

# The Conceptual Algorithm of the International Multimodal Transport (CAIMT)

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The presented paper comes as a summary of a theoretical work presenting an original algorithm describing International Multimodal Transport (IMT) mechanisms and processes. Since containers appeared in early 1960s on the regional, and later on, on global scale in logistic operations, the IMT has become the fastest growing combination of an international through-transport. With use of various modes of transport IMT has significant influence on global trade development. Due to its characteristic the IMT process is exposed on the global unitization, standardization, safety, security and economization (optimization) challenges. Thus, there is a need for scientific approach in building a standardized conceptual model of IMT referred in this paper to CAIMT. CAIMT is an original, deterministic algorithm, presented in the block notation, identifying typical procedures as a logical continuation of the programmed sequence of the basic IMT operations. The suggested CAIMT has a potential in further standardization of IMT procedures and can be scientifically developed through the modeling of the IMT processes and safety/security procedures. In addition, in terms of empirical aspects, algorithmization of the main IMT processes can lead to their application in the various expert systems. Summing up, this method (CAIMT) comes as an optimal instrument that can be utilized in order to build further pillars for IMT development, standardization and optimization.

**Keywords:** algorithm, International Multimodal Transport, containerization

## 1. INTRODUCTION

The new transportation techniques development, such as containerization and other means of unitization with increase of internationalization and globalization of foreign trade, introduced simultaneously a significant need for common standards in container handling operations. In such international transportation conditions, container “[...] could be transported by different means of transport, such as ships, railway wagons, road vehicles or aircrafts, from the point of origin to the final place of destination, without being unpacked for sorting or verification when being transferred from one means of transport to another” (UNCT 2001, 12). This new type of transportation caused demand for a single transport operator.

Gradually, more unimodal operators took the risk and responsibility for the whole through-transport under single contract (door-to-door) in order to achieve higher level of competitiveness and better market recognition. Moreover, in the case of loss or damage to the goods involved in the through-transport operations, from the shippers’ (consignees’) perspective the best option was also to establish only one single operator (responsible for the overall transportation process), rather than to pursue several unimodal carriers involved in transportation subprocesses with dispersed responsibility. This totally new approach has triggered development of the multimodal transport managed by the one entity (De Jong et al 2004, 34). There was also need for a legal, operational and technical framework for multimodal transport of

goods, especially in international conditions, where multimodal transport is only a part of international logistics chain of supply (Liu and Lin 2009, 58). Figure 1 indicates a typical shipper's perception of the multimodal transport within the international logistic chain of supply framework.

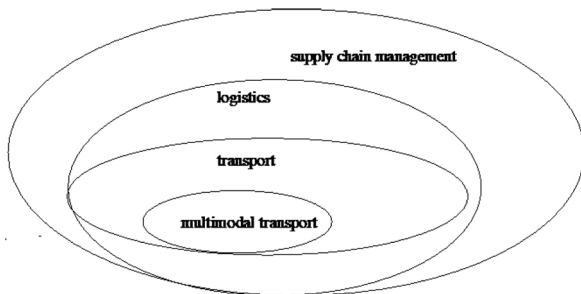


Fig. 1: Shipper's (consignee's) perspective on multimodal transport of goods

Source: G. de Jong, H. Gunn, W. Walker, *National and International Freight Transport Models: An Overview and Ideas for Future Development*, Journal Transport Reviews, Volume 24, 2004 - Issue 1, p. 23

It can be derived from the Figure 1 that multimodal transport services are part of the international transport framework (e.g. *Trans-European Transport Networks – TEN-T*) within which different international (and particular - national) logistic supply chain strategies are made feasible in transport corridors (depending on the current national technological status and actual regional infrastructure potencial). Thus, transport-related decisions are dependent upon a set of transport service requirements, such as lead-time, costs, operator's reliability and market good practices, law regulations, safety and security issues, national and geopolitical determinants, terminal equipment availability, environmental restrictions etc (Harris et al 2015, 123). It is suggested (Schramm 2012, 76) that the shippers are not much familiarized with all of these conditions and often do not specifically demand a special transportation mode in the beginning of the overall process, but rather expect reliable transport performance in whole. It means that the shippers expect to receive an optimized door-to-door service from the transport companies (logistic operators) without the need for their own different options calculation, and this leads directly to wider IMT utilization. In order to fulfill this demand and to achieve a high level of multimodal transport performance, intensive co-operation and co-ordination are essential internationally and globally between all modes of transportation.

## 2. IDENTIFICATION OF THE RESEARCH FIELD

### MT definitions, evolution and development

Essentially, multimodal transport is a through-transport combination of various transport modes with the use of standardized MT containers. Containers ensure the multimodal transport of unitized cargo from its origin to its final destination, with expected efficiency and least possible risk (UNCTAD 2001). The various types of a through-transport (multimodal transport) combination are presented on Figure 2.

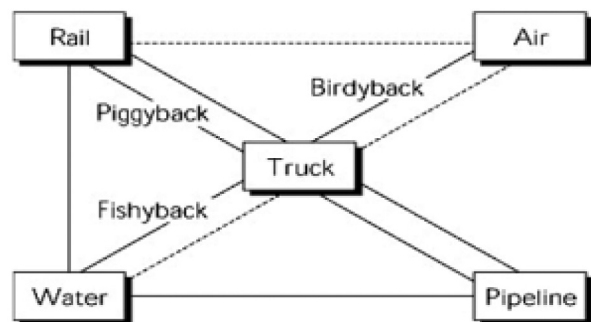


Fig. 2: A through-transport modes combination (the multimodal transport combination)

Source: <http://minussignkm.spot.com/2015/08/lm5002-logistics-and-supply-chain.html>

Invention and development of the Piggy Back System (PBS) has accelerated further growth of containerization as a main means of the door-to-door transport. Piggy Back transportation includes the movement of motor-carrier trailers on flatcars (TOFC) and containers on flatcars (COFC) – currently with the ability to provide double/triple stack (UNCTAD 1995, 98). An innovation solution is the RoadRailer (bimodal), which provides a railroad transport with the ability to haul trailers on special wheel sets (adaptors) and avoids the use of flatcars.

PBS and its technology enforced introduction of safety solutions (e.g. containers are fitted with the vertical connectors - twist locks), standardization in the handling processes (e.g. ships are equipped with rail structures for vertical sliding and stowing into the ship's hold bay – cell guides) and caused much more technological innovations for the ease of switch between different modes of transport. Consequentially, at container terminals the supra structure has appeared such as a forklift-type device (e.g. reach stackers), gantries/cranes STS type etc (Miler 2015, 50).

