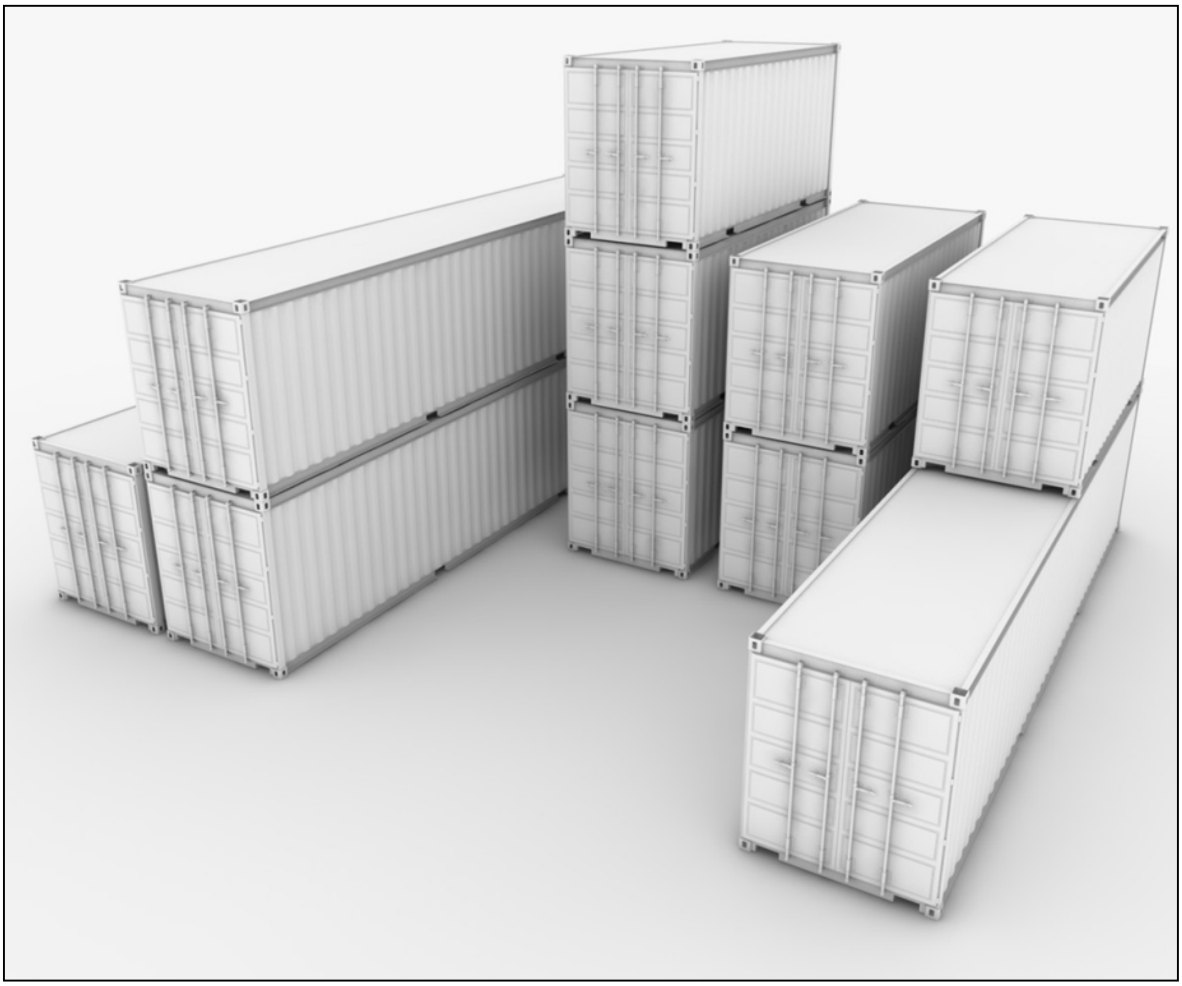
# Stowage Coordination



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At a very basic level, stowage coordination is the practice of determining, where on a vessel, containers should be loaded to allow for the optimal load and discharge of that vessel. It should take into account considerations for the ports in the rotation, the number of ports in the rotation, the correct segregation of the cargo, the number of cranes required and the overall vessel stability. Of course, the reality of stowage coordination is much more complex than this implies.

Stowage is a giant puzzle that needs to be solved. The difference between stowage and an actual puzzle is that there is no one single end result to stowage. There are numerous combinations that can be applied to solve the puzzle and none of them can be described as truly correct or incorrect. Every scenario will have positive and negative aspects to it, often depending on what the stowage coordinator is trying to achieve with this particular stow. The other aspect is that this is a never ending puzzle in that it does not even really have an end result, just steps along the way. Very rarely do container ships completely discharge and then re-load. Container ships usually operate in a never ending loop of port calls. At every port, some containers will be discharged, some more will be loaded. The puzzle has many different solutions but rarely does it have an end goal.

Due to the dynamic nature of container shipping operations, there is no 'one size fits all' solution to stowage. Every service, often every port and/or vessel, will have differing requirements and restrictions that affect the stowage. What works well for one particular stow may not work at all for another. What makes stowage coordination particularly challenging to teach is that it is unusual to have one answer to any question. More often than not, the answer to a particular stowage question will be 'it depends'. Accurate, but unhelpful.

The best way to look at stowage is to break it down into its individual components. There are quite clear rules for each specific aspect of stowage, such as hazardous cargo segregation, and it is then up to the stowage coordinator to look at the stowage he or she is currently trying to solve and then apply the solutions that work this time. It's rather like a 'stowage toolbox'. Not every tool will fit every problem but there is a solution to everything. Ultimately, if nothing in the toolbox will work then restowing containers will solve everything. It's not an elegant solution and it comes at a cost but it is always there as a backup.

What should be remembered about stowage is that virtually every decision that the stowage coordinator makes comes down to a trade off or compromise. If I make 'this' decision, what effect will 'that' have elsewhere? Often, a good stowage is about coming up with the solution that has the least negative effect on something else.

What makes stowage even more complex is that the coordinator is often having to work with a combination of actual information, forecast information and experience. This is the main reason that stowage is still quite a manual 'thought based' process. Container shipping is simply too dynamic to have 100% (or even close to) accurate forecasts which means that the even the best automated stowage system in the world is currently still no match for the human brain.

While these notes do not aim to cover every topic in stowage, they do aim to cover some of the least explained topics. There are some very good books available that explain ship stability, ship construction and hazardous cargo stowage, plus the IMDG code so I will not go into those in much detail, but there is very little available about how stowage works, crane intensity and how stowage interacts with terminal operations. That is what I will focus on in these notes.

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There are many different sizes and types of containers in the world today. The two most basic and common are the 20 foot and 40 foot. One 20ft until equals 1 TEU (Twenty Foot Equivalent Unit) and one 40ft until equals 2 TEU. This is important to know as vessels sizes are described based on the maximum number of TEU they can carry.

The standard height for containers is 8’6” but there are variations called 40ft High Cubes that are 9’6” high. The standard width for containers is 8’0”. 45 foot containers are always 9’6” high (diagram bottom left). Overleaf is a list of the new ISO codes in use and the different types of containers.


As container shipping evolved, containers began to be developed for specific cargos or trades. Thus the standard 20 and 40ft units are just the tip of the iceberg when it comes to container types.

This wider range of container types also allowed shipping lines to charge additional premiums based on the container used. For example, a refrigerated (Reefer) container is much more profitable than a container holding only dry cargo.

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## New ISO Codes

**Container ISO-Codes**

| New ISO | L x W x H in feet | Feet mark | * | Description of container | Old ISO |
|---|---|---|---|---|---|
| 20G0 | 20 x 8 x 8 | 20' | - | general container | 2000 |
| 20G1 | 20 x 8 x 8 | 20' | - | general container with ventilation holes | 2010 |
| 20H1 | 20 x 8 x 8 | 20' | - | port hole reefer container | 2040 |
| 20T0 | 20 x 8 x 8 | 20' | - | tank container | 2070 |
| 22G0 | 20 x 8 x 8,5 | 20' | 20'GC | general container | 2200 |
| 22G1 | 20 x 8 x 8,5 | 20' | - | general container with ventilation holes | 2210 |
| 22V0 | 20 x 8 x 8,5 | 20' | - | highly ventilated container | 2213 |
| 22RO | 20 x 8 x 8,5 | 20' | 20'RF | integral reefer container | 2230 |
| 22R1 | 20 x 8 x 8,5 | 20' | - | integral reefer/heated container | 2232 |
| 22H2 | 20 x 8 x 8,5 | 20' | - | thermal insulated external container | 2242 |
| 22U0 | 20 x 8 x 8,5 | 20' | 20'OT | open top container | 2250 |
| 22U1 | 20 x 8 x 8,5 | 20' | 20'OT | open top container - removable top | 2251 |
| 22P1 | 20 x 8 x 8,5 | 20' | 20'FLAT | flat rack with fixed ends | 2261 |
| 22P2 | 20 x 8 x 8,5 | 20' | - | flat with fixed corner posts only | 2262 |
| 22P3 | 20 x 8 x 8,5 | 20' | - | flat with collapsible ends | 2263 |
| 22P5 | 20 x 8 x 8,5 | 20' | - | open sided container | 2265 |
| 22T0 | 20 x 8 x 8,5 | 20' | 20'TC | tank container - non dangerous liquid | 2270 |
| 22T5 | 20 x 8 x 8,5 | 20' | 20'TC | tank container | 2275 |
| 22B0 | 20 x 8 x 8,5 | 20' | 20'BULK | dry bulk container | 2280 |
| 25G0 | 20 x 8 x 9,5 | 20' | 20'HC | general high cube container (9,6) | 2500 |
| 25R1 | 20 x 8 x 9,5 | 20' | 20'HCRF | integral high cube reefer container (9,6) | 2532 |
| 28U1 | 20 x 8 x 4 | 20' | - | half height open top container | 2650 |
| 26T0 | 20 x 8 x 4 | 20' | - | half height tank container | 2670 |
| 28P0 | 20 x 8 x 4 | 20' | - | platform flat | 2960 |
| 42G0 | 40 x 8 x 8,5 | 40' | 40'GC | general container | 4300 |
| 42G1 | 40 x 8 x 8,5 | 40' | - | general container with ventilation holes | 4310 |
| 42V0 | 40 x 8 x 8,5 | 40' | - | highly ventilated container | 4313 |
| 42RO | 40 x 8 x 8,5 | 40' | 40'RF | integral reefer container | 4330 |
| 42U1 | 40 x 8 x 8,5 | 40' | 40'OT | open top container | 4350 |
| 42U1 | 40 x 8 x 8,5 | 40' | 40'OT | open top container with removable top parts | 4351 |
| 42P1 | 40 x 8 x 8,5 | 40' | 40'FLAT | flat rack with fixed ends | 4361 |
| 42P2 | 40 x 8 x 8,5 | 40' | - | flat with corners posts only | 4362 |
| 42P3 | 40 x 8 x 8,5 | 40' | - | flat with collapsible ends | 4363 |
| 42P5 | 40 x 8 x 8,5 | 40' | - | open sided container | 4365 |
| 42B0 | 40 x 8 x 8,5 | 40' | 40'BULK | dry bulk container | 4380 |
| 45G0 | 40 x 8 x 9,5 | 40' | 40'HC | general container high cube (9,6) | 4500 |
| 45R1 | 40 x 8 x 9,5 | 40' | 40'HCRF | integral reefer container high cube (9,6) | 4532 |
| 48U1 | 40 x 8 x 4 | 40' | - | half height open top container | 4650 |
| 48P0 | 40 x 8 x 2 | 40' | - | platform flat | 4960 |

* Most frequented written slang mark

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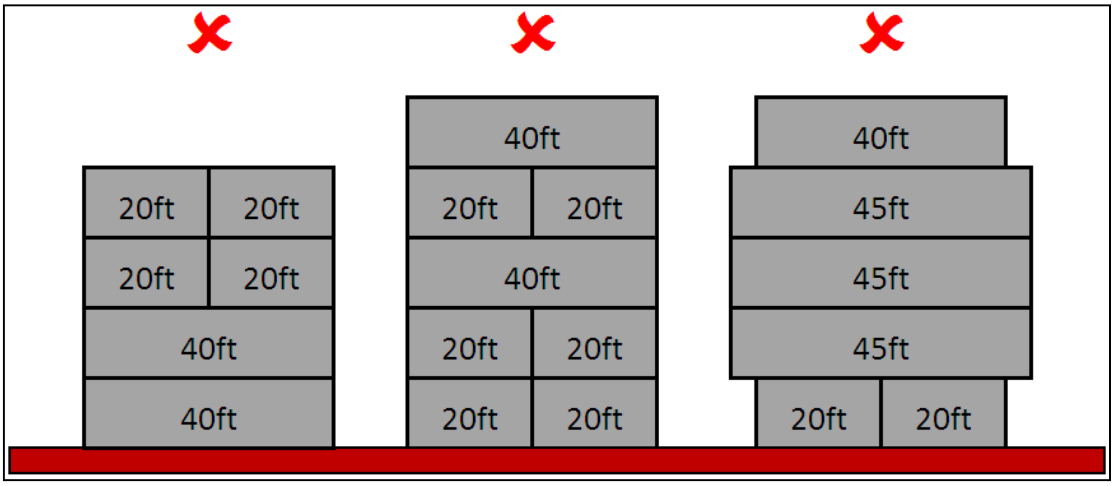
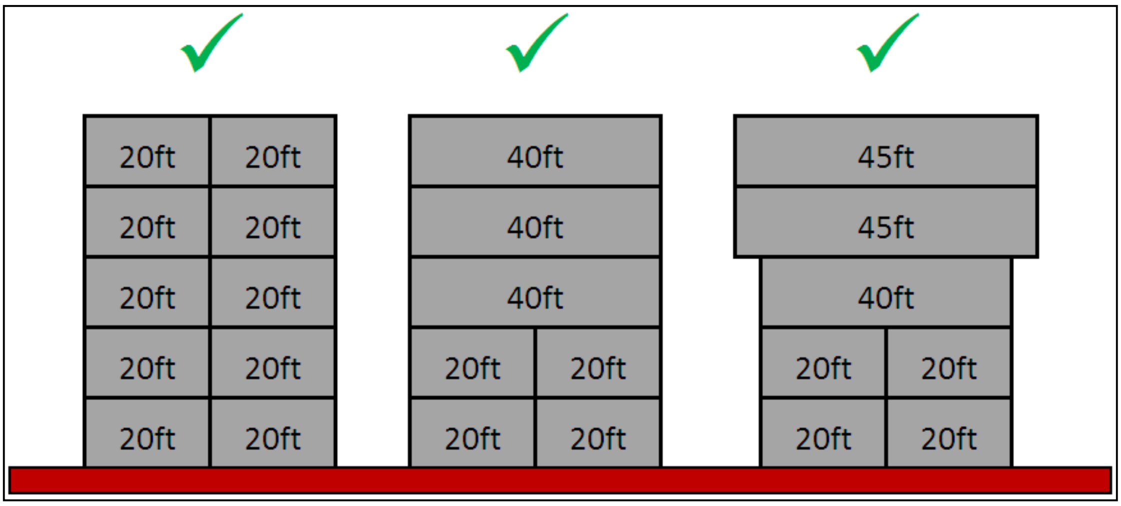
Containers have to be loaded onboard a vessel in a specific sequence in order to maintain their structural integrity. Below are examples of how containers cannot be loaded without risk of the stacks on deck collapsing.




The correct manner of on deck stowage is shown in this diagram. Containers maintain their structural integrity through the corner posts. There is very little strength in the walls or roof of the containers.

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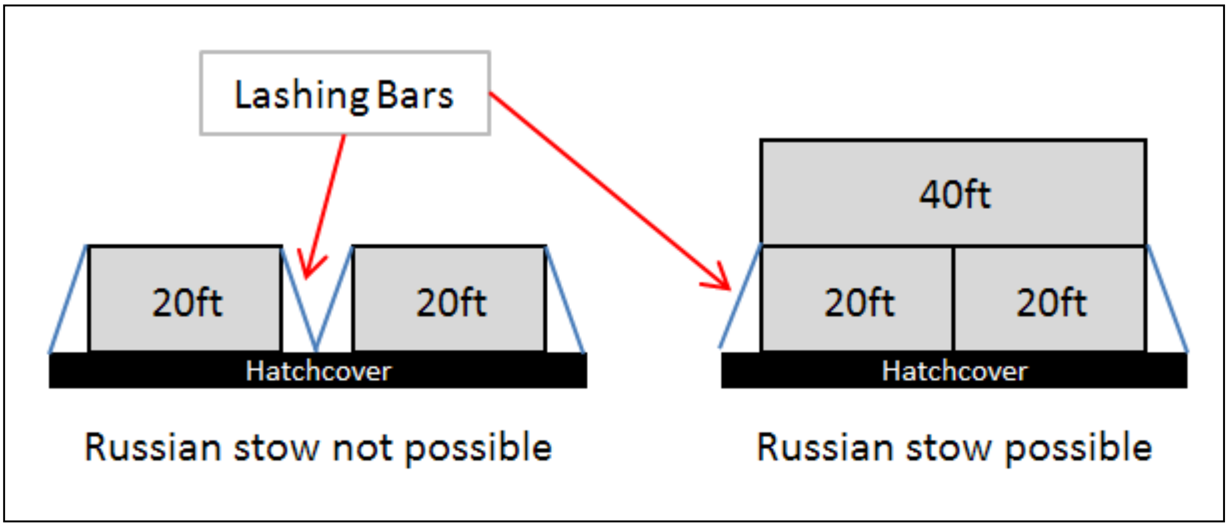
The pattern of container stowage on deck also depends on the construction of the hatch cover. Some vessels have the ability to stow 40ft units on top of 20ft units on deck, this is known as Russian Stowage. Other vessels cannot do this. In the latter case, it is important for the stowage coordinator to stow as many of the 20ft units underdeck as possible, otherwise this will start to reduce the possible cargo intake of the vessel since 20ft units can be stowed much higher underdeck than they can on deck.




**<u>Other Container Examples</u>**

20ft Dry

40ft Dry

40ft High Cube

45ft Dry

20ft Reefer

40ft Reefer

45ft Reefer

40ft Open Top

20ft Open Top


20ft Flat Rack


40ft Flat Rack

20ft Tank

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## Reefer Containers

Refrigerated containers (Reefers) container cargo that has to be maintained at a specific, and constant, temperature (often foodstuffs). The container itself is fitted with its own motor that maintains the containers internal temperature.


These motors have to be connected to the vessels power supply in order to run. Each vessel will have a number of reefer dedicated bays that are fitted with power connections. Not every slot onboard will have this power connection so each vessel has a limit as to how many reefers can be loaded.

Reefer containers have a very high profit margin for the shipping line so it is very important for the stowage coordinator to be able to stow as many of these units onboard as is practical. On some trades (such as from South America) it is the reefers that drive the trade and thus the stowage. Often, the carriage of reefer containers is a seasonal thing as it is dictated by the various fruit growing seasons.

Due to the fact that the containers are connected to a power supply, the reefer motor is considered an "ignition source" and this must be taken into account when loading Hazardous Containers in close proximity. (See Hazardous Cargo notes).

## Out of Gauge Containers

Another profitable commodity for a shipping line is Out of Gauge cargo. This is, very simply, cargo that will fit onto an ISO container base, but its dimensions are such that it is over height, over width or over length. There are special types of containers designed to load this kind of cargo such as Open Tops, Flat-Racks and Platforms. Below are examples of this type of cargo.

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## BreakBulk Cargo

BreakBulk cargo is very similar to OOG cargo. The only difference is that it is too large to fit onto a single ISO type container. Again, this is quite profitable but has its own challenges from a stowage perspective. Depending on the weight and size of the piece it may or may not be loaded using the terminal crane or it may be loaded and discharged using a floating crane.

Examples of BBLK cargo being loaded.

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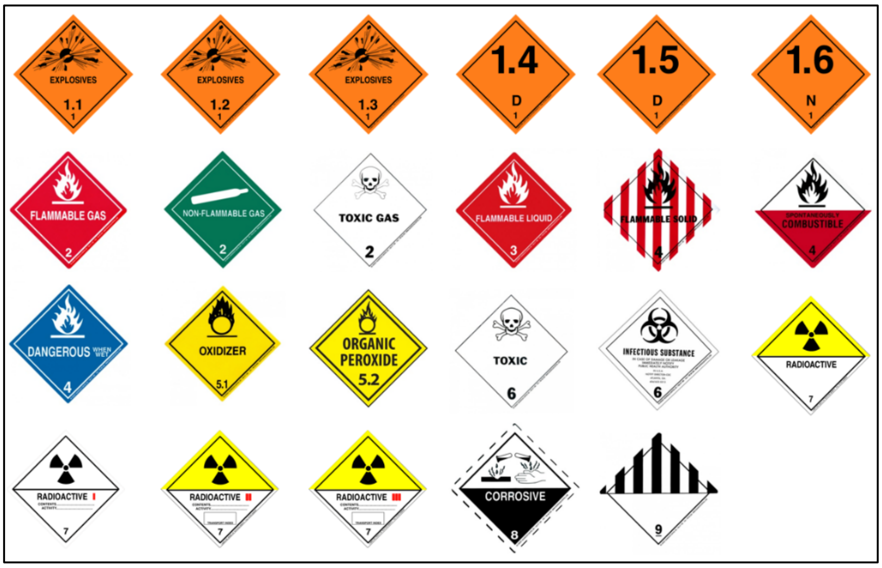
## Hazardous Containers

Hazardous containers are not limited to specific types of containers.

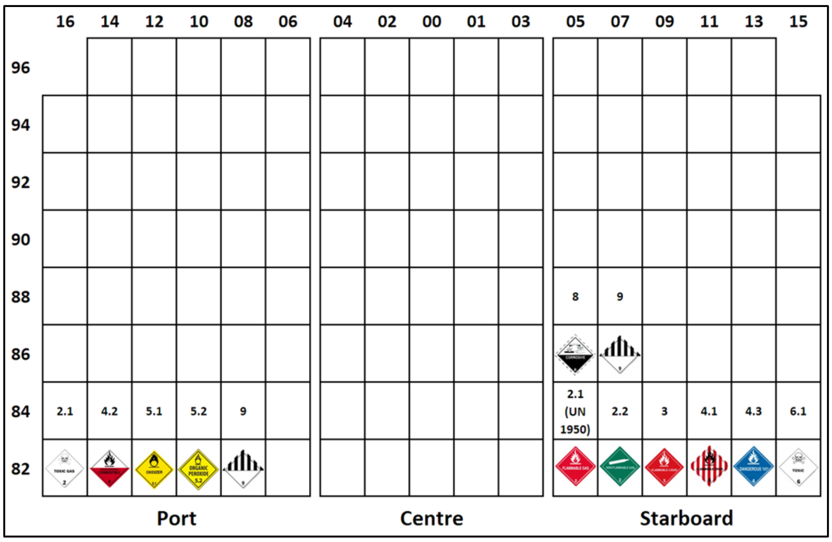



All hazardous cargo is covered by the IMDG code in terms of what can be loaded into containers, what Class it is (see left) and the UN Number for each individual commodity. The Storck guide also covers the segregation requirements needed onboard the vessel to ensure that commodities that are not compatible do not get loaded without the required separation.

There are some general guidelines for the stowage of hazardous containers from the shipping lines perspective:

- No hazardous cargo to be stowed in Bay 01 and 02
- No hazardous cargo to be stowed above the breakwater in bay 03
- No hazardous cargo to be stowed in the outermost row on deck in any bay, except fumigated units
- No hazardous cargo to be stowed in stacks outside the hatchcover which are liable to be damaged from seawater from below
- No hazardous cargo to be stowed in first tier positions that rest on two different hatchcovers
- Hazardous cargo may be loaded underdeck as per the vessels Document of Compliance and company in-house rules

From a more general perspective, when possible, the hazardous containers can be stowed on the port and starboard side of the vessel (as depicted). Doing this in each bay with hazardous cargo will minimize the amount of segregation problems when the vessel is being stowed.

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# Stowage Considerations

A stowage for a single port cannot be viewed in isolation. An individual SI is just a snapshot of a vessel at a particular point in time and does not give any context to the evolution of the stowage. Each stowage has an impact, either positive or negative, on future ports in the rotation and is, itself, a product of decisions take earlier in the port rotation. Increasing the CI in one port can result in a reduction of CI in a later port. It doesn't make sense to increase CI unless we can be confident that the cranes are actually available to us. It does not give any indication of the reasons and constraints in earlier ports that led to the way the vessel currently looks.

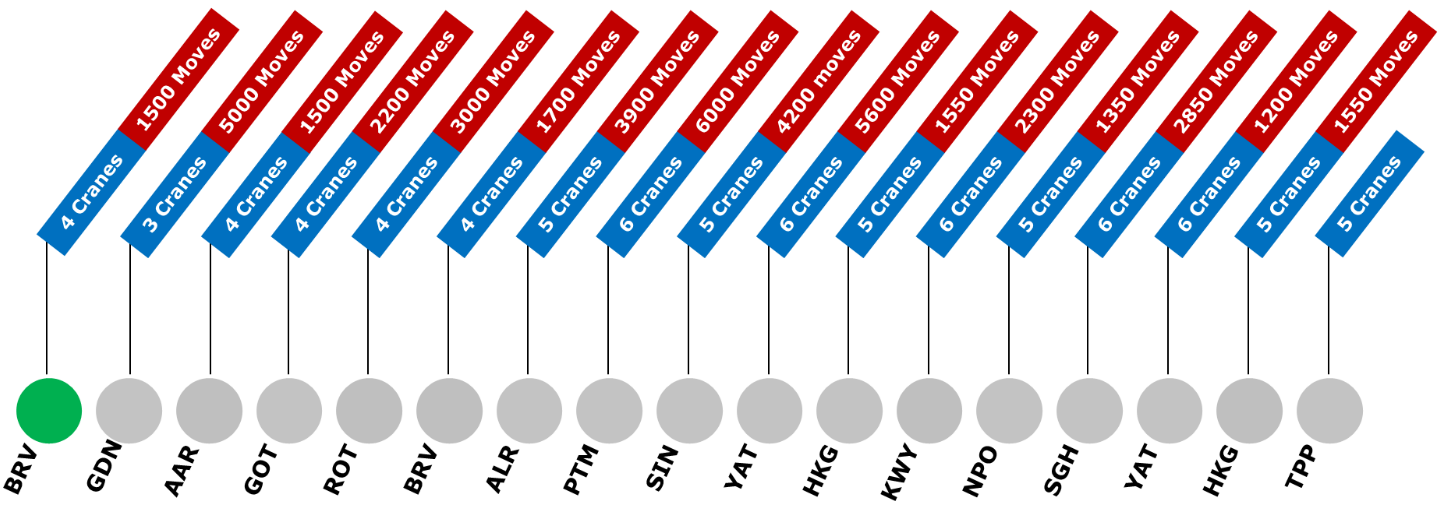
**Commercial Requirements (Examples):**

The need to evacuate MTY's to Asia, reefer cargo loadings, IMO, OOG and BBLK are all likely to have an effect on stowage. Keeping the reefer positions open, without restows can result in a deliberate reduction of CI in an earlier or later port. The same can apply to IMO and OOG. BBLK is pre-planned onto the vessel long before the actual load port CI is sent. The commercial need to reserve this space will inevitably reduce the coordinators options in the earlier ports.

Full units cannot be stowed on top of MTY units for safety reasons. When MTY's are loaded early in the port rotation, or in insufficient quantities to completely fill entire bays, they will need to be loaded into positions onboard where they may have to be restowed later on. From a commercial point of view it is better to load the MTY's and perform the restows than not evacuate the MTY's at all.

Contingencies are another reality of the operational environment in which we work. Europe in the winter sees port closures and delays, Asia during typhoon season has similar effects. Lack of MTY's in a particular port or region can lead to inducement calls to ports not originally in the schedule. Ultimately, all of these scenarios (plus many others) lead to additional restows and non-optimal stowage solutions. None of this is down to the coordinator's ability but is merely the result of unforeseen circumstances.

Stowage can basically be viewed at three different levels. Firstly, the service that the vessel is currently operating in. This is very high level view and only looks at the number of ports in the service, the number of cranes required in each port and the estimated movecount for each port. This is essentially a high level template for the service.

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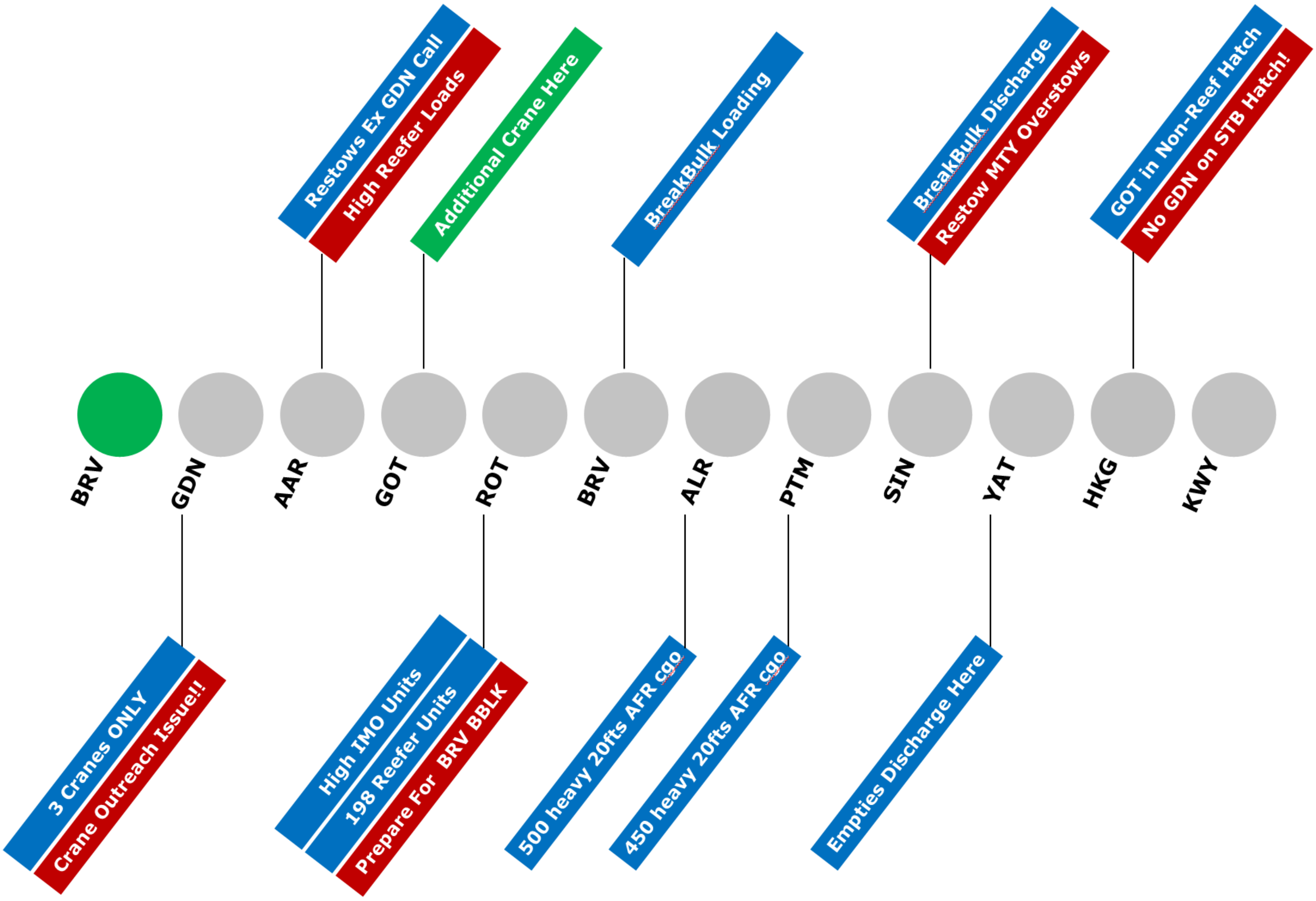
# Stowage Considerations

The second level the coordinator is considering covers the next few ports in the rotation from the one he is currently stowing. As well as the cranes and the movecounts, this is where there is more concrete information available about what is coming up in the next few ports. In reality, the coordinator is never just planning the port the vessel is about to arrive at, they are planning for all the future ports as well. At this level there will be more accurate forecast data regarding the overall cargo for the current region. There may also be more specific information such as high number of hazardous cargo out of some of the ports, pieces of breakbulk that are coming (which the vessel will need to be prepared for and reefer information.




