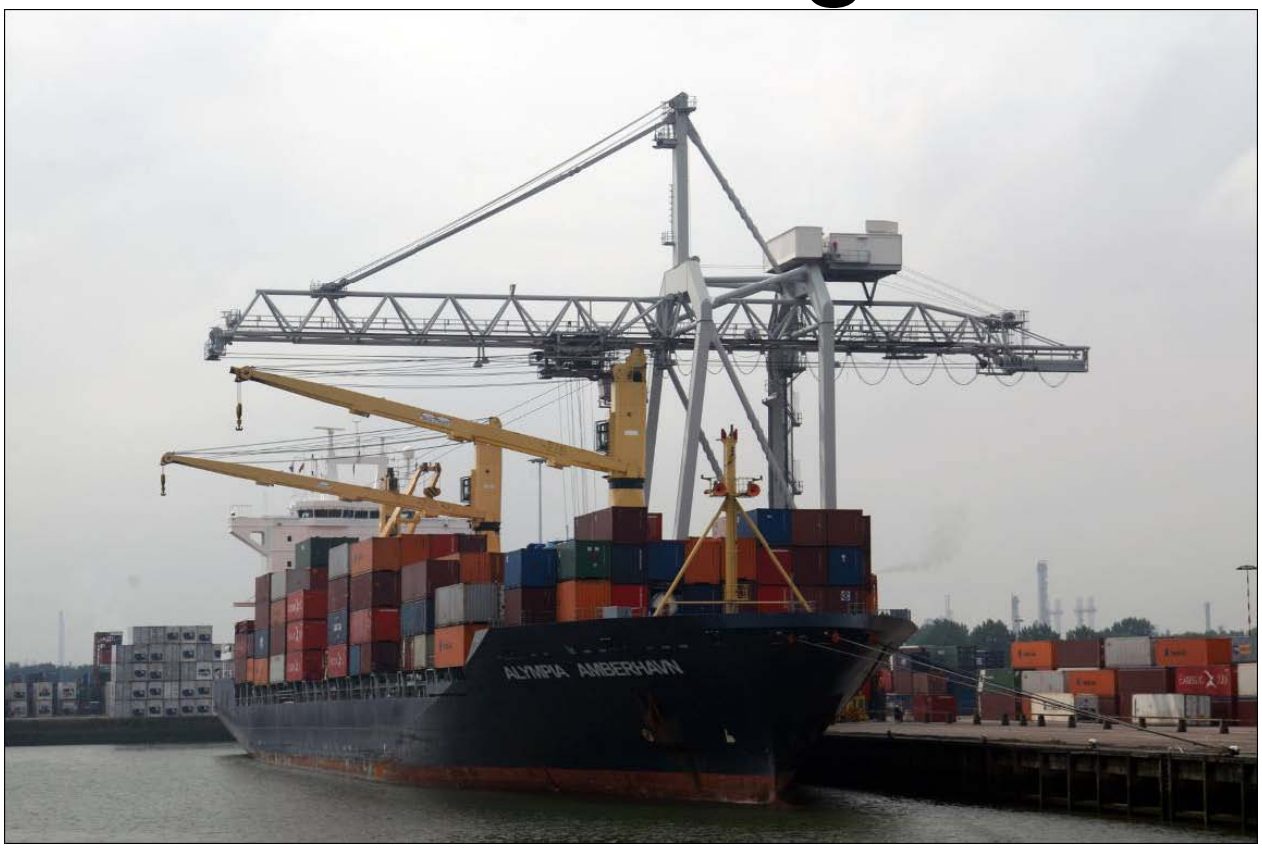
Container logistics



Final assignment for the

A-lympiad 2009

Garderen,

March 13 and 14 2009

WISKUNDE A-LYMPIADE NEDERLANDSE

TEXAS INSTRUMENTS

GUIDE FINAL MATHEMATICS A-LYMPIAD 2009

IN ADVANCE:

- First read the full text of the assignment so you will know what you have to do this weekend.
- Divide tasks where possible and consult when needed.
- If you need them, you can get materials such as coloured paper, scissors, A2-sheets of paper etc. from the committee table.