In available sources the terms through transport, combined transport, intermodal transport and multimodal transport are very often used in the common context of cargo movement from its origin to the final destination and treated as complementary terms. Due to the fact, that these four terms have quite similar meanings, the United Nations as well as the European Conference of Ministers of Transport and the European Committee for standardization (ECMT/CEN) made a distinction between them by introduction of the transportation terminology and related definitions. These four terms have been defined as:

- *Unimodal Transport*: the transport carried out by one mode of transportation only, where the each carrier issues its own transport document (CMR, B/L, air waybill, consignment note, etc.) (UNCTAD 1995, 98),
- *Intermodal Transport*: the transportation of goods by several modes of transport where one carrier organizes whole transport process from the point of origin to the point of final destination without changing the transport unit, however depending on how the responsibility for entire process is shared, different types of documents are used (UNCTAD 1995, 99). European definition is focused on technology of transportation processes and states as follows: “the movement of goods in one and the same loading unit or vehicle which uses successively several modes of transport without handling of the goods themselves in changing mode” (ECMT 2002, 345).
- *Multimodal Transport*: transportation where the carrier (transport operator) organizing the entire process takes responsibility for the complete ‘door-to-door’ transport and issues a multimodal transport document (UNCTAD 1995, 101). The European definition of multimodal transport states: “the movement of goods whereby at least two different modes are used in a door-to-door transport chain under one document” (ECMT 2002, 346),
- *Combined Transport (the term in use mainly in EU)*: the transportation of goods in one and the same loading unit or vehicle by a combination of road, rail, and inland waterway modes, which means it is an intermodal transport where the major part of the European journey is by rail, inland and waterways or sea and any initial or final legs carried out by road are as short as possible (ECMT 2002, 347).

In Figure 3 the existing structure of intermodal- and trans modal transportation operations is explained.

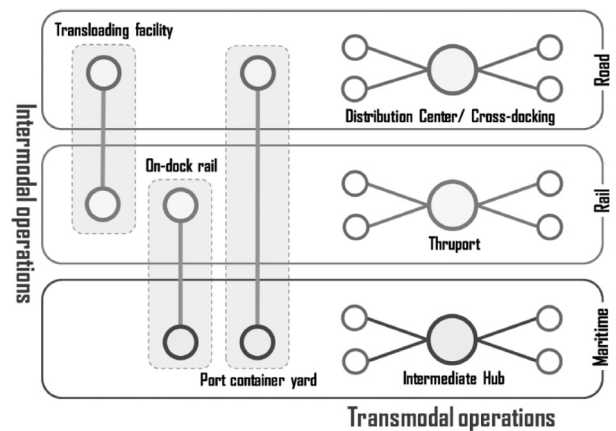


Fig. 3: An intermodal and transmodal operations in transport processes

Source: Rodrigue J-P., Dept. of Global Studies & Geography, Hofstra University, New York 2017; [https://people.hofstra.edu/geotrans/eng/ch3en/conc3en/intermodal\\_transmodal.html](https://people.hofstra.edu/geotrans/eng/ch3en/conc3en/intermodal_transmodal.html)

Within existing logistic chains of supply more effective relations are triggered by further functional integration and strategies such as “Just-in Time” and “door-to-door”. At the same time they are relevant examples of interdependencies created by the totally new type of relations in freight management.

Both geographical and, first of all, functional integration take place concomitantly. Transportation in recent decade has become more important and thus much more integrated process. Integration takes place through the entire logistics process, including supply, production, distribution and retailing activities, enabling several corporations (playing the role of the logistic supply chain integrators) to establish global production networks, which include the national, regional and local scale of activity (see Fig. 4).

As it is presented in the above figure, multimodal transport integrates different spectrum of geographical scales from global to the local, representing the regulation of movements of a corridor within integrated multimodal transportation system. The system composes a set of competing hub centers where converge regional and local transportation networks (a level of macro- and mezzo logistics) (Harris et al 2015, 125). Depending on the geographical scale being considered, the regulation of flows is coordinated at:

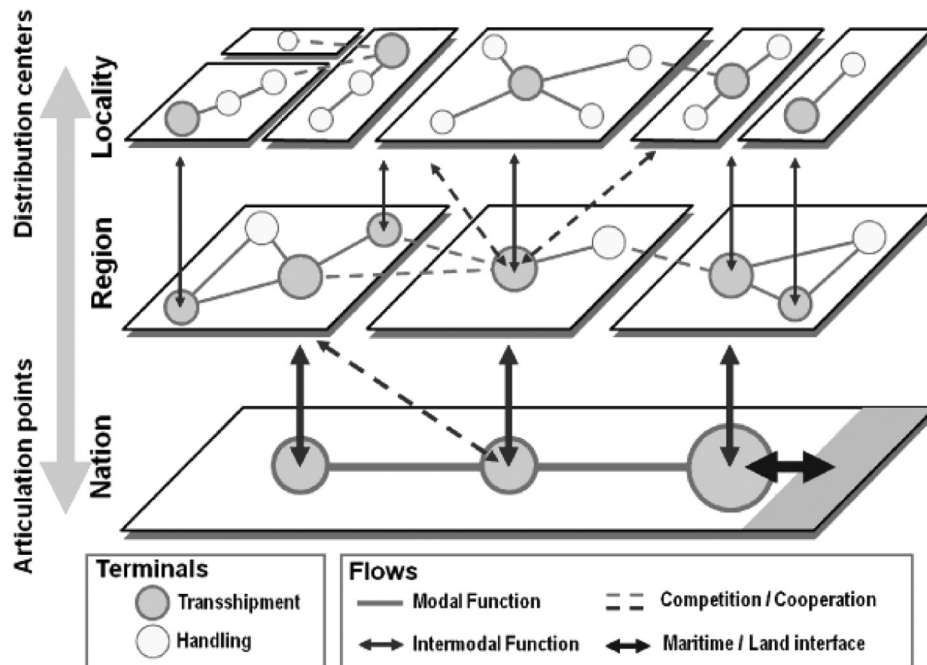


Fig. 4: Converges of local, regional and national networks in the multimodal transport  
 Source: <http://pmmagsmartech.spot.com/2011/06/multimodal-transport-system.html>

- the local level by distribution centers, commonly composed of a single transport terminal, or
- the global level by articulation points composed of major transport terminals (very often Logistic Distribution Centers) and related activities.

In global approach, an articulation point can simultaneously have a modal or intermodal convergence of functions (particularly if it is the interface between several modes of transportation located in the same major terminal). The regional multimodal network converges at major articulation points allowing and establishing linkages with the international (global) transportation system. Links are maintained through maritime-land interfaces (mostly represented by the multimodal seaport container terminals) thus the port cities are the main agent in this function and process (as several ports have opted for this multimodal transportation technology to consolidate their status of hub centers) (De Jong et al 2004, 38; Kuriata 2014, 37). Moreover, with the development of new modal and intermodal infrastructure, port urban regions have a growing accessibility to the international market. And, since geographical integration led to industrialization in new regions and international exchange, significant changes in the routing of flows appeared leading directly to further and deeper IMT utilization.

