



# PLANT LIFE IN PORT OPERATIONS

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## Purpose

- The purpose of this presentation is to cover the background drivers that influence Plant Life.
- Key point is that understanding these drivers should affect decisions on pricing of port services and equipment replacement.



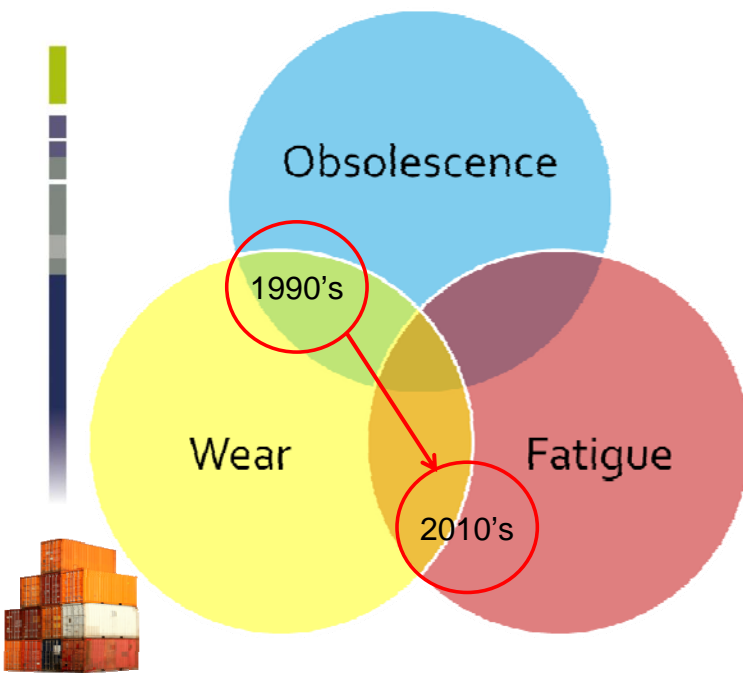


## Outline

- Wear vs. Fatigue
- Drivers behind Fatigue in Ports
- Managing Changes
- Affect on pricing Port services
- Crane Life
- Straddle/Forklift Life