TIME MANAGEMENT:

- Keep an eye on the time when you work on the different parts.
- Start thinking early about the data you need to ask the experts about.
- Be sure to have enough time left to prepare (and practice !) your presentation on Saturday!
- You have to hand in your report on Saturday afternoon before 13:00.

HANDING IN:

Friday night: the list of data you want
Saturday afternoon: the detailed answers for all parts, written in a report that can be read without the text of this task document. Add the list of the desired data

The jury will receive copies of your work. Of course the copies must be legible. So use a black pen for writing and only print on A4 size paper. Any drawings that you hand in, must copy well, and it is therefore better not to use a pencil to make them.

JUDGING:

Among other things, the following points are important for the jury:

- How complete the answers for the various parts are;
- the representation of calculations and the method used
- the efficency of the proposed schedules
- The use of math;
- The argumentation used and how choices that have been made are justified;
- The depth to which the various assignments have been answered;
- The style of presentation: form, legibility, (copyable) illustrations etc;
- Originality and creativity.

Container logistics

Introduction

Figure 1: the Ceres Paragon terminals container transshipment terrain in Amsterdam

Many goods are transported in containers, and a part of that transport takes place by ship. When a container ship arrives in port the job of unloading and loading begins, and of course that needs to be done as fast as possible. The quay cranes lift the containers from the ships and put them alongside. A vehicle, the *straddle carrier*, picks up the container and moves it to a temporary depot, the *stack*. The stack consists of several *stack blocks*. The carrier can move one container at a time (see figure 2).

Figure 2: a straddle carrier at work

A stack has a *sea side* and a *land side*. The containers in the stack (see figure 1) are placed in rows with enough space between them for the wheels of the carrier. The straddle carrier as it were ‘straddles’ the containers, as you have seen in the introduction movie. The trucks are loaded in a fixed location outside the stack. Normally there are several carriers at a time in use. The handling as a whole (unloading, storage, loading) is called *transshipment* of containers. This transshipment must be done as efficiently as possible both in time and cost.
This assignment is about making the transshipment of containers as efficient as possible.

To start with...

To start with, you will look at a simplified situation. In figure 3 you can see a schematic representation of a stack block with containers that have to be removed, and locations were containers have to be placed. You can find the picture larger and in colour in the appendix. The stack block consists of six rows of nine place where a container can stand. So, you could put a total of 54 containers in this stack block. At the beginning and the end of each row are the inoput and output points. Containers that are taken from the stack block are put there; containers that have to be put into the stack are waiting there (please note: the drawing is not to scale: there can be several containers in an input or output point).

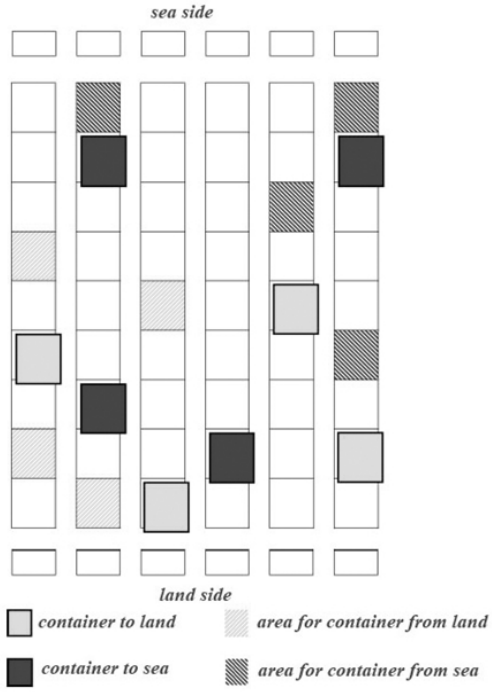


Figure 3: schematic representation of a stack block

Now there are four different possible movements for the containers:

- From the sea side, just unloaded from the ship, into the stack. These containers are put in the blue shaded places.
- From the land side, just delivered by truck, into the stack. These containers are put into the green shaded places.The technical term for these movements is *storage*.
- From the stack to the sea side, to be loaded into the ship. These are the blue containers.
- From the stack to the land side, to be loaded on a truck. These are the green containers.The technical term for these movements is *retrieval*.

