

# A Novel Technique of Simheuristic for the Irregular Cutting Stock Problem with Free Rotations

**Andrés De-las-Casas and David Álvarez-Martínez**  
Department of Industrial Engineering, Faculty of Engineering  
Universidad de Los Andes  
Bogotá, Colombia  
[ag.de10@uniandes.edu.co](mailto:ag.de10@uniandes.edu.co), [d.alvarezm@uniandes.edu.co](mailto:d.alvarezm@uniandes.edu.co)

**Gustavo Gatica**  
Universidad Andrés Bello  
Chile  
[ggatica@unab.cl](mailto:ggatica@unab.cl)

**Luis Miguel Escobar-Falcón**  
Program of Systems Engineering  
Universidad Libre  
Pereira, Colombia  
[luism.escobarf@unilibre.edu.co](mailto:luism.escobarf@unilibre.edu.co)

**Rubén Iván Bolaños and César Augusto Marín-Moreno**  
Research, Development & Innovation Department  
Integra S.A.  
Pereira, Colombia  
[rbolanos@integra.com.co](mailto:rbolanos@integra.com.co), [cmarin@integra.com.co](mailto:cmarin@integra.com.co)

## Abstract

The cutting stock problem is a classic problem of combinatorial optimization. However, the variant of the problem with two-dimensional irregular items has been scarcely explored. In this problem, the items have a free shape and must be located within a set of identical sheets with fixed dimensions. The main objective is to minimize waste, which is the same as reducing the number of bins where a specific demand for objects can fit. In this work, the items can be rotated freely and be placed without a fixed orientation; this allows the solution of this problem to be more consistent with the different applications in the industry where it appears.

The literature proposes classical techniques of column generation and metaheuristics. However, integrate column generation procedure and simulation environment using the Unity engine is novel.

The methodology considers a column generation procedure to select the subset of sheets composing the solution. An auxiliary problem will create each of the proposed bins to be given to the master problem as columns. Through a two-phase construction procedure, the slave problem is solved. With the Unity engine, a local search with exchange and insertion operators is implemented.

The proposed technique was validated with instances from the literature of cutting stock problem. New best-known solutions were obtained for three different test cases. Compared to previous works, the computing time is satisfactory and reasonable. In general terms, the methodology presents successful

results. For future work, it is recommended to use the simulation environment not only to execute classic perturbation movements on the items but to introduce physical moves that are applied on the sheets.

### **Keywords**

Cutting Stock, Simulation, Optimization, Cutting and Packing, Column Generation, Unity.

### **Acknowledgements**

The authors would like to thank SENA (Servicio Nacional de Aprendizaje), Integra S.A and COLCIENCIAS.

### **Biographies**

**Andrés De-Las-Casas** has a degree in Industrial Engineering from the University of Los Andes, Bogotá, Colombia and a M.Sc. in Operations Research at the same university, with experience in optimization and logistics.

**David Álvarez-Martínez** is an Associate Professor, his main scientific activity area is Operation Research and Computer Sciences. Within Operations Research David focuses on the problems modeling, solution and application related to supply chain management, manufacturing and production, logistics and transport, as well as cutting stock problem, staff recruitment, goods packaging, vehicle routing, among others. From a technical point of view, David's research focuses on specialized software development, through the use and development of accurate and approximate optimization methods. Profile: Postdoctoral Fellow, Applied Optimization Systems Group, Polytechnic University of Valencia - UPV (Spain); Ph.D. in Electrical Engineering (Automation Science), São Paulo State University - UNESP (Brazil); M.Sc. in Electrical Engineering (Computer Science), Technological University of Pereira - UTP (Colombia) and B.Sc. in Systems and Computer Engineering, Technological University of Pereira - UTP (Colombia).

**Gustavo Gatica**, Professor of Computer Science in the University of Andres Bello, with more than 10 years of experience on research projects, has a Ph.D. from the University of Santiago de Chile.

**Luis Miguel Escobar-Falcón** has a degree in Computer Science Engineering (2007) and a M.Sc. degree in Electrical Engineering (2012) from the Technological University of Pereira, Colombia. He has a Ph.D. in Engineering (2019) in the same university, having his abroad period in the University of Bio-Bio, Chile and the University of Bologna, Italy (2016). Currently is the Research Coordinator of Integra S.A, operator of the Bus Rapid Transit System of Pereira, Colombia, and Professor in the Program of Systems Engineering of The Free University in the same city. Has experience working and implementing solutions for operations research problems such as Packing Problems, Vehicle Routing Problems and Scheduling Problems.

**César Augusto Marín-Moreno** is the Manager of the R+D+i department at Integra S.A, the operator of the massive transit system in the city of Pereira, Colombia. He recently completed his Ph.D. in the Technological University of Pereira (2019), working problems oriented to Tactical and Operational Planning. He is expert in project formulation and PMP certified.

**Rubén Iván Bolaños**. is currently the Development Coordinator of Integra S.A. Ph.D. student at the Technological University of Pereira, working Vehicle and Crew Scheduling Problems, and Rostering for BRT (Bus Rapid Transit) operators.