SYSTEMS AND
INDUSTRIAL ENGINEERING – ROBOTICS SERIES

Modeling and Simulation of Logistics Flows 2

Dashboards, Traffic Planning and Management

Jean-Michel Réveillac

ISTE WILEY

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Contents

About This Book

There are already several works about logistics, operational research, decision support, the theory of graphs, dynamic programming, etc., but few of them gather all of these domains together by proposing an overall vision that focuses less on pure and hard mathematical aspects, without totally ignoring them, while offering numerous practical exercises.

This book is one of three volumes. This first volume tackles theoretical aspects with corrected exercises for each chapter, finishing with a presentation of the principal software systems dedicated to operational research (OR) and logistical simulation. The second and third volumes are dedicated to practice and specialized applications of software programs.

Most of the studies proposed here are able to be completed using a simple calculator, a sheet of paper and a pen or even with the help of a spreadsheet on Microsoft Excel, Apache OpenCalc, Apple Numbers, etc.

The presented techniques and their uses are multiple, yet I am sure that a student, a software programmer, a developer, a technician, an engineer, an IT specialist, a decision-maker and you, the reader, will find practical applications that were unexpected in your professional or even personal life.

Intended public

This work is designed for all those who encounter logistical problems linked to flux management, decision support, optimization of journeys or rounds, research for an aim when confronted with multiple constraints, creation of dashboards, relevant simulations, etc.

The works presented require a minimum level of mathematical knowledge, and a post A level student in science or economics will not encounter major difficulties. I tried to maintain simplicity and go straight toward the objective in the theoretical approach without going into great demonstrations, which to me do not seem necessary.

In terms of the practical exercises, on a laptop, tackled in Volumes 2 and 3, a good knowledge of the exploitation system (track, records and lists, files, names, extensions, sheet, movement, etc.) will prove essential.

Since a few works use a spreadsheet, it is thus necessary to master the basic functionalities of this type of software program. It will also be convenient to know the primary use of pivot table data manipulation tools.

If we know about *visual basic application* (VBA) language or its equivalent, we can easily understand, improve, enrich and create new solutions to certain problems.

Lastly, if we understand the basic systems for managing data and relational algebra, then we will be at ease in every domain explored.

Organization and contents of the book

This work is composed of three volumes:

– Volume 1: Theory and fundamentals;

– Volume 2: Dashboards, traffic planning and management;

– Volume 3: Discrete and continuous flows in 2D/3D.

Volume 1 presents an introduction followed by 10 chapters and a conclusion:

– approach for logistics;

– an overall view of operational research;

– basics of the theory of graphs;

– calculation of optimal routes;

– dynamic programming;

– planning and scheduling with PERT and MPM;

– calculation of waves in a network;

– hiding trees and tours;

– linear programming;

– modelization of route traffic;

– diverse software programs for RO and simulation of logistical flux.

Here, we will find the fundamental concepts needed in order to understand the second volume. Numerous examples accompany the theory and each chapter ends with a series of exercises with their solutions.

The conclusion, as indicated by the name, tries to establish a picture of the current state of theoretical logistics and its future development.

Appendices 1 and 2 bring a few other elements. We will find them in the following order:

– table of the law of the normal reduced center;

– a presentation and a mini-manual dedicated to the calculation software program GeoGebra.

Volume 2 starts with an introduction completed with four chapters that put into practice the software tools in cases of practical application in order to finish with a conclusion:

– the different tools used in this volume;

– operational research with a spreadsheet;

– dashboards with a spreadsheet;

– scheduling and planning with a project manager;

– simulation of route traffic.

The conclusion presents new functionalities that should appear on spreadsheets and project management systems as well as the evolutions and points of similarity between traffic simulators and new infrastructures that emerge in traffic networks.

Appendix 1 is dedicated to the installation of a solving tool in Microsoft Excel. Appendix 2 is consecrated to the installation of Java development kit.

