

ENCE 667
Project Performance
Measurement

Patuxent Water Treatment Plant
Upgrade schedule analysis

Presented by:

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Project Overview

- Location: Laurel, Maryland
- Total Cost: \$45 million
- Capacity: 56 MGD
- Owner: Washington Suburban Sanitary Commission
- Contractor: Danis Environmental Industries
- Phases: Stage I & Stage II

Stage I

- Demolition of Filter Unit 1
- Construction of 3 treatment trains
 - Flocculation Basin
 - Sedimentation Basin
 - Chlorine contact chamber
 - Deep bed filters
 - Backwash tank
 - Chemical feed system
- Duration: 385 working days

Stage I Existing Filter Unit



Stage I Demolition of Filter Unit



Stage I Construction of new process structure



Stage II

- Demolition of Filter Unit 2, 3 & 4
- Construction of 2 treatment trains
 - Flocculation Basin
 - Sedimentation Basin
 - Chlorine contact chamber
 - Deep bed filters
 - Backwash tank
 - Chemical feed system
- Duration: 650 working days

Purpose of the Upgrade

- Save \$24 Million using High-rate processes
 - Static Mixers for rapid mixing
 - Four-stage tapered-energy flocculation shaft
 - Sedimentation plate settlers
 - Granular activated carbon
 - Sand filters with air backwash
- Capable to run at 72-80 MGD in emergency situation

Project Objectives

- To complete Stage I at the minimum time/cost tradeoff.
 - Develop a CPM schedule
 - Determine Critical Path
 - Crash activities in the critical path
 - Estimate cost associated with crashing

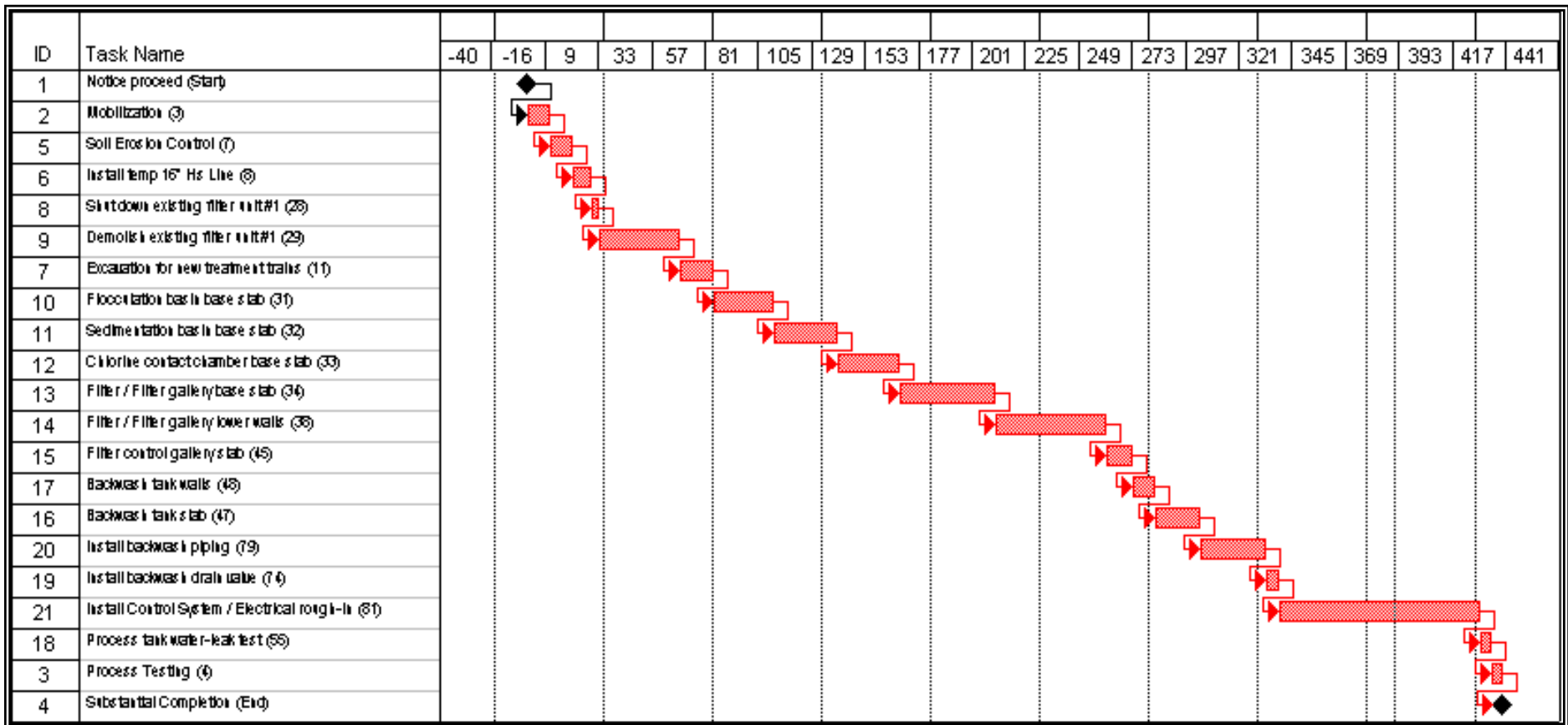
Project Performance Measurement Concepts Used

- CPM Schedule
- Gantt Chart
- Linear Programming
 - Minimize project cost
 - Obtain optimal crashing time
- Time/Cost trade-off curve

