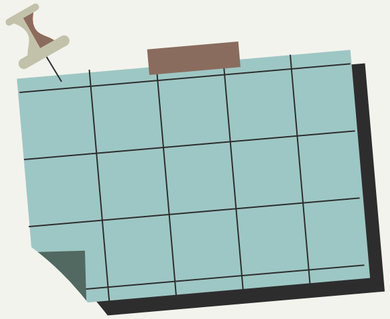
Construction Project Optimization Analysis

Multi-Method Approach for Taiwan Social Housing

Group Member：郭哲豪、周世晟、宋肇恆



Introduction

Problem Statement

- Social housing construction challenges in Taiwan
- Need for comprehensive project optimization
- Current inefficiencies in schedule, cost, and resources

Introduction

Research Objectives

- Optimize construction scheduling using multiple methods
- Improve resource allocation efficiency
- Enhance cost control
- Identify and mitigate risks

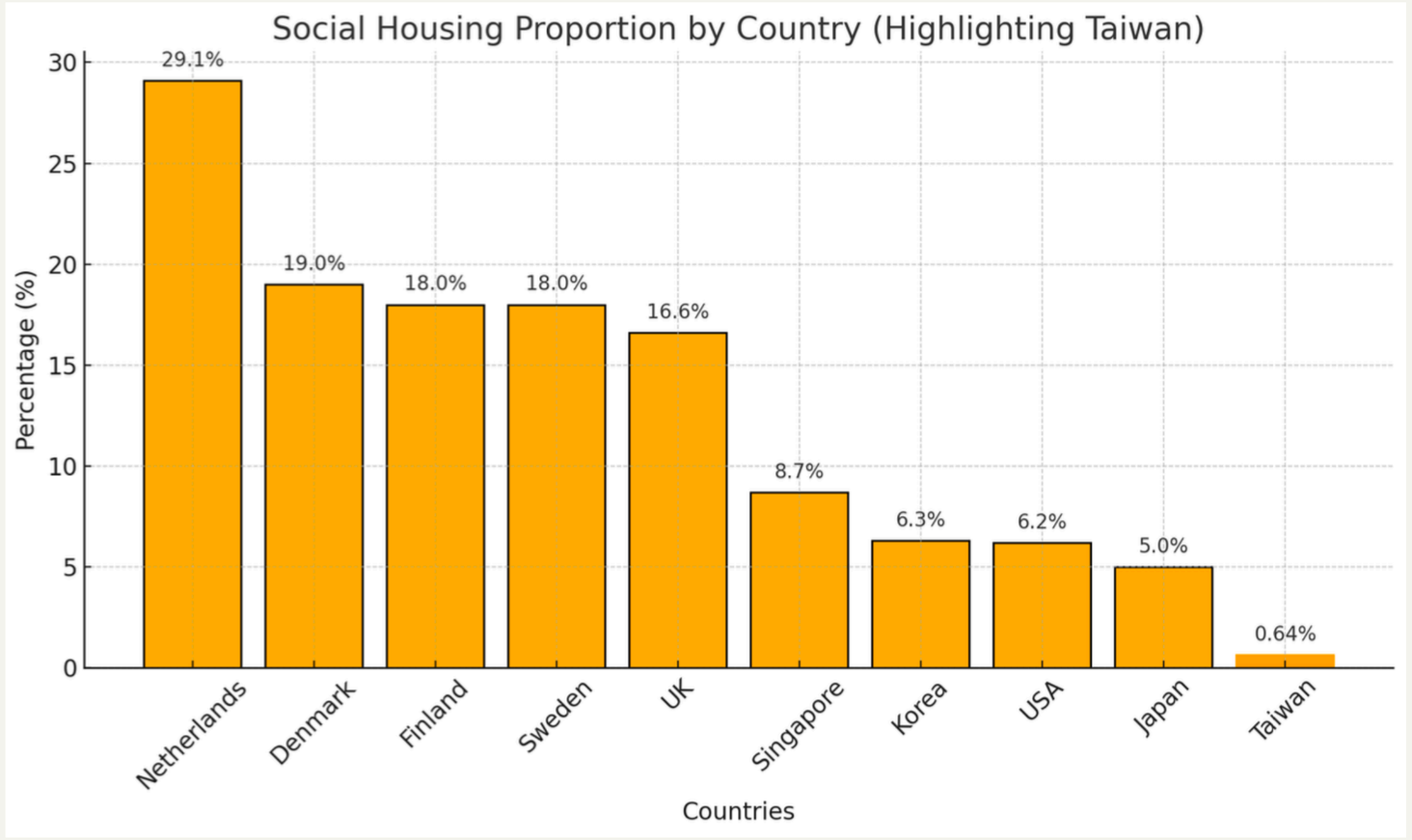
Research Background

Current Housing Challenges in Taiwan

- Housing Market Issues
  - High Housing Prices
  - Unstable Rental Market
  - Insufficient Social Housing Supply (0.64% vs 5% standard)

