Objective

The term project will allow you to directly apply one or more advanced methods to address a multi-project management problem in a practical setting, as introduced below. The project's objective is for you to leverage the theoretical aspects of project management learned in class and beyond, place project management in a realistic context of an infrastructure operations and maintenance organization, and gain project management experiences from collaborating with your peers.

Problem Statement

Limited project execution resources available (mainly specialist crews and major equipment) pose significant challenges for planning and scheduling infrastructure operations and maintenance projects. These resources are shared to serve multiple projects, making it challenging to allocate available crews to specific projects subject to resource availability limits as well as contractually obligated constraints such as projects' deadlines and delay penalties. Operation and maintenance of the municipal sewer and water mainline infrastructure is critical for providing essential services to the public. The project management team is tasked with scheduling projects to ensure timely project deliveries and achieve high levels of resource utilization efficiency and client satisfaction.

In operating an extensive network of water and sewer lines, three categories of projects are defined as follows.

1. **Client-demanded Projects**: this category comprises new water and sewer line installations or repairs demanded by clients. Houses, hospitals, institutional, commercial, and industrial premises are connected to a city water/sewer system (mainlines and branch lines).
2. **Prioritized Projects:** the maintenance department inspects and monitors the infrastructure network to identify defects and dysfunctions and plan many projects with various priorities. If residents encounter any issues with their area's sewer or water mainline, such as leaks, blockages, or damage, they promptly report to the City through the official website or a dedicated hotline. Formally assessed risk levels as well as regulatory deadlines are considered in setting the priority index of a project. For instance, those projects that pose lower risks to disrupt the public are scheduled to a later time window.
3. **Emergency Projects:** Emergencies can be collapsed or broken pipes, sewer backups, lost services, and unexpected floods. Emergency projects call for an immediate response; the project team is required to respond promptly (i.e., within 2 hours), aiming to minimize disruptions to residents and businesses by completing the work within 72 hours.

Full-time professional construction crews are each equipped with the required machinery and tools such as Backhoes and trucks. Your team is assigned for project planning, including scheduling and allocating the crews to deliver the projects.

Assignment A) As mentioned above, projects prioritization follows formal field hazard evaluation and risk analysis (this is out of the scope of Term Project). Table 1 shows the scale of priority index (PI).

Table 1: Priority Scale for prioritizing projects

Top	High	Normal	Low	Lowest
1	2	3	4	5

Eight fulltime crews are available as per Table 2 to complete the projects as listed in Table 3. Project data is updated at the end of September 2023. The column "Date Ready" represents the date on which site is ready for construction. Consider a standard calendar five days week with 8 hrs. /day with all statuary holidays being non-working days for all the crews.

Table 2: crews' availability within a three-weeks planning horizon

Crew_ID	Cr_01	Cr_02	Cr_03	Cr_04	Cr_05	Cr_06	Cr_07	Cr_08
Availability	15	15	15	14	15	15	14	15

Table 3: Projects' input data for October 2023

#Project	Site ID	Duration	Date Ready	Deadline	PI$_j$
1	3	2	02-10-2023	16-10-2023	2
2	5	2	02-10-2023	16-10-2023	1

3	6	2	02-10-2023	16-10-2023	1
4	4	3	02-10-2023	17-10-2023	4
5	3	2	02-10-2023	17-10-2023	3
6	7	2	03-10-2023	17-10-2023	2
7	3	3	03-10-2023	18-10-2023	2
8	7	2	03-10-2023	18-10-2023	1
9	4	3	03-10-2023	18-10-2023	1
10	3	2	03-10-2023	17-10-2023	1
11	4	3	04-10-2023	18-10-2023	3
12	6	2	04-10-2023	19-10-2023	4
13	4	2	03-10-2023	18-10-2023	4
14	8	2	02-10-2023	18-10-2023	1
15	6	1	05-10-2023	19-10-2023	3
16	9	2	04-10-2023	19-10-2023	2
17	9	2	03-10-2023	19-10-2023	2
18	8	2	04-10-2023	19-10-2023	3
19	10	2	02-10-2023	19-10-2023	3
20	7	2	05-10-2023	19-10-2023	3
21	4	3	05-10-2023	19-10-2023	3
22	1	3	05-10-2023	19-10-2023	2
23	2	1	02-10-2023	19-10-2023	2
24	5	3	02-10-2023	19-10-2023	2
25	9	3	04-10-2023	20-10-2023	4
26	7	3	06-10-2023	20-10-2023	2
27	3	2	06-10-2023	20-10-2023	4
28	6	3	02-10-2023	20-10-2023	4
29	5	2	04-10-2023	20-10-2023	3
30	2	2	04-10-2023	20-10-2023	3
31	3	2	05-10-2023	20-10-2023	3
32	9	2	02-10-2023	20-10-2023	2
33	1	2	02-10-2023	20-10-2023	2
34	8	3	02-10-2023	20-10-2023	1
35	9	2	06-10-2023	20-10-2023	3
36	1	2	03-10-2023	20-10-2023	4
37	10	2	05-10-2023	21-10-2023	3
38	7	3	05-10-2023	21-10-2023	3
39	10	2	07-10-2023	21-10-2023	2
40	2	3	06-10-2023	20-10-2023	3
41	10	2	06-10-2023	21-10-2023	3
42	2	3	09-10-2023	22-10-2023	4
43	5	2	09-10-2023	21-10-2023	2
44	7	2	10-10-2023	24-10-2023	1
45	6	2	07-10-2023	21-10-2023	3
46	4	2	05-10-2023	21-10-2023	1
47	3	2	07-10-2023	21-10-2023	2
48	1	2	12-10-2023	21-10-2023	2
49	2	2	09-10-2023	21-10-2023	1
50	8	3	09-10-2023	21-10-2023	1
51	3	3	10-10-2023	21-10-2023	1
52	9	2	10-10-2023	22-10-2023	4
53	7	3	09-10-2023	22-10-2023	4

