THE STANDARDIZED CONTAINER:

Gateway Technologies in Cargo Transportation[1]

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Abstract

Large technical systems are difficult to change. This paper explores whether gateway technologies may enhance system flexibility. It analyses the gateway characteristics of the freight container in the system of cargo transportation between 1965 and 1995. A conceptual framework for standardised gateways is developed that focuses on compatibility within and between the political, operational and technical domains ('POT domains').

The International Standardisation Organization (ISO) Series 1 container standard caused a revolution in international intermodal transportation during the 1970s. But the standard had a modal and a geographical bias. Competitive standardised gateways developed in parallel (e.g. pallet and swap body). Efforts to align the dimensional characteristics of these gateways failed. The ISO container had become - foremost politically - entrenched. The study concludes that both the impact of the ISO container and the development of competing modes of transportation indicate that standardised gateways can enhance system flexibility.

1. Introduction

From the fifties onwards the world economy experienced a strong growth. International division of labour increased and, in parallel, trade in and transport of (semi-)processed goods. The flow of (semi-)processed goods exceeded that of raw material (bulk goods). The mean distance in transportation increased. However, the labour costs on ocean liners and in harbours formed a bottleneck in cargo handling. Furthermore, loading and unloading ships required too much time. For much cargo *unitisation* and specifically the use of containers

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offered a solution[1]. Packing goods in wooden or metal casings eased transport and transhipment. As was then estimated, 75% of the general cargo could be transported in this manner (Immer, 1967).
Containerisation solved the problem of congestion in harbours. Increased efficiency was achieved. Containers could be handled in a mechanised form (cranes) - a process which was later to be (semi-)automated. The required labour force decreased. Costs dropped and profit margins for stevedores grew. Liners could increase the number of shipments per year. Although higher initial investments were required, containerisation stabilised the costs of liners companies. From the 1960s onwards, container use expanded strongly. For example, between 1968 and 1974 the number of container transhipments steadily rose from 150,000 TEU (Twenty foot Equivalent Unit, i.e. the 20 ft ISO-container) to 1,107,000 TEU in the largest European harbour, the Rotterdam harbour (Witthöft, 1977).
With unitisation - and in particular containerisation - the concept of transportation changed. Without repackaging goods, containerised cargo was transferred from terminal to terminal or directly from producer to consumer (*door-to-door transport*). The earlier focus on separate transport activities shifted towards increased consideration of the *transport chain*. The upscaling and integration of cargo transport signals the arrival of a transport revolution (Van Driel, 1990).
The real revolution was brought about by standardising container dimensions (Grey, 1992). The standardised container highly facilitated the flow of goods between the transport subsystems of sea, rail and road.[2] It had the characteristics of a *gateway technology* between transport subsystems, a concept which David & Bunn (1988, p.170) define as

> " a means (a device or convention) for effectuating whatever technical connections between distinct production sub-systems are required in order for them to be utilised in conjunction, within a larger integrated production system."

In this study, the concept of gateway technology is examined by looking into the case of the standardised container. The container referred to is the freight container of which the dimensions have been established in ISO TC104, a technical committee of the International Standardisation Organization (ISO). They are called ISO containers for short. The central questions are:

> *In what manner did the ISO container function as a technological gateway between transport subsystems? How did its role in the overall cargo transport system develop?*

The first question is addressed by examining the early process of container standardisation. This part foremost draws on the information provided by former participants in container standardisation and on the Swedish archive of ISO container standardisation (1967-1989)[3]. The proceedings of conferences on containerisation in the last three decades shed light on the second question.
The study is of interest in three ways. Firstly, it elucidates the relation between standardisation and gateway technologies. Secondly, in taking a longitudinal approach to

container standardisation, developments in gateway characteristics become apparent. Thirdly, the case provides material to assess a more recent situation, namely the increasing use of the swap body, an alternative container device in European continental transport.
The structure of the paper is as follows. In section 2, the conceptual framework is developed. The relation between gateway technologies and standardisation is defined. The notion of 'POT' domains is introduced to specify the forms of compatibility involved in container standardisation. Section 3 describes the controversies that occurred during the ISO standards process. It treats standardisation of container dimensions and corner fittings, and the more recent proposal for future container dimensions. Section 4 examines issues of political, operational and technical compatibility more closely. Following, the competitive gateways of pallets and swap bodies are related to the evolution of the ISO container (section 5). The paper closes with conclusions (section 6).

2. Conceptual framework

In social studies of large technical systems such as electricity networks, gas supply and irrigation systems, it is common to speak of socio-technical systems in order to emphasise that these systems comprise both social and technical components (e.g. Hughes, 1987; Kaijser, 1999; Ravestijn, 1997). These studies indicate that the sheer number of interdependent components and subsystems complicate the introduction of changes. Numerous institutions and companies are involved. Together, they constitute the *actor network* (Mulder, 1992). In order to co-operate effectively, participating actors need to develop common views, beliefs, etc. about how the technical system should work. Paradigms develop which structure the activities of the actor network (Van den Belt & Rip, 1987). Specialisation of actors in certain areas of the technical system, shared paradigms and interdependence among these actors and among technical artefacts are criteria that induce social and technical entrenchment. Large technical systems therefore appear to have their own momentum (Hughes, 1987).
Joerges notes that standardisation plays a crucial role in the evolution of large technical systems (1988, p.30). But few studies exist that clarify this role. Usually standardisation is not viewed as a factor, which enhances system flexibility (Hanseth *et al.,* 1996). The common opinion is that standards embed yesterday's state-of-the-art technology because formal standards processes take too much time. Moreover, standards institutionalise company interests and technological paradigms (Egyedi, 1997). Standards are compromises that do not reflect the technical optimum. Standards are thus seen to hold back technical innovation. However, such views too often confuse economic and technical arguments (Egyedi, 1999). Counter to current beliefs, as I will argue in the following, standardisation can facilitate change in large technical systems. More specific, the flexibility, which is required for system innovation, lies in the standardisation of *gateway technologies*. The latter concept has been used and adapted to compatibility theory by David & Bunn (1988), on which I heavily draw. They largely base their theoretical work on the historical case of the AC/DC rotary converter for electricity networks. I will elaborate their concepts to analyse the role of the standardised container in the system of cargo transportation.
The standardised container is a gateway between different subsystems of transportation. It is

a means to organise the flow of goods more effectively. Although it is a technical artefact, the container is above all an organisational innovation. As an *efficiency-enhancing* gateway it plays a pivotal role in the transportation system.

2.1 Gateway technologies and standardisation

Standardisation, be it for the purpose of replicability, reducing needless diversity, interoperability or interconnection, always involves creating compatibility. I categorise gateways according to the scope of system interconnection involved. Some gateways are dedicated, that is, they link an exclusive and specified number of subsystems. Gateways linking specific proprietary systems, such as the computer networks of Digital and IBM, belong to this category. Other gateways have generic properties. Generic gateways are the result of standardisation. An example is the A4 paper format in relation to paper storage and processing devices. In cases where different complementary standards are needed, reference models are sometimes used to guide standards activities. An example is the Open Systems Interconnection (OSI) Reference Model, which was used in the field of telematic services[4]. Thus, gateway technologies can be categorised as *dedicated, generic or meta-generic,* depending on the scope of the interconnection concerned.

Level of Standardisation	**Scope of Gateway Solution**
High (modelled)	Meta-generic
Medium (standardised)	Generic
Low ('improvised')	Dedicated

Table 1: Relationship between the level of standardisation and the scope of the gateway solution.

The degree of standardisation to which a gateway is submitted determines the scope of the gateway solution. Where no standardisation occurs, and the connection between subsystems is, at it were, '*improvised'*. This corresponds to a dedicated gateway. *Standardised* gateway solutions, aimed at connecting an unspecified number of subsystems, correspond to generic gateways. Gateways, which are based on *modelled* solutions, that is, standardisation at the level of reference frameworks, embody meta-generic properties. Table 1 summarises the relationships.

