

# SINMAR-TMM an Innovative System for Freight Terrestrial Multimodal Transport Management

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**Abstract:** *SINMAR-TMM* is an intelligent system for freight terrestrial multimodal transport management created within *Amtrans* program, a Romanian research, development and innovation project coordinated by the National Institute for Research and Development in Informatics. CFR-MARFA, the Romanian freight railway Transport Company is the user and co-financier of the system. The *SINMAR-TMM* system supports the planning and monitoring processes specific to freight multimodal terrestrial transport. *SINMAR-TMM* is dedicated to economic agents involved in the freight multimodal terrestrial transport as freight providers, freight buyers, forwarding agencies, freight railway transport operators, freight road transport operators, container / standard transport unit owners, warehouses / terminals operators. The *SINMAR-TMM* system contains a set of integrated hardware and software components and uses and integrates a diversity of ICT<sup>1</sup> technologies.

**Keywords:** multimodal terrestrial transport, container, transport planning and monitoring, GPS, GIS, RFID, GPRS

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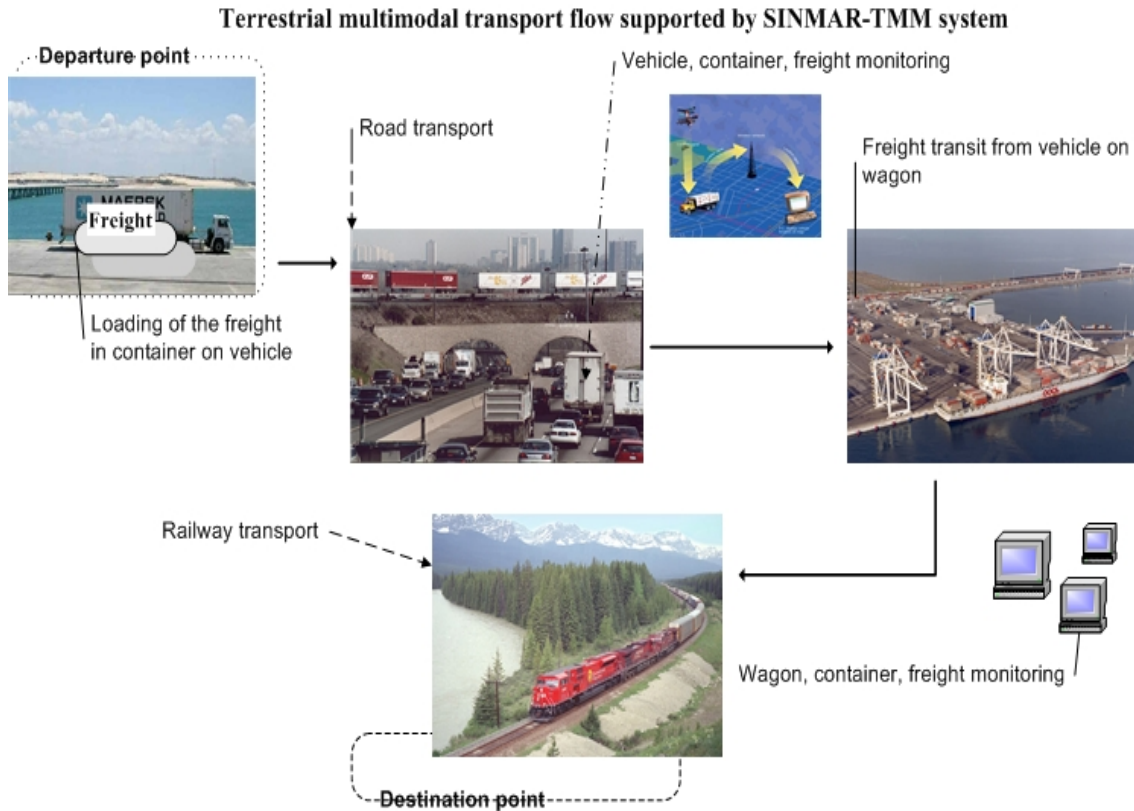
## 1. Introduction

SINMAR-TMM system is a modern, innovative, multifunctional and integrated system for informational management of the freight multimodal terrestrial transport. The system integrates new technologies that support the data acquisition and information management. The system integrates hardware and software components into a multifunctional platform designed for flow planning and monitoring of freight multimodal land transport.