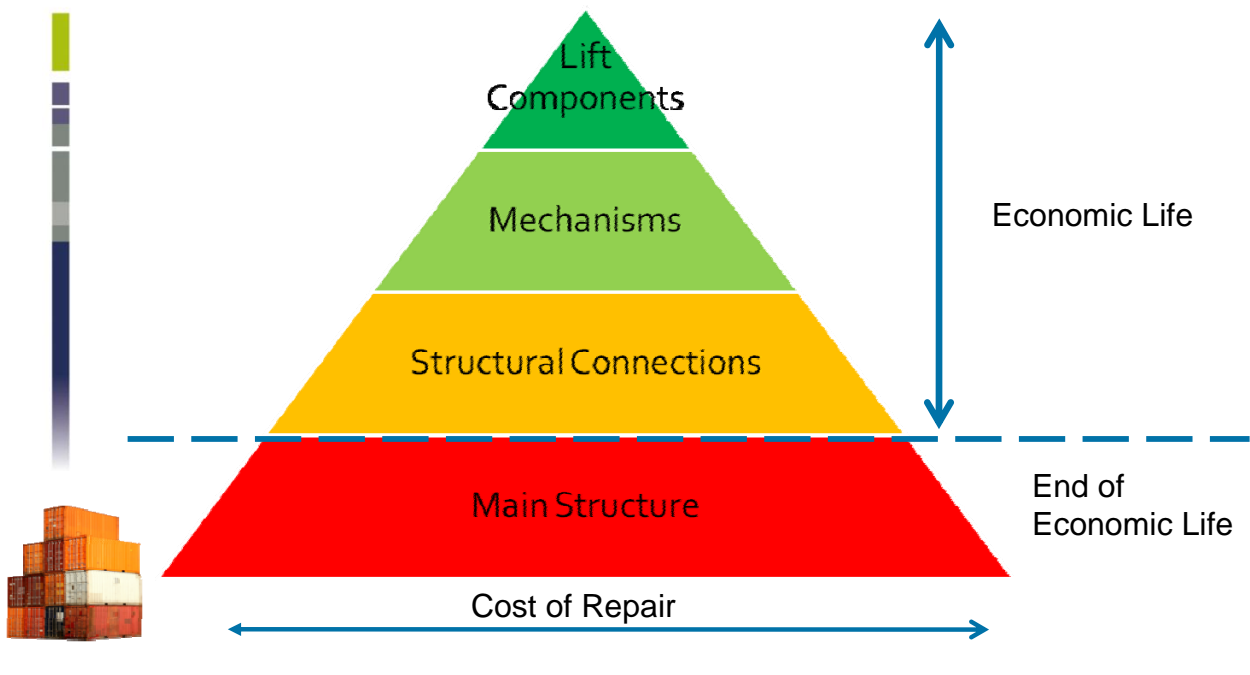


## Wear vs. Fatigue – Port Plant



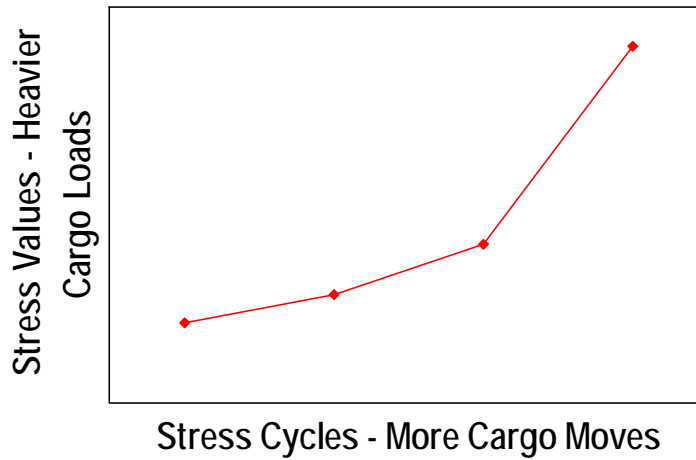
I predict that future plant replacement will be due to fatigue instead of wear & obsolescence in Ports.

# Economic Life – Failure of Components



# Why Is Fatigue Increasing For Ports

- Combination of increased stress cycles and higher stress values



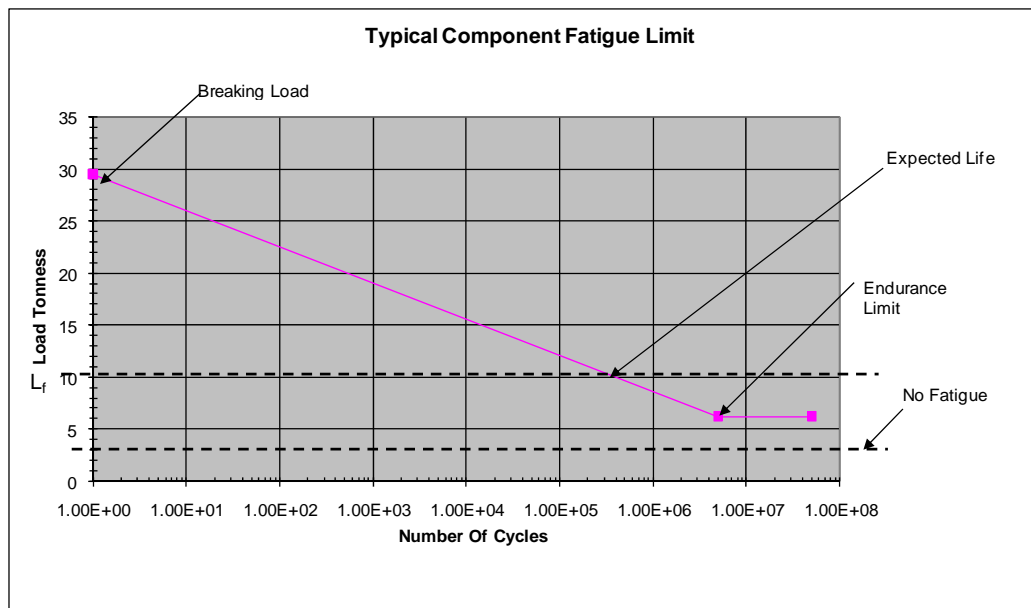


## Why is Fatigue Such a Problem?

- Failures can occur during normal operation, totally unexpected and can undermine the confidence in the equipment
- The failure can occur a long time after the event that initiated it
- Fatigue failures have a low probability but when they occur, can have catastrophic results
- Unlike wear, there is no gradual decline in performance, just complete failure