2.2 Compatible subsystems

In intermodal transportation, the transport modes constitute the subsystems. The container functions as a technological gateway when it creates compatibility between different transport modes. Subsystems can be compatible in two ways (David & Bunn, 1988, p.172). They can be

- *compatible complements,* that is, when subsystems A and C can be used together (e.g. plug and socket), and/or
- *compatible substitutes,* that is, when subsystems A and B can each be used with a third component C to form a productive system (e.g. IBM clones with DOS).

Thus, gateway technologies "make it technically feasible to utilise two or more components/subsystems as compatible complements or compatible substitutes in an integrated system of production." (David & Bunn, 1988, p.172) Both forms of compatibility are present in the transport system. The subsystems of deep-sea transport, on the one hand, and road, rail, short sea or coastal transport, on the other hand, are compatible complements. In respect to the deep-sea subsystem, the subsystems of road and rail represent compatible substitutes for land transport. (See figure 1.)

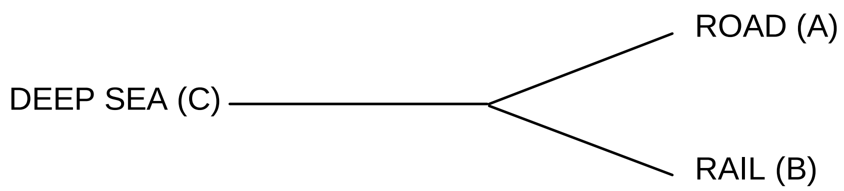

Figure 1: Illustration of compatible complements and substitutes in the transport system.

More specifically, with regard to intercontinental transport, the subsystems of road/rail/short sea/coastal sea are partly compatible substitutes. There are only partly so, because short sea, coastal and rail transport will generally need the complementary service of road transport to provide a full terminal-to-door service. Only the road transport system can, because of its flexibility and the denser and finer road infrastructure, cover the end-trajectory by itself. This is an important feature of road transport. Thus, only with regard to medium and long haul transport are there any real alternatives.[5]

2.3 Compatibility between 'POT' domains

The concept of compatibility generally refers to the *technical domain* (David & Bunn, 1988, p.165). This only partly covers the compatibility issues in respect to the standardised container. In the field of transportation, it is useful to distinguish the three 'POT' domains: the Political, Operational and Technical domains. The *political domain* consists, for example, of the economic, environmental and transport policies of a country. The standardised container is subject to national regulation for the transport modes of different countries. For example, road regulation is primarily a national affair and, European railway companies are still mainly operating on a national basis. Container standards must overcome incompatibilities between different transport policies and other political and regulatory differences.
Furthermore, the intermodal container has to forge compatibility between different subsystems of transportation. This problem, firstly, has an *operational component.* The transport subsystems operate differently. They face other problems, and have other interests,

priorities and customers, and therefore have different requirements with regard to containers. For example, the safety hazards of container transport differ for each subsystem. Because, interdependencies between subsystems increase, in the process of standardisation questions will have to be answered such as: Are the extra costs of designing a safe container for one transport mode - which might increase its tare weight - acceptable to another transport mode if the latter has an alternative, cheaper or more efficient means of transportation?
Secondly, compatibility between subsystems of transportation has a *technical component.* The intermodal container must offer an interface with the vehicles used in different transport modes. Containerised transport has to cater to the environmental requirements of intercontinental and continental systems (e.g. salt water in sea transport), etc.

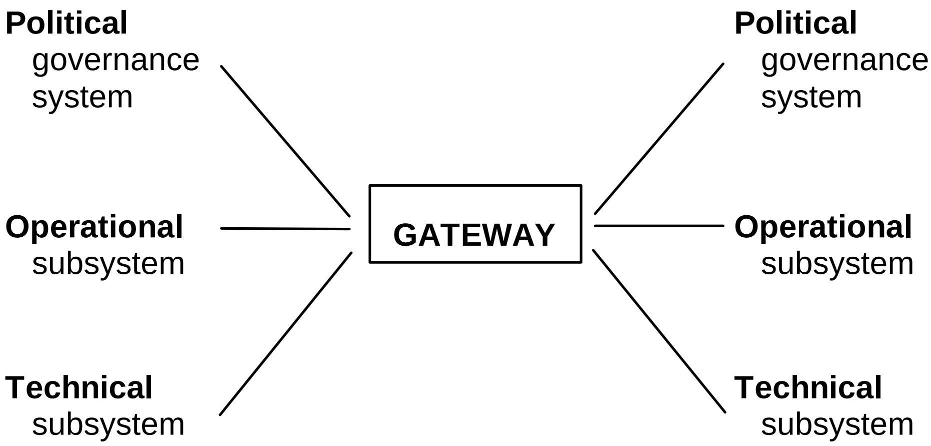

Figure 2: Technological gateways and compatibility between the 'POT' domains in large technical systems.

Thus, an intermodal transport system requires compatibility in all three domains. Container standards need to reconcile different national transport regulations and interests; they must bridge the different economic and operational interests of all transport modes; and the technical adaptations, to which each transport mode should comply in order to achieve intermodal transportation, must be economically and technically viable. In other words, the container standard must link political, operational and technical considerations in order to fulfil its gateway potential. (See figure 2). The degree of compatibility on all three domains determines the gateway characteristics of the container and the scope of the gateway solution. The more effective a gateway is in forging compatibility in these domains, the more important its role in the transport system.[6]

2.4 Governance structures

Different actor networks operate in the POT domains. They have distinct governance structures and regimes[7]. Three types of governance are of immediate relevance for this study.

Firstly, there are the national, regional and international *political and regulatory arenas* and multi-lateral networks. Examples are the Intergovernmental Maritime Consultative Organization (IMCO) and the Economic Commission for Europe (ECE) of the United Nations.[8]

Secondly, there are different forms of *co-ordination between operational actors* on uni- or intermodal transport. Actors who are operationally involved in container transport are: shippers, ocean liners, railways, road hauliers, ferries, terminal operators, container industry, producers of container handling equipment, engineers involved in the design and construction of the modal means, etc. Of special relevance here are the governance structures of and between actors in road, rail and deep-sea transport.

Thirdly, the regime of the international *co-ordinative structure for standardisation* is of relevance. The International Standardisation Organization (ISO) is the primary international forum for container standardisation. Its standards regime is based on a number of principles, which together could be called the 'standardisation ideology' (Egyedi, 1996a). For example, the standardisation procedures are designed to bring about a democratic standards process; as truly international standards are striven for and wide acceptance of the standard is crucial, decisions should preferably reflect consensus; national delegates should impartially represent the national interests[9]; ISO technical committees should try to arrive at technically optimal solutions; etc. Of interest in the following sections is, therefore, what was institutionalised during standardisation and why.

3. Standardisation of freight containers in ISO TC104

To indicate the spread of the standardised container: in 1990, the world fleet comprised 5,102,563 dry cargo containers (in TEUs). Merely 1.6% deviates from the ISO specifications for container height and length (TNO/Logitech, 1991). In 1993, 95% of the world container fleet still conforms to the standardised width of 8 ft (Wormmeester, 1993).

3.1 Prelude to international dimensions

The driving force behind the surge of containerisation in the 1960s and 1970s lies in the US. In the mid-1950s, two pioneer shipping companies, *Matson* and *Sea-Land*, demonstrated the advantage of using containers. Both companies used detachable cargo boxes with special corner fittings for intermodal transport between ship and road. Matson and Sea-Land were captive systems. "The containers stayed within the confines of the owner's distribution system and his personal control." (Grey, 1992, p.81) In Grey's view, Matson and Sea-Land account for the evolution of the container concept. However, standardising its dimensions brought about the revolution.

In 1958, the *Materials Handling 5* (MH-5) *Sectional Committee of the American Standards Association* (ASA) started developing standard dimensions for the US domestic container for intermodal transport. The standard width was determined by road regulation. The height of 8 ft was settled on in 1959. The container length provided more difficulties. The lengths of 20/40 ft, 12/24 ft and 17/35 ft were proposed. The 40 ft length derived from railway regulation. Railway companies were at the time permitted to move boxcars that is closed railway wagons, of 40 ft at the most. The lengths of 12/24 ft answered to the needs of West

Coast operators (e.g. Matson). The lengths of 17/35 ft were based on the overall trailer length then permissible in all states (e.g. Sea-Land). When in 1959 several states changed their regulation for road vehicles to 40 ft, the 17/35 ft combination was dropped. In 1961, the MH-5 committee settled on a width and height of 8 ft and on the lengths of 10, 20, 30 and 40 ft (Muller, 1961). The standard was published as MH-5.1 in 1965.
Sea-Land and Matson together handled 70% of the US container transport in 1965. Neither company acquiesced in the MH-5's results. In order to apply for government orders, they attempted to get the US Department of Commerce to accept the 35 ft and 24 ft, too (Van den Burg, 1969). As a result, the US Congress changed the Merchant Marine Act in a way that no preference was given to MH-5 dimensions.

