



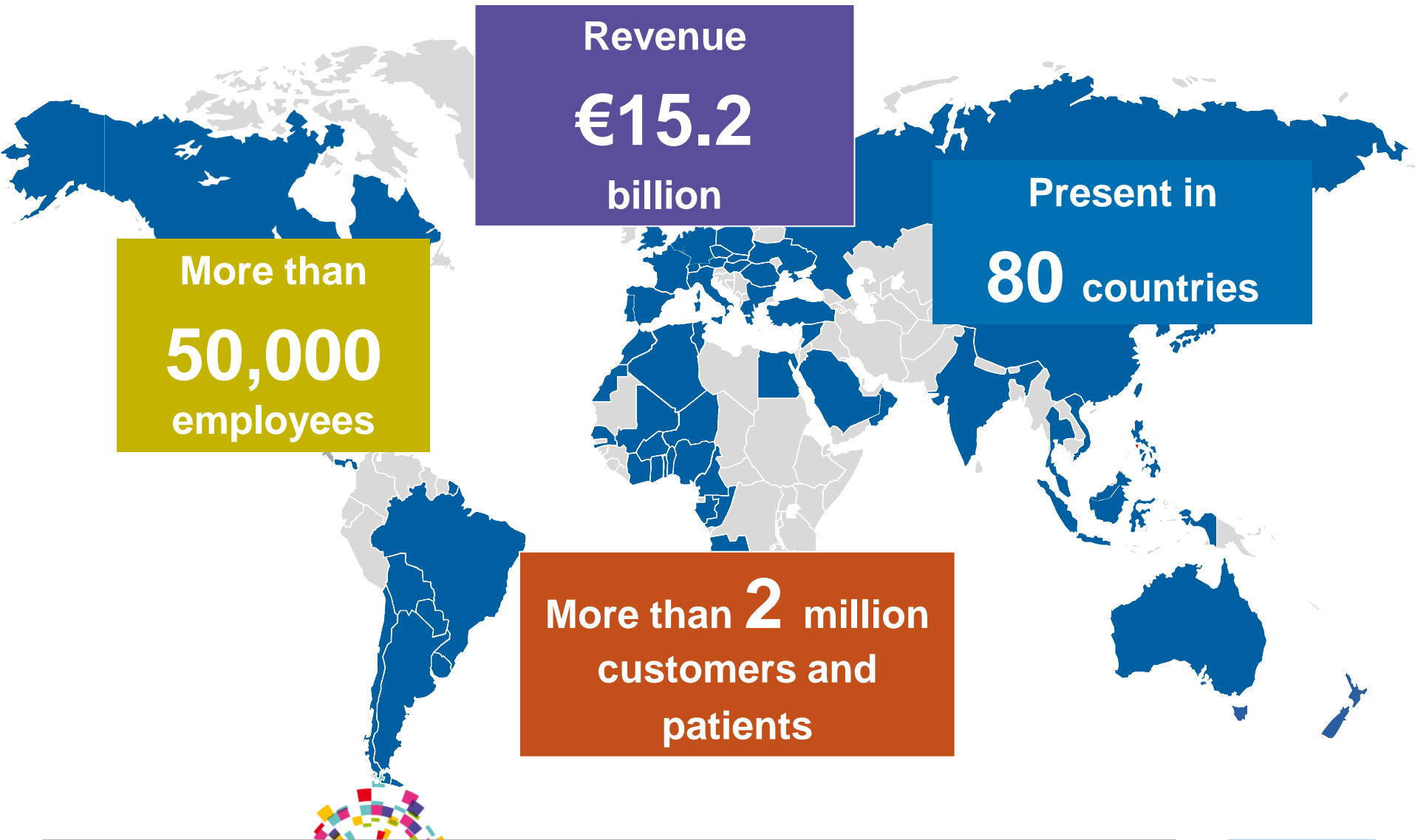
# EURO/ROADEF 2016 Challenge

## Inventory routing for gas distribution

April 2015

Air Liquide R&D | Applied Mathematics Global Lab | Operations Research Team

# World leader in gases, technologies and services for Industry and Health



# Air Liquide as a solution provider

... CONTRIBUTING TO MULTIPLE SECTORS



