INTRODUCTION TO AUTOSTOW(#) FUNCTION IN DPW TERMINALS AS PART OF STANDARDISATION AND OPTIMISATION OF VESSEL AND TERMINAL OPERATIONS

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Abstract: *The paper summarises DP World's experience in optimisation of container terminal waterside operations using NAVIS Vessel AutoStow function. AutoStow function, as demonstrated by DP World in Australia, provides more efficient ship planning and container terminal operation; standard level of service with reduced cost. The ship planning function in DP World in Australia is based on implementation of vessel working and terminal yard strategies to defined plans, where overall terminal strategy might be compromised because of manual input and control. Introduction of automated ship planning function allows DP World Australia's ship planning team to optimise customer and terminal needs ensuring most effective terminal operations with minimum cost.*

Keywords: *optimisation, container terminal, ship planning.*

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1. INTRODUCTION

Container ship travel on "round-robin" routes where at each port of destination (POD) containers may be unloaded and additional containers destined for subsequent ports may be loaded. Determining a viable arrangement of containers that facilitates this process, in cost effective way, makes up the container stowage problem [1]. Stowage planning is the core of ship planning [2]. Stowage plan defines positions for all containers on boars of a ship, accordingly to the orders of ports in a ship rotation. Usually stowage planning does not act with specific containers identified by numbers, but on categories of containers. Constraints to be satisfied mainly result from the stability of the ship [2].

In former times, stowage plans were created by the captain of the ship, but nowadays the creation of stowage plans is a two-step process. Firstly, a rough stowage plan is created by the shipping line that considers stowage positions on the vessel. Secondly, based on the rough stowage plan of the shipping line, the ship planners of the container terminal create a more precise stowage plan with specific containers [3].

Stowage planning in real terminal operation is either a manual or optimization process based on software application. Because the stowage plan is generated before the beginning of ship loading, optimization concept is offline. Stowage optimization concept has been implemented in numerous software applications. Some of examples are *SimpleStow* flagship program designed specifically for stowage planning of container vessels and container data processing, developed by AMT Marine software Inc. [4]; Autoship Systems Corporation Stowage Planning Systems which includes hydrostatics analysis engine – *Autoload* [5]; Navis VESSEL AUTOSTOW application module that automatically generates stow plans for the entire ship or by specific bay based on rules set by the planner combining vessel stowage factors with yard constraints and operational parameters [6].

The current ship planning function in DP World Australia (DPW) container terminals was based on implementation of vessel working and yards strategies to defined plans, where overall terminal strategy might be compromised because of manual input and control. Ship planning relay on individual skills and planner's ability to optimise customer and terminals needs ensuring service is delivered in most effective way with minimum cost to terminal. The current planning process is tentative and doesn't allow terminal management to assess several plans (options) based on different strategies in short period of time. Furthermore the current planning process is relatively slow to respond to unplanned disruptions in vessel operations.

Therefore, ship planning needs to move towards dynamic planning in order to ensure optimum results for dynamic terminal operations and that terminal strategies are followed at all times.

As a solution, DP World National Planning Centre (NPC) is implementing AutoStow in DPW terminals as part of optimisation of vessel operations. Hence, introducing the planning process based on the AutoStow software application module is the main objective of this paper.

The remaining of the paper is organized as follows. Section 2 presents AutoStow application module, while section 3 describes planning process based on this software tool. Some concluding remarks are given in section 4.

2. AUTOSTOW APPLICATION MODULE FOR STOWAGE PLANNING

AutoStow is an advanced application module that plans ships to distribute work among terminal Automated Stacking Cranes / RTG / straddles in operations including vessel, rail, and yard points of work.

Preparation for AutoStow function required full assessment of:

- Vessels
- Cargo Configuration
- AutoStow Factor Filters
- Operational Strategies
- Yard Allocations

Our main goal with AutoStow function is to minimize the crane delay and to select the optimum container from yard that matches projection with optimum utilisation of yard equipment and terminal resources.