3.2 Dimensions

In September 1960, US representatives proposed a programme similar to that of the MH-5 committee to the International Standardisation Organization (ISO). In 1961, an ISO committee on container dimensions was installed: the ISO Technical Committee 104 (TC104) on Freight Containers. Its first meeting was held in New York. Participants were representatives from ocean shipping companies (e.g. naval architects), railway companies, manufacturers of container handling equipment etc. TC104 established three working groups: one for terms and definitions, one for dimensions and one for specification, testing and marking.
In the beginning, MH-5 and ISO TC104 worked in parallel. The US was a driving force in TC104. But the issues raised in ISO also affected MH-5 developments (Rath, 1973).
ISO TC104 soon determined that the container standard should be a *performance* standard. That is, standardisation should not entail detailed specifications. For example, the standard was not to make any reference to the material used for an ISO container. TC104's sole aim was to achieve operational exchangeability (Rowbotham, 1978). This put an end to early discussions on whether containers should be made of aluminium (US) or steel (Europe).
Two proposals on container dimensions were considered. The US put forward the results of its MH-5 committee, while European representatives proposed a container which conformed to the standard of the International Union of Railways (UIC), a smaller container that was much used by Europe's national railways.
Series 1 containers. An international enquiry was held in 1961 to determine the largest permissible size of transport vehicles. Container dimensions would have to stay within their limits. The US road regulation (40 ft length and 8 ft width) was stricter than the dimensions permitted by European regulation. Therefore, in 1962, TC104 accepted the proposal of the Americans (then 8 x 8 x 10/20/40 ft). The Series 1 dimensions were supplemented with the lengths of 30 ft, 6'8" and 5 ft in 1963. (See figure 3.) These two smaller sizes were chosen to allow containers to be coupled together to form a unit with the overall length of a larger single unit (Rowbotham, 1978). This required special coupling devices (see Egyedi, 1996b).
A bargain between width and length. One of the main controversies concerned the container width proposed by the US (8 ft or 2438 mm). In 1963, the Dutch delegation proposed a width of 2500 mm, a width permitted in most of Europe, in order not to lose 62 mm of space.[10] The Scandinavian countries, Belgium, Germany, France, Italy and Spain backed the proposal. It was mainly opposed by the US, the UK - the Common Wealth countries - and

Japan, and first of all because of road regulation in these countries. However, the UK and Japan also opposed as a matter of principle. They reasoned that if they gave in to 2500 mm, the next step would be a container width of 2600 mm, which indeed eventually happened in, for example, the Benelux. These opponents coupled the acceptance of the 8 ft width to the 40 ft container length. They would only accept a 2500 mm width in combination with a maximum length of 30 ft[11]. To maintain the 40 ft length, the proponents of a wider container gave in. They felt that 40 ft was indispensable to deal with the expected increase in cargo volume. They comforted themselves with the idea that the daily costs of containers would probably drop due to the wide application of standardised containers. Cheaper use would compensate loss of width.
The Series 1 standard was published in February 1968 as ISO/R 668. In 1969, the US delegation proposed a height of 8'6", which was used by North Atlantic Services (ISO/TC104 (USA 19)240). Although initially accepted exclusively for the 40 ft container, in 1972 this height was also accepted for 20 and 30 ft containers (ISO/TC104 (Sec.196) 337, July 1972). Furthermore, the 5 ft and the 6'8" container turned out to be too small for transatlantic traffic and, in any case, the idea of coupling containers bounced off in ISO context. Therefore, both lengths were dropped.

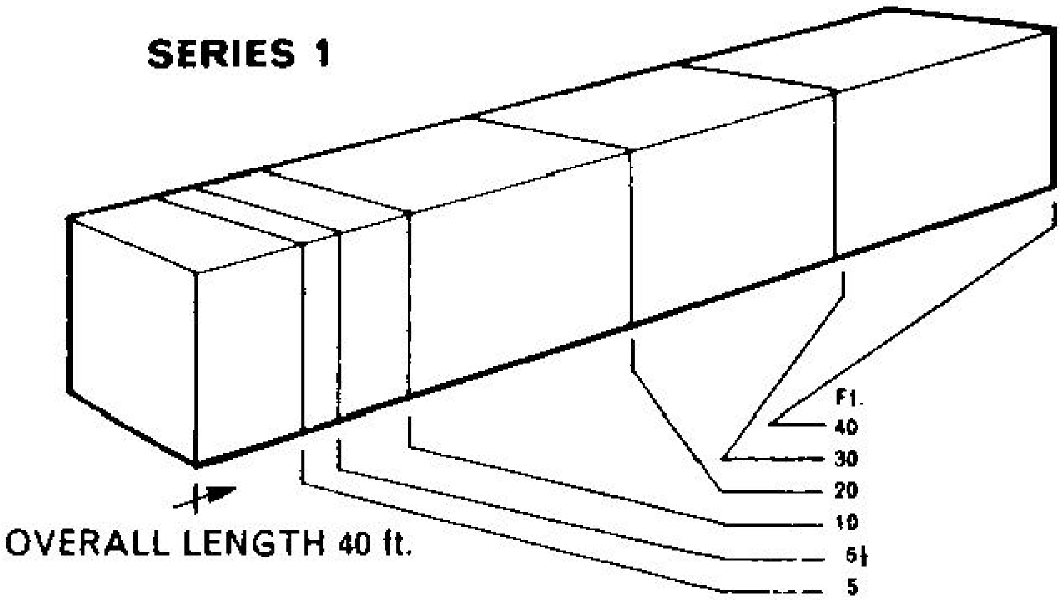

Figure 3: The first ISO Series 1 and Series 2 dimensions. (Source: Koster & Tilsley, 1968)

Series 2 containers. During the April 1963 meeting, TC104 decided to include UIC container dimensions as ISO Series 2, despite opposition from the US. It was drafted in 1968. But, for several reasons, the Series 2 ended up as a technical report and not as a standard. Firstly, UIC containers were "intended essentially for internal continental systems" (ISO/TC104 (Sec.196) 337, p.10, July 1972). Secondly, because the US was Europe's most important trading partner, the Series 2 did not have the priority of European committee members. Economies of scale in intercontinental transport were after all the core-issue in containerisation. Rail/road stood to gain from this. UIC acquiesced in the decision and committed itself to the ISO Series 1 (Ratter, 1968).

Series 3 containers. Work on a third series container dimensions started in the late 1960s. In order to arrive at a truly international series of standards, a political gesture was made to the Soviet-Union, where small containers were in use. Many such units circulated in the region. A fate comparable to that of the Series 2 later befell the Series 3. Firstly, the scope of Series 3 was argued to be of an internal continental type. Secondly, Series 3 containers would demand other handling techniques than Series 1. It was feared that developing countries would develop facilities for Series 3 to the neglect of Series 1, thereby restricting their economic growth. Thirdly, inclusion of Series 3 would lead to a proliferation of sizes, which counteracted the aim of standardisation. (TC104 N395, December 1975)

3.3 Corner fittings

Corner fittings are an essential part of containers. With help of twistlocks, they provide the means to lift and stack containers in a (semi-) automatic way. (See figure 4.) The subject was first raised in the ISO TC104 working group C meeting in London, 1962. There were two options, both of US origin. One was a corner fitting, which K.W. Tantlinger designed in 1955 together with the twistlock. It was patented by Sea-Land. The other option was that of the *National Castings Company*. Its solution was very similar to Matson's.

