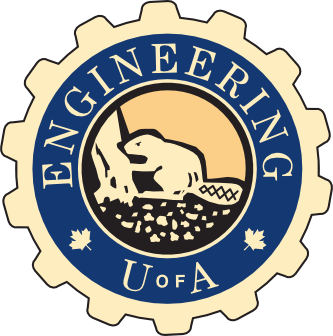
**CIV E 601**

**TERM PROJECT**

**Progress Report**



**Presented By:**

**Lily Ren, Suzana Trac, Haoran Liang, Owen Zhao**

# Introduction

Group 7 is pleased to submit the following update per the ‘Term Project Statement and Specifications’ document uploaded on e-class. This document provides a high-level update on approaches considered for implementation on the group project. The group continues to work diligently to complete this project.

# Project Update (Assignment A)

## Question 1 and 2

Further research and discussion following the initial project update has yielded a deeper understanding of Questions 1 and 2 in Assignment A as posed by the term project. Per the information provided, it is understood that a solution is desired to address a Resource-Constrained Multi-Project Scheduling Problem (RCMPSP), in which resource constraints and prescribed timelines limit the projects that can occur within specific time periods. Projects are each assigned a priority of *PIj* corresponding to their importance and/or urgency.

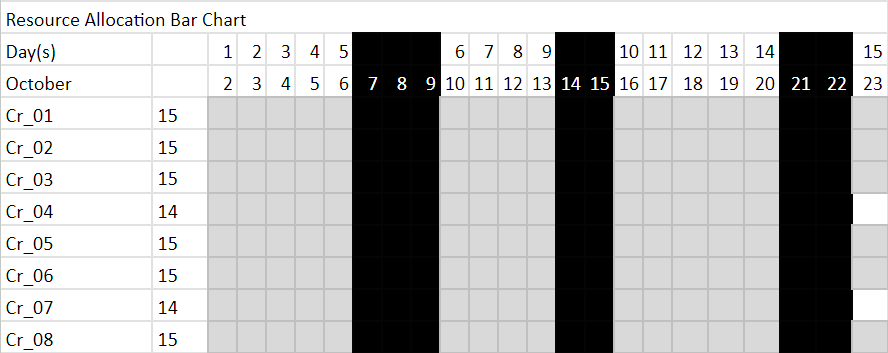
There are numerous literature methodologies to approach RCMPSPs. This assignment is different from the norm where the priorities of projects have already been provided. Noting that project selection and timelines specified by the date ready and deadline dates are key factors in determining which projects (within the overall portfolio of projects) will be scheduled, the goal of the exercise is to find a feasible schedule that will (1) optimally allocate constrained resources to select projects within the 3 week period as per Question 1, and (2) while reducing overall portfolio duration for Question 2.

Based on Browning & Yassine [1], static RCMPSP is evaluated as follows:

* A set of projects is defined as *l* = 2,..., *L*
* Each project consists of *i* = 1, …, *Nl* activities
* Each activity’s duration is specified as *d*
* Each activity requires *rjk* units of resources of resource type *k∊K* during it duration
* Resource *k* has a renewable capacity of *Rk*
* At any time, if a set of non-precedence constrained activities requires more than *Rk* for any *k*, then some activities will be delayed

Assignment A has a *l* = 85 projects in a portfolio and does not dive into each project and its activities. We can assume each project in the portfolio as an activity in one mega-project. Predecessor-successor relationships for these projects/activities are not provided and therefore they can be considered as non-precedence constrained activities. A standard 8-hour per day, 5 days per week working calendar is assumed for all activities in Assignment A.1.

For part 1 of Assignment A, *ΣRk* = 118 days with 8 resources (crews) over the course of the three-week planning window. However, the project durations are summed at *Σd* = 146 days before the October 23, 2023 deadline. This means some projects will be delayed and not meet the October 23, 2023 deadline. We will be exploring the extension of the planning horizon and the extension of the working hour from 8 to 10 hours per crew per day in Question 2 to address these projects.



For Question 2 of Assignment A, *ΣRk* = 158 days with 8 resources (crews) over the course of a four-week planning window. The project durations are summed at *Σd* = 191 days for all 85 projects before the October 28, 2023 deadline. This means that some activities will be delayed even if the planning horizon is extended for one more week. We also investigated the hours required in order to complete all of the projects, which comes to a total of 1528 hours assuming 8 hours worth of work per day. Further work is needed to determine the best way to schedule the rest of the projects.

The following constraints and considerations imposed upon the portfolio of projects in Assignment A:

* Assigned priorities *PIj* on each project
* Date in which the project site becomes available and deadlines on each project, which represent both the Early Start and Late Finish
* The data provided allows for the calculation of slack through *SLK=LS-ES*, where ES represent the earliest start time of a project and LS represent the latest start time of a project and prioritization based on slack priority where an index is determined by slack divided by max slack [2]
* Resource availability and capacity, i.e. the number of days that a crew is available for during the three-week period

Our goal is to employ a simple, elegant, and practical method to optimize the amount of high priority projects completed within the three-weeks duration, while minimizing delays per Question 1, and extend the methodology to schedule the remainder of unscheduled projects in Question 2.