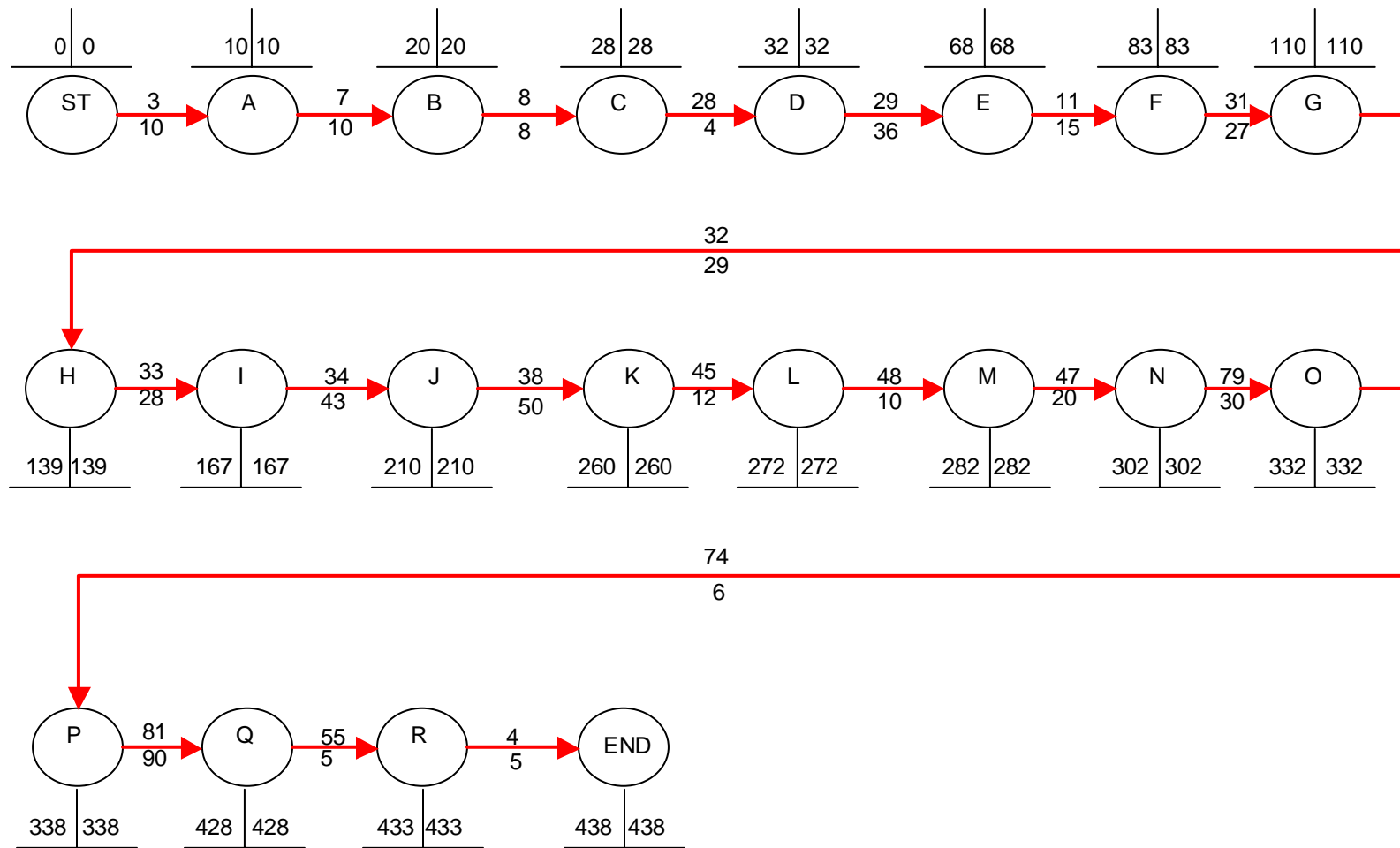
Project Activities

ID	Task Name	Duration	Predecessors
3	Mobilization	10	-
4	Process Testing	5	55
7	Soil Erosion Control	10	3
8	Install temp 16" Hs Line	8	7
11	Excavation for new treatment trains	15	29
28	Shut down existing filter unit #1	4	8
29	Demolish existing filter unit #1	36	28
31	Flocculation basin base slab	27	11
32	Sedimentation basin base slab	29	31
33	Chlorine contact chamber base slab	28	32
34	Filter / Filter gallery base slab	43	33
38	Filter / Filter gallery lower slab	50	34
45	Filter control gallery slab	12	38
47	Backwash tank slab	20	48
48	Backwash tank walls	10	45
55	Process tank water-leak test	5	81
74	Install backwash drain valve	6	79
79	Install backwash piping	30	47
81	Install Control System / Electrical rough-in	90	74