An important part of the early discussions took place in the Handling and Securing Task Force of MH-5. The committee was chaired by Tantlinger, a former employee of Sea-Land, working for Fruehauf and chairman of the Truck Trailer Manufacturers Association (TTMA). He describes the standards process as a dog fight, brought about by a mix of proprietary interests and business relationships (Tantlinger, circa 1982, p.9). In Tantlinger's words, the National Castings Company had a box type corner fitting which skirted around the earlier Sea-Land patent and a spreader with multiple part engaging lugs which, inserted in the corner fitting, were forced apart with a central wedge.

National Castings' solution was turned down because it had not been proven in general use and was not cost competitive. The problem with Sea-Land's corner fitting was that it was patented and therefore not suited as a national standard. To break the deadlock, Tantlinger approached his former employer to release the patent. Although the latter had earlier faced MH-5's refusal to include Sea-Land's 35 ft length in the American Standard, he complied. The letter dated January 29 1963 permitted dimensional changes to the fitting and to the twistlock.

But the controversies continued. A TTMA proposal for a modified Sea-Land box type fitting and twistlock was turned down, and no American Standard could be presented at the ISO meeting in Hamburg (1964). However, Tantlinger did describe the TTMA proposal to participants of the ISO TC104 and distributed half-scale models to illustrate the mechanism. In the The Hague meeting in 1965, the design was evaluated and accepted unanimously.[12]

In the course of container standardisation, Sea-Land's patent on the corner fitting and the twistlock was not the only one to be released. In a letter dated March 7 1966, Strick released a patent covering "the twist lock lifting mechanism with the non-rotating collar" (ISO/TC104 129E, annex Y). More recently, use of a patent covering a system for automatic identification of containers was granted on a non-exclusive, royalty free basis. Such company reactions are sparse in other standards processes.

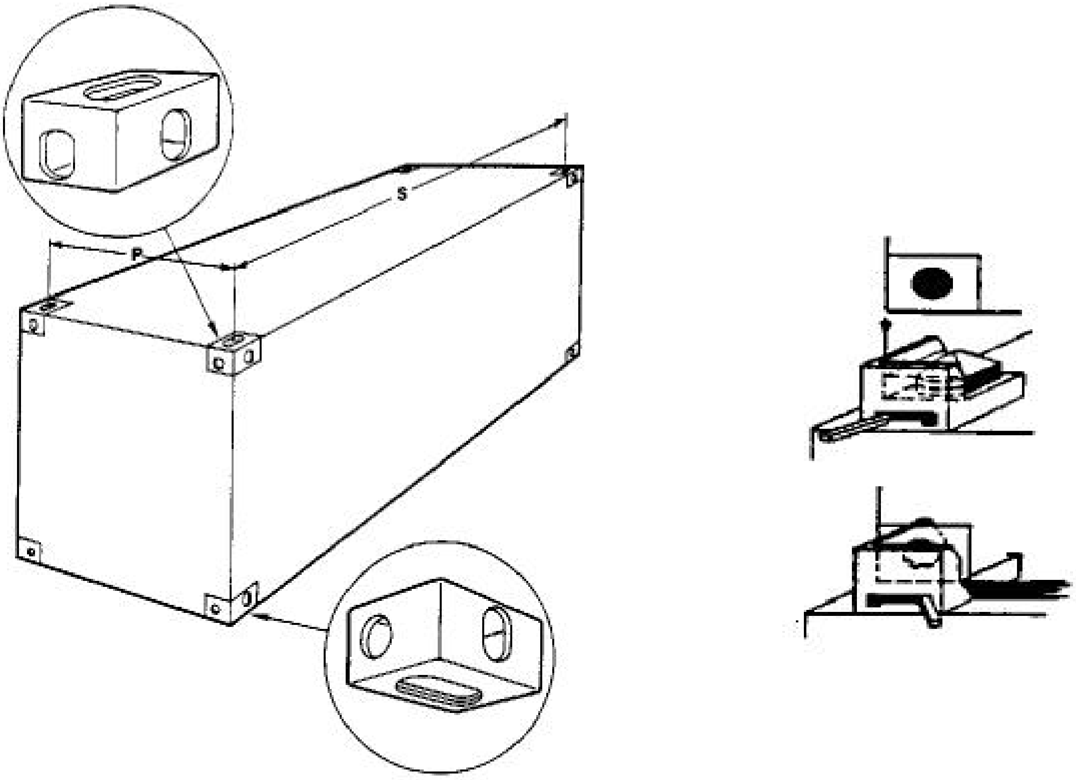

Figure 4: Corner fittings of the ISO container and the twistlock mechanism (sources: ISO/R 668 corner fittings, and SIS standardisation archive (1966), with kind permission from the NNI, Delft, and the SIS, Stockholm).

3.4 'Future' container dimensions

In the early 1980s, the US passed a law, which unified regulation on size and load of road vehicles in the different states. The law had implications for container dimensions: it set a maximum length of 45 ft (later 48 ft[13]), a height of 9'6" and a width of 8'6". In response to the request of US delegates, TC104 installed a working group on Future Containers in 1982 to examine if there was more wide-spread demand for larger containers. The chairman of TC104, Vincent Grey, was of the opinion that a new generation container was needed, which better served land-transport requirements. He made two radical proposals. Firstly, he proposed a change of width from 8 ft to 8'6". Secondly, instead of one container, which withstands the transport forces of all modes, he proposed several containers, each designed to protect it from mode-inherent forces. This measure would reduce the tare weight of containers for road and rail, whose sturdiness was foremost an answer to maritime requirements.
Strong objections were raised. Shipping liners argued that a revision of the standard would

require too much investment. European and developing countries pointed to their legal constraints on the width of road vehicles. (Vladimirou, 1983) With regard to container width, the dominant European standpoint was that the inner width of the container should be suitable for palletised cargo. Containers of 40 ft and longer were increasingly (un)loaded with palletised cargo. The size of two pallets, including the tolerance for overhanging cargo, added up to an inner width of 2460 mm[14]. A steel container with the proposed outer width (2591 mm) would make the corrugated iron sides unnecessarily strong and heavy. This was the technical side to the (operational) argument. The political side to it was that countries such as Switzerland had reluctantly changed their rules from 2500 mm to 2550 mm and refused even wider containers. In 1985, TC104 concluded that, although the height of 9'6" had its advantages, there was no need to change the existing dimensions. The working group was dissolved.

The US again brought up the question of enlarging dimensions in 1987. The working group was reinstalled to examine if voluminous cargo demanded larger container dimensions. The working group started by discussing the internal dimensions that would best accommodate standard load units (pallets). Following, the external dimensions were deduced. Soon consensus was reached about the height and width of the *new Series 2* container. Its length was, however, disputed. A French study concluded that the full/half lengths of 49'/24'5" and 41'/20'6" would offer the best loading capacity. An American advisory group came up with the 48'6,5"/24'1,75" length combination. (TNO/Logitech, 1991, pp.9-12) The French solution was chosen. Apart from new dimensions, the draft standard included mandatory corner fittings at all eight corners and, for the 49 ft container, also four mandatory intermediate fittings to be identically located as the top corner fittings of the Series 1 40 ft container. The latter was optional for the half-length future container. The proposal was accepted as an ISO TC104 committee draft in 1991.[15] Before submitting the draft standard for voting in ISO, the committee decided to await the results of a world-wide evaluation of the consequences of the proposed 'future' container dimensions.

The general conclusion of the survey was that the advantages of the full-size 49 ft container would not outweigh the problems it posed (COST 315, 1994). The expected profits were marginal; the dimensions exceeded restrictions posed by road regulation; high investments were required for technical and operational adaptations in industrial and developing countries; and the installed base in the Series 1 containers was too high.[16] On the basis of these results, the UN and the European Commission (DG VII) opposed larger container dimensions. TC104 acquiesced in the results.

