 -8	11	5	6	8	11 to 15 // speed depends on weather
16: Hard tile in the LOBBY	5	13	5	5	5	could be done by a subcontractor//13 to 16
17: Wood treatment	10	16	8	10	12	16 to 17
18: Flooring installation LOBBY	22 -28	17	22	25	28	17 to 18 // 17&18 could be crashed to 30 days
19: Carpeting	9	16, 18	8	9	10	16,18 to 19
20: Public restroom	9	12	8	9	10	12,13 to 20
21: Glass installation LOBBY	3	12	3	3	3	12 to 21
22: Ceiling tile	5	14	5	5	5	14 to 22
23: Doors installation & matching hardware LOBBY	10	18, 19, 20, 22	8	10	12	18,19,20,22 to 23 // happening together with 23&24
24: M.E.P. LOBBY	10	18, 19, 20, 22	8	10	12	18,19,20,22 to 24

Node Network and Critical Path for Lobby





Makespan: 15+5+10+25+9+10=74 Days

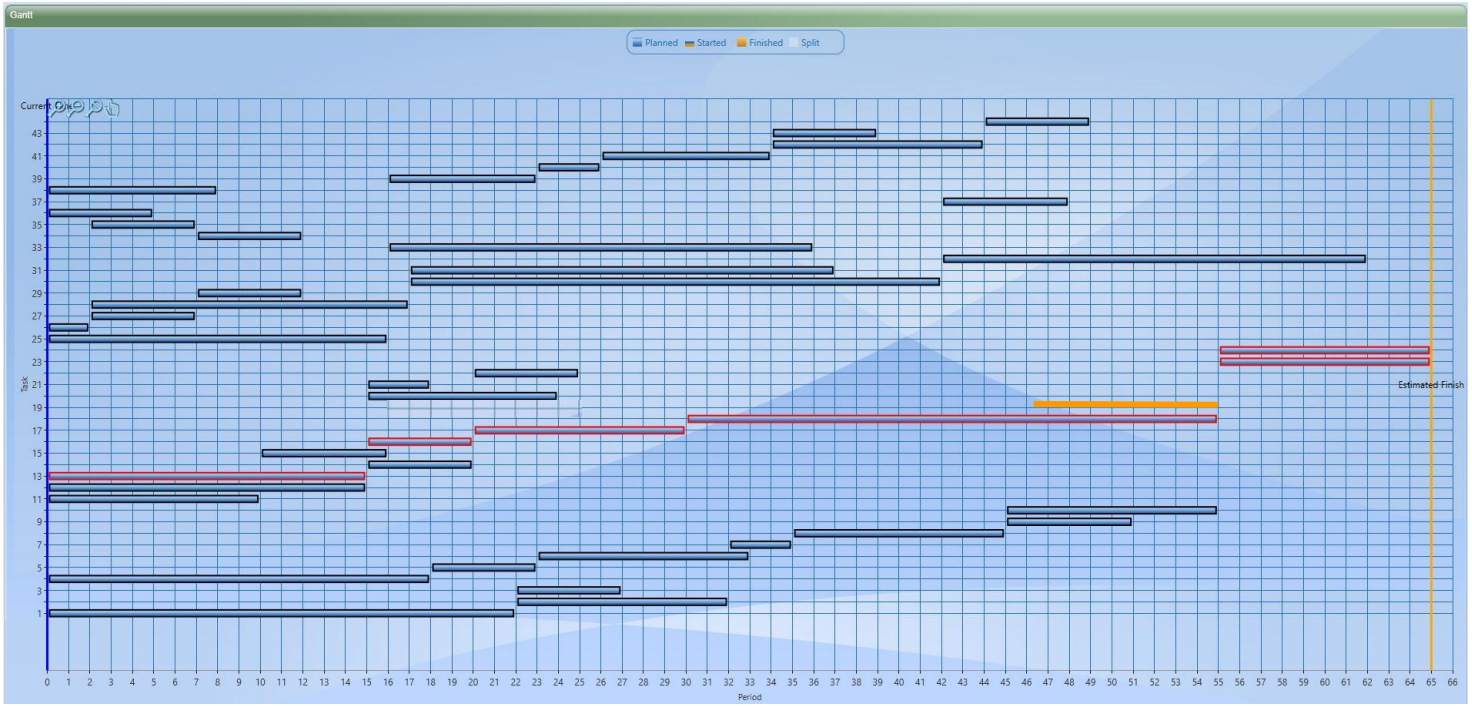
Original Critical Path from Public Record

Original Makespan: 15+5+10+25+9+10=74+15=89 Days--does not meet the requirement of 81 days!