### 3. IMT DEFINITION AND AREA OF APPLICATION

Since the trends of international trade growth with the fixed role of transportation are well established (excluding short periods of recession), as a natural consequence, the global priority is now shifting to the geographical and functional integration in the frame of logistic chains of supply. Geographical integration implies using effectively the comparative advantages of time and space while maintaining the cohesion, capacity and efficiency of the freight distribution systems. The emergence of logistical nodes consolidation went quickly and is a direct outcome of containerization and globalization. As the outcome, the complex networks involving flows of commodities, modules, parts and finished goods as well as information have been established, which in turn demands a very advanced and high level of logistic and transport management (Harris et al 2015, 128).

Global logistic chains of supply networks have been advocated as an adequate paradigm to represent and widely explain the current global settings of international trade and transportation. In such international and global environment there was a need to establish the powerful actors, which are not directly involved on production and consolidation of supply chains, but mainly



are responsible for managing the flows utilizing transport as a facilitation tool for international trade. Thus, international multimodal transport companies have been well set up within last two decades in the international transportation market.

The term of the international multimodal transport (IMT) is explained on the most acceptable and authoritative way in the article 1(1) of the UN Convention on International Multimodal Transport of Goods 1980 and defines international multimodal transport as the “[...] means the carriage of goods by at least two different modes of transport on the basis of a multimodal transport contract from a place in one country at which the goods are taken in charge by the multimodal transport operator to a place designated for delivery situated in a different country.” (UNCTAD 1980; UNCT 2001).

For better understanding, this definition should be read in conjunction with the definition of the term multimodal transport operator (MTO) provided in article 1(2) of the above-mentioned MT Convention, which states that “ ‘Multimodal transport operator’ means any person who on his own behalf or through another person acting on his behalf concludes a multimodal transport contract and who acts as a principal, not as an agent or on behalf of the consignor or of the carriers participating in the multimodal transport operations, and who assumes responsibility for the performance of the contract.” (UNCTAD 1980; UNCT 2001).

Thus, based on both definitions, the main features of the IMT are:

- the carriage of goods is performed by two or more modes of transport under one contract,

- one document is issued and one responsible party (according to the definition – MTO) for the entire carriage is established (however, according to the definition it might subcontract the performance of some, or all modes of the carriage to the other carriers),
- the country of Shipper / Consignor / (Freight) Originator / The shipping party is different than country of Consignee / Freight Receiver.

#### 4. THE IMT CONCEPT AND MAIN PROCESSES

The International Multimodal Transport is therefore a concept, which places the responsibility for the entire transport activities under one operator. MTO is responsible for the management and coordination of the total shipment (all phases as a door-to-door process), ensuring the continuous movement of the goods along the optimized route (not necessarily the shortest) and use of the optimal means of transport configuration (taking into account the time, cost and risk factors). This allows the most efficient, cost-effective, flexible and safety transportation process according to the standards and shippers requirements for delivery. This demands also simplified documentation as well as the use of electronic tools such as electronic data interchange (EDI), means of transport tracking/monitoring systems, containers tracking tools, bar codes or Radio Frequency Identification (RFID) solutions for transportation management improvement (Miler 2015, 48). The concept of the IMT phases is presented in Figure 5.

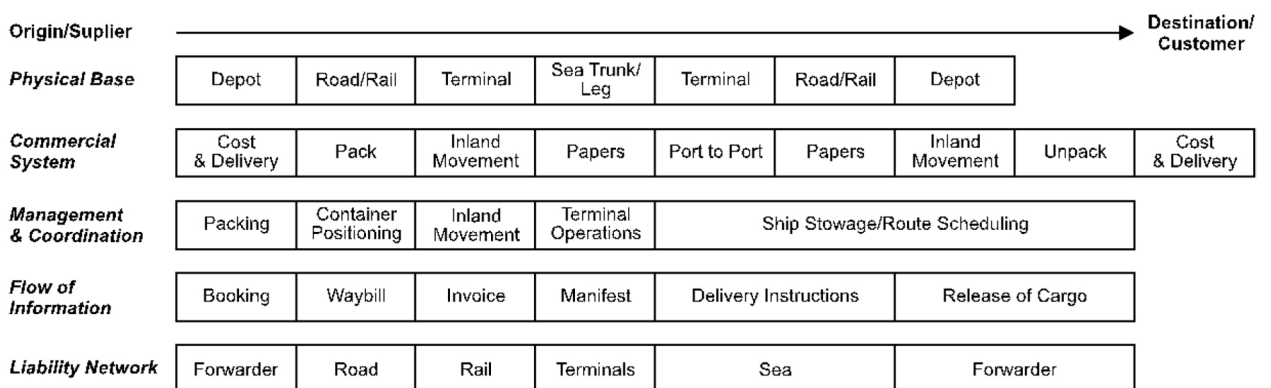


Fig. 5: Components of a multimodal transport system’s model

Source: G. de Jong, H. Gunn, W. Walker, *National and International Freight Transport Models: An Overview and Ideas for Future Development*, Journal Transport Reviews, Volume 24, 2004 - Issue 1, p. 25

As the MTO has accepted total responsibility and liability to perform the entire transport contract, simultaneously has become the sole interface point for the shipper’s transport function. The entire process covered by MTO responsibility is depicted in Figure 6.

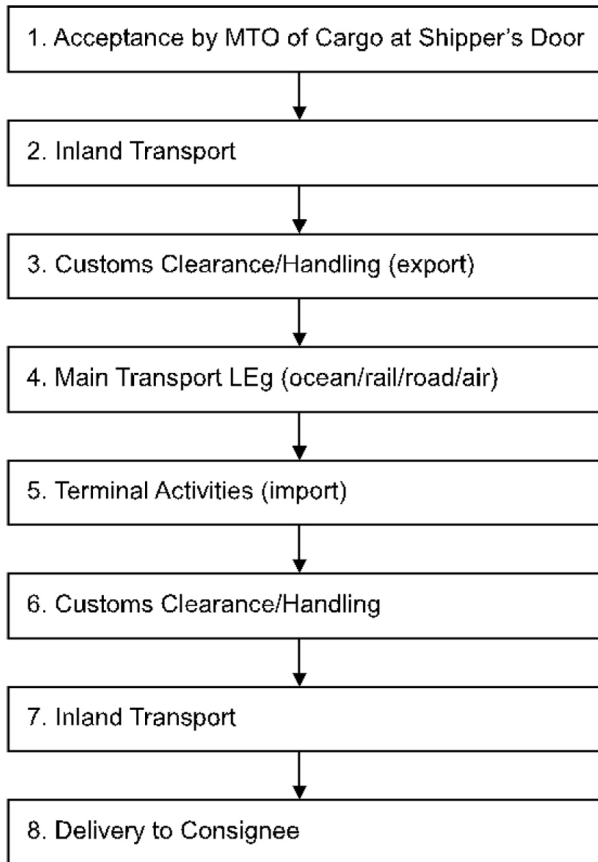


Fig. 6: Typical steps in the transport chain covered by MTO responsibility

Source: G. de Jong, H. Gunn, W. Walker, *National and International Freight Transport Models: An Overview and Ideas for Future Development*, Journal Transport Reviews, Volume 24, 2004 - Issue 1, p. 27