An example of freight multimodal terrestrial transport flow assisted by SINMAR-TMM system is presented in Figure 1.

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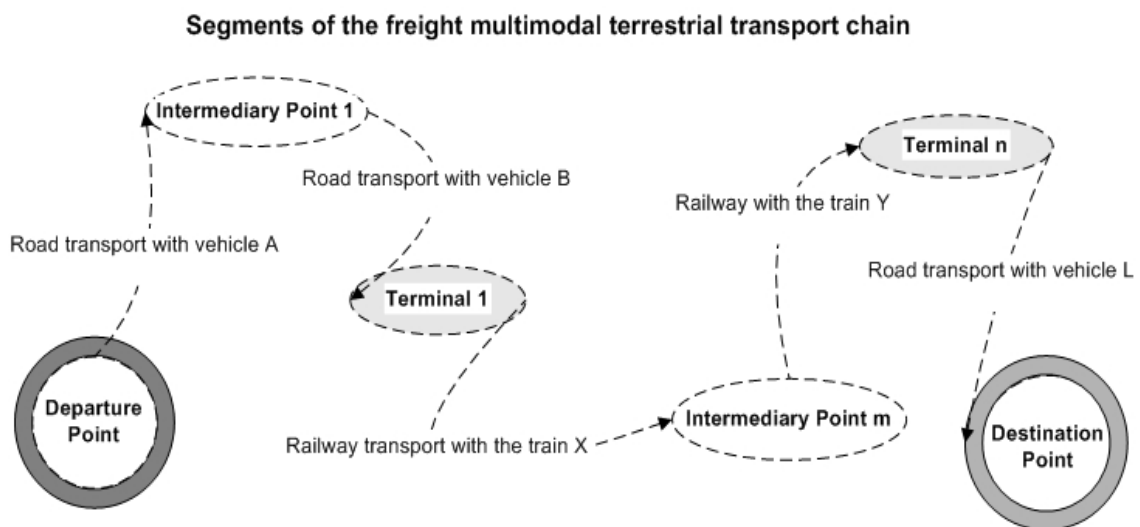
<sup>1</sup> ICT - Information and Communication Technologies



**Figure 1: Terrestrial multimodal transport flow supported by SINMAR-TMM system**

## 2. Multimodal Terrestrial Transport Chain

The route of freight multimodal terrestrial transport is structured in transport segments that connect the successive points of the transport chain. An example of route is presented in the figure 2. Two successive transport segments may be of the same transport mode.



**Figure 2: Segments of the freight multimodal terrestrial transport chain**

### 3. Transport Monitoring Devices

The hardware components of SINMAR-TIM system that have been developed by the project team are the following:

- Programmable Device for Positioning and Communication - DPPC - device for data acquisition for vehicle monitoring in real time using GPS, GSM and GIS technologies.
- Autonomous Device for Positioning and Communication – DAPC - device for data acquisition for container monitoring in real time in multimodal terrestrial transport using GPS, GSM and GIS technologies.
- Radio Localization Fix Device for locomotive and wagon monitoring – DLFDR - device that uses electronic labels and electronic label readers based on RFID technology, for data acquisition for wagon monitoring in railway transport.

The system takes into account different transport strategies. For each strategy there is one or more solutions for real time transport monitoring as it is presented in Table 1.