Although the forecast information available is never 100% accurate, it can be used as a guide for how to stow the upcoming ports. A planner should always be careful not to take forecasts as completely accurate as this will potentially lead them to close off options that may be needed later.

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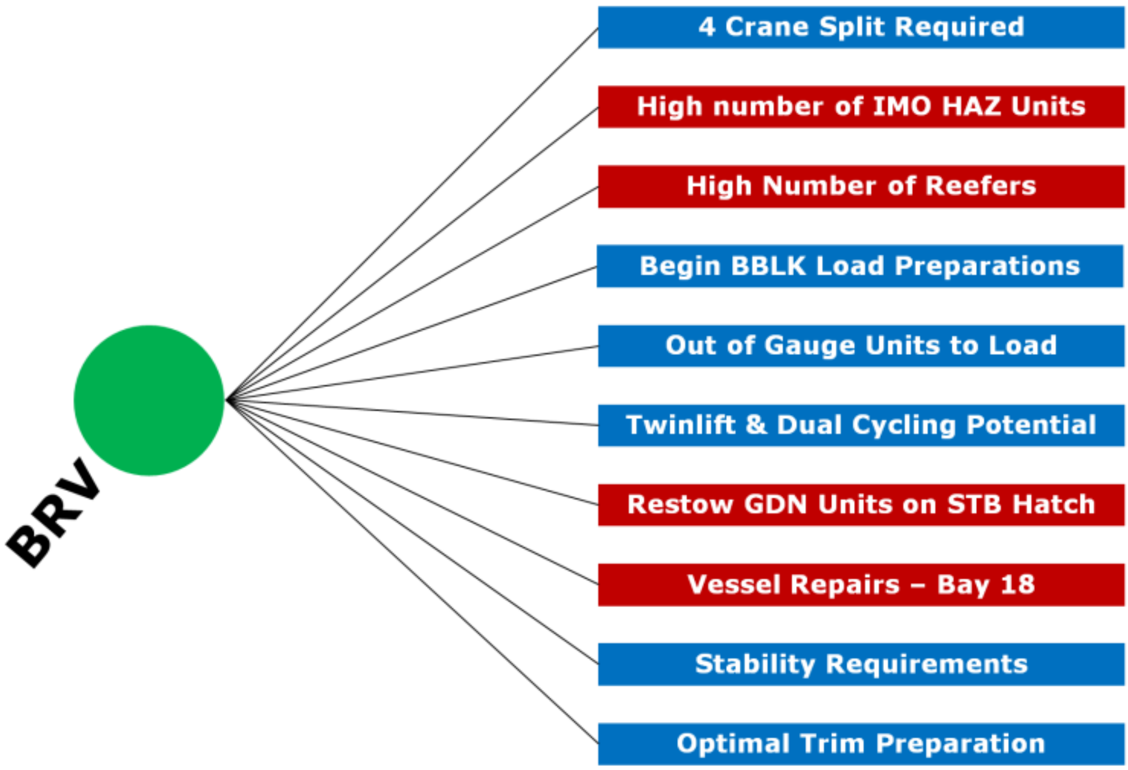
# Stowage Considerations

Finally, we get down to the level where we are looking at the current stowage. This is made up of the loadlist for the port and information from the ship regarding the stability condition. This is now where he is paying close attention to the specific cargo mix and the port requirements and restrictions




Stowage is very detailed work at this point and where the planner is stowing individual containers onto the vessel and ensuring that all the current port and vessel restrictions and requirements are being met. These are a combination of commercial plus operational considerations and ensuring that the stowage sent meets all legal requirements. These include (but not limited to) the stowage of hazardous containers and the overall stability of the vessel. The above is just an example of some of the considerations the planner may be working with.

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# Stowage Considerations

If we look at a much more detailed view of what a planner can potentially be looking at when doing the stowage it will contain some of the below items. Some services will have more considerations to be taken into account than others.

What makes one stowage more complicated than another usually has less to do with the size of the ship (and thus the high volume of containers) and more to do with the percentages of special cargo. One stow cannot be compared directly to another.

For example, an 18,000 TEU vessel on an Asia to Europe trade will have very high volumes but very low percentages of special cargo. A 2,000 TEU vessel running from West Africa to Europe will have a much higher percentage of special cargo plus there will be many more restrictions in the West Africa Ports than encountered in Europe or Asia. Therefore, the difficulty of any individual stowage is comprised of many different factors.

| General | Terminal | Vessel | Cargo | Cargo Cont'd | Stability |
|---|---|---|---|---|---|
| • Crane Intensity<br>• Restows<br>• Restow costs per port<br>• Overstows<br>• Port of loading<br>• Port(s) of discharge<br>• Change of destinations<br>• Reefer allocation | • Crane height limits<br>• Crane reach ability<br>• Crane lift capacities<br>• Twin lift capability<br>• Dual cycling ability<br>• Tandem hoisting<br>• Dual hoist capability<br>• Gantrying of cranes<br>• Crane repairs<br>• Crane breakdowns<br>• Boom up/down over accommodation<br>• Crane productities (Single, TL, DC etc)<br>• Manhattan Towers<br>• Low move bays<br>• Hatchcover moves | • Russian stowage<br>• Reefer bays<br>• Document of compliance<br>• Vessel restrictions (temp. or permanent)<br>• Vessel repairs<br>• Stack weight limits<br>• Stack height limits<br>• Onboard cranes<br>• Bottom space availability | **IMO -**<br>• 9 UN Classes<br>• 3468 UN Numbers<br><br>• Class 1 – Explosives<br>• Class 2 – Gases (2.1 flammable, 2.2 non-flammable, non-toxic, 2.3 toxic)<br>• Class 3 – Flammable Liquids<br>• Class 4 – Flammable Solids (4.1, 4.2, 4.3)<br>• Class 5 – Oxidizing substances and organic peroxides<br>• Class 6 – Toxic and infectious substances<br>• Class 7 – Radioactive substances<br>• Class 8 – Corrosive substances<br>• Class 9 – Miscellaneous substances<br>• Specific segregation requirements<br>• Maersk Line in-house rules | **OOG –**<br>• Over height<br>• Over width<br>• Over length<br>• Weight<br>• Lifting requirements<br>• Protection required<br>• Stowage restrictions<br><br>**BBLK –**<br>• Vessel restrictions<br>• Gantry or floating crane<br>• Size and weight restrictions<br>• POL and POD restrictions<br>• Floating crane costs<br>• Impact on cranesplit<br>• BBLK should never be restowed<br>• BBLK should never be on top of live reefers | • GM (vessel stability)<br>• Shear Force<br>• Torsion<br>• Bending Moment<br>• Visibility rules<br>• Line of Sight<br>• Windstacks<br>• Lashing forces |

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# Stowage Considerations

Despite the fact that one stow cannot be directly co mpared to another, there are some over-riding factors that have to be taken into account for every stowage, no matter how large or small the vessel is.

If the safety aspects cannot be satisfactorily met, then it doesn't matter how good the stowage is, it will need to be adjusted.

**Safety**

- **Vessel Stability**
  – GM, Torsion, Bending Moments, Shear Force
- **Cargo**
  – lashing forces, windstacks, stackweights
- **Special cargo stowage**
  – safely stowed, accessible by ships staff (IMO, Reefer, BBLK, OOG)
- **Ballast and draft considerations**
  - seaworthy sailing condition, within port draft limits, air draft considerations

**Flexibility**

- **CraneSplit**
  - in current and future ports
- **Ports**
  – requirements and restrictions
- **Service**
  – requirements and restrictions
- **Vessel**
  – requirements and restrictions

**Productivity**

- **Terminal**
  – restrictions, requirements and capabilities
- **Learning's**
  - from Terminal Partnering Project
- **Reductions**
  - in restows, low moves bays, hatch cover moves
- **Increase**
  - in CraneSplit, Twinlifting and Dual Cycling

Whenever a stowage is being created, the planner is keeping an eye on both operational and commercial concerns. If the vessel cannot be filled because of wasted space or unnecessary restows, then the vessel will not be profitable. If the port stay is longer than anticipated, the vessel will have to burn additional fuel to reach the next port on schedule. All of this costs money in an industry where the profit margins are very small to begin with.

On the Asia Europe trades, virtually no company makes money but it is a vital link for serving the much more profitable North/South trades. Therefore, while it's difficult to make money between Asia and Europe, if the planner can keep the costs down then less money will be lost overall.

To aid the coordinator in remembering all the various restrictions and requirements, some companies employ the use of service checklists. Example overleaf.

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**Stowage is a non-linear process:**

"This is a function that has too many factors to be computed using linear mathematics. This is the reason why we as humans consider ourselves so extraordinary, the ability to solve non-linear problems. A non-linear problem is a problem that is so abstract that it cannot easily be solved by a computer, for example stowage problems, there are simply too many factors for a computer to process."

Stowage is complex problem that is little understood outside the world of stowage coordinators. Utilization, terminal productivity and stowage quality are mainly affected by three main areas:

**1) Forecast Quality**
**2) Port Rotation**
**3) Coordinator Ability**

**1) Forecast Quality**

The accuracy of our forecasts is not up to the level that is required for creating an optimal stowage, both coordinators and automated systems (such as SHOP - Stowage Handling Optimization Program) are adversely affected by this. Every stow requires numerous decisions to be taken that will have an effect, either positive or negative, on later ports and the overall utilization of a vessel. If, for example, the forecast quality were to be 95% accurate then more correct decisions could be made. When the forecast quality is sub-optimal, decisions have to be taken that may prove to be incorrect but a coordinator (or system) has no way of knowing this at the time. Accurate forecasting would give the planner the ability to pre-plan the ports ahead in the rotation to a much greater level of accuracy than is currently possible. If we know what is coming, we can plan for it. When we do not have a clear picture of the road ahead, the result is having to keep as many options open as is possible and this can lead to an overall deterioration in the perceived stowage quality. Essentially, the stowage coordinator has to plan for a series of "what-if" scenarios because we cannot rely totally on a forecast.

**2) Port Rotation**

The complexities of a network drives the complexities of the stowages to a large degree. When the port rotation is increased above 3 or 4 ports per region, the number of possible stowage outcomes increases exponentially. This dramatically increases the opportunities for incorrect decisions to be made. The fewer the ports in a rotation, the more consolidated the cargo will become for each port. With the same volume of containers to be dealt and a smaller number of stowages, it becomes possible to utilize a vessel better with fewer restows. Essentially, the more ports we have to deal with, the greater the chance there is for something to go wrong.

**3) Coordinator Ability**

Without a doubt, the experience, background and training of coordinators has an impact on stowage quality and vessel utilization but this cannot be viewed in isolation. The way vessels are utilized and the effects of the stowages on port productivity can be traced back to the two other areas discussed, Forecast Quality and Port Rotation. Increasing the level of stowage coordinator

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training alone will not solve the challenges that a stowage department faces.

## Stowage Quality

This is a difficult area to define because a lot of what makes a stowage good depends on what the requirements are at the time. There is no generic definition of a good stowage.

What was the coordinator trying to achieve with this stowage? What were the primary operational and commercial requirements at the time? Was it crane split, reefers, BBLK, IMO, OOG, reduced ballast, optimal trim etc?

What would be the definition of a good stowage on one particular vessel in a port on a service would not necessarily make a good stow on a different vessel but on the same service and port next week. The requirements and containers to be loaded and discharged change from stowage to stowage.

Virtually everything in stowage is a trade-off. Because we have long port rotations, we have a loss of flexibility. To compensate for this and to provide higher crane intensities, we have to divide the vessel into more sections. By doing this there is a loss of crane and terminal productivity. We could, for example, reduce crane intensities to gain higher terminal productivities through more consolidation of the cargo. But if we did that then we would be unable to deliver the number of cranes required for the full voyage. Some ports would have to deploy fewer cranes which would result in a decrease in schedule reliability and higher fuel costs.

Stowage Coordinators have to continually work to balance the commercial and operational requirements of the organization and they are not always going to be compatible with one another.

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# Example Service Checklist

| Service Data | SVC NAME XXX | | | | | | | | | | | | | | | | SVC Manager ID |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Port Rotation | Port 1 | Port 2 | Port 3 | Port 4 | Port 5 | Port 6 | Port 7 | Port 8 | OCEAN LEG | Port 10 | Port 11 | Port 12 | Port 13 | Port 14 | Port 15 | Port 16 | |
| Proforma Moves | 1200 | 2000 | 1850 | 2500 | 4500 | 1200 | 2000 | 3500 | | 2000 | 1850 | 2500 | 4500 | 1200 | 2500 | 3400 | |
| Proforma Port Stay (Hrs) | 12 | 18 | 17 | 24 | 18 | 10 | 18 | 32 | | 15 | 18 | 20 | 32 | 10 | 18 | 28 | |
| Proforma Crane Intensity | 5 | 6 | 5 | 4 | 7 | 4 | 5 | 6 | | 5 | 6 | 5 | 5 | 7 | 5 | 6 | |
| Proforma BMPH | 100 | 111 | 109 | 104 | 250 | 120 | 111 | 109 | | 133 | 103 | 125 | 141 | 120 | 139 | 121 | |
| Berthing Side (P/S) | Port | Port | Port | Stbd | Port | Stbd | Port | Stbd | | Port | Port | Stbd | Stbd | Port | Port | Stbd | |
| Crane Outreach (Rows) | 23 | 23 | 23 | 24 | 23 | 24 | 23 | 23 | | 24 | 23 | 23 | 23 | 23 | 23 | 23 | |
| Crane Separation (40/80) | 40 | 40 | 40 | 40 | 80 | 40 | 40 | 40 | | 40 | 40 | 80 | 40 | 40 | 40 | 40 | |
| Max Draft Alongside (m) | 14.1 | 14.5 | 15.1 | 14.9 | 14.1 | 14.5 | 15.1 | 14.9 | | 14.1 | 14.5 | 15.1 | 14.9 | 14.5 | 15.1 | 14.9 | |
| Max HC on Deck | 8 | 7 | 8 | 9 | 9 | 7 | 8 | 9 | | 9 | 8 | 8 | 7 | 6 | 8 | 9 | |
| Min Draft Alongside (m) | 13.5 | 13.4 | 12.1 | 13.5 | 13.4 | 12.1 | 13.4 | 13.5 | | 13.5 | 13.4 | 12.1 | 13.5 | 13.4 | 12.1 | 13.5 | |
| Water Density | 1.025 | 1.025 | 1.025 | 1.025 | 1.025 | 1.025 | 1.025 | 1.025 | | 1.025 | 1.025 | 1.025 | 1.025 | 1.025 | 1.025 | 1.025 | |
| Restow Cost (USD) | $90 | $120 | $110 | $100 | $250 | $125 | $100 | $250 | | $55 | $50 | $65 | $50 | $33 | $70 | $65 | |
| Stowage Remarks | Open | Open | Open | Open | Open | Open | Open | Open | | Open | Open | Open | Open | Open | Open | Open | |

**Free Text Under Stowage Remarks:**

High Reefer Load in this Port
IMO Heavy Port
No BBLK near accommodation
etc

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One of the main aspects of stowage coordination is to stow the current port with a view on the future and the need to keep as many options open as possible. Since the loadings in the future ports are always a forecast, and the accuracy of this forecast will vary from company to company, it cannot be assumed that what is predicted to happen will actually be what shows up in the final loadlist. Although the forecast is a guide, it doesn't make sense to "close doors", in a stowage sense, based on that.

There a number of general guidelines that can be applied to stowage that will help to keep as many future options open as possible as well as to solve a lot of the potential stowage and stability issues before they even occur.

Up/Down Stowage is one of the basic concepts of stowage. If we look at a single bay, and we assume that we are going to have to load more than one port of discharge in that bay (see CI), then there are a number of different ways that we can load the containers in that bay. We can take those containers and spread them out horizontally so that we have one port spread across the lower tiers of the bay with another port spread out horizontally on the higher tiers above that. Alternatively, we could take the same containers and stow them vertically. That is, the centre hatch, both below and above deck will contain only one port of discharge and the port and starboard wing hatches will only contain the other port of discharge. Which one is better? More importantly, why is it better?

Looking at the horizontal stowage to begin with, there are a few major down sides with this. If the on deck cargo is discharged in the first port but there is cargo for a port later in the rotation below deck, the on deck free space cannot be used in the current port. As a coordinator, we have closed a door on something that we may need later. Even if there is cargo that we are able to load on deck (such as for the same POD as is loaded below deck), there is no guarantee that it will be suitable for on deck stowage. It may be that the cargo has a higher average weight or there are predominantly more 20ft units. This can either cause stackweight issues or, in more serious cases, vessel stability issues. If we load the bay horizontally then we are making a lot of assumptions about what is going to happen in future ports and left ourselves with limited options.

One final consideration with this is the port rotation. Although the vessel schedule has the ports in a specific sequence, this should never be considers as "set in stone". If we take Northern Europe in the winter time as an example, there is a lot of bad weather and some ports can be more prone to weather closures than other. If this happens, it is conceivable that the vessel will have to swap the port rotation around in order to not be sitting outside a port waiting for it to reopen. If this happens and we have stowed the bays horizontally, then everything that was originally destined to be discharged first will now have to restowed so that the cargo below deck can be accessed. Although it is not possible to be looking at weather forecast 6 weeks in advance, we can take some basic knowledge about what "may" happen and apply it to the stowage in the load ports. Although I have used Northern Europe as my example, the same is applicable in the US during the winter and Asia during the typhoon season. The only difference with these scenarios is when they are most likely to occur during the year.

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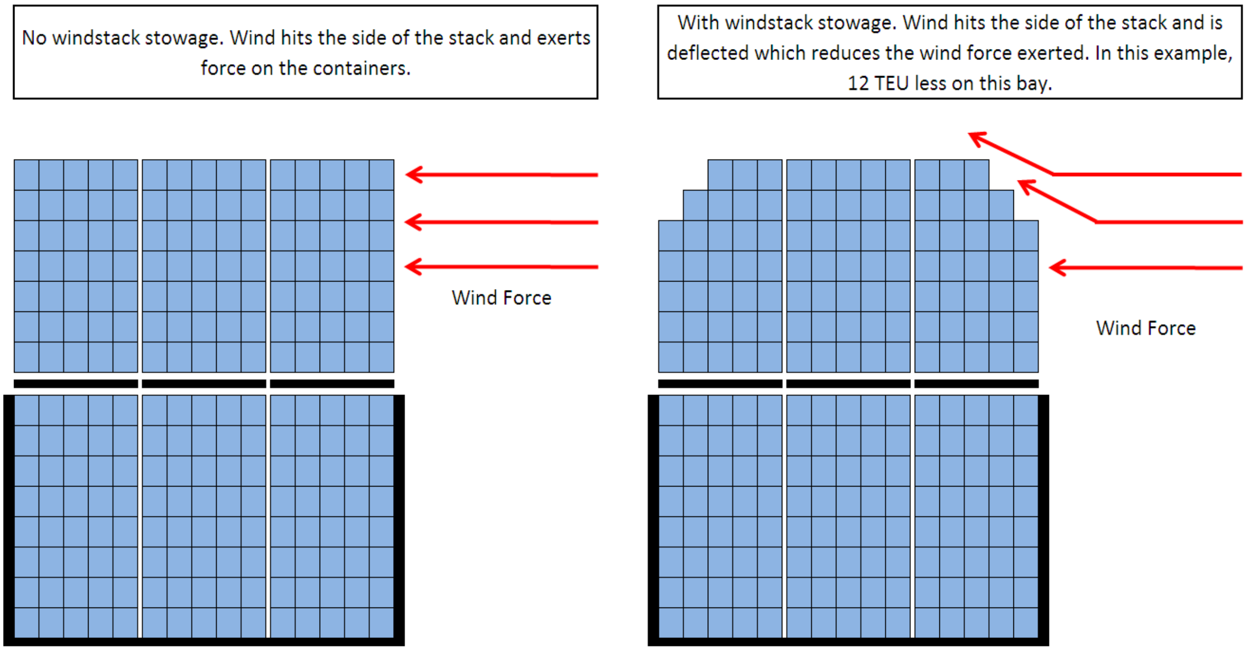
## Windstacks

Some lines adopt the windstack stowage (right diagram) principle within our stability software whereas others generally opt for block stowage (left diagram). The basic principle behind this is that when the wind force hits the side of the stack of containers it will put a large strain on the lashings with a greater likelihood that they will fail when block stowed because wind forces have to be added to the acceleration and roll period forces. When windstack stowage is used, the theory is that the force of the wind is deflected upwards, thus reducing the load on the lashings.




As a result of this type of stowage, a line may have lower insurance costs but there is a downside in the form of a lower utilisation of the vessel. As can be seen in the illustrations above, the windstack stowage has a loss of 12 TEU when compared against the block stow. When scaled up to include all bays on the vessel, this can be a significant reduction in utilisation.

This can be compensated through the use of so-called pyramid stowage on the forward bays that allows us to increase the utilisation. See Line of Sight for explanation.

Various projects are in place at shipping lines to see wheretheye can reduce the impact on utilisation because of windstacks by reducing the wind-force speed calculation whilst still maintaining the safety of the vessel and cargo.

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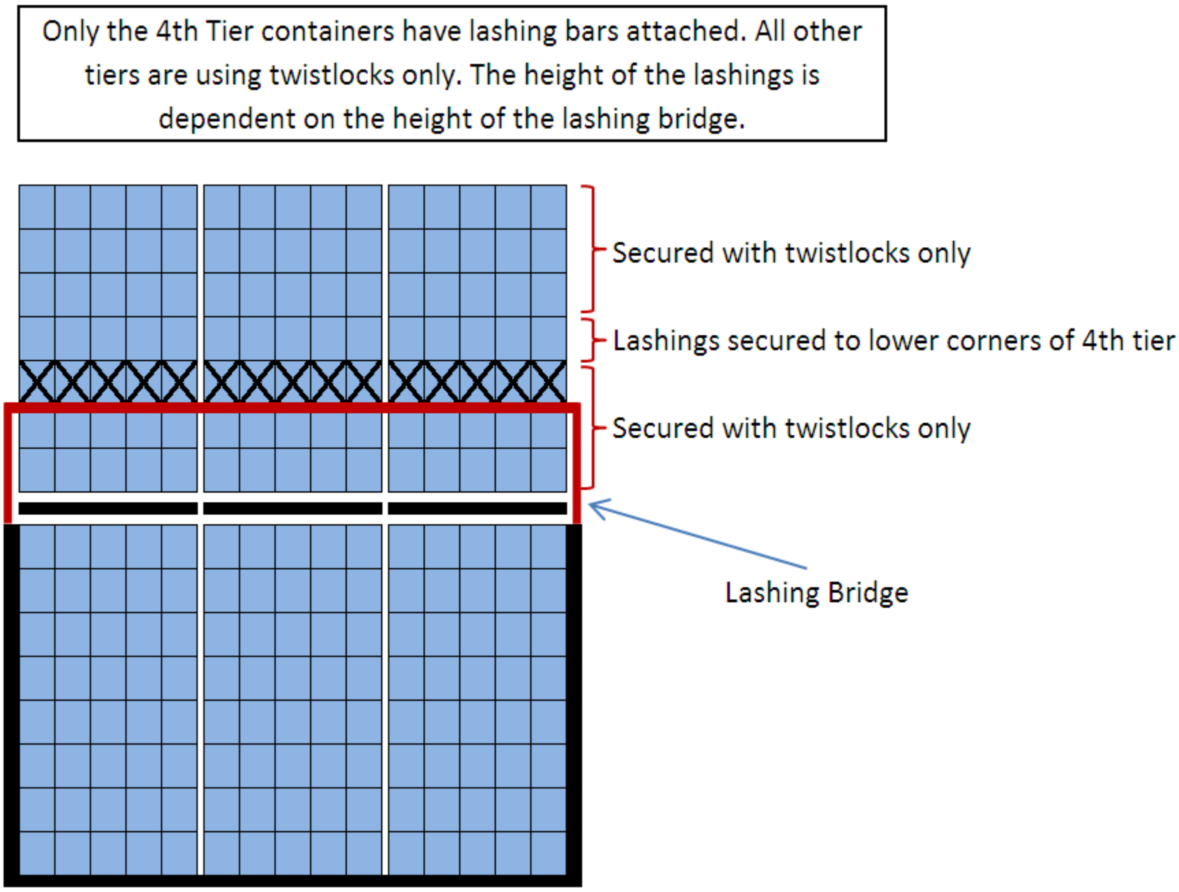
**Lashings**

Lashing bridges (in red) enable the vessel to fix lashing bars to containers higher up the stack than is possible on older vessels that are not equipped with lashing bridges.




The result of this ability to secure the bottom of the 4th tier (or 5th tier on vessels with 3 tier high lashing bridges) is that the lashing forces are reduced thus allowing us to stow tiers of containers higher on deck than was previously possible.

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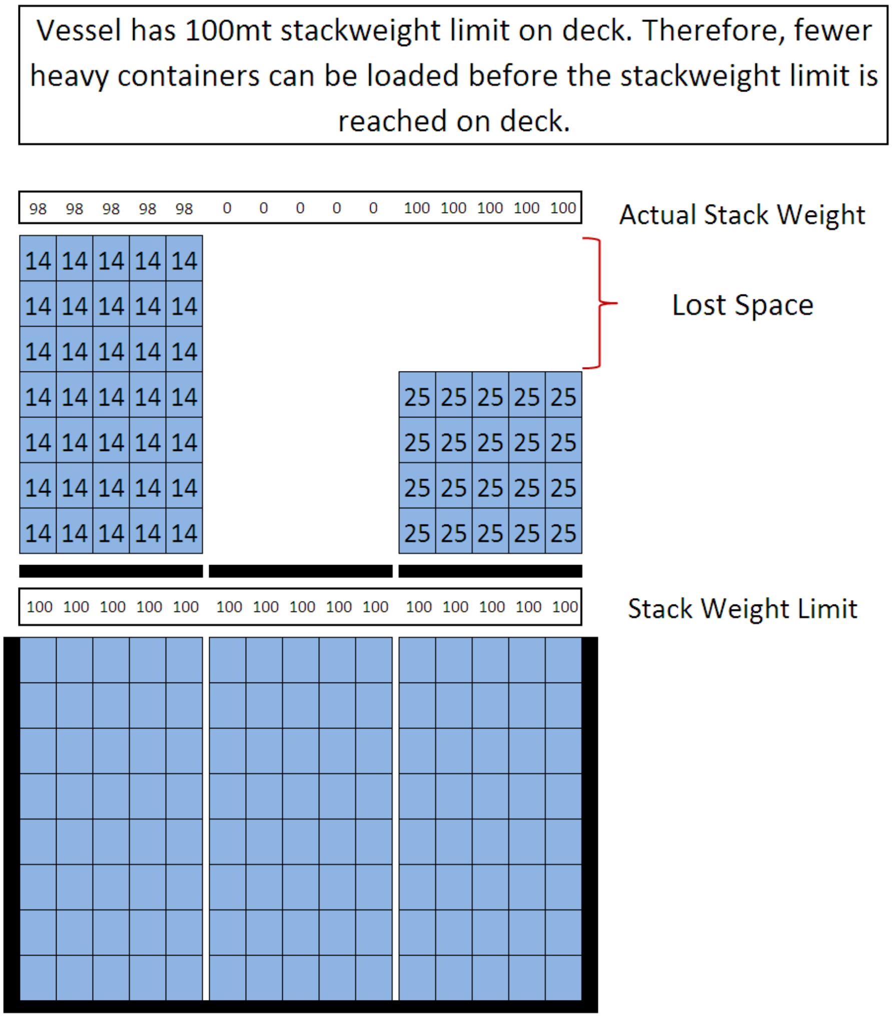
**Stackweight Usage**

When looking at ways to maximise the vessel intake, it is also important to make best use of the individual stackweights. Underdeck stackweights are generally higher than on deck due to the additional strength that the tank-top is designed with. Hatch-covers generally have lower stackweight limits as they lack this additional structural strength. The reason for this is that although hatch-covers have to be strong enough to support the weight of the containers loaded on to them, they also have to be light enough for a gantry crane to lift them.

Heavy units are usually preferred below deck. Firstly to take advantage of the stackweight but also because heavy units underdeck will help maintain the vessel GM.




In the above illustration, the stack on the left shows full use of the available stackweight whereas the stack on the right has used all the stackweight but resulted in a loss of TEU intake.

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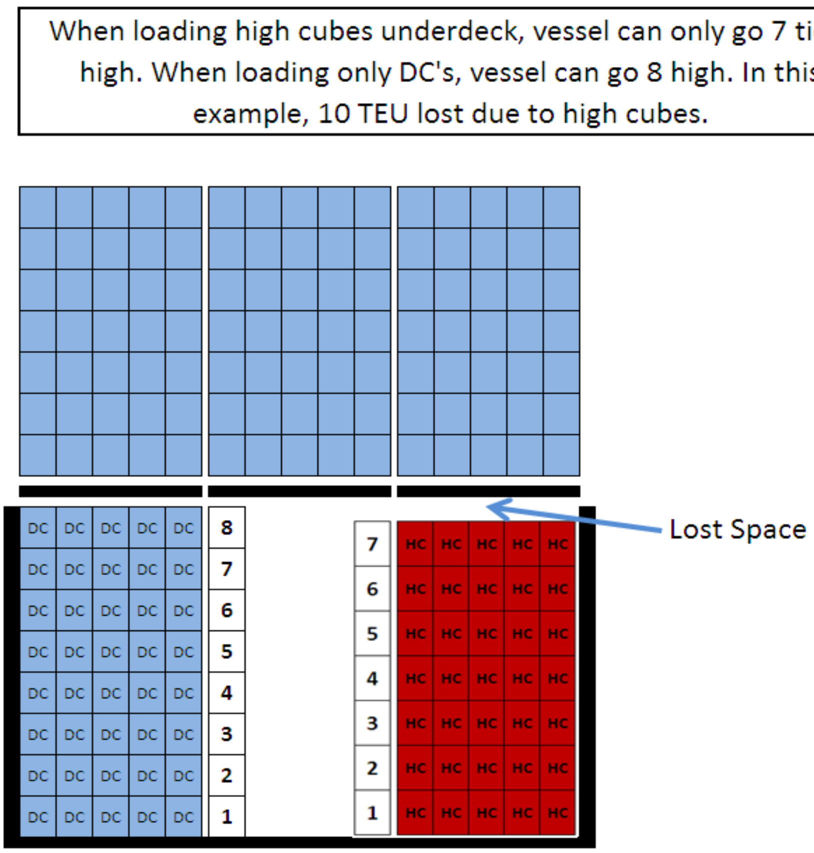
## Stackheight Usage

In the same way that stackweight can affect a vessel intake, stack height also plays an important role. When loading high cubes in a bay, most vessels will lose the top tier because they are generally designed around a container height of 8’ 6”. Some vessels are capable of taking a specific number of high cubes underdeck without slot loss.

When stowing HC’s below deck, it is preferable to only stow a number of them per stack that will not result in loss of slots. Due to the nature of the cargo mix, this is not always possible.

On deck, the issue of stack height still plays a part, especially on the forward bays of the vessel. Too many high cubes in a forward stack can result in lost slots due to exceeding the SOLAS Line of Sight regulations.

