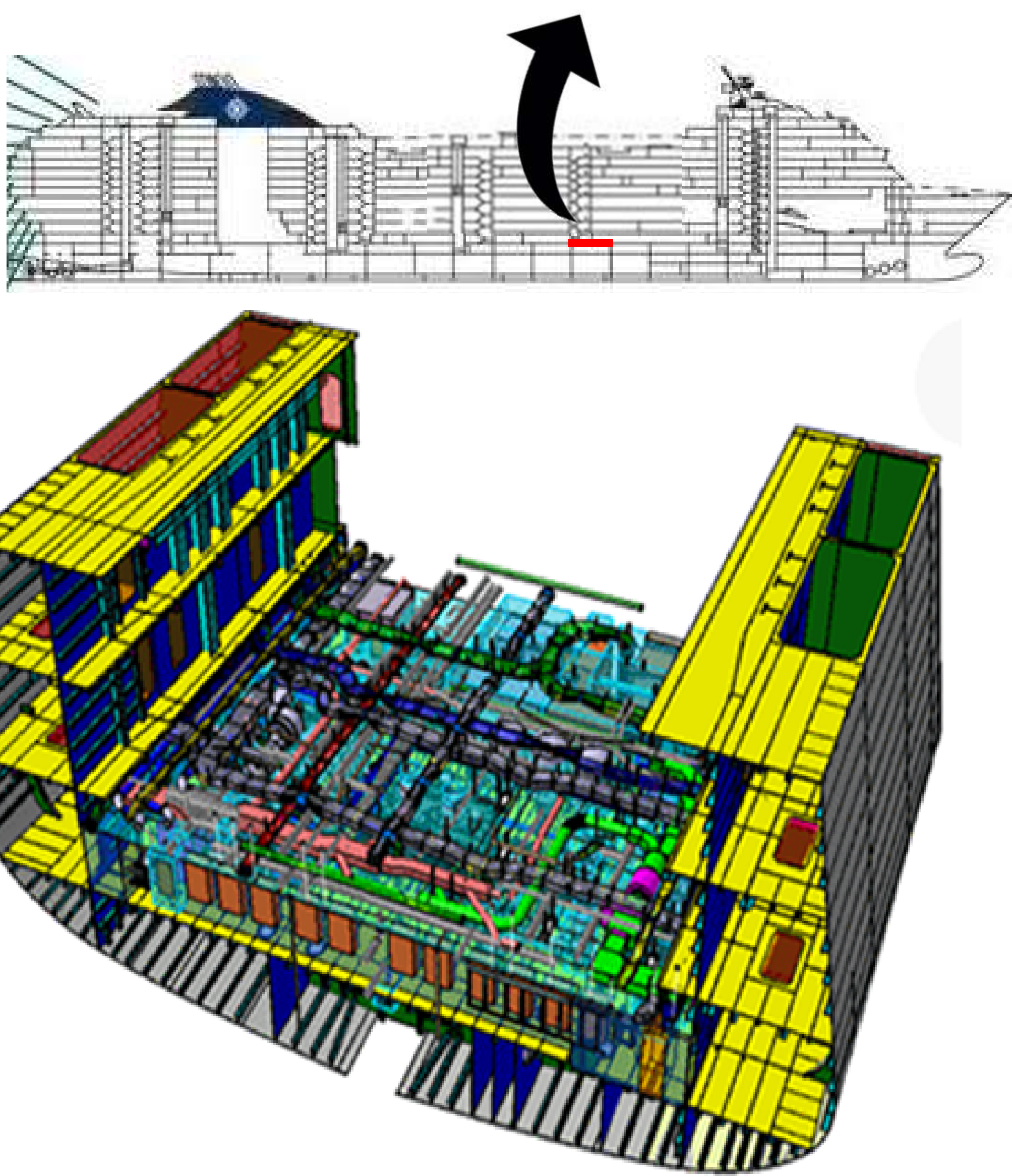
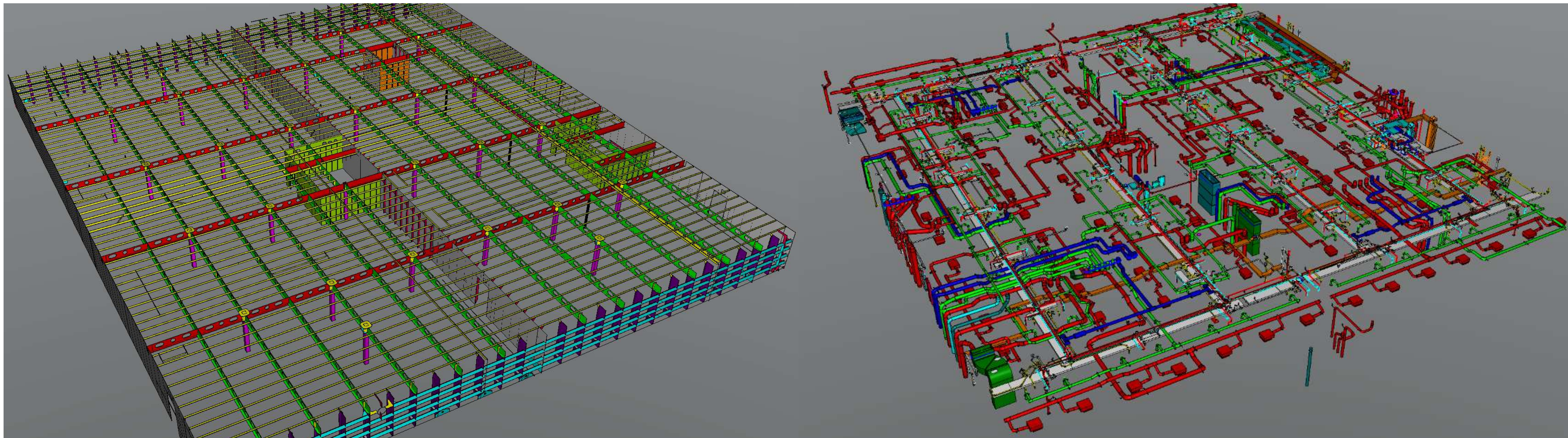