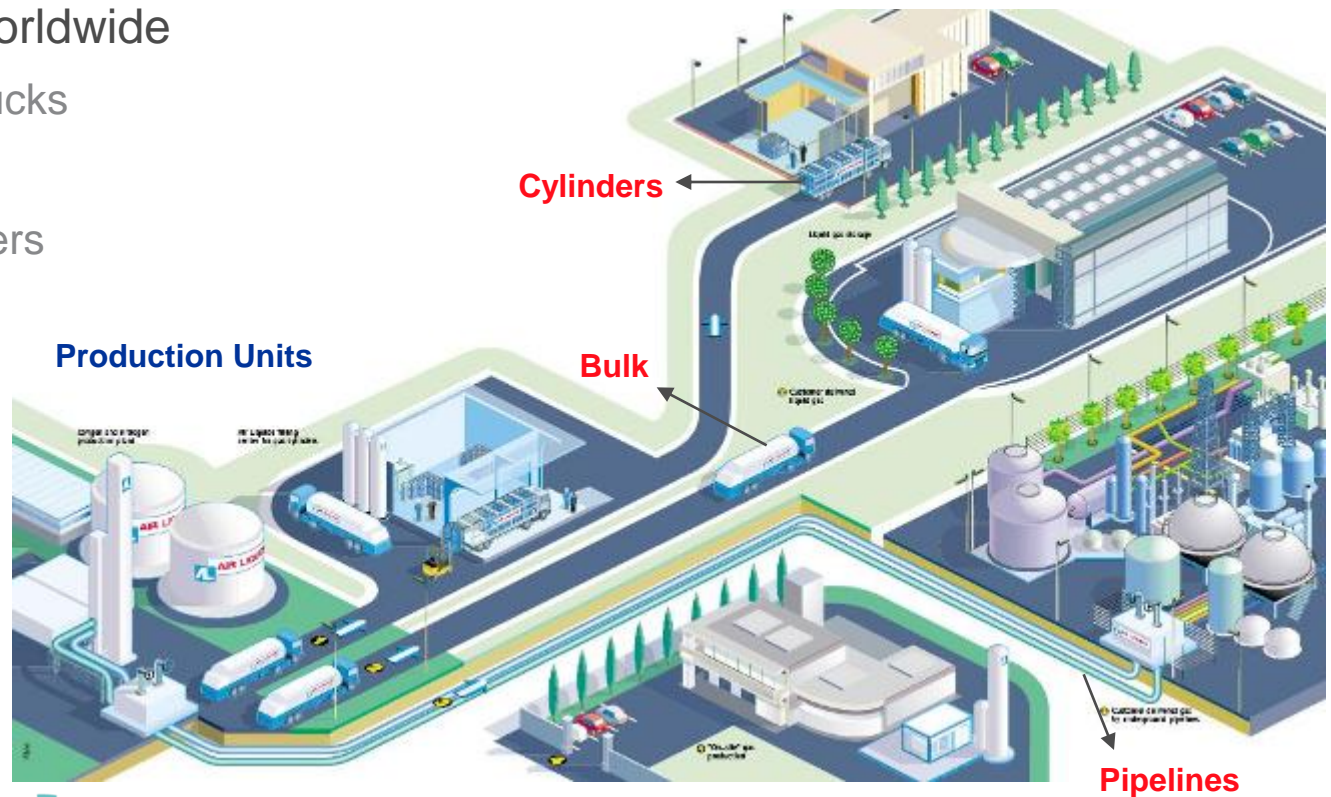
... WITH A UNIQUE VANTAGE POINT



Gas distribution

# Gas distribution modes

- 3 modes of distribution: pipelines, **bulk** & cylinders
- Bulk Distribution: trucks deliver gases to tanks at customer sites
- Bulk activity worldwide
  - Over 2500 trucks
  - 40 000 tanks
  - 350 dispatchers