**Table 1. Modalities for freight transport monitoring in multimodal terrestrial transport**

Monitored object	Transport mode	Devices for transport monitoring		
		Container	Vehicle	Wagon
Freight in vehicle	Road transport		DPPC	
Freight in vehicle on wagon	Railway transport		DPPC or	DFLR
Freight in container on vehicle	Road transport	DAPC or	DPPC	
Freight in container on vehicle on wagon	Railway transport	DAPC or	DPPC or	DFLR
Freight in wagon	Railway transport			DFLR
Freight in container in wagon	Railway transport	DAPC	or	DFLR
Vehicle without freight	Road transport		DPPC	
Vehicle without freight on wagon	Railway transport		DPPC or	DFLR
Wagon without freight	Railway transport			DFLR

### 4. Software Components

The software components of the SINMAR-TMM system are structured in five categories:

- Client subsystems that provide services for freight multimodal terrestrial transport management by the user.
- Central management centre that integrates all services for devices monitoring.
- Data acquisition with monitoring devices.
- Web services for system component integration.
- Database with stored data and database management system.

### 5. SINMAR-TMM Functionalities

SINMAR-TMM functions are structured in six categories:

- Freight transport modalities management in multimodal terrestrial freight transport.
- Monitoring devices management.
- Information visualisation.
- Information archive management.

- Database saving and restoring.
- Access and communication management.

The functions related to "Freight transport modalities management" are:

- Management of the agents involved in multimodal terrestrial freight transport: registration of the agents in SINMAR-TMM database (identification, presentation, localisation, contact), updating of the registered information at agent level, agent access management.
- Transport chain management (departure point and destination point indication, terrestrial multimodal transport chain definition, chain component segment specification, means of transport specification at transport segment level).
- Freight management in the terrestrial multimodal freight transport at route segment level (type, name, characteristics).
- Container management in the terrestrial multimodal freight transport at route segment level (type, identification, characteristics).
- Vehicle management on the road freight transport segments of terrestrial multimodal transport chain (type, identification, characteristics).
- Wagon management on the railway freight transport segments of terrestrial multimodal transport chain (type, identification, characteristics).
- Wagon set management on the railway freight transport segments of terrestrial multimodal transport chain (type, identification, characteristics).
- Representation on the Europe digital map of the transport flow on the segments of the terrestrial multimodal freight transport chain.

The functions related to "Monitoring devices management" are the following:

- Management of the DPPC devices used for vehicle monitoring on terrestrial multimodal transport chain.
- Management of the DAPC devices used for container monitoring on terrestrial multimodal transport chain.
- Management of the DFLR devices used for wagon monitoring on terrestrial multimodal transport chain.

The functions concerning „Information visualisation" are:

- Visualisation of the information managed by the system based on user requirements at agent level involved into a terrestrial multimodal freight transport chain using selection criteria created dynamically by the user.
- Providing of status reports, information reports and statistic reports.

The functions concerning „Information archive management" are:

- Automatic creation of archive with data managed by the system.
- Information extraction from archived data.

The functions related to „Database saving and restoring" are the following:

- Saving of SINMAR-TMM system database.
- Restoring of SINMAR-TMM system database.

The functions concerning „Access and communication management" are:

- Assurance of the access security to the information in conformance with access rights.
- Assurance of the communication security between system components.

## 6. System Services

The SINMAR-TMM services are:

- System administration: functional and database integrity assurance, information confidentiality keeping at business partner level, real time answer to user requirements, authentication control, monitoring devices management.
- Client registration and password and access rights providing.
- Freight multimodal terrestrial transport planning:
  - Connection to the system using the identification number and password.
  - Business partner and multimodal transport contract registration.
  - Multimodal terrestrial transport route segment registration.
  - Route search and route segment search.
- Freight multimodal terrestrial transport monitoring:
  - Management of the devices used for transport standard unit (wagon, vehicle, container) monitoring in real time on multimodal terrestrial transport route.
  - Device parameter setup.
  - Data acquisition regarding transport standard unit location.
  - Freight and transport standard unit monitoring on transport segments included in the transport route specified in multimodal terrestrial transport contract.
  - Representation on the map of information concerning freight and transport standard unit monitoring.