Development of MTO functions has an impact on already existing concept of IMT. Moreover transport terminology relating to intermodal/multimodal transport (regionally and globally) continues to evolve. However in the temporary stage of the IMT development it becomes possible to built an original algorithm describing International Multimodal Transport (IMT) mechanisms and processes in order to open modeling possibilities.

### 5. THE CONCEPTUAL ALGORITHM OF THE INTERNATIONAL MULTIMODAL TRANSPORT (CAIMT) DESCRIPTION

As it was stated, the IMT operation is made up of the number of unimodal stages of transport, where each of these stages is subject to the mandatory international regulations and „good practices”. However concerns are still expressed regarding the proliferation of individual and divergent approaches of the single MTO, which would add more confusion to the already existing uncertainties pertaining to the legal and operational regime of IMT.

The lack of a widely acceptable IMT theoretical platform make it unable to conduct necessary research based on modeling techniques. Furthermore algorithmization of the main IMT processes can lead to their application in expert systems. Thus, proposed CAIMT comes as an optimal instrument to built further pillars for IMT development and optimization. Before specific algorithm for IMT (CAIMT) is presented a term of algorithm should be defined.

The term algorithm is a finite sequence of clearly defined actions necessary to perform tasks of a certain type. The classic definition of algorithm states that it is an unambiguous principle of calculating input data into output data in a finite time period (Kuriata 2014, 39). The mathematic approach allows to state (Kuriata 2014, 40-42):

The algorithm  $\Lambda$  comes as the following expression:

$$\Lambda = \langle D, R, \Delta, q, f \rangle \tag{1}$$

where:

D – a countable set referred to as the algorithm domain

R – a countable set referred to as the algorithm range

$\Delta$  – a finite alphabet in which:

$$\Delta^* \cap R = \Phi \tag{2}$$

q – coding function  $q: D \rightarrow \Delta^*$

f – relation of transitions

$$f \subseteq \Delta^* \times (\Delta^* \cup R) \tag{3}$$

U – the control set

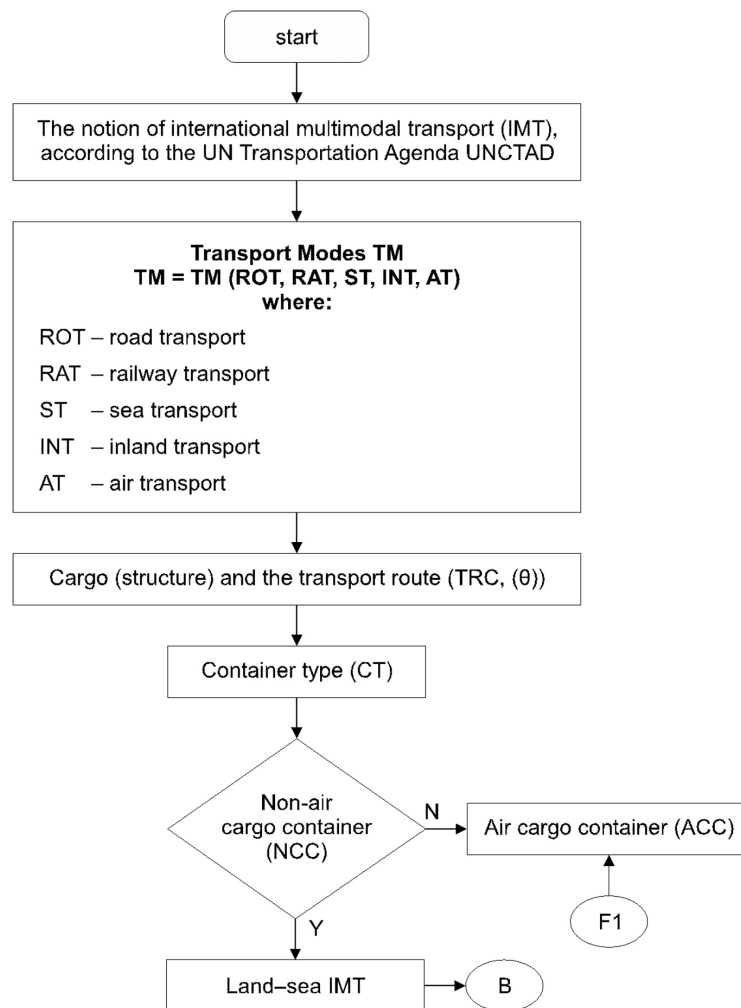
where for each  $y_0 \in \Delta^*$  the set