The proposed steps for the order of project selection are as follows:

* First consider the assigned priority on each project
* For all projects with the same priority, consider the projects with the minimum slack
* For all projects with the same priority and slack, consider the projects with the earliest deadline
* Assign the nearest available crew to said project and repeat the prioritization process

## Question 3

The scenario posed by Question 3 is understood to be a reactive scheduling problem in which the baseline schedule (previously completed in Questions 1 and 2) is updated due to a disruption event, which, in this case, is the addition of a new project. While there are a number of papers outlining reactive scheduling methods due to activity duration and resource availability as sources of uncertainty, there is a lack of literature specifically relating to new project arrival [4]. Literature reviewed for new project arrival required rigorous mathematical computations as part of the rescheduling process [4].

As such, for simplicity, Group 7 will opt to employ the complete rescheduling method as the reactive procedure to solve this problem [5]. This involves complete regeneration of a new up-to-date schedule after occurrence of the disruption event [5]. This method has also been proven to excel in makespan performance compared to other reactive scheduling methods [4].

Rescheduling is done by following the methodology utilized to address Questions 1 and 2 on a modified project network in which projects that are already finished by October 10 are omitted from the original project network [5]. Projects that have already started by October 10 but are not yet completed are kept in the network with the projected remainder of the project duration as their planned duration, assuming that the remaining duration is known when a project is not completed at a particular time [5]. The emergency project is assigned the highest priority (priority 1) and is assumed to be able to occur concurrently with other projects. For simplification, it is also assumed that projects currently in progress on October 10 can be delayed to accommodate resource allocation to the emergency project, with no additional time required for start-up and remobilization should the project be completed at a later time.

## 

## Assignment A - Alternative Methodology

Another methodology is being explored with the development of an algorithm to optimize the ordering of projects with the following considerations:

**QA\_1: Enhancing Schedule**

1. **Constraints Introduction.** Identify constraints: Planning time duration, crew availability, exclusion of weekends and holidays, and ensuring project integrity. Emphasize the utmost importance of these constraints.
2. **Schedule Evaluation.** Traverse all potential schedules and compute *ΣPIj* (where *j* represents a specific project) for each schedule.
3. **Identifying the Best Schedule.** Determine the schedule with the highest *ΣPIj* as the best schedule.

**QA\_2: Handling Unplanned Projects**

1. **Adjustment of Unplanned Projects.** Schedule the remaining "unplanned" projects by either extending the planning horizon.
2. **Setting a Standard.** Define Project *k* as a delayed project. Find the schedule with the minimum *ΣPIk*.
3. **Improving Efficiency.** Enhance the schedule considering the delayed project, aiming for the schedule with the least overall *ΣPIk*.

**QA\_3: Additional Constraint Inclusion**

1. **New Constraint Introduction.** Incorporate an additional constraint: One crew must allocate 2 days starting from October 10 for an emergency project.

# Project Update (Assignment B)

In Assignment B, Group 7’s goal is interpreted as scheduling multiple resource-constrained projects in order to minimize liquidated damages (LDs) and other delay costs. A resource price-based priority rule developed by Lawrence and Morton [6], can be adapted to form the basis of the scheduling process. This method has been proven to provide schedules with significantly lower average costs for weighted scheduling problems compared to other heuristic methods introduced in literature [6].

The priority rule used to determine project scheduling priorities minimizes the sum of project delay costs, weighted per project importance [6]. A weighted slack-based scheduling rule has been adapted to multi-project scheduling with resource pricing, and assuming that the duration of a project is equivalent to its cost, the scheduling rule can be shown here:

[6]

Where is the penalty costs for each time unit it is delayed by, is the average durations of all projects, is the project duration (which is assumed to be proportional to crew usage), is the latest starting date for a project prior to incurring delay costs, is the date currently being scheduled, and is an empirically determined planning parameter. For this problem, is taken to be 12 as literature has indicated this value resulted in best overall performance [6].

The priority rule indicated above essentially serves as a cost-benefit rule that compares the estimated cost of delaying a project to the resource savings realized by delaying its start [6]. A project that is not started by will incur delay costs of per day [6]. Projects with positive slack ( > 0) may be unable to be scheduled prior to due to resource constraints, and are charged a discounted delay look-ahead penalty that decays to 0 as slack goes to infinity [6]. Opportunity costs, that are assumed to be proportional to the project duration in this case, balance the potential delay costs by representing the cost of using resources required to complete project *ij* [6]. [6].

## Assignment B - Alternative Methodology

For simplicity and ease of implementation, an alternative approach is also being explored for Assignment B and may be employed pending additional consideration and evaluation:

1. **Constraints Introduction.** Highlight constraints: Planning time duration, crew availability, and exclusion of weekends and holidays as primary considerations.
2. **Evaluation Metric.** Calculate *W* for each potential schedule to maximize profits to the firm and minimize delay costs: *W = Σ Contract Price - Σ Delay Penalty - Σ Liquidated Damages*.
3. **Selection of the Best Schedule.** Determine the schedule with the highest value of *W* as the best schedule, indicating its optimal feasibility and profitability.

# Conclusion

Group 7 would like to thank the instructor and TA’s time in reviewing this project update, and the group looks forward to completing the project assignments per an optimal methodology selected from those outlined above. Should there be any questions, please do not hesitate to contact any group member.

Regards,

| Lily Ren |  |
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| Suzana Trac |  |
| Haoran Liang |  |
| Owen Zhao |  |

# References

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