54	4	3	09-10-2023	22-10-2023	3
55	3	3	09-10-2023	22-10-2023	2
56	5	2	08-10-2023	22-10-2023	2
57	4	2	09-10-2023	22-10-2023	1
58	7	2	10-10-2023	23-10-2023	4
59	8	1	10-10-2023	23-10-2023	4
60	3	2	08-10-2023	23-10-2023	3
61	3	3	10-10-2023	23-10-2023	3
62	7	1	08-10-2023	23-10-2023	2
63	9	2	12-10-2023	23-10-2023	2
64	6	3	12-10-2023	23-10-2023	1
65	8	2	11-10-2023	23-10-2023	1
66	4	2	12-10-2023	23-10-2023	1
67	9	3	10-10-2023	23-10-2023	1
68	8	2	12-10-2023	24-10-2023	3
69	6	2	12-10-2023	24-10-2023	3
70	8	2	13-10-2023	25-10-2023	3
71	9	1	14-10-2023	24-10-2023	2
72	7	2	14-10-2023	24-10-2023	2
73	6	3	09-10-2023	24-10-2023	5
74	6	2	10-10-2023	24-10-2023	3
75	7	3	10-10-2023	25-10-2023	2
76	8	3	10-10-2023	25-10-2023	3
77	5	1	11-10-2023	25-10-2023	3
78	4	3	12-10-2023	26-10-2023	2
79	7	2	12-10-2023	26-10-2023	1
80	2	3	12-10-2023	26-10-2023	1
81	10	1	12-10-2023	27-10-2023	3
82	1	3	16-10-2023	27-10-2023	1
83	8	1	16-10-2023	28-10-2023	4
84	10	2	16-10-2023	28-10-2023	4
85	2	3	16-10-2023	28-10-2023	1

Assumptions:

- Note that projects are independent of one another with no dependency or precedence relationship.
- Each crew can perform at most one project at a time, each project requires the allocation of one crew for construction. Therefore, each project client is served by exactly one crew.
- Each crew carries the required tools and materials to the site at the beginning of each workday on a particular project.

Question_1: plan and schedule the above projects as many as possible in the next three weeks so that the projects meet their deadlines and project priority index is considered. No project should be scheduled beyond its deadline. Plan as many higher priority projects in the schedule as practically possible. Please provide reasonings as well as calculations to account for your project plan and schedule.

Question_2: propose a solution to schedule the remaining "unplanned" projects either by extending the planning horizon or allowing overtime (allowed overtime is max 2 hrs./day for each crew).

Question_3: Assume the fieldwork is progressing as per planned. However, on October 10 there is an emergency project that is estimated to take 2 days. How do you respond to this emergency in your plan.

Assignment B) Regarding the first category of projects requested by clients (mainly commercial, business, or educational projects), it is crucial to note that delays beyond the agreed-upon due dates are subject to penalties. If the delays exceed a specific limit outlined in the contract, the client reserves the right to terminate the contract and receive

liquidated damages. Consequently, it is crucial to avoid or reduce potential financial, contractual, and legal consequences in planning and scheduling. Now only consider projects with the input data given in Table 4.

Table 4: Projects data for the case example

Project Id.	Duration (Day)	Due Date (Day)	Deadline (Day)	Contract Price	Delay Penalty/Day	Liquidated Damage
1001	4	12	18	$ 10,000	$ 1,000	$ 12,500
1002	5	15	19	$ 15,000	$ 1,050	$ 18,750
1003	2	10	15	$ 9,000	$ 750	$ 11,250
1004	3	11	15	$ 10,000	$ 1,000	$ 12,500
1005	4	12	16	$ 12,000	$ 900	$ 15,000
1006	2	10	15	$ 10,000	$ 800	$ 12,500
1007	2	10	15	$ 10,000	$ 800	$ 12,500
1008	3	12	18	$ 11,000	$ 950	$ 13,750
1009	2	10	15	$ 10,000	$ 900	$ 12,500
1010	2	10	15	$ 10,000	$ 900	$ 12,500
1011	3	12	17	$ 11,000	$ 950	$ 13,750
1012	4	15	21	$ 12,500	$ 1,100	$ 15,625
1013	2	10	16	$ 10,000	$ 900	$ 12,500
1014	3	12	16	$ 10,000	$ 900	$ 12,500
1015	2	14	16	$ 8,500	$ 900	$ 10,625
1016	3	15	20	$ 9,500	$ 1,000	$ 11,875
1017	2	12	17	$ 8,500	$ 850	$ 10,625
1018	2	10	15	$ 9,000	$ 950	$ 11,250
1019	3	13	19	$ 10,000	$ 1,000	$ 12,500
1020	2	11	15	$ 9,000	$ 950	$ 11,250

Your team is required to plan the projects for a three-week window. Assume all the projects are ready for construction and three construction crews are readily available as per Table 5.

Table 5: Crew availability (day) on three weeks planning horizon

Crew Id.	Cr_01	Cr_02	Cr_03
Capacity	15	14	15

Each project only requires one construction crew, and no work interruption is allowed.

Deliverables and deadlines

Term project deliverables and deadlines are listed in the following table.

No.	Deliverable name	Deadline	Basic Requirements
1	Project Update	Oct.11	A written project update (minimum 500 words) in pdf
2	Progress update	Nov.02	A written project update (minimum 500 words) in pdf
3	Final Presentation	Nov.22	Video presentation limited to 10 Minutes
4	Final Report	Dec.01	Well-structured report in pdf including approach, solution, results, conclusion, clearly stated contribution of each member, and original files such as Excel files/any other tool used in the zipped folder