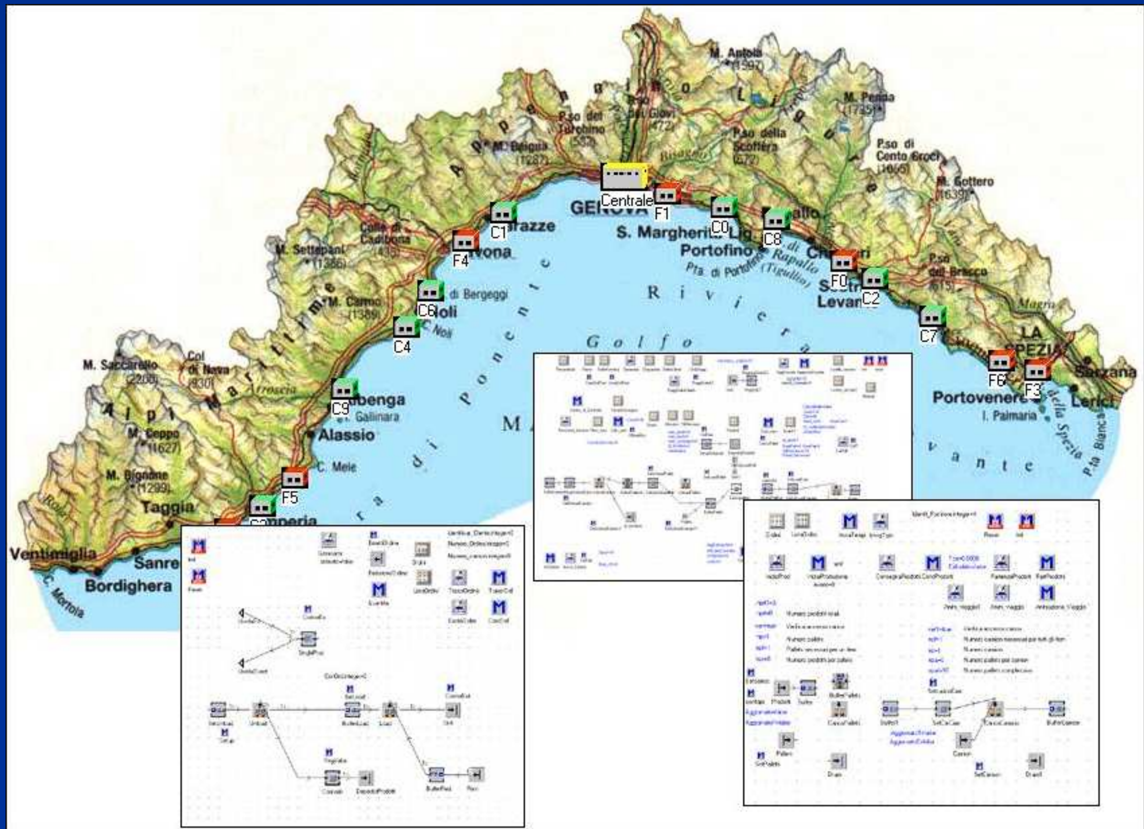
DISCRETE EVENT SIMULATION APPLIED TO MODELLING AND ANALYSIS OF A LOGISTIC CHAIN



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The service offered to customers in a logistic chain

- The capability of supplying the right product at the right time, to comply with delivery schedules and to respect required conditions at very low costs, is one of the fundamental prerequisites of a distribution system of a logistic chain.

- The value added to the product, deriving from optimal logistics, increases customers' satisfaction, thereby guaranteeing better competitiveness and business survival in increasingly competitive markets.

- Inadequate supplies and communications caused the decrease of business market shares associated to revenues reduction and lower quality of services to customers

The Logistic chain

- The logistic chain – analyzed in this work – is located on the Ligurian coast and is made up of 10 customers, 1 distribution station and 7 suppliers.
- Connections among the various nodes are ensured by road haulage.
- Figure 1 shows the flow of orders and products among customers, distribution station and suppliers.
- If customers orders start during the day n the products will be delivered during the day n+1.