2.1 Vessels

Vessel profile files have been updated with necessary data in relation to Stack Weights and Stack Heights (Figure 1.). The biggest challenge was to determinate permissible stack weights based on vessel dynamic stability. In consultation with vessel operators standard vessel sailing condition on departure each port were assessed and standard (predefined) GM[1] was established (Figure 2.). That allowed us to determine one sailing condition on departure and set permissible stack weight for that condition only.

[1] GM denotes "metacentric height of a vessel". For a vessel to be stable the numerical value of GM must be positive. The available GM must always be larger than the required GMs. The requirements vary considerably for different types and sizes of vessels.

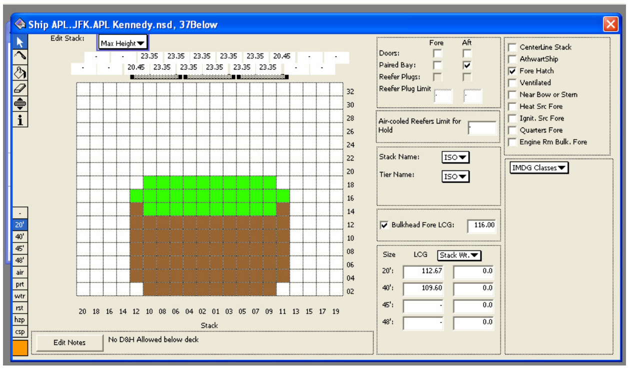


Figure 1. Vessel Profile File: Stack Heights

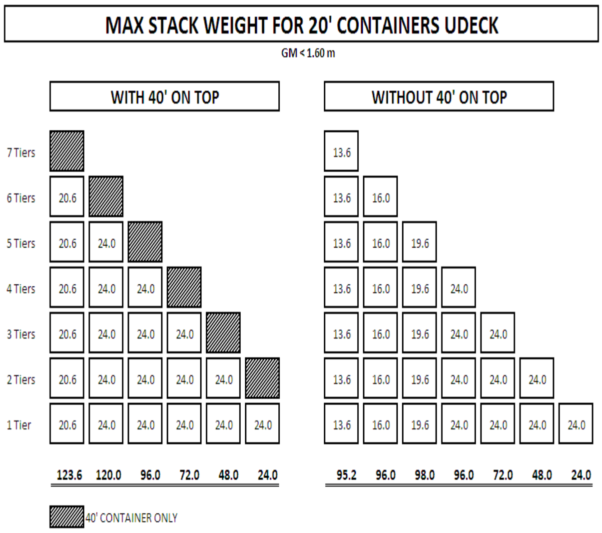


Figure 2. ANL Windarra: Permissible Stack Weights for 20' Containers for GM <1.6m

2.2 Cargo Configuration

Cargo configuration is very important factor for ship and yard planning as vessel slots and stows are allocated based on cargo configuration. In our analysis we were looking for the model ship, core cargo, trends and season oscillations by Trade (Service). Extra heavy containers are dominant out of Australia and keeping vessels' stack weights within limits is planners' biggest challenge. Vessels ex Australia usually hits their DWT allocation before TEU allocation. In some trades more than 75% of 20' are heavier than 24t, which is max weight per 20' slot on most ships (see Figure 3.). Yard allocations were adjusted to allow optimum container selectivity in cases where majority of 20' are heavier than vessel slot: extra heavy containers (>24t) are grouped (one allocation) and light containers (<15t) were spread in several weight groups (allocations). This allows better access to light containers to match permissible stack weight (refer to Figure 2.).