Volume 3 starts with an introduction followed by four chapters dedicated to the modelization and simulation of flux in a 2D or 3D environment. Each case is different and taken from situations encountered in reality. A conclusion concludes this Volume 3:

– different software programs used in this third volume;

–simulation of discreet computerized flows;

–simulation of mixed flows;

–3D flows and evacuation simulation;

–3D flows for transporting and storing.

The conclusion conveys the future evolutions of software programs and their integration into society. At the end of each volume, we will find a bibliography and a list of Internet links. A glossary is also available that will elaborate on certain acronyms and some very specific terminology surrounding logistics and operational research.

Conventions

This book uses the following typographic conventions:

– *italics*: used exclusively for important terms used for the first time in the text, one can generally be found in the glossary at the end of the work mathematical terms, comments, equations, expressions or variables present in the theoretical and practical chapters among examples and exercises;

– *(italics)*: these are the terms in English or in foreign languages;

– UPPER CASE: these are reserved for names of windows, icons, buttons, files or lists, menus or submenus. This can also be elements, options or commands present in the window of a program;

– `courier`: this font is used for VBA code lines. These lines can end with the symbol ↵, which implies a return to the obligatory line when inputting.

Any comments are signaled by the presence of a keyword: COMMENT. They will complete the explications already provided. Theorems are signaled by the keyword: THEOREM. The figures and tables have captions to further their understanding.

Vocabulary and definition

Like for all techniques, logistical optimization tools have their own vocabulary. Words, acronyms, abbreviations and specific names that are not always familiar; this is the role of the Glossary found at the end of the book.

Acknowledgments

It is my particular duty to thank the team at ISTE, and my editor Chantal Ménascé who had confidence in me, Jacqueline Gélinier from the company 1point2, distributor of ExtendSim and PathFinder software programs, Clair Augsburger of FlexSim France, not forgetting my dear friend, Pascal Mauny, director of IUT of Chalon-en-Saône and lecturer at the University of Bourgogne, for the time and attention granted to me for writing the preface.

Finally, I would like to thank my wife, Vanna, who has supported me throughout writing this book.

Jean-Michel RÉVEILLAC
November 2016

Introduction

I.1. Logistics, information systems and software

The last chapter of Volume 1 of this series ended by looking at the software used for solving the different logistical problems that industrial, commercial and administrative structures face on a daily basis [REV 17a].

Since its inception, logistics has been omnipresent and has undergone significant development. Globalization, the explosion of the internet and the constant push to look to do everything better, quicker, more effectively and for less money, have greatly contributed to its expansion.

Although we are still only in the early stages, can we say that logistics has reached full maturity? Nothing could be less certain. The Internet of Things, still in its infancy, should profoundly change the normal rules relating to product management in the years to come.

The steps being taken by our cities towards becoming intelligent cities or "*smart cities"* will soon cause upheaval in our daily lives and our work habits, in public transport, in business and even in our own homes.

The centralization of many different kinds of data and the increase in central file storage has only just begun. We are currently living in a world of information systems and databases and that will continue to be the case in the future. However, aside from the impact this has on ourselves as individuals, our environment and the objects we use will be implicated in this massive warehouse of data that is currently being put together.

In 1997, the concept of "*big data"* first appeared. For many researchers this is one of the challenges that the information industry will have to deal with between

2020 and 2030: how to properly manage and analyze this enormous accumulation of content.

The optimization and the simulation of logistical flows plays an important role in this phenomenon. Data is collected and is then used to build models and structures in order to optimize constraints present in the field.

A variety of different types of software are used and can be divided into two categories: the specifics that deal with particular areas, such as *flow simulations* (extendSim, FlexSim, Arena, Witness), management and project *planning* (Microsoft project, Sciforma PS, GanttProject, MicroPlanner), calculating and *optimizing routes* (Gazoleen, Portatour, Mapotempo, Geoconcept, TourSolver), the management of *warehousing*[1] (Speed, Reflex WMS, Mecalux Easy WMS) and general applications, such as spreadsheets (Microsoft Excel, Apple Numbers, OpenOffice Calc) or calculation managers (Mathematica, Mapple, Xcas, GeoGebra).