Project Schedule



AOA Diagram Original



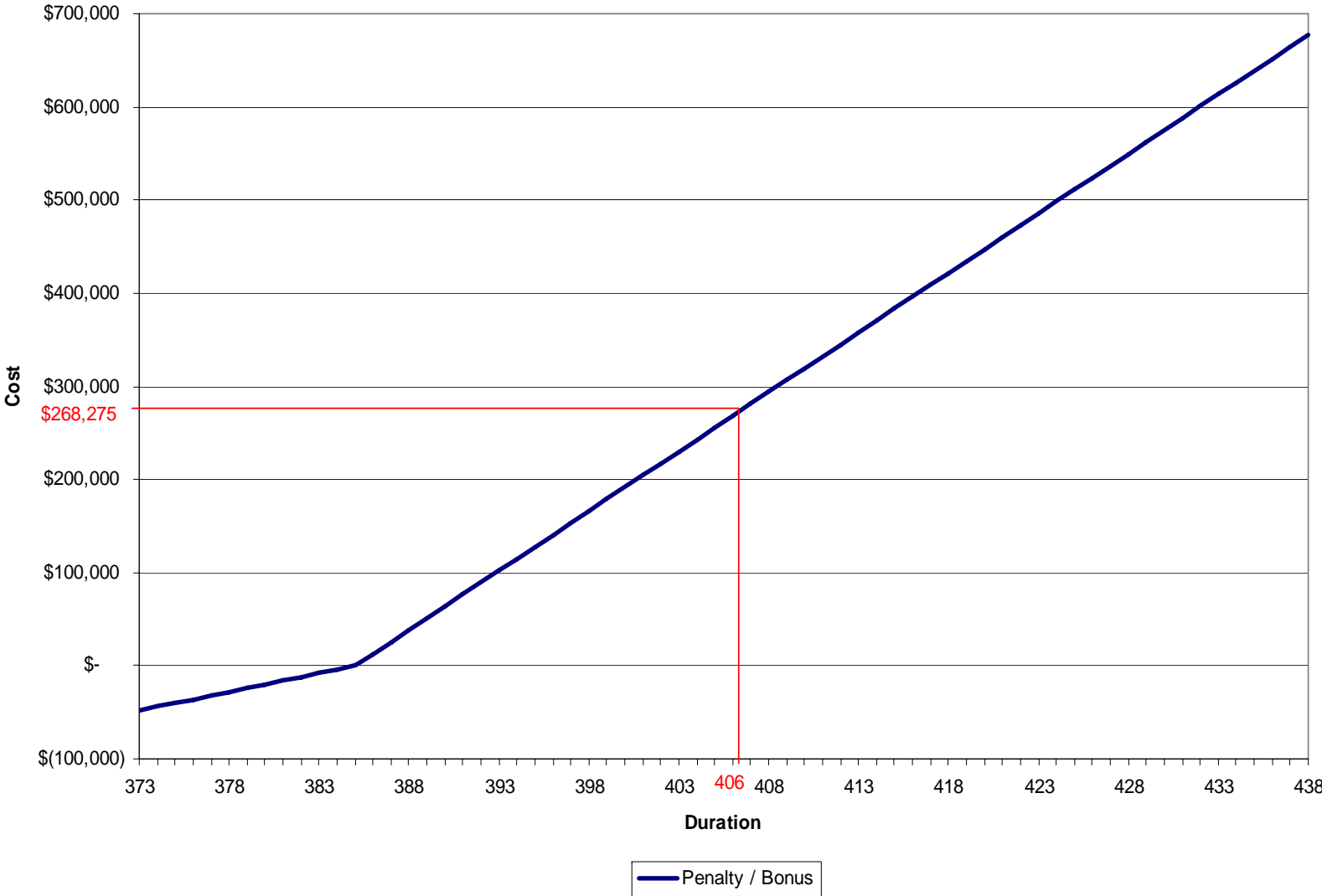
Project Crashing

- Estimated duration: 438 days
- Contractual required date: 385 days
- Difference: 53 days
- Penalty: \$12,775 per day
- Bonus: \$4,000 per day

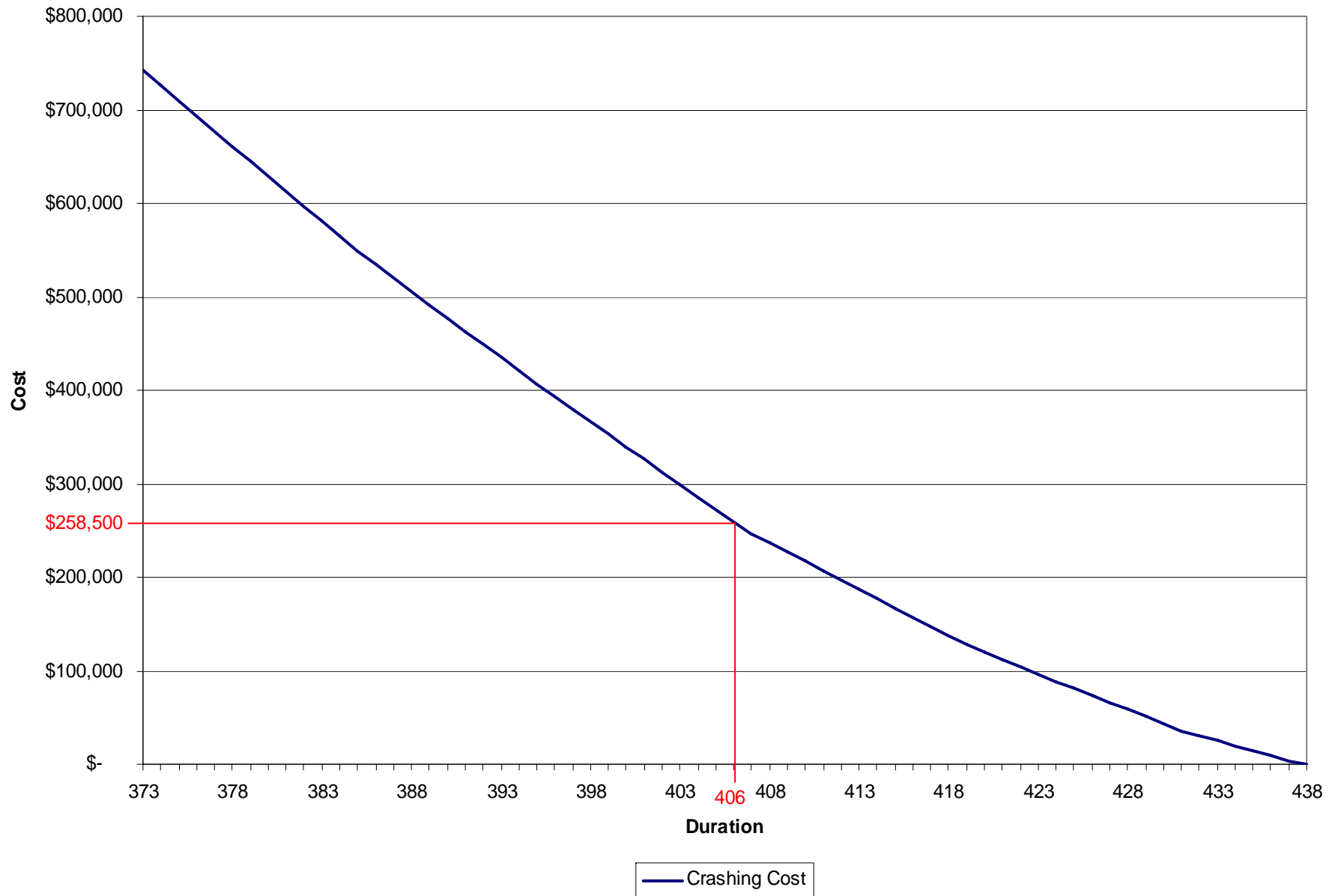
Project Crashing

Activity	Original Duration	Max. Crash duration	Cost per crash unit
3	10	2	\$ 8,000.00
4	5	1	\$ 5,500.00
7	10	1	\$ 8,000.00
8	8	3	\$ 13,500.00
11	15	3	\$ 16,800.00
28	4	0	\$ 12,000.00
29	36	5	\$ 14,500.00
31	27	5	\$ 7,500.00
32	29	5	\$ 14,000.00
33	28	2	\$ 5,000.00
34	43	8	\$ 13,500.00
38	50	9	\$ 15,850.00
45	12	1	\$ 10,000.00
47	20	3	\$ 5,500.00
48	10	1	\$ 4,000.00
55	5	1	\$ 9,500.00
74	6	1	\$ 11,500.00
79	30	4	\$ 7,500.00
81	90	10	\$ 10,000.00

