Introduction

In this Assignment, I will use the Solver program to investigate optimal solutions in two case studies, each subject to a set of equalities or inequalities. The Solver tool is part of Microsoft Excel's "What-If?" analysis suite. (Microsoft Corporation, 2018).It can be used to find the minimum, the maximum or a target value solution to a variety of complex problems using one of three algorithm types.

<u>Simplex Linear Programming (Simplex LP)</u>

Linear programming is a type of mathematical optimisation used to evaluate the minimal or maximal solution to a problem, subject to one of more linear constraints (Bazaraa, et al., 2009). In practice, several linear programming techniques may be used in order to find the optimal solution to a given problem. The *Simplex* algorithm first developed is considered to be the first method of linear programming and was developed by George Dantzig and his research team in 1947 (Feiring, 1986). This method was developed to solve problems that were defined by "a *single*, linear objective function that was to be optimized subject to a set of *rigid*, linear constraints" (Ignizio, 1985).

<u>Nonlinear 'Generalized Reduced Gradient' (GRG Nonlinear)</u>

This method is used to find a "locally optimal" solution to a non-linear problem. Local optimisation deferrers from global optimisation in that it is assumes the initial conditions are close to the solution. In this way, the first convergence to a maximum (or minimum if that is the target) that the algorithm encounters is presented as the solution. (Young, 2018) (Frontline Systems, Inc., 2018)

<u>Evolutionary</u>

This method is used to find a "globally optimal" solution to a non-linear problem, and is much more resource intensive. The program will seed random starting values for the model to use, and the "best fit" solution from the first round is then used to seed the next iteration of the process, and so forth. This broader scope is thus narrowed down to the optimal solution. (Young, 2018)

In this Assignment, I will use the Simplex method to investigate optimal solutions. Although the simplex method can be demonstrated graphically, for efficiency and clarity I will be using the Solver Add-In function in Excel 2010 to generate the solutions.

Assignment Part 2

Workplace Data Analysis

Case Study 2 – Workplace Data Analysis

This Case Study will investigate the most profitable distribution of work hours based on a fictional Ground Control Ltd client *Eastern Power Networks* (EPN) and their contract specifications. Work is issued as an overall number of man-hours by EPN, with specific limits on how the Ground Control Utility Arboriculture (GCUA) division is able to complete the works. A schedule of rates for the work is defined in Table 4 below, separated into Manual and Machinery work categories.

The most profitable (maximal) man-hour distribution will be generated using Linear Programming techniques with summary results provided in Table 6. Full details of the model used and solution are provided in Appendix B.

Work Category	Rate Type	Rate Code	Calculated Rate margin (£)
Manual	Arborist	A	16.52
Manual	Out-of-Hours Arborist	B	32.02
Machinery	Cherry Picker	C	39.96
Machinery	Winch Tractor	D	50.82
Machinery	Forestry Harvester	E	60.66
Machinery	Forestry Mulcher	F	59.66
Machinery	Stump Grinder	G	33.64
Machinery	Mobile Crane	H	208.99

Table 4 – Schedule of rates from Client, and the relative work categories.

<u>Client Requirements:</u>

- Total of 16,000 work hours issued, all work must be completed.
- Out-of-Hours Manual work cannot exceed other Manual work.
- No more than 10,000 hours of Manual work to be completed.
- No more than 1,000 hours of Out-of-Hours work to be completed.
- No more than 50% of all work to be completed by Machinery.
- No more than 10% of work completed using Mobile Cranes.
- At least 20% of all work to be completed using Cherry Pickers.
- At least 5% of work to be completed in each Rate Type.

Constraints Analysis

Details of Client requirements (constraints) are described in Table 5 below. The client's constraints have been modelled algebraically, and assigned a variable for ease of association in the SOLVER statement in Appendix B.

Requirement	Logical Representation(s)	Constraint Variable
Total of 16,000 work hours must be completed.	(A+B+C+D+E+F+G+H) = 16000	X_1
Out-of-Hours Manual work not to exceed other Manual work.	B <= A	X_2
No more than 10,000 hours of Manual work to be completed.	(A+B) <= 10000	X_3
No more than 1,000 hours of Out-of-Hours work to be completed.	B <= 1000	X_4
No more than 50% of all work to be completed by Machinery.	(C+D+E+F+G+H) <= (16000)*0.5	X_5
No more than 10% of work completed using Mobile Cranes.	H <= (16000)*0.1	X_6
At least 20% of all work to be completed using Cherry Pickers.	C >= (16000)*0.2	X_7
At least 5% of work to be completed in each Rate Type.	A >= (16000)*0.05 B >= (16000)*0.05 C >= (16000)*0.05 D >= (16000)*0.05 E >= (16000)*0.05 F >= (16000)*0.05 G >= (16000)*0.05 H >= (16000)*0.05	X_8 X_9 X_{10} X_{11} X_{12} X_{13} X_{14} X_{15} X_{16}

Table 5 – Client requirements for work scope, described mathematically.

Results

A Summary of results is described in Table 6 below. The maximal Gross Profit calculated is £773,740, based on the Linear Programming model described in Appendix B.

Rate Type	Rate Code	Calculated Rate margin (£)	Man-Hours Allocated	Gross Profit (£)
Arborist	A	16.52	7,000	115,640
Out-of-Hours Arborist	B	32.02	1,000	32,020
Cherry Picker	C	39.96	3,200	127,872
Winch Tractor	D	50.82	800	40,656
Forestry Harvester	E	60.66	800	48,528
Forestry Mulcher	F	59.66	800	47,728
Stump Grinder	G	33.64	800	26,912
Mobile Crane	H	208.99	1,600	334,384
Totals:			**16,000**	**773,740**

Table 6 - Summary to show optimised man-hour allocation. See Appendix B for details.

Conclusions

The model described in Appendix B adheres to all Client requirements (constraints). If the above model is used, the average profit per man hour on this contract is £48.36.

References

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