In Volumes 2 and 3 of this series, I wanted to introduce you to the optimization and the simulation of logistical flows across some of these types of software. The ones that I chose and focused on are those that I use in my everyday work, not just in my role as an IT engineering consultant but also when teaching students.

The majority of the cases dealt with here come from practical cases that have been bowdlerized several times in order to avoid overloading how they are presented and to thus facilitate access for a novice who can then look into it further should they wish.

In this second volume, we will work successively with Microsoft Excel, the project manager Microsoft Project and the road traffic simulators, Ring road, RoadTrafficSimulator, Intersection simulator, Green Light District (GLD) and AnyLogic[2].

The studies carried out using spreadsheets will employ a number of the operational research techniques described in Volume 1 [REV 17a].

In turn, we will look at:

– Dynamic programming using the so-called Knapsack Problem (KP) problem solving method. This exercise will use a solution employing Visual Basic

1 Software for the management of warehousing is often referred to using the acronym Warehouse Management System (WMS).
2 Although Anylogic is a general flow simulation program, the example that I will present in this volume will focus on the modeling of road traffic.

Application (VBA) with which you will develop two detailed and commentated procedures.

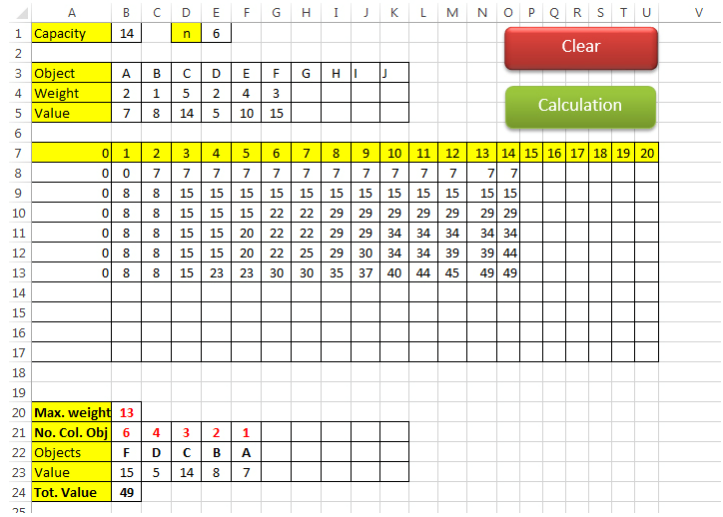


Figure I.1. *Knapsack with Microsoft Excel*

– *Scheduling*: where you will design a critical path resolution matrix based on simple calculation formulae, the majority of which will integrate conditional instructions.

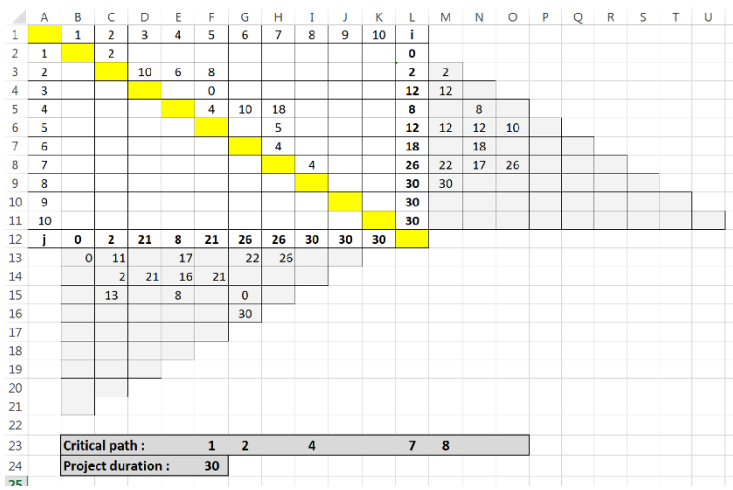


Figure I.2. *A critical path calculation matrix*

– The planning of tasks will enable you to discover how a histogram can be used in order to generate a *Gantt chart,* either connected or unconnected to a calendar.