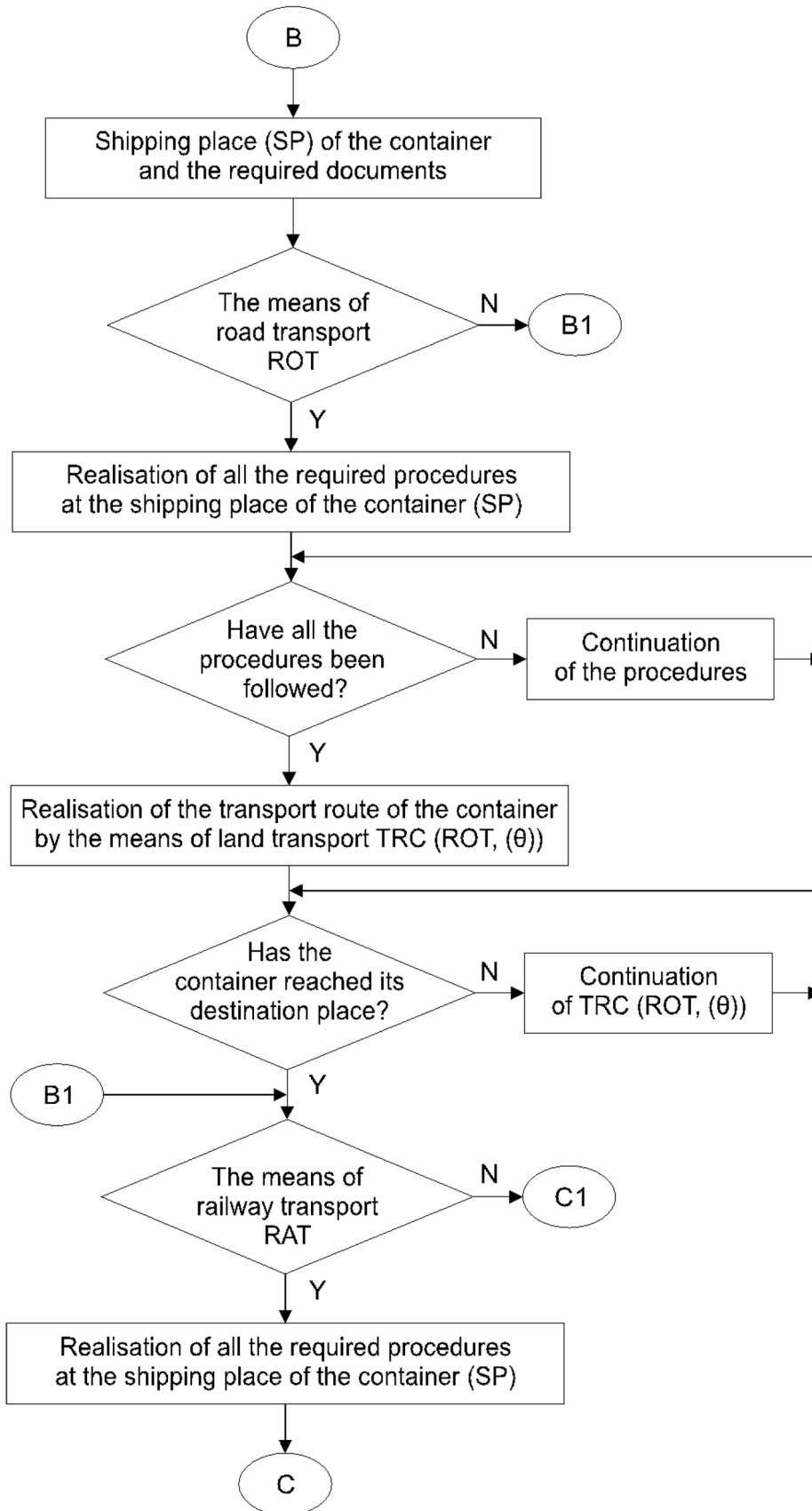
$$\{(y_0, y_1); (y_0, y_2)\} \in f \tag{4}$$

has fewer than  $k_A$  elements and  $k_A = \text{const}$ .

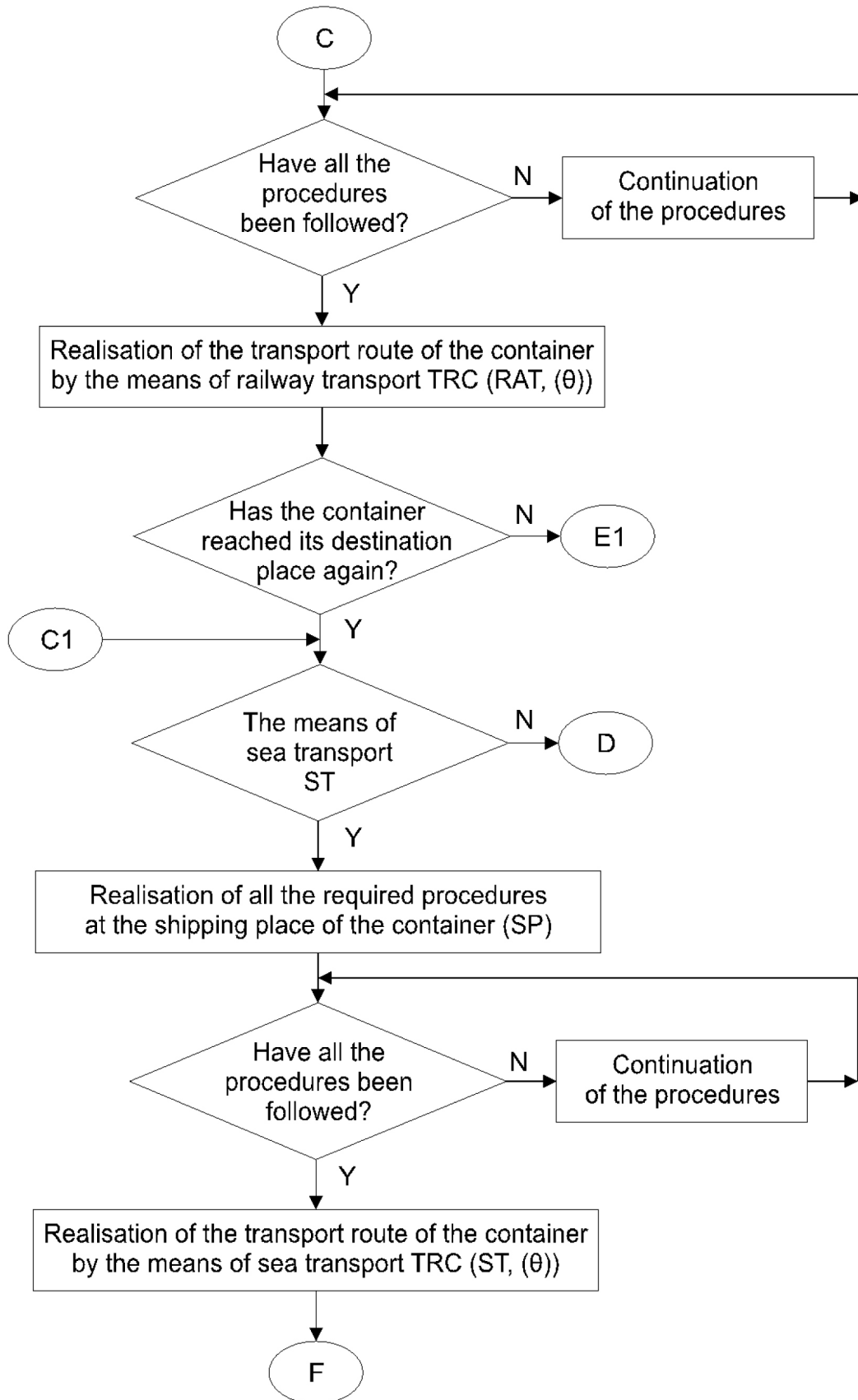
The pairs  $(y_0, y_2) \in f$  are referred to as action, and indivisible actions are referred to as operations. The  $I_x$  represents the number of operations performed by the A algorithm for the input data  $X \times D$ . Each activity or activity sets are assigned with a graphic image referred to as a block.

