Yard automation from simulation to reality and beyond

- Dr. Lawrence Henesey
- Business Development Manager

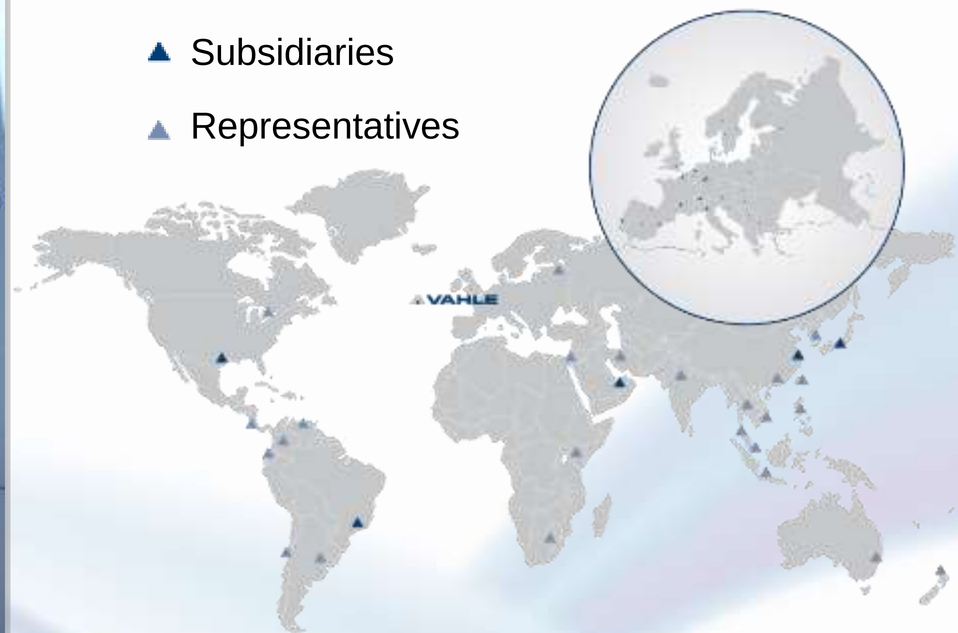
In 20 minutes……

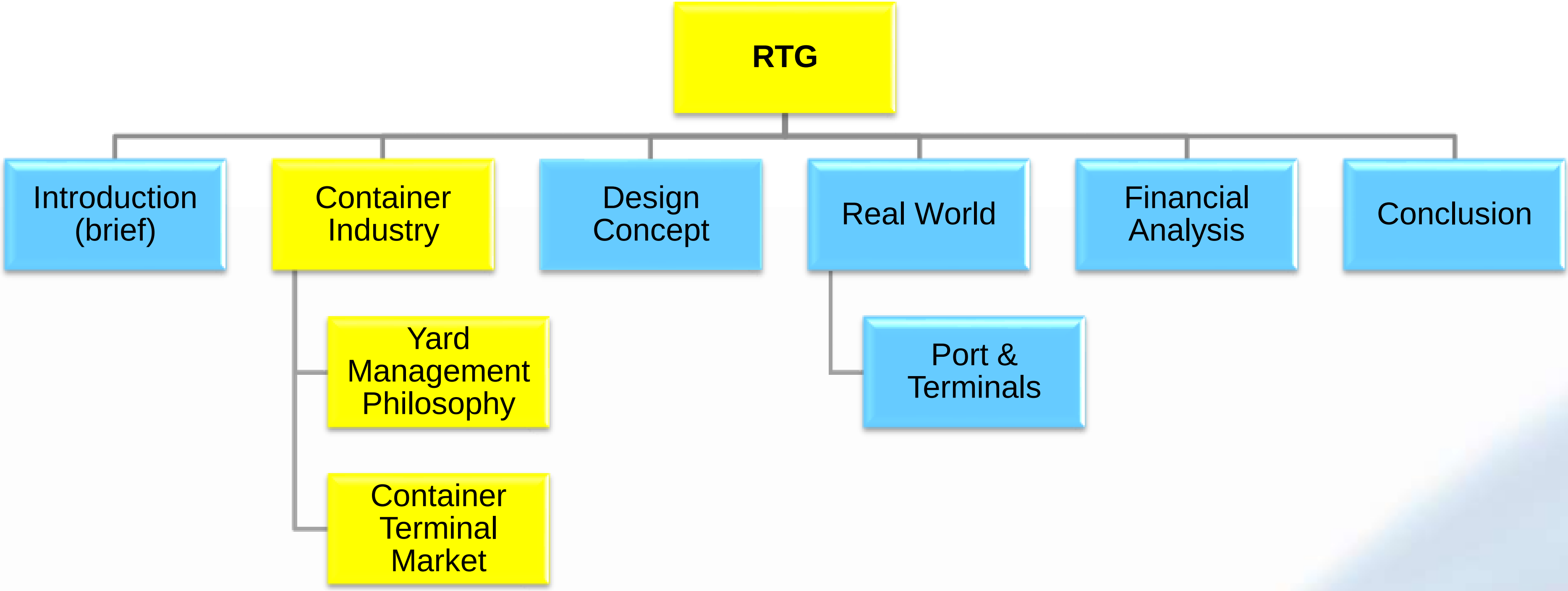
- **RTG**
  - Introduction (brief)
  - Container Industry
    - Yard Management Philosophy
    - Container Terminal Market
  - Design Concept
  - Real World
    - Ports & Terminals
  - Financial Analysis
  - Conclusion