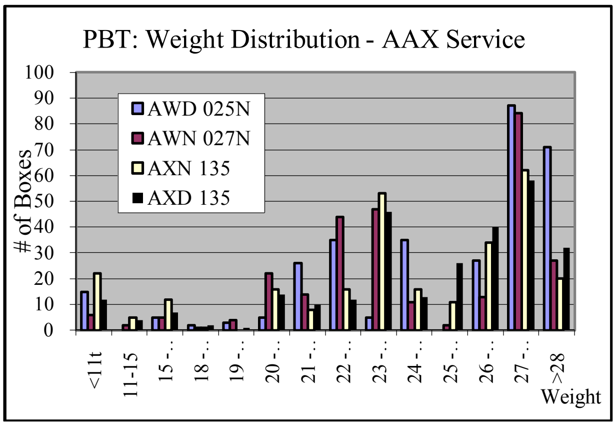


Figure 3. Weight Distribution – 20' Dry AAX Service ex SYD

2.3 AutoStow factor Filter

AutoStow filters have been created based on vessel operator's stow requirements. The Stow factor must be in synchronisation with the Yard Strategy and Expert Decking which then ensure that AutoStow will select containers correctly. Projections are created in accordance to the AutoStow factors Filters defined as per below Figure 4.

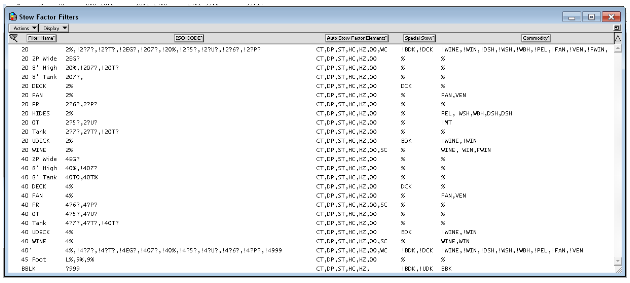


Figure 4. Stow Factor Filters

2.4 Operational Strategies

An AutoStow strategy is made up of a standard set of AutoStow parameters which are actually numerical decision factors that are accumulated and weighted against each other to determine the best stowage outcome for a container. This way, the system assigns the lowest scoring matching container to a vessel slot.

Terminal operational strategies have been defined as well as triggering points where the terminal will switch on to new strategy (eg: resources available, cargo configuration, volume, etc).

Auto Stow strategies are split into three parts (Figure 5.):

- Configuration – Settings related to the terminal Equipment and operational philosophy and operational needs
- Options – Settings related to container conditions that might be included or allowed in the AutoStow calculation process, it determinates how system shall handle the optional container conditions
- Penalties – settings (penalties) that allows calculation and evaluation of the best candidate. With penalties user controls the behavior of AutoStow by weighting the variables with penalty points

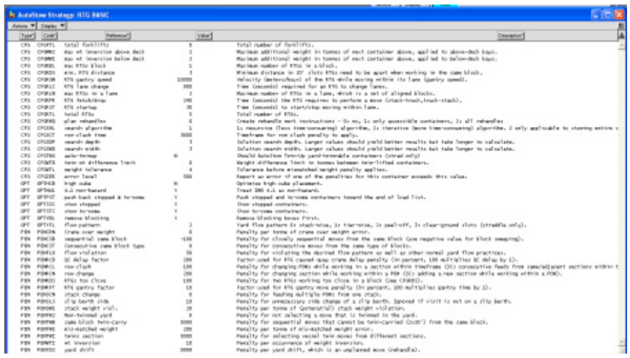


Figure 5. AutoStow Strategy – RTG Terminal Sydney

In RTG Terminals strategies are to be created by Cranage and resources available, for straddle and ASC terminals CONFIG Settings are simple and they have only one strategy.

Penalty values balance inevitable trade□offs between competing yard and vessel efficiencies, and customize strategies that reflect operational objectives. By setting parameter values, we configure the strategy the system uses to avoid problems such as rehandles, weight inversions, and CHE clashes in the yard. The best strategy depends largely on the type of CHE, but also on particular terminal's practices.

AutoStow chooses the best container to load by evaluating each candidate. The control of the behavior of AutoStow is by weighting the variables with penalty points. The higher the penalty, the less chance that action will occur.

AutoStow assign container to particular Point Of Work (POW) based on set parameters that take into consideration in real time:

- Estimated time of move
- Crane productivity / rate
- ASC / RTG productivity
- Current position of ASC / RTG
- Number of rehandles (defined by flow pattern)
- Permissible stack weight
- Multiple point load in twin lift option
- Late receivals etc

The projections for all POWs will be sorted based on move time, so they will be intermingled, and AutoStow will plan them in that order.

