

Explosive Ordinance Disposal Resource Constrained Training - Executive Summary

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Introduction

1. The Explosive Ordinance Disposal Training and Evaluation Unit Two (EODTEU TWO) conducts platoon training courses based on specialty requirements. Each course consists of several modules, such as Nuclear, Chemical and First Aid. Each module has constraints such as prerequisites, calendar training days, and resource requirements. The availability of these resources has a direct impact on the conduct of training. For example, if module A requires 10 resources, but only 8 are available on a particular day, then module A cannot be conducted on that day. This paper serves as a proof on concept in problem formulation on a method to solve the EODTEU TWO resource constrained training allocation problem.

Aim

2. This executive summary aims to:
- a. Identify the optimal training plan that minimizes total number of training days.
 - b. Present the scheduling delays incurred when resources are attacked.
 - c. Identify resources whose unavailability would adversely affect completion time.
 - d. Recommend Courses of Actions to create a more robust training system.

Model Formulation

3. The problem is first formulated as an Integer Linear Program (ILP). The objective is to minimize total completion time subject to precedence relationships and constraints on duration, resources¹ and contiguity of modules. Thereafter, the model is adjusted to allow for attacks² on resources, incorporated as delays to completion time, and solved as an interdiction problem using Benders Decomposition.

Results

4. Table 1 shows the minimum completion time associated with a corresponding number of attacks. It also shows which resources are attacked on which days. As a comparison, it will take 50 days to complete all modules if there are no precedence, resource or contiguity constraints involved.

¹ Resources utilized in the model are: (1) Medical Vehicles, (2) Demo Ranges, (3) Rhino, (4) RHIB, (5) Corpsman, (6) EOD Trainer.

² Attacks may be in the form of terrorist actions, unscheduled maintenance of resources or natural calamities.

Number of Attacks	Resources Attacked	Completion Time
0	NIL	60 days
1	EOD Trainer (Day 32)	66 days
2	Demo Range (Day 55) Rhino (Day 60)	70 days
3	EOD Trainer (Day 33) EOD Trainer (Day 50) EOD Trainer (Day 60)	74 days
4	Demo Range (Day 3) Demo Range (Day 23) Demo Range (Day 46) Demo Range (Day 55)	83 days

Table 1: Completion Times of Interdiction Model

Analysis

5. Timing of Attacks. We see from Table 1 that the majority of attacks are made in the latter half of the training schedule. This is intuitive when considering the precedence relationships that create a bottle neck towards the end of the training plan. Figure 1 shows the precedence relationship of the modules.