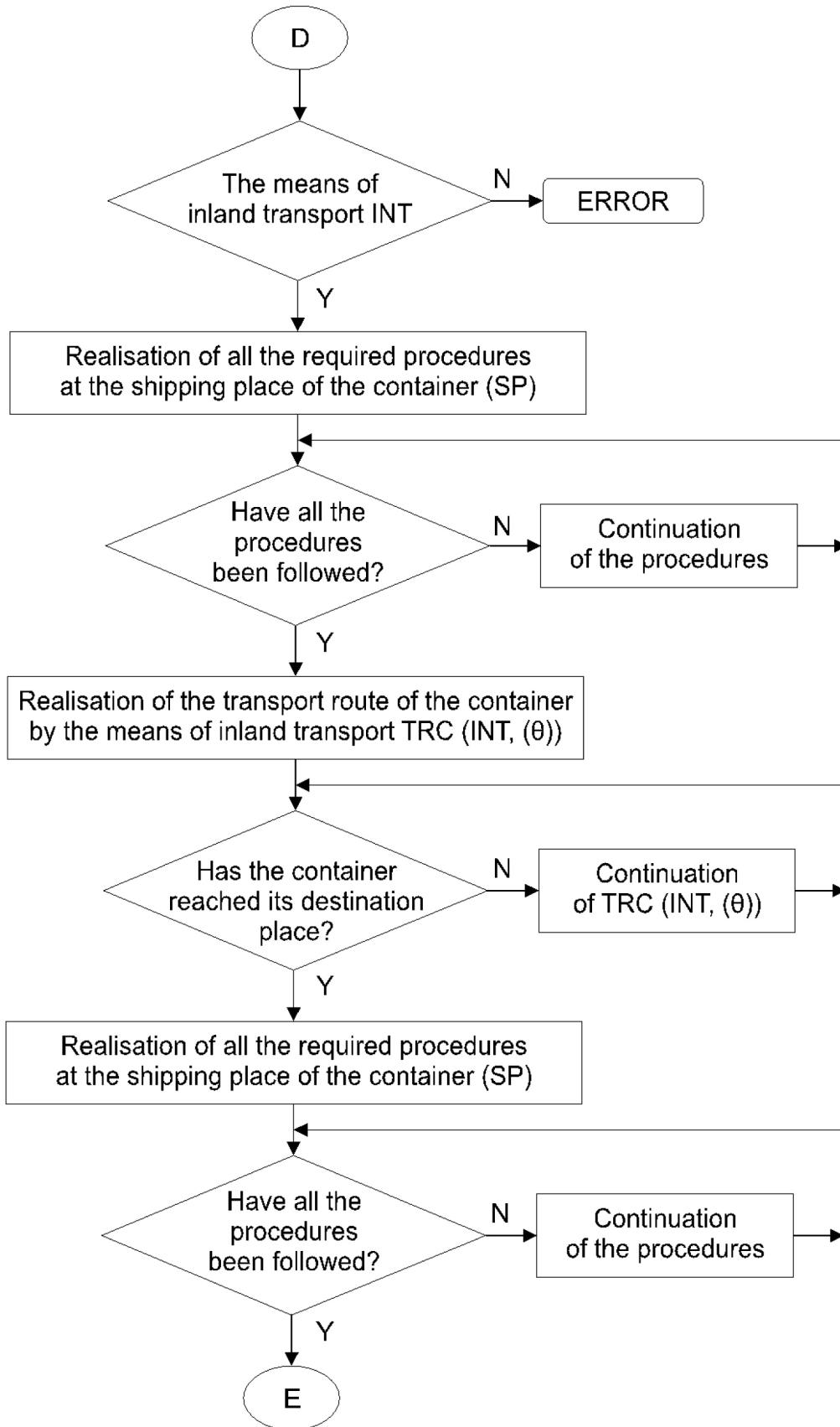
This way understood algorithm could be treated as a foundation for CAIMT. Integrated transportation and logistic processes as an integral part of CAIMT have been presented in Figure 7.

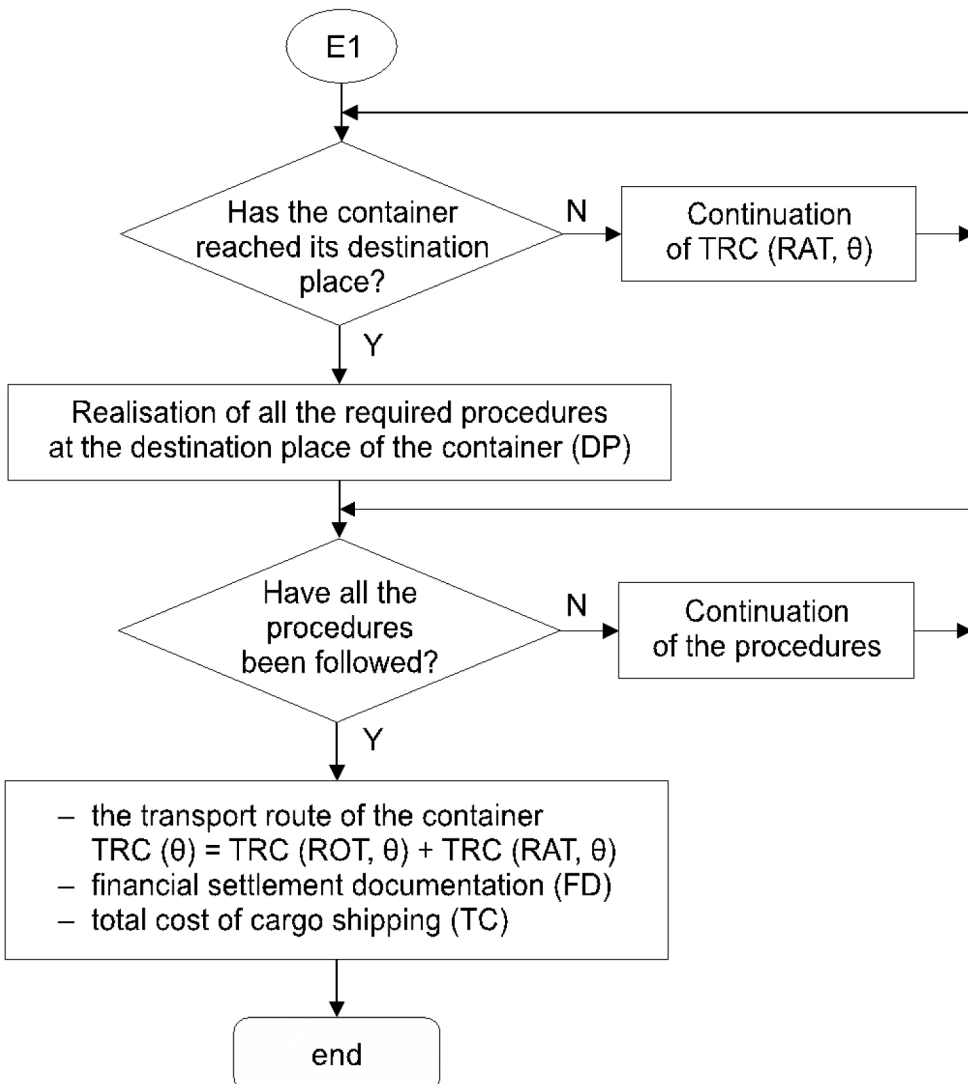
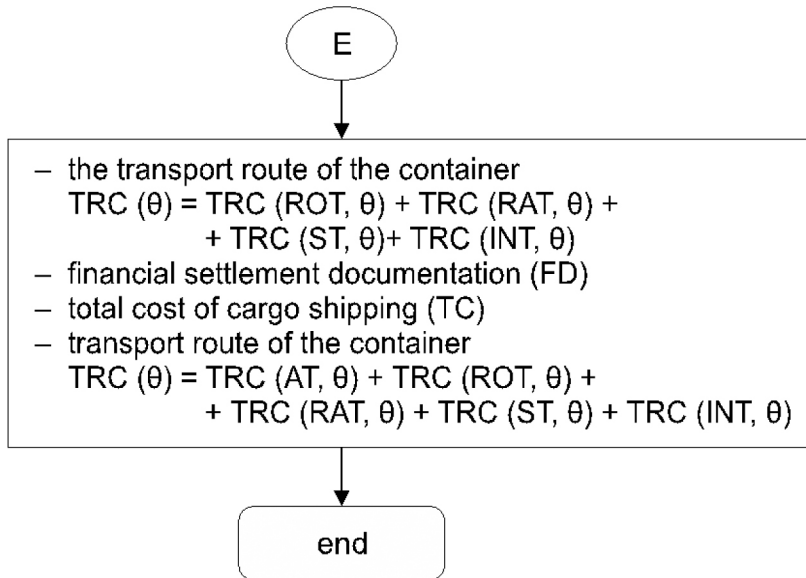