## 7. Technologies Used and Integrated

The SINMAR-TMM system uses and integrates languages, technologies and tools like: GIS<sup>2</sup>, GPS<sup>3</sup>, GSM<sup>4</sup>, GPRS<sup>5</sup>, RFID<sup>6</sup>, SQL<sup>7</sup>, T-SQL<sup>8</sup>, MS-SQL 2000 Server, programming framework .NET, C#.Net, VB.Net, IIS5.0<sup>9</sup>, Web services, WSE2.0<sup>10</sup>, XML2.0<sup>11</sup>, ADO<sup>12</sup>.Net, WSDL<sup>13</sup>, UDDI<sup>14</sup>.

## 8. Communication

The SINMAR-TMM system users have been structured in seven categories: freight provider, freight buyer, forwarding agency, freight railway transport operator, freight road transport operator, container / standard transport unit owner, warehouse / terminal.

The information communication flow between monitoring devices, users and operating center is presented in Figure 3.

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<sup>2</sup> GIS - Geographical Information System

<sup>3</sup> GPS - Global Positioning System

<sup>4</sup> GSM - Global System for Mobile Communications

<sup>5</sup> GPRS - Global Packet Radio Service

<sup>6</sup> RFID - Radio Frequency Identification

<sup>7</sup> SQL - Structured Query Language

<sup>8</sup> T-SQL - Transact-SQL

<sup>9</sup> IIS - Internet Information Services

<sup>10</sup> WSE - Web Services Enhancements

<sup>11</sup> XML - eXtensible Markup Language

<sup>12</sup> ADO - ActiveX Data Objects

<sup>13</sup> WSDL - Web Services Description Language

<sup>14</sup> UDDI - Universal Description Discovery and Integration

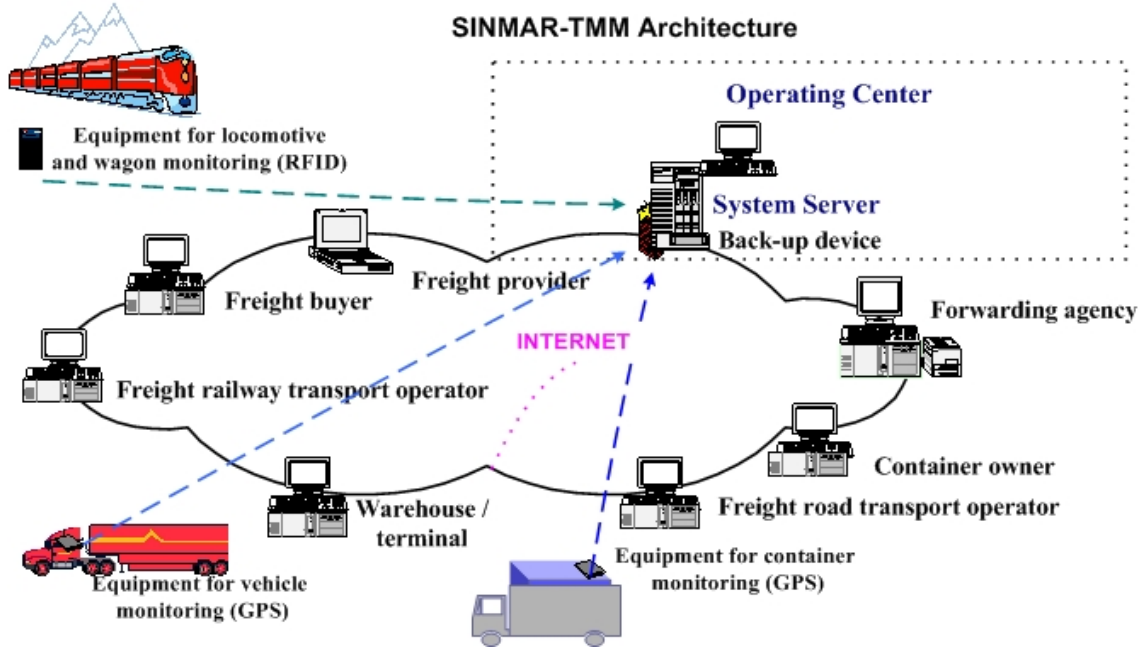


Figure 3: Communication architecture of the SINMAR-TMM system

## 9. System Qualities and Performances

The quality characteristics regarding system architecture are: flexibility, openness, modularity. The principal quality characteristics of services offered by the system are: accessibility, confidentiality, real time dialog. The qualities concerning system functionalities are: reliability, interoperability, robustness, security, user-friendly interface.

## 10. System Interfaces

The system is currently in the testing phase. Some of system interfaces are presented in the figures below.