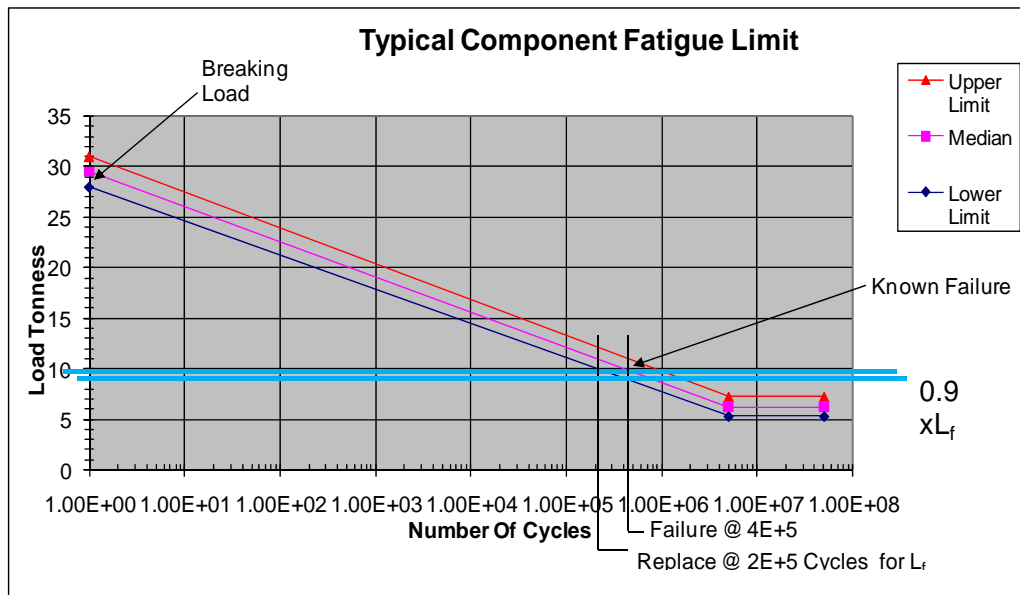
# Predicting Fatigue Failure

- The likelihood of a fatigue failure is product of the loads vs the cycles



# Avoiding Fatigue

1. Reduce loading by 15-10%
2. Reduce component life by 50%



# Permissible Stress & Life

BS2573:Part 1: 1983

Rules for the design of cranes

16% Stress Reduction Doubles Design Life

Table 24 (concluded)

		Permissible tensile fatigue stress $P_f$ (in $N/mm^2$ )							
$f_{min}$		Number of cycles $N$							
$f_{max}$		$3.2 \times 10^4$	$6.3 \times 10^4$	$1.25 \times 10^5$	$2.5 \times 10^5$	$5.0 \times 10^5$	$1.0 \times 10^6$	$2.0 \times 10^6$	$4.0 \times 10^6$
Class F constructional detail	1.0	432	432	432	432	432	432	432	410
	0.9	413	391	370	350	331	313	297	281
	0.8	385	353	323	295	270	247	226	206
	0.7	361	322	287	256	228	203	181	161
	0.6	337	296	259	226	198	173	151	132
	0.5	316	273	236	203	175	151	130	112
	0.4	278	241	208	179	154	133	114	99
	0.3	246	213	184	159	137	118	102	88
	0.2	225	195	168	145	125	108	93	80
	0.1	203	176	152	131	112	97	83	72
	0	187	162	140	121	104	90	77	67
	-0.1	175	152	131	113	98	84	71	63
	-0.2	166	143	124	107	92	79	68	59
	-0.3	154	133	115	99	85	74	63	55
	-0.4	146	126	109	94	81	70	60	52
	-0.5	138	119	103	89	77	66	57	49
	-0.6	133	114	99	85	73	63	54	47
-0.7	129	111	96	82	71	61	53	45	
-0.8	124	107	93	80	69	59	51	44	
-0.9	116	101	87	75	64	56	48	41	
-1.0	112	97	84	72	62	54	46	40	