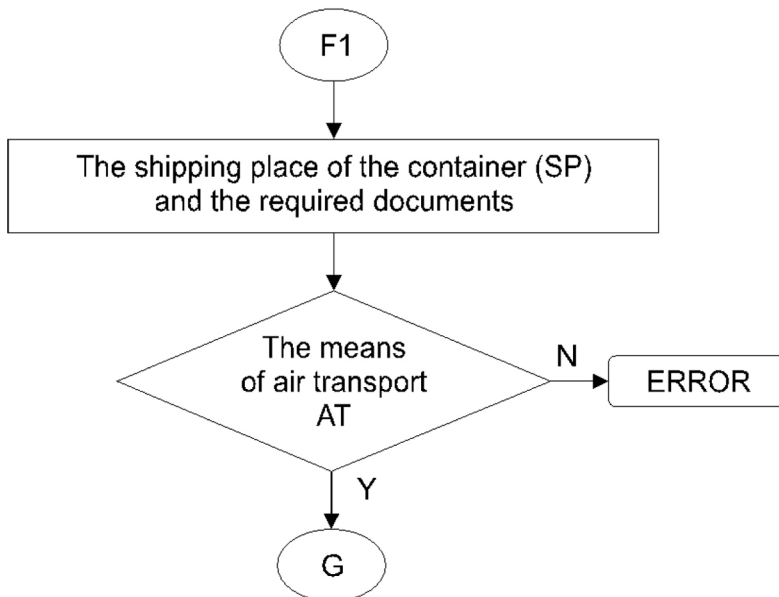
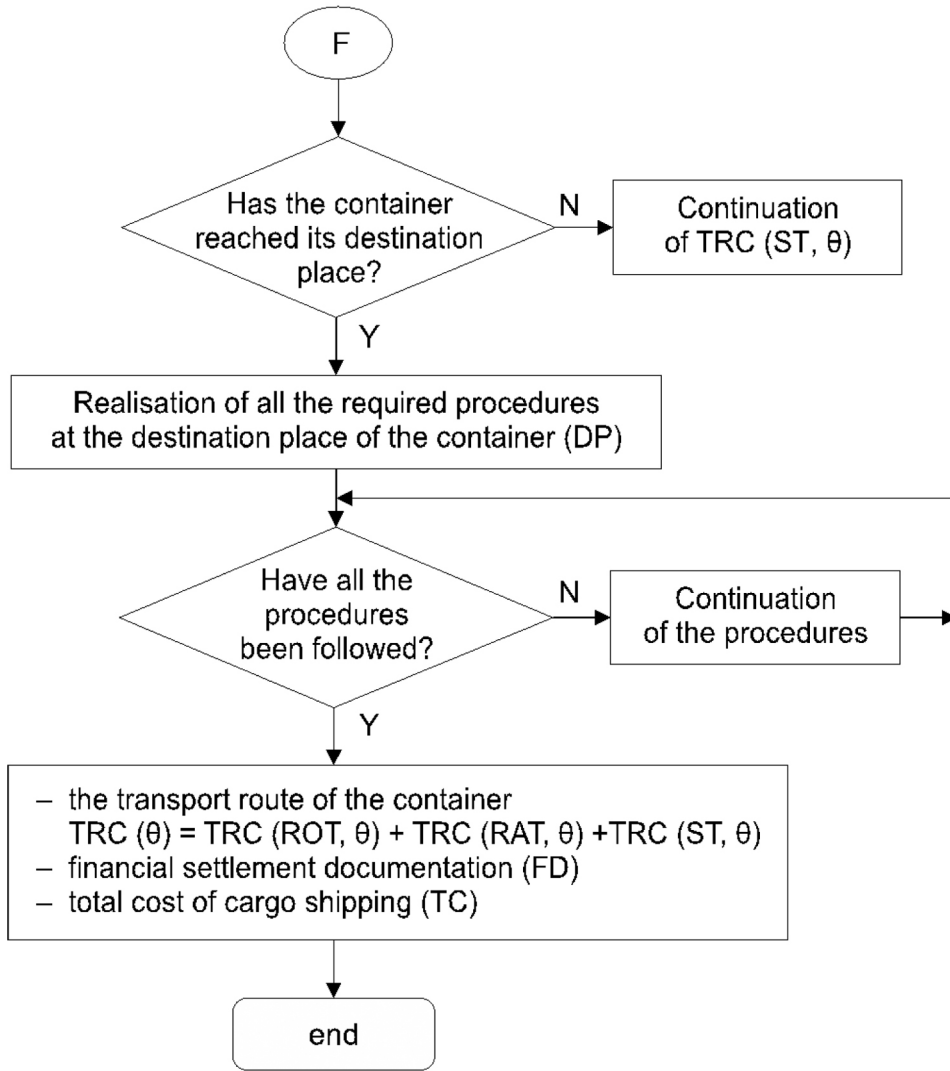