Research Background

Current Housing Challenges in Taiwan



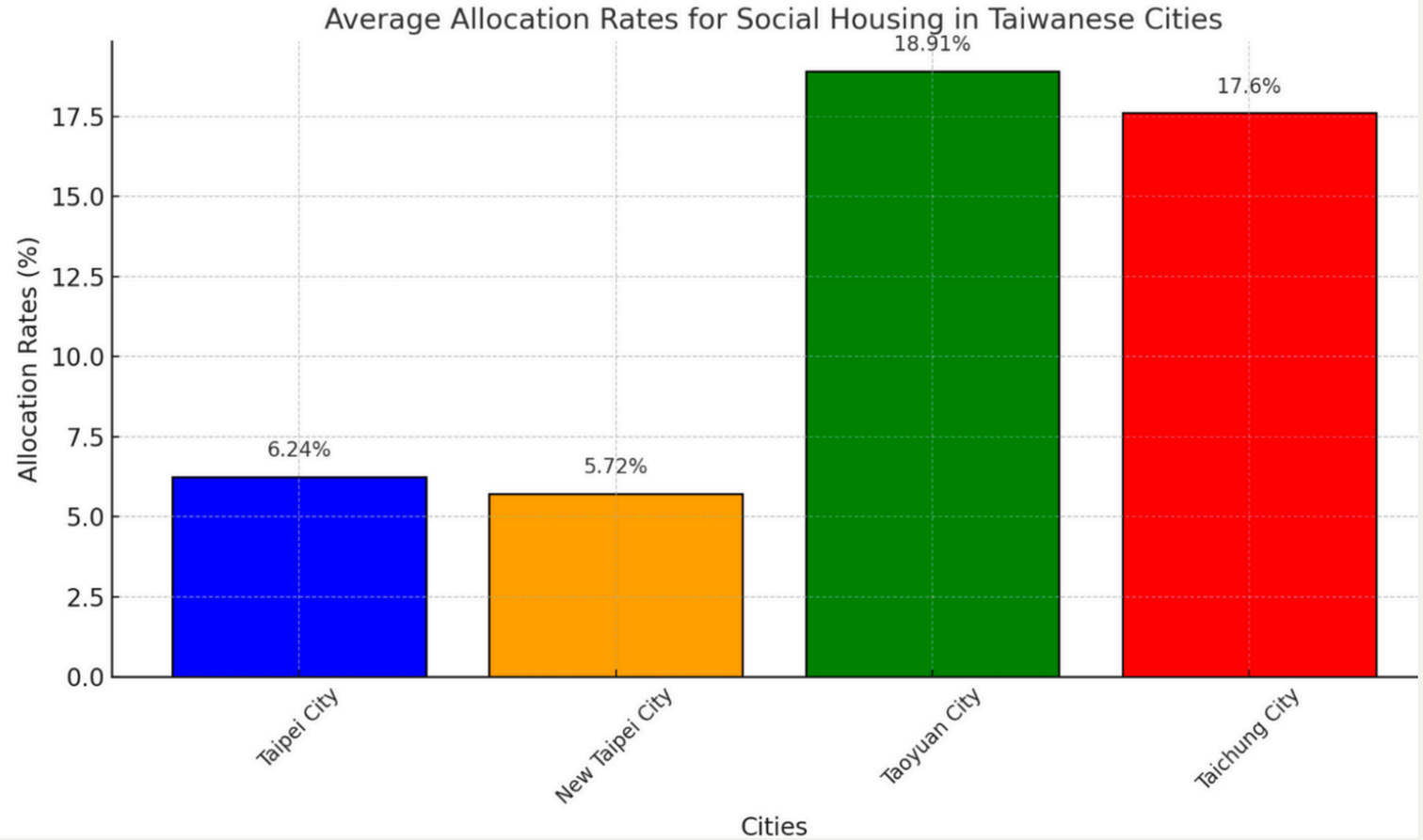
Research Background

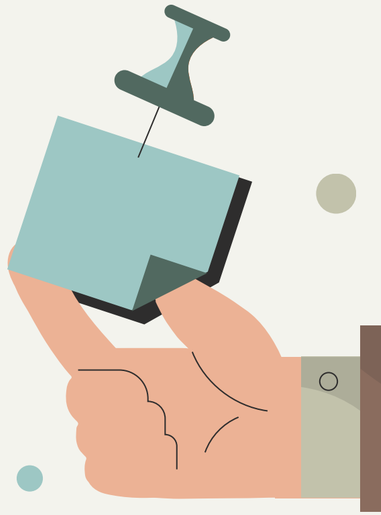
Current Housing Challenges in Taiwan

- Social Housing Supply Statistics
  - Significantly behind other developed nations
    - Netherlands: 29.1%
    - Taiwan: 0.64%
    - Regional peer Japan: 5.0%