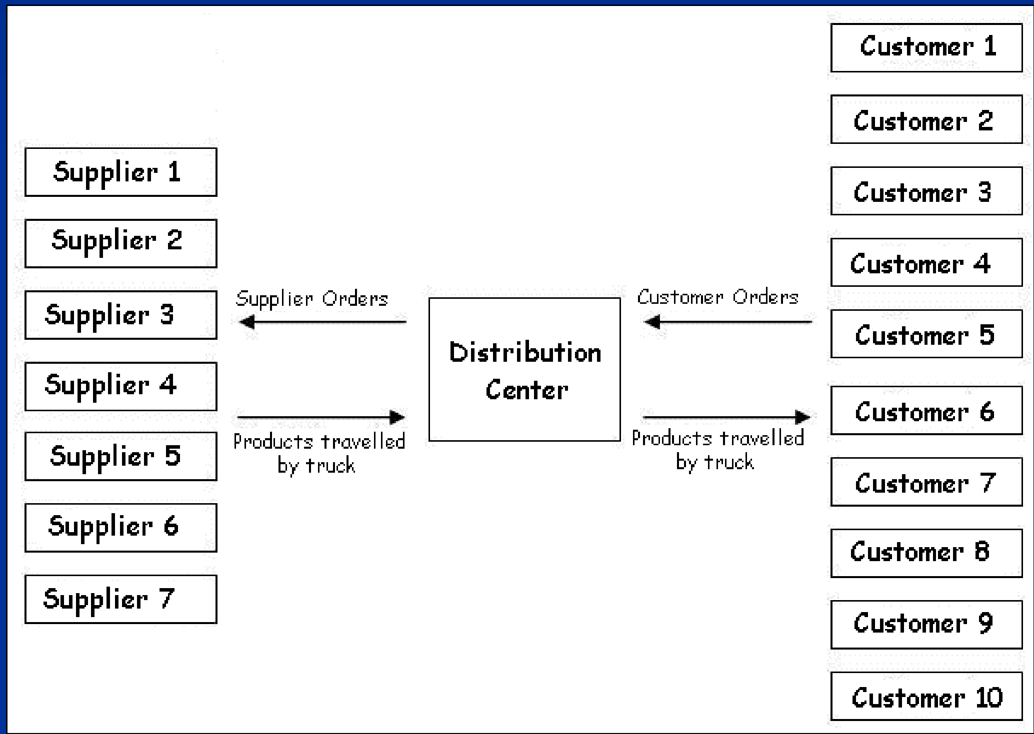


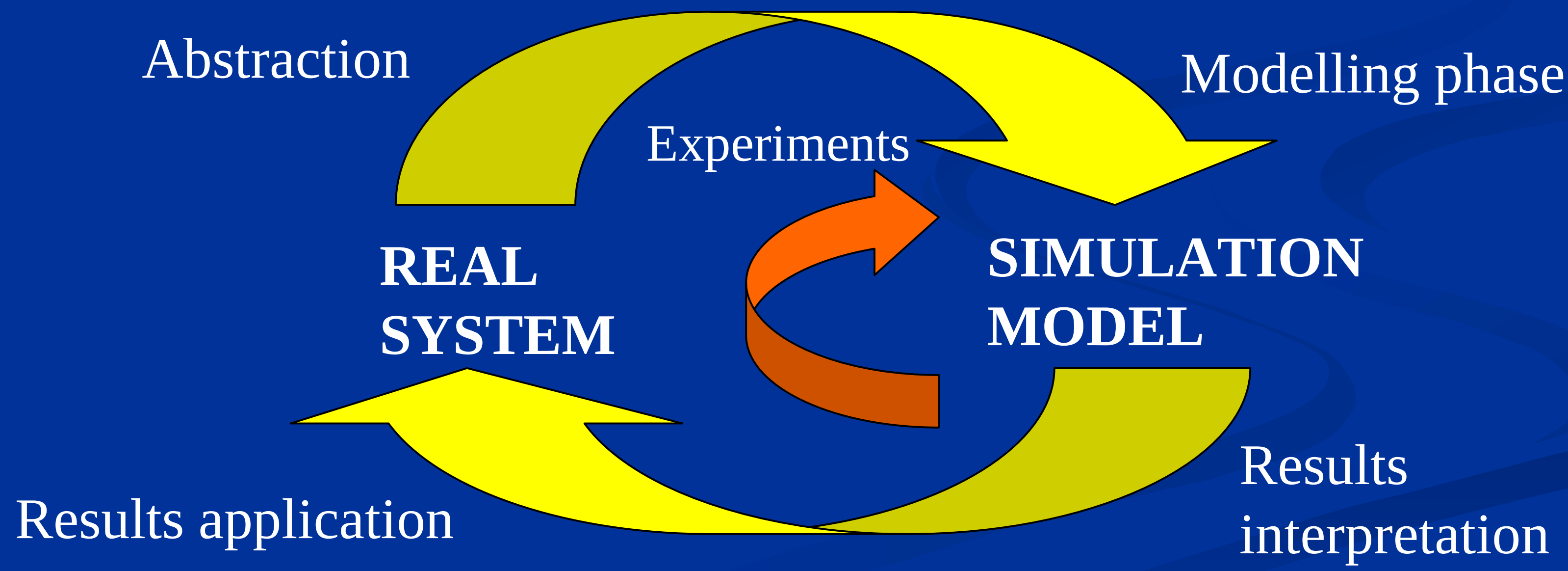
Fig. 1 – Orders and products flow along the logistic chain.