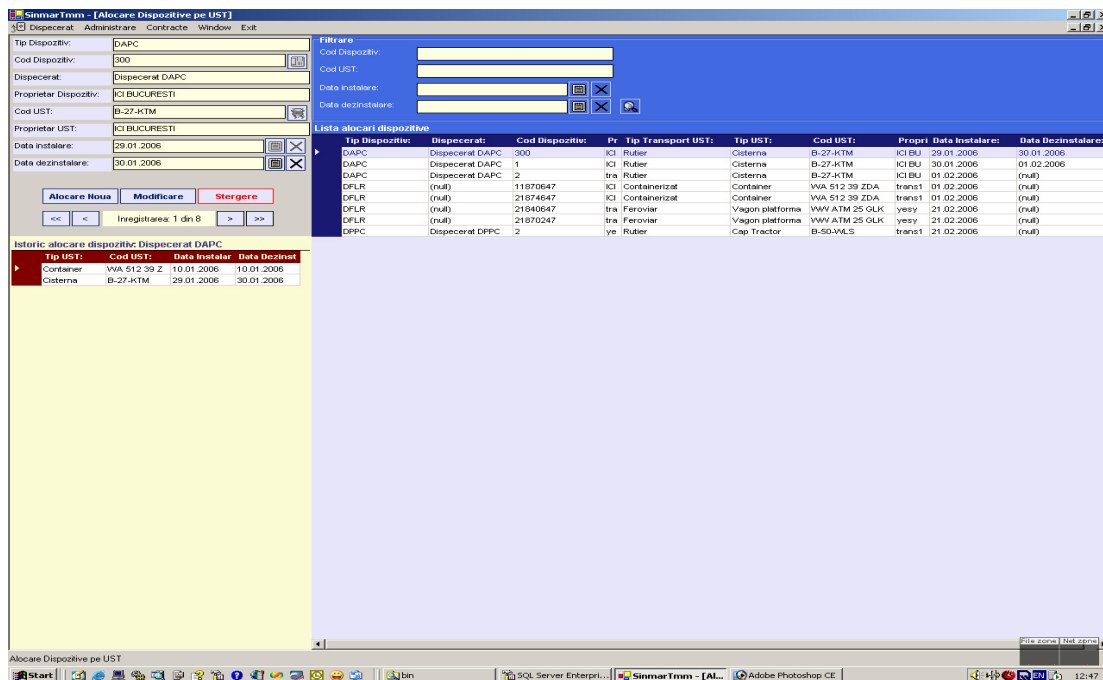


Figure 4: Allocation of the monitoring devices to standard transport units

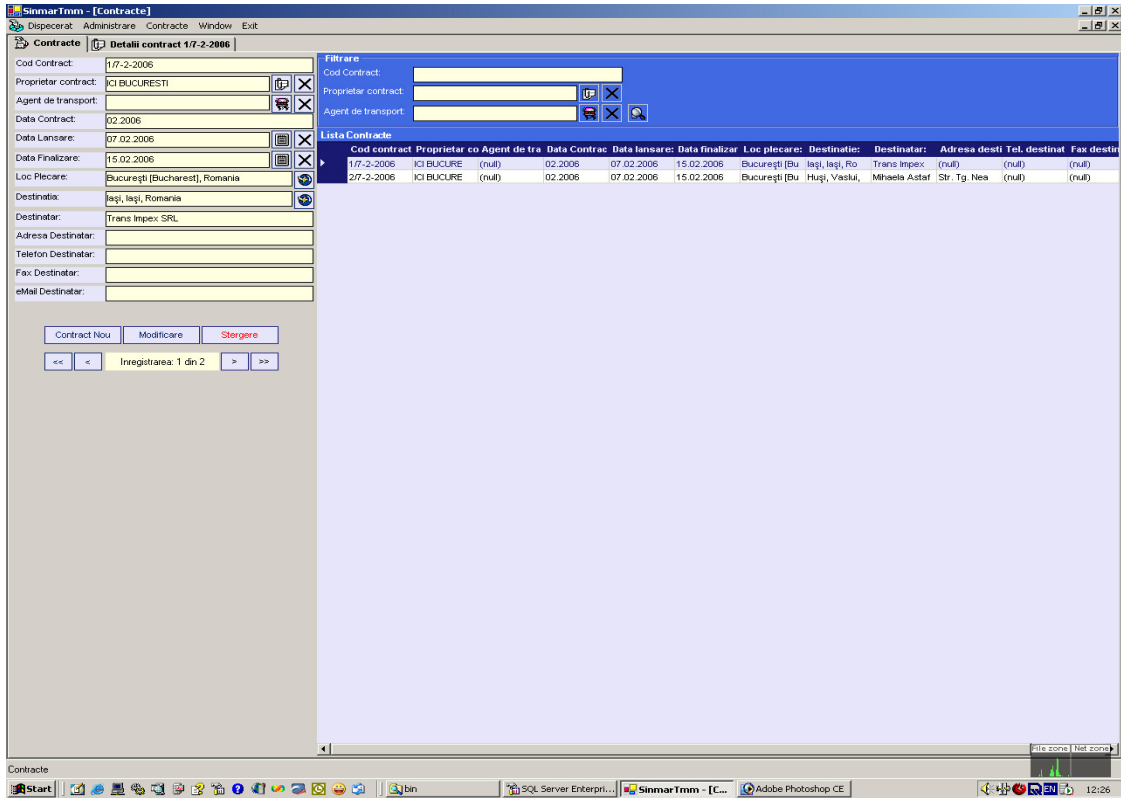