A brief illustration is given of the problems of technical and operational compatibility that dimensional changes would have created (COST 315, 1994). Part of the discussion in TC104 on the future container concerned the high-cube container (8'6" ft wide, 9'6" ft high and 49' long). Most cellular containerships could not accommodate this size. If its dimensions were to have been accepted, the ocean shipping companies would have had to build new vessels, adapt existing ships or install better lashing systems. Otherwise, loss of capacity would have occurred. The same applied to vessels sailing on inland waterways. The 'future' container implied a severe loss capacity for vessels transporting containers on the Rhine. The width of canals and the height of bridges preclude the use of broader ships and further stacking of containers, respectively. Problems would have arisen for vehicle elevators on board of ro/ro ships. Moreover, the greater variety of container dimensions would have required more stacking space in terminals. Because of lack of space in most terminals, the 49 ft container was difficult to manoeuvre. Adaptation and/or replacement of container handling equipment in ports and inland terminals would have been needed. New gantry cranes would have been needed because the distance between the legs of gantry cranes was too small for the width of the high-cube. For the railways, special low platform wagons would have been required. Although US railways had suitable wagons, there would have been a loss of capacity on the existing 40 ft and 60 ft wagons in Western Europe. For Eastern Europe, which had few container wagons, there was no problem. For developing countries, which did have container transport by rail, costly adaptation would have been needed. Due to potential overloading and uneven loading, safety hazards of containerised road transport would have increased. Special vehicles would have been required to accommodate the proposed height. Smaller tires would have been needed and new chassis to compensate the extra height. Smaller tires involved higher maintenance costs. Etc.

3.5 Standards process reviewed

Matson and Sea-Land's proprietary use of containers started off standardisation in the US, which in turn spurred international standardisation. A dedicated gateway solution was converted into a generic solution for intermodal cargo transport. I quote Vincent Grey, who was chairman of ISO TC104 during these years.

> "What emerged from the ISO Committee were Standard Container sizes that did not match either Sea-Land's or Matson's boxes. The corner fittings were different from theirs and so were the container ratings, the test methods, the marking system, the chassis securing method, and so forth. This was not a wilful effort to isolate the two pioneering companies but was the result of broadening the scope of operations within which the containers would have to survive. The emergence of an ISO Container depended on an amalgamation of service environments of a world-wide distribution system."
> (Grey, 1992, p.82)

Standards regime. Grey refers to the difficulty of aligning the different political, operational and technical demands under the voluntary consensus regime of the ISO. The standards regime, that is, the aims and principles that guide international standardisation, strongly shaped the committee process. Several events illustrate this. In order to raise international commitment, the standards programme of TC104 initially included the European UIC container and the USSR container. Furthermore, TC104 adhered to the basic rule of avoiding proprietary and patented solutions in order not to restrict the use of standards. Moreover, national membership of the ISO meant that national regulation had to be taken into account. Lastly, in search for `technically optimal solutions' the services of research centres were called in. For example, tests were held to determine the safety requirements for container handling and transport. In sum, the standards process was conducted in a way that, according to the formal standardisation ideology, would maximise the scope of the gateway solution.
Institutionalisation in standards. Certain interests were institutionalised in the process of

container standardisation. A matter-of-fact example is the institutionalisation of land transport-oriented regulation. National road regulation determined dimensional limits. Further, the intermodal systems of Matson and Sea-Land, which triggered standardisation, centred on deep sea transport. Accordingly, TC104 also focused on intermodal systems that included deep sea transport. The interests of intermodal deep sea shipping companies presided over those of land-based intermodal operators. The Series 1 dimensions and the sturdiness of the containers institutionalise this. Furthermore, the sole survival of Series 1 is a symptom of the influence of the US in the ISO TC104 standards process.

It is also instructive to note what was explicitly *not* institutionalised. For example, specifications that might favour certain regional economic interests in container production (i.e. aluminium or steel containers), were avoided by developing performance standards. In addition, solutions, which were connected to company interests in dimensions (Matson and Sea-Land) and in patented solutions (National Castings Company), were rejected.

POT entrenchment and the future container. Analysing the controversies about enlarging container dimensions from the perspective of POT domains, the following occurred. With the regulatory change in the US in the 1980s, the bottleneck for dimensional change shifted to other regions (political domain). The former US restrictions, in particular on container width, had hampered more efficient land-bound transport in Europe (operational domain). The regulatory change opened up the possibility to create operational compatibility between flows of palletised and containerised cargo. Later discussions on future container dimensions centred on the palletised container. The standards process was a technical endeavour to find the optimal - operational - match between pallet and container sizes. Interesting is that in these ISO committee discussions the regulatory constraints on road transport were treated as 'soft' restrictions. Technical and operational compatibility between container handling equipment and the container corner fittings was a 'hard' requirement.

The dimensions of the 'future' container were ultimately rejected on the basis of a world-wide survey. Objections were rooted in all three POT domains. Too many technical adaptations were needed; there were too little operational advantages to be gained by an additional container standard; and, overall, national economic considerations and road regulation ruled out the proposed lengths and widths.

4. Compatibility and the standardised container

The Series 1 standard was a political, operational and technical compromise. How effective was it in achieving compatibility within and between the 'POT domains'? Below, first an impression is given of what it means to make transport subsystems adapt technically to the standardised container (section 4.1). Next, operational compatibility is treated. Early containerisation in the Netherlands illustrates which strategies different operational actors pursued when faced with containerisation (section 4.2). Lastly, controversies about containerisation in UN bodies are used to illustrate problems of political compatibility (section 4.3).

4.1 Complementary technical adaptations

In response to container standardisation, transport vehicles, tools such as cranes and infrastructural provisions had to be adapted (e.g. Matson Research Corporation, 1970). In the late 1950s and early 1960s, conventional cargo ships were converted into containerships. Naval architects were called upon to determine if conventional ships could cope with concentrated loads. The ships needed enlarged hatches. Etc. These first generation containerships had a capacity of about 500 TEU. The second generation containerships were specially built for container transport. These had a capacity of about 1500 TEU. They had cellguides in which containers could be stacked six high. The use of third generation containerships started in 1972. They could accommodate circa 3000 TEU. The present fourth generation containership can carry more than 4000 TEU. (Klein Woud, 1987)

Port facilities had to be adapted. Piers were fortified to deal with the extra weight of cranes. Other storage areas were needed. Special lifting equipment was developed (e.g. forklift trucks, gantry cranes, bridge cranes, straddle carriers). Likewise, inland terminals demanded storage space, paved storage areas, traffic control systems, maintenance facilities for containers and equipment, etc.

Initially, railway companies could transport containers with existing flatbed railcars or piggyback cars. Framecars were modified to carry containers. To accommodate 20, 30 as well as 40 ft containers, a European container wagon of 60 ft was designed (3 x 20 ft, 2 x 30 ft, 20 ft + 40 ft). Again, special handling equipment was needed at terminals.

Where road transport was concerned, containers could be carried on a skeletal chassis, a flatbed trailer or a truck. Here too lifting devices were required.

4.2 Operational governance changes in the Rotterdam harbour

Containerisation affected the separate transport sectors in different ways, as the early developments in the Rotterdam port show. The Rotterdam harbour is a junction of intercontinental and continental container transport. It offers natural conditions for short sea, coastal and inland river shipping and man-made conditions for road and rail transport to the hinterland. Below, I focus on deep sea, road and railway container transport.

Deep sea transport. Ocean liners have co-operated in international conferences since 1875 (Gwilliam, 1978). Conferences were organised to limit and regulate competition in particular trades or on particular routes. Some were closed and not accessible to outsiders (European conferences); others were supposedly open, but difficult to join (US conferences). Deals were made about tariffs, market share and capacity supply. Pools were formed, wherein participants had a right to a certain percentage of the market. By and large, there was consensus about what a fair market share consisted of (Gilman, 1983). The comparable - and often large - size of shipping companies facilitated co-operation in this sector (Van Driel, 1990).

An important reason for European liners to start with containerisation was that Sea-Land offered cargo services at a rate, which was 12%, lower than the conference rates. Initially, containerisation developed hesitantly. High investments were needed to build containerships or to convert conventional ships. Although these containerships could accommodate much more cargo, the profits were uncertain. There was also the risk of overcapacity on certain trade routes. To minimise risks, co-operation was sought. Different forms of co-operation developed in Europe and internationally, most of them between 1965 and 1970.

In the Netherlands, a series of mergers and purchasing activities started in 1963[17]. A merger in 1970 (Needled) supplied the financial means to invest in containerships and the scale to operate them. It was also initiated to improve the position of Dutch liner companies in their negotiations with European and international consortia, which were being created at the time. These consortia operated on particular routes and controlled the market of container transport.[18] In sum, containerisation intensified co-operation between Dutch liners.