Project start date :		03/02/15		
Task	**Start**	**Duration**	**End**	**Variation**
A	**03/02/15**	**1**	**03/03/15**	**1**
B	03/03/15	10	**03/17/15**	14
C	03/03/15	5	**03/10/15**	7
D	**03/03/15**	**8**	**03/13/15**	**10**
E	03/03/15	4	**03/09/15**	6
F	03/11/15	2	**03/13/15**	2
G	**03/11/15**	**4**	**03/17/15**	**6**
H	**03/15/15**	**2**	**03/17/15**	**2**
I	03/15/15	1	**03/16/15**	1
J	**03/17/15**	**1**	**03/18/15**	**1**
K	**03/18/15**	**1**	**03/19/15**	**1**
L	**03/19/15**	**1**	**03/20/15**	**1**

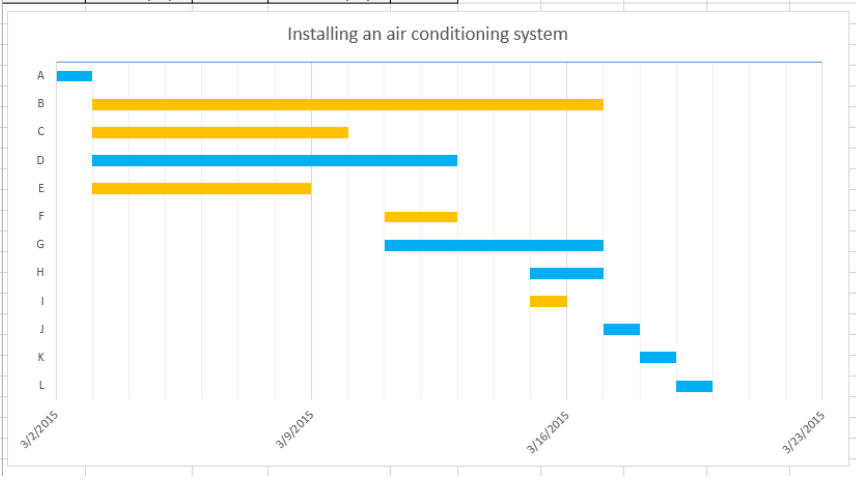


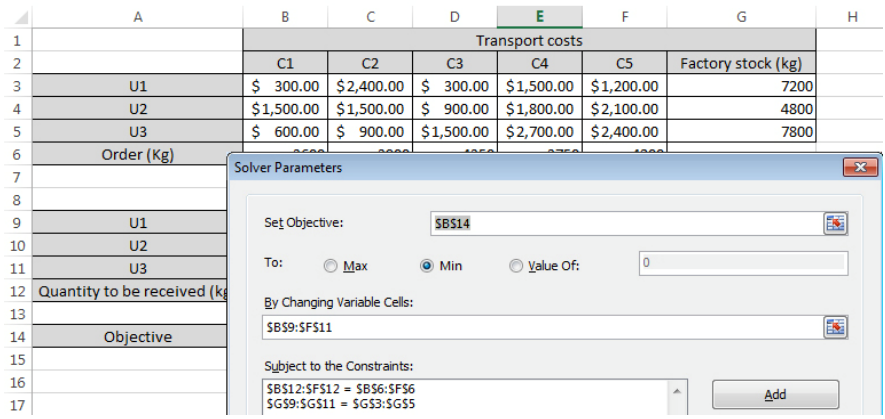
Figure I.3. *Gantt chart with Microsoft Excel*

– The management of *maximal flows* will lead you to implement, in the same way as dynamic programming, two detailed and annotated procedures in Visual Basic, connected to a spreadsheet.