2.5 Yard Allocations

In principle terminal operations planning processes have 4 major tasks: which are: to deliver container at right place at right time, in right order and in right condition in most efficient and profitable manner.

The main challenge of vessel and yard planning is to synchronise needs and optimise two processes: landside and waterside, where yard is a buffer zone between those two processes.

Containers received in terminal at landside side are to be positioned in the yard in slots and in quantities that will ensure efficient vessel operations; the operations that will start up to 5 days after container is received .

Containers are segregated based on the following criteria:

- Length
- Type (general, reefer, empty , hazardous etc)
- Vessel / Visit
- Port of Discharge
- Special stows (commodity) – eg. Wine, hides etc
- Height (Standard, High Cube)
- Weight classes etc

Yard allocation filters were assessed by Service / Trade, cargo configuration, volume and special requirements and Stacking and Section Factors as well as Expert Decking Settings were adjusted accordingly (Figure 6.)

PBT	ALLOCATION FILTERS									
Service	Lenght (20', 40' 45')	POD	ISO Specials (Tanks, 2P Wide, OT, FR)	Height (8', ST, HC)	Category (Dry, Empty, Reefer))	HAZD Class	OOG	Special Commodity: Wine, Hides,	Weight Class	Special Stow (UDECK, DECK))
AAX	Y	Y	2PW	Y	Y				Y	
ANP	Y	Y			Y					
Swire	Y	Y	F/R		Y					
VSA - PNW	Y	Y			Y					
VSA - PSW	Y	Y		Y	Y					
AAS	Y	Y			Y				Y (KSH, HKG, BNE)	
ASAL	Y	Y		Y	Y				Y (SIN, PKG)	
AANA	Y	Y		Y	Y				Y	
Oceania/Trident	Y	Y		Y	Y					
CKA	Y	Y		Y	Y				Y	
ACE	Y	Y		Y	Y				Y	
EAX	Y	Y			Y				SIN, PKG	

Figure 6. Adjustment of Allocation Filters based on Service and Stow factors

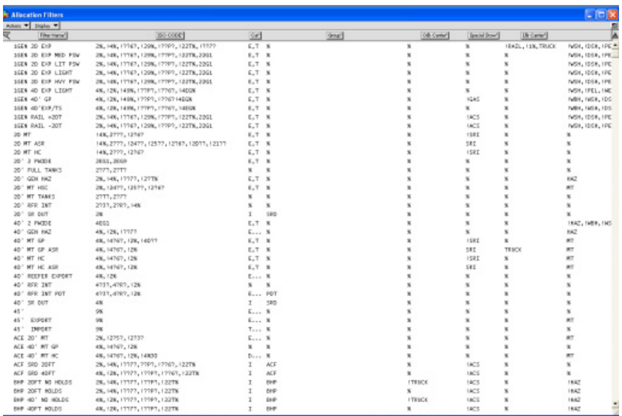


Figure 7. L PBT Allocation Filters

3. PLANNING PROCESS USING AUTOSTOW

AutoStow plans the ship, move-by-move, based on the estimated move time (Figure 7.), which is determined by the order assigned to the work queues (Figure 9.), and at the rate assigned for crane productivity at each Point Of Work; in other words it uses the crane work order set in Quay Commander and the productivity rates set for the quay cranes in the crane shifts to determine the time an ASC / RTG has to complete moves.

Planners first have to ensure that Vessel Call Details are set: (vessel Estimated Time of Arrival, Start Work Time, Estimated Time of Departure, and Strategy.