Penalty/Bonus



Crashing Cost

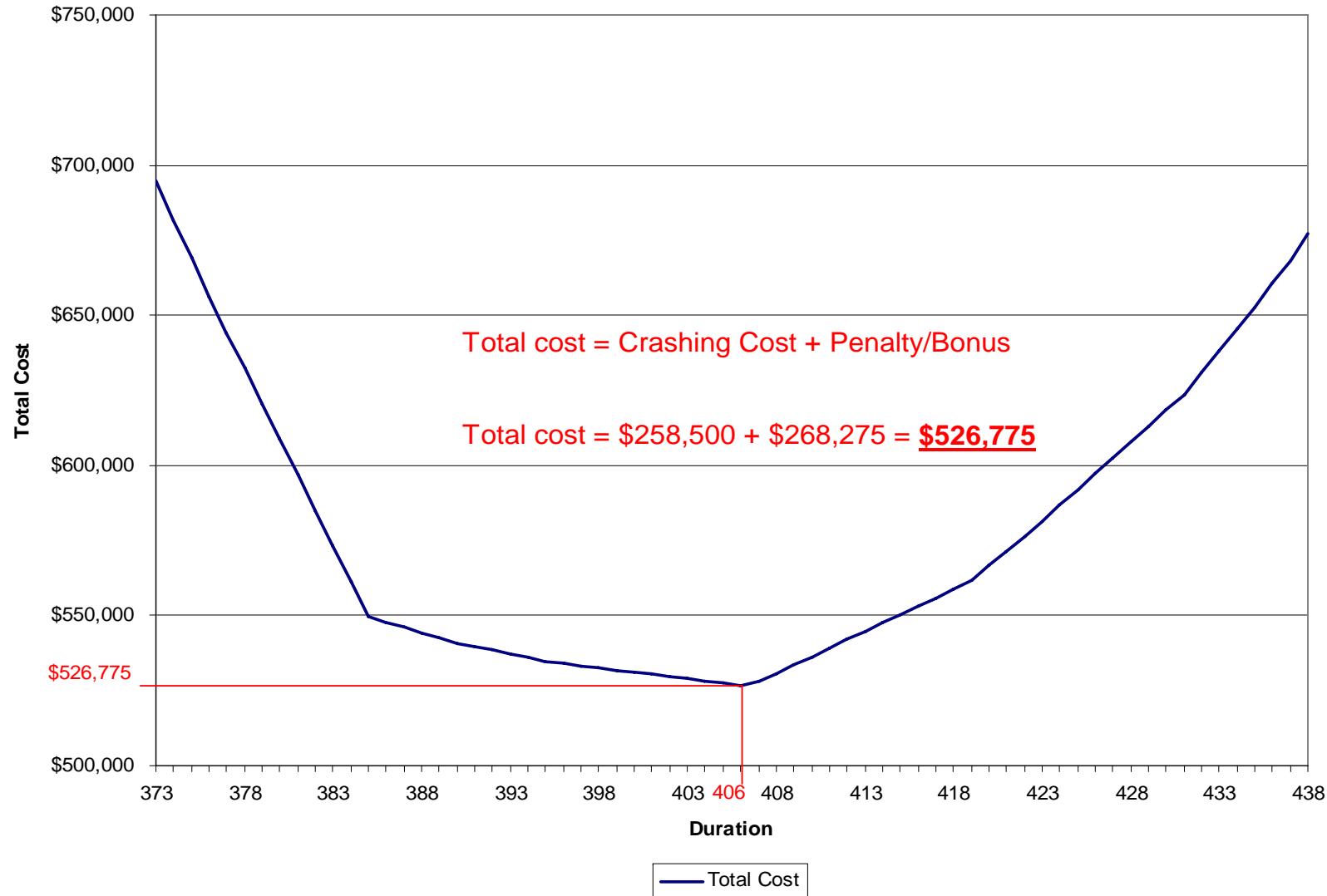


Project Crashing

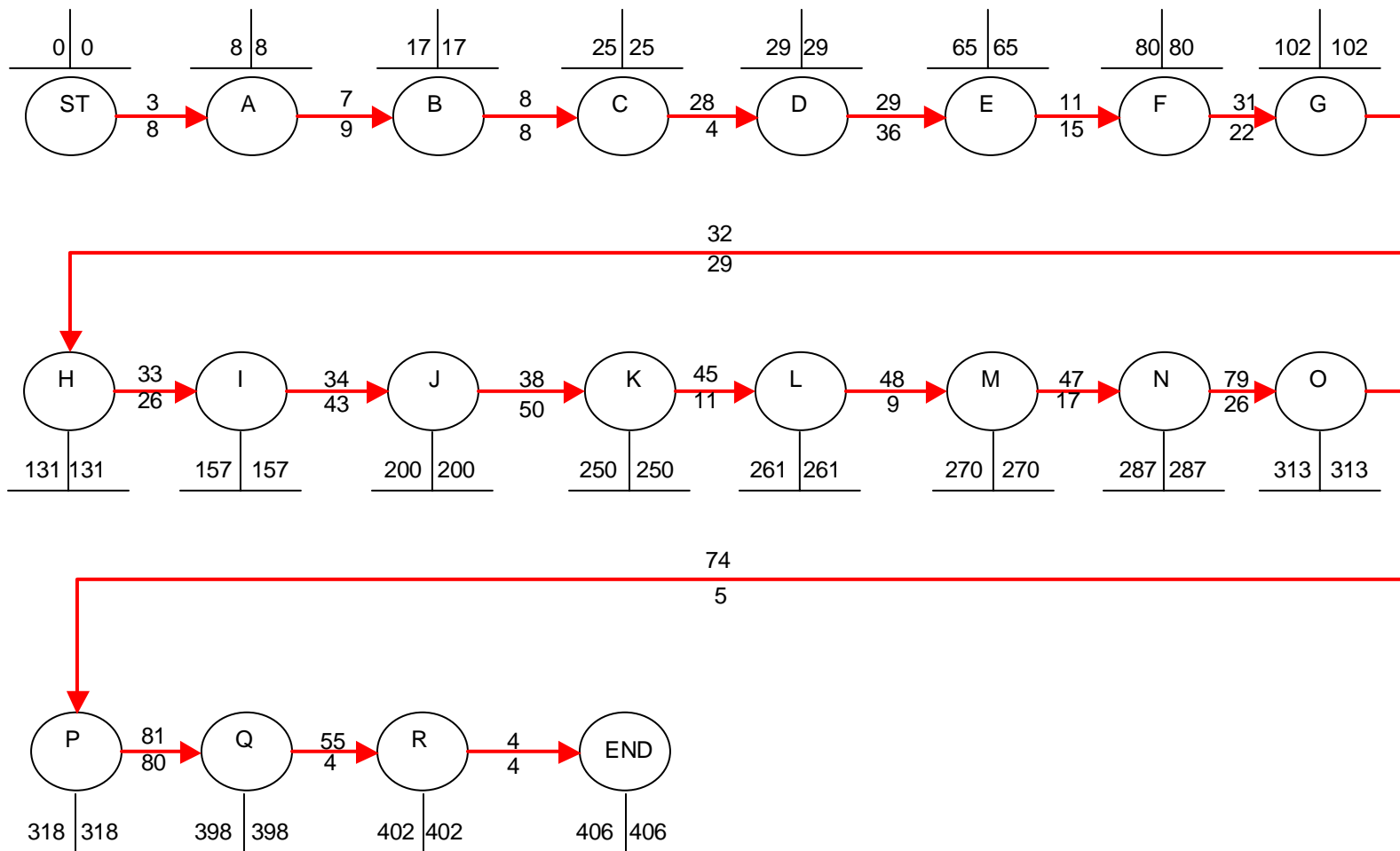
For optimal duration (406 days)