The movements take place as follows. The straddle carrier starts its route on the input/output point at the bottom left. There are two containers there that have to go into the stack. In the row that the carrier enters, there is a container that has to be taken to the land side. The carrier can move up and down in a row; it can only change rows by moving completely out of the row and turning. This turning takes much more time than moving back and forward *between two containers* in a row.

Assignment 1

Figure 3 shows eight storages and eight retrievals. These are, as it were, the tasks for the straddle carrier. These will be performed by one carrier. The carrier will start and finish at the input/output point at the bottom left.
Make as efficient a route as possible for the carrier to perform the given storage and retrieval orders. Describe this route clearly and clarify why it is as efficient as possible. Take care to depict this route, including all the actions, clearly.

...and then...

For assignment 1 you knew where to put to storage containers; they were also already in place in the various input/output points. In the following assignment you hav to decide yourself where to put them.
From now on you can also stack the containers; the straddle carriers are tall enough to lift a container over a maximum of two stacked containers. That doubles the capacity of the stack, but now it can happen that the container at the bottom must be retrieved, and the one at the top has to stay in the stack. That means you have to move containers within the stack, *reshuffling* this is called.
Figure 4 shows a stack block of eight rows with six places; you can also find a larger version of this drawing in the appendices.

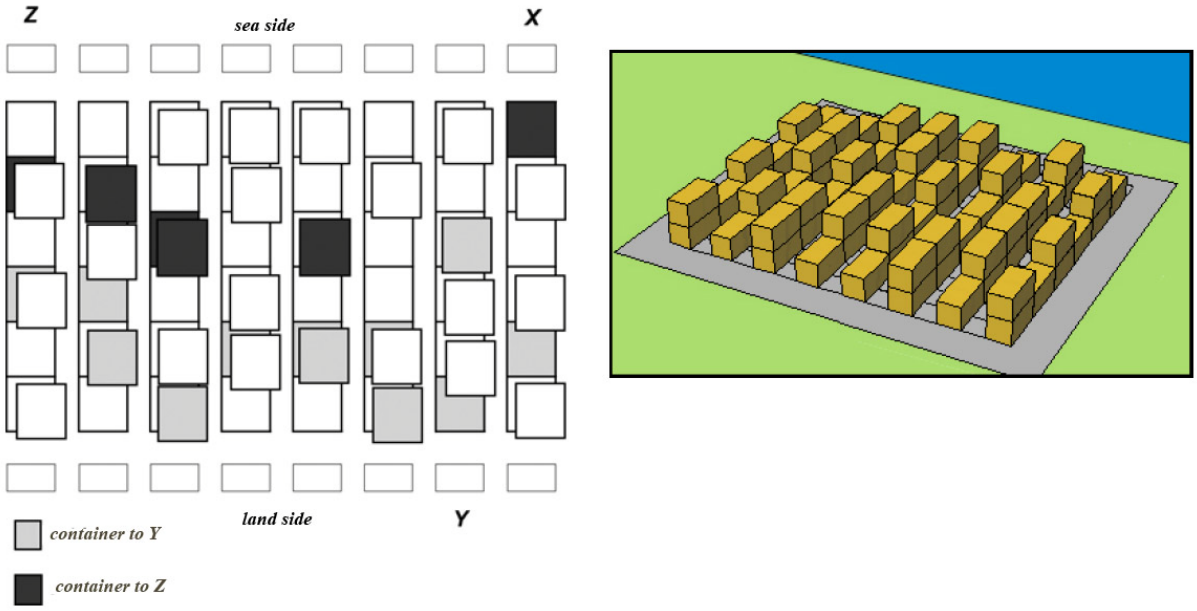


Figure 4: stack with containers and 3D representation

Ships moor to unload or load (at *X* and *Z*), this is done using the two quay cranes. These cranes can handle one container at a time. Trucks arrive to load or unload at *Y*.