– The *transport models* will be based on a tool found in Microsoft Excel, known as Solver. You will learn how to use it by inputting the different elements required for its use: objective, variables and constraints across the two examples.

	A	B	C	D	E	F	G	H
1	From	To	Flow	Capacity		Nodes	Net Flow	Supply/Demand
2	S	P1	6000	10000		S	14000	
3	S	P2	8000	8000		P2	0	0
4	S	P3	0	6000		P3	0	0
5	P1	P2	0	4000		R1	0	0
6	P1	R1	6000	6000		R2	0	0
7	P2	R1	4000	4000		R3	0	0
8	P2	R2	2000	2000		R4	0	0
9	P2	R3	2000	2000		R5	0	0
10	P3	P2	0	4000		P1	0	0
11	P3	R3	0	6000		T	-14000	
12	R1	R2	4000	4000				
13	R1	R4	6000	6000				
14	R2	R4	4000	4000				
15	R2	R5	2000	3000				
16	R3	R2	0	6000				
17	R3	R5	2000	2000				
18	R4	T	10000	12000				
19	R5	T	4000	4000				
20								
21								
22						No. Nodes	10	
23								
24								
25								
26								
27	No. Edges		18			Create tables		Solve
28	Maximum flow		14000					
29								

Figure I.4. *An example of a spreadsheet for maximal flows*



	A	B	C	D	E	F	G	H
1		Transport costs						
2		C1	C2	C3	C4	C5	Factory stock (kg)	
3	U1	$ 300.00	$2,400.00	$ 300.00	$1,500.00	$1,200.00	7200	
4	U2	$1,500.00	$1,500.00	$ 900.00	$1,800.00	$2,100.00	4800	
5	U3	$ 600.00	$ 900.00	$1,500.00	$2,700.00	$2,400.00	7800	
6	Order (Kg)							
7								
8								
9	U1							
10	U2							
11	U3							
12	Quantity to be received (kg							
13								
14	Objective							
15								
16								
17								

Figure I.5. *Calculating transport costs using the Microsoft Excel solver*

– *Linear programming* also requires the use of the solver in order to process the *simplex*. In this exercise you will learn how to create a spreadsheet that will formalize the inequations of the constraints of a PL problem as well as the economic function, followed by configurating the solver in order to find the optimal solution.

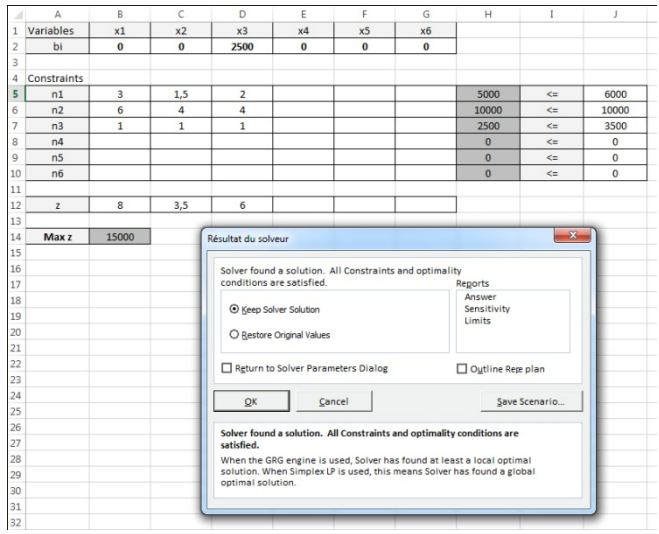


Figure I.6. *An example of linear programming, spreadsheet and solver*

Secondly, the spreadsheet will also make it possible to create *dashboards* implementing complex *pivot tables* that will work with one or a number of databases.