Figure 5: Management of the transport contract

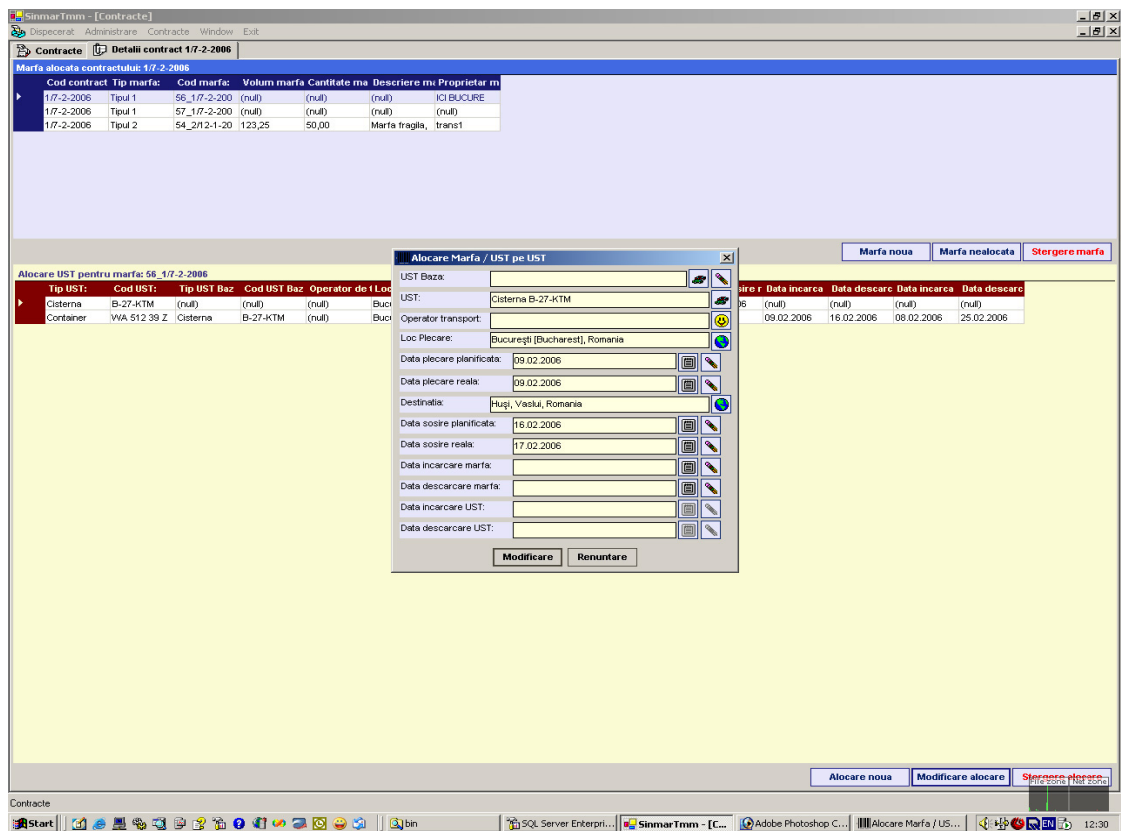


Figure 6: Management of the freight, transport segments and means of transport related to a contract