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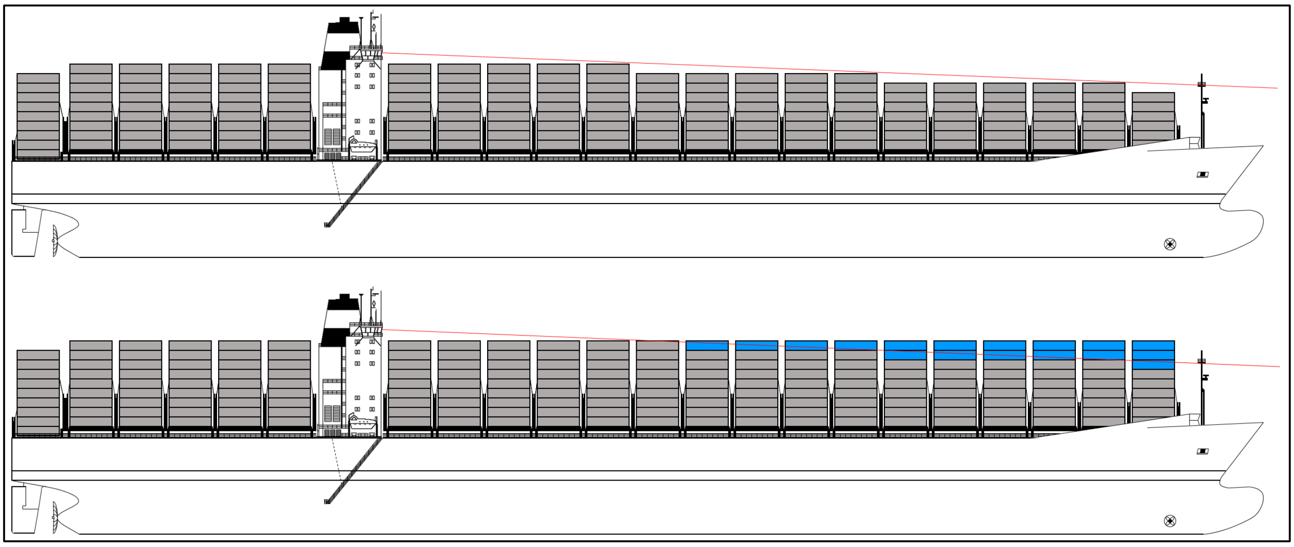
**Line of Sight Rules:**

The SOLAS line of sight rules state that:

> "The view of the sea surface from the bridge shall not be obscured by more than two ship lengths, or 500m, whichever is less"

These rules were written at a time when vessels were much smaller than today. For the majority of vessels that are stowed on the Asia – Europe trade today, the 500m rule applies.

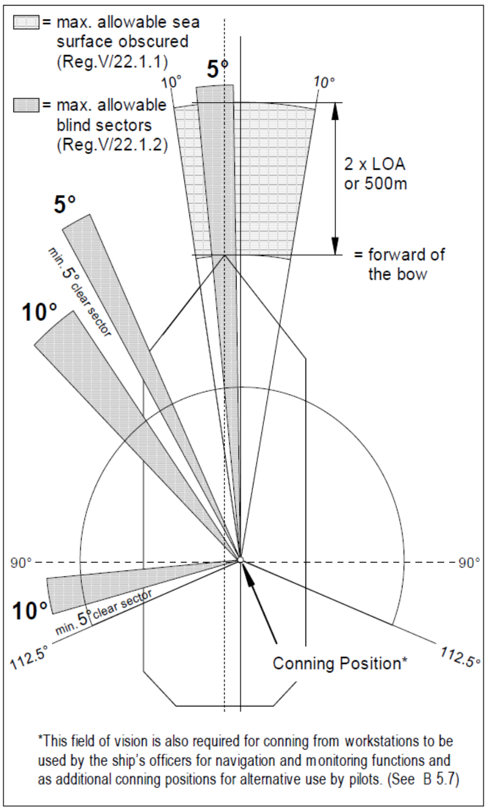
The Line of Sight can be seen in the vessel stability program (OSP). Below is an illustration of how much loss in utilisation there is when the LoS rules are applied:



However, the rules are not as clear cut as they first appear. It is possible to load containers above the line of sight, without contravening the rules, so long as the total blind sector (when viewed from the bridge) does not exceed 10° within an arc of 10° either side of the centerline. Each individual blind sector within that arc must not exceed 5° and there must be a gap of 5° in between in the blind sectors.

This is more easily seen in the diagram overleaf.

In practice, what this means for a line is that they can make use of so-called pyramid stowage on the forward bays. That is to load containers above the line of sight but within the allowable blind sectors.

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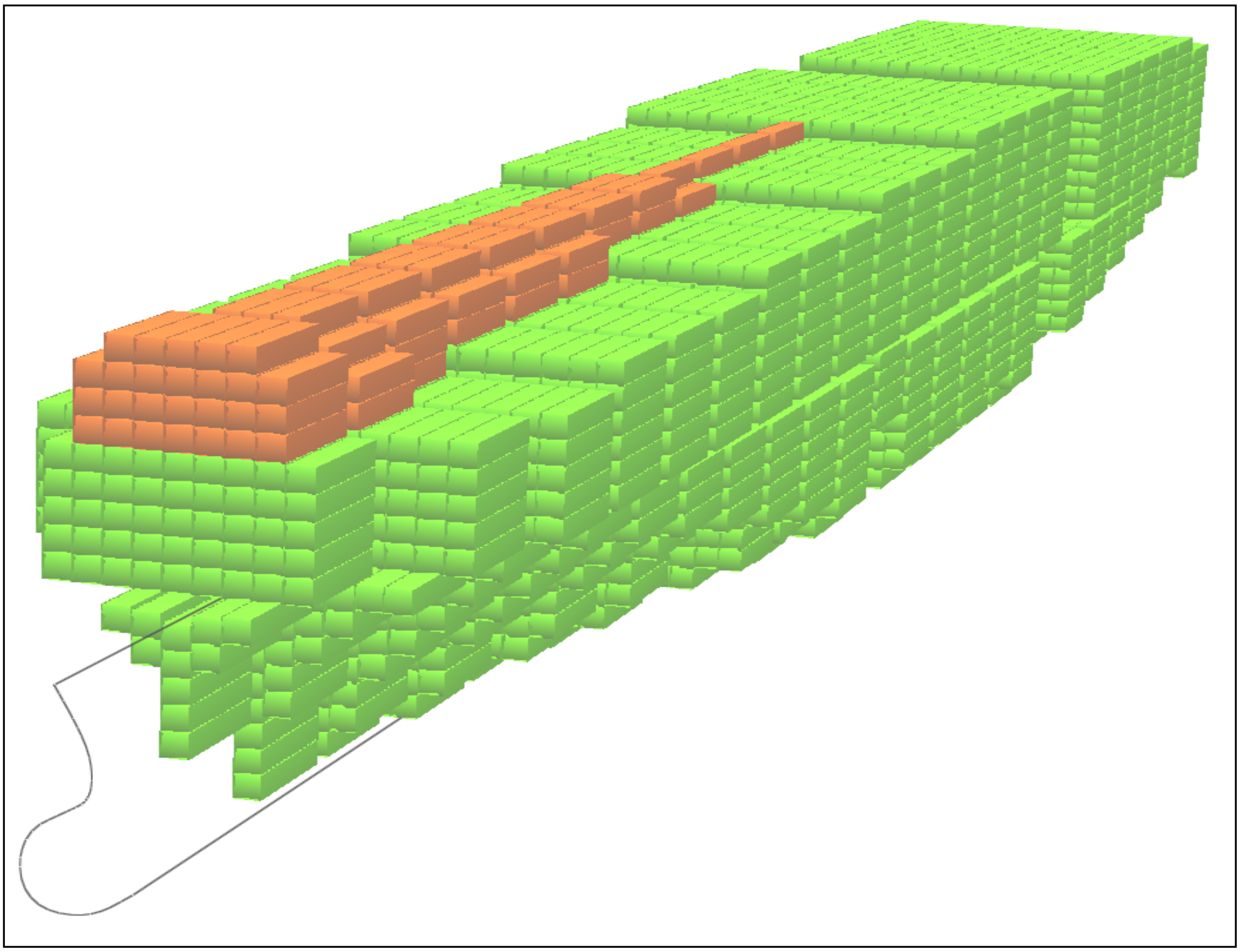
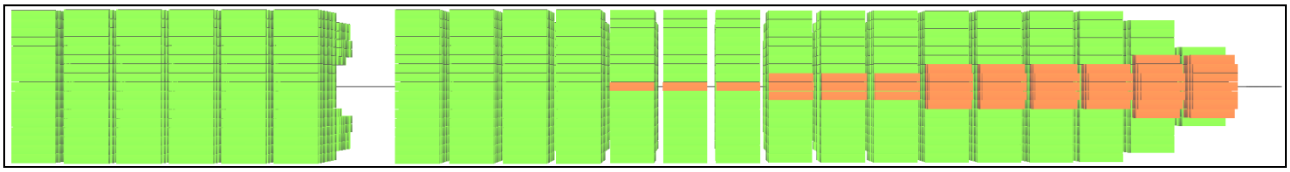


Above: 3D view of the vessel. Orange containers are pyramid stowage.



Above: Top view of the same vessel.

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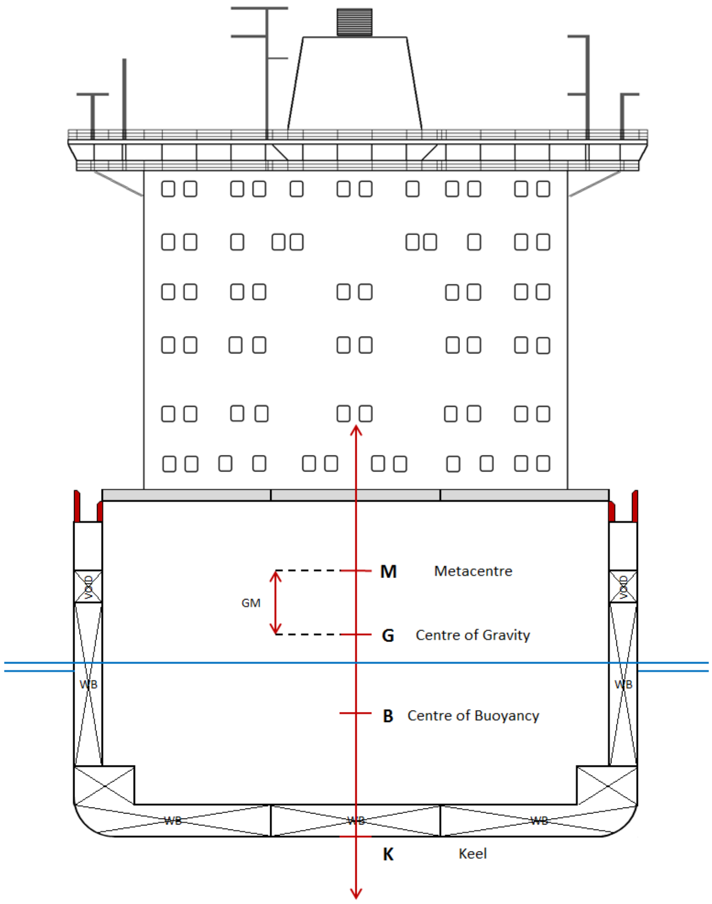
As mentioned earlier, there are several excellent books that cover the stability explanations and calculations in great deal so I will not focus in detail on those. This is a reasonably high level look at the forces that are applied to a vessel and how the stowage coordinator has to work with them in order to produce a stowage that will allow the vessel to sail in a safe condition.

There are four main forces that a coordinator needs to work with:

1) GM
2) Bending Moment (BM)
3) Torsion Moment (TM)
4) Shear Force (SF)

They must also be aware of how draft is calculated, what are the differences between calculated, deflected and read draft (including the application of draft corrections), air draft, overall vessel trim and list as well as TPC (Tonnes Per Centimetre). There should also be a basic understanding of ballast operations and how ballast can be manipulated to correct issues with the stowage.




How does this link in with stowage? Well, there are a few simple principles that can be applied when placing the containers on the vessel that will avoid the majority of the stability issues before the coordinator even checks the stow in the vessels stability program.

Heavy units should generally be loaded low down in the ship with the weights becoming progressively lighter as units are placed higher up the stack. This applies both on deck and underdeck (see explanations on stackweight and utilization). By following this basic rule, the coordinator is working towards a sufficiently large GM that the vessel will be able to sail in a safe and legal condition. As with most subjects in stowage, there are exceptions. It can be true that there is a need to actively work to reduce GM on trades such as those covering the North Atlantic in winter time. With exceptionally bad weather, the vessel will be prone to high amounts of rolling while enroute, if the GM is too high then this can lead to excessive force on the lashings and, ultimately, containers lost overboard. For these cases, it is preferable to concentrate the heavier containers higher up on the vessel and thus reduce the GM.

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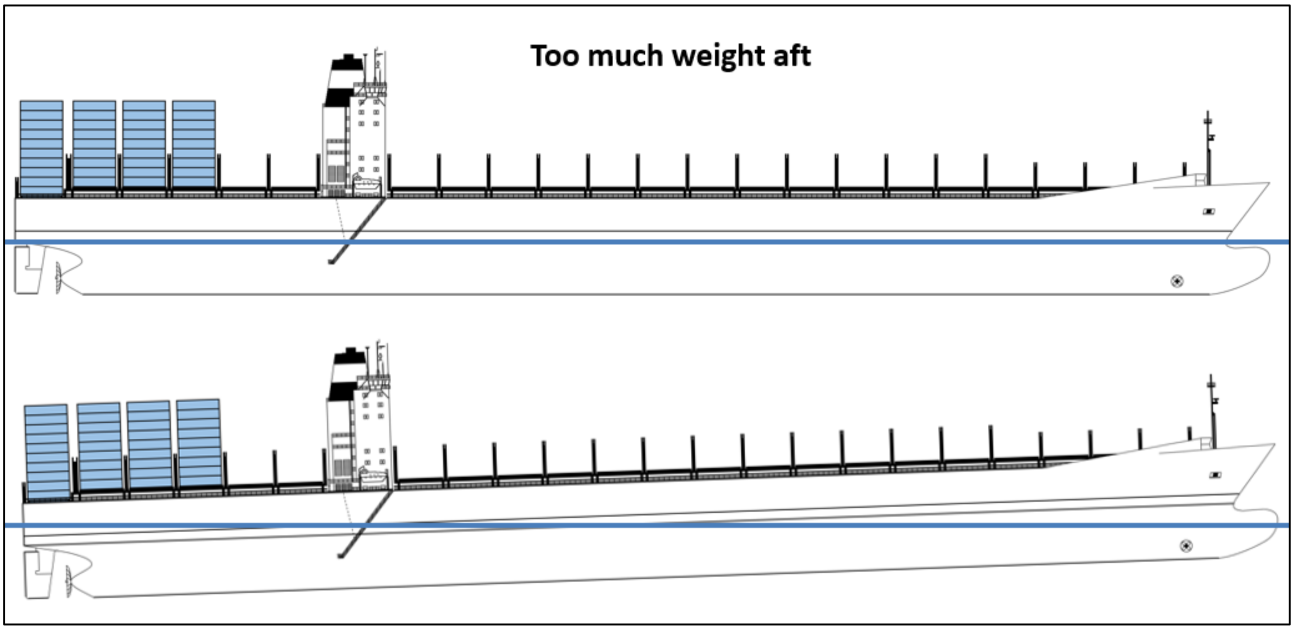
Symmetrical stowage is the practice of loading approximately the same cargo weight, usually for the same port of discharge, on each side of the vessel. This is especially true when the need arises to split the bays into more than one port of discharge. A sensible approach would be to have the same port of discharge in the port and starboard wing hatches (with approximately the same weight in each side) and then a different port of discharge in the centre hatch. This basic rule will avoid the problem of excessive listing of the vessel but will also resolve most of the torsion issues.

If the vessel was simply listing over to one side because of a weight imbalance then it is a relatively easy fix to pump ballast into the opposite side of the vessel to bring it back upright again. However, with imbalanced weights in multiple bays, the problem of torsion can be introduced. Torsion is a notoriously difficult stability issue to resolve by using ballast.

On most modern container vessels the wing ballast tanks are lined up with the individual cargo holds. Unfortunately for us, each cargo hold will contain two to three bays. It is unlikely that we would be stowing the same port of discharge in two adjacent hatches on only one side of the vessel. Since the bays only line up with 50% of the ballast tank, pumping ballast into the tank on the opposite side of the bay will correct the vessel list, but it will not correct the torsion. In fact, it can often be seen that this makes the torsion problem worse. The more ballast that is introduced in this manner, the worse the problem will get. The coordinator can find that they are essentially 'chasing' the problem around the vessel in an attempt to fix it with ballast. The simple solution is symmetrical stowage. This will avoid the weight imbalance and reduce the amount of ballast that is required onboard the vessel. Less ballast usually equals lower fuel costs. This does come with a cost to terminal productivity though, see the Manhattan Towers explanation.

**Trim**




Too much aft trim will increase the friction on the vessel caused by the stern being in the water. This will increase fuel consumption.

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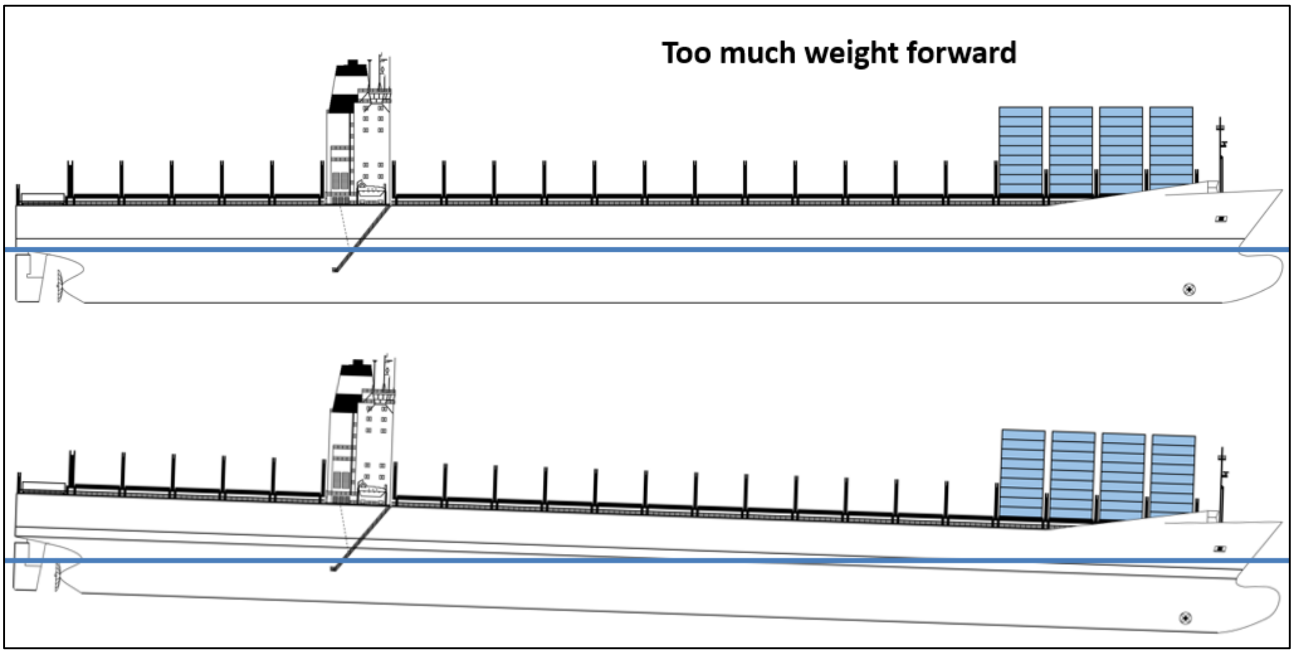
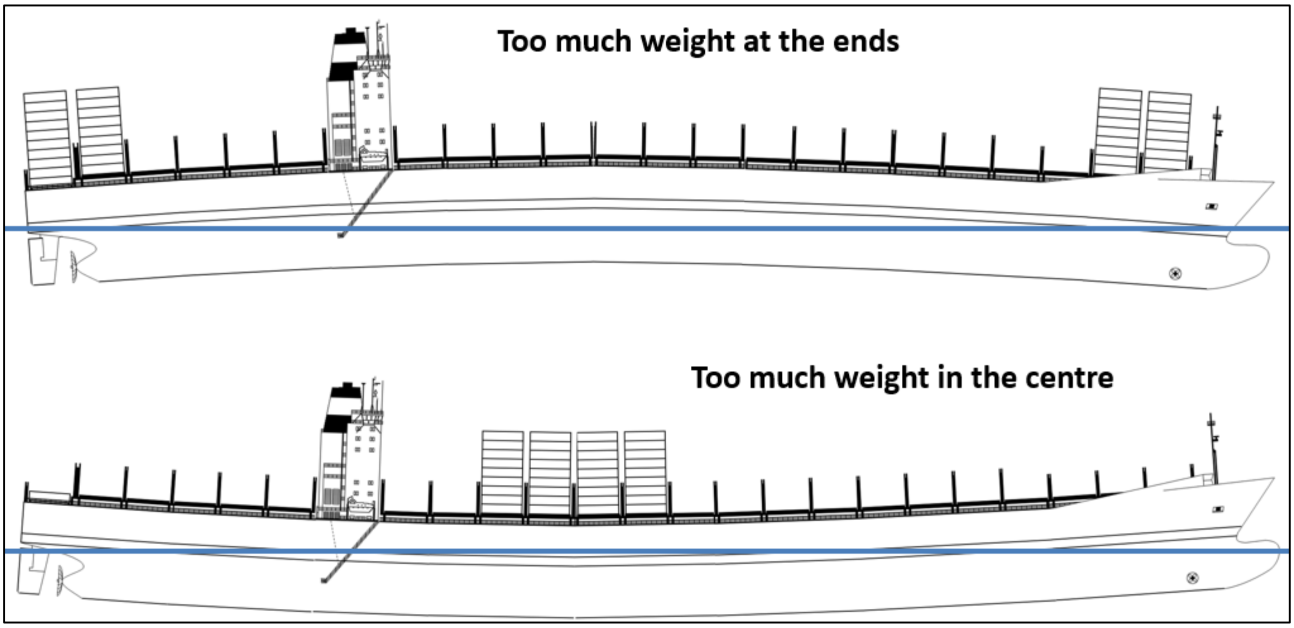
**Trim**




When there is too much trim forward, the rudder and propeller may not be sufficiently submerged. Particularly at low speeds, it will be difficult to control the vessel.

**Bending**




Bending or hogging the vessel will, over time, reduce the structural integrity of the vessel. Evenly balanced weights from forward to aft will avoid this issue.

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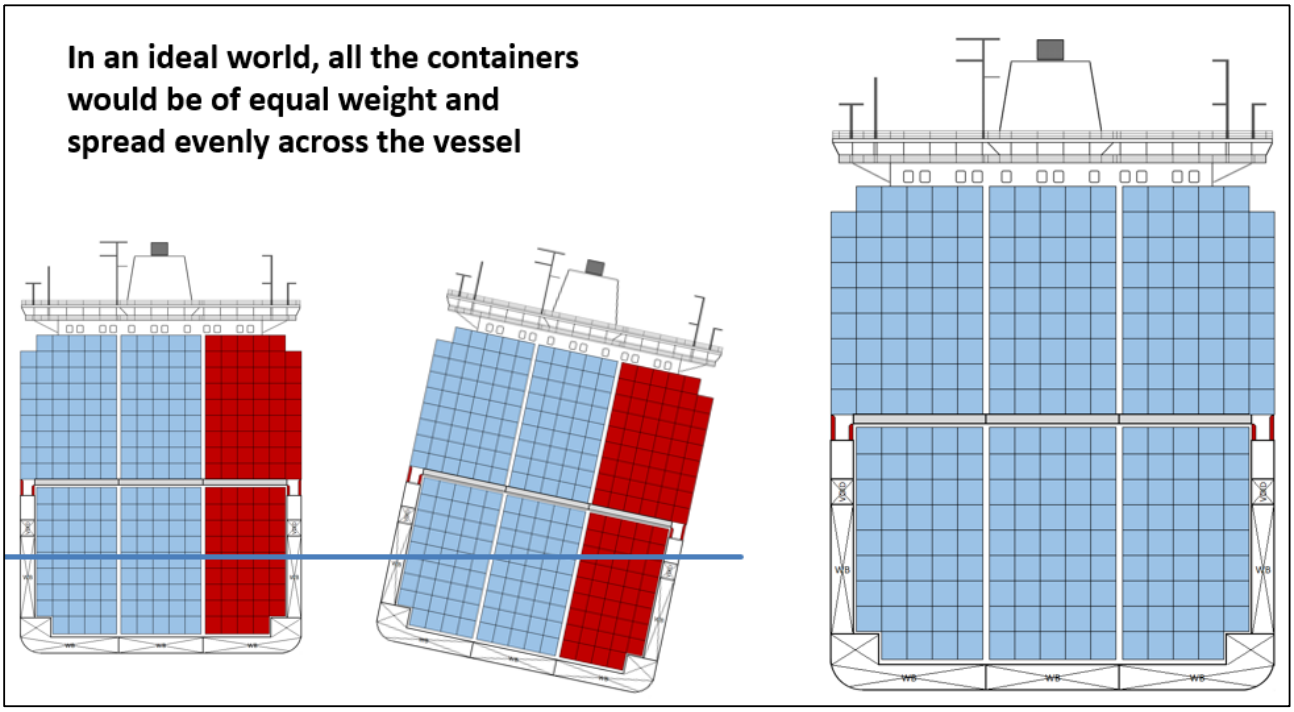
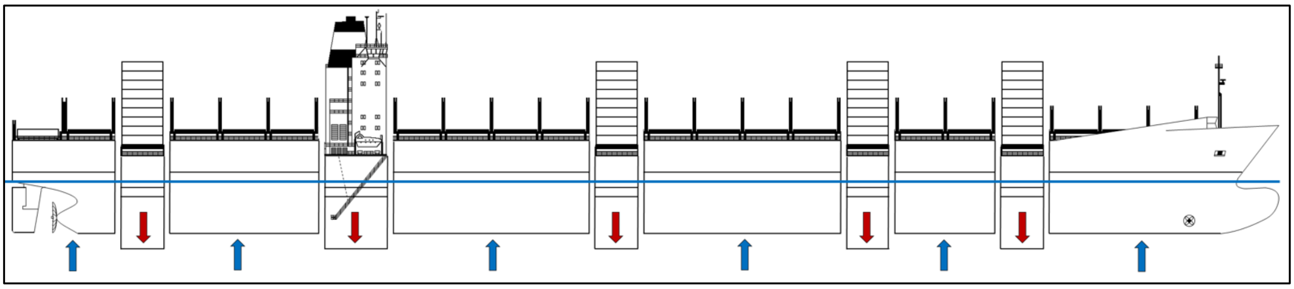
## Listing




This scenario also includes torsion problems but that is covered in the chapter on Towers and Torison.

## Shear Force



Shear force is caused by the weight of the cargo pushing down and the buoyancy of the vessel pushing up in the empty bays of the vessel. This is similar to the problem of bending but it is calculated over more specific areas of the vessel length (at each frame).

By far the largest impact on the vessel port stay and the service efficiency is the Crane Intensity delivered in each port. The number of cranes that should be delivered in each particular stowage is dependent on several factors. The first consideration is the number that has previously been agreed for the service or with the terminal. This doesn't require much in the way of explanation here. The question is more about Crane Intensity and what can be considered optimal, especially in relation to productivity in the terminals. Shipping lines are continually looking to achieve higher BMPH in order to facilitate faster turn around times so providing a higher CI in the stowage would seem to be a logical place to start, but this is not always true.

If there are a fixed number of cranes in a port or allocated to a particular service then it's fairly clear cut and doesn't make a lot of sense to over-plan the CI. Once you hit the number of cranes available, any increase in CI will not result in more cranes being deployed and so the BMPH will not go up, indeed, it may even start to decrease. As seen from the explanation on Manhattan Towers, increasing CI beyond a certain level on the service overall will produce an impact on something else in a different port. This is essentially what stowage is all about. However, increasing CI that result in an increase in the occurrence of Manhattan Towers is not the only impact that exists.

If, for example, there are five cranes available but we decide to plan the stowage with a Crane Intensity of eight, what are the implications? Since the number of moves will remain the same no matter what CI we deliver, to deliver that higher CI we will need to spread the moves over a larger area of the vessel's length. To keep it relatively simple, lets say that we have 2000 moves and a CI of 5. Assuming each crane is planned approximately evenly then each crane will have 400 moves in 5 locations on the vessel. If all of these groups of 400 moves are each located in 5 consolidated bays then the terminal will likely be able to achieve a good rate of productivity since the cranes will never have to move from their starting location during the operation. If we now take our 2000 moves and divide it by 8, each new group of locations on the vessel will now only contain 250 moves. What this now means for the terminal is that the cranes cannot stay in the same location during the cargo operations. They will be performing smaller amounts of work and then need to move. This is very disruptive. The crane must be aligned with each bay prior to commencing work, the prime movers will need to be moved to the new location on the quay and re-aligned with the crane as will the twistlock bins and stevedores. If the crane has to move past the accommodation then this will usually require the crane boom to be raised and then lowered. All of these operations will cause time to be lost and have a negative effect on the overall BMPH.

The conclusion to the above is that, while it can make sense to deliver a high CI in the stowage, it only makes sense if the cranes are actually available for deployment on the vessel. As is often the case, there are still other factors that need to be considered. As just described, there will be 'operational' losses during the cargo operations. This is not just restricted to crane movements but also encompasses a wide range of influences from shift changes, meal breaks, crane breakdowns, crane hanging time and yard equipment breakdowns all the way through to weather. These factors combine to cause the terminal to have 'non-operational time' or 'operational losses' which will translate into a loss of BMPH. If a terminal plan starts off with CI of 4.0, they will never finish with an executed CI of 4.0. How much they will lose during the execution will depend on the overall efficiency of the terminal but a reasonable guide would be somewhere in the range of 0.2-0.5. So if they start with a CI of 4.0, the final executed CI will be 3.5-3.8. Of course, some terminals will fall outside this range. It is therefore, always wise to slightly over-plan the CI to account for the

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operational losses but how much to over-plan is always dependent on the operational efficiency of the terminal in question.

There are also different terminal preferences when it comes to Crane Intensity delivery. Some terminals will prefer to have single, large, consolidated bays for each crane (so a CI that approximately matches the planned crane deployment) whereas others will prefer to have a CI that is much higher than planned crane deployment. The reasoning is quite logical in both cases and relates directly to the type of terminal.

The first group that prefers the single, consolidated bays are going for one (or both) of two things. Higher productivity and a reduction in Manhattan Towers to work over. If the crane can stay in the same location on the ship then it will generally hit a higher GMPH as just discussed but this comes with a risk attached to it. If there is a crane breakdown during the operation or one crane is working much slower than the others, it is very hard for the terminal planner to re-assign some of the cargo work to a different crane to re-balance the overall crane split. Since the blocks of work are much larger and consolidated into single bays, it’s not possible to move that work to a different crane because of the separation required between the cranes. This preference tends to be seen in terminals that are relatively stable in their operational crane speeds and have a good maintenance record. On the flip side of this, a terminal that is less stable or is more prone to breakdowns will usually prefer more bays to work with smaller amounts of containers in each location. During the operation, the terminal planner will monitor the overall crane split and re-assign certain bays to different cranes, depending on the performance of each crane. This allows the terminal to mainain a relatively stead crane split throughout the operation, with the aim of having all cranes completeing work at approximately the same time. The first option is setting a very clear plan in place before operations begin, on the assumption that all will go to plan. It leaves very little in the way of room to maneuver. The second option leaves room to make changes and will allow for a more dynamic operation with plenty of opportunities to correct problems that may occur.