Road transport. In 1967, more than 50% of the container transport to and from the Rotterdam harbour was served by road (Hennus, 1967). In the beginning of containerisation, there were two categories of road hauliers. The first category consisted of a large number of small transport companies and a few big companies, who transported containers as an extra. This group had some experience with co-operation (e.g. price-setting and cargo-sharing) and primarily served the local Rotterdam area. Containers simplified the transport service. The relative ease of container transport made road hauliers exchangeable. Without too many investments, the second group, the newcomers, could enter this previously closed market. Most newcomers were not inclined to co-operate with other organisations on tariffs. Transport rates declined. The newcomers broke up the semi-stable structure between traditional providers. Notably, the liners, who owned the containers, made no move to purchase road companies in order to control the full transport chain (Van Driel, 1990, p.396). However, they drove a hard bargain, harder than the traditional clients of road hauliers did. The position of the road hauliers worsened.

Over the years they attempted to regain their position vis à vis liner companies through co-operation. The first attempt took place in 1966 between 70 mostly internationally-oriented Dutch road hauliers (*Combicon*). However, negotiations on tariffs were unsuccessful and the co-operation broke up in 1974. Again, in 1981, an association of container transport companies was established (*Vereniging van Zeecontainervervoerders*). It focused on furthering the interests of its members, such as reducing the waiting time at harbour terminals (Van Driel, 1990). This attempt also failed.

Competition from inland shipping companies became tangible in the 1980s. For longer distances it was a cheaper alternative to road transport. In order to compete on international container transport, four medium-sized Rotterdam-based road transport companies established One Way Trucking (1988).

In sum, containerisation facilitated market entry for newcomers who disrupted the earlier mode of operation; it weakened the position of road hauliers vis à vis ocean liners and it increased competition.

Rail transport. The Dutch railway service was until recently a national monopoly. Cargo transportation policy was nationally-oriented. Long distance, cross-border container transport was taken up by *Intercontainer*, an organisation established in 1967 by a number of European railway companies. Intercontainer's objective was to organise and promote container transport on the European continent (ECMT, 1993, p.72). To do so, it bought transport capacity from its members, the national railway companies.

During the 1970s, Intercontainer faced growing competition from piggy-back organisations (i.e. truck on railway wagon). The European piggy-back companies were organised in the *Union Internationale des Sociétés de Transport Combiné Rail/Route* (UIRR). It was

established by road hauliers, who constituted a significant part of its shareholders and therefore had a strong influence on its activities.
In 1983, the two organisations struck a bargain. The bargain, the *Montbazon agreement*, entailed that transportation of ISO containers, on which Intercontainer had focused, would be Intercontainer's prerogative; the market for transport of trailers and semi-trailers by rail would be UIRR's domain; and both could transport swap bodies (Steijn, 1994; see section 5.2). However, in 1992 the European Commission decided that the Montbazon agreement stilted competition and the agreement was dissolved.

Summarising, the ocean liners and the European railway companies developed more integrated forms of governance in response to the introduction of the container. The co-operative efforts of the Rotterdam road hauliers, on the other hand, largely failed. The operational governance structures of deep sea and rail can be said to have been more compatible with containerised transport than the road sector was. Intermodal co-operation between deep sea and rail could therefore proceed with greater ease and facilitated their role as compatible compliments in containerised transportation.

4.3 Political controversies in the United Nations

In the early 1970s, UN circles started paying attention to container standards. The UN was concerned about the effects of container standards on trade patterns of developing countries. The subject was first discussed at a UN/IMCO Conference in Geneva, 1972. In 1974, the UNCTAD formed an *Ad Hoc Intergovernmental Group on Container Standards*. It was to prepare a *Convention on International Multimodal Transport*. The report of the Ad Hoc group contained some very critical comments about ISO TC104's manner of operating. It objected to the larger dimensions, which were recurrently discussed at ISO meetings. The developing countries (the Group of 77) criticised the technical committee for failing to take their interests into account. They feared that larger containers would make earlier investments obsolete. Their criticism further pertained to problems of container handling in ports, to the special characteristics of the commodities exported by developing countries, to the infrastructural alterations which larger container dimensions required, and to procedural *faux pas* of TC104 (i.e. TC104 meetings were exclusively held in industrial countries and the experts, which drafted container standards, also came from these countries).
The developing countries pleaded for universal adherence and application of ISO standards and objected to the voluntary nature of standardisation. Their idea was to have ISO standards universally adopted by making them part of the Convention on International Multimodal Transport. Defendants of the ISO system reiterated that standards are seldom universally applicable. The acceptance of ISO standards should be based on their technical merits and they should remain up to date. Each country should choose its own pace of change. (Miyamoto, 1978)
The developing countries sought to solve part of their problems by tightening government control on activities of multimodal transport operators in their territory. The draft Convention was to contain an article where "the right of regulation and control at the national level is recognised". It mentioned "consultation at the national level (...) before the introduction of multimodal services in developing countries" and "consultation at the national level on terms

and conditions of service (...)" (Miyamoto, 1978, p.239).
The issues that were raised, indicate tension between different forms of governance. Firstly, there was political tension between the interests of the industrial and the developing countries. Successively, the gap between the benefits of containerisation for developing and industrial countries widened. Secondly, on the surface the multi-lateral UN regime questioned the efficacy and political neutrality of ISO's standards regime. The actual problem was that the - in principle democratic - standards process and the voluntary nature of standards' application made it difficult to curb new developments. Thirdly, there was tension between the network of operational and political actors, that is, between container transport operators and the national governments of developing countries. The operators operated rather independently from national systems of governance.
A different problem of political compatibility was the various national policies related to transportation. For example, the mix of economic and environmental policies in the Netherlands affected medium and long haul container transport in contradictory ways. The desired change in modal split[19] away from road transport required internal alignment between Dutch economic and environmental policies, and external alignment with the transport policies of other European countries. Transport subsystems may have been technically interchangeable, but to make them operationally and politically interchangeable was a different matter.

5. Competing gateways

The impact of the ISO container on the transport system depends to a large extent on the alternative gateways available in the early 1960s and thereafter. Were there other, competitive means of cargo transportation, which could also improve its efficiency and which could offer better gateway facilities in respect to one or more of the POT domains?
In the early 1960s, there were a number of alternatives for container transport. Conventional road transport, with its advantage of flexibility, was much used in combined transport. Examples are roll-on/roll off (ro/ro) transport, where trucks drive on and off ferries and liners, and *piggy-back* transport (i.e. truck on railway wagon). Both combined systems had the advantage that no repackaging of cargo was necessary. However, although ro/ro was much used in short sea shipping, it was less suitable for intercontinental journeys. Piggy-back transport was, of course, land-bound. These modes of combined transport could therefore only substitute a segment of container-based intermodal transport.
Below, two other alternatives are discussed. The first is the pallet, which was a competitor of the container throughout the transport chain. The second alternative is the swap body. It was designed for road and intermodal road/rail transportation.

5.1 Pallet

Palletised transport was in the early days perceived as a full alternative to the container-based system. For example, in 1967 the United Steamship company used new ships designed for fast discharge of palletised cargo and for efficient use of fork lift trucks in moving palletised cargo in the holds (Immer, 1967). Norwegian studies concluded that such ships are less costly to operate (Van den Burg, 1969). Other shipping lines kept all options open. In 1967,

the European ACL consortium, for example, built ships for the combination of ro/ro, containers of 20 and 40 ft and palletised cargo.
Analogous to containerised systems, pallet use improved efficiency in the transport chain. Its use reached even further. Olsen Lines, for example, a Norwegian shipping company, was a strong proponent of palletisation because,

> "With the pallet as an integral part of the packing for internal transport within the factory, we have found it expedient to use it as the basis for the planning of our transport routines as well, instead of making it necessary to repack or to subject it to additional packing in the form of containers." [20]

The possibility of combining the benefits of the two gateways was not a viable option. To many people it was inconceivable to waste precious space in containers on pallets. These people adhered to what was called the 'full-down' paradigm. At a TC104 meeting in 1963, the Scandinavian countries tried to get the container adapted to the 800 mm x 1200 mm pallet, but without results (SIS, 1967.11.02, T 37.15, p.2.). The dominant view was clearly expressed by Gerson in a symposium discussion (Spooner,1968, p.70):

> "Does Mr. Spooner agree that the pallet is essentially an instrument for short sea journeys rather than a deep sea one where the loss of cubes would be too great, and where one would think that the pallet had already been superseded by the container?"