Research Background

Current Housing Challenges in Taiwan





Research Background

Current Housing Challenges in Taiwan

- Social Housing Supply Statistics
  - Regional disparities in allocation rates
    - Taoyuan City: 18.91%
    - Taichung City: 17.61%
    - New Taipei City: 5.72%
    - Taipei City: 6.24%

Motivation

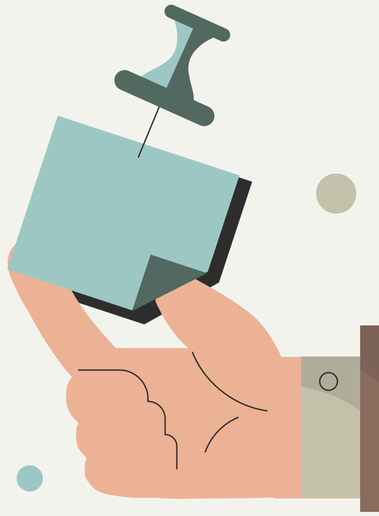
Construction Industry Challenges

- Project Management Issues
  - Schedule delays in housing projects
  - Inefficient resource allocation
  - Limited use of optimization techniques
  - Project completion time overruns

Motivation

Construction Industry Challenges

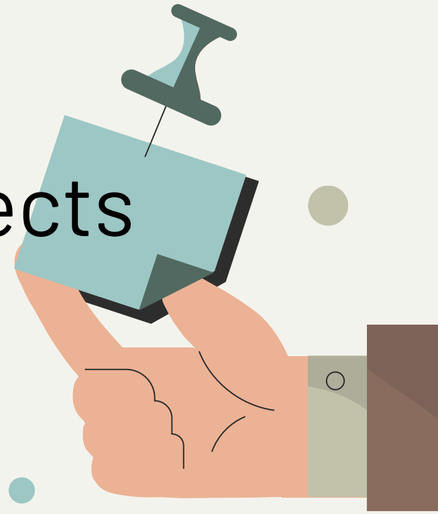
- Current Project Management Practices
  - Traditional scheduling methods
  - Limited application of CPM
  - Resource allocation inefficiencies
  - Cost control challenges



Motivation

Improvement Opportunities

- Schedule Optimization Potential
  (Subsidized House Construction Project in Hill Mulya Housing, Samarinda City)
  - CPM implementation success cases
  - Demonstrated 9-day reduction in similar projects
  - Resource utilization improvements



Motivation

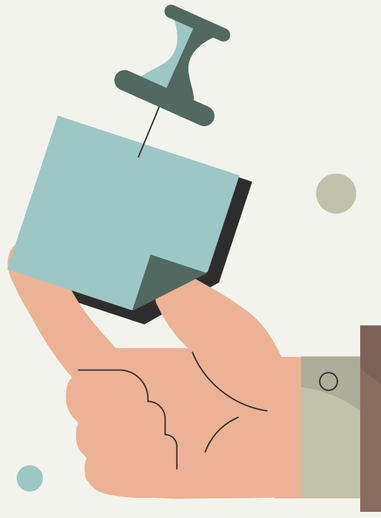
Improvement Opportunities

- Technology Integration
  - Modern project management tools
  - Data-driven decision making
  - Advanced scheduling techniques

Literature Review

Critical Path Method (CPM) Studies

- Beatrix et al. (2019) demonstrated CPM effectiveness in housing projects, achieving 15% schedule reduction
- Jufriyanto & Zainuddin (2019) applied CPM in apartment development, optimizing resource allocation
- Tjakra & Pratasis (2016) showed successful CPM implementation in complex building projects



Literature Review

Resource Optimization

- Maprilana (2019) - "Scheduling Project Analysis Using CPM Method" highlighted resource leveling benefits
- Telaumbanua et al. (2017) studied construction workflow optimization through CPM
- Mahapatni (2019) explored construction project planning and control methods

Literature Review

Social Housing Development

- Construction Efficiency
  - Hidayatul et al. (2018) evaluated time scheduling for housing construction
  - Research on type-30 house construction optimization
  - Studies on cost-efficiency in social housing projects

Case Study

A dataset related to the issue of social housing in Taiwan

- Taiwan Construction Workflows
  - Local construction standards
  - Social housing specifications
  - Regional building practices
- Kaggle Construction/Project Management Examples
  - Project scheduling templates
  - Resource allocation models & Activity duration benchmarks

Methods

Analytical Methods Applied

- Critical Path Method (CPM)
  - Schedule optimization
  - Network analysis
- PERT Analysis
  - Probabilistic duration estimates
  - Uncertainty management