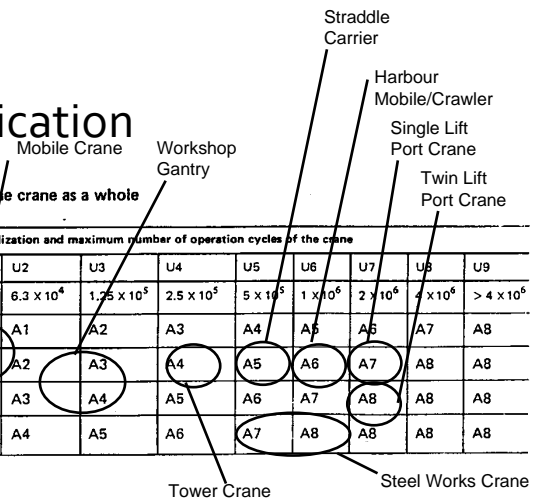
# Recognise Finite Life

- Commercially & technically need to recognise the limited number of lifts a machine can do

## Crane Classification

Table 3. Group classification of the crane as a whole

State of loading	Nominal load spectrum factor $K_p$	Class of utilization and maximum number of operation cycles of the crane								
		U1	U2	U3	U4	U5	U6	U7	U8	U9
		$3.2 \times 10^3$	$6.3 \times 10^4$	$1.25 \times 10^5$	$2.5 \times 10^5$	$5 \times 10^5$	$1 \times 10^6$	$2 \times 10^6$	$4 \times 10^6$	$> 4 \times 10^6$
Q1 Light	0.5	A1	A1	A2	A3	A4	A5	A6	A7	A8
Q2 Moderate	0.63	A1	A2	A3	A4	A5	A6	A7	A8	A8
Q3 Heavy	0.8	A2	A3	A4	A5	A6	A7	A8	A8	A8
Q4 Very heavy	1.0	A3	A4	A5	A6	A7	A8	A8	A8	A8



# Load Spectrum

$$K_p' = \sqrt[3]{\left\{ \frac{C_1}{C_r} \left( \frac{P_1}{P_{max}} \right)^3 + \frac{C_2}{C_r} \left( \frac{P_2}{P_{max}} \right)^3 + \frac{C_3}{C_r} \left( \frac{P_3}{P_{max}} \right)^3 + \dots + \frac{C_n}{C_r} \left( \frac{P_n}{P_{max}} \right)^3 \right\}}$$