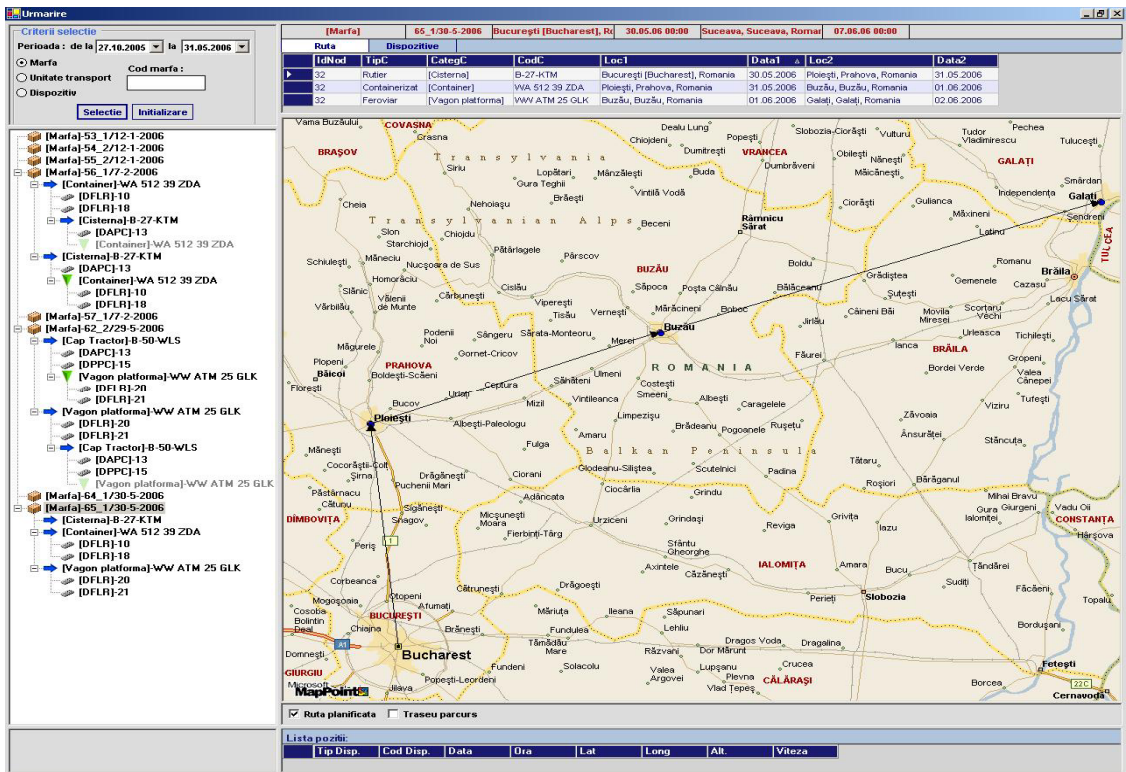


Figure 7: Visualisation of the multimodal transport planning