Activity	Original Duration	Max. Crash duration	Crash duration	Cost per crash unit	Crashing Cost
3	10	2	2	\$ 8,000.00	\$ 16,000.00
4	5	1	1	\$ 5,500.00	\$ 5,500.00
7	10	1	1	\$ 8,000.00	\$ 8,000.00
8	8	3		\$ 13,500.00	\$ -
11	15	3		\$ 16,800.00	\$ -
28	4	0		\$ 12,000.00	\$ -
29	36	5		\$ 14,500.00	\$ -
31	27	5	5	\$ 7,500.00	\$ 37,500.00
32	29	5		\$ 14,000.00	\$ -
33	28	2	2	\$ 5,000.00	\$ 10,000.00
34	43	8		\$ 13,500.00	\$ -
38	50	9		\$ 15,850.00	\$ -
45	12	1	1	\$ 10,000.00	\$ 10,000.00
47	20	3	3	\$ 5,500.00	\$ 16,500.00
48	10	1	1	\$ 4,000.00	\$ 4,000.00
55	5	1	1	\$ 9,500.00	\$ 9,500.00
74	6	1	1	\$ 11,500.00	\$ 11,500.00
79	30	4	4	\$ 7,500.00	\$ 30,000.00
81	90	10	10	\$ 10,000.00	\$ 100,000.00
Total	438	65	32		\$ 258,500.00