There can often be confusion surrounding the differences between Stowage Planned CI, Terminal Planned CI and Terminal Executed CI. For the sake of clarity, the Stowage Planned CI is Total Moves/Longest Crane (Longest crane being defined as the two forty foot adjacent bays with the highest move count). This calculation can also be done in time (see Crane Intensity Explanations). Terminal Planned CI is the same calculation but the longest crane definition is different. For a terminal this is the physical longest crane (dependent on how many cranes they plan to deploy) so it may just be the same two adjacent forty foot bays or it may be include three or four bays (this is usually only calculated in moves, not time). Terminal Executed CI is the CI that can be calculated at the end of the operation and will include the influence of the ‘operational losses’. It will also account for the different speeds at which the cranes physically operated plus changes to the stowage that may occur during the operation. Essentially it can be described as Stowage Planned CI is an ‘ideal world’ scenario whereas Terminal Planned and Executed CI are ‘real world’ scenarios.

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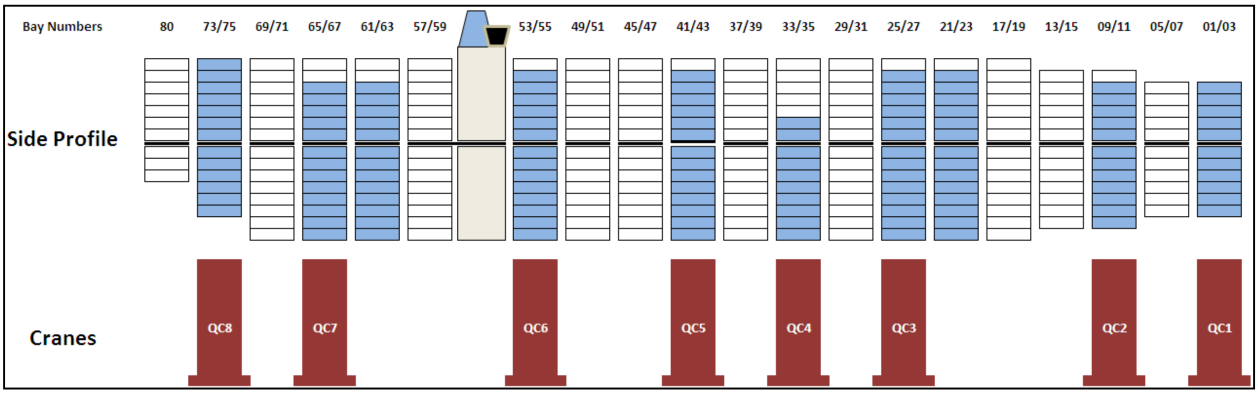
## Crane Split vs Crane Intensity

Crane Split is simply the number of cranes that can be deployed on a vessel. It is not an indication of how even the number of moves between the cranes are.




In the above example, 8 cranes can physically work on the vessel so this is an 8 crane split.

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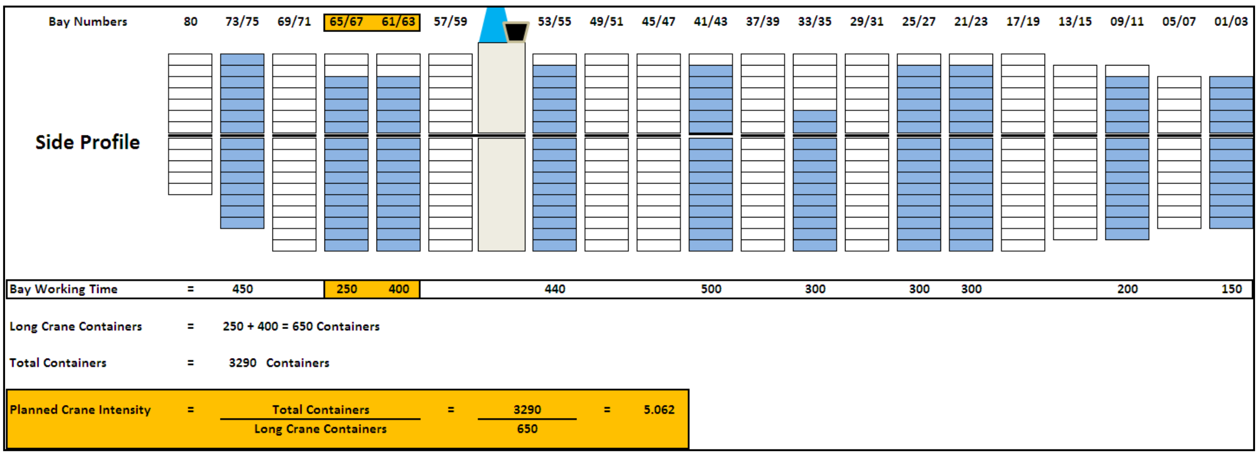
Crane Intensity is a simple calculation to give an indication of how many cranes can be deployed on a vessel.




Using the same example, you can see that the 8 crane split becomes a crane intensity of 5.06 due to the differences in the bay move-counts.

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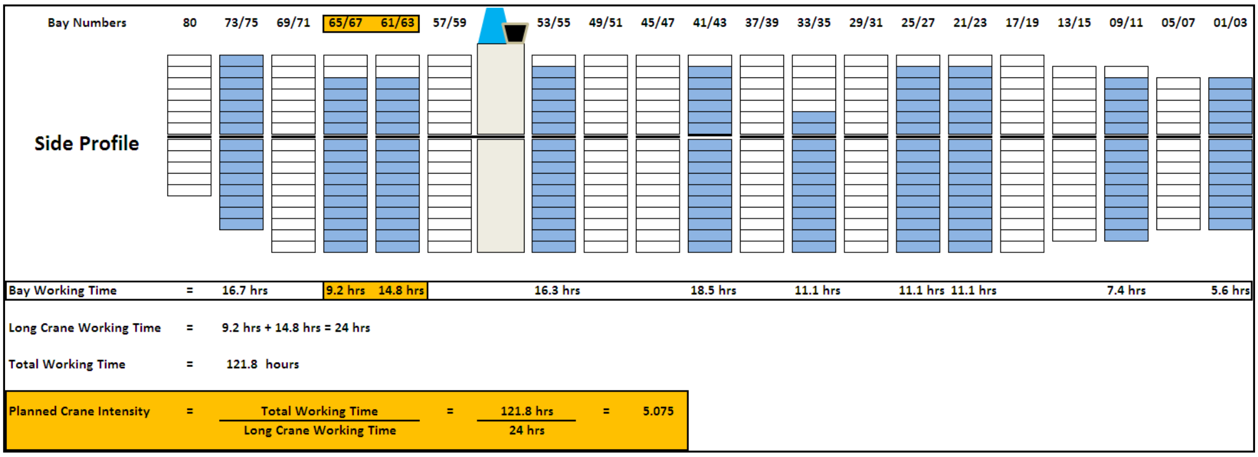
To take this a step further and incorporate time into the Crane Intensity Calculation, you can see that this allows us to account for the fact that terminals do not operate at a single speed. There are different productivities for each type of move (single load, single discharge, twinlift load/discharge, dual cycling, OOG load/discharge etc).

This allows for a much more accurate Crane Intensity calculation than is possible for a stowage coordinator to work out manually.




The diagrams on the following pages explain exactly how the calculation is made.

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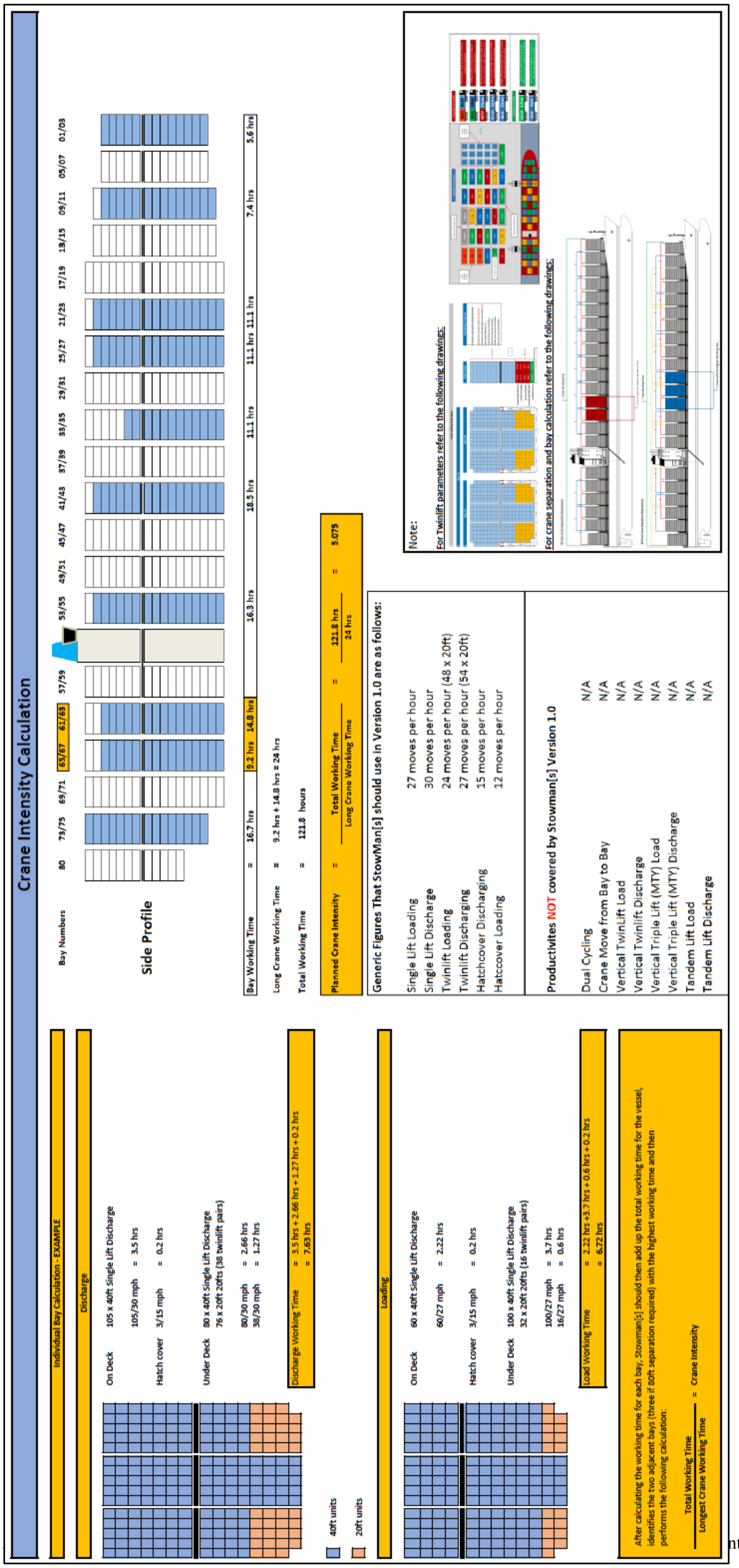


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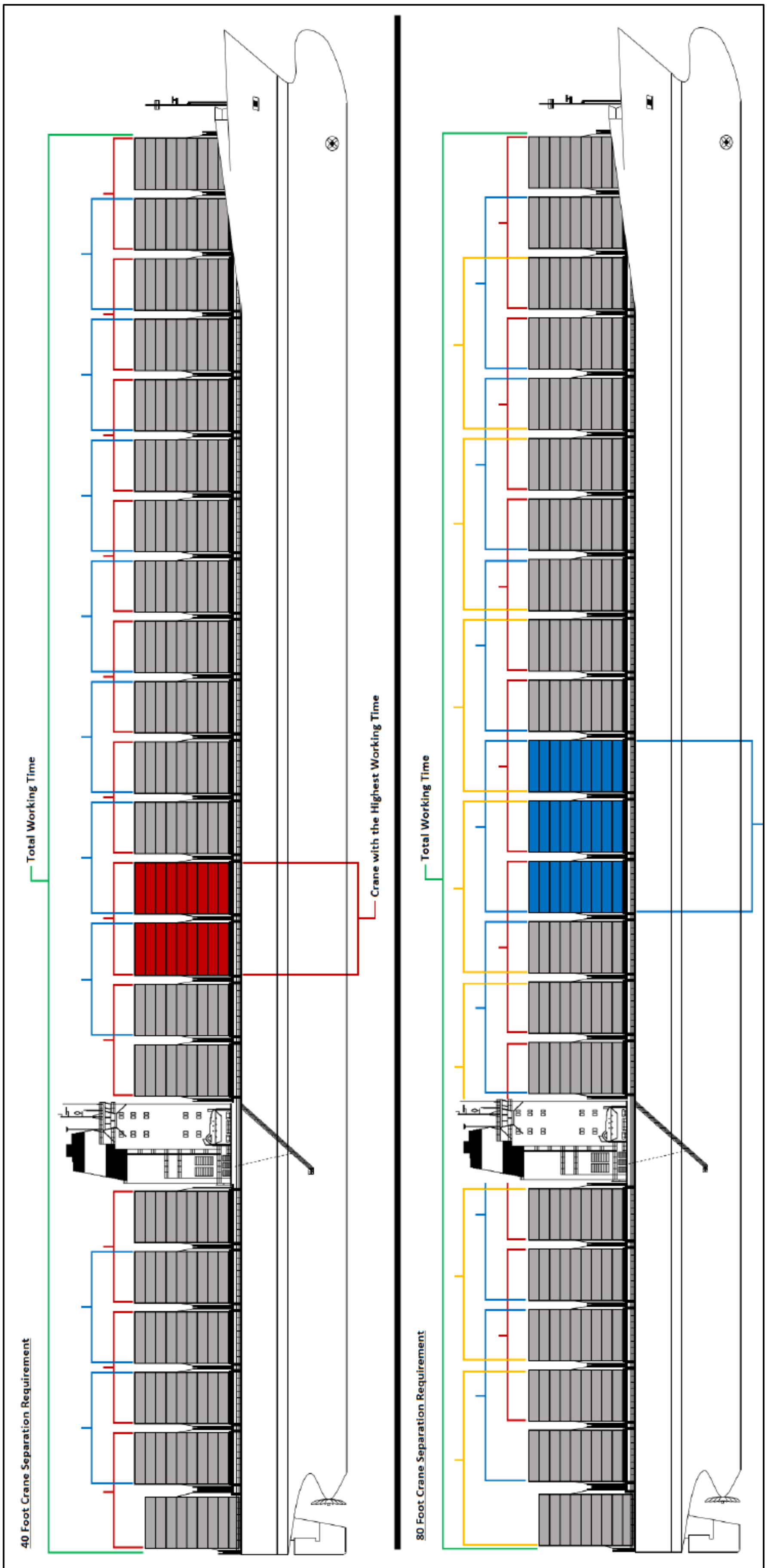


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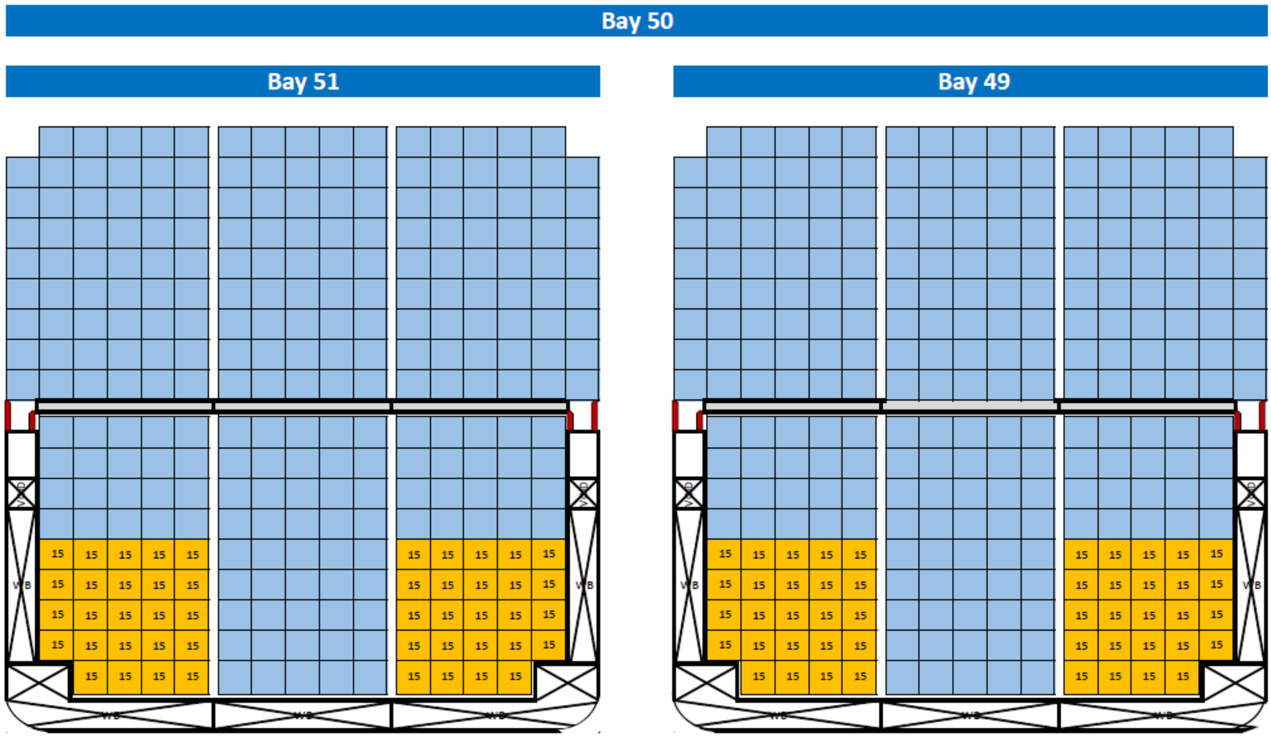
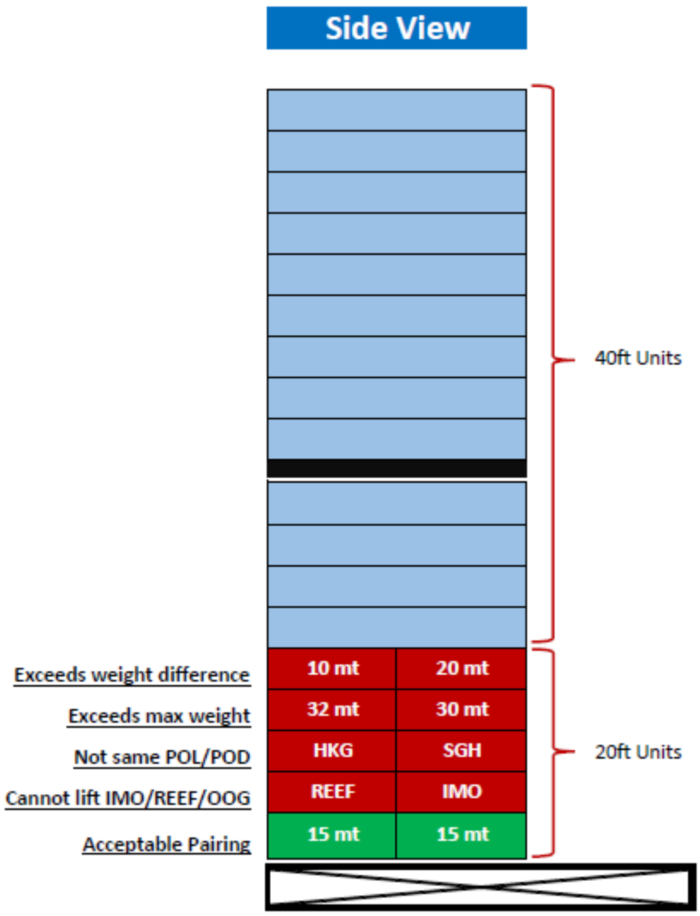
# Twin Lift Restrictions




## Twinlifting Criteria

In Version 1.0 the generic settings should be:

Paired units must be for same POL and POD

Maximum combined weight no more than 60 mt

Max weight difference 8mt

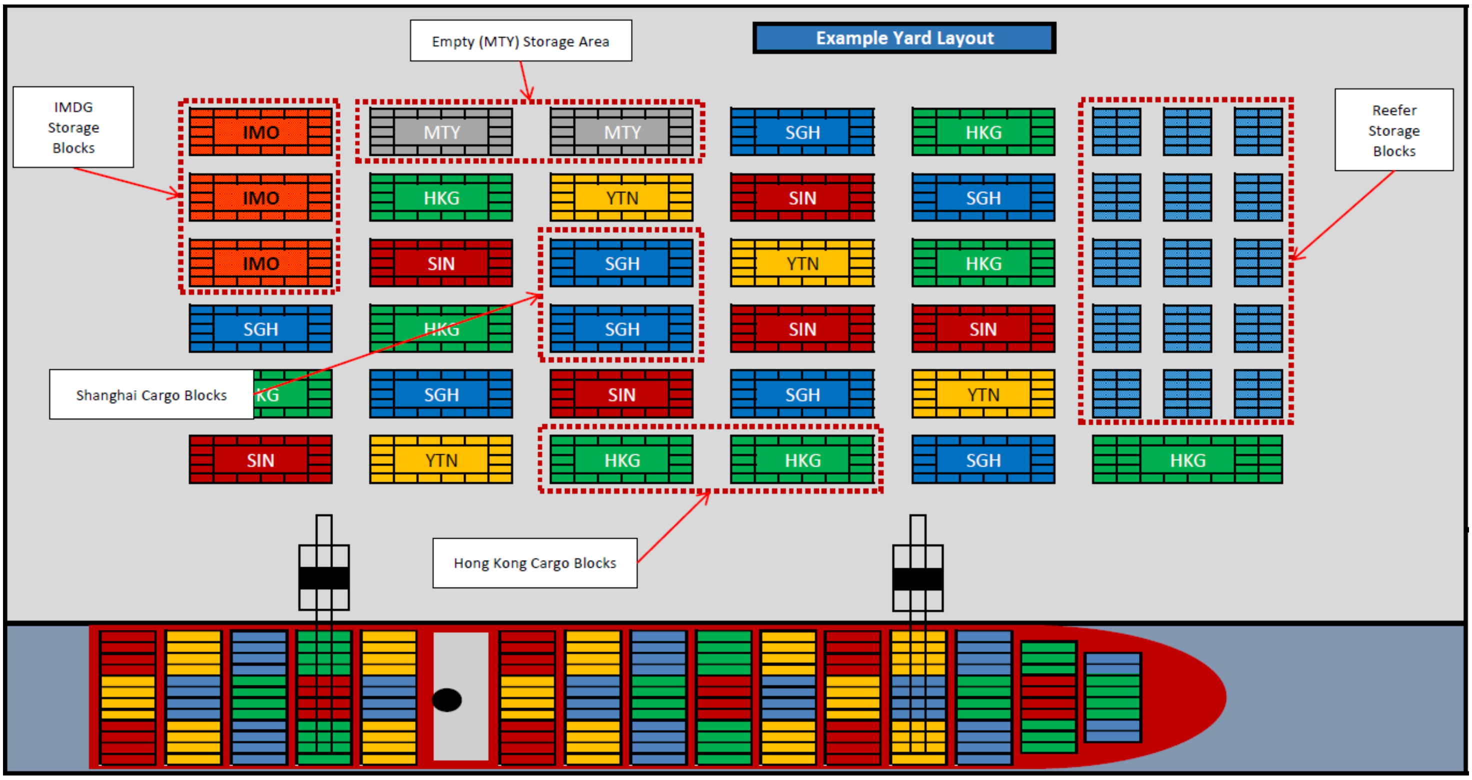
Only DC boxes can be twinlifted

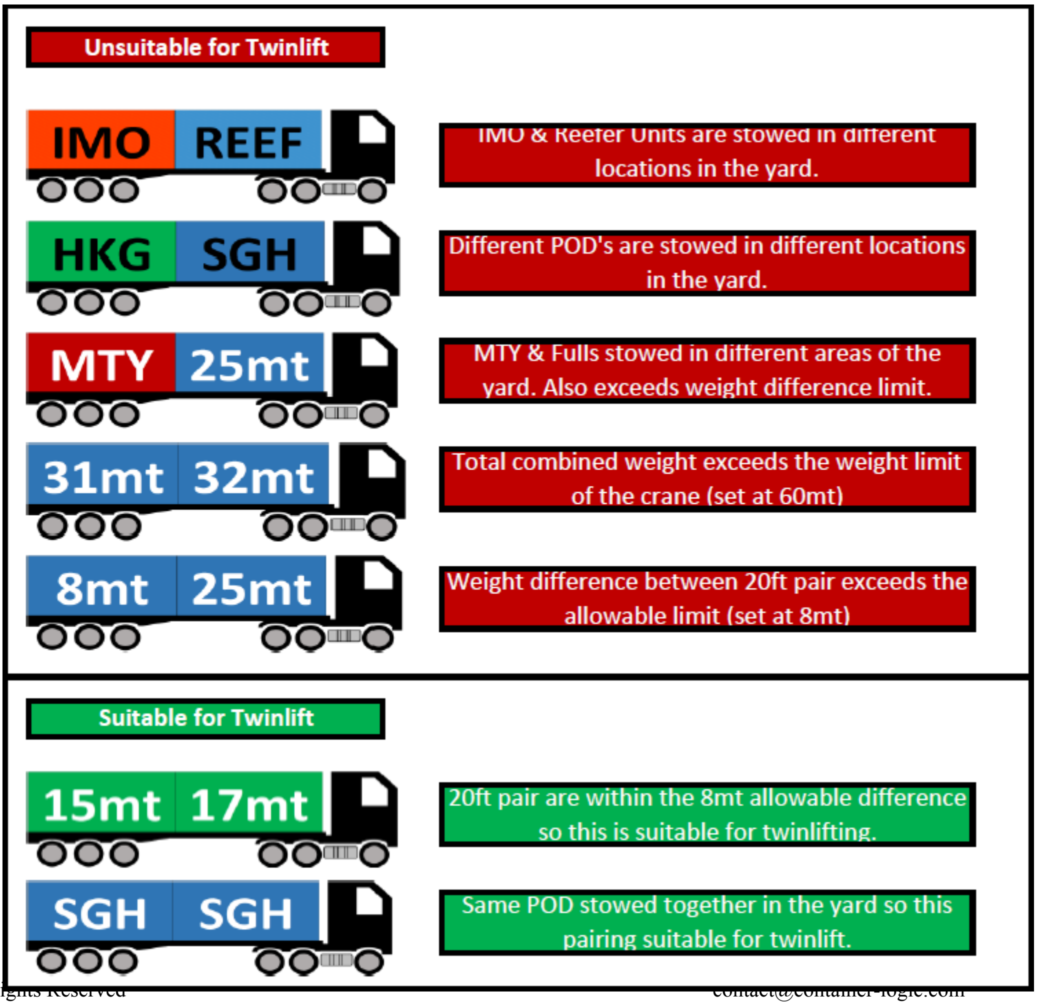
OOG units cannot be twinlifted

Reefer units cannot be twinlifted

IMO units cannot be twinlifted

# Twin Lift Terminal Yard Restrictions

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Crane Intensity can be viewed a two distinct levels, what CI can be delivered in an individual port and what can be delivered on a service in total (maximum crane intensity).

If we were only to consider a single port and disregard all others in a service then it is relatively simple to calculate and is more to do with the physical attributes of the vessel and the cranes than anything else. The cranes will be a specific size and need a separation distance between them since they are wider than a single 40ft bay. The most common separation requirement is one bay clearance between the 40ft bay that is currently being worked. For example, if Bay 22 is being worked on, the next closest crane (aft) will be at Bay 30. Bay 26 will not be workable due to the width of the cranes. 80ft or even 120ft separation can also be seen in some terminals, usually those working with older cranes but is not that common.

Now that we know how far apart the cranes must be, we can look at the vessel. If we are working with 40ft separation then we can have a crane working on each alternate bay. So a vessel that has 22 bays in total will be able to work a maximum of 11 cranes. However, as discussed previously, this is an 11 crane split and not a CI of 11. The reason for this is mainly because the bays in the mid part of the vessel will be much larger capacity than those at the forward and aft ends of the vessel. Unless we split the container moves evenly across the 11 different bays/cranes, then we will have a CI that is much lower than our starting point of 11. Generally, it would not make sense to deploy this many cranes and although this can be seen in the publicity photos from some terminals, it's not usual practice because it simply makes no sense since the vessel will not sail until the longest crane has finished working anyway.

In the real world, we are not just looking at a single port and so we have to take a more high level look at CI. It is much more important to know how many cranes can the service as a whole deploy. Again, the vessels physical characteristics will come into play but in a slightly different way.

As a planner, you need to decide how you are going to divide up the vessel to give a combination of best crane intensity in each port, maintain the overall vessel stability and ensure that you load the maximum number of containers possible. This is where vessel torsion and Manhattan towers will come into conflict. As described in the section on stability, symmetrical stowage is the simplest way to avoid torsion issues on the vessel since the weights are more or less balanced purely from the way the stow has been done. In an ideal world, we would just be planning a single load/discharge port into single bays but then we suffer on the overall CI we can deliver.

Looking at our example vessel, there is a relatively simple way that the bays and vessel can be divided up so as to meet as many of the stowage criteria as possible. Rather than keeping consolidated bays, we can double the amount of cranes that can be deployed by dividing the bays into two. One port is loaded in the port and starboard wing hatches, another port is loaded in the centre hatch (this works equally well for four hatch vessels). Each hatch will have to be both loaded and discharged so it is assigned a load crane and a discharge crane (therefore 2 cranes). On this vessel, it can easily be split into 43 sections, thus 86 cranes.

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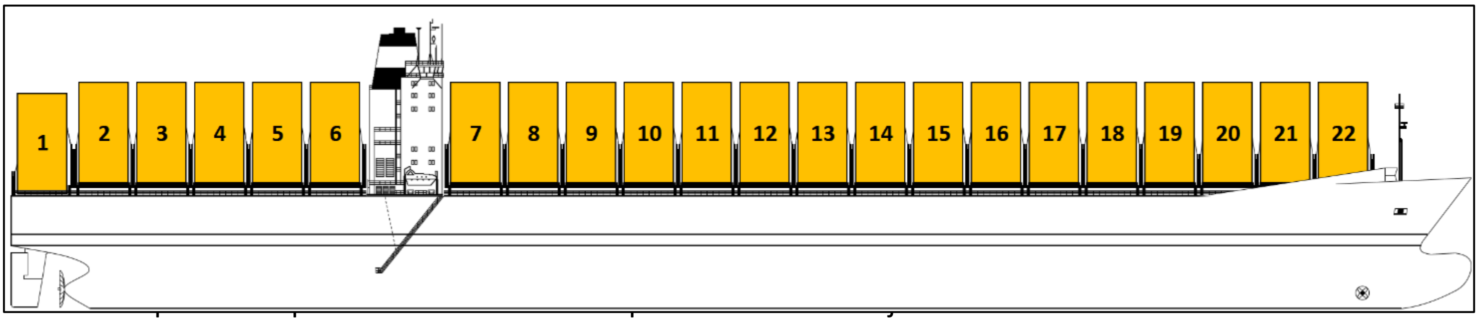


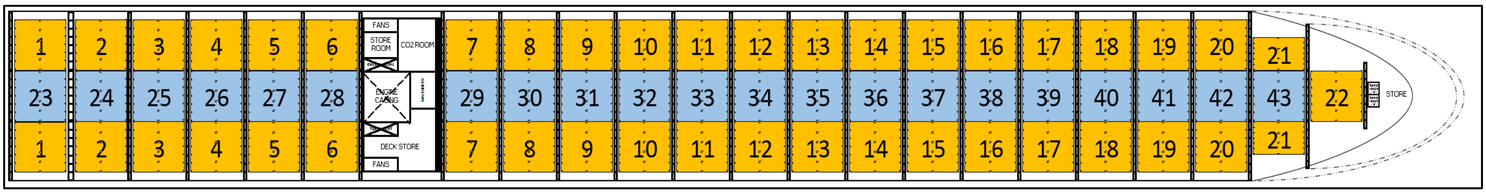


What this doesn't give us is an indication of how to split the CI's we can plan for between the ports that the vessel calls at. For this, we need to start looking at the predicted movecounts in each port. What we need to identify is how many moves can justify using an additional crane. For example, if we start off with 300 moves in total, that really only justifies the use of one crane on a vessel of 10000+ TEU. But how many moves are needed to justify a second and third crane. Of course, it is entirely possible to split the 300 moves into 3 bays and work with 3 cranes but it is hard to justify doing that. For a terminal, that is a lot of expensive labour for only 3 hours work. It is probably preferable from their point of view to deploy one crane and work for 9 hours. There isn't a single answer to this question as it's very subjective. It will depend on the size of the vessel, the scheduled port stay, what kind of terminal is the vessel in etc.