Methods

- Earned Value Analysis
  - Cost performance tracking
  - Schedule performance tracking
- Resource Utilization Analysis
  - Resource leveling
  - Capacity optimization
- Risk Analysis
  - Risk identification
  - Mitigation strategies

Activity Codes & Construction Dependencies

Work	Volume	Labor_Ty	Amount	Index	Duration	Total_Dur	Activity	Prior_Activities
Formwork_Installation	35	Foreman	1	0.011	0.35	1	A	-
		Worker	2	0.013	0.225			
Site_Preparation	22	Foreman	1	0.056	1.3	8	B	A
		Worker	2	0.56	6.7			
Foundation_Testing	2.5	Foreman	1	0.045	0.25	2	C1	B
		Worker	2	0.85	2			
Foundation_Backfill	6.2	Foreman	1	0.013	0.09	7	C2	C1
		Worker	2	0.13	0.42			
Waterproofing_Base	8.2	Foreman	1	0.035	0.4	3	D	C2
		Worker	2	0.65	3			
Sand_Base	5.1	Foreman	1	0.032	0.16	7	E	D
		Worker	2	0.32	0.8			
Stone_Foundation	5.4	Foreman	1	0.04	0.21	3	F	E
		Worker	2	0.8	2.1			
RC_Foundation	9	Foreman	1	0.08	0.68	6	G	F
		Worker	2	1.6	6.8			
MEP_Rough_In	15	Foreman	1	0.042	0.85	4	H	G
		Worker	3	0.72	4			
Ground_Beam	1.1	Foreman	1	0.32	0.33	3	I	H
		Worker	2	5.7	2.85			
Column_Construction	1.1	Foreman	1	0.4	0.44	5	J	I
		Worker	2	7.1	3.85			
Structural_Testing	2	Foreman	1	0.065	0.35	2	K	J
		Worker	2	0.75	2			
Ring_Beam	1	Foreman	1	7	0.35	3	L	K
		Worker	2	6.4	3.2			
Block_Wall	5	Foreman	1	0.02	0.1	9	M	L
		Worker	2	0.62	1.55			
Wall_Finishing	27	Foreman	1	0.02	1	8	N	M
		Worker	2	0.62	8.1			
Door_Frame_A	3	Foreman	1	0.25	1	2	O1	M
		Worker	2	0.82	1			
Door_Frame_B	1	Foreman	1	0.25	0	2	O2	O1
		Worker	2	0.82	0			
Window_Type_A	3	Foreman	1	0.25	1	2	P1	M
		Worker	2	0.82	1			
Window_Type_B	1	Foreman	1	0.25	0	2	P2	P1
		Worker	2	0.82	0			
Glass_Installation	5	Foreman	1	0.25	1	2	P3	P2
		Worker	2	0.82	2			
Steel_Roof	56	Foreman	1	4.5	4	22	Q1	N,O2,P3
		Worker	2	20.6	21			
Roof_Covering	56	Foreman	1	0.4	0	22	Q2	Q1
		Worker	2	4.2	4			
LED_Installation	4	Worker	3	2.6	3.47	3	R1	Q2
Switch_Installation	3	Worker	3	2.6	2.6	3	R2	R1
Socket_Installation	4	Worker	3	2.6	3.47	3	R3	R2
Plumbing_Fixtures	3	Foreman	1	0.04	0.12	2	S1	Q2
		Worker	2	0.01	0.02			
Water_Supply	11	Foreman	1	0.04	0.15	2	S2	S1
		Worker	2	0.01	0.03			
Drainage_System	12	Foreman	1	0.01	0.12	2	S3	S2
		Worker	2	0.01	0.06			
Ceiling_Frame	13	Foreman	1	0.035	0.45	3	T1	R3,S3
		Worker	2	0.35	2.26			
Ceiling_Panel	36	Foreman	1	0.005	0.18	3	T2	T1
		Worker	2	0.1	1.8			
Floor_Tiling	32	Foreman	1	0.035	1.12	12	U	T2
		Worker	2	0.7	11.2			
Skirting	4	Foreman	1	0.032	0.12	12	V	U
		Worker	2	0.32	0.64			
Interior_Painting	27	Foreman	1	0.02	0.54	8	W1	V
		Worker	2	0.6	8.1			
Exterior_Painting	20	Foreman	1	0.02	0.4	8	W2	W1
		Worker	2	0.6	6			
Landscaping	33	Foreman	1	0.032	1.05	6	X	W2
		Worker	2	0.32	5.25			
Quality_Inspection	1	Foreman	2	0.08	0.5	1	Y	X
						194		

Analysis Results

CPM Schedule Analysis

- Reduce the project timeline from the original 194 days to 177 days
- 8.8% reduction in project duration
- Maintained all required activities
- Identified flexible scheduling opportunities
- Streamlined critical path activities

