MANAGEMENT AND CONTROL OF POLLUTION EVENTS IN A PORT ENVIRONMENT

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Objectives

This application aims to simulate the operation of a port focusing on possible pollution spills that may occur due to such activities as ship arrivals and departures, oil loading and unloading, stocking etc. The use of simulation more clearly defines the impact of waste management policies, emergency planning, rescue and recovery procedures. Focus is given to resource management and to the right information level that each component of the system should have in order to achieve the best overall performance. For instance, a low reaction level may increase the spreading of pollution spills before a team may recover them. The objective of this application is to test the use of simulation as a decision support tool for the Port Authority for real time management and control of every day pollution events. Through the use of simulation the Operator may predict the impact of decisions before any action is taken, thereby forecasting the consequences of different recovery policies. The simulator may also be used for operator training.

This project has been set up by Servizi Ecologici S.p.A., a Genoa Port Authority's Company, and it is partly funded by Regione Liguria.

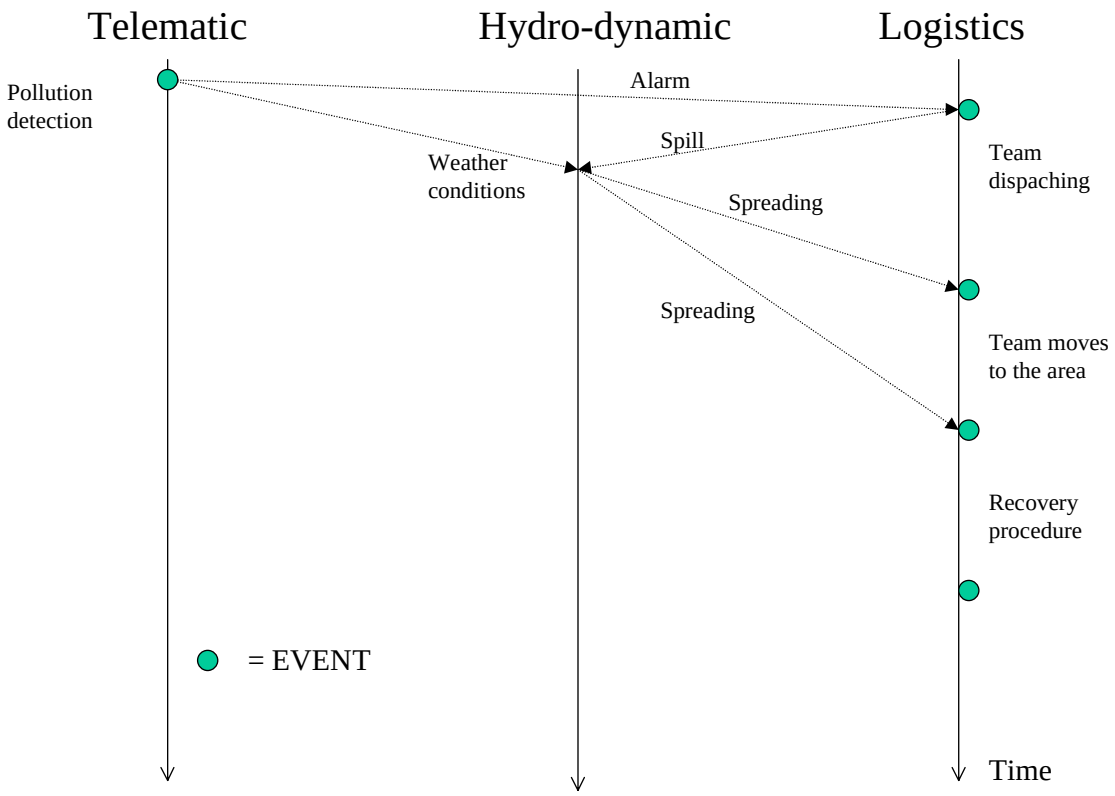
The application components

The application is actually made of three modules:

1. The Logistics model, that takes into account all the logistic issues related to a port operation, and simulates the generation and the recovery of pollution spills.
2. The Hydro-dynamic model, that takes care of the pollution spreading within the area.
3. The Telematic Model, that considers the information levels and communication relationships between port operators and port authorities.