There are some general guidelines that can be used by looking at the way the vessel is being split and how you split the vessel will depend on how to calculate the number of moves required to justify planning for each additional crane.

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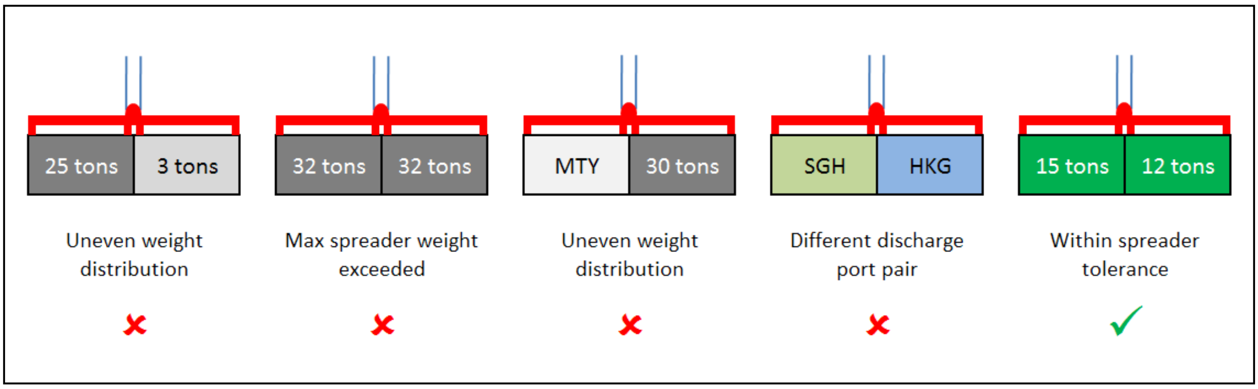
Twinlifting is, very simply, the practice of lifting two 20 foot containers with the crane at the same time. In the early days of containerisation, only single lifting of containers was possible due to the design of the spreaders. Telescopic spreaders were developed so that they could either lift single 20 foot units or be extended to lift 40 foot units. This was quite time consuming from a terminal perspective. As cranes evolved, the twinlift spreader was developed. This is still a telescopic design, usually with a range from 20-45 feet. Even though twinlift was now possible, there are still vessels that have fixed 20 foot holds so there was still a need for spreaders to handle 20ft single lift operations. These spreaders have four twistlocks fixed into the extreme corners of the spreader but they are also fitted with an additional four retractable twistlocks in the centre of the spreader to facilitate the twinlift operations. These retractable twistlocks allow the crane operator to switch easily between 40 foot and 20 foot twinlift mode quickly and with much less mechanical wear and tear on the spreader compared to being continually extended and retracted.

The main gain from twinlifting is the significant increase in productivity that is now possible. For every load or discharge move that the crane is performing, it is now lifting two containers instead of just one. However, this doesn't mean double the productivity of single lifting. Where a crane may be performing around 30 moves per hour when in single lift mode, the GMPH is likely to be reduced when in twinlift mode. The crane may now be performing around 25 moves per hour. Although the GMPH has dropped, the crane is still physically moving 50 containers per hour against the previous 30. The reason for this loss in GMPH is normally due to the increase in weight that the crane is now lifting. The heavier the weight, the longer the move is likely to take.




There are some restrictions and requirements that need to be considered when planning for twinlift operations. Weight is the primary factor. The combined weight of the two containers cannot exceed the safe working load (SWL) of the spreader, usually around 60 tons. Secondly, the weight difference between the two containers has to be within the limits for the spreader. This restriction is more variable and will often come down to what a terminal feels they can safely handle. Some terminals/spreaders can only work with a tolerance of +/- 5 tons difference between the two units whereas others will work with an empty container and a 30 tons container. These limits and restrictions need to be verified with the terminal but the most common difference seen is around 12 tons difference. These two weight limitations are physical restrictions of the crane and are directly related to safety, if they are not adhered to then twinlift operations will not be performed.

The next group of limitations are more related to self-imposed terminal requirements as to when twinlift can be performed. Usually the terminal will require the 20 foot pair to be loading to the same destination (i.e. both containers bound for Rotterdam) or, if being discharged for transhipment then already paired up on the vessel by next port of discharge (i.e. transhipped in

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Rotterdam but loading on another vessel for New York – so already paired based on New York as final destination). Terminals have to stack discharged units from a vessel in the yard based on their own set of criteria. How the yard is segregated will depend on that particular terminal strategy but this does have implications for twinlift. If the 20 foots are being transhipped and are paired up on the vessel as per the current discharge port but not by the onward and final destination then they may opt to single lift discharge the units. This may not sound entirely logical but you need to remember that the terminal is not only considering the stacking on the vessel but the stacking in the yard and how that will impact both the discharge operations on this vessel and the load operations on the next vessel. Different destinations and connections will be stacked in different areas of the yard. If the 20 foots are loaded onto the truck (or prime mover) as a pair (but not paired by final destination) then it will have to drive to two different areas of the yard so that each container can be stacked in the yard separately. This will result in a longer driving distance and a longer cycle time to get back to the crane. For the terminal, they will either have to assign more prime movers to the crane or accept a loss in GMPH whilst waiting for prime movers to return to the crane. More resources always equals more costs for a terminal (labour, fuel, prime movers etc). An alternative is to take all the 20 foot pairs to a yard dumping blocks and just stack them all together in the yard. This removes the need for additional resources at the discharge stage and will allow the crane to maintain the GMPH level but it will require the terminal to perform 'house-keeping' moves to separate and stack them correctly later. Again, more cost. If there house-keeping moves are not done then it is likely that the units will have to be single lifted onto the onward connecting vessel.

Some more specific requirements that a terminal may impose are not twinlifting of reefer or hazardous units. This is normally done because these units are segregated into different areas of the yard (reefers still require power and only specially equipped slots in the yard can provide this). Some terminals may cite safety restrictions as a barrier to twinlifting these units.

If we exclude the reefer and hazardous limitations but adhere to the weight limit requirements then it is realistic to expect that between 80-90% of 20 foots have potential to be twinlifted with the large gain in productivity to go with that.

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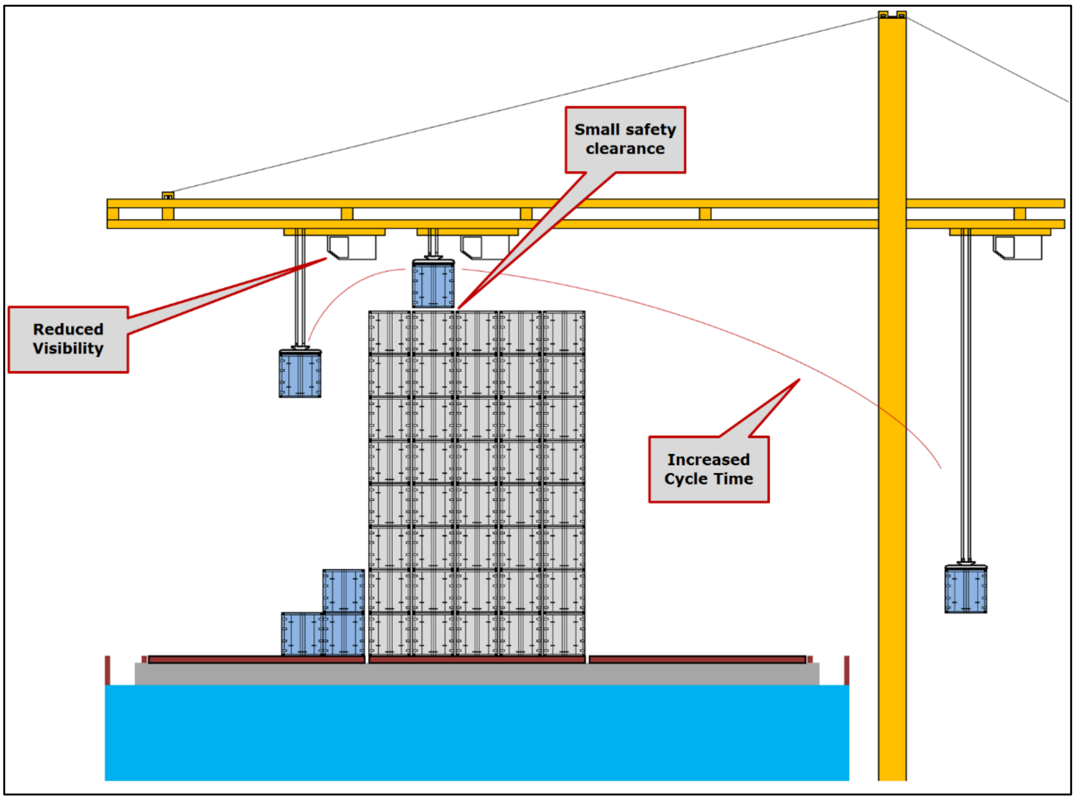
Shorter port stays lead to lower fuel consumption as a vessel sails to each port in the scheduled port rotation. To facilitate this, there is an ever-increasing demand to deliver higher numbers of cranes in the stowage to each of the ports. The logical theory being that the more cranes that can work on a vessel simultaneously, the higher the BMPH that can be achieved and the shorter each individual port stay will be.

This can be very effective in services that have a relatively short port rotation (i.e. 3 ports in Europe, 3 ports in Asia). High numbers of cranes can be delivered to each terminal and the vessel can be set up in such a way that a port will completely discharge and then completely back-load entire bays. If the stowage and the port rotation allows for the coordinator to deliver these large, consolidated bays (i.e. 6 cranes, 6 entire bays), then high levels of productivity can be achieved.

Due to the increasing size of vessels, there is a pressing need for shipping companies to fill these vessels in order to achieve the economy of scale that modern neo post-Panamax vessels offer. With shipping companies trying to attract customers to fill these vessels using a diverse range of products to suit every need, port rotations can increase up to 20 or 25 port calls. Virtually every port in that rotation will have the same intense focus on BMPH and overall productivity, often due to agreements signed with the shipping lines, the lines themselves are still looking to reduce the all important fuel consumption and, as a result, high numbers of cranes will be required for each port in the rotation.




Given that a ship is a fixed length and a gantry crane is a fixed size, there is a limit to how many cranes can physically work on a vessel at any one time. For example, a ship with 22 bays would physically support 11 cranes, assuming each crane requires 40ft of separation from the adjacent

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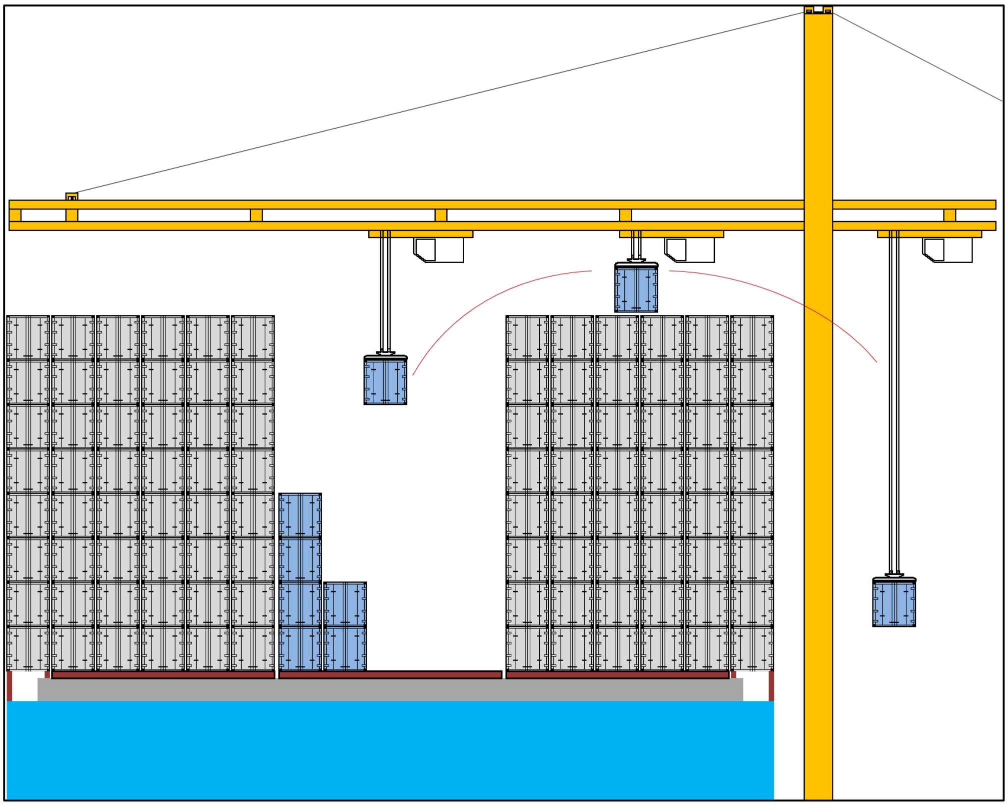
crane. However, it's not enough to consider what is possible in one single port, one must also consider what the service overall requires in order for the vessel to maintain the planned schedule.

If you first go with the idea that consolidating the cargo into single large bays will give you the highest productivity possible the you will immediately run into a problem with a service that has a medium to long port rotation. If the vessel has 22 bays and you are only loading one port of discharge into each bay then you will (in a number of sequential ports) be able to use a maximum of 22 cranes to load the vessel. When you discharge the same bays in later ports you will also use 22 cranes. Therefore, the vessel will support a maximum number of 44 cranes on the service. This is actually quite limited when you consider that for an average service of 20 ports, using the same vessel you will need to deliver about 90-100 cranes just to maintain the schedule.

If you look at a vessel where each bay is split into three separate hatch covers, but you also assume that in order to avoid torsion problems with the vessel you will have to stow symmetrically (i.e. one port of discharge in the wing hatches, another port in the centre hatch). We still only have 22 bays but just by splitting those bays into two different discharge ports, you will now easily be able to deliver 90 cranes on the service. This may not yet meet your overall requirements but not it is simply a matter of splitting some of those bays further in order to deliver the required number.



So, we have solved the crane delivery problem by looking at how we allocate space to cranes on the vessel. All good? Not quite. As with virtually everything in stowage, this comes at a cost and, in this instance, that cost is terminal productivity.

Whenever we load more than one port of discharge into a bay it is inevitable that, at some point, at least one crane will have to work over the top of containers on deck that have been loaded in an

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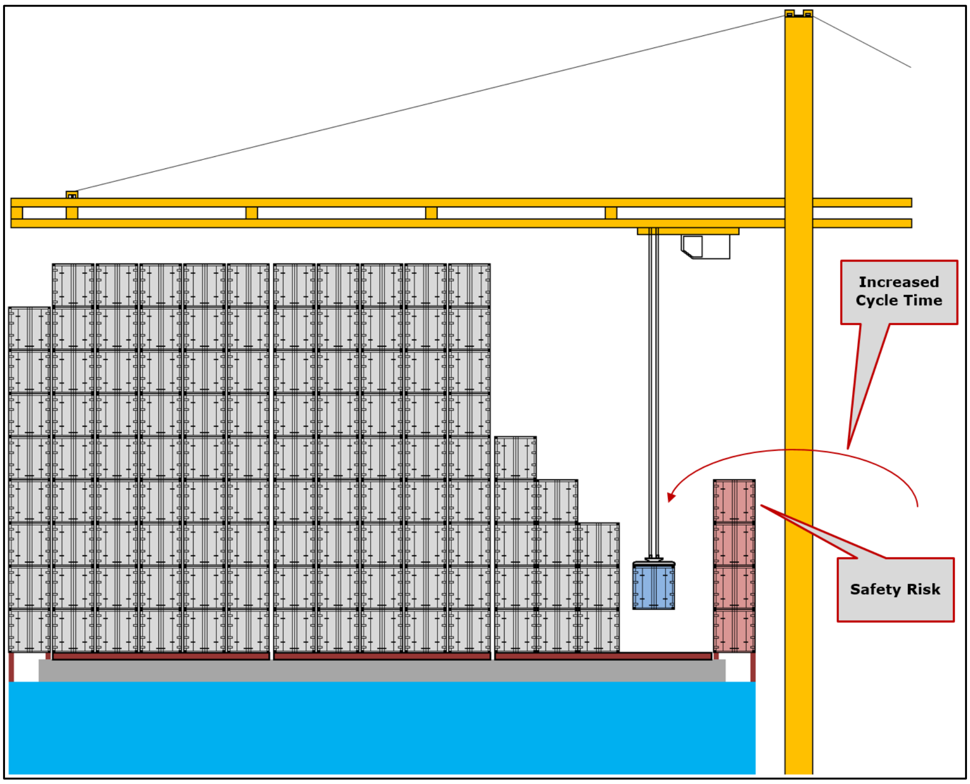
earlier port in the rotation. These towers on deck are known as Manhattan Towers. Whereas with our consolidated bays the crane had a completely clear deck in front of it, now that same crane will have to lift the containers on the offshore side of the vessel up and over a tower that may be up 8 or 9 tier high. This will significantly increase the distance that the containers have to be moved thus increasing the cranes “cycle time” and lowering the GMPH.

Aside from the fact that there is an additional distance to be travelled, there is also the proximity of the stack to the crane that has to be considered. When the clearance between the container being lifted and the containers onboard the vessel is limited, the crane driver will have to slow down because it becomes harder to judge the available clearance. Misjudgements can lead to accidents. If the crane hoists the container too close to the top of it’s range, then it will reach the point where the limit-switches kick in and automatically slow the crane down.

All of these combined will lower the GMPH. If this is happening on many of the cranes working on the vessel then there will be a corresponding decrease in the overall BMPH of the vessel as well. In order to combat this, the answer is often to plan for more cranes in each port. This general thinking being that even with the increase in towers that more cranes create, this still gives an overall positive benefit to BMPH by compensating for the lower GMPH on each individual crane.

The definition of a tower will vary from terminal to terminal. If the vessel has a single outboard row that is independent of the hatch cover, it may only be loaded 3 or 4 high but due to the risk of colliding with the outboard row, a terminal will likely classify this as a tower.




Finally, there is the probability that the final terminals in the port rotation will have to go into bays that have been loaded in earlier ports and “top off” the cargo. This is usually due to the higher GM

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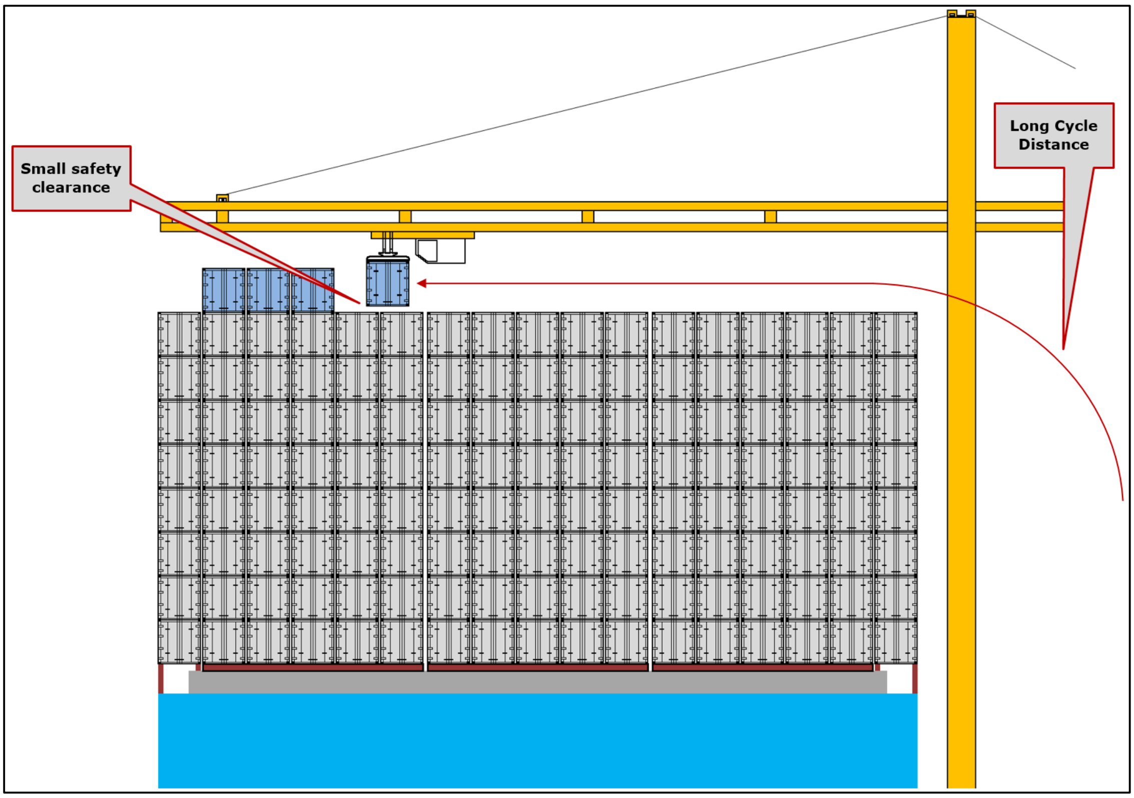
in earlier ports not allowing for loading up to the top tier on deck. By the last port, the GM will be lower and the top tiers can be loaded. While this is very bad for the terminal productivity, it allows the line to fill the vessel and that's where the money can be made.




Other reasons for this practice and other "low move bays" can be:

1) **Container Numbers**

When we receive a loadlist, the number of units for each POD are unlikely to correspond exactly to the size of the bays available on the vessel. Planners will still have to load the "left-over" units on the vessel which can lead to a low number of units being stowed on particular bays.

2) **Special Cargo**

IMO units cannot simply be stowed anywhere on the vessel. There are rules governing specific bays or holds that can accept IMO cargo on the vessel. There are also specific requirements for the compatibility and segregation of IMO units from one another. For these reasons, VS will generally designate the forward bays of a vessel for the stowage of IMO units. These bays are well away from the accommodation, engine room and reefer locations. To maximize the IMO loadings and reduce potential safety clashes, when we load IMO units in the forward bays we will not usually fill the remaining space with non-IMO units as this creates issues further down the port rotation.

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**3) Data Quality & Updated Weights**

Container weight updates after sailing or terminals not correctly following the weight plan can lead to lashing and/or stack-weight errors. These can also be caused by changes in the vessel stability condition (draft, GM etc. This will often result in nominal numbers of units needing to be moved in a single bay.

**4) Stability & Lashing Forces**

When a vessel is relatively empty (such as in the mid point of a region) it is likely that it will have a high GM. When the vessel is at sea and is subject to the external forces of the weather (known as a dynamic seaway) it will roll from side to side in a short, violent motion (as opposed to a low GM which results in a slow, rolling motion with much lower acceleration forces). This puts more strain on the lashings that secure the containers on deck. As such, in the earlier ports, it is often not possible to load the complete bay all the way up to the highest tiers because we would exceed the lashing forces. When this is the case, planners have to stow as high as they can and then return to the same bay in a later port to load the remaining tiers on deck as the vessel GM reduces towards the end of the region.

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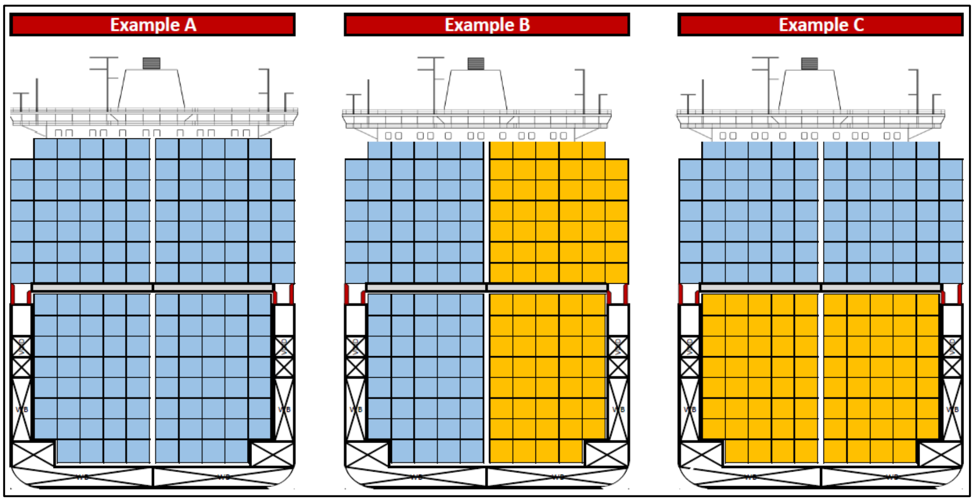
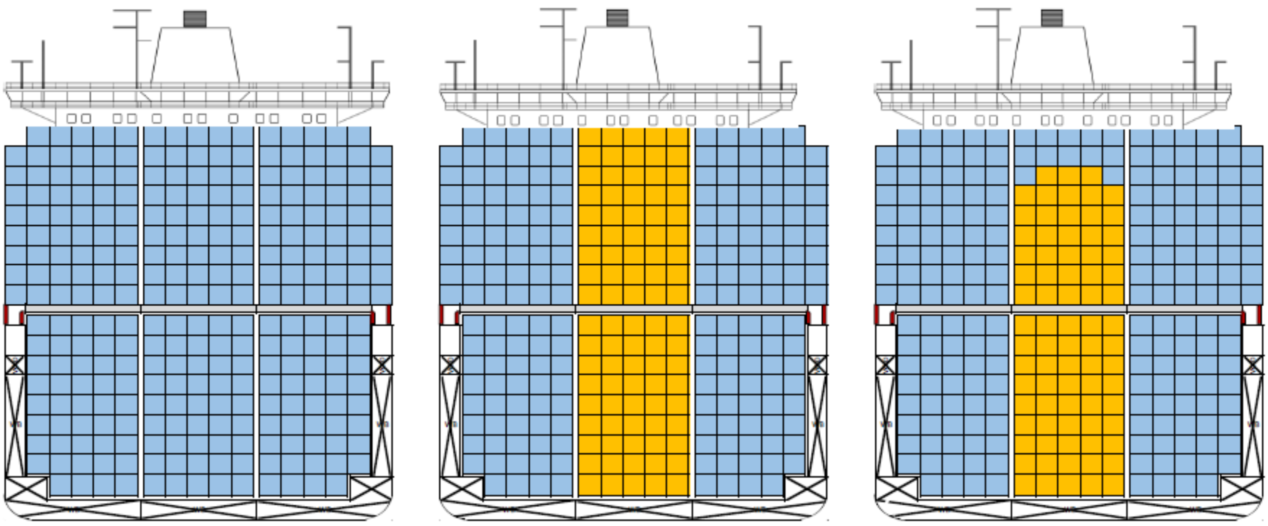
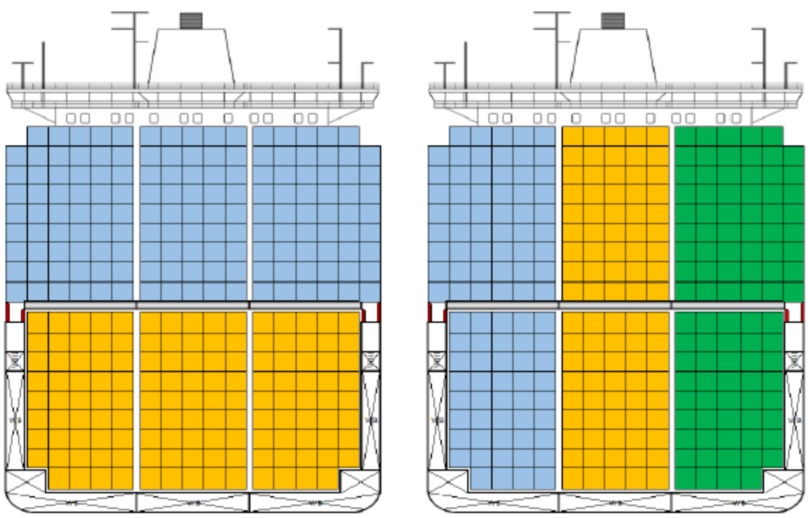
# Stowage for Different Vessel Sizes





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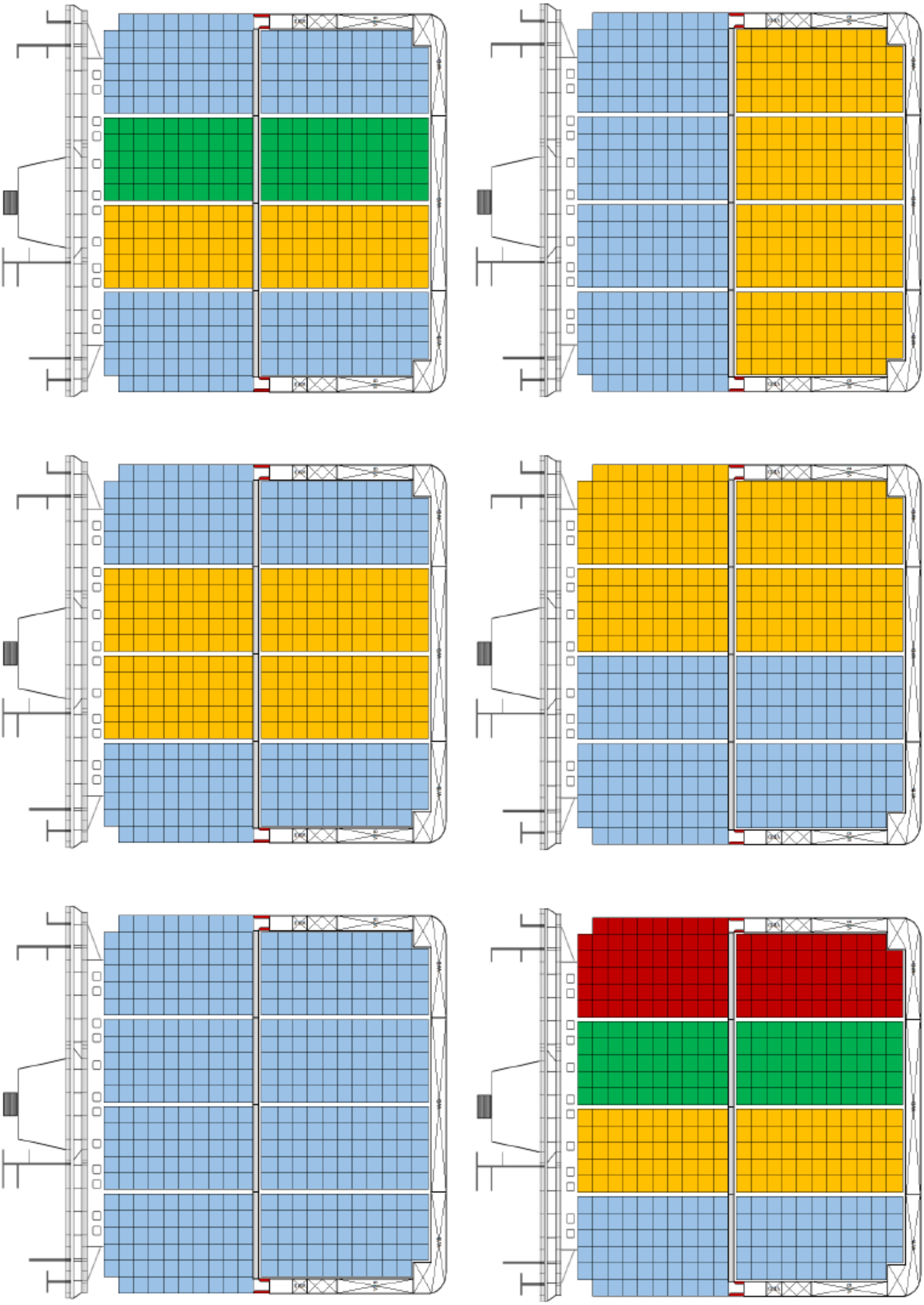
# Stowage for Different Vessel Sizes