Sensitivity Analysis



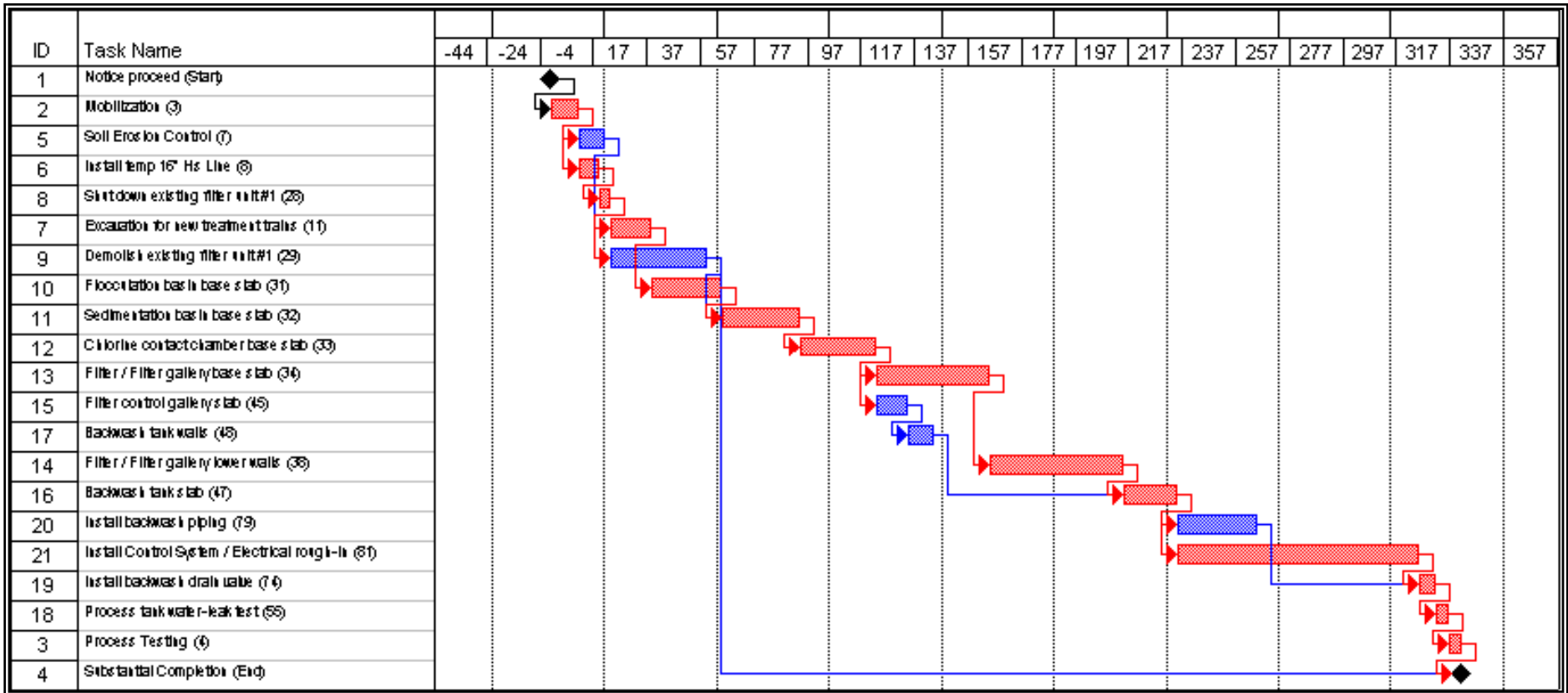
AOA Diagram Original – Crashed



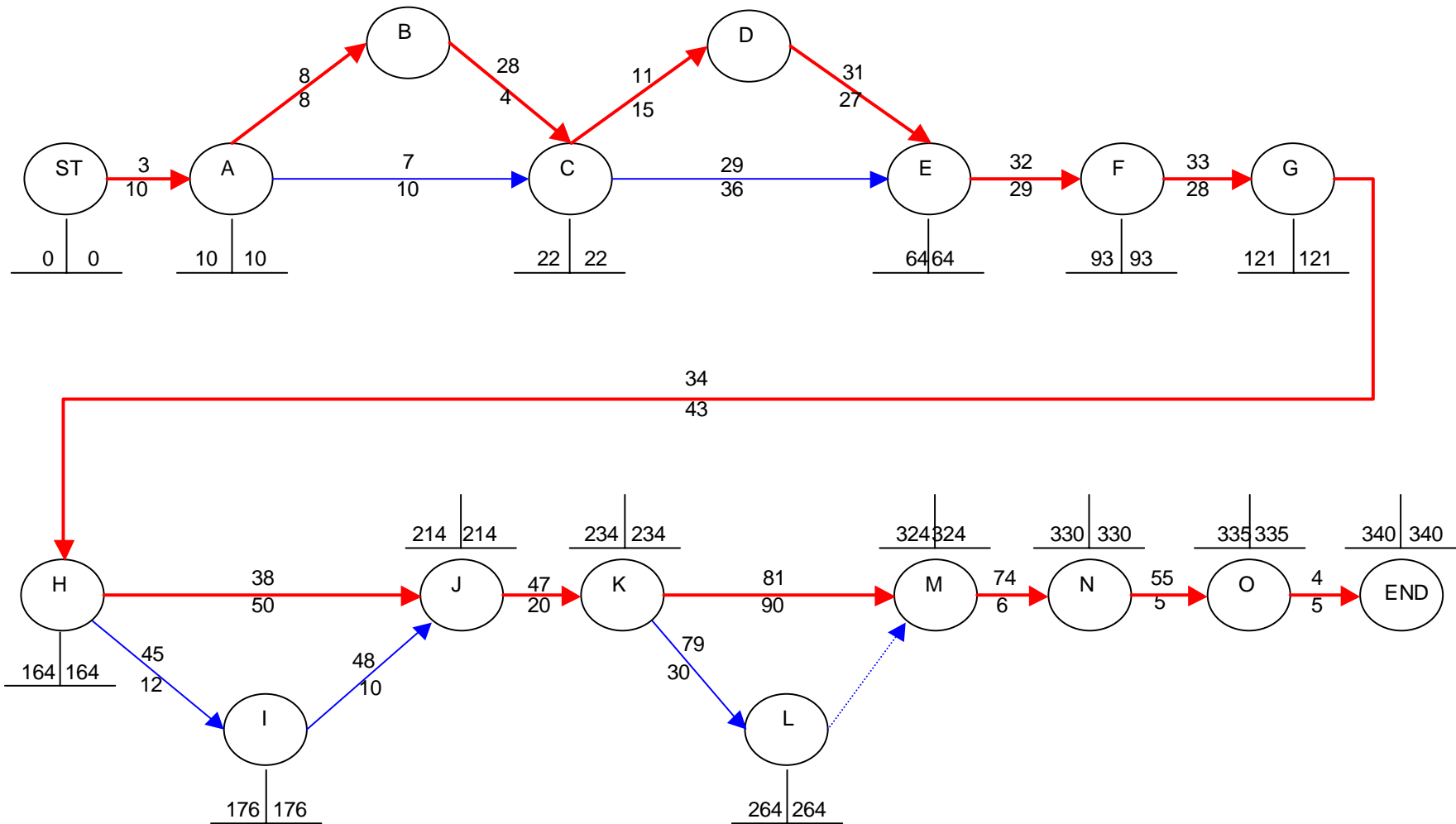
Schedule Alternative

- Some activities relations were changed in order to have parallel activities.
- Possible changes in the critical path.
- Estimated duration should decrease.
- Crashing: 53 days less than the estimated duration.