A ship arrived at *X* carrying a hundred containers. The following things have to be done:

- Twelve containers have to be unloaded from the ship at *X* and be stored: two near the sea side and ten near the land side. The place these are stored, has not been specified, it's still to be determined.

- Twelve containers that are already stored on the landside have to be transported with trucks at *Y*. These are the green containers in figure 4.
- Six containers on the sea side of the stack must be retrieved and transported to a ship at *Z*. These are the blue containers in figure 4.

The quay cranes can only place the containers in one spot near the ship. These places have been marked with *X* and *Z*. To let the unloading of the ship at *X* go on continuously, every container must be removed from there immediately. This is done by the straddle carriers.
It is also important that the loading of the ship at *Z* goes on continuously. And off course, the truck drivers can't wait too long.
In this situation you will need more than one straddle carrier. Using more straddle carriers allows planning the transshipment in such a way that the unloading by the quay cranes can go on continuously. However, there are costs involved with using the straddle carriers.

Assignment 2

Investigate how many straddle carriers you will need in the situation described here to perform the transshipment as efficiently as possible. Draw up routes for the straddle carriers to be used and calculate how much time and money the whole transshipment process will cost.
Read below to find out how to get the data you need!
HINT: as long as you don't have the data you can still start designing your plans.

The consultancy agency
To be able to calculate the assignment above, you will of course need information, which you can get from the consultancy agency that will be present on Friday, in the following way.
- Make a list of the data you want. These data can be numerical data (eg a distance, a time), or the answer to a yes or no question.
- The maximum amount of data is ten.
- Hand in the list on Friday before 5.30 pm to Aldine or Iris. All teams will get the required data at the same time, before 7.30 pm
- Friday night between 20.00 and 21.30 the consultancy agency is open and one of the members of your team will have five minutes (at a previously announced time) to ask questions.

finally...

As discussed in the introduction, the transshipment of containers is only a small part of the complete logistic chain of transporting containers from the suppliers to the customers. Optimising the routes for the straddle carriers that carry out the storage and retrieval orders, contributes to creating a more efficient transshipment process in the terminal: this saves time and money. Using mathematical models and calculations allows the optimisation of more processes in the terminal. Furthermore an optimisation in the logistic chain is certain to have a large impact, and may result in savings that are of great importance, certainly in these times of economic crisis.

Final assignment

In the appendix you will find a schematic of the situation within the container terminal. Give a brief description for each of the numbered spots in the schematic to indicate the possibilities you see for optimisation. Each time, answer for example the following questions:
What processes within the container terminal itself can you optimise more? How would you do it? What mathematics, what calculations are needed? What are the effects upon the entire chain?

Presentation

Over the weekend you will be handed a question. You must formulate an answer to this question in exactly *two* minutes. Some practice will be required! Every question will be given to two teams. The questions are formulated to give the audience at the presentation a good understanding of the assignment.