Corporate Data

- > € 100 mil. in sales
- 620 employees worldwide (01.01.2014)
- 11 VAHLE subsidiaries worldwide
- Representated in 52 countries
- 100% family owned

- Subsidiaries
- Representatives

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VAHLE ELECTRIFICATION SYSTEMS

Trends	Container Terminal	Consequence
Increasing competition of terminals		More efficient systems
Globalization		New investments in modern port facilities
Bigger Vessels		Bigger Cranes & faster logistics
Increase in energy costs		Automation of Container Yards
Increasing environmental demands		Electrification or Green Terminals

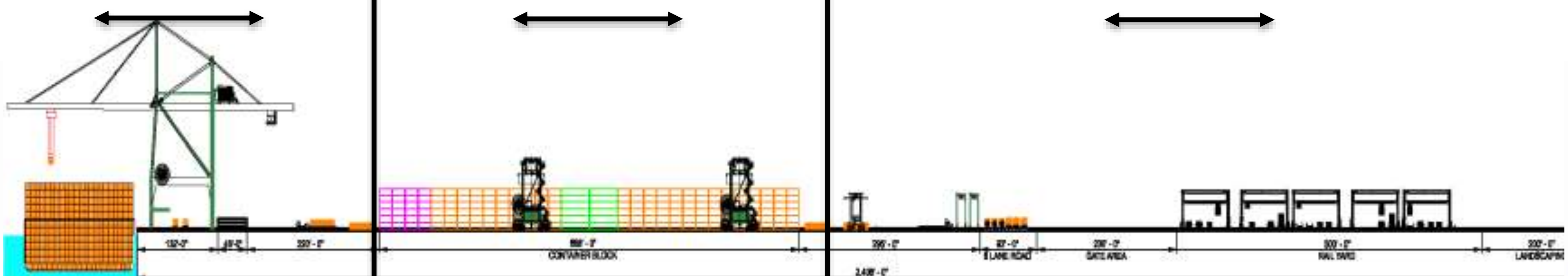
Container Ports and Shipping

- ✓ Ports and terminals industry projected growth rate of 6% - till 2017
- ✓ Total global container throughput will be 830 million TEU (Twenty-foot Equivalent Units) by 2017. Growth rate of 40% between 2011-2017.
- ✓ Conservative growth rate of 5% will double current global container volumes by 2025
- ✓ Containerisation with strong port development in various regions.
- ✓ More Large ships ordered, 445 new ships with capactiy of 3,27million TEU
- ✓ Larger ships means more time at port - leading to more costs.