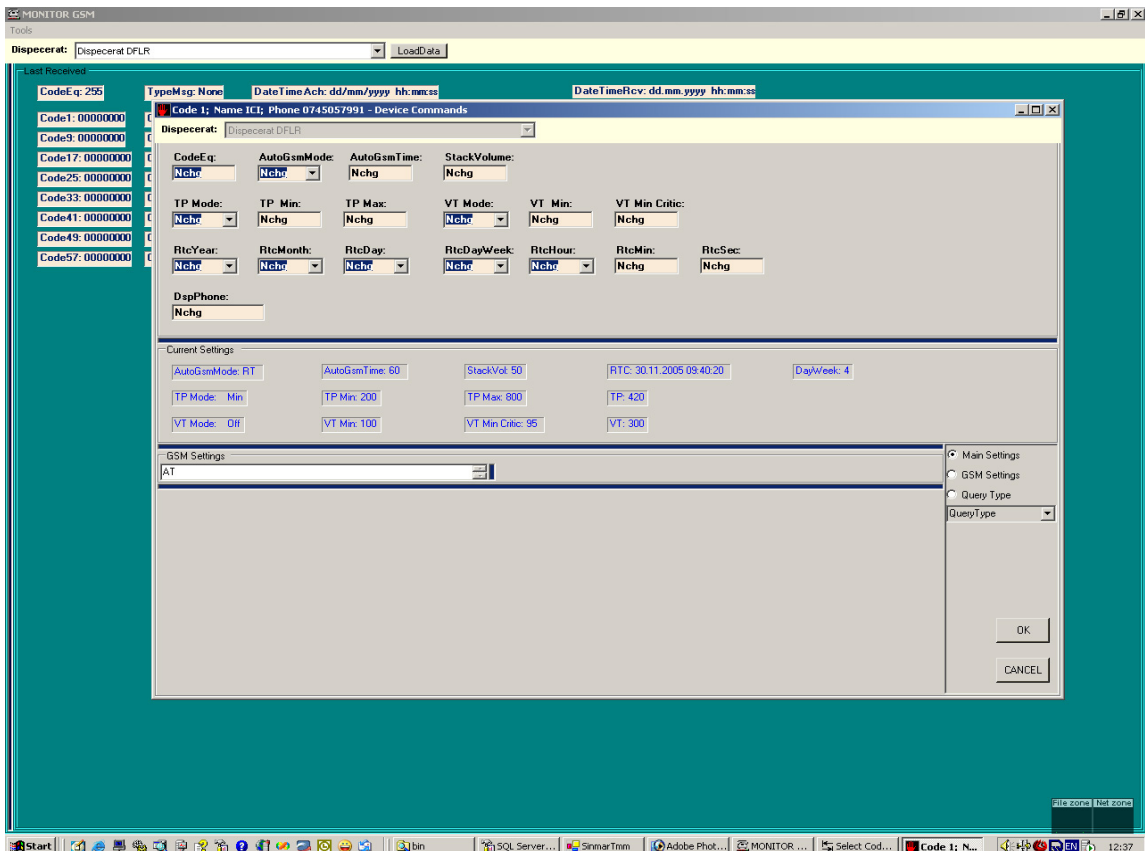


Figure 8: Radio Localization Fix Device Management