Client category (All)

Net margins	Designation						
VENDOR	Product A	Product B	Product C	Product D	Product E	Product F	Grand Total
Degeorges R.	$ -	$1,126.40	$ 512.00	$ 307.20	$ 307.20	$ 460.80	$ 2,713.60
Dupont V.	$ 204.80	$ 614.40	$ 460.80	$ 716.80	$ 256.00	$ 307.20	$ 2,560.00
Durant V.	$ 768.00	$ 204.80	$1,433.60	$ 51.20	$ 102.40	$ 512.00	$ 3,072.00
Fabre D.	$ 358.40	$ 256.00	$ -	$ 204.80	$1,075.20	$ 358.40	$ 2,252.80
Felin G.	$ 512.00	$ 460.80	$ -	$ 256.00	$ 768.00	$ -	$ 1,996.80
Marchand M.	$ 716.80	$ -	$ 204.80	$1,126.40	$ 409.60	$ 716.80	$ 3,174.40
Martin C.	$ 614.40	$1,024.00	$1,280.00	$1,075.20	$ 870.40	$ 460.80	$ 5,324.80
Pizarelli B.	$ 1,024.00	$ 102.40	$ 256.00	$1,433.60	$1,280.00	$ 716.80	$ 4,812.80
Richard T.	$ 153.60	$ 204.80	$ 409.60	$ 614.40	$ 512.00	$1,024.00	$ 2,918.40
Grand Total	**$ 4,352.00**	**$ 3,993.60**	**$ 4,556.80**	**$ 5,785.60**	**$ 5,580.80**	**$ 4,556.80**	**$ 28,825.60**

Figure I.7. *A pivot table mixing numbered and graphic data*

Within project management, we will set up a design and manufacturing plan for a machine-tool by integrating the different tasks, the resources, the costs, the creation of dashboards, reports and monitoring. We will see in detail the Gantt chart type displays and the Méthode des potentiels Métra (MPM) network, plus the Work Breakdown Structure (WBS) codification, margin calculation and the management of the over-use of resources. All of these different studies will employ the principles developed in Chapter 5 of the first volume of this series, which dealt specifically with scheduling.

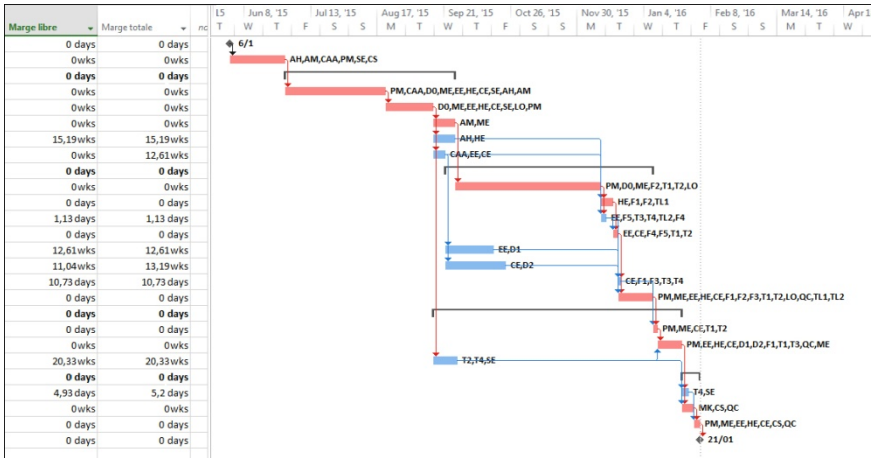


Figure I.8. *A design and manufacturing plan for a machine-tool within Microsoft Project*

Chapter 4 will focus on a particular field that is highly complex, *road traffic management*. We will examine several problems linked to the circulation of vehicles in a range of situations and contexts, at different levels, while using various programs.

Several examples will be given for each of the five applications being studied:

– a traffic jam simulator;

– an editor-simulator of traffic flow in a model incorporating junctions and traffic lights;

– an optimization simulator for an intersection managed by traffic lights;