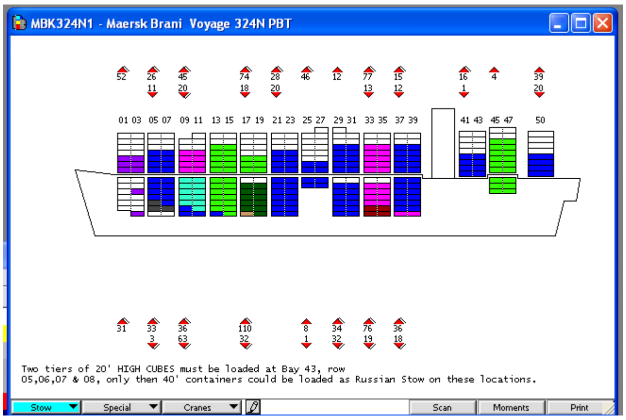


Figure 8a. Work Queue Indicating Move Time

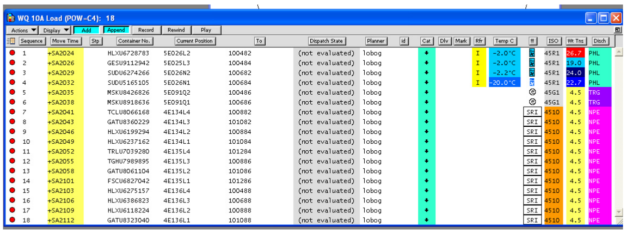


Figure 8b. Work Queue Indicating Move Time

Projection shell be synchronised with load list; Quay Commander Set (Figure 9.). Desired Pre-defined working patterns (PWP) are set.

Resources and operational requirements are determinate and AutoStow strategy is set accordingly.

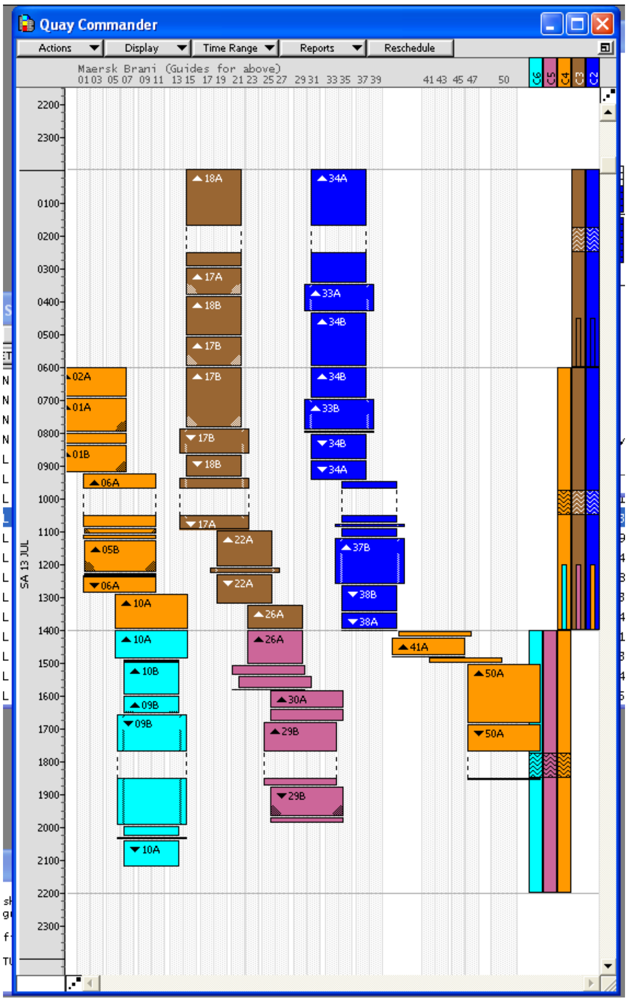
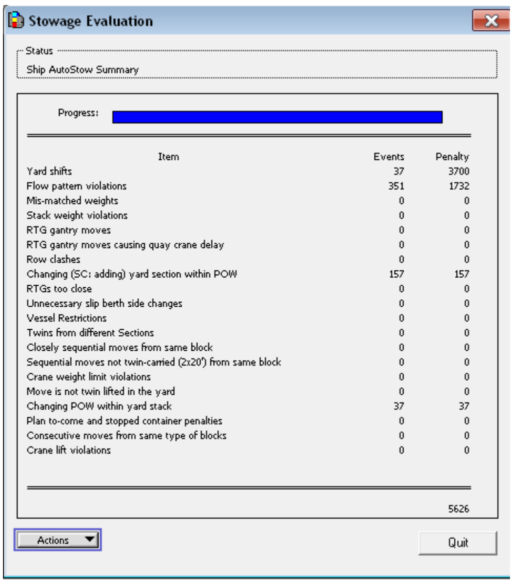