Analysis Results

Project duration: 177 days

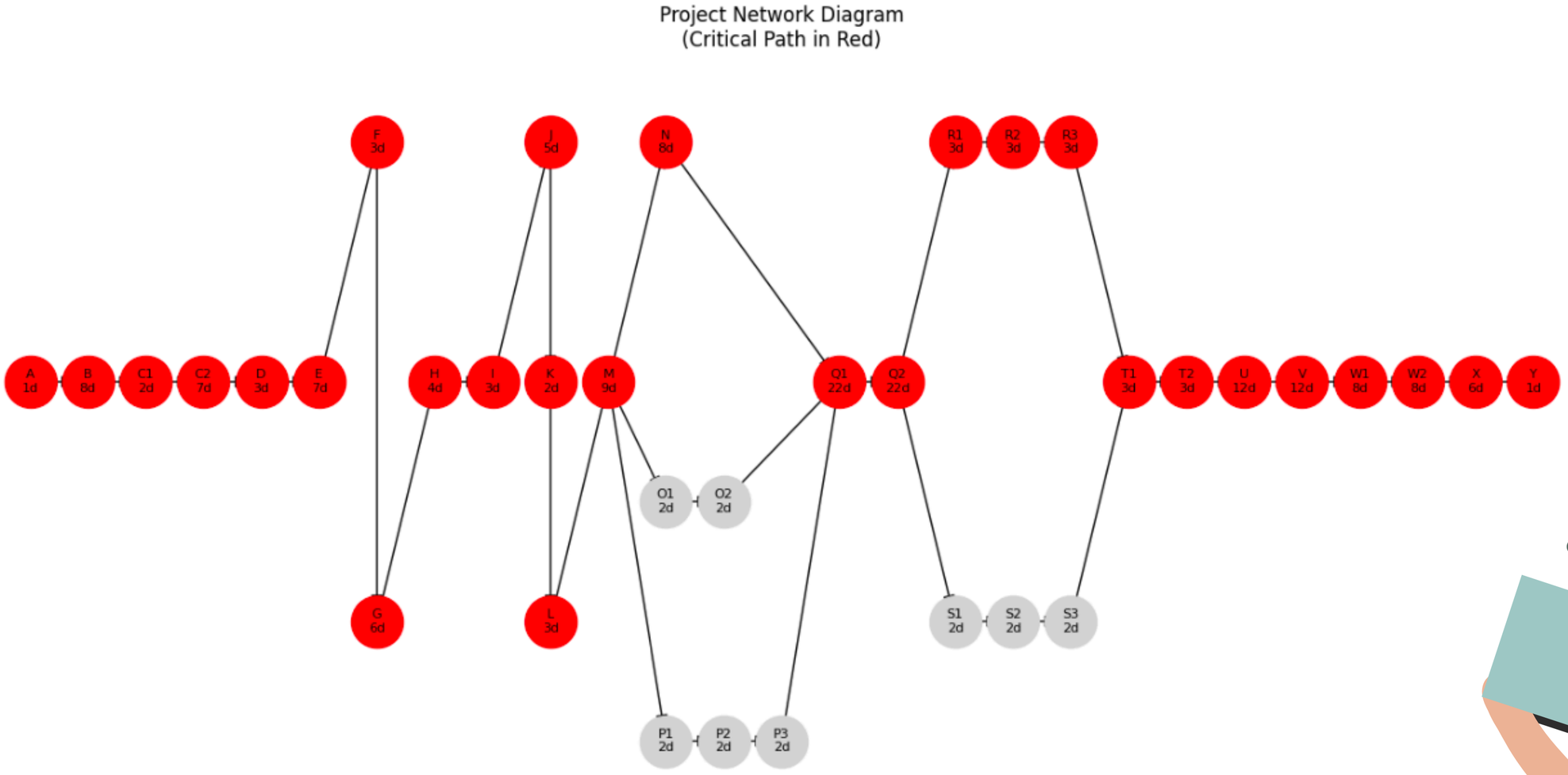
Critical path sequence:

A -> B -> C1 -> C2 -> D -> E -> F -> G -> H -> I -> J -> K -> L -> M -> N -> Q1 -> Q2 -> R1 -> R2 -> R3 -> T1 -> T2 -> U -> V -> W1 -> W2 -> X -> Y

Detailed Activity Analysis:

	Activity	Duration	ES	EF	LS	LF	Total_Float	Critical
0	A	1	0	1	0	1	0	True
1	B	8	1	9	1	9	0	True
2	C1	2	9	11	9	11	0	True
3	C2	7	11	18	11	18	0	True
4	D	3	18	21	18	21	0	True
5	E	7	21	28	21	28	0	True
6	F	3	28	31	28	31	0	True
7	G	6	31	37	31	37	0	True
8	H	4	37	41	37	41	0	True
9	I	3	41	44	41	44	0	True
10	J	5	44	49	44	49	0	True
11	K	2	49	51	49	51	0	True
12	L	3	51	54	51	54	0	True
13	M	9	54	63	54	63	0	True
14	N	8	63	71	63	71	0	True
15	O1	2	63	65	67	69	4	False
16	O2	2	65	67	69	71	4	False
17	P1	2	63	65	65	67	2	False
18	P2	2	65	67	67	69	2	False
19	P3	2	67	69	69	71	2	False
20	Q1	22	71	93	71	93	0	True
21	Q2	22	93	115	93	115	0	True
22	R1	3	115	118	115	118	0	True
23	R2	3	118	121	118	121	0	True
24	R3	3	121	124	121	124	0	True
25	S1	2	115	117	118	120	3	False
26	S2	2	117	119	120	122	3	False
27	S3	2	119	121	122	124	3	False
28	T1	3	124	127	124	127	0	True
29	T2	3	127	130	127	130	0	True
30	U	12	130	142	130	142	0	True
31	V	12	142	154	142	154	0	True
32	W1	8	154	162	154	162	0	True
33	W2	8	162	170	162	170	0	True
34	X	6	170	176	170	176	0	True
35	Y	1	176	177	176	177	0	True

Network Diagram



Analysis Results

PERT Schedule Analysis

- Most Likely Duration: 170.7 days
- Standard Deviation: 4.1 days
- Confidence Intervals:
  - 68% chance: 166.6 to 174.8 days
  - 95% chance: 162.4 to 178.9 days
- Focus on high CV activities
- Buffer needed for high-risk activities

Analysis Results

High Risk Activities (CV > 0.2):

Activity_Code	Expected_Time	CV	Risk_Level
C1	2.166667	0.230769	High
K	2.166667	0.230769	High
O1	2.166667	0.230769	High
O2	2.166667	0.230769	High
P1	2.166667	0.230769	High
P2	2.166667	0.230769	High
P3	2.166667	0.230769	High
S1	2.166667	0.230769	High
S2	2.166667	0.230769	High
S3	2.166667	0.230769	High

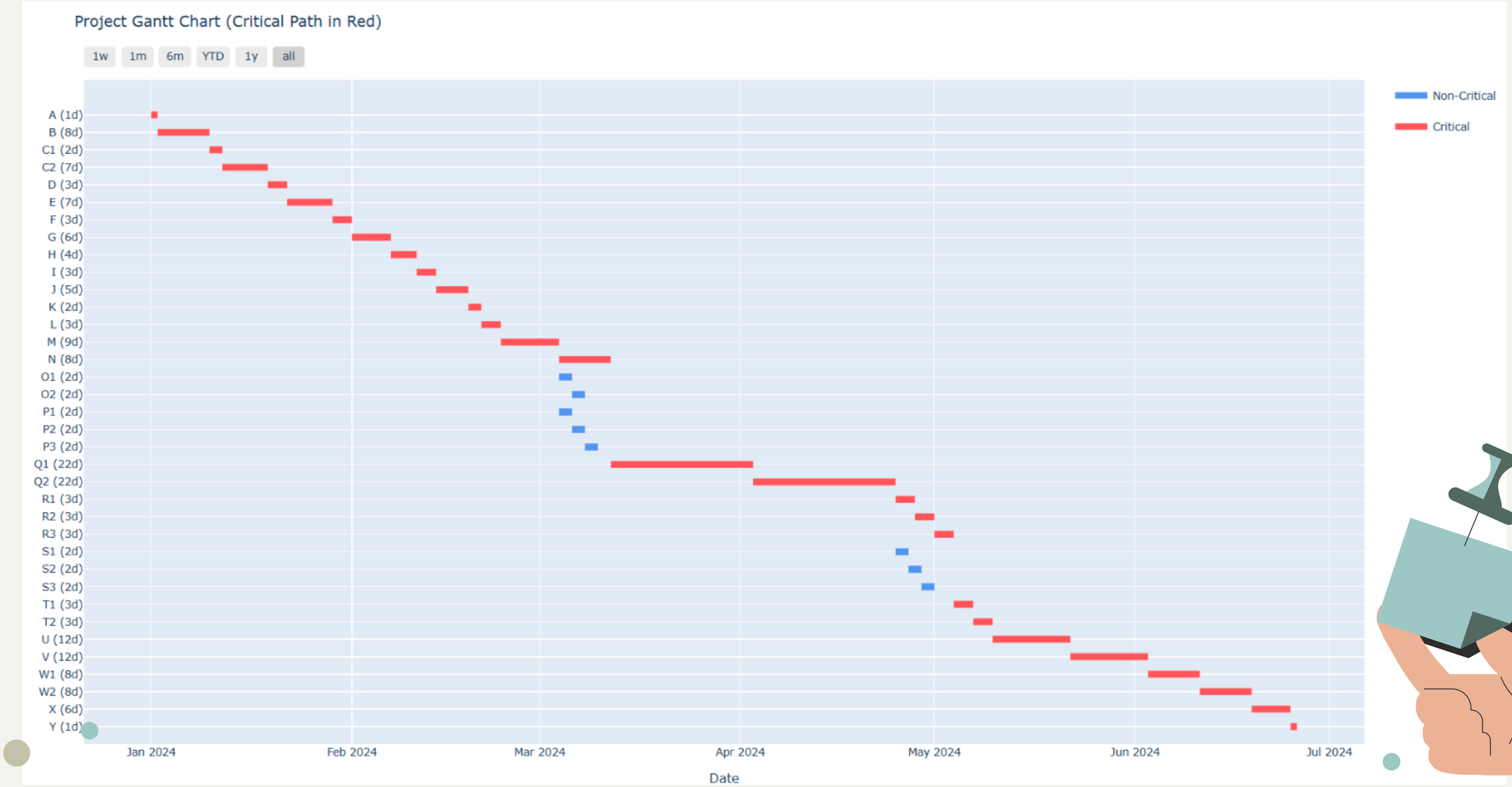
PERT Analysis Summary:

Most Likely Project Duration: 170.7 days
Project Standard Deviation: 4.1 days
68% Confidence Interval: 166.6 to 174.8 days
95% Confidence Interval: 162.4 to 178.9 days

Activity Time Estimates:

Activity_Code	Expected_Time	Std_Dev	CV
A	1.166667	0.166667	0.142857
B	8.333333	1.000000	0.120000
C1	2.166667	0.500000	0.230769
C2	7.166667	0.833333	0.116279
D	3.166667	0.500000	0.157895
E	7.166667	0.833333	0.116279
F	3.166667	0.500000	0.157895
G	6.166667	0.833333	0.135135
H	4.166667	0.500000	0.120000
I	3.166667	0.500000	0.157895
J	5.166667	0.500000	0.096774
K	2.166667	0.500000	0.230769
L	3.166667	0.500000	0.157895
M	9.166667	0.833333	0.090909
N	8.166667	0.833333	0.102041
O1	2.166667	0.500000	0.230769
O2	2.166667	0.500000	0.230769
P1	2.166667	0.500000	0.230769
P2	2.166667	0.500000	0.230769
P3	2.166667	0.500000	0.230769
Q1	22.333333	1.666667	0.074627
Q2	22.333333	1.666667	0.074627
R1	3.166667	0.500000	0.157895
R2	3.166667	0.500000	0.157895
R3	3.166667	0.500000	0.157895
S1	2.166667	0.500000	0.230769
S2	2.166667	0.500000	0.230769
S3	2.166667	0.500000	0.230769
T1	3.166667	0.500000	0.157895
T2	3.166667	0.500000	0.157895
U	12.166667	1.166667	0.095890
V	12.166667	1.166667	0.095890
W1	8.166667	0.833333	0.102041
W2	8.166667	0.833333	0.102041
X	6.166667	0.833333	0.135135
Y	1.166667	0.166667	0.142857

Gantt Chart


Project Gantt Chart (Critical Path in Red)
1w
1m
6m
YTD
1y
all
Non-Critical
Critical
A (1d)
B (8d)
C1 (2d)
C2 (7d)
D (3d)
E (7d)
F (3d)
G (6d)
H (4d)
I (3d)
J (5d)
K (2d)
L (3d)
M (9d)
N (8d)
O1 (2d)
O2 (2d)
P1 (2d)
P2 (2d)
P3 (2d)
Q1 (22d)
Q2 (22d)
R1 (3d)
R2 (3d)
R3 (3d)
S1 (2d)
S2 (2d)
S3 (2d)
T1 (3d)
T2 (3d)
U (12d)
V (12d)
W1 (8d)
W2 (8d)
X (6d)
Y (1d)
Jan 2024
Feb 2024
Mar 2024
Apr 2024
May 2024
Jun 2024
Jul 2024
Date

Analysis Results

Critical Activities Analysis

This outlines the duration, impact level, and the earliest start (ES) and earliest finish (EF) times of all activities, helping identify the **critical path** affecting project progress.

1. CRITICAL ACTIVITIES ANALYSIS

Activity	Duration	Impact_Level	ES	EF
A	1	Low	0	1
B	8	Medium	1	9
C1	2	Low	9	11
C2	7	Medium	11	18
D	3	Low	18	21
E	7	Medium	21	28
F	3	Low	28	31
G	6	Medium	31	37
H	4	Low	37	41
I	3	Low	41	44
J	5	Low	44	49
K	2	Low	49	51
L	3	Low	51	54
M	9	Medium	54	63
N	8	Medium	63	71
Q1	22	High	71	93
Q2	22	High	93	115
R1	3	Low	115	118
R2	3	Low	118	121
R3	3	Low	121	124
T1	3	Low	124	127
T2	3	Low	127	130
U	12	High	130	142
V	12	High	142	154
W1	8	Medium	154	162
W2	8	Medium	162	170
X	6	Medium	170	176
Y	1	Low	176	177

Analysis Results

Resource Bottleneck Analysis

Highlights resource over-allocation issues during specific days, listing the concurrent activities and their associated **resource levels**.

This helps pinpoint areas requiring optimization.

```
2. RESOURCE BOTTLENECK ANALYSIS
----------------------------------------

Day 63: 4 concurrent activities
Resource Level: 3.0
Activities: M, N, O1, P1

Day 64: 3 concurrent activities
Resource Level: 3.0
Activities: N, O1, P1

Day 65: 5 concurrent activities
Resource Level: 3.0
Activities: N, O1, O2, P1, P2

Day 66: 3 concurrent activities
Resource Level: 3.0
Activities: N, O2, P2
```

Analysis Results

Resource Impact Analysis

- **Peak resource demand**: During days 63 to 66, we required 3 foremen and 6 workers to manage activity peaks
- **Average resource utilization**: 1 foremen and 2 workers per day, demonstrating effective resource allocation

```
Peak Resource Requirements:
Maximum Foremen needed: 3
Maximum Workers needed: 6

Average Resource Utilization:
Average Foremen per day: 1
Average Workers per day: 2

Resource Leveling Opportunities:
------------------------------------------------
Activity O1:
  Float available: 4 days
  Resources that could be shifted: 1 foremen, 2 workers
Activity O2:
  Float available: 4 days
  Resources that could be shifted: 1 foremen, 2 workers
Activity P1:
  Float available: 2 days
  Resources that could be shifted: 1 foremen, 2 workers
Activity P2:
  Float available: 2 days
  Resources that could be shifted: 1 foremen, 2 workers
Activity P3:
  Float available: 2 days
  Resources that could be shifted: 1 foremen, 2 workers
Activity S1:
  Float available: 3 days
  Resources that could be shifted: 1 foremen, 2 workers
Activity S2:
  Float available: 3 days
  Resources that could be shifted: 1 foremen, 2 workers
Activity S3:
  Float available: 3 days
  Resources that could be shifted: 1 foremen, 2 workers

Peak Resource Periods:
------------------------------------------------
Peak Foremen Usage occurs on days: [63 64 65 66]
Peak Workers Usage occurs on days: [63 64 65 66]
```

Analysis Results

Cost and Performance Impacts

- **Cost Performance Index (CPI):** 0.98, indicating stable cost control, delivering $0.98 of value per dollar spent.
- **Schedule Performance Index (SPI):** 0.33, reflecting the need for improvement in schedule adherence, though timeline compression has eased schedule pressure.

Analysis Results

- **The Estimate at Completion (EAC):** $197,936.49, exceeding the original budget by only $4,936.49.

```
EARNED VALUE ANALYSIS RESULTS
==========================================================================================
Budget at Completion (BAC): $193,000.00
Planned Value (PV): $193,000.00
Earned Value (EV): $62,750.00
Actual Cost (AC): $64,355.00

PERFORMANCE METRICS
--------------------------------------------------
Schedule Variance (SV): $-130,250.00
Cost Variance (CV): $-1,605.00
Schedule Performance Index (SPI): 0.33
Cost Performance Index (CPI): 0.98

FORECASTS
--------------------------------------------------
Estimate at Completion (EAC): $197,936.49
Variance at Completion (VAC): $-4,936.49
To Complete Performance Index (TCPI): 0.98

COST VARIANCE ANALYSIS
==========================================================================================

Activities with Significant Variances (>5%):
Activity  Budget  Actual  Variance  Variance_Pct       Status
       Y    1000     900       100     10.000000 Under Budget
       D    3000    2800       200      6.666667 Under Budget
       M    9000    9500      -500     -5.555556  Over Budget
       L    3000    3200      -200     -6.666667  Over Budget
      R1    3000    3200      -200     -6.666667  Over Budget
      T1    3000    3200      -200     -6.666667  Over Budget
      C2    7000    7500      -500     -7.142857  Over Budget
      C1    2000    2200      -200    -10.000000  Over Budget
      P3    2000    2200      -200    -10.000000  Over Budget
       A    1000    1200      -200    -20.000000  Over Budget

PROJECT PERFORMANCE ASSESSMENT
==========================================================================================
Schedule Performance: Behind Schedule
Cost Performance: On Budget

RECOMMENDATIONS
==========================================================================================
- Implement cost control measures
- Review cost overrun activities for optimization
- Accelerate critical activities
- Review resource allocation
```

Conclusions

- Resource utilization was **efficient** throughout the project.
- Adjustments were made to **optimize progress** during key periods.
- Critical activities were completed on time with **fewer delays**.
- Project timeline was **shortened**, resulting in significant time savings.

Thanks!