Project Schedule



AOA Diagram Alternative



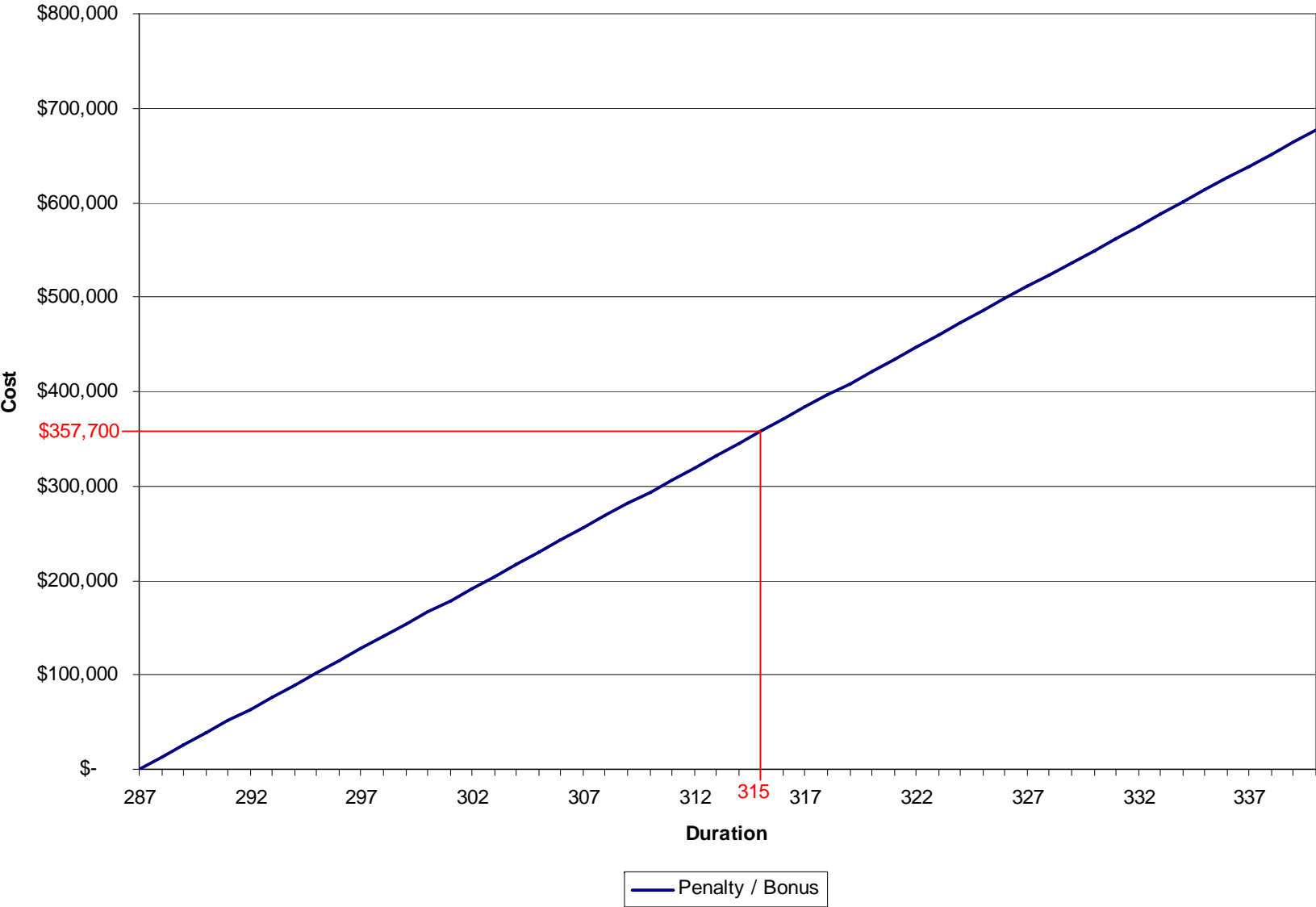
Project Crashing

For contractual date (287 days)

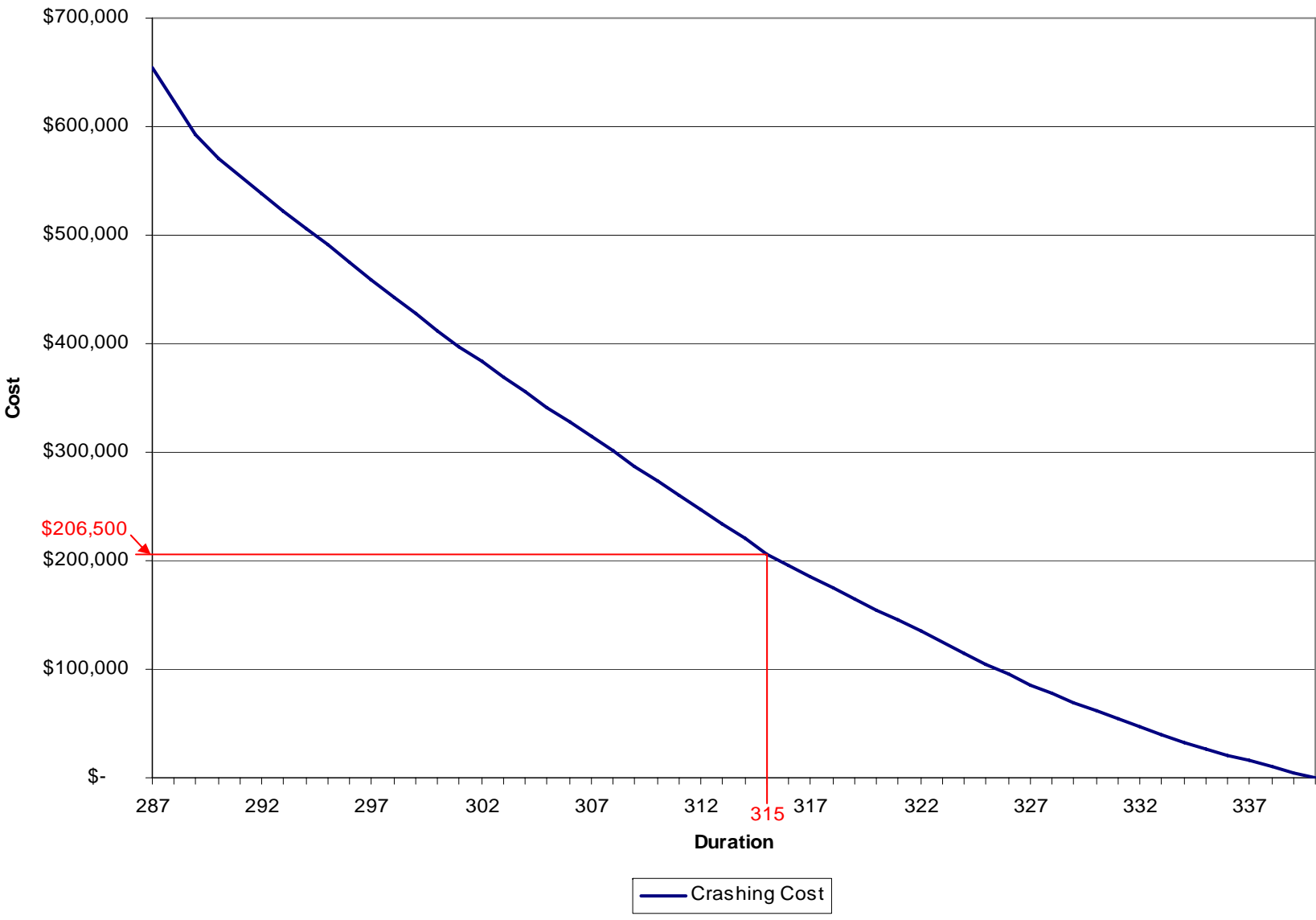
Contractual date = Estimated duration - 53 days = 287 days