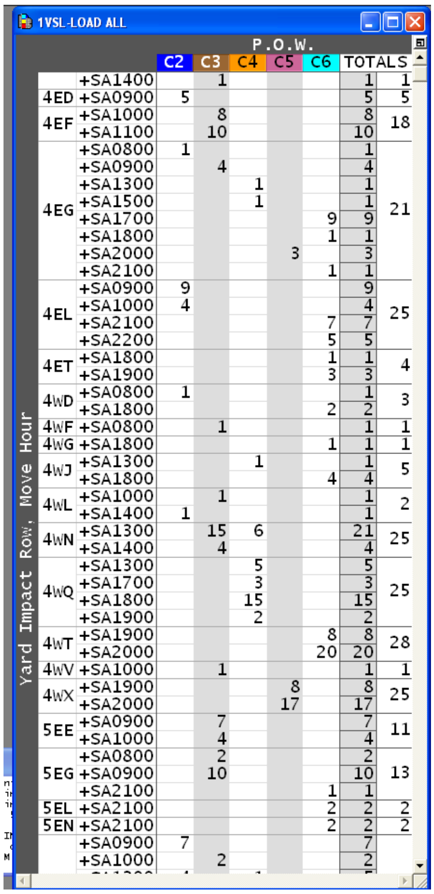
Figure 9. Quay Commander

After running the AutoStow load plan and results are analysed (Figure 10.) and minor adjustments are to be made if planner is not fully satisfied. For example planner have to check yard clashes by Move Hour versus Points of Work (Figure 11.)



Item	Events	Penalty
Yard shifts	37	3700
Flow pattern violations	351	1732
Mis-matched weights	0	0
Stack weight violations	0	0
RTG gantry moves	0	0
RTG gantry moves causing quay crane delay	0	0
Row clashes	0	0
Changing (SC: adding) yard section within POW	157	157
RTGs too close	0	0
Unnecessary slip berth side changes	0	0
Vessel Restrictions	0	0
Twins from different Sections	0	0
Closely sequential moves from same block	0	0
Sequential moves not twin-carried (2x20') from same block	0	0
Crane weight limit violations	0	0
Move is not twin lifted in the yard	0	0
Changing POW within yard stack	37	37
Plan to-come and stopped container penalties	0	0
Consecutive moves from same type of blocks	0	0
Crane lift violations	0	0
		5626

Figure 10. AutoStow Stowage Evaluation



Row	Move Hour	C2	C3	C4	C5	C6	TOTALS	
	+SA1400		1				1	1
4ED	+SA0900	5					5	5
4EF	+SA1000		8				8	18
	+SA1100		10				10	
4EG	+SA0800	1					1	21
	+SA0900		4				4	
	+SA1300			1			1	
	+SA1500			1			1	
	+SA1700					9	9	
	+SA1800					1	1	
	+SA2000				3		3	
	+SA2100					1	1	
4EL	+SA0900	9					9	25
	+SA1000	4					4	
	+SA2100					7	7	
	+SA2200					5	5	
4ET	+SA1800					1	1	4
	+SA1900					3	3	
4WD	+SA0800	1					1	3
	+SA1800					2	2	
4WF	+SA0800		1				1	1
4WG	+SA1800					1	1	1
4WJ	+SA1300			1			1	5
	+SA1800					4	4	
4WL	+SA1000		1				1	2
	+SA1400	1					1	
4WN	+SA1300		15	6			21	25
	+SA1400		4				4	
4WQ	+SA1300			5			5	25
	+SA1700			3			3	
	+SA1800			15			15	
	+SA1900			2			2	
4WT	+SA1900					8	8	28
	+SA2000					20	20	
4WV	+SA1000		1				1	1
4WX	+SA1900				8		8	25
	+SA2000				17		17	
5EE	+SA0900		7				7	11
	+SA1000		4				4	
5EG	+SA0800		2				2	13
	+SA0900		10				10	
	+SA2100					1	1	
5EL	+SA2100					2	2	2
5EN	+SA2100					2	2	2
	+SA0900	7					7	
	+SA1000		2				2	