Recommendation Overview

- Option 1: Reschedule
  - Can we relax some of the precedence requirements given in the original plan ?
- Option 2: Crashing
  - What if the manager does not want to rearrange the tasks?
  - How do we incentivize the subcontractors?
- Option 3: Reschedule + Crashing-Goals and Constraints
  - Ideally we want to optimize the scheduling using both approaches.

Recommendation-Option 1: Reschedule



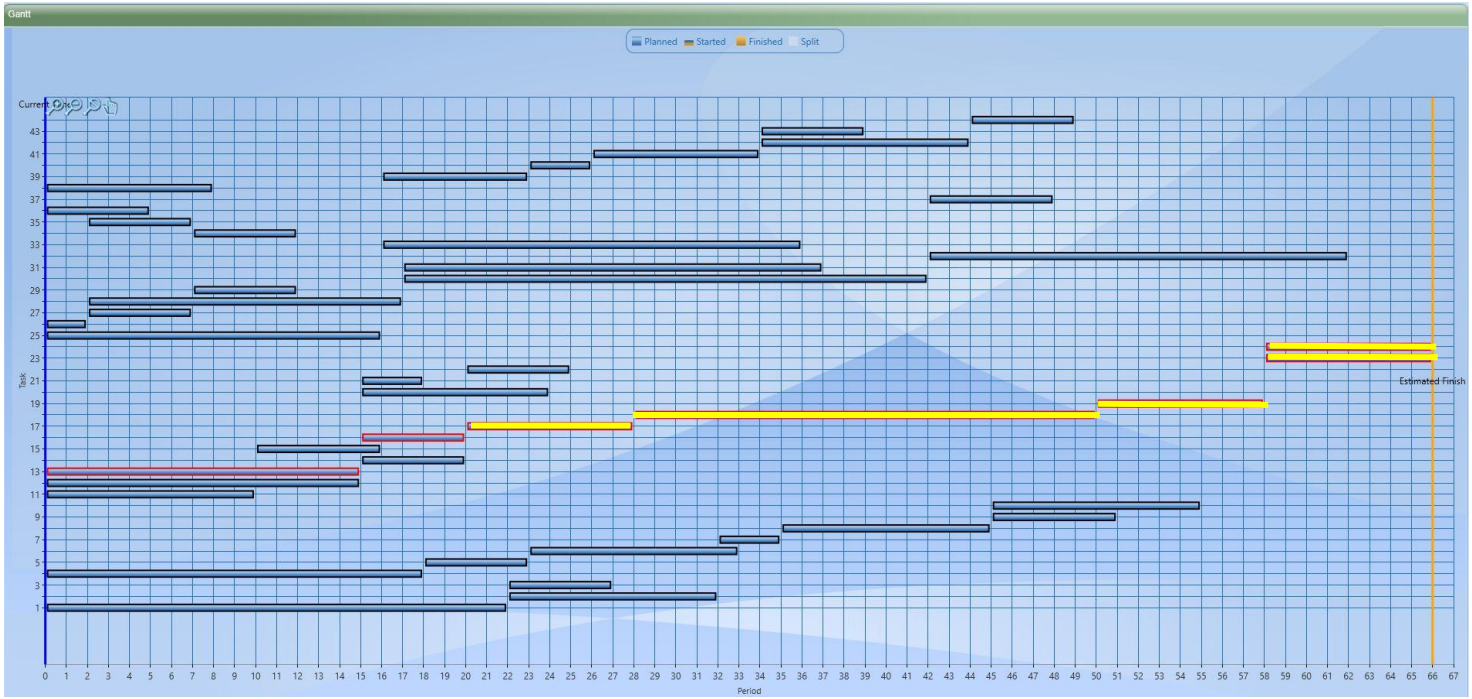
- Task 19 (Carpeting)