The Logistics model interacts with the Hydro-dynamic model generating pollution spills with certain characteristics in a few areas within the port. The Hydro-dynamic model receives this information and calculates the spreading of the pollution spill over time, also taking into account the information on weather conditions received from the Telematic model.

The Logistics model interacts with the Telematic model simulating the arrival of alarms. The Hydro-dynamic model interacts with the Logistics model relaying back the level of pollution spreading that has occurred by the time the dispatching of the recovery team has been completed. The Logistics model simulates the recovery operation. Since it usually takes some time between the dispatching and the arrival of the recovery team, the Hydro-dynamic model is used to predict the aggregate area of the pollution spill. This way the Logistics model forecasts the time and effort needed for the recovery procedure, and also detects possible bottlenecks or critical events.



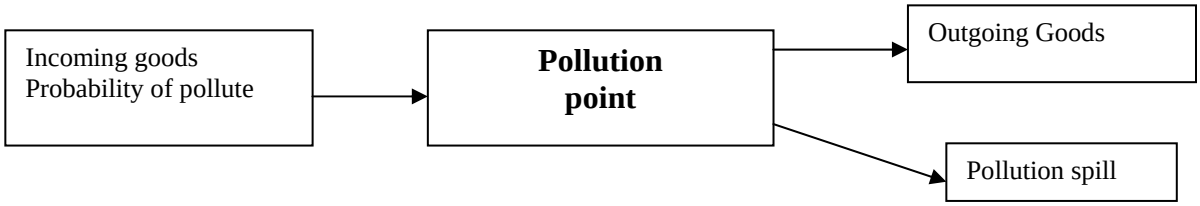
In the following chapters a description of the Logistics model is given.

The Logistics Model

This model manages the generation of pollution spills through the association of each flow of goods (e.g. crude oil) with a potential to pollute.
The final model is being developed in MODSIM III (Compuware Corporation), an object-oriented simulation language. MODSIM III provides object-oriented programming, discrete event simulation capabilities, and animated graphics all in one language. It is used to build

large, process-based discrete event simulation models through modular and object oriented development techniques.
A first prototype showing the main capabilities and model's processes has been developed using SIMPROCESS (CACI). SIMPROCESS is a hierarchical and integrated process simulation tool. SIMPROCESS integrates process mapping, hierarchical event-driven simulation, and activity-based costing into a single tool. Most of the snapshots included in this paper are taken from the SIMPROCESS model.

Goods are transported by carriers: ships, pipelines, trains, trucks etc. These goods are handled in a sequence of activities while crossing the node (loading, unloading, handling, stocking, delivery). During each of these activities pollution spills may occur according to some probability function.



The point where a pollution spill may occur is characterized by a "transfer function" that according to the incoming goods generates:

- The amount of pollution
- Type of pollution
- Propagation time
- Warnings and or alarms

Pollution spills may also occur as a consequence of the utilization of plants and resources. In this case, the outgoing level of pollution can be larger than the incoming level as in the case of pump stations. The opposite may also occur, such as the case with waste management plants.

Each plant is described as:

- incoming goods and their tendency to pollute
- outgoing goods and their tendency for pollution
- Duration of handling
- Warning and alarms
- Other events directly resulting from the handling of goods