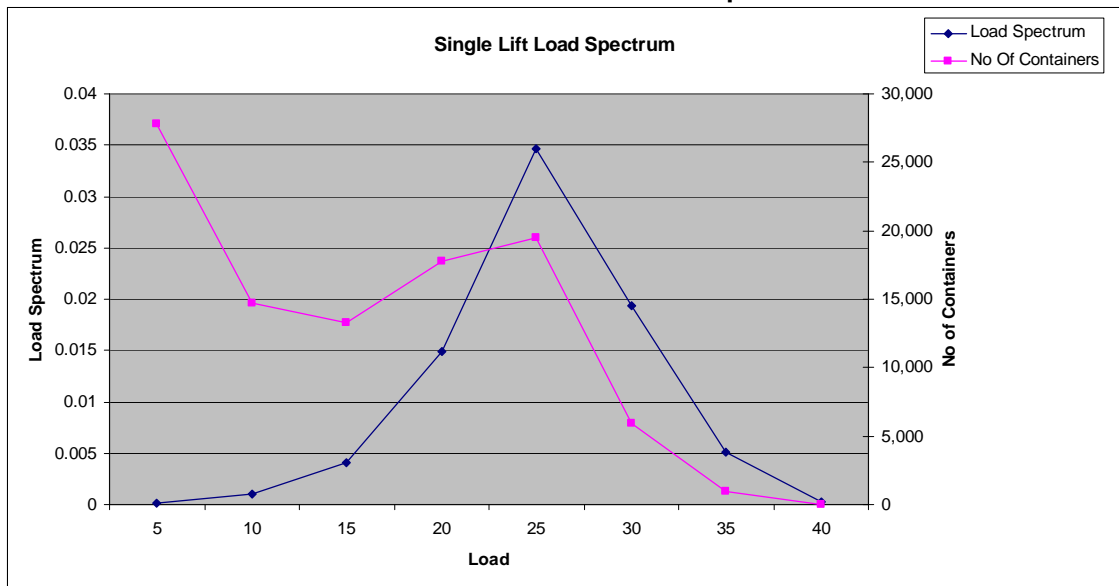
Load Spectrum Formula

SWL 40 Tonne	40 t		
Spreader Dead Load	14 t		
Total	54		
	Load Weight	Number of Lifts	Load Spectrum
Cargo			
MT 20ft	2	100	0.0125663
MT 40ft	4	65	0.0116300
FCL 12t	12	24	0.0129414
FCL 20t	20	10	0.0120583
FCL 32t	32	4	0.0119449
Ship Lid 38t	38	3	0.0129414
Heavy Lift 61t	61	1	0.0129429
Total		207	0.4431510



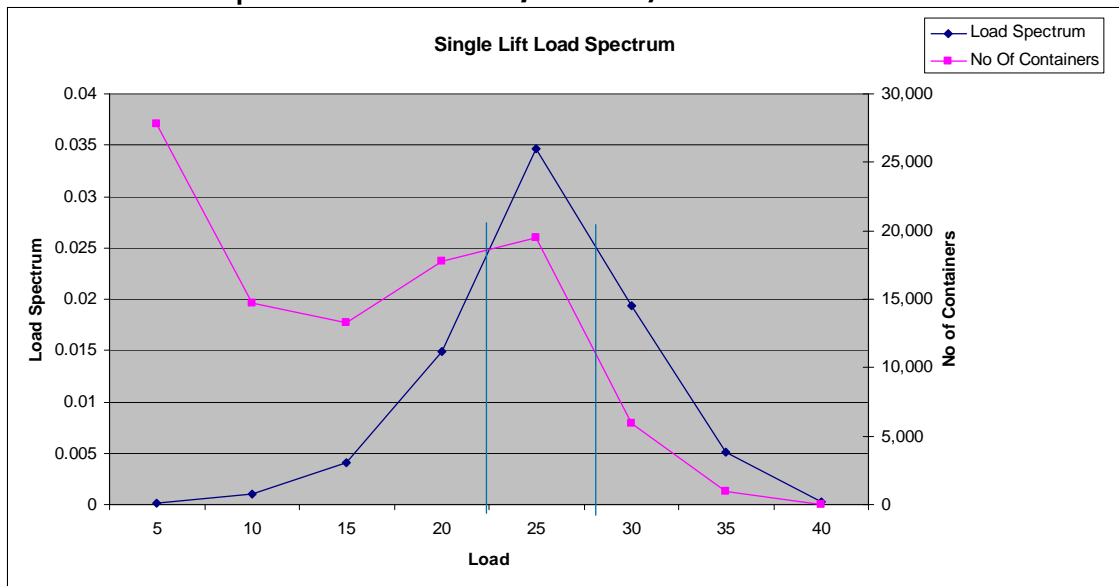
# Expected Load Spectrum at Ports of Auckland

- Based on container weight range at Ports of Auckland in 2004



# Expected Load Spectrum at Ports of Auckland

- 18,000 22t containers have same load spectrum as 12,000 27t containers!



## Affect of Peak Loads

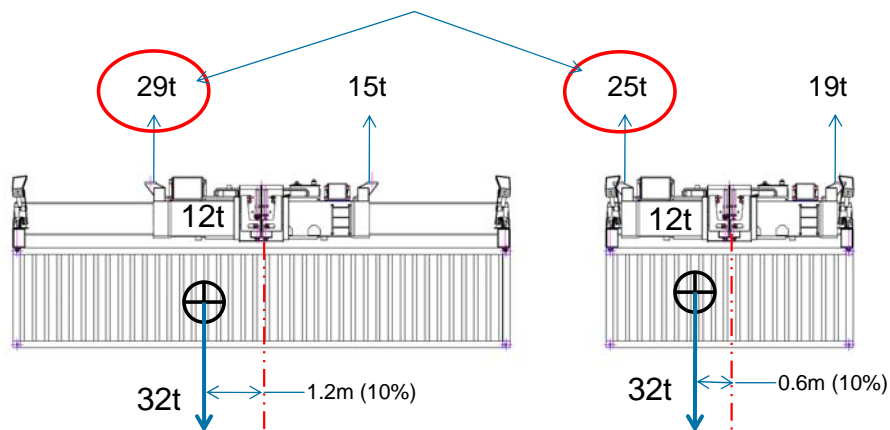
Peak loads can occur due to:

- Load Imbalance
- Dynamic Movements
- Snagging
- Overloading
- Using the Load Spectrum formula, we can see that peak loads, contribute greatly to the “fatigue” of the crane structure and components.