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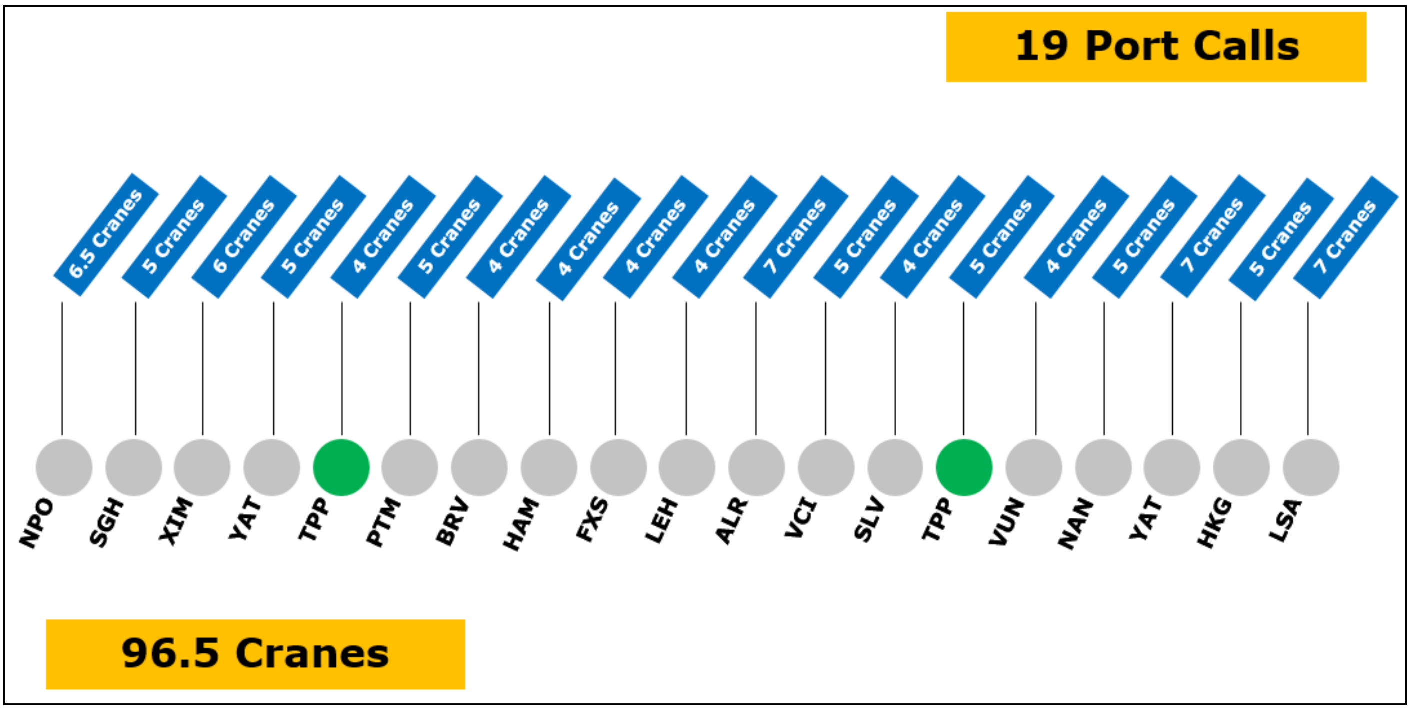
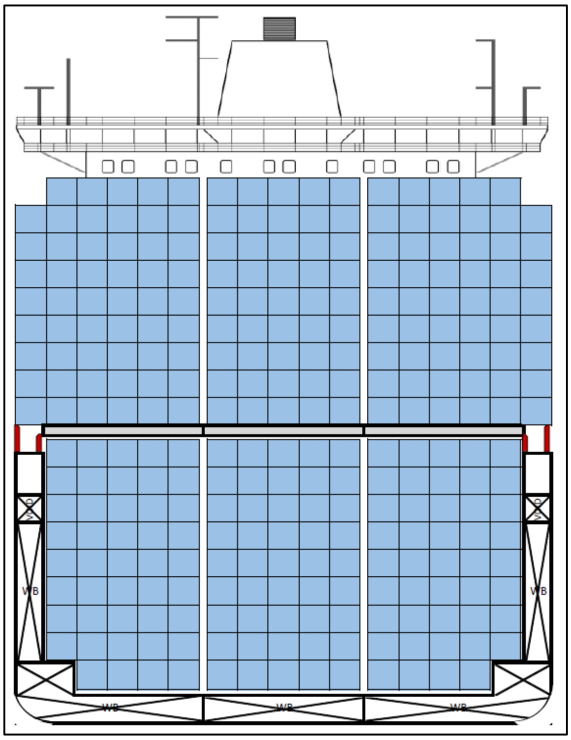
As mentioned in the chapter on Manhattan Towers, there is a loss of productivity for the terminal when working over these towers. This is one of the biggest complaints that terminals make to shipping lines. However, the terminals themselves are also part of the cause.

Every terminal wants high numbers of cranes deployable on a vessel. Since they usually get paid by the moves that they do, if they can get the vessel out faster, they can get the next one alongside and therefore make more money.

If we look at an example service from Asia to Europe we can start to see the problem:




Each port is requiring a relatively high number of cranes and the ideal scenario would be to have large, consolidated bays:



However, if we were to stow the ship so that each bay had only one port of discharge in it, we can easily see the problem (overleaf).

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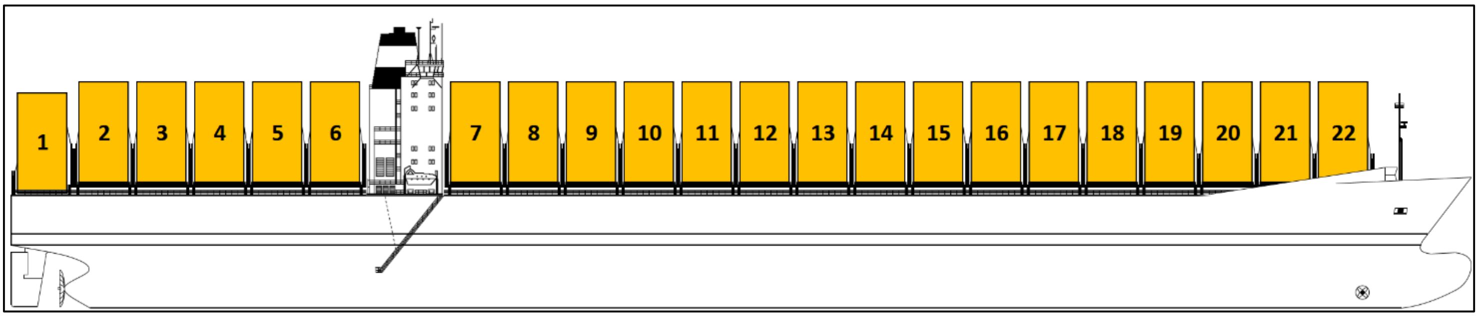
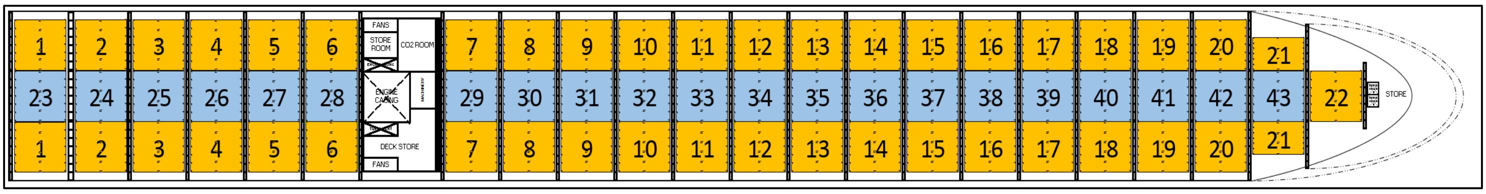
# Towers & Torsion



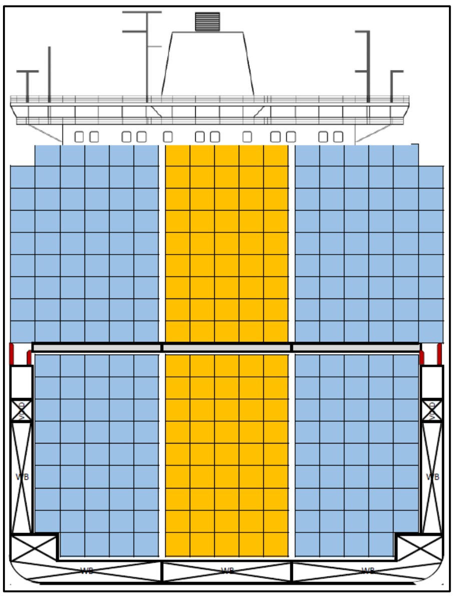

When the bays are purely one Port of Discharge, it is only possible to have 22 bays on a typical 9,000 TEU vessel. If you take each bays as one load and one discharge, you have a maximum of 44 cranes if the vessel is stowed this way.

However, if you were to split the bays into two ports of discharge, you will be able to deploy more cranes in more ports:

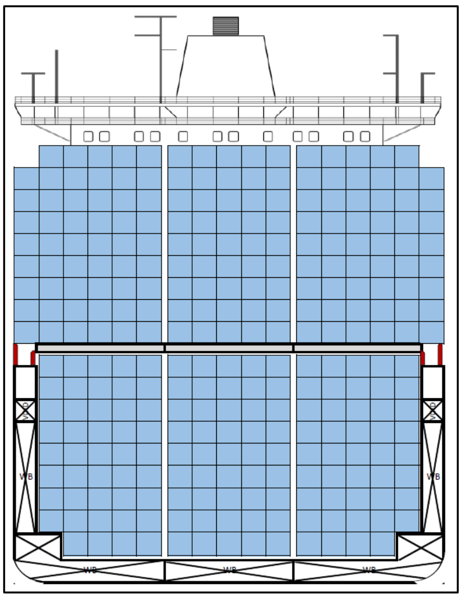



Using the same principle as above, you now have 86 cranes to work with but this is still short of the 96.5 target. What this means is that while the majority of the bays will be split into 2 POD's, some will have to be split further to accommodate all the crane requirements.

Whilst we have now managed to accommodate the crane requirements of each port, we have had to do so by creating Manhattan Towers which we know will have a detrimental effect on the crane productivity.



**VS**



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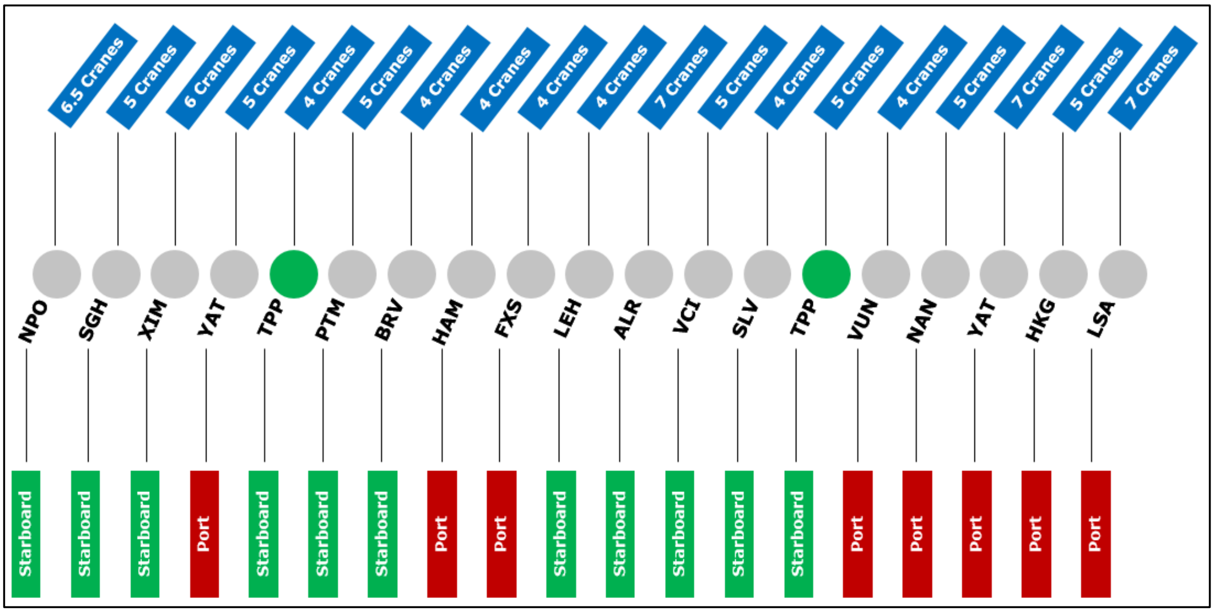
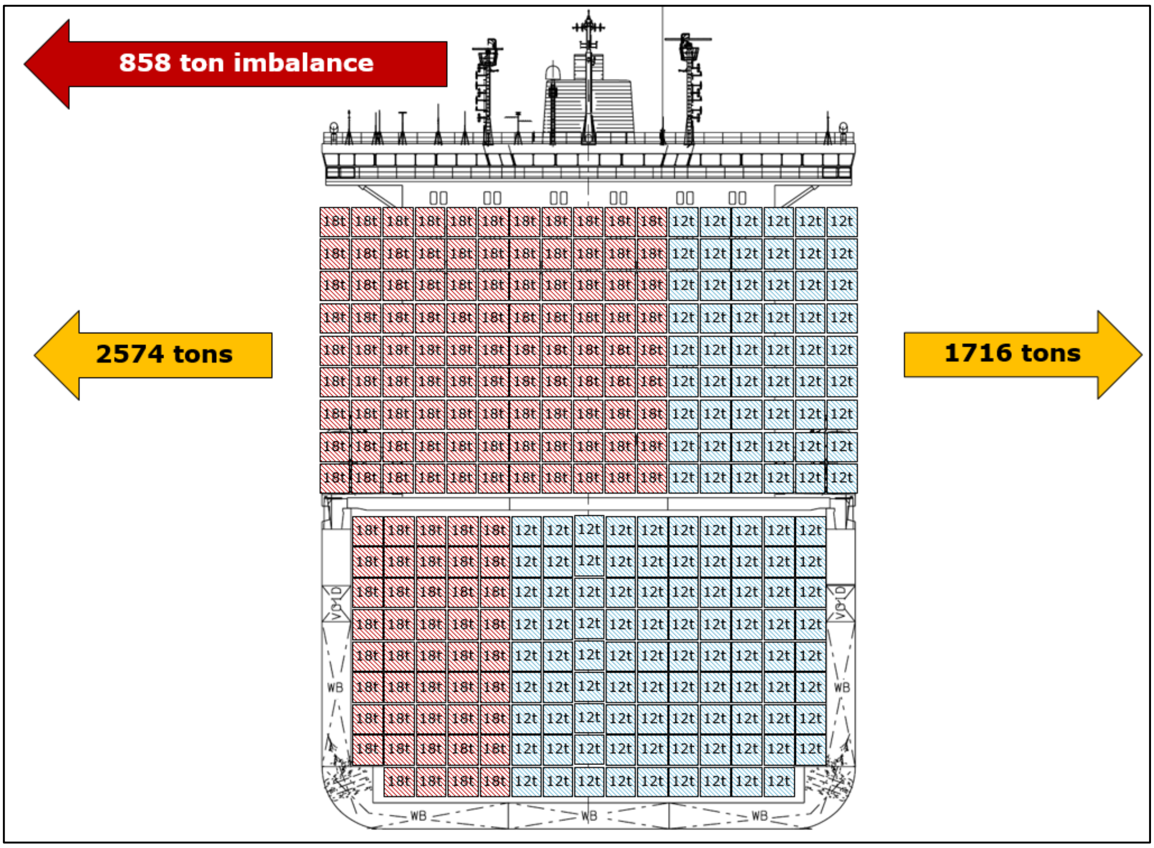
From the terminals perspective, the logical thing to do would be to stow one POD on each side of the vessel so that they don't need to work over the top of towers. Unfortunately, there are a couple of things that prevent this. The first is that although vessels berth either on the port of starboard side (depending on the terminal), it is not spread equally over the ports as seen in the diagram below:




Whilst this is an issue, it is not the major problem. The real issue is torsion issues with the vessel when the cargo is not evenly balanced from port to starboard.

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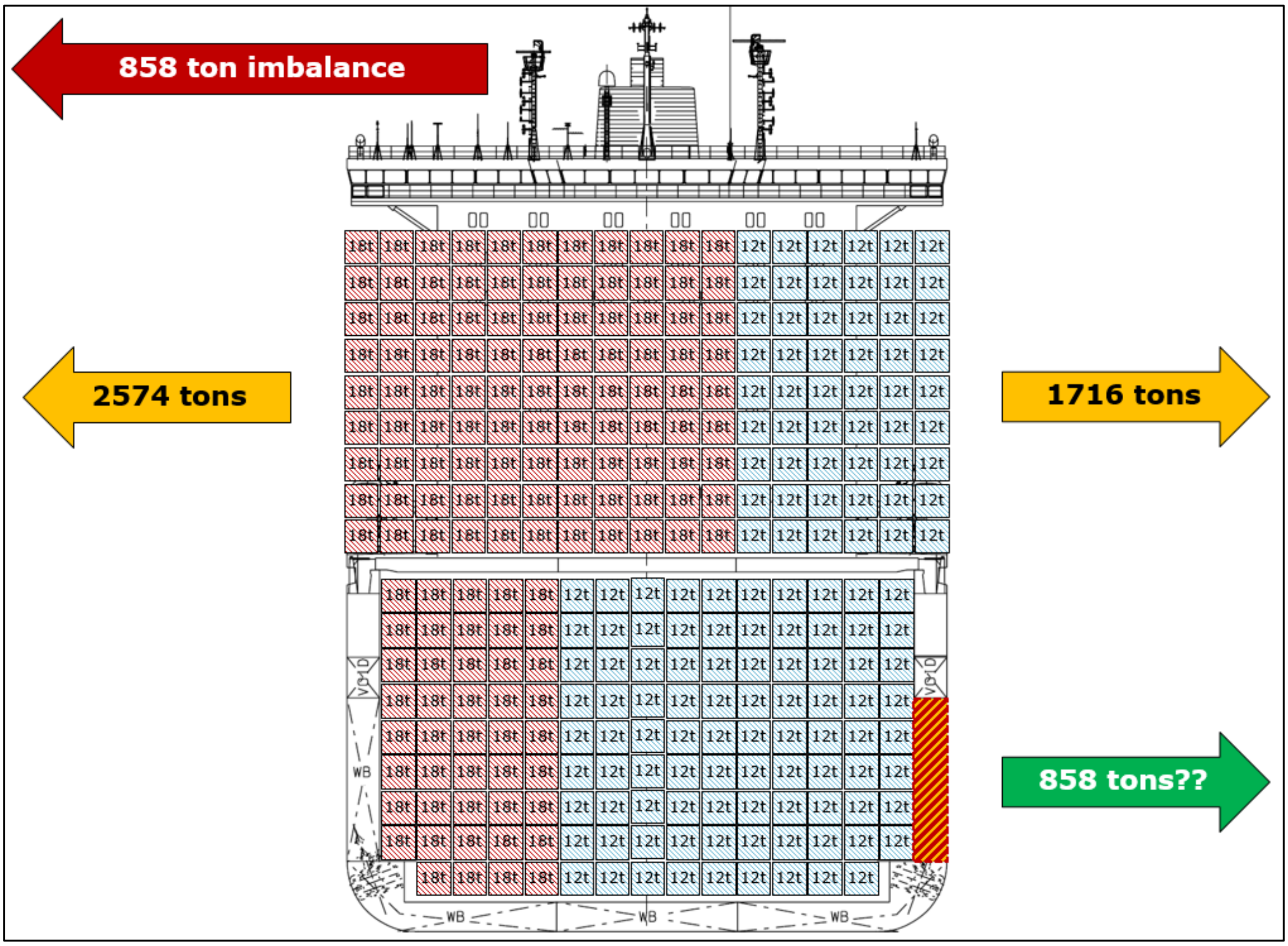
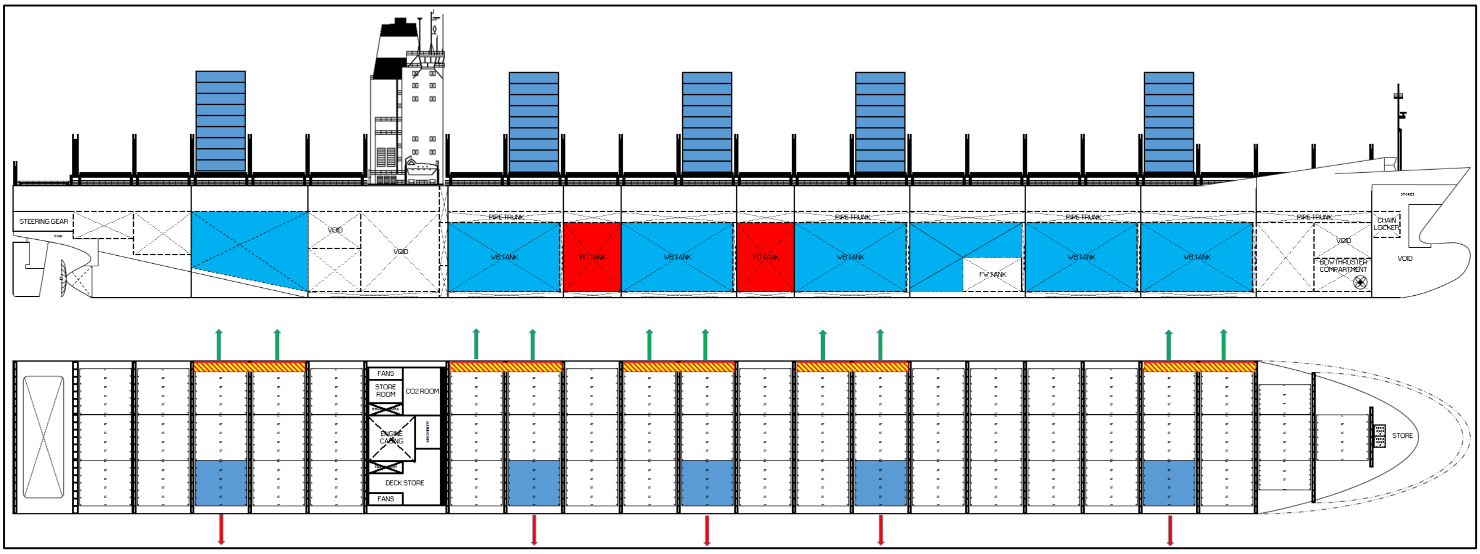
Again, looking at it from the terminals logical perspective, the answer would be to balance out the weights using the vessels ballast tanks:




The challenge with this approach is that although it is a good idea in theory, the vessel's ballast tanks do not line up with individual bays. So by adding ballast in one side of the vessel you create more torsion than you started with.



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To sum up, the root causes of this problem are:

**Port Rotation Length**

→ **Long port rotations require vessel to be split multiple times to deliver required CI.**

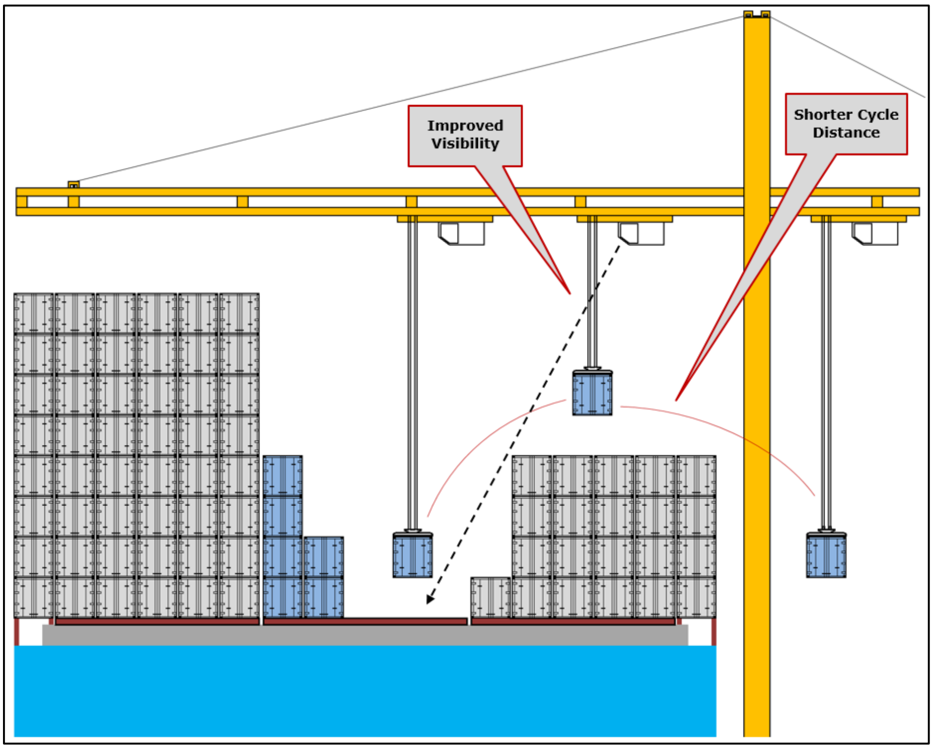
**High Crane Deployment**

→ **Ports want high CI to hit BMPH targets. What happens when we can't deliver?**

**Stability Requirements**

→ **Symmetrical stowage is one of the basic stowage principles to avoid vessel torsion.**

One solution that goes some way to resolving the problem is the practice of having less cargo on one side of the vessel in some bays so that a terminal doesn't have to work over such high towers. It's not a complete answer but it is a compromise between high CI and Manhattan Towers.

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How many cranes is the optimal number to deliver in a stowage? As with many stowage questions, the answer is that it depends on a number of factors. It is always related to what the coordinator is trying to achieve with this particular stow. What is the over-riding priority? It could be berth productivity, terminal flexibility or just the basic need to provide a minimum number of cranes in this particular port.

There are some basic concept to understand about what the number of cranes will do to the port stay and terminal operations.

Often, there is an assumption that a planned crane intensity should be as high as possible. In fact, the higher the better. But is that really true? That depends on the number of cranes that are actually available. Assuming that we have a high number of cranes physically available in the terminal for this vessel, then the logical conclusion is that if we plan for the maximum number of cranes and the terminal can deploy them, then the port stay will be shorter. This is not always the case.

There are a number of misconceptions surrounding the link between Crane Intensity and Berth Productivity. To start with a basic question:

**Does a higher CI equate to a higher Berth Productivity?**

The answer is, it depends. But what does it depend on? It comes down to whether there are more cranes available to deploy. If there are additional spare cranes that can be made use of then it absolutely makes sense to deliver a higher CI. In this instance, a higher CI will equate to a higher berth productivity. When there are no additional cranes available, berth productivity will suffer.

**So, if no extra cranes available, should we aim to deliver precisely on proforma?**

No, this isn't a good thing either. When we create a stowage and the terminal creates their working sequence, it's a plan, it's all theoretical. Neither plan takes into account the real world challenges that a terminal faces when they start to work the vessel. When we plan precisely for proforma cranes, we are not taking into account the operational losses that occur during the port stay:

- Shift Changes
- Meal Breaks
- Crane Movement Between Bays (Gantrying)
- Hatch Cover Moves
- Low Move Bays
- Crane Movement Past Accommodation (Boom Up/Boom Down)
- Gear Box Movements
- Different cranes work at different speeds (Operator Efficiency)

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I have excluded crane breakdowns from the list as this is not something we should plan for. In a terminal with spare capacity they may simply bring in another crane, in other terminals we will have lost the crane completely.

So, it is better to plan slightly higher than profoma?

**How much above proforma is an optimal amount?**

0.5 Cranes is a good indication. A well performing terminal will generally manage to keep their operational losses to within 0.2-0.5 cranes throughout the entire operation. By slightly over-planning the CI, we are now taking into account the realities of vessel operations and the terminal should end up with an approximately even crane split and a CI close to proforma (note this excludes any crane breakdowns).

**Does it sometimes make sense to over-deliver on the CI?**

This depends on the terminal the vessel is in. If there is additional (and available) crane capacity then a higher CI will allow for the terminal to deploy additional cranes and equate to a corresponding increase in BMPH.

If you look at terminals globally, there are some regions where this may be achieved fairly easily, others that may require some pre-planning and those where it cannot be done. Terminals that are in regions where there are labour unions and labour issues are less likely to be able to deploy additional cranes on an adhoc basis. These are the terminals that book the labour by the shift and have to pay even if the labour is not fully utilised. This cost is for the terminal account so it is in their interests to have fewer gangs to work a vessel (assuming it can sail on proforma). This includes most of **Europe, US, Middle East, Japan, Australia and New Zealand.**

Terminals that do not have these issues have a lot more flexibility in terms of crane deployment. Generally this is limited to **PRC terminals.** They have the crane capacity and they do not pay for labour in the same way as terminals elsewhere.

So, if we over-deliver on PRC stowages then there is a good chance that the higher CI will equate to a higher BMPH. If we want to over-deliver anywhere else, we need to be communicating to find out whether there are additional resources that we can make use of (and that is makes sense to use).

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**What happens if we over-deliver CI but there are no additional cranes available?**

By delivering additional CI but with no additional resources available, we are creating much more operational losses during the cargo operations. Higher CI will result in:

- Additional crane movement between bays
- More bays worked with lower average moves per bay (Low move bays)
- More hatch cover moves
- More potential for shifting cranes past the accommodation
- Additional gearbox movements

All of these will result in a loss of BMPH and a lower Berth Productivity than we could have achieved by staying within 0.5 of the proforma cranes.