Source: Drewry Consulting at PEMA fall meeting, Dubai. Oct. 2014.

Scope for optimising container processes

Water Side | Yard/Storage | Land Side



Water Side	Yard/Storage	Land Side
Current State: 55%	Current State: 75%	Current State: 80%
Future State: 100%	Future State: 100%	Future State: 100%

Container handling solutions for horizontal transport should be prioritized, since it has the greatest impact on throughput. The **stack is the main** problem - its low service levels is the main reason contributing to the other container 'handling' processes.

Cost to delay a 18,000 TEU ship for one day

Capital cost of vessel (in US $)	$\$190\,000\,000 \times 0.1 \times \frac{(1 + 0.1)^{20}}{(1 + 0.1)^{20} - 1} \times \frac{1}{350}$	**63 764**
Daily operating cost (in US $)	$\frac{\$17\,500\,000}{350}$	**50 000**
Daily cost of containers (in US $)	**Assuming 20 % 20 ft / 70 % 40ft / 10% reefer boxes 18 000 TEU x 2.4 (sets per vessel) x [(0.20 x US$0.58) + (0.70 x US$0.90) + (0.1 x US$8.00)**	**66 787**
Cargo inventory (in US $)	**18 000 TEU x 0.8 (load coefficient) x 10 ton / TEU x 0.08 x US$ 3 000 / ton x (1 / 365d)**	**219 000**
Total		**$399 441**

Source: Dr. Lawrence Henesey, Blekinge Institute of Technology, Sweden

Yard Management Philosophy

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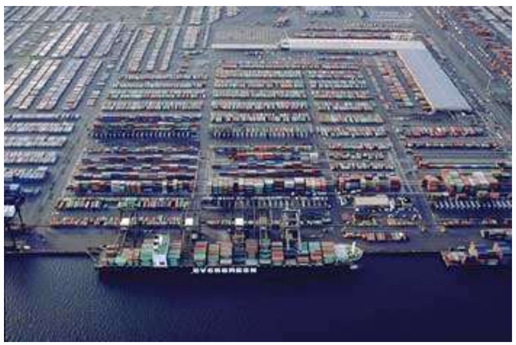
We agree with the management philosophy that a container terminal's performance is **"steered"** by it's container yard



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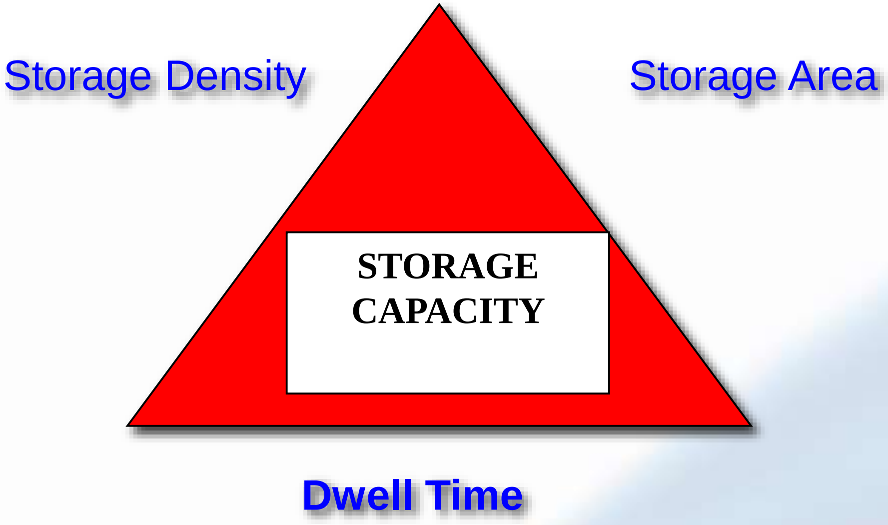