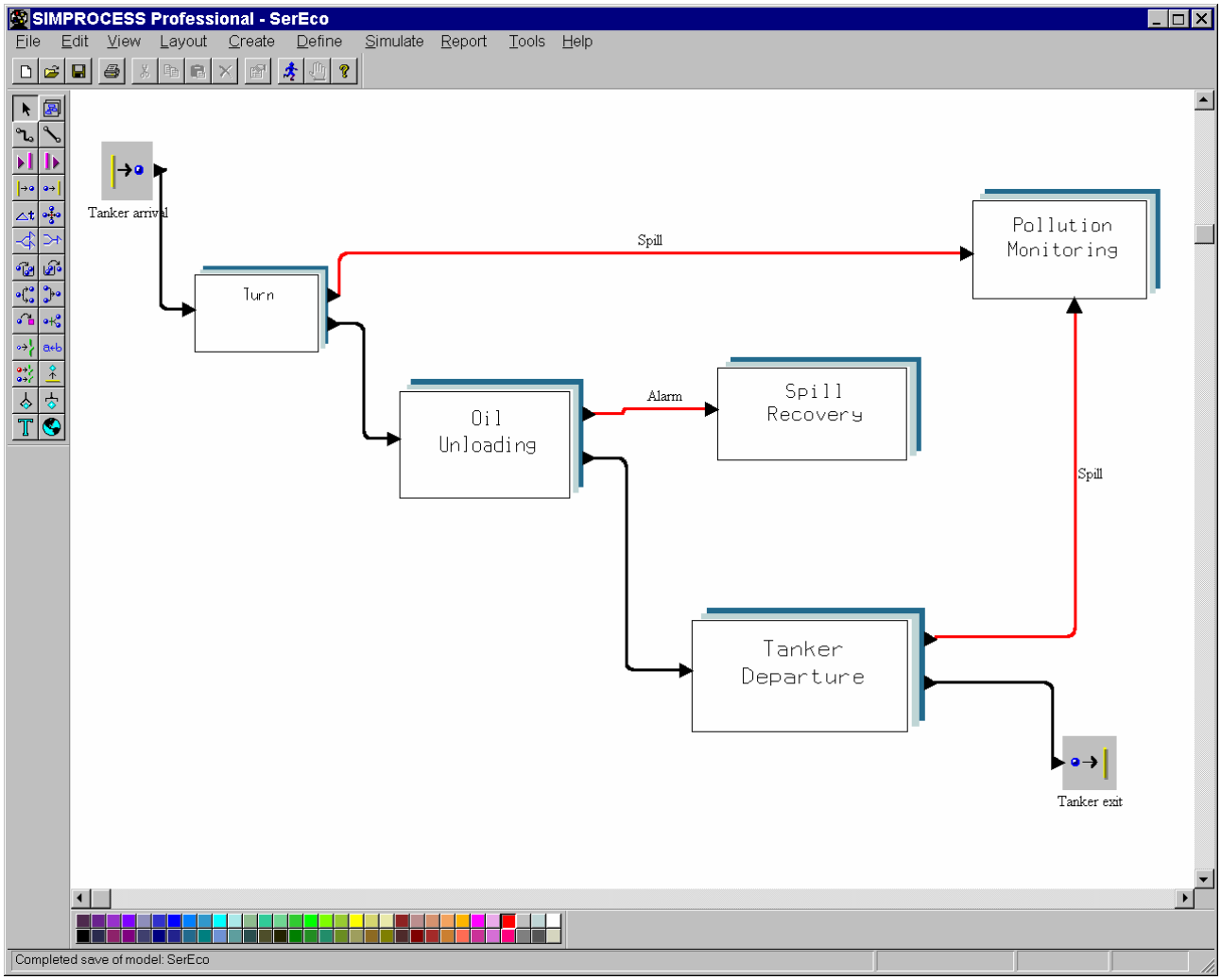
The generation of any type of pollution provokes:

- The propagation of the pollution occurrence, characterized by the propagation time and spreading.
- Potential warnings or alarms characterized by telematic levels and delays