An automated pipeline routing system based on machine learning and mathematical programming

1st Challenge. The Pipeline Routing Problem

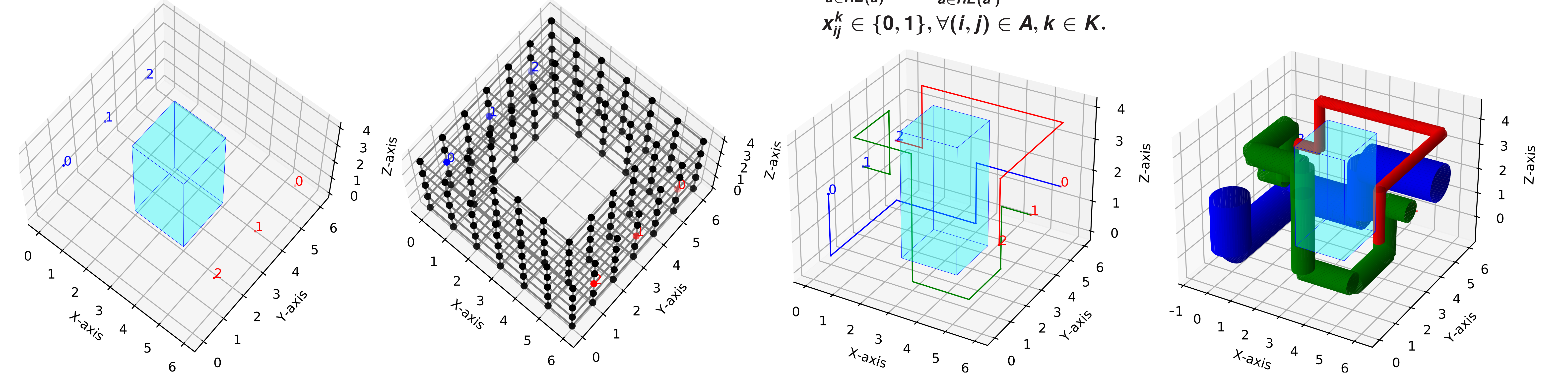


In ship building, pipeline routing is a difficult problem since space is rather limited. This constraint and others related to obstacles, costs, legislation or operability, are considered to set the pipe layout by means of a mathematical model. In this work we sketch out some issues and proposed solutions that show the usefulness of mathematical tools and artificial intelligence in automatic design engineering.