## Affect of 4oft Containers

- Cargo Loads are increasing - 4oft Hicubes & rail transported containers
- Load imbalance of 4oft containers increases the component stresses. With no weight increase, stress is increased 16%



## Affect of Over-Weight Containers

- Manifest weights are often under-declared by the tare weight of the container. For 40ft HC container, the “missing” weight is 4 tonnes, or 14% of the gross load of 28 tonnes

Payload (28t) + 40HC Tare (4t) = Gross (32t)

If declared Payload (28t), then actual +14%

- Poorly packed containers can have large imbalance. The affect is greater “peak” loads on lifting equipment and resulting fatigue.



## Managing Changes - Adding a Twin-Lift Spreader to a Single Lift Crane





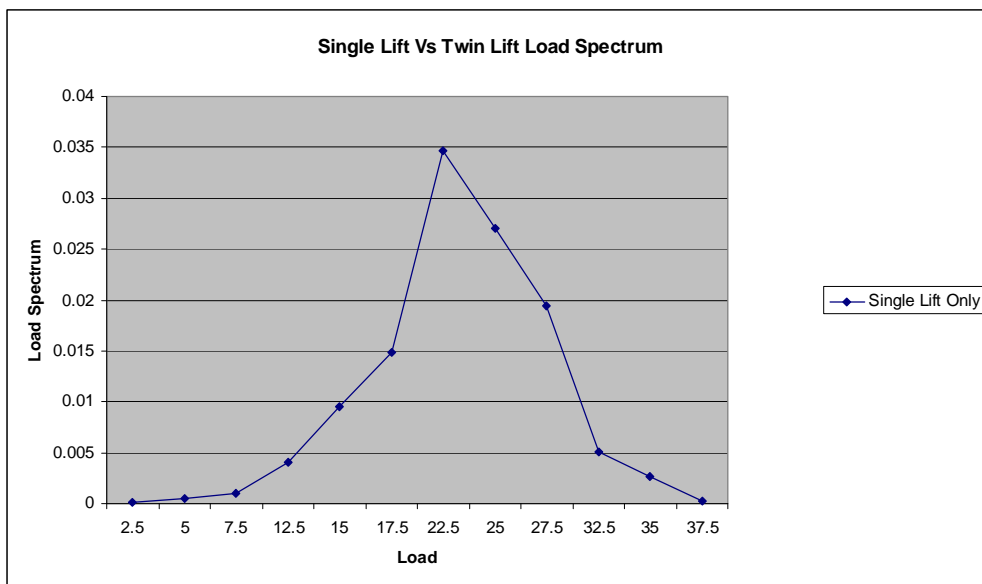
## Managing Changes - Adding a Twin-Lift Spreader

- If a single lift crane has a twin lift spreader is added:
  - SWL reduced by the additional weight of the spreader
  - Load imbalance protection is installed
- Need to consider the effect on the load spectrum of the crane