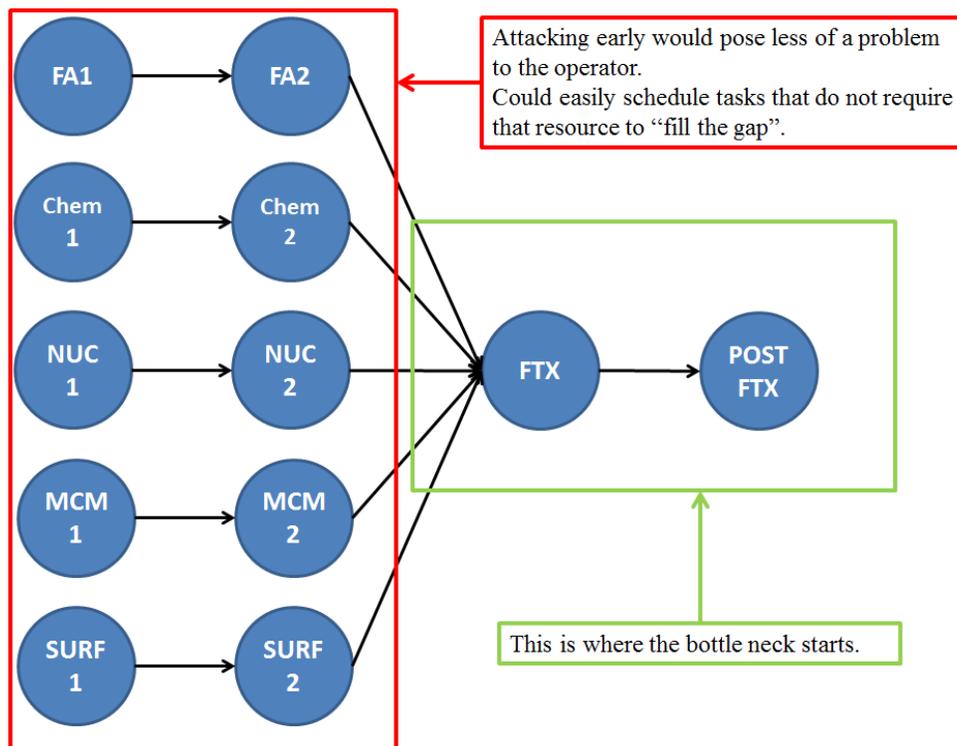


Figure 1: Precedence Relationships of Modules

6. Resources Attacked. The resources attacked all correspond to those with relatively larger delays. The attacked resources are also required in almost all the modules. This again is intuitive as the attacks will then provide the greatest payoff to the attacker.

7. Operator Resilience Curve. Fig 2 shows the operator resilience curve for EODTEU TWO. As the number of attacks increase from 0 to 3, the corresponding increase in completion time appears to be almost linear. However, the gradient of attack steepens when the number of attacks increases from 3 to 4. This indicates that as the number of attacks increase beyond 3, the delays incurred will increase exponentially.

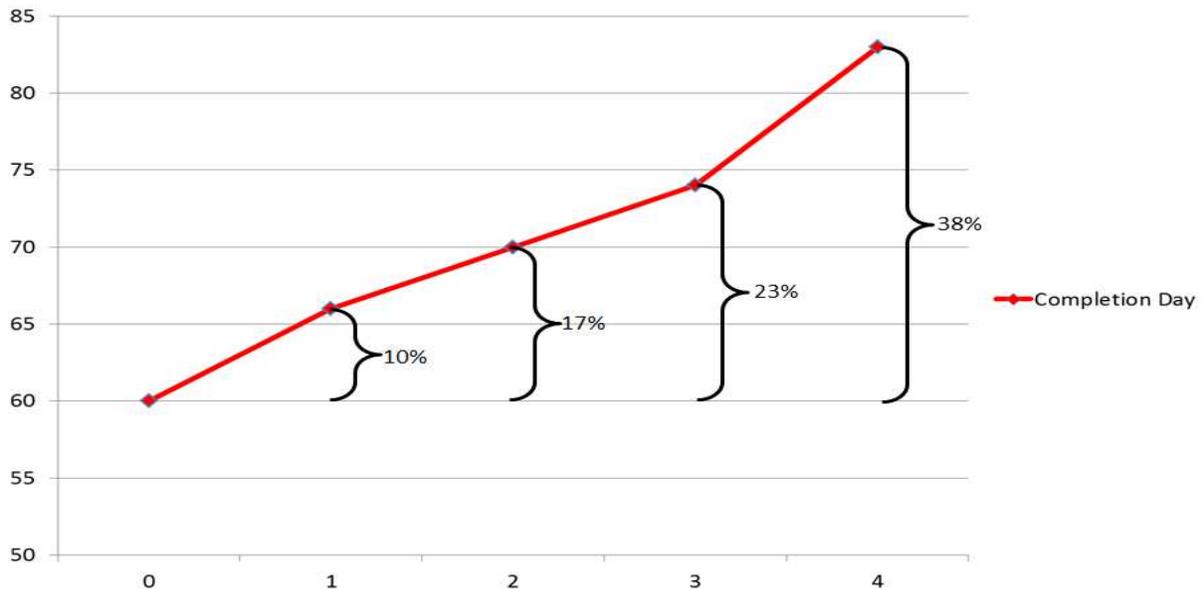


Figure 2: Operator Resilience Curve

Recommendations

8. Relieving Bottleneck. Measures to relieve the bottleneck can be undertaken to afford EODTEU TWO more alternatives in the latter half of the training schedule. For example, First Aid can be removed as a prerequisite for the conduct of FTX. In the event that FTX cannot be conducted due to resource unavailability, it will still be a viable option to conduct First Aid during that time period.

9. Creating Redundancy. Additional resources can be acquired to create a buffer. However, these buffer resources must be properly separated from the original resource pool to prevent an attack from incapacitating the entire resource pool. Also, in certain instances, simulation can be leveraged upon to provide an alternative to resources such as Demo Ranges.

10. Improving Security of Resources. Security can be improved to prevent sabotage against critical resources. For example, vehicles that give a high payoff to the attacker, such as the Rhino can be stored at a location close to base security. This will reduce the resource's susceptibility to sabotage.