

# CISAMS: Integrated Circularity and Sustainability Assessment of Manufacturing Systems



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## **Deliverable 5: Analytical trade-offs assessment method**

**Greece 2.0**

**Basic Research Financing Action  
(Horizontal support of all Sciences)**

**Sub-action 1: Funding New Researchers**

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## 1 EXECUTIVE SUMMARY

In this deliverable, the Analytical trade-offs assessment method is presented. The results from the independent assessment of Circularity (C), Environmental Sustainability (ES) and Social Sustainability (SS) that were obtained in the first three work packages are used in an analytical trade-offs assessment method in order to obtain the set of Pareto Optimal Alternatives combining information from all three pillars. We recall that the independent assessment of C, ES and SS takes place in two steps: a) the Bayesian Best Worst Method (BBWM) is used in order to obtain the weights for each indicator category within each pillar C, ES and SS, and b) the PROMETHEE-II method is used in order to independently rank the alternatives for each pillar C, ES and SS. The outcome of PROMETHEE-II is the net-flow for each alternative, which results in three different rankings according to C, ES and SS, separately and independently.

In this deliverable, we start from these three distinct rankings and attempt to arrive at the set of Pareto Optimal (or Efficient, or nondominated) alternatives. The AUGMECON2 method [1] is used for this purpose. The input matrix to the AUGMECON2 contains the Circularity Index (CI), Environmental Sustainability Index (ESI) and Social Sustainability Index (SSI) as columns and has the several alternatives as rows. The three composite indices CI, ESI and SSI are the net-flows associated with each alternative from the PROMETHEE-II application to the pillar C, ES and SS, respectively. We take care to rescale the real numbers between  $[-1, 1]$  that constitute the new flows to the range  $[0, 100]$  of positive integers. Then the AUGMECON2 method proceeds with its two steps: i) compute the payoff table via lexicographic optimization so that the grid of the constraint objectives can be defined and ii) implement the walking procedure on the constraint objectives grid (e.g., a 2D grid in all our cases) so that the AUGMECON sub-problem is iteratively solved and provides the exact Pareto Front / exact Pareto Set. The application of the Analytical trade-offs assessment method is illustrated via the use of 2 Case Studies: first, the Plastics (PVC) extrusion and second, the Aluminium Production applications. The description of the alternatives and the indicators for each case study have been included in D4 and is omitted here for brevity. The Pareto Front is obtained in each case study and it is commented upon. We conclude that the AUGMECON2 method complements the Analytic Hierarchy Process (AHP) ranking procedure, offering objectivity to the Decision Maker (DM), since it highlights the Pareto Optimal Alternatives that can rank low in the AHP ranking but may still be of interest to the Decision Maker due to the different insights it offers, since AHP is an a priori method and AUGMECON2 is an a posteriori method.