Colofon

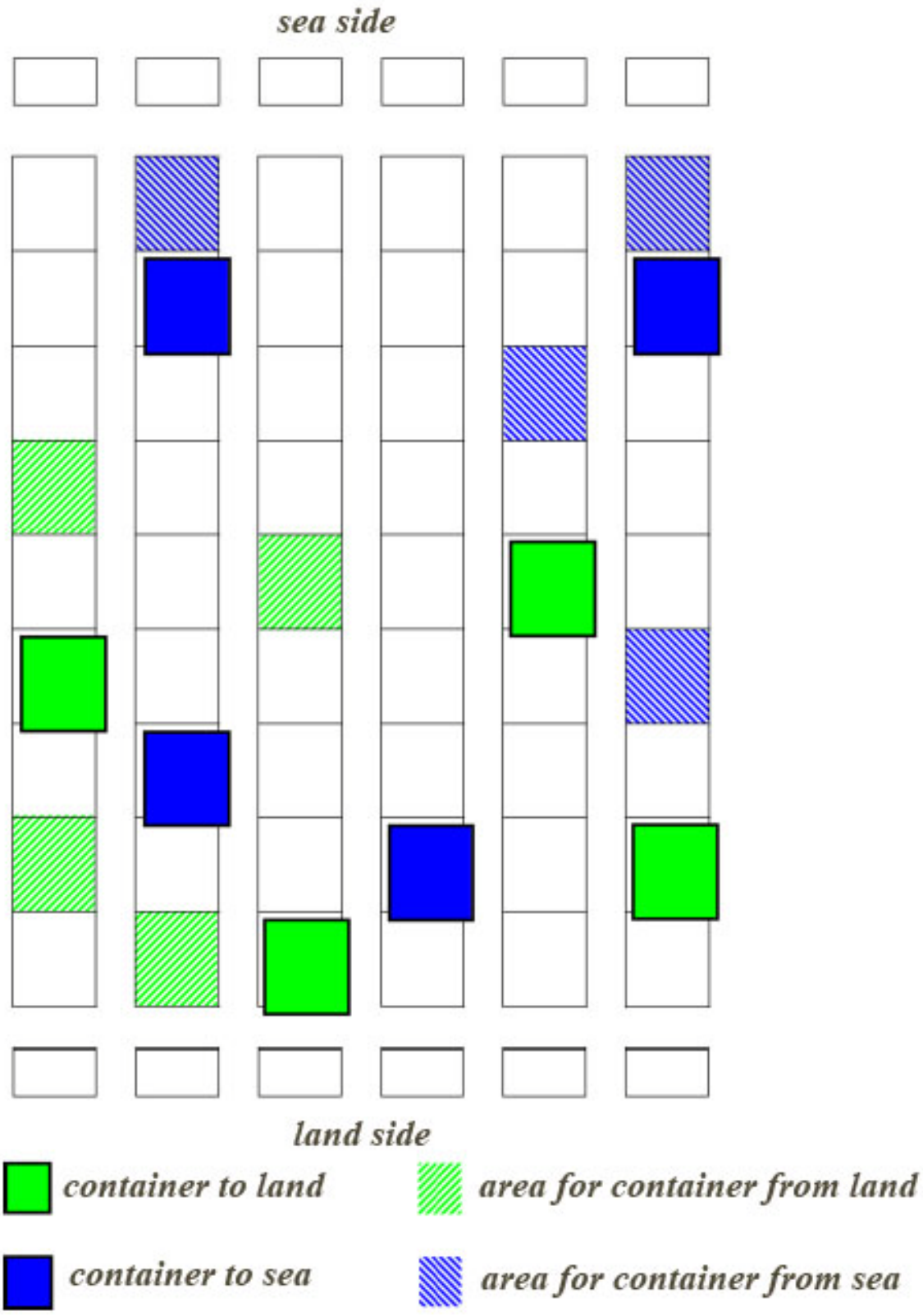
Alympiade commitee:
Tom Goris, Dédé de Haan, Aldine van der Ham - Aaten, Willem Hoekstra, Matthias Lippert, Johan van de Leur, Ruud Stolwijk, Iris Vis en Monica Wijers.

Thanks to Dr Iris F A Vis, Associate Professor of Logistics at the VU University Amsterdam, Faculty of Economics and Business Administration. Assignment 1 is based on: Vis, I.F.A. and Roodbergen, K.J. (2009), Scheduling of container storage and retrieval, *Operations Research*, forthcoming. See http://www.irisvis.nl/container/