Problem formulation

In a such type of system particular attention have to be dedicated to customer satisfaction measured by a service level. It's very important to find the most important parameters of the system that affect the service level and find also an appropriate model that explain service level in terms of these parameters.

Use of simulation

- Simulation is the imitation of the operation of real world process or system over the time. The simulation is used to analyze a system, design and manage a system, answer to what-if questions.



Use of simulation

- It is now widely recognized that the simulation is a very powerful tool for analyzing some systems whose high complexity, owing to the relationships linking the variables involved and the random nature of those variables, prohibits the use of analytical methods and models (unless they are extremely simplified).

- The analysis of a logistic chain , in which it isn't known the relations between input-output and parameters such as loading and unloading time, travelling time, production time, quantity of product, etc., are stochastic variables imposes the use of simulation as a problem solving methodology.

The modelling phase of the distribution chain

We selected a hierarchical approach used in the modelling phase in order to plan both the operation of the logistic network and activities within each node.

The modelling was performed in four steps:

- customer modelling;
- supplier modelling;
- distribution station modelling;
- integration of customers, suppliers and distribution station into a single distribution network overlapping a map of Liguria.

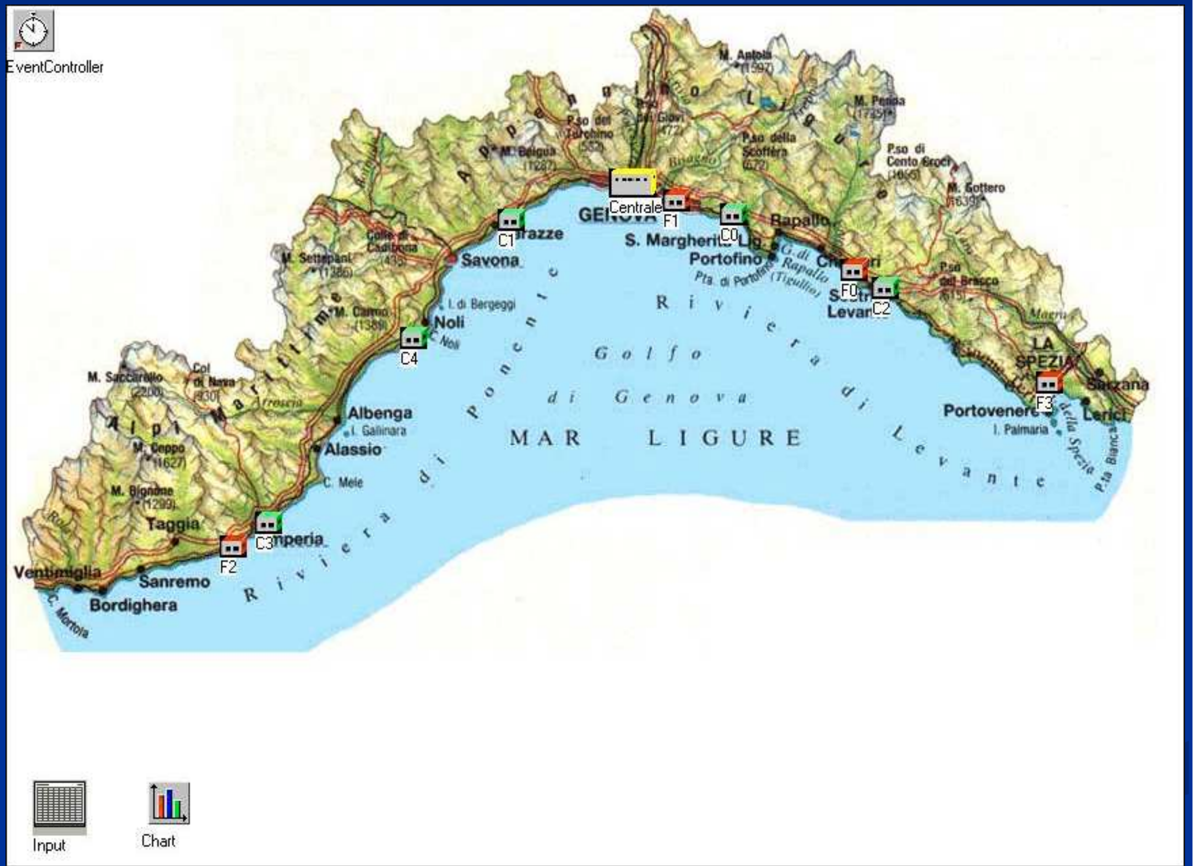
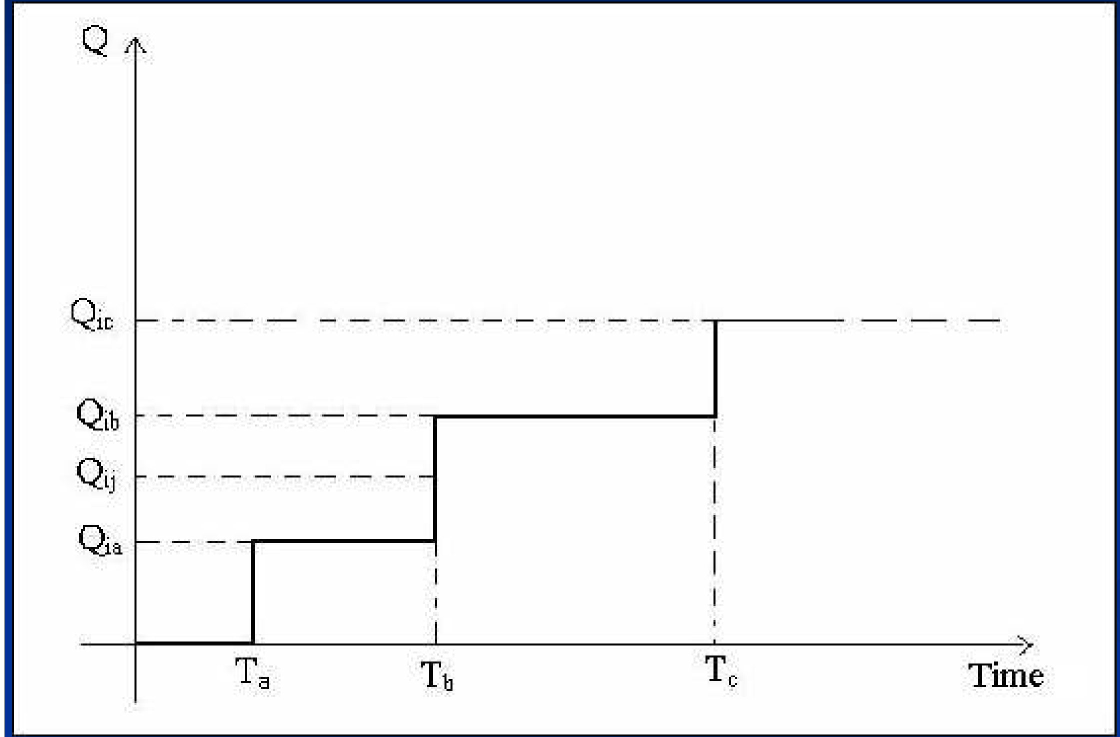