Thus, some people assigned pallet and container to specific geographical transport trajectories. This view was partly rooted in practice[21]. To others they represented different systems of transport (e.g. Rowbotham, 1978).

5.2 Swap body

The ISO Series 1 containers were not designed for palletised European continental transport. In the late 1960s, using the full width permissible by road regulation, the German swap body (*Wechselkasten*) for combined rail/road transport was conceived[22]: a pallet-wide container with four foldable supporting legs, four bottom corner fittings, and, at the time, with an open top and a canvas cover. The foldable legs are used for temporary storage on the terminal or near the factory. Unlike the ISO container, the *Wechselkasten* did not require separate lifting equipment in order to be dismounted from road vehicles. Lifters were either part of the chassis or attached to the corners of the swap body (Hausmann, 1968, p.52). (See figure 5.)
The swap body was made of lighter material than the ISO container and could not be stacked (Rath, 1973, p.187).
In the 1970s, swap body systems also took off in countries such as Sweden, Norway and France[23]. Their external width was always 2.50 m, but their length varied from 6 to 12 m (Rath, 1973). National standards were drawn up.

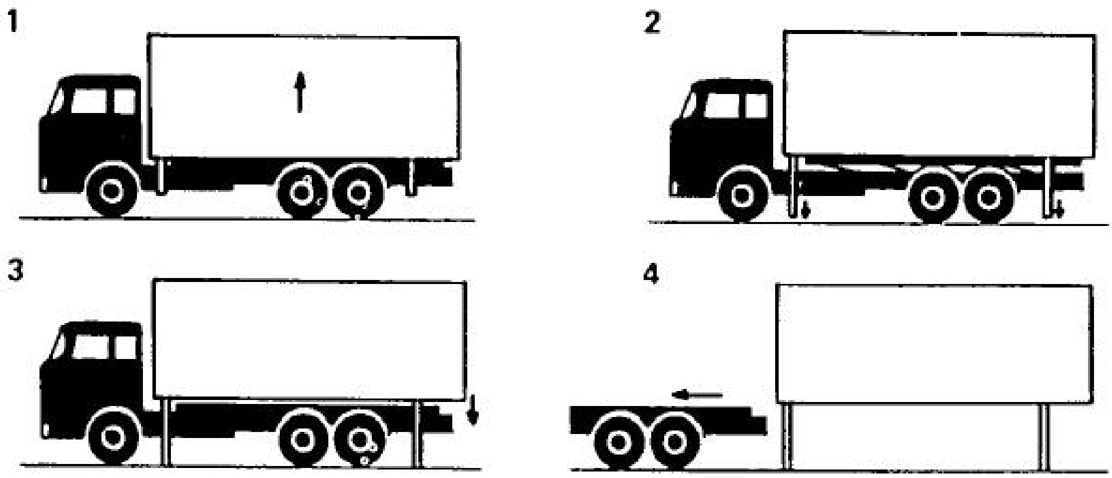

Figure 5: Unloading principle of the swap body. (source: Jensen, 1985, with kind permission)

The European Commission, who saw in the use of swap bodies for combined road/rail transport a means to shift the modal split in favour of rail transport, encouraged European-wide standardisation. The *Comité Européen de Normalisation* (CEN/TC119) completed standardisation of swap body dimensions in 1992. The CEN swap body had an internal width of 2.44 m[24], and an external width of 2.50 m. It accommodated the two most common pallet sizes 0.80 x 1.20 m and 1 x 1.20 m (ISO 6780). Its length varied. Table 2 depicts the lengths as standardised by the CEN (CEN, 1992) and the UIC. The UIC dimensions were those used by the European railways in 1995. Presently most European railway fleets accommodate the C715 swap body - the most common length in road transportation - next to the 20 ft ISO container (COST 315, 1994).[25]

Swap body classification according to:		**Length**
CEN	**UIC**	**[mm]**
C625	1	6250
C715		7150
C745	2	7450
C782		7820
		8050
		9125
A1219	3	12190
A1250	3a	12500
A1360	4	13600

Table 2: Length of swap bodies standardised according to CEN (1992) and UIC. (Source: Rutten, 1995)

Except for the location of the intermediate bottom fittings, which coincided with that of the corner fittings of the 20 ft container, CEN swap bodies differed from the ISO container in length, width, height, capacity and design. But since then, a new generation of swap bodies has emerged. These are stackable, have eight corner fittings and can be handled by ISO lifting equipment (Wormmeester, 1993, p.11).

5.3 Gateways compared

In a way, the Montbazon agreement between Intercontainer and the UIRR promoted the use of swap bodies on the European continent. As the agreement determined that only swap bodies were to be transported by both organisations, it encouraged their use to the detriment of the ISO container. The number of swap bodies in Europe grew (ECMT, 1993).
Thus, competing cargo systems developed around different gateways. The operational actors reacted differently. While European railway companies increasingly invested in swap bodies, some producers of container handling equipment developed spreaders that could handle variable dimensions, and containerships were built with flexible cellguides.

Gateways	**Modal Bias**	**Geographical Bias**
ISO pallets	Short sea	Europe
ISO containers	Deep sea	US, intercontinental
CEN swap bodies	Rail, Road	Continental Europe

Table 3: Modal and geographical bias in standardised intermodal units.

Comparing the standardised gateways, the ISO container was with reason also called a 'maritime container'. (See Table 3.) It best suited the deep sea subsystem and US road regulation. But it was not designed to serve the needs and fully exploit the possibilities of the European continental transport system in the 1970s, where formerly road regulation was less restrictive. In economic terms, the contribution of intercontinental transport to land-bound transport is modest. Most cargo traffic takes place within Europe. Combined with the growing demand for palletised cargo, the difference between the width of the ISO container and the lawfully permissible width provided an incentive for further development of an alternative gateway system. The mismatch between operational interests of actors in intercontinental transport, on the one hand, and continental transport, on the other, corroded the potential of the ISO container as the unquestioned gateway for intermodal transport.

6. Conclusion

Gateway characteristics. The aim of ISO standardisation was to develop an exchangeable container, a performance standard. It was to be a generic, semi-modelled gateway solution (e.g. modular container lengths), the result of which was the ISO Series 1. The standards process led to technically, and partly operationally, compatible cargo transport modalities. However, it also institutionalised asymmetries in the operational and political domain. The standard had a *modal bias* in that it was especially cut out for - withstanding the racking forces of - deep sea transport. It further had a *geographical bias*. The Series 1 dimensions complied with the more restrictive US regulation, and was biased towards intercontinental transport as opposed to continental transport (Europe, Soviet Union). The standard further embedded an *economic bias* towards industrial countries.

Competing gateways. The study shows that, if the degree of political, operational and technical compatibility is not all three addressed in standardisation, competing gateways develop. From the start, the ISO Series 1 container was not designed to accommodate pallets. In the 1960s, containerisation and palletisation were competitive systems of cargo handling. The means of transport (ships, trucks, railway wagons and containers) were fully stowed in order to make shipment worthwhile (the 'full-down' paradigm). In the early 1970s, a *shift in transport paradigm* took place from 'space' to handling considerations. Decreasing cargo handling costs was recognised to be more profitable than 'full-down' transport. Accordingly, the use of pallets in containers stopped being a waste of space and became instead a means to increase efficient (un)loading of containers.

In the meantime, a competitive gateway developed in Europe: the swap body. It was designed to combine the advantages of palletisation and containerisation and to exploit the width permitted by European road regulation. The swap body was primarily applied in road transport, partly in combination with rail. The Montbazon Agreement of 1983, which divided the containerised market between Intercontainer (rail) and the UIRR (piggy-back) reinforced its use on the European continent. The agreement encouraged the development of a continental system, which competed with the ISO container-based transport system.