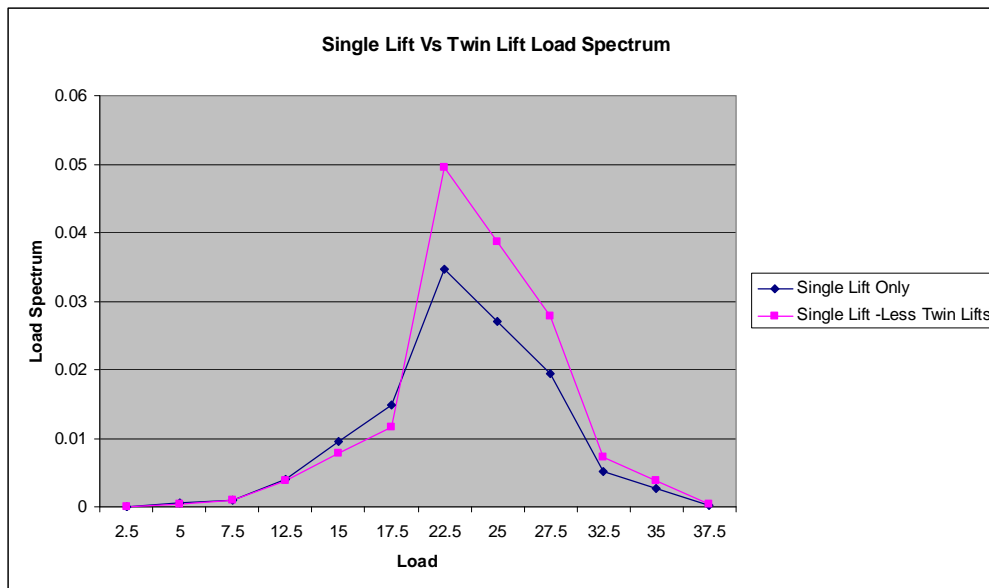
# Managing Changes - Adding a Twin-Lift Spreader

Original Load Spectrum at Ports of Auckland



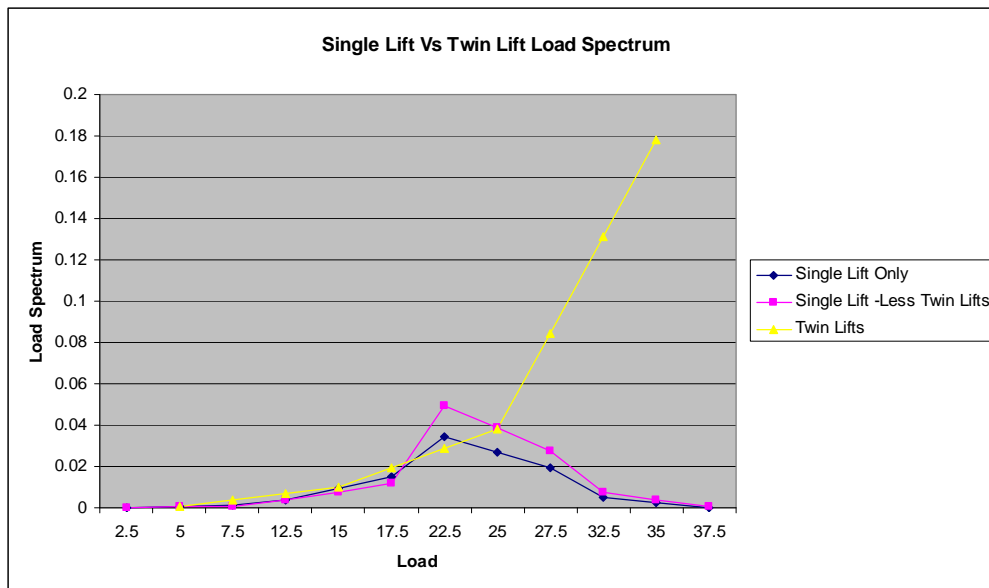
# Managing Changes - Adding a Twin-Lift Spreader

Effect on Load Spectrum by removing 30% containers to be being twinned



# Managing Changes - Adding a Twin-Lift Spreader

Effect on Load Spectrum with 30% containers being twinned (45% 2oft)





## Managing Changes

- Operating to within the SWL is not enough
- Must operate within the duty of the crane to ensure operating life and reliability
- Need to review changes in operation and predict their impact on the life of equipment and hence true costs



How does fatigue effect pricing of services?



## Move Rate Pricing

- Move rate pricing is popular with logistics operators as their revenue is based on moves.
- For the equipment operator, their costs are based on:
  - Labour hourly cost
  - Maintenance/operational hourly cost
- So by maximising moves per hour, profitability is maximised.
- However the mass of each move will effect long term asset costs. Need to reflect the actual consumption of fatigue life.



## Utilisation Pricing

- Utilisation pricing is common with equipment hirers.
- For the person hiring the plant, they will want to maximise the number of lifts per hour to minimise the hirage cost.
- However the number and mass of each move will effect long term asset costs. Need to reflect the actual consumption of fatigue life.