  - Carpeting areas are first floor, second floor and stairs

  - Carperting could be completed by own crew

New Makespan: 15+5+10+25+10+15=80 ≤ 81 Days

Recommendation-Option 2: Crashing

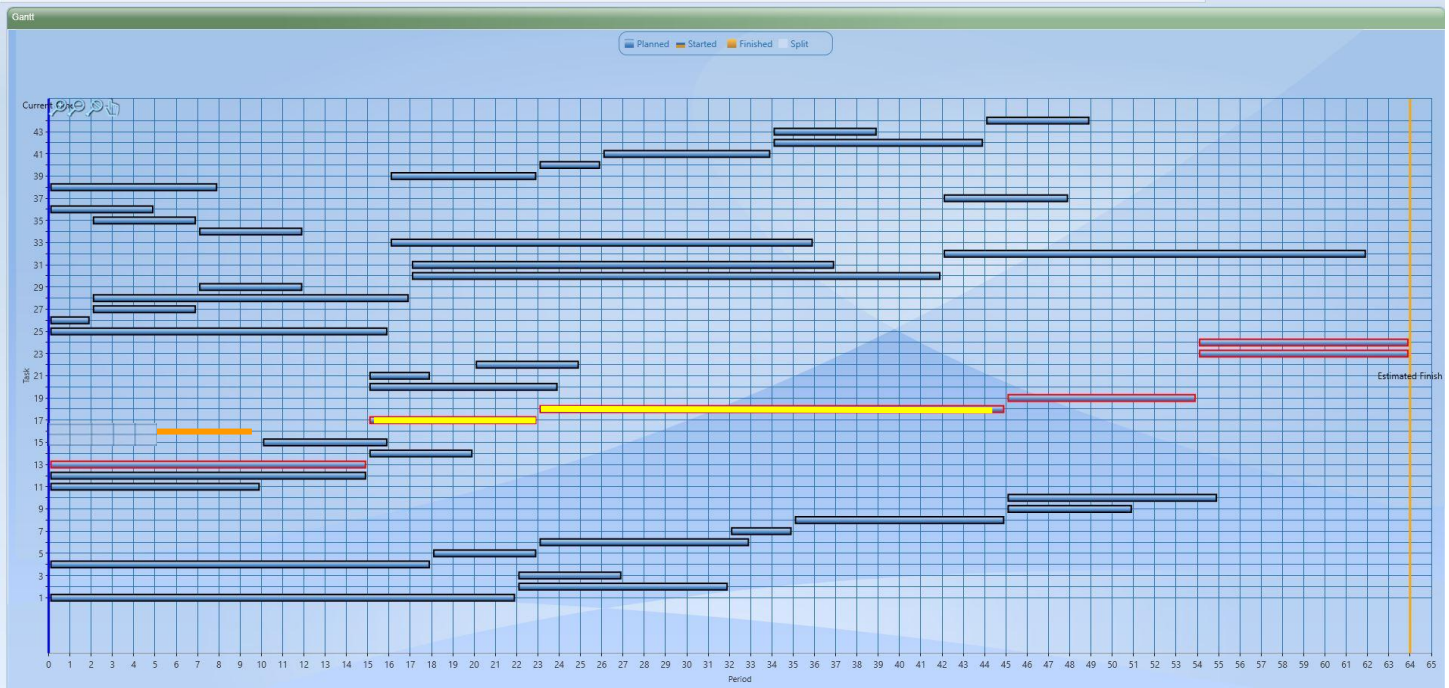


- Wood Treatment & Flooring installation

  Could be shortened by employing the crew to work overtime
- Doors Installation & MEP
- Carpeting

New Makespan: 15+5+8+22+8+8+15=81≤81 days

Recommendation-Option 3: Reschedule + Crashing



- Hard Tile

  -Hard Tile could be completed by subcontractors

  -Drywall would be working on different parts of the lobby

- Wood Treatment & Flooring installation

New Makespan: 15+8+22+9+10+15=79 ≤ 81 days

Conclusion

Three proposed options all work better than the original critical path, Project Manager should choose the option according to the change of requirements and preferences

Some other alternatives (contingency plan):

-Reallocate resources: Since the Store/Cafe/Kitchen session is a smaller project and finishes in 55 days, we could recycle their labor to work on lobby project.