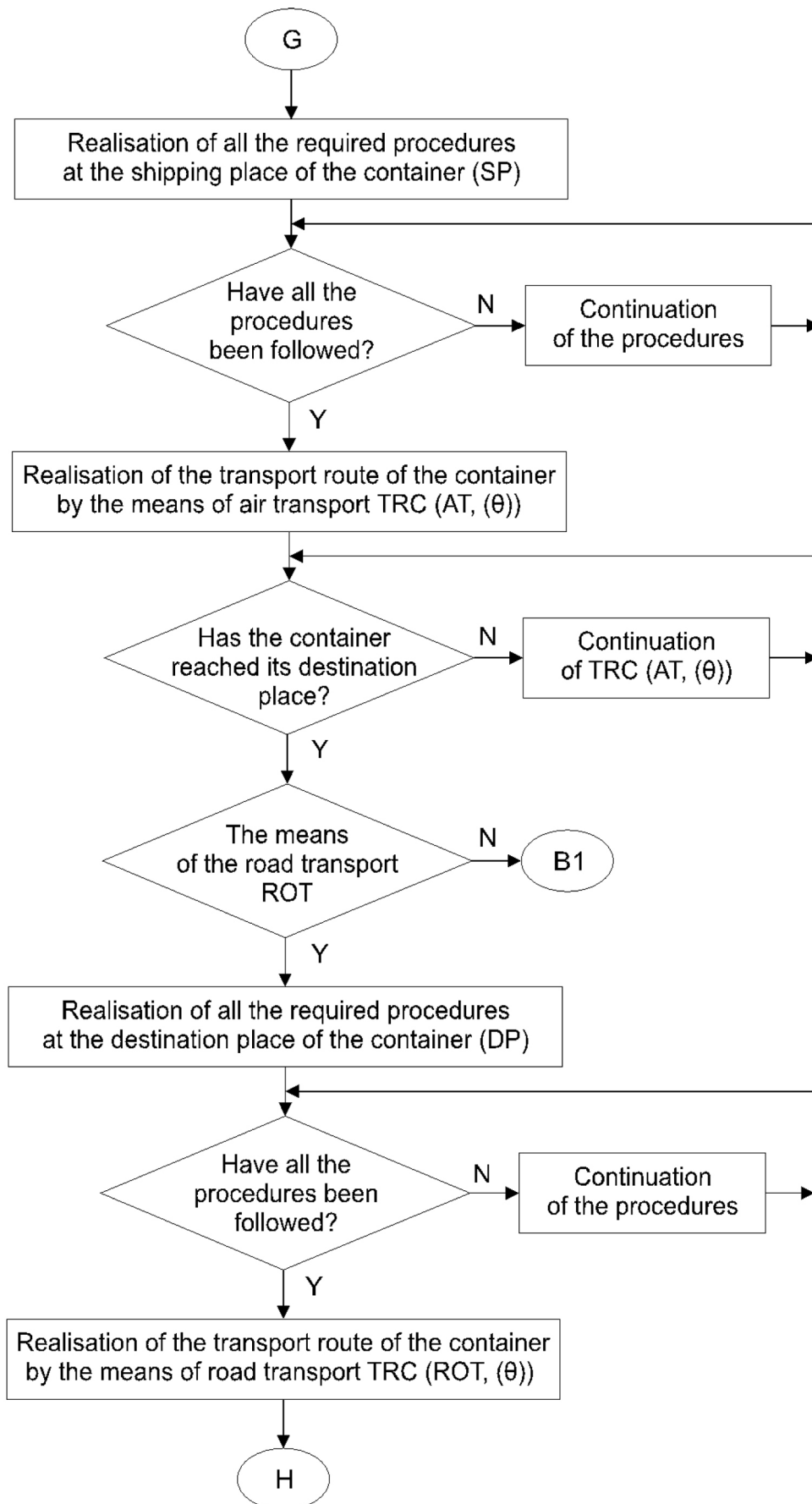














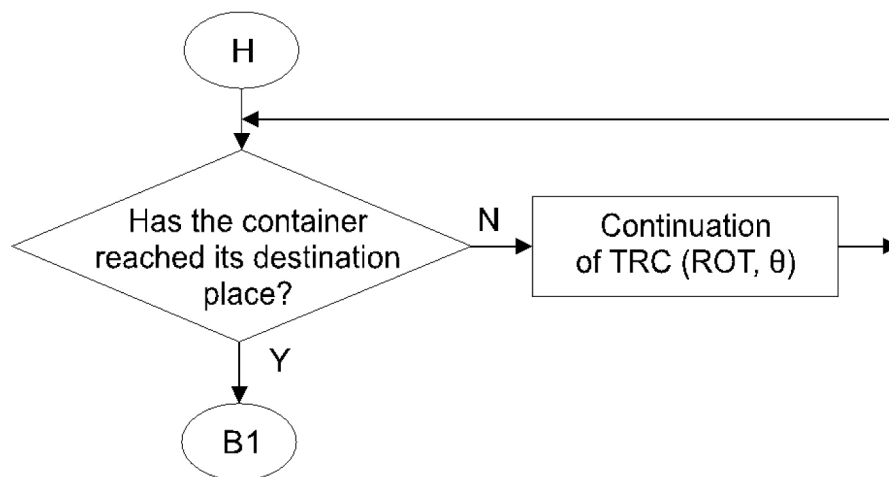


Fig. 7. Original CAIMT description

Source: Authors' own concept

## 6. SUMMARY AND CONCLUSION

Dynamic development of the international (global) multimodal transport with all its challenges (e.g. legal, operational and technical) generates the need for scientific approach in building a standardized conceptual model of IMT.

Proposed CAIMT is an original, deterministic algorithm, presented in the block notation, identifying typical procedures as a logical continuation of the programmed sequence of the basic IMT operations (which depend also on national or/and unimodal standards and regulations).

The suggested CAIMT has a potential in further standardization of IMT procedures and can be scientifically developed through the modeling of the IMT processes and safety/security procedures. In addition, in terms of empirical aspects, algorithmisation of the main IMT processes can lead to their application in expert systems. Summing up, this method (CAIMT) comes as an optimal instrument to built further pillars for IMT development and optimization.

However, the nature and scope of any possible course of action concerning proposed CAIMT would need to be decided at an international/global level, and with the full involvement and world-wide participation of all the interested parties (especially including MTO).

The adoption of any individual, national or regional solutions would contribute to the existing

uncertainty and lack of uniformity in some of IMT fields and thus, work to the detriment of the international community. International coordination and cooperation are essential in order to arrive at widely acceptable solution.

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