## Maintenance Scheduling

- Maintenance is often scheduled on Utilisation or “Hours”
- Maintenance is a large part of the operating cost or equipment hire.
- Again, the number and mass of each move will effect long term maintenance costs. Need to reflect the actual consumption of fatigue life.





## STS Crane Life

Determined by:

- Number of moves (containers)
- Weight Range of containers
- 20/40/Twin Lifting Mix
- Classification of Crane

Reduced by:

- Peak loadings
- Poor Maintenance



## Straddle Carrier/Forklift Life

Determined by:

- Combination of Number of moves (containers) and laden distance travelled
- Weight Range of Moves
- 20/40/Twin Lifting Mix
- Travel speed

Reduced by:

- Damage
- Poor Maintenance



## Straddle Distance Vs Moves

For 4-7,000 hours operation per year

	8 Moves Per Hour	15 Moves Per Hour
400m Laden Distance	15 Years	10 Years
800m Laden Distance	10 Years	No Possible

There appears to be no difference between terminals in equipment life that do 8 vs. 15 mph. Due to lower laden distance. In most cases the 15 mph operations run at lower maximum speeds and achieve significant reductions in fuel/maintenance costs.

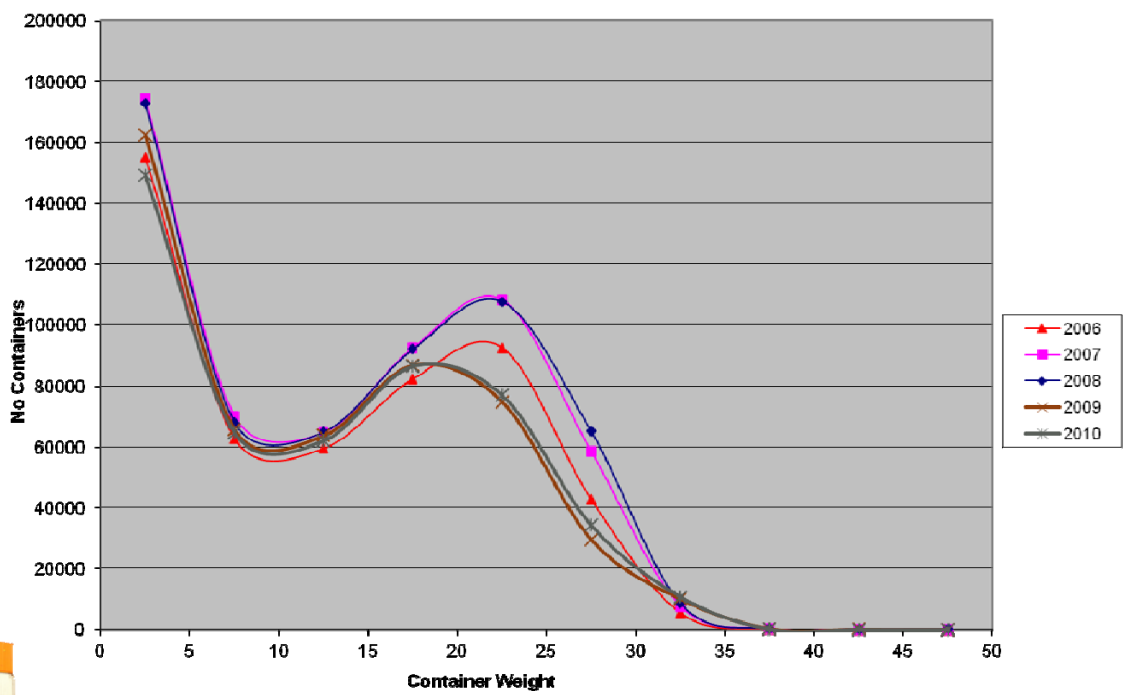


## Threats – Increase Loading

- Rail Containers not being restricted by road truck axle limits
- Hubbing – new trans-ship cargo will be heavier commodity export containers from provincial ports
- Conversion of breakbulk to containers e.g. logs, fuel, wheat, water
- Fewer importers consolidating cargo into heavier 40ft containers



# POAL Container Weight Range 2006-10



Thank you for your attention!