-Consider using buffer (“No room in the timeline for errors or mistakes, which would inevitably occur”)

Appendix A: Contingency Plan

- **Internal mobilization**
  - Since the bookstore/cafe/kitchen session is a smaller project and finishes in 55 days, we could send their workers to help with the lobby project.
  - The manager should definitely focus on using as much resources on the lobby session where the jobs take the longest time.

- **Besides crashing/resequencing activities approach, we can prioritize the more time demanding items**
  - They are: flooring installation (18), hard ceiling (12) and drywall installation (13); all three of them take a descending order of time of 22, 15 and 15, respectively.
  - Flooring installation: the only premise to start task 18 is to finish task 17 due to the minimum requirements of starting 18 we can simply put first of 18.
  - Hard ceiling and drywall both have identical duration, we can prioritize either one to have the same result at the end; the reason to make hard ceiling to go first is to avoid items happen later such as, put a thin concrete layer, hard tile to go smoothly. On the other hand, to prioritize drywall is a preparation step of door installation.

Appendix B: Construction Site Snapshot

THE LOBBY OF WOC SEPTEMBER 2009

Source: Photo provided by American Constructors Inc.

FRONT OF WOC SEPTEMBER 2009

Source: Photo provided by American Constructors Inc.

Appendix C: Project Memorandum & Warranty Contract

MEMORANDUM

AMERICAN
CONSTRUCTORS

A-381
World Outreach Church
Close-Out

September 24, 2009

MEMORANDUM

To: (*Name*) — (*Company*)

From: Tom Grott — Senior Project Manager

Re: World Outreach Church — Murfreesboro

Subject: Project Close-Out Requirements

Attached please find a summary of all Close out Manuals, Operation Manuals, Warranties, Guarantees, As-builts, and other items required for close out of the World Outreach Church Project. While there are certain items, such as Final Release of Lien's, General Warranty/Guarantee's, that cannot be completed at this time, there are many items that can and should be prepared immediately and submitted. Examples of items needed immediately that are necessary for our final inspections are as follows:

1. Flame Spread Ratings on all fabrics, carpets, VCT flooring, vinyl or rubber base, acoustical ceiling tile, etc.
2. UL Ratings on fire dampers, fire caulk barriers, insulation, and other items.
3. Field Use and/or As-built drawings for all trades, whose work is complete.

In addition, all operation and maintenance manuals and close out manuals for MP&E trades can be immediately prepared and submitted.

Please review the attached list carefully and begin this process immediately. These items are to be forwarded in ***triplicate*** to our field office located at (*Address*) no later than (*Date*). If you have any further questions concerning this please feel free to contact me.

GENERAL GUARANTEE AND WARRANTY

General Guarantee and Warranty

World Outreach Church
Murfreesboro, Tennessee 37128

Job No. A-381

We hereby guarantee that all work performed and all materials and equipment furnished under this contract are in accordance with the Contract Documents and are free from defects of equipment, materials, or design furnished, or workmanship performed by this Contractor or any of our Subcontractors or Suppliers at any tier.

In accordance with Article 12.2.2 of AIA Document A201, if within one (1) year after the date of Substantial Completion of the _____ work or designated portion thereof or within one (1) year after acceptance by the Owner of designated equipment or within such longer period of time as may be prescribed by law or by the terms of any applicable warranty required by the Contract Documents, any of our work is found to be defective or not in accordance with the Contract Documents, we shall correct it promptly after receipt of a written notice from the Owner or his agent to do so unless the Owner has previously given us written acceptance of such conditions.

Thank you for sharing this special moment with us!

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