Copper Reclamation Program Asset Optimization

BUSINESS PROBLEM

As legacy copper telephone networks are retired for fiber optics, vast quantities of recoverable copper remain embedded in underground conduits and aerial installations across dispersed sites. Telecommunications companies face extraordinary combinatorial complexity: coordinating extraction crews across hundreds of sites with staggered readiness windows, activating sorting facilities, and routing recovered material through a multi-echelon supply chain to recycling plants while respecting contractual obligations, workforce constraints, and transportation economics.

DATA SOURCES

[Excel workbook - extraction site characteristics, crew and garage capacity by month, sorting facility candidates with rental costs and throughput limits, recycling plant specifications including cable type acceptance, recovery rates, processing fees, and capacity bounds.]

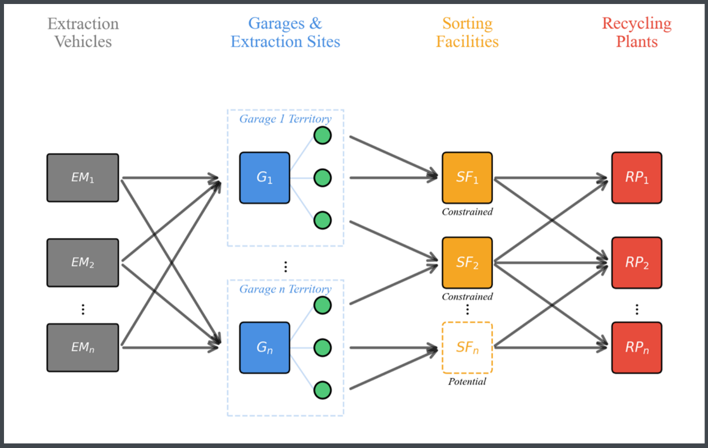
[OpenRouteService API - real-world driving distances between all location pairs for heavy-goods vehicles.]

Data Types and Format

Categorical (nominal), Count (integer), Numeric, Relational Data, Spatial, Static, Structured

APPROACH

A Mixed-Integer Linear Programming framework was developed in Python using Gurobi to simultaneously optimize all interdependent decisions across the planning horizon. The model determines extraction method selection, timing, crew-to-site assignment, sorting facility activation, and recycling plant routing in a single unified formulation. The objective maximizes profitability, balancing copper revenue against extraction costs, mobilization, facility rental, transportation, and smelting fees.



Charles Boury
MIT Leaders for Global Operations, Class of 2026

IMPACT

The framework replaces labor-intensive manual planning that previously required extended consulting engagements, delivering solutions with provable optimality guarantees and transparency into cost drivers and capacity bottlenecks. Operators can run scenario analyses, perform sensitivity testing, and replan as conditions change within a single working session. The modular architecture allows network nodes to be added or modified through Excel alone, requiring no code changes.

Copper prices rose approximately 40% in 2025, and the IEA projects a 30 to 40% supply deficit by 2035 driven by electrification, renewables, and AI data center demand. Secondary recovery is a strategic necessity. The core innovation is the novel integration of facility location, crew scheduling, and multi-echelon routing into a single MILP. The framework generalizes to e-waste reverse logistics, end-of-life vehicle recovery, and any problem with distributed sites, mobile crews, and multi-echelon routing.

DRIVERS	Legacy copper telephone networks are being retired for fiber optics, unlocking recoverable copper across hundreds of dispersed sites. Manual planning relied on spreadsheets and consultants, requiring weeks per plan. Rising copper prices and projected supply deficits made program efficiency a strategic priority.
BARRIERS	The decision space spans hundreds of sites, dozens of crews, multiple facilities, and several recyclers simultaneously. Decisions are coupled through capacity constraints, contractual obligations, and transportation economics. Scenario analysis and rapid replanning were effectively impossible manually.
ENABLERS	Gurobi enabled tractable optimization at realistic problem scale. The OpenRouteService API provided accurate real-world driving distances for heavy-goods vehicles. A modular Excel input interface allowed operators to configure the full problem without code changes.
ACTIONS	Designed a modular data pipeline ingesting parameters from a structured Excel workbook. Pre-calculated a full distance matrix via the OpenRouteService API. Formulated a MILP in Python using Gurobi capturing extraction method selection, timing, crew assignment, facility activation, and recycling plant routing. Validated on real and fictive case studies of several hundreds of sites across multiple zones over a 12-month horizon.
INNOVATION	Novel integration of facility location, crew scheduling, and multi-echelon routing into a single MILP. The formulation captures crew continuity, single-peak ramping, distance-based method feasibility, and short-haul versus long-haul logistics. A subset replanning mode enables stable re-optimization by locking committed decisions and resolving only flexible variables.
IMPROVEMENT	The framework solves realistic instances within one hour versus weeks of manual effort. Operators run scenario analyses and replan within a single working session. Solutions carry provable optimality guarantees unavailable through manual planning.
BEST PRACTICES	Design the end-to-end data pipeline before the optimization model. Separate committed from flexible decisions in replanning. Parameter-driven modularity is essential for operational adoption. Treat the framework as decision support, not a replacement for operational judgment.
OTHER APPLICATIONS	The framework generalizes to reverse logistics and infrastructure decommissioning with distributed sites, mobile crews, and multi-echelon material flows. Direct applications include e-waste recovery, end-of-life vehicle processing, and industrial equipment decommissioning.