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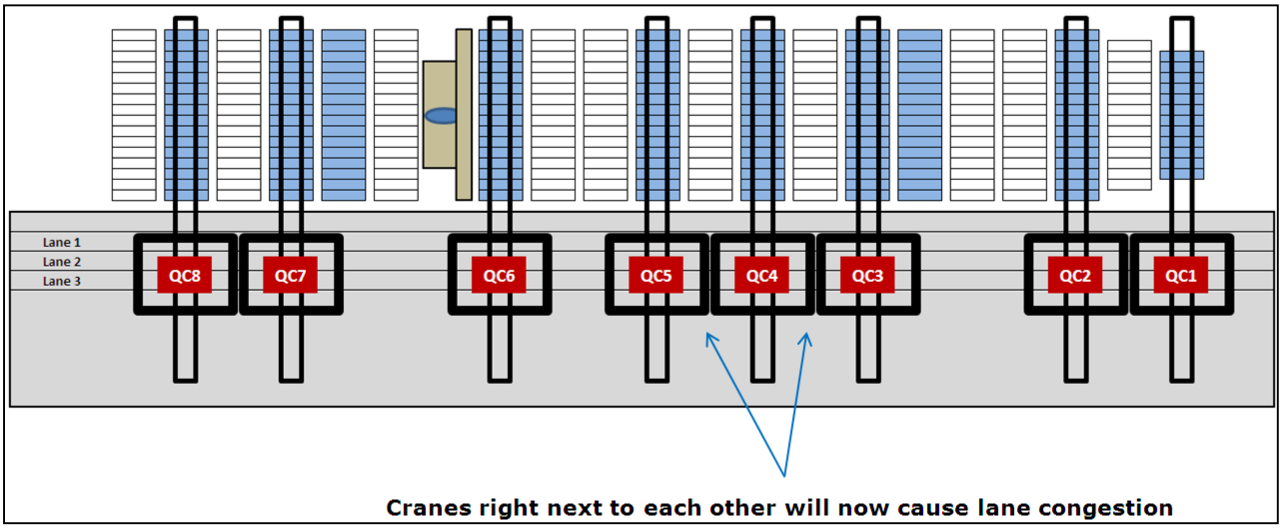
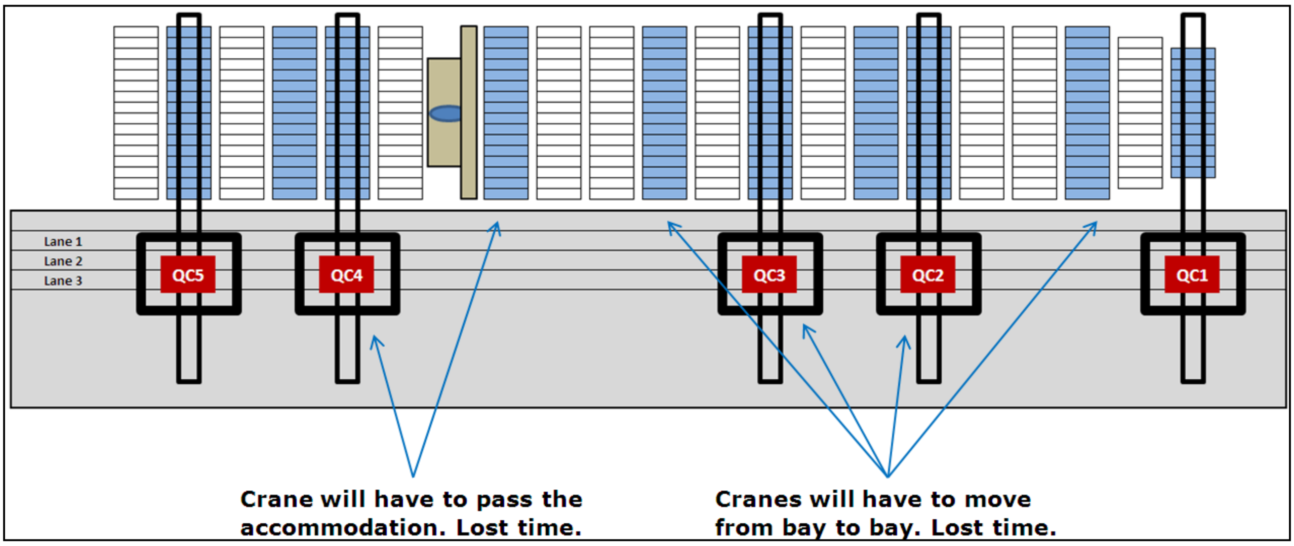
## Crane Deployment

If the terminal deploys more cranes that the Crane Intensity we deliver, this can have the effect of hiding the operational losses when we look at the final BMPH, but it is a very inefficient way of working.

Over deployment will result in cranes working very close together, loss of lane use underneath the cranes and congestion on the quay:




If we over-deliver on the CI, the end result is more crane movements, more hatch moves, lower average moves per bay and ultimately, more operational losses and lower berth productivity.

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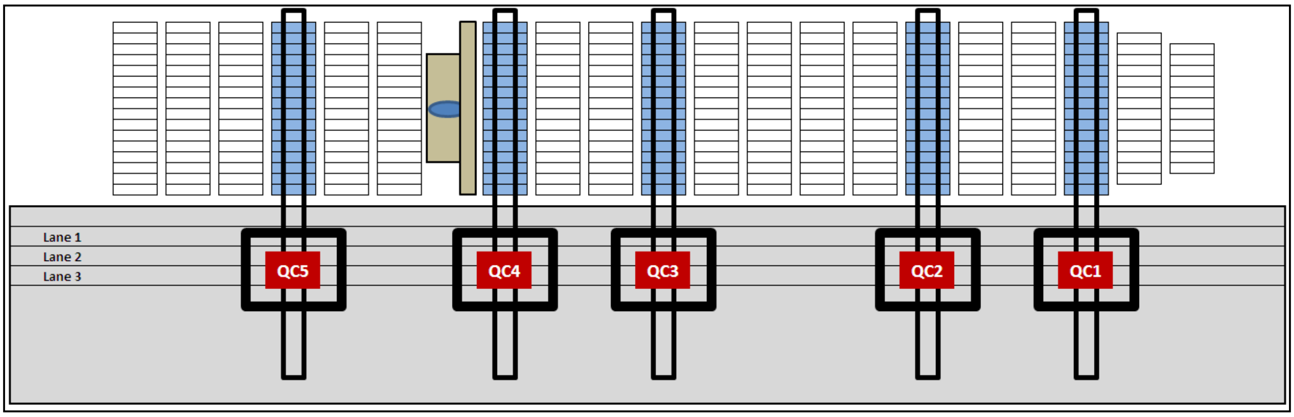
The diagram below shows a CI that is approximately the same as the crane deployment. This means there are very little operational losses built into the plan. The cranes can stay in the same location for the duration of the port stay. No crane needs to boom up and move past the accommodation. Hatchcovers movements are kept to an absolute minimum and the average moves per bay is as high as it can be.

On the downside, this plan does not build in a "buffer" for the expected operation losses. From a terminal perspective, this is a bit of a risky plan. If one crane works slower than the others or there is a breakdown, there is no opportunity for them to shift the work sequence around.

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**Crane Intensity Evolution:**

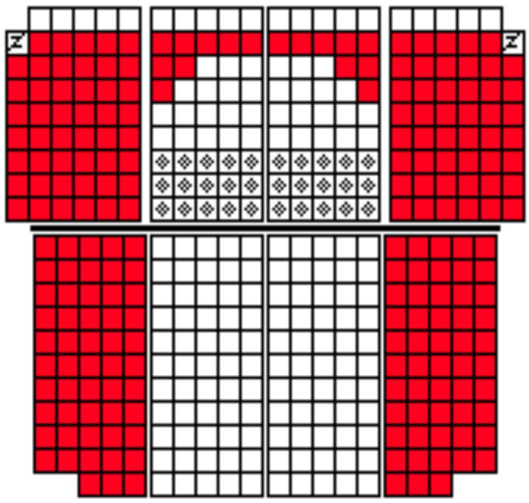
A planner currently stows for a specified amount of cranes in each port in the rotation. This is usually determined by the number of moves, the berthing window and the number of cranes available.

Until now, when the planner has been asked to estimate how many cranes a specific move-count will support, a general calculation has been made. For each vessel type, a certain number of moves will justify one extra crane.

For example, a 15,000 TEU vessel will require about 450 moves as a minimum for each crane. Where does this 450 moves come from?

We take the largest bay on the vessel and assume that the wing hatches, plus the centre wind-stacks, will be loaded and discharged (See diagram). This comes to 450 moves:

- This allows certain assumptions to be made on what scenarios are likely to be encountered and offers the optimal combination of flexibility within the stowage and high CI.
- Symmetrical stowage in this way reduces the ballast required and keeps the stowage within the vessel torsion limits.



There is a downside to this approximate calculation. When we have port calls that involve fairly low move counts, the crane intensity will be correspondingly low. When we have very high move-counts, the implication is that VS will be stowing for much higher numbers of cranes than is practical.

For example 4500 moves suggests 10 cranes. That may be physically possible (depending on vessel size) but has detrimental effects on ports either side in the rotation.

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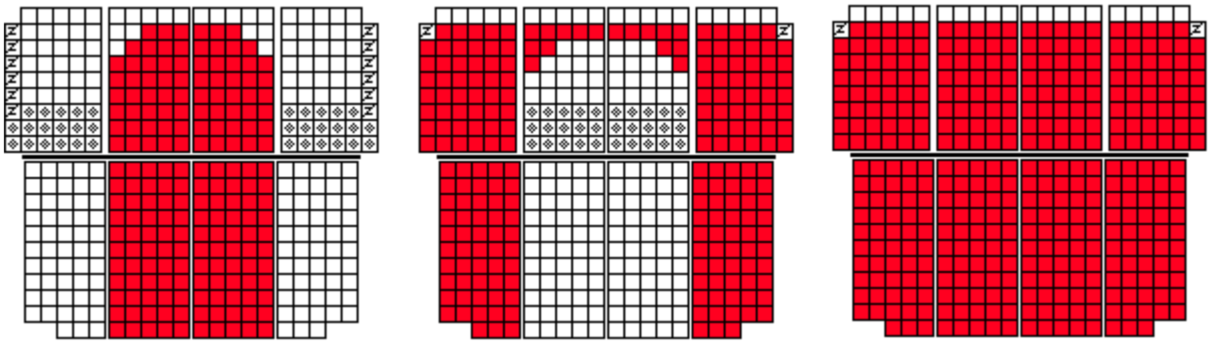
When we look at how a coordinator stows a vessel, it can be seen that as the move-count varies, the way the bays are loaded also changes.

If we have low move-counts, there is a tendency to stow just in the centre of the hatches. For move-counts around the proforma, the wings are used and for very high move-counts, full bays tend to be favoured:



The reason for this changing stowage technique is that each option will deliver an optimal number of cranes for that move-count without adversely impacting the other ports in the rotation.

In order to cater for high CI's combined with the number of ports in Maersk Line services, it is necessary to use the above techniques and divide the vessel into multiple "sections".

Dividing the vessel to increase CI has the following negative effects:

- Increased working over Manhattan Towers (port/stbd loading is not a practical solution to this due to vessel stability requirements).
- Increased restows for lashing and wind-stack correction (VS could improve on the wind-stack restows).
- Increased ballast and bunker consumption to compensate for the towers.
- Decreased dual cycle potential (unless stowing for the full bay option)
- Decreased tandem lift potential (mainly in Asia).
- Increased crane gantrying required.
- Increased hatch-cover lifting (potentially).
- Increased instances of low move bays.
- Increased restows in case of port swaps or omissions.
- Lower productivity due to fewer average moves per bay.

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## Crane Intensity – The Next Stage

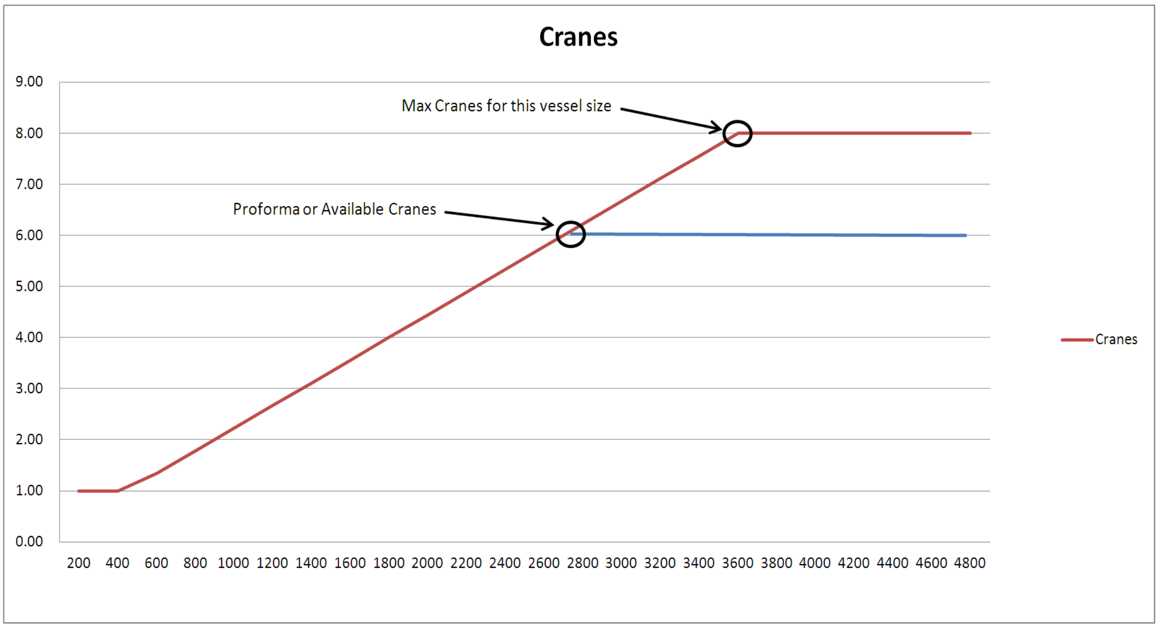
Taking the idea of different stowage techniques for different move-counts on step further, we are exploring the possibility of generic CI calculations based on move-count and vessel types (the CI bracket concept, but not terminal specific).

If we can determine at what move-count we switch from centre hatches to wing hatches to full bays then it may be possible to incorporate the CI brackets into the Stowage Quality Model. This would then be applicable for any port or service. The only requirement would be to have done the calculations for that particular vessel type.

The graph below shows the concept:

**9000 TEU or more**
**450 MPC**
**8 Cranes Max**

| Moves | Cranes |
|---|---|
| 200 | 1.00 |
| 400 | 1.00 |
| 600 | 1.33 |
| 800 | 1.78 |
| 1000 | 2.22 |
| 1200 | 2.67 |
| 1400 | 3.11 |
| 1600 | 3.56 |
| 1800 | 4.00 |
| 2000 | 4.44 |
| 2200 | 4.89 |
| 2400 | 5.33 |
| 2600 | 5.78 |
| 2800 | 6.22 |
| 3000 | 6.67 |
| 3200 | 7.11 |
| 3400 | 7.56 |
| 3600 | 8.00 |
| 3800 | 8.00 |
| 4000 | 8.00 |
| 4200 | 8.00 |
| 4400 | 8.00 |
| 4600 | 8.00 |
| 4800 | 8.00 |




We would read the move-count, look up the vessel type and that would then show the Crane Intensity required.

MPC stands for **M**oves **P**er **C**rane

***Please note that the graph above is just an example and should only be used for reference.***

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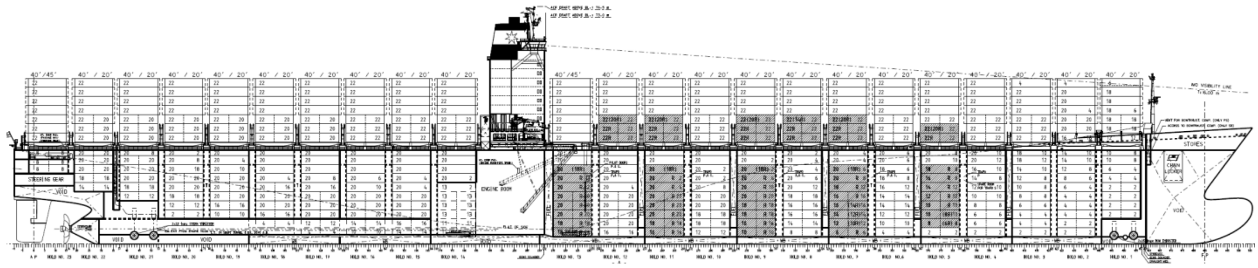
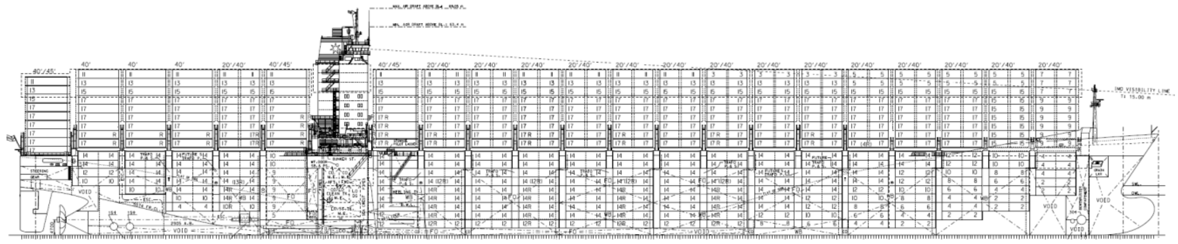
**<u>Vessel Groups</u>**

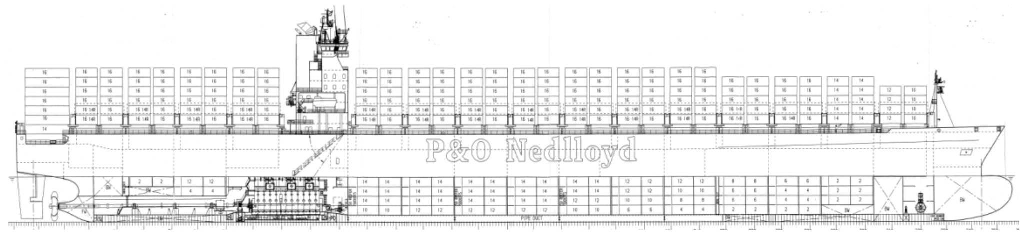
The first thing we can do is to spilt the fleet into vessel groups:



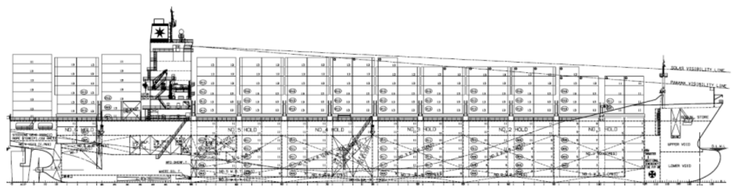
<u>9000 TEU and above – Maximum 8 cranes, MPC 450</u>



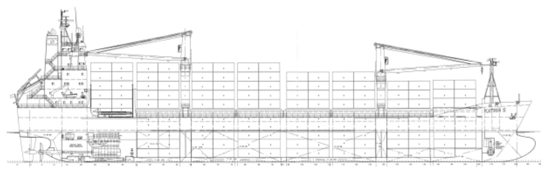
<u>6000–9000 TEU – Maximum 7 cranes, MPC 350</u>




<u>4000–6000 TEU – Maximum 6 cranes, MPC 300</u>



<u>2000-4000 TEU – Maximum 5 cranes, MPC 200</u>



<u>0-2000TEU – Maximum 4 cranes, MPC 150</u>

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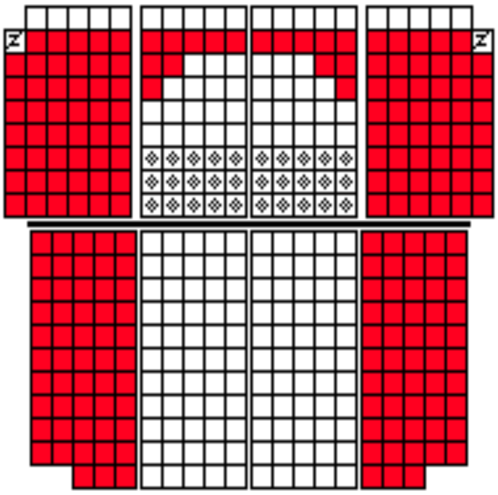
**How do we get the MPC for each vessel group?**

We take the largest bay on a vessel and calculate how many containers it will take to load and discharge the wing hatches, plus centre windstack stowage.

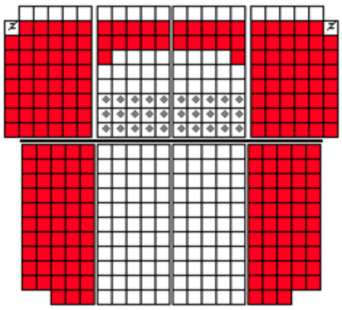


For the PS class (9000 TEU and above) this 450 MPC

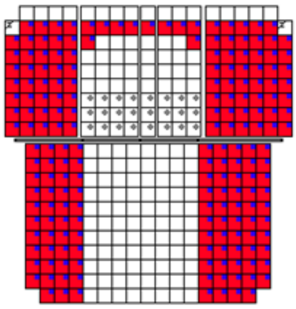
**Dividing the vessel up into these "sections" allows for the following:**

- Optimal balance between delivering High CI and stowage flexibility.
- Symmetrical stowage avoids torsion and ballasting issues that result in additional restows.
- Completing a "section" will reduce grocery moves.

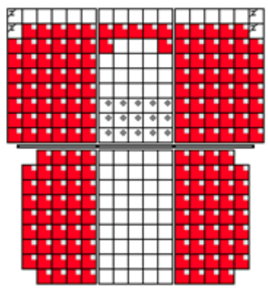
Examples



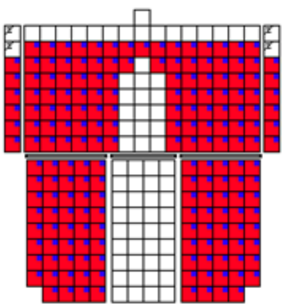
Emma Maersk - 444 MPC



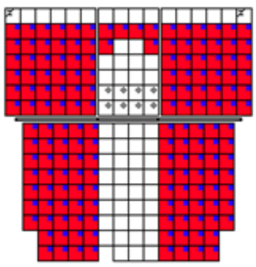
Maersk Eubank - 386 MPC



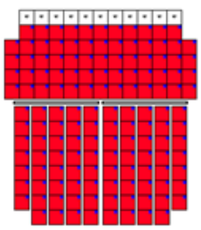
Margrethe Maersk - 374 MPC



Sovereign Maersk - 378 MPC



Maersk Semakau - 328 MPC



Jervis Bay - 282 MPC

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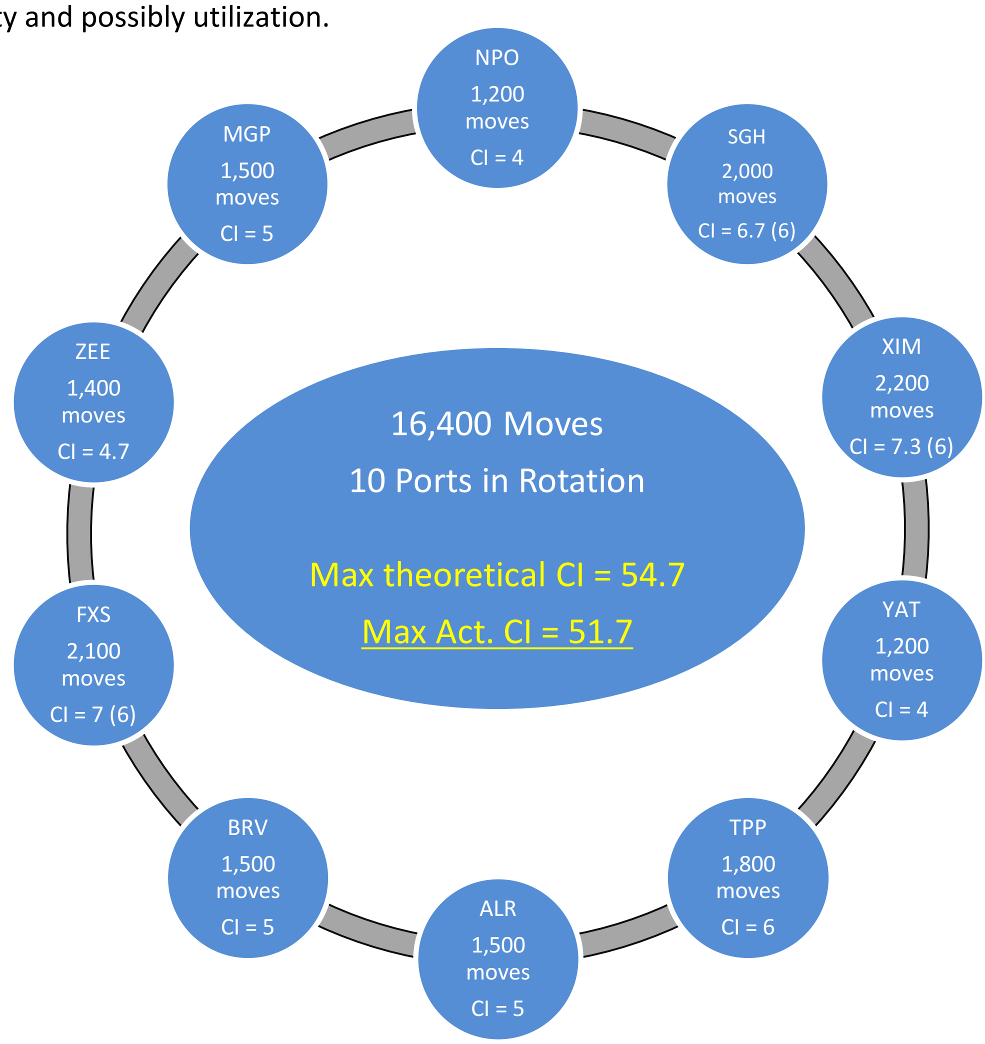
**Maximum Crane Intensity Theory**

Going one stage further than this is the idea of looking at whether it is possible to determine a maximum **voyage** crane intensity i.e. on the whole round trip, what is the maximum number of cranes that can be planned for? Then we can look more closely at how the resources are allocated between the ports.

We are able to see how many cranes (in total) are theoretically possible on any given service/vessel type and then look into the services as they are currently setup and determine whether there is potential for increasing the number of cranes we stow for. Increasing the number of cranes in the stowage only makes sense when the cranes are actually available for us to deploy. Simply increasing the CI without increasing crane deployment may mean a reduction in cranes in a later port where we do have cranes available.

Single ports in single bays would be the ideal scenario but the length of the port rotations exclude this as a realistic possibility on the majority of the Asia to Europe networks. In order to allow for an increase in the max CI capability, planners have to divide the vessels further and introduce mixed bays and up/down stowage. This will increase the potential max CI but at a cost to terminal productivity and possibly utilization.

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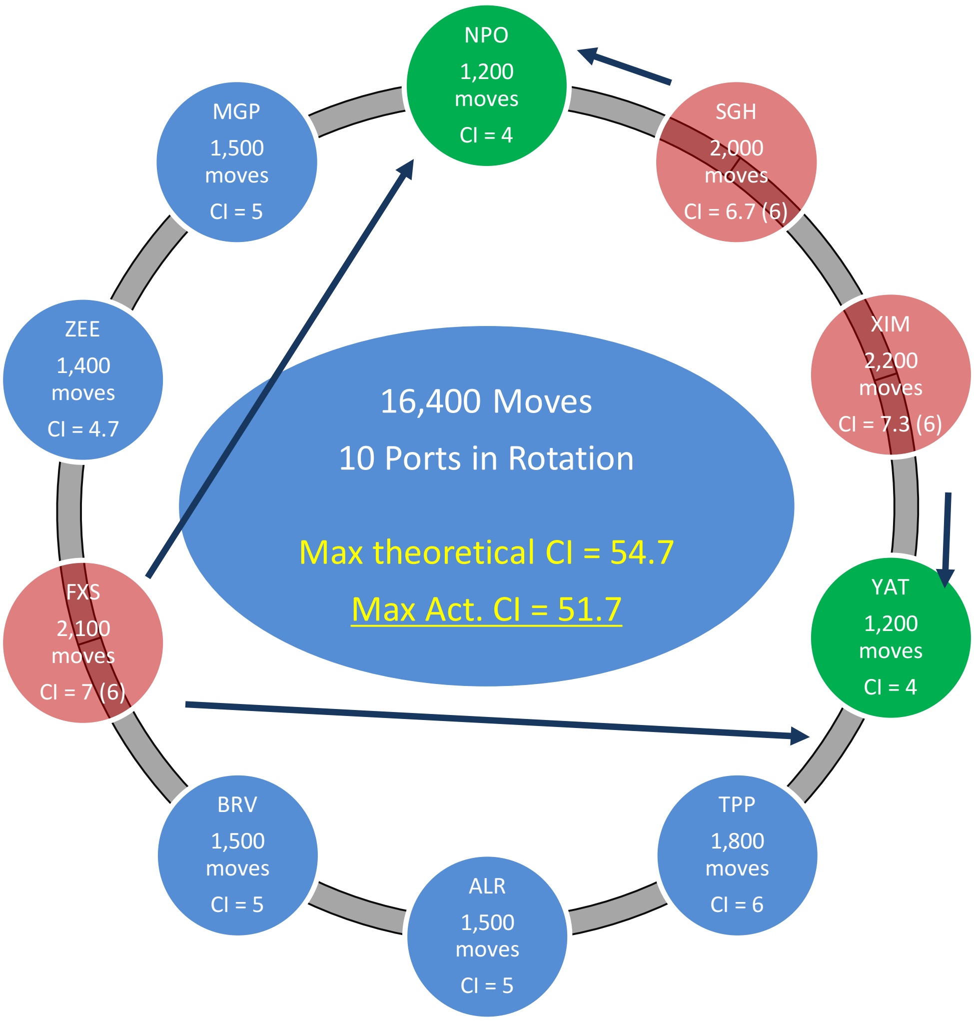
In these examples, it can be seen that the Max CI for the voyage is 60. It is possible to increase the CI for a specific port, but those cranes have to be deducted from a port later in the rotation.




For this example, we know that we cannot exceed 6 cranes for this vessel so we (potentially) have 3 spare cranes on this service in FXS, SGH and XIM.

Looking at the remaining ports, we need to determine which ports are likely to have additional available cranes.

From these ports, we need to look at the GMPH to determine where we could make the most gain by re-deploying those "spare" cranes.

In this example, the likely candidates would be YAT and NPO.

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Dual cycling can be a very effective method for a terminal to increase its productivity, if they have the capabilities and expertise to execute it. During normal operations, when single lifting, the crane is only handling a container for half of the total cycle time (from quay to vessel and back to the quay). This means that for the remaining 50% of the operation it is moving an empty spreader. This is quite an inefficient method of operation and dual cycling aims to capture that 'lost' operational time. Traditionally, a bay would be first discharged completely and then back loaded. Dual cycling combines the load and discharge operation into a single, continuous, work sequence. The crane will pick up a container and loads it on the vessel then picks up a container for discharge from the vessel before returning back to the quay for the next load container in the sequence.

There are a number of factors that need to be considered and in place, both from a stowage and terminal perspective, before a bay can be considered suitable for dual cycling operations.

Generally a terminal will require the same size/type of containers to be in a bay both for discharge and loading. This means that if 40 foot units are to be discharged from the bay then 40 foot units will need to be back loaded into the bay, it does not usually matter whether they are a combination of 8'06" or 9'06" high units. For example, if there are three tiers of paired up 20 foot units under deck and then six tiers of 40 foot units on top then the terminal is unlikely to consider this a bay that is suitable for dual cycle operation. While there are no physical restrictions that prevent dual cycling in this scenario, there are two main factors that are cited by terminals as a barrier to dual cycle.

Firstly, wear and tear on the spreader. If the crane operator is continually switching between 40 foot and 20 foot twinlift operation, this will put additional strain on the spreader. The fear being that, over time, this will lead to a higher rate of spreader malfunction and significantly reduce the lifespan if the parts are not being replaced frequently enough. This also comes down to the maintenance program that the terminal has in place. The second issue is safety related, particularly with night time operations. If the crane operator forgets to switch the spreader into twinlift mode after loading a 40 foot unit then there is a risk of significant damage to the cargo and vessel if the operator does not realise prior to lifting the units out of the hold. It will still be possible to lift the 20 foot pair up to the top of the hold while only using the single lift spreader mode as the cell guides underdeck will hold the pair together as the crane lifts. When the 20 foot pair is lifted clear of the hold, they will now separate and end up hanging from either end of the spreader. Not only will this damage the vessel and cargo if they fall back into the ship but it will also cause major damage to the spreader itself. Slightly less catastrophic but still nonetheless serious is if the spreader is landed on top of a 40 foot container whilst still set to twinlift mode. This will punch four holes in the centre of the roof of the container. Whilst both of these are valid concerns from terminals, it should be stressed again that they are not physical barriers to dual cycle operations.