Fig. 2 – Logistic network located on the Ligurian Coast

Events sequencing in the distribution chain

- Customers issue their orders concerning 10 different products.
- Orders are sent to the distribution station which, in turn, sorts them out among the suppliers.
- Each supplier informs the distribution station about its products delivery schedule.
- The distribution station plans the number of trips towards customers according to supplier delivery schedule and to a security factor, Fs.
- Products delivery at the distribution station is performed at a different time with respect to the time evaluated during the forecast step (manufacturing or transportation problems of the suppliers).
- Each item quantity received by the distribution station is inferior to the quantity required (reliability of suppliers).
- Products distribution to customers is performed according to two parameters: customer importance defined by a number of priorities, trucks downtime at the distribution station.

Planning of number of trips toward customers



Qij: Item i quantity as required by customer j
Qia: Item i quantity delivered by supplier a
Qib: Item i quantity delivered by supplier b
Qic: Item i quantity delivered by supplier c
Ta: Supplier a delivery schedule
Tb: Supplier b delivery schedule
Tc: Supplier c delivery schedule

Quantity Qij will be available at the distribution station by time Tb. By generalising *n* items trucks arrivals at the distribution station are foreseen by time Tk so as to fill the order and to make available the products quantity required by customer *j-th*, $\sum_{i=1}^{i=n} Q_{ij}$ To time Tk a security factor Fs is added.

Performance indexes

- The quality of the service offered to customers is measured by the following indexes:

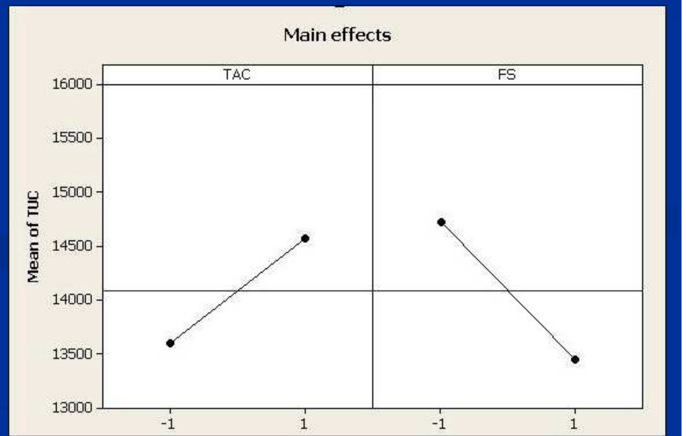
$$SL = \frac{\sum_{i=1}^{i=n} Q_{r,i}}{\sum_{i=1}^{i=n} Q_i}$$

$$SL_{(10-a.m.)} = \frac{\sum_{i=1}^{i=n} Q_{r,i}^{10 a.m.}}{\sum_{i=1}^{i=n} Q_i}$$

- n: number of items;
- $Q_{r,i}$: total quantity of item i received;
- Q_i: total quantity of item i required;
- $Q_{r,i}^{10 a.m.}$ total quantity received by 10:00 A.M. of the day after order placement.

Some results of the simulation

Example of table of Service Level										
Day/Customer	**C0**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**
1	0.99	0.90	1.00	0.58	1.00	0.92	0.30	0.95	0.82	1.00
2	1.00	0.95	0.91	0.51	1.00	1.00	0.23	0.91	0.86	1.00
3	0.97	0.95	0.96	0.49	1.00	1.00	0.33	0.99	0.80	1.00
4	1.00	0.96	0.97	0.45	0.95	1.00	0.31	1.00	0.86	0.96
5	1.00	1.00	1.00	1.00	0.91	0.52	0.95	0.82	1.00	0.50



The simulation model was employed to carry out the analysis of sensitivity on the trucks downtime (TAC) parameter and security factor (Fs) parameter in order to evaluate their impact on the truck utilization time (TUC) and on the quality of the service offered to customers (Service Level).