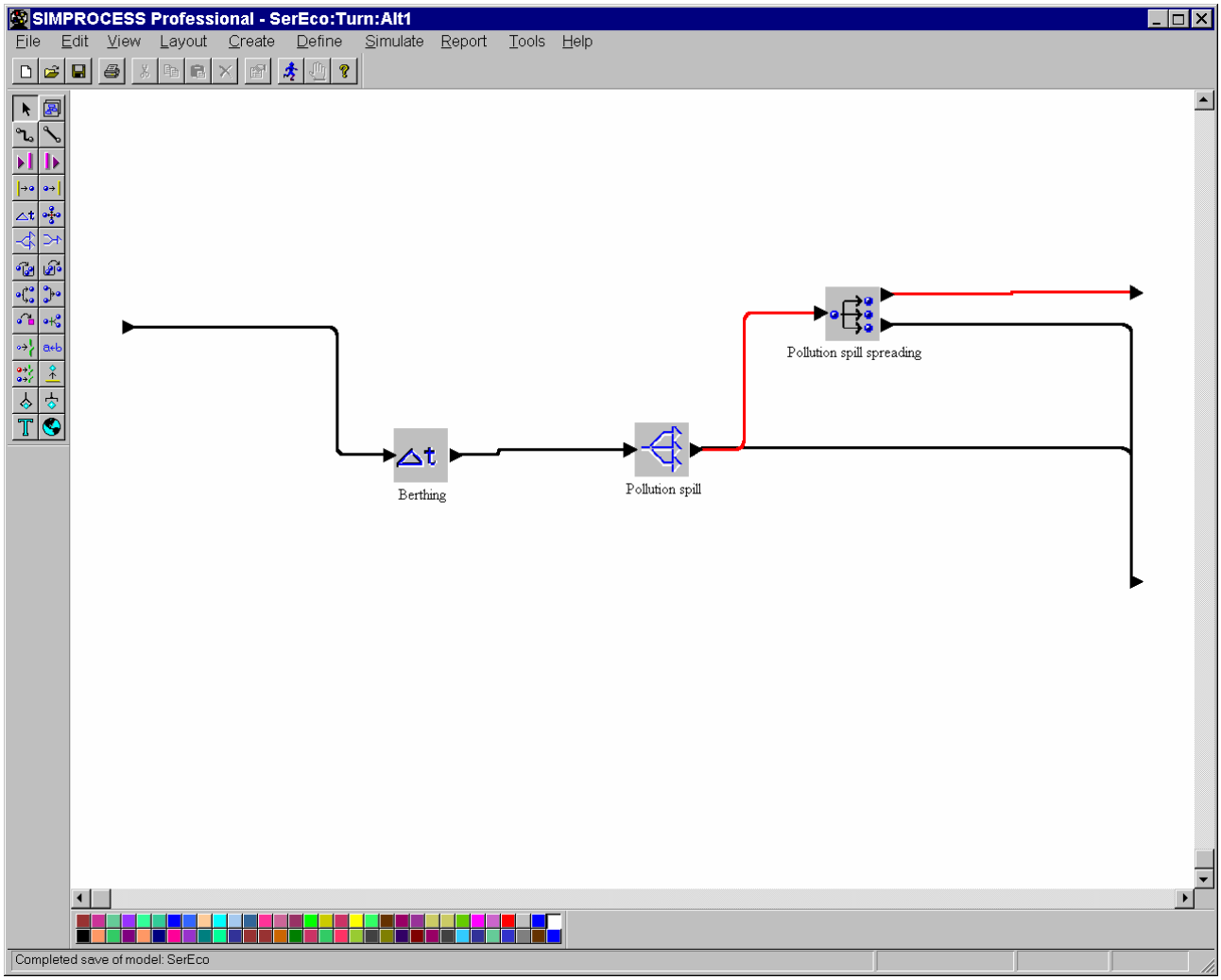
If a pollution spill warning occurs after a transmission delay, a rescue and recovery procedure is activated. Each rescue and recovery procedure is characterized by a sequence of activities. Each activity involves coordination and operational efforts, and may be defined by a process of resource allocation, carrying out each activity, and resource release. The type of allocation (number and kind of resources involved) as well as duration of the activity are related to the level and timeliness of the pieces of information.
Should the pollution spill fail to be signaled, a specialized agent has the task to monitor the overall pollution levels and to activate the appropriate warnings or alarms, in turn activating the rescue and recovery procedure. This task periodically monitors a number of variables and activates related procedures when necessary.