Assuming the above conditions can be met does not automatically mean that all units in a bay can be dual cycled. Although it is theoretically possible to dual cycle all units on deck, it is not very practical in reality so on deck is normally considered as a single lift operation. Before cycling can be commenced under deck, space has to be cleared by discharging some of the containers until there is a minimum of one complete empty row. The number of rows that must be empty prior to commencing will vary from terminal to terminal. One row is the minimum but two seems to be more common. The logic behind two rows is that if there is one completely empty row between the rows being loaded and discharged at all times then the difference between the load and discharge stacks

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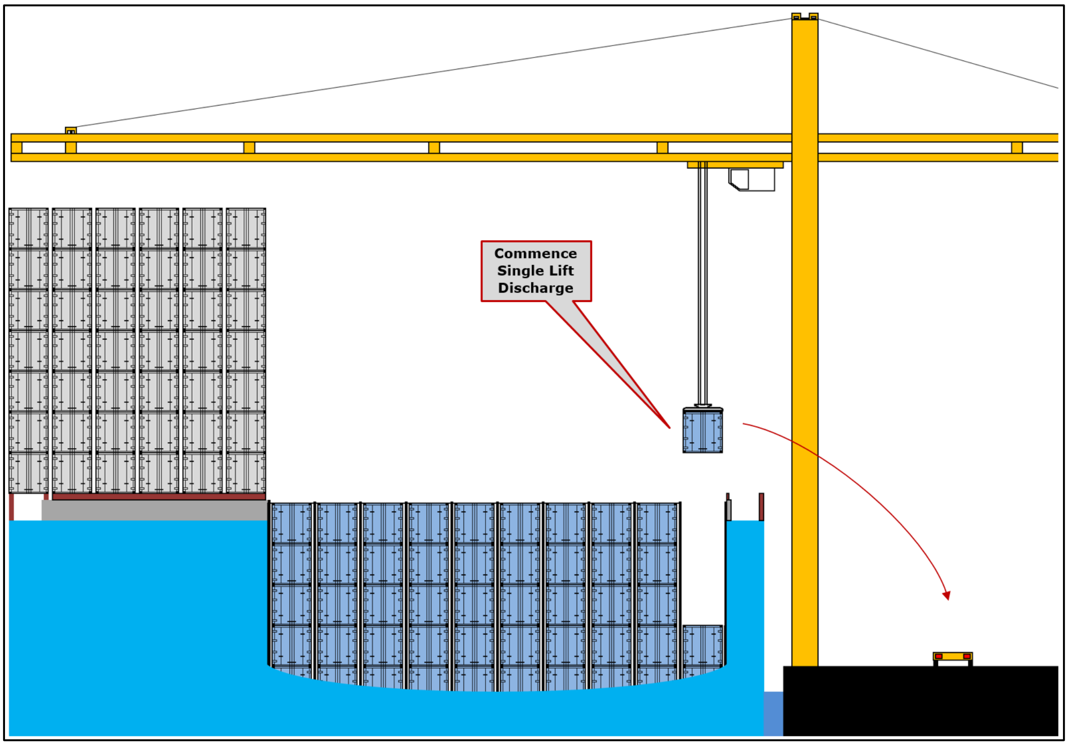
is clearly defined for the crane operator. If at any point the crane operator confuses the two different stacks then the work will get out of sequence and this can be quite time consuming to rectify and will have an impact on the yard operations.

As the cycling operation gets underway, each movement of the crane will either be handling either a discharge or load unit. There will be no time during the cycle where the spreader is not handling a container. When all of the units for discharge have been removed from the bay, the crane will switch back into single lift mode to load the remaining containers. In all, a maximum of approximately 40% of the containers in a bay can have the potential for dual cycling operations. Each terminal will set a minimum number of dual cycles in a bay before they will consider it worth the extra efforts to set the work sequence up for it. 30-40 cycles is a common minimum level but, for a terminal with restricted yard space and the need to keep as much space free as possible, this number can be much lower.

One final benefit to dual cycling is the overall vessel stability during cargo operations. Due to the nature of the work sequence in a bay that is being cycled, the overall weight distribution across the vessel will be much more balanced than if it was being single lifted. Container vessels tend to have relatively low capacity anti-heeling ballast pumps which can struggle to keep up with the cargo operations, especially when working with high numbers of cranes. Dual cycling can help to alleviate the problems that can be caused due to excessive listing of the vessel, such as spreaders becoming jammed in the cellguides.

**Step One**

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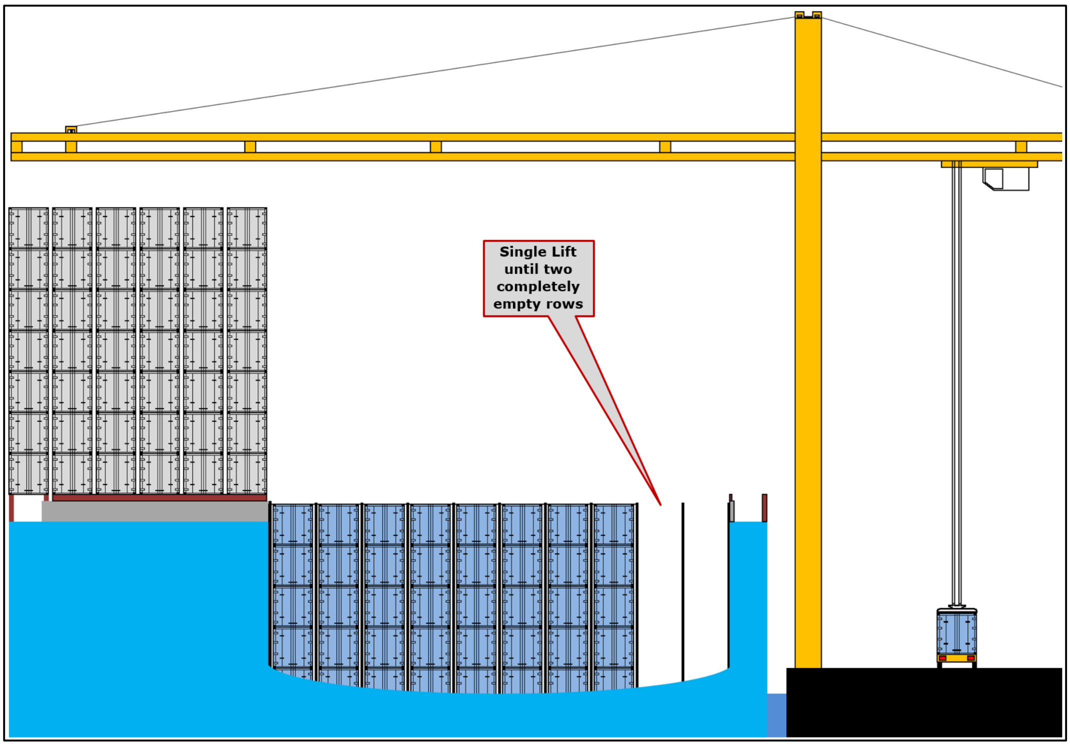
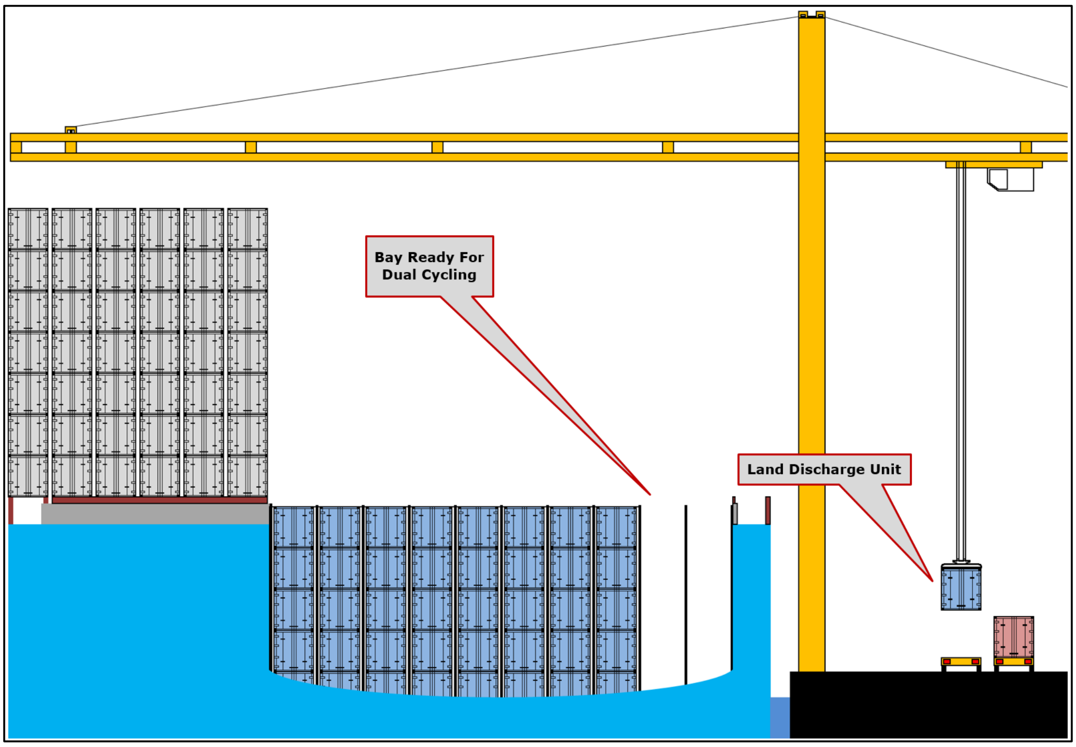
## Step Two




## Step Three

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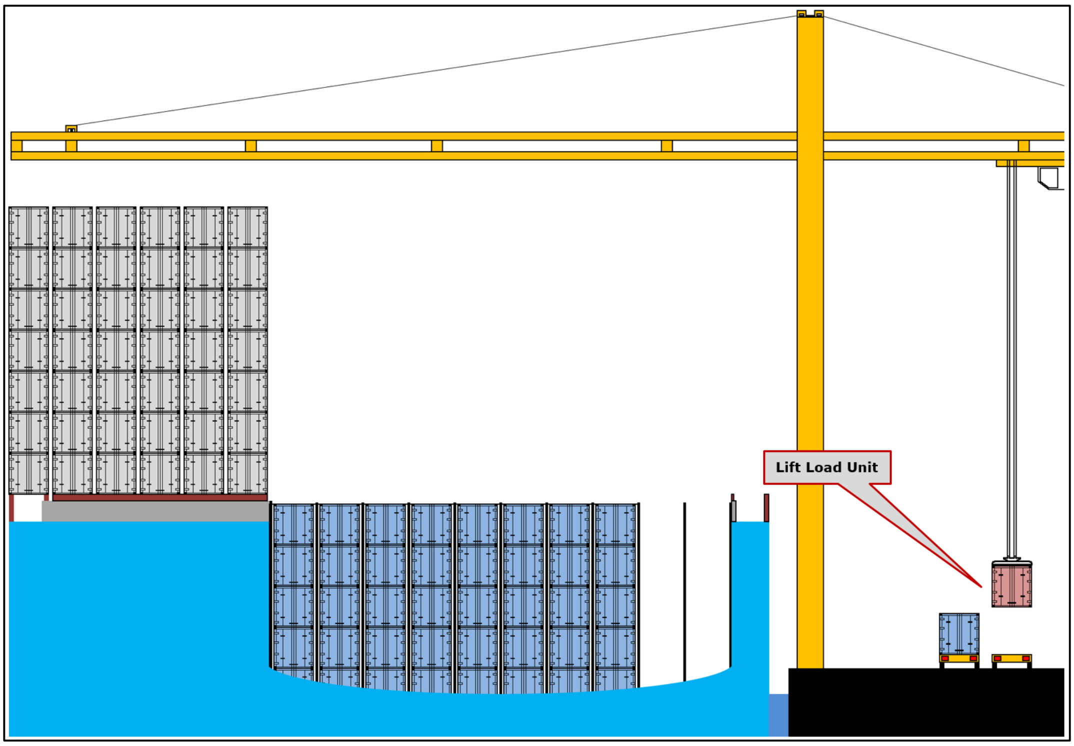
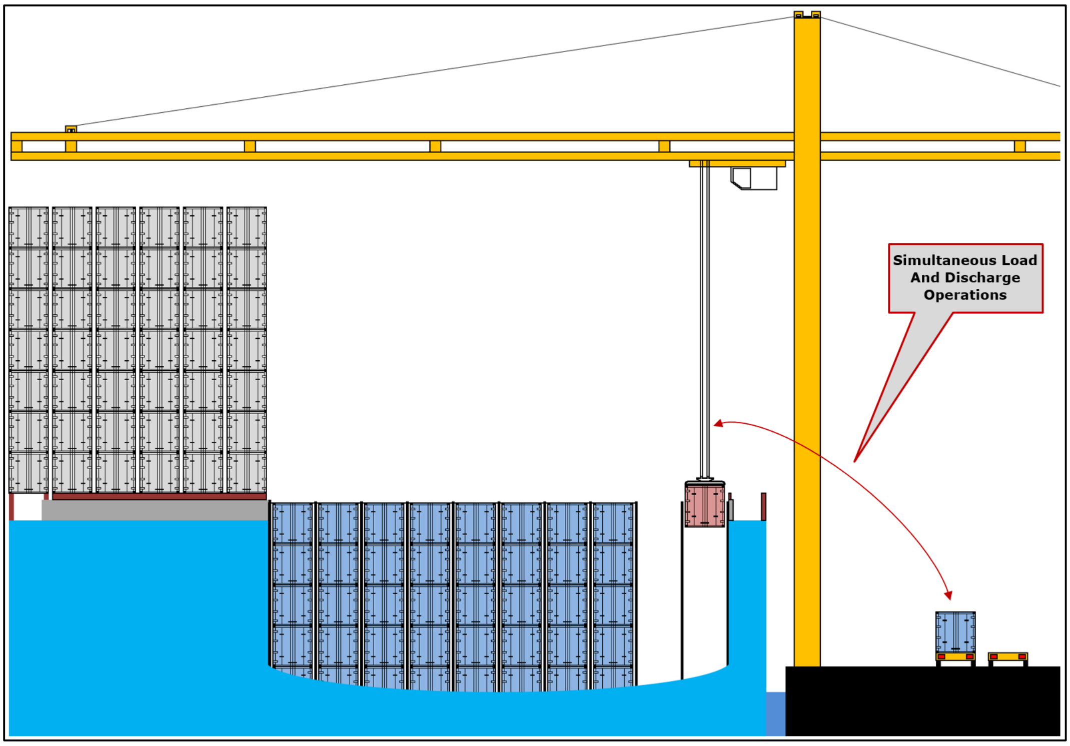
## Step Four




## Step Five

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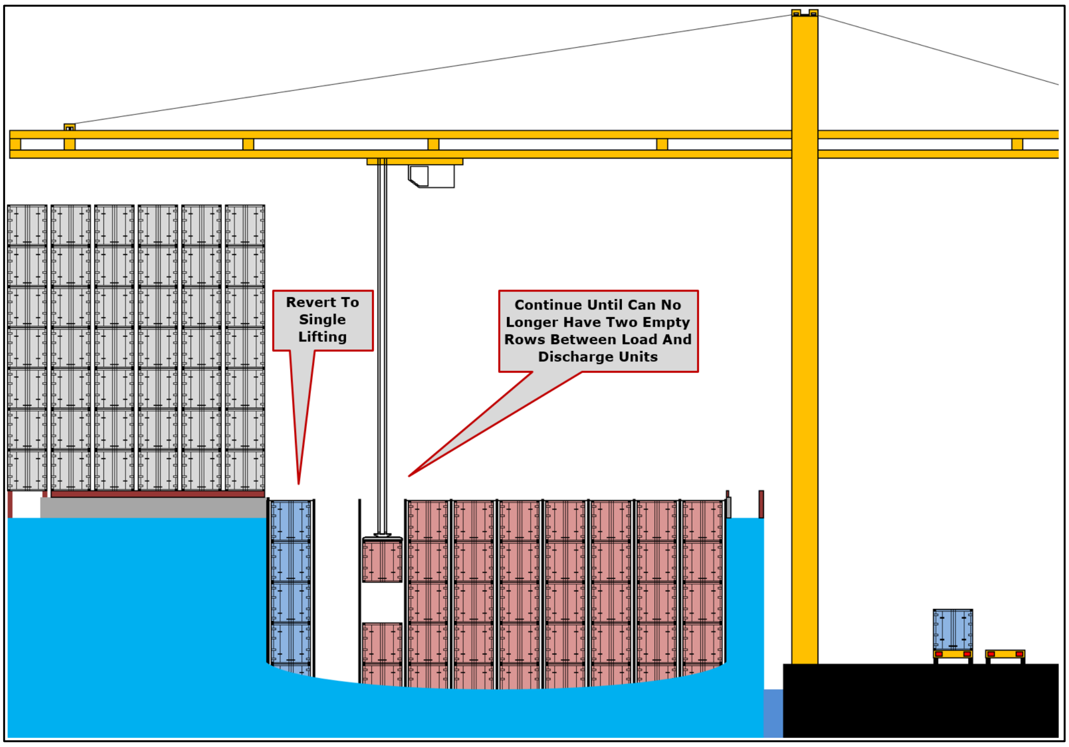
**Step Six**




The downside to this is that by increasing dual cycling opportunities, the coordinator has to consolidate the load and discharge cargo into fewer bays. The end of result of this is a reduction in crane intensity. On balance, there is more to be gained by achieving a higher CI than deliberately reducing CI in favour of DC.

There will only be a gain in port stay reduction if the dual cycling opportunities are planned and executed on the longest crane.

From a terminal perspective, it would be preferable to have the same equipment types both in a bay and for load and discharge. This is very often not practical for stowage. If we limit the amount of different types of containers in a bay then it is much more difficult to make maximum use of the underdeck stackweights and thus fill the bay with as much as it is capable of carrying. When this is done in a number of bays then neither is it possible to maximize the vessel intake.

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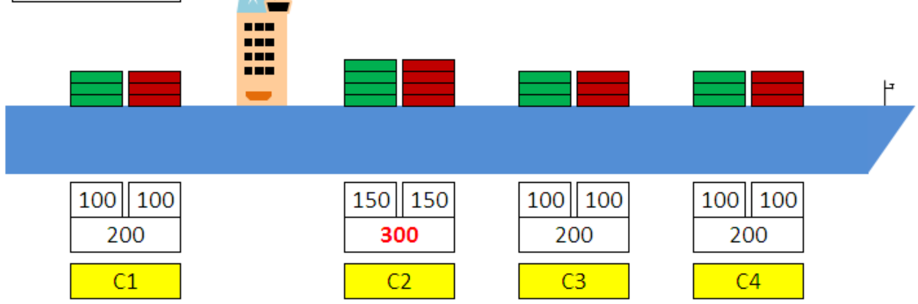
The diagram below shows the different effects of dual cycling on different bays and the impact on port stay and CI.

Example One

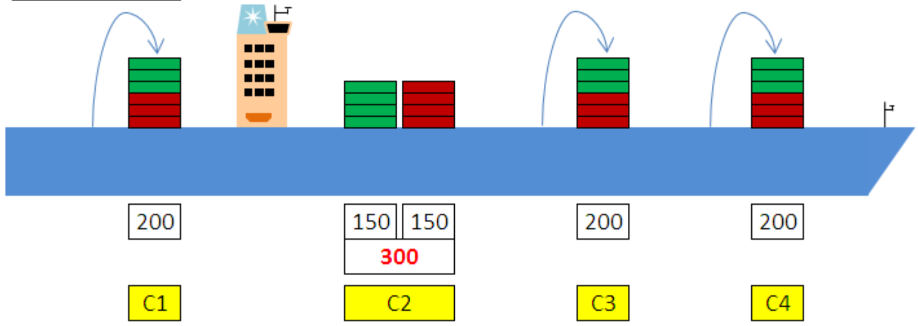
**No dual cycling. All bays single lifted.**




| | | | |
|---|---|---|---|
| C1 | 200/25 = | 8 | Hours |
| C2 | 300/25 = | 12 | Hours |
| C3 | 200/25 = | 8 | Hours |
| C4 | 200/25 = | 8 | Hours |
| Port Stay | LC = | 12 | Hours |

Example Two

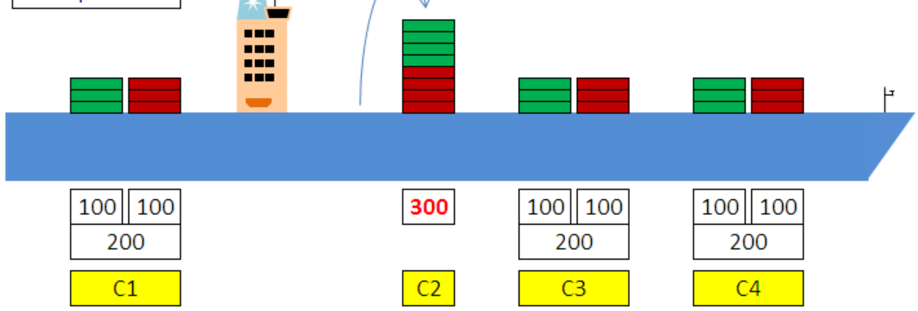
**Dual cycling only on shorter cranes.**




| | | | |
|---|---|---|---|
| C1 | 200/35 = | 5.7 | Hours |
| C2 | 300/25 = | 12 | Hours |
| C3 | 200/35 = | 5.7 | Hours |
| C4 | 200/35 = | 5.7 | Hours |
| Port Stay | LC = | 12 | Hours |

Example Three

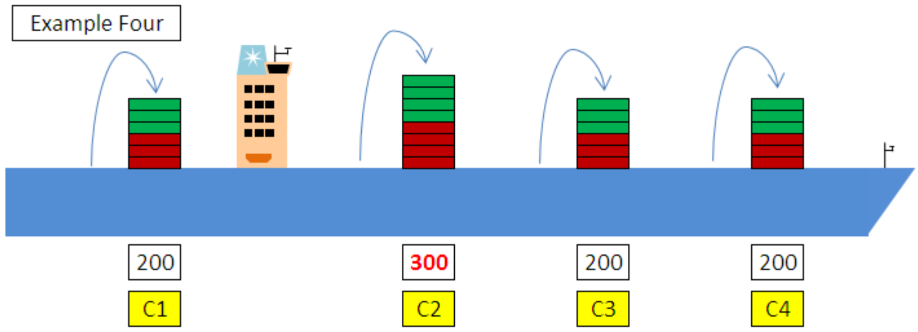
**Dual cycling only on long crane.**




| | | | |
|---|---|---|---|
| C1 | 200/25 = | 8 | Hours |
| C2 | 300/35 = | 8.6 | Hours |
| C3 | 200/25 = | 8 | Hours |
| C4 | 200/25 = | 8 | Hours |
| Port Stay | LC = | 8.6 | Hours |

Example Four

**Dual cycling on all cranes.**




| | | | |
|---|---|---|---|
| C1 | 200/35 = | 5.7 | Hours |
| C2 | 300/35 = | 8.6 | Hours |
| C3 | 200/35 = | 5.7 | Hours |
| C4 | 200/35 = | 5.7 | Hours |
| Port Stay | LC = | 8.6 | Hours |

**If terminal Single Lifts @ 25 MPH and Dual Cycles at 35 MPH**

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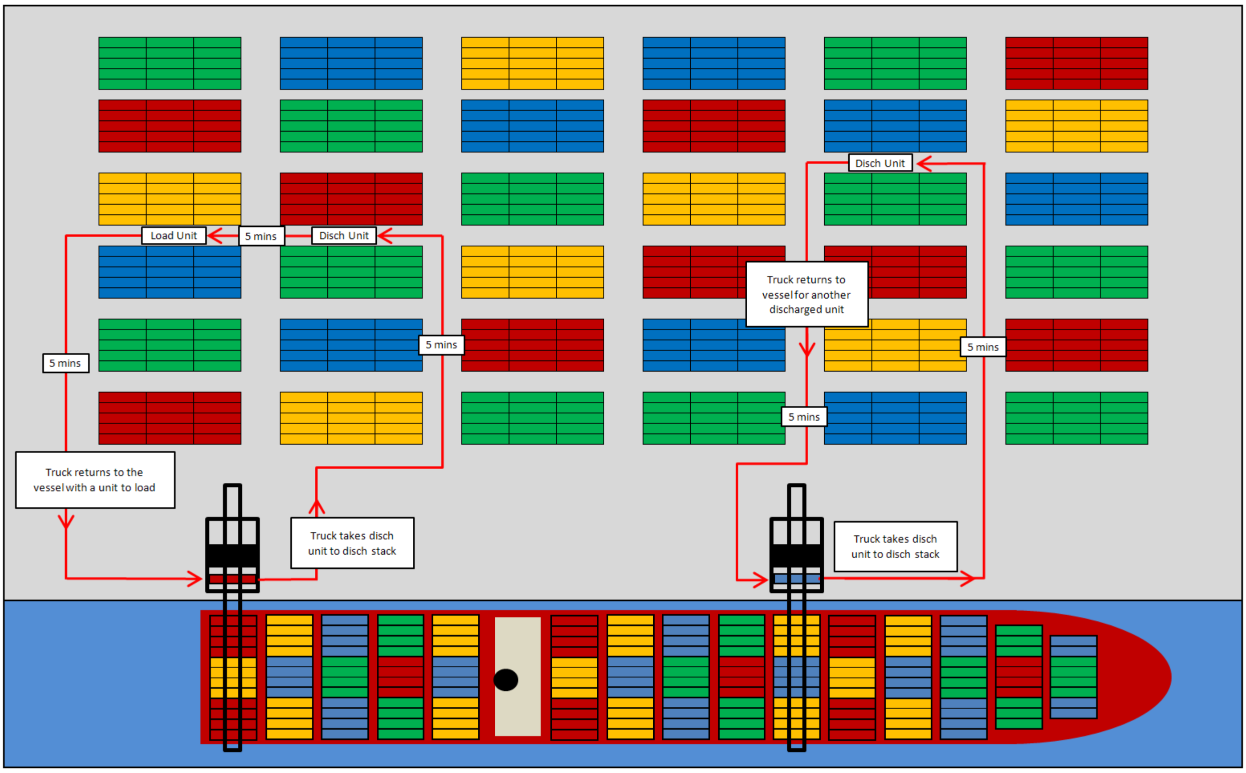
# Dual Cycling




**Dual Cycling Operation**

Crane Productivity 20 dual cycle MPH (40 containers per hour)
Crane needs a truck every 3 minutes to have continuous operation
Truck cycle time is 15 minutes
Therefore 5 trucks are needed for continuous operation

**Single Cycling Operation**

Crane Productivity 30 MPH
Crane needs a truck every 2 minutes to have continuous operation
Truck cycle time is 10 minutes
Therefore 5 trucks are required for continuous operations

Dual cycling is a relatively complicated process for a terminal to incorporate into their working sequence and some terminals are very reluctant to try it.

The above diagram shows the difference in truck travel distances in the terminal and the potential benefits to dual cycling.

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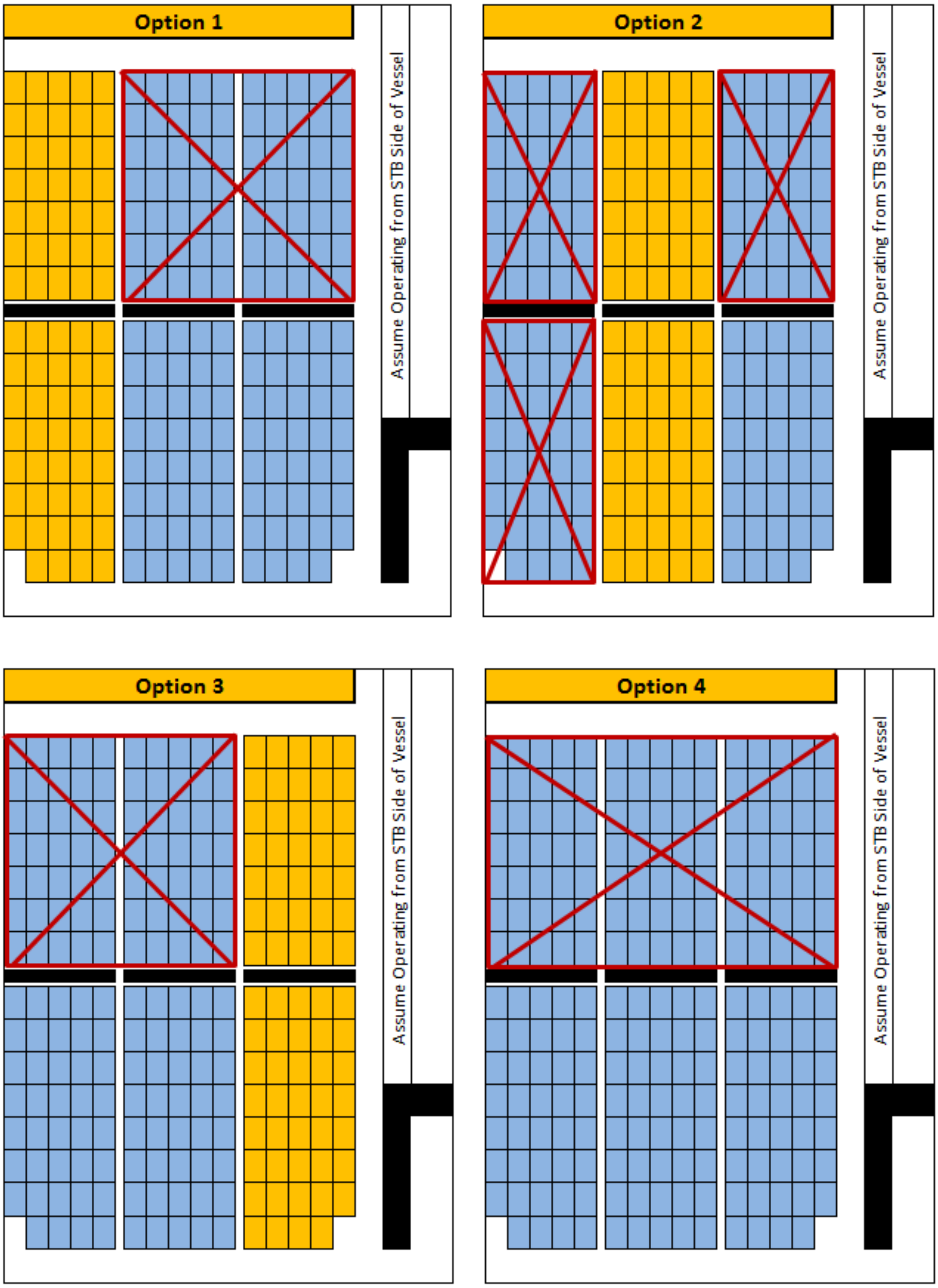
From a terminal perspective, the following are possible dual cycling scenarios:




Remain Onboard Cargo

Load/Discharge Cargo

Not practical to Dual Cycle

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**Improvements**

So what can coordinators do to improve the stowages they send? More awareness of the various issues outlined in this document is a good start. There are also a number of basic stowage techniques that should be reviewed to reduce restows, increase utilization and improve productivity.

Stowage has generally been a fairly reactive environment and more focus is being placed on becoming more pro-active. This is partly as a result of the fact that we sit at the end of the operations process within the shipping line.

**Restow reduction**

A lot of emphasis is placed on the need to reduce restow costs. Areas where we could make improvements include :

- Up/Down stowage vs horizontal stowage (despite this creating towers on deck)
- Stowing for wind-stacks within a bay
- Terminal errors – communication to raise general awareness

**Utilization**

- Maximizing the use of stackweight and stackheight limits
- Full use of the lashing limitations
- Finishing a bay whenever possible (rather than topping off elsewhere)
- Best use of vessel high cube capabilities under-deck
- Best use of Russian Stow potential on deck
- Maximum use of pyramid stowage (within line of sight rules)

**Productivity**

- Consolidation of cargo whenever practical
- Matching CI to availability of cranes
- Use of twinlift – within terminal limits
- Maximizing dual cycling potential
- Maximizing tandem lift potential
- Reduction in hatchcover movements
- Reduction in low move bays as far as practical
- Reduction in Manhattan Towers (where no increase in restows can be foreseen)

There is also a direct correlation between the stowage department setup and the quality of the stowages that can be produced. Overleaf is an example, using StowMan, of how a stowage centre/process can be organised.

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