Converging gateways. Presently, the new generation of swap bodies has corner fittings that can be handled by ISO lifting equipment. It has further become stackable. In other words, its design entails - partial - outer convergence to the handling mechanisms of the ISO container and inner convergence to palletised cargo.

In respect to the ISO container, regulatory change in the US in the 1980s opened up the possibility to create pallet compatible containers. ISO's proposal for the 'future' container of the late 1980s assimilated elements from the ISO Series 1 (e.g. the overall design and corner fittings), from the palletised transport system (its inner width) and from the swap body system (its external half-size length).

ISO and CEN concerns indicate that the perspective of standardisers has shifted from a focus on specific intermodal gateways (containerisation, palletisation, swap bodies) to compatibility between gateways in the transport system.

Competitive governance. The different interests of developing and industrial countries regarding containerisation led to rivalry between UNCTAD and ISO's standards regime. The rivalry pertained to the question how container standardisation should be governed.

Furthermore, formerly the pace of change in road regulation set limits to container standardisation. However, while drafting 'future' container dimensions, dimensional regulatory constraints were treated as 'soft' restrictions. This may signify a more general trend, namely that de facto developments and standards proposals are increasingly pushing regulatory limits.

Changing gateway characteristics. Over time the standardised container lost some of its generic properties. Through world-wide use, it became entrenched. In an economic, political and operational sense its meaning shifted from a generic multi-modal gateway to a bimodal, quasi-*dedicated gateway solution.* However, in view of early developments, the case indicates that standardised gateways can, indeed, facilitate change in large technical systems. Moreover, it shows that although a gateway may become entrenched, this does not preclude the development of competitive gateways and systems.

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Abbreviations

ASA	American Standards Association, predecessor of the American National Standards Institute (ANSI)
CEN	Comité Européen de Normalisation
COST	European Co-operation in the field of Scientific and Technical Research
DG VII	Directorate-General for Transport (Commission of the European Union)
ECMT	European Conference of Ministers of Transport
ISO	International Organization for Standardisation
MH	Materials Handling
TC	Technical Committee
TEU	Twenty foot Equivalent Unit (20 ft ISO-container)
UIC	Union International Chemins de Fer (International Railway Union)
UIRR	Union Internationale des Sociétés de Transport Combiné Rail/Route (European piggyback organisation)

UNCTAD United Nations Conference on Trade and Development
UN/IMCO United Nations/ Inter-Governmental Maritime Consultative Organization

Notes

1. Unitisation is "the assembly into a single load of quantities of one or many different items of supply, in such a manner that it can be moved unbroken from source to a destination or use (...)" (Van den Burg, 1969, p.23).
2. The relevance of the ISO container for air transport has been negligible. Its volume and tare weight is not well suited for air cargo transport conditions.
3. Interviews were held with Ir. F. Oudendal, Ir. H.E. Gustafsson and Dr.ir. G.J. Wormmeester. The archive was kindly provided to me by Ir. H. Wärhem of the STG Allmänna Standardiseringsgruppen in Stockholm, who was from 1962 onwards the secretary of the Swedish committee for container standardisation. I am indebted to them.
4. The OSI reference model (ISO 7498 and CCITT X.200) identifies logically separate, generic functions in data communication. It depicts these as a set of hierarchically ordered layers, which address areas of standardisation.
5 To prevent confusion, I do not refer here to the more immediate form of compatibility between the container and, for example, the road vehicle. This aspect is treated separately in section 4.
6. In general, depending on the large technical system concerned, some domains may prove more elementary for the system's workings than others may. An example stemming from the 1880s is that of two telephone operators (Bell and AT&T), who operated in the same area. They had physical interconnection (technical gateway). But rather than use it, they rebuilt the local system to double wire in order to connect with the regional system. In this example forces in the operational domain are dominant.
In the case of transport subsystems, the operational domain (here: intercontinental and continental transport) and the political domain (here: national and regional transport policies) have a strong geographical component. This is also recognisable in other large technical systems. E.g. in the case of the AC/DC converter AC had a regional scope and DC had a local scope.
7. The terms 'regime' and 'governance structure' are more or less interchangeable in the present context. Schneider & Werle (1995) use the term governance structure literally, i.e. to denote the way an actor network or organisation governs a particular field of interest. Regimes are agreements, at once resulting from and facilitating co-operative behaviour, by means of which actors regulate their relations with one another within a particular issue area. (adapted from Powell & DiMaggio, 1991, p.6)
8. The UN/IMCO is a specialised agency of the United Nations whose members are governments with maritime interests. IMCO became much involved with the safety of cargo, crew and ships after 1969-1970, when dozens of containers were lost over the side of containerships at sea. The UN/ECE is a UN body for regional development and co-ordination of economic activities. ECE set up the first convention on container transport covering a European service. (Rath, 1973, pp.20-21).
9 Generally, however, the national delegations consist of parties with a direct technical or economic interest in the work item.

10. This proposal was not put forward with the idea of palletised cargo in mind. At the time containers were filled manually as it was more or less inconceivable to waste precious space on pallets.
11. At that time the UK in particular used containers with a 30 ft length. In the automobile industry this length is still used.
12 TC104 decided on eight corner fittings. In subsequent meetings, the working group discussed their location, tolerances, safety issues etc.
13. The reason why at a later stage trailers and containers of 48 ft were accepted was that the railroads expanded towards the 50 ft boxcar. Road hauliers pointed out that this would give the railways an unfair advantage. The federal government partly conceded, but did not want a 50 ft container on the road. The compromise of 48 ft resulted.
14. The size should be chosen in a way that does not require plastic foliage to prevent cargo from hanging over the pallet. There has to be some tolerance. Thus, a tolerance of 20 mm to the right and to the left up, added with the width of two pallets (800 x 1200 mm, 1000 mm x 1200 mm, i.e. 2400 mm) would make an inner width of 2460 mm ideal. Most Europeans delegates favoured an external width of 2550 mm.
15. The normal procedure is that committee drafts are offered for voting and, if accepted, then acquire the status of Draft International Standard, which in turn - after acceptance - becomes an International Standard.
16. The half-sized container is viewed more favourably. Its width permits palletised loading, it can be handled with current equipment, and it is easier to accommodate within the existing infrastructure.
17. In 1963, two Dutch shipping lines merged into the Needled Lijnen in order to reduce operating costs. For the same reason KJCPL purchased KPM in 1967. In 1970, these two companies again merged with a third company (VNS) into the Nederlandse Scheepvaart Unie, later re-named Needled. (Van Driel, 1990)
18. In 1965 and 1966, the British founded two consortia: the Overseas Containers Ltd. (OCL) which e.g. covered the route between Australia and New Zealand, and the Associated Container Transportation (ACT). The Atlantic Container Lines (ACL) consortium consisted of five European liners, i.e. the Holland America Line, the Swedish Transatlantic Line, the Wallenius Line, the French Line and the Canard Line, and provided a joint service on the North Atlantic route. (Immer, 1967)
19. With the term modal split I refer to the proportion of the total amount of transported cargo which each transport modality accounts for.
20. Fred Olsen (1967) quoted in Van den Burg (1969, p.186).
21. "The container system must be adjusted/adapted to the needs of shippers and consignees, especially those who still have difficulties in integrating an intercontinental cargo conveyance system which is quite different from, and in some cases, incompatible with their own national and continental physical distribution set-up. Using containers parallel to palletised distribution often requires additional investments (...) " (Muheim, 1978, p.15)
22. The German railways used the swap body as a means to regain cargo transport from road hauliers.
23. Container industry, Volume 1, 1978, pp.264-265.

24. 2.44 m is according to a CEN study the absolute minimum as there is no tolerance for cargo bulging over the side of the pallet. An internal width of 2.46-2.48 m and an external width of 2.55 m would be preferable. (COST 315, 1994, p.10)
25. The class C swap body is particularly used in Germany. In 1990 Germany roughly had 50,000 C715 units, of which about 55 % were used in intermodal transport. Over 80% of the swap bodies are of class C. Class A is mainly used for intermodal transport in France. (Rutten, 1995, p.127)