In the simulation model, the generation of this sequence of activities is triggered by the arrival of a certain quantity and type of goods (such as crude oil), carried by a transportation mean (a tanker). Each type of goods and transportation mean has a different sequence of activities (process) and a different pollution probability.

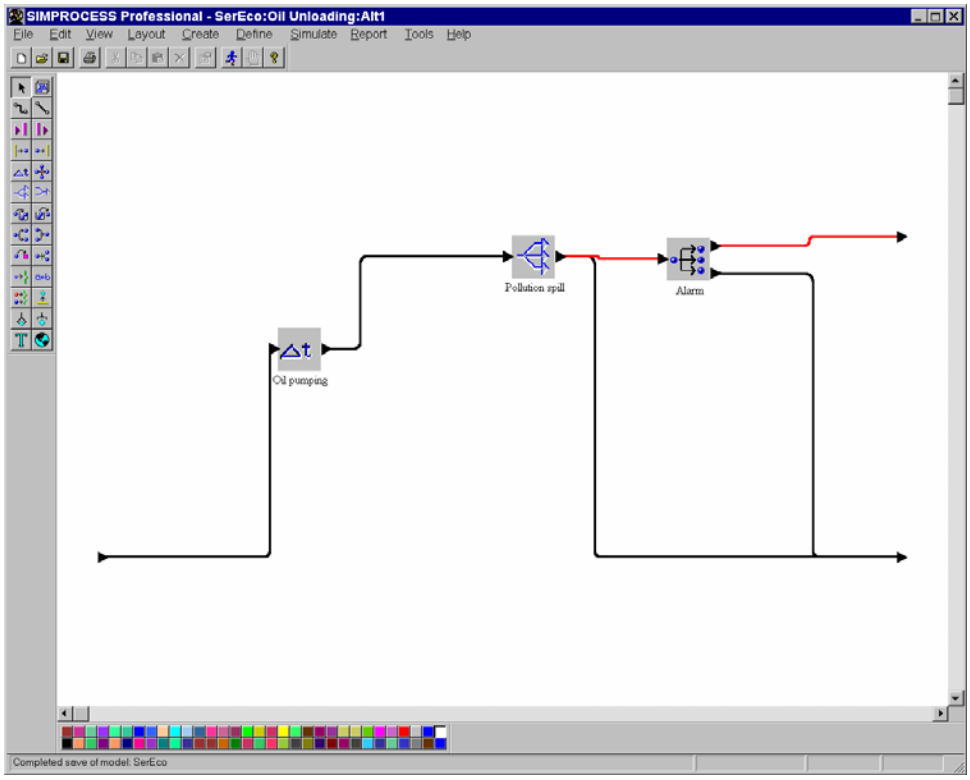
For instance the process of the arrival and unloading of a tanker may be characterized by the following process:

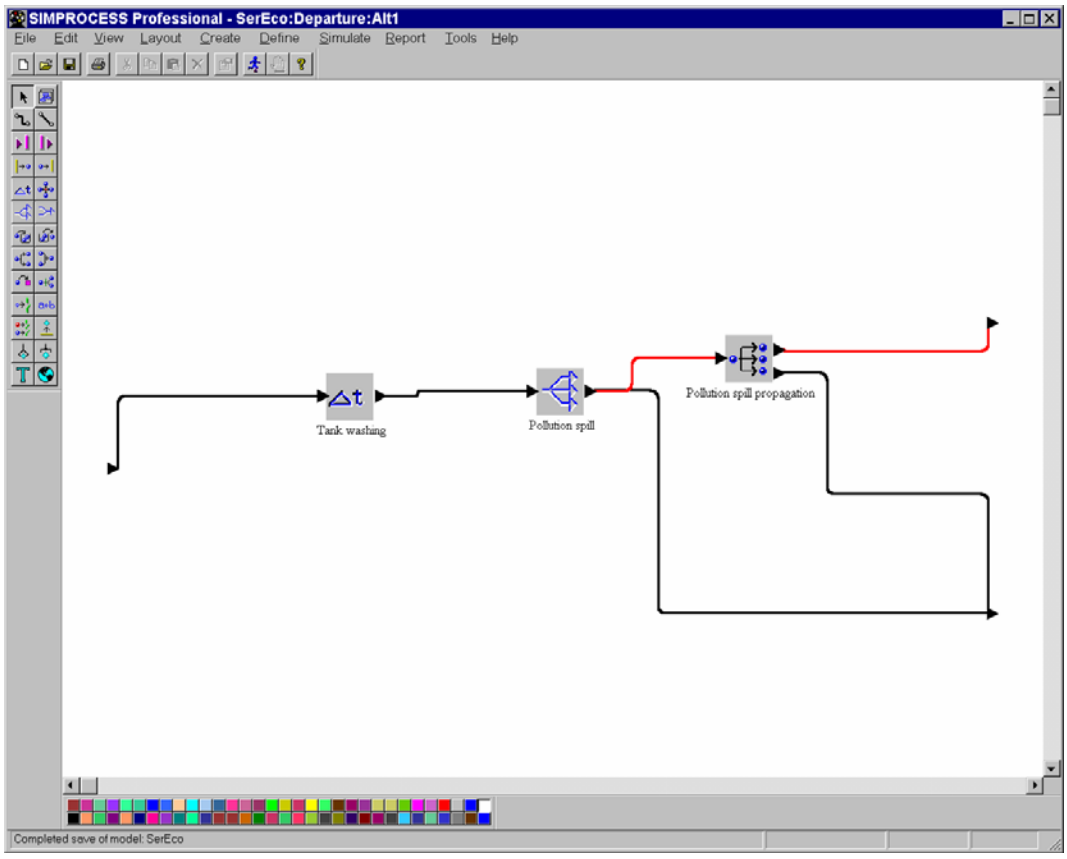


1. Turn: this may generate a pollution spill that may not be signaled. In this case this event is added to a list of non-signaled events with indication of time of event, kind and quantity of the spill, and place where the event occurred.



2. Crude oil unloading and stocking: this may generate a signaled pollution spill. A message, showing the time, quantity and kind of the spill is passed to the agent overseeing the recovery procedure. After a transmission delay a recovery procedure, such as the following, is activated.
   - Allocation of the recovery team
   - Allocation of the necessary boats and equipment
   - Location of the polluted area
   - Recovery (depending on the timeliness of the alarm)
   - Return to the port and release of the resources

