Chapter 1. What is Operations Research?

Note. In this chapter, we give some basic terminology of O.R., including mathematical models, feasible solutions, optimization, and iterative algorithms. We present a little history and several examples to motivate the study.

Note. Taha states that the first "formal activities" of Operations Research (or "Operational Research" in the U.K., or simply "O.R." for short) were performed in England during World War II in attempts to efficiently allocate war material based on "scientific principles." A brief history of O.R. can be found William Thomas' "History of OR: Useful history of operations research," *ORMS-Today*, **42**(3), 2015 (available online as a Public Article on the ORMS-Today website; accessed 1/27/2022). This source largely agrees with Taha's claim, stating: "All serious accounts of the origins of O.R. agree that the term was initially applied in Britain just prior to World War II to distinguish research done to integrate radar technology into aerial combat operations from the research and development being done in laboratories and workshops." Thomas mentions the developing mathematical methods of the 1950s of linear programming, inventory theory, search theory and queuing theory as coming into the area of O.R., instead of being scattered through mathematics, statistics, and economics. Sadly (in my view), he also states: "Oddly, as thoroughly as O.R. and M.S. [Management Science] ultimately embraced theory, the sources of the power of that theory are not often discussed."

Example. Consider a business person who has to travel between Fayetteville (FYV) and Denver (DEN) over a 5 week period. Weekly departure from Fayetteville occurs on Mondays and returns on Wednesdays. A regular round trip ticket costs $400, but a 20% discount is granted if the round trip dates span a weekend. A one-way ticket in either direction costs 75% of the regular price. How should the tickets be bought for the 5-week period to minimize cost?

Discussion. We use this example to introduce some terminology and to illustrate the possible complexity of the problem. We need to find

1. the decision *alternatives*,

2. the *restrictions* under which the decision is made, and

3. an *objective criterion* for evaluating the alternative.

Three *alternatives* are:

(1) buy five regular FYV-DEN-FYV tickets with departure on Monday and return on Wednesday of the same week,

(2) buy one FYV-DEN ticket, four DEN-FYV-DEN tickets that span weekends, and one DEN-FYV ticket,

(3) buy one FYV-DEN-FYV to cover Monday of the first week and Wednesday of the last week, and four DEN-FYV-DEN to cover the remaining trips in such a way that all tickets span a weekend.

The *restriction* on the alternatives is that the person must be able to leave FYV on Monday and return on the first Wednesday of the same week. To minimize cost, the *objective criterion* is the total price of the tickets. For the three alternatives given, we have:

$$
\begin{aligned}
\text{Alternative (1) cost} &= 5 \times \$400 = \$2000, \\
\text{Alternative (2) cost} &= 0.75 \times \$400 + 4 \times (0.8 \times \$400) + 0.75 \times \$400 = \$1880, \\
\text{Alternative (3) cost} &= 5 \times (0.8 \times \$400) = \$1600.
\end{aligned}
$$

Of the three alternatives, the cheapest is alternative (3). We could maximize costs easily by buying 10 one-way tickets for a total of $10 \times (0.75 \times \$400) = \$3000$.

Revised: 1/31/2022