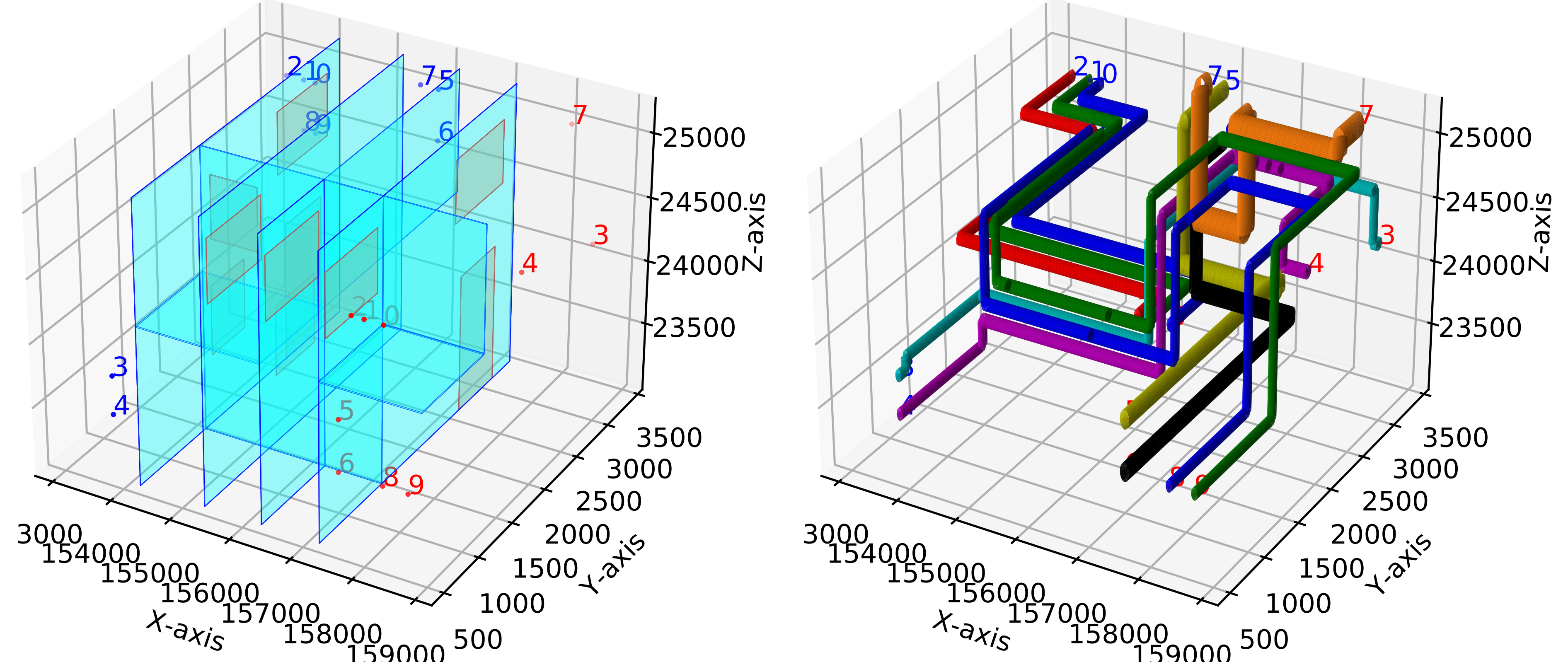
Solution Method

1. The discretization of the solution space.
 2. An approximation of the design by means of a mathematical model capturing characteristics of the problem.
 3. A cost function to take into account the naval design such as total length, number of elbows, priority zones, etc. They have been included in the objective function as both, bonuses and penalties.
- We model the automatic pipeline routing problem in an efficient way so that the problem can be solved exactly and we also develop machine learning heuristics which provide feasible good-quality solutions.

$$\begin{aligned}
 \min \quad & \sum_{(i,j) \in A} \sum_{k \in K} c_{ij}^k x_{ij}^k, \\
 \text{s. a} \quad & \sum_{k \in K} \sum_{j \in V} x_{ij}^k \leq 1, & \forall i \in V, \\
 & \sum_{j \in V} x_{ij}^k - \sum_{j \in V} x_{ji}^k = 0, & \forall k \in K, i \in V (i \neq s^k, t^k), \\
 & \sum_{j \in V} x_{s^k,j}^k = 1, & \forall k \in K, \\
 & \sum_{i \in V} x_{i,t^k}^k = 1, & \forall k \in K, \\
 & \sum_{k' \in K: k' \neq k} \sum_{\substack{a' \in A \setminus A^v \\ d_{aa'} < R^{kk'}}} x_{a'}^{k'} \leq M(1 - x_a^k), & \forall a \in A \setminus A^v, k \in K, \\
 & \sum_{\bar{a} \in RE(a)} x_{\bar{a}}^k + \sum_{\bar{a} \in RE(a')} x_{\bar{a}}^k \leq 1, & \forall a, a' \in A^v : d_{aa'} \leq D^k, a \neq a', k \in K, \\
 & x_{ij}^k \in \{0, 1\}, \forall (i, j) \in A, k \in K.
 \end{aligned}$$



Case Study



Representation of application of the proposed methodology to one of the realistic instances provided by our partner, Ghenova: shows the actual applicability of our solution methods to solve scenarios that appear in naval design.

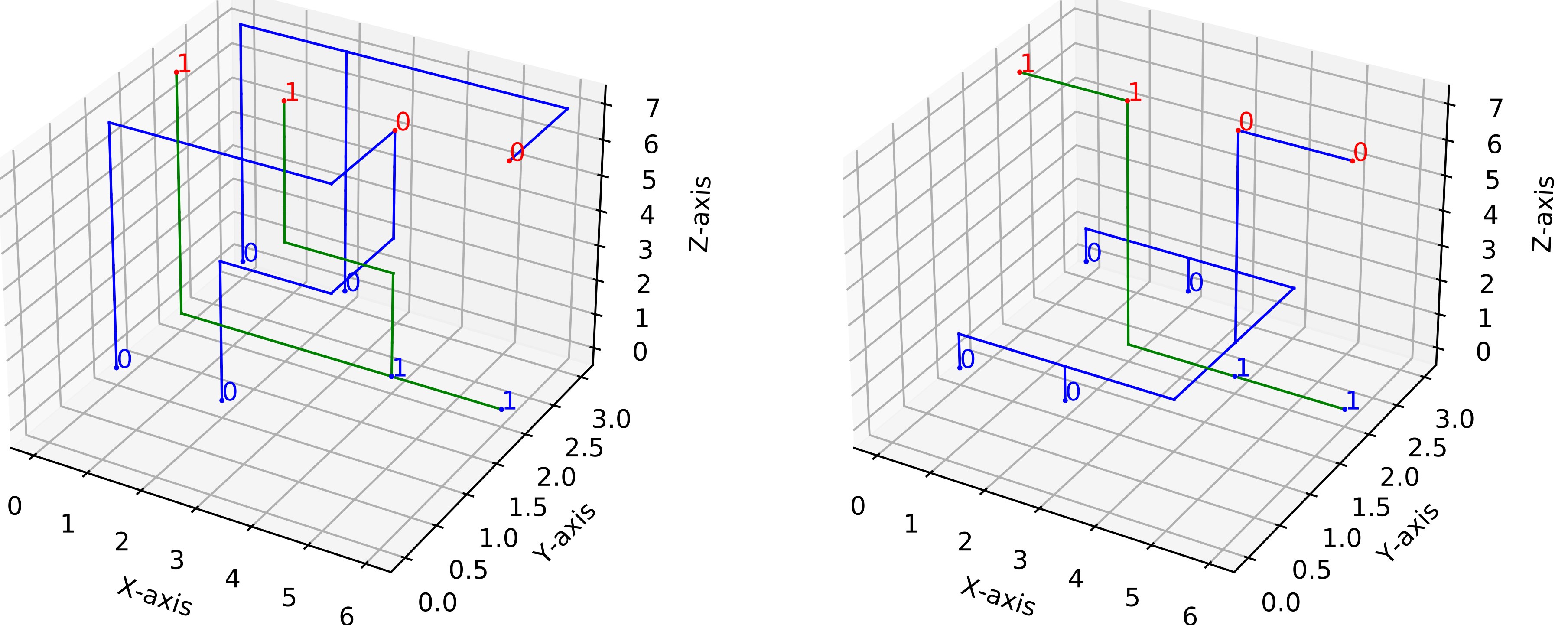
Technology Readiness Level (TRL 5-6)

The prototype is integrated within Ghenova’s software via an external gateway (Nextcloud).

2nd Challenge: Cable Trays Problem



A tray is a space with capacities in which wire or pipe commodities (climatization or electrical for example) concentrate and pass through. Commodities from several sources join as soon as possible into a single entity which travels to sinks and separates as later as possible filling the demand of those sinks.



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