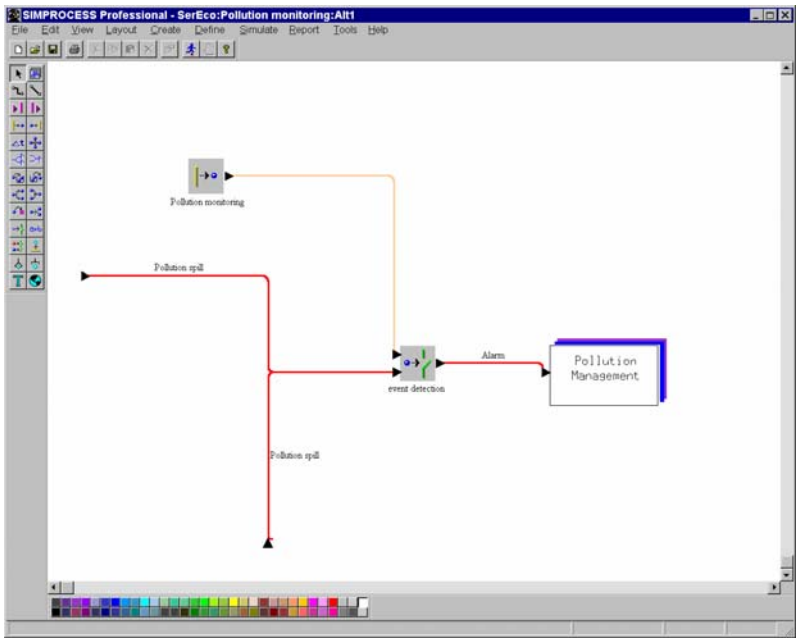


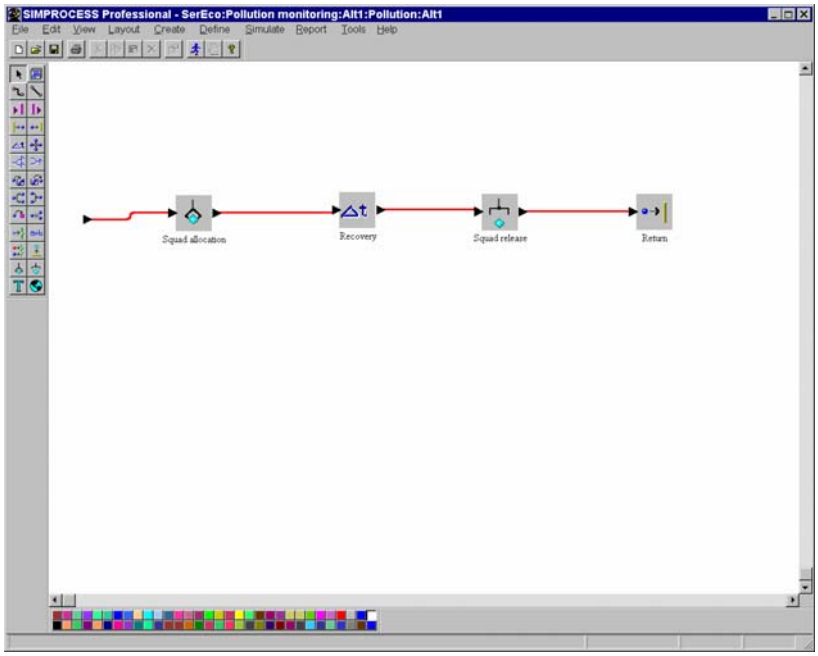


3. Tanker Departure

4. Washing of tanks. This is a non-signaled event that follows the same procedure as item 1.

5. Exit from the system





In the case of a cruise ship the process may be as follows:

1. Turn: this may generate a pollution spill that may not be signaled. In this case this event is added to a list of non-signaled events with indication of time and kind of event, as well as quantity of the spill, and where the event occurred.
2. Disembark passengers
3. Waste unloading and management. This event may increase or decrease the pollution levels in the system
4. Loading of passengers and supplies
5. Exit from the system

Each activity is associated with the necessary parameters (delays, probabilities, types, resources, quantities)

The monitoring and control function periodically detects non-signaled pollution events, issues an alarm and manages the recovery resources.
Similar processes can also be defined for different carriers, such as trucks, trains and pipelines, each of which possesses the potential to pollute.

A wide range of potential data categories include:

- Kind of goods
- Type of carrier
- Process (sequence of activities) performed by each carrier when calling the port
- Plants and port resources necessary to perform each activity
- Personnel and devices for recovery teams
- Information levels and timeliness
- Emergency management procedures
- Telecommunication levels

Further developments

At this stage the three modules interact in an "off-line" way, that is to say they just emulate actual communication protocols. The next step would be to fully integrate these models in order to make them react to live data. This will re-configure the application as a true on-line decision support tool where the operator may decide using data from both environmental and logistics parameters. A possible approach would be to integrate the simulation models with co-operative intelligent agents, that "learn" both from the User's day-to-day operation and from the simulated scenarios, thereby leading the operator to the right course of action when facing a particular situation.