# Vendor managed inventory

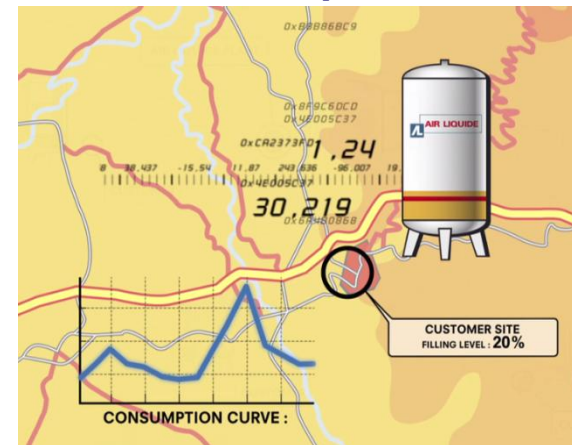
- Air Liquide monitors the customers inventories (telemetry and forecast) and manage the deliveries
- Reduced (but still significant) number of call-in customers (orders) without telemetry and forecast

## Data collection at the customer site:

Measures of stock level are transmitted by telemetry units



## Customer consumption forecast:

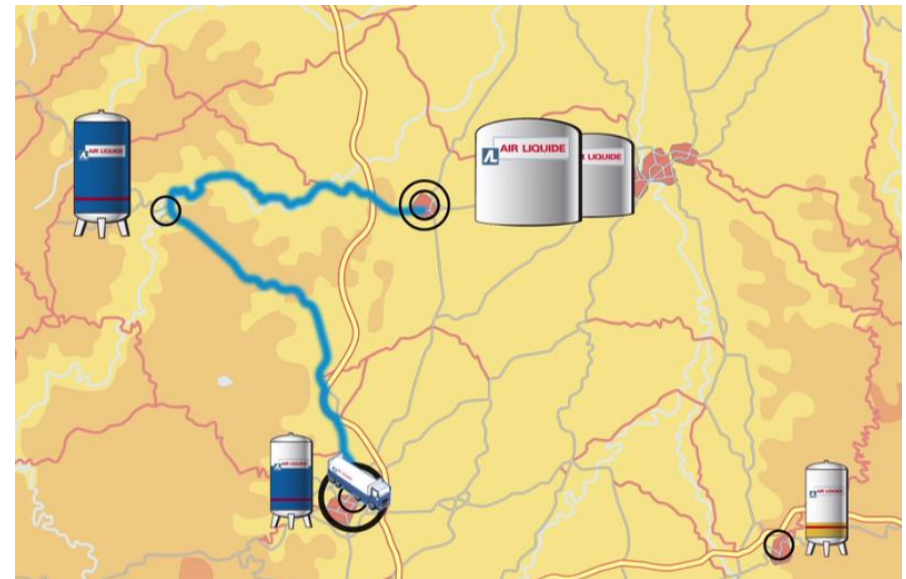




The  
bulk gas distribution  
**challenge**

# Air Liquide distribution challenge

- Generalization of the inventory routing problem (IRP) with vendor managed inventory replenishment
- Several decisions need to be made:
  - **When** to deliver to each customer?
  - **How much** to deliver to each customer?
  - **How** to deliver to each customer?
    - **From where:** depot / source?
    - **With what** resources: tractor / trailer / driver?
    - In **combination with** other customer deliveries (route)?