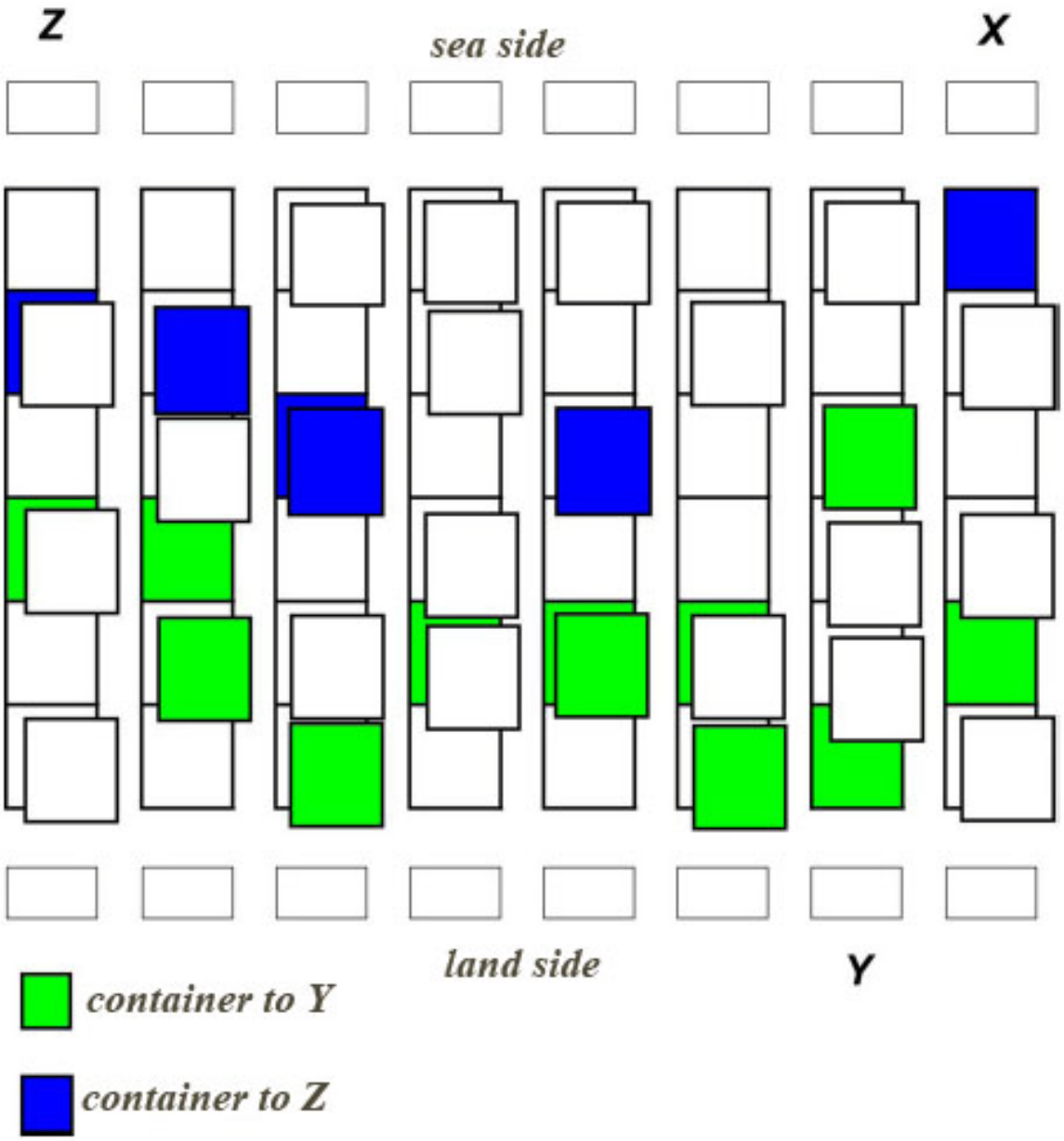
Photographs and illustrations: Tom Goris (cover, figure 3, 4, 5), Ceres Paragon terminals, Amsterdam (figuur 1), www.usatoday.net (figure 2), Iris Vis (appendix 3)

Translation out of Dutch: Nathalie Kuijpers

Appendix 1


sea side
land side
container to land
area for container from land
container to sea
area for container from sea

Appendix 2



Appendix 3: Schematic view of all logistic processes within a container terminal