Figure 11. Yard Impact Row and Move Hour by Point of Work

A feedback and report of any anomalies is important for further adjustments of yard allocations (Figure 12.), penalties, weight groups etc. Operational team is regularly assessing: AutoStow algorithm used and parameters related to Weight management, Container Handling Equipment (CHE) deployment and Yard Flow management for fine tuning of related penalties and settings.

AutoStow require correct preplan and projections. Time spent on preplan will increase where time on sequencing will be reduced. AutoStow will increase consistency and accuracy of our product by focusing on projections rather than actual container and by eliminating simple planning errors, it will also allow planner to promptly respond on any replanning requirements.

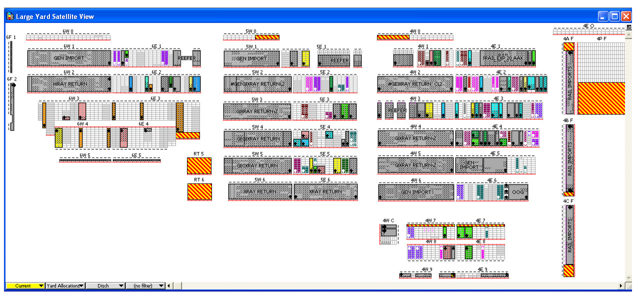


Figure 12. PBT Yard Allocation

AutoStow require more time to be spent on pre-plan but actual time on sequencing containers from yard will be reduced (Figure 13.). Overall planners will have more time available for checking and ensuring optimum terminal operations are met at all times. On long term actual savings are coming from reduced time required for checking as AutoStow strategies are developed and finetuned; and prompt respond on any replanning requirements during vessel operations. AutoStow will also increase consistency and accuracy of our product by focusing on projections rather than actual container and by eliminating simple planning errors.

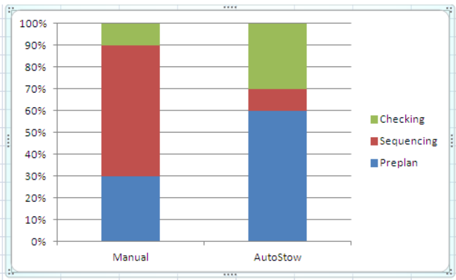


Figure 13. Time required for Manual v Auto Stow ship planning

4. CONCLUSION

Ship planning function, as part of terminal operations, is based on implementation of vessel working and yard strategies to defined plans, where overall terminal strategy might be compromised because of manual input and control. The ship planning relay on individual planner's skills; it is tentative process and it doesn't allow assessment of several plans (options) in short period of time. This process is relatively slow to respond to dynamic terminal operations and unplanned disruptions of vessel operations.

Automatisation of ship planning process using NAVIS Vessel AutoStow allows dynamic planning that ensures optimum results for dynamic terminal operations. It also ensures that terminal strategies are followed at all times.

Successful implementation of AutoStow function require full assessment of vessels and cargo configurations (external factors) and terminal operational strategies (internal factors) which must be clearly defined.

Automated ship planning using AutoStow increases consistency and accuracy of ship planning product, standardisation of waterside terminal operations and it increases planner's abilty to quickly respond on any changes and any replanning requirements.

Following implementation of AutoStow in DP World Melbourne terminal overall ship planning time has been reduced by 1 to 1.5 hrs for the vessels with exchanges of up to 2000 containers.

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