Activity	Original Duration	Max. Crash duration	Crash duration	Cost per crash unit	Crashing Cost
3	10	2	2	\$ 8,000.00	\$ 16,000.00
4	5	1	1	\$ 5,500.00	\$ 5,500.00
7	10	1	1	\$ 8,000.00	\$ 8,000.00
8	8	3	3	\$ 13,500.00	\$ 40,500.00
11	15	3	3	\$ 16,800.00	\$ 50,400.00
28	4	0		\$ 12,000.00	\$ -
29	36	5	2	\$ 14,500.00	\$ 29,000.00
31	27	5	5	\$ 7,500.00	\$ 37,500.00
32	29	5	5	\$ 14,000.00	\$ 70,000.00
33	28	2	2	\$ 5,000.00	\$ 10,000.00
34	43	8	8	\$ 13,500.00	\$ 108,000.00
38	50	9	9	\$ 15,850.00	\$ 142,650.00
45	12	1		\$ 10,000.00	\$ -
47	20	3	3	\$ 5,500.00	\$ 16,500.00
48	10	1		\$ 4,000.00	\$ -
55	5	1	1	\$ 9,500.00	\$ 9,500.00
74	6	1	1	\$ 11,500.00	\$ 11,500.00
79	30	4		\$ 7,500.00	\$ -
81	90	10	10	\$ 10,000.00	\$ 100,000.00
Total			56		\$ 655,050.00

Penalty/Bonus



Crashing Cost



Sensitivity Analysis

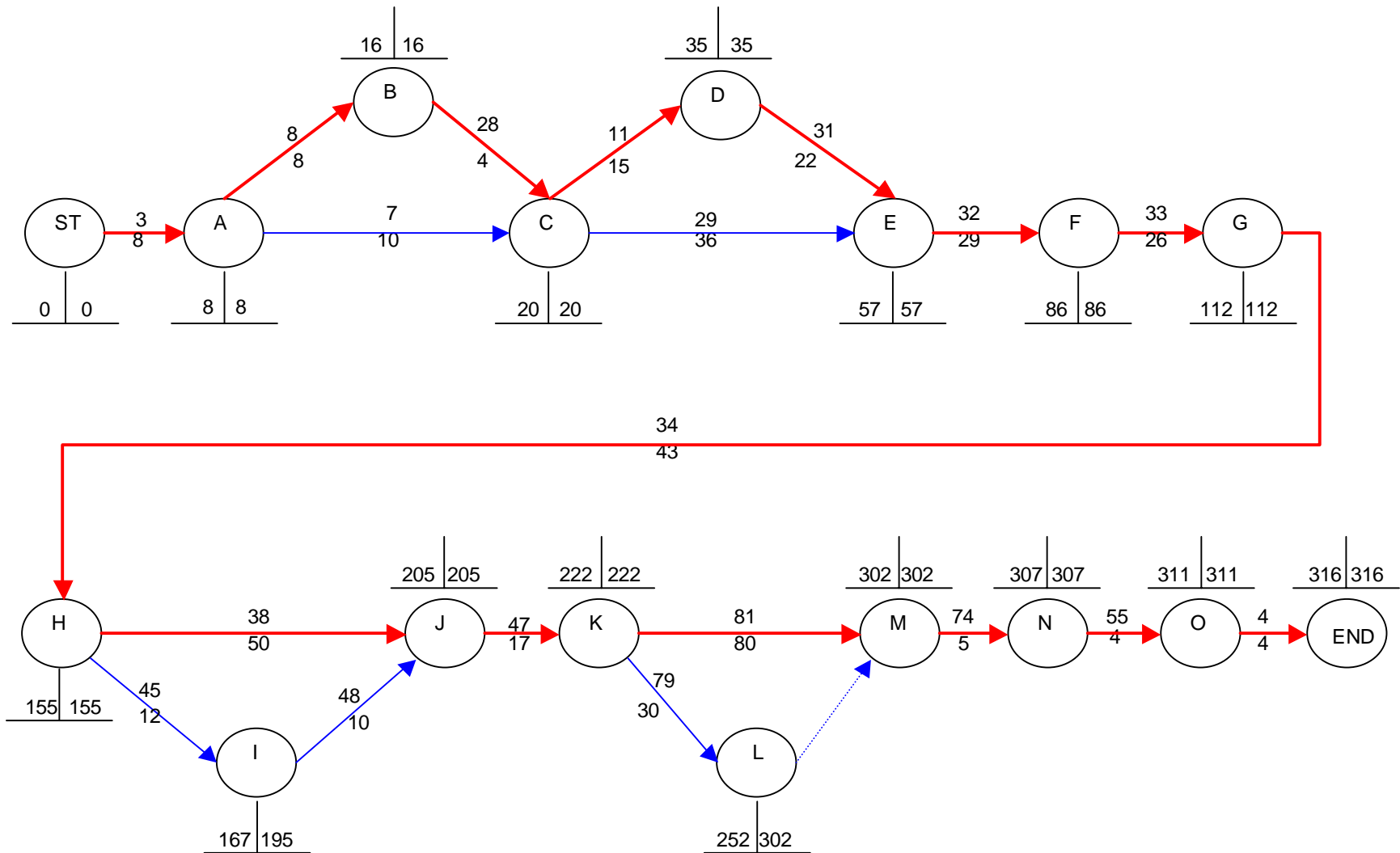


Project Crashing

For optimal duration (315 days)

Activity	Original Duration	Max. Crash duration	Crash duration	Cost per crash unit	Crashing Cost
3	10	2	2	\$ 8,000.00	\$ 16,000.00
4	5	1	1	\$ 5,500.00	\$ 5,500.00
7	10	1		\$ 8,000.00	\$ -
8	8	3		\$ 13,500.00	\$ -
11	15	3		\$ 16,800.00	\$ -
28	4	0		\$ 12,000.00	\$ -
29	36	5		\$ 14,500.00	\$ -
31	27	5	5	\$ 7,500.00	\$ 37,500.00
32	29	5		\$ 14,000.00	\$ -
33	28	2	2	\$ 5,000.00	\$ 10,000.00
34	43	8		\$ 13,500.00	\$ -
38	50	9		\$ 15,850.00	\$ -
45	12	1		\$ 10,000.00	\$ -
47	20	3	3	\$ 5,500.00	\$ 16,500.00
48	10	1		\$ 4,000.00	\$ -
55	5	1	1	\$ 9,500.00	\$ 9,500.00
74	6	1	1	\$ 11,500.00	\$ 11,500.00
79	30	4		\$ 7,500.00	\$ -
81	90	10	10	\$ 10,000.00	\$ 100,000.00
Total			25		\$ 206,500.00

AOA Diagram Alternative – Crashed



Conclusions

- Optimal duration should be 406 days
 - Cost: \$526,775
- When estimating the project bid, scheduling analysis should be performed to evaluate the necessity of crashing the project. If that is the case, the cost should be included in the bid.

Future Extensions

- PERT Analysis
- Limited resources allocation

Questions