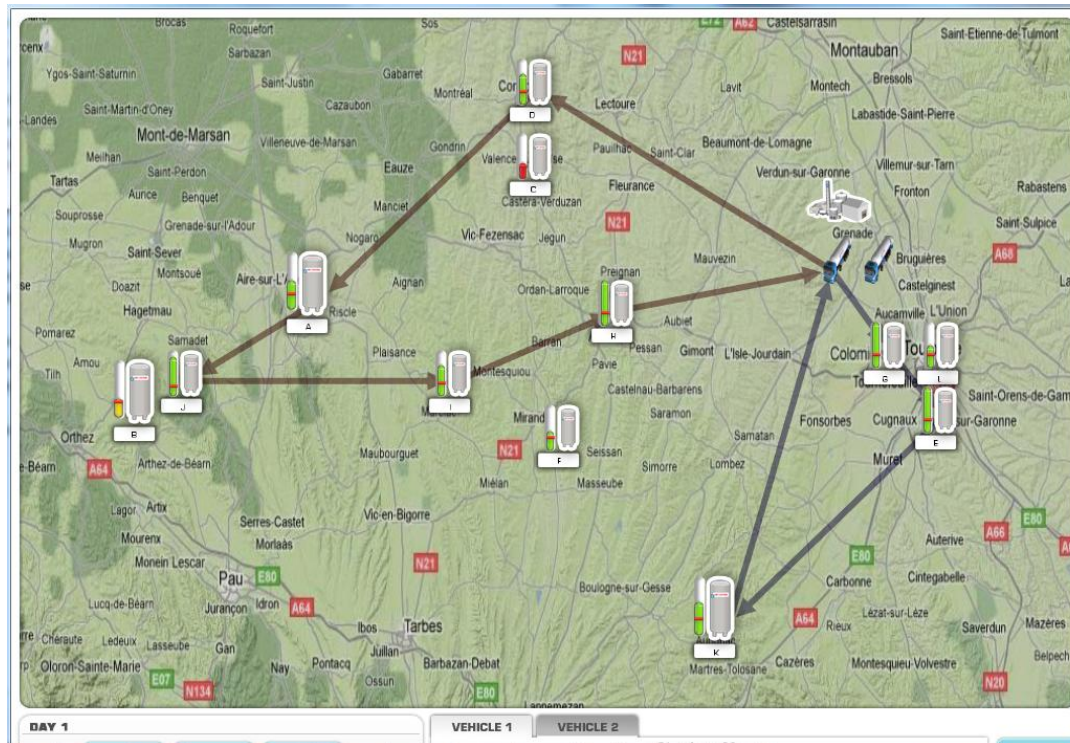
# Air Liquide inventory routing main features

- Vehicles: Drivers/Trailers/tractors
- Multi-products / Multi-Sources / Multi-Depot
- Multi-trip routing
- Split delivery feature
- Drivers working regulation constraints
- Availability time windows (Drivers, Tractors, Trailers, Customers and Sources)
- Compatibility between transportation resources (Drivers/Tractors/Trailers)
- Sites access restrictions: Compatibility resources / sites
- Capacities & Quantities constraints
- Delivery precedence constraints
- Source / customer compatibility (purity/certification constraints)



# Air Liquide distribution efficiency goals

- **Objective:** the goal is to optimize the bulk distribution / transportation planning over the long term
  - Minimizing the **logistic costs**
  - Providing a **high level of product availability** for our customers
    - Avoid product shortage (run-out) at the customer tank
    - Satisfaction of orders of call-in customers



# Version 1 and Version 2

- Version 2 is built on top of the version 1 (extended scope).
- The extensions described on version 2 give to the mathematical model a good fit with the reality of the Air Liquide IRP.

Version 1	Version 2
Only VMI customers	Mix of VMI and call-in customers
Customers available 24/7	Each customer has opening hours
Shifts last less than a working day	Shifts can last several days (with resting layovers with fixed cost)
Driver can drive only one trailer	Driver can drive several trailers
One source	Several sources
Trailers are always available	Trailers may have maintenance unavailabilities
Small-medium instances	Medium-big instances.





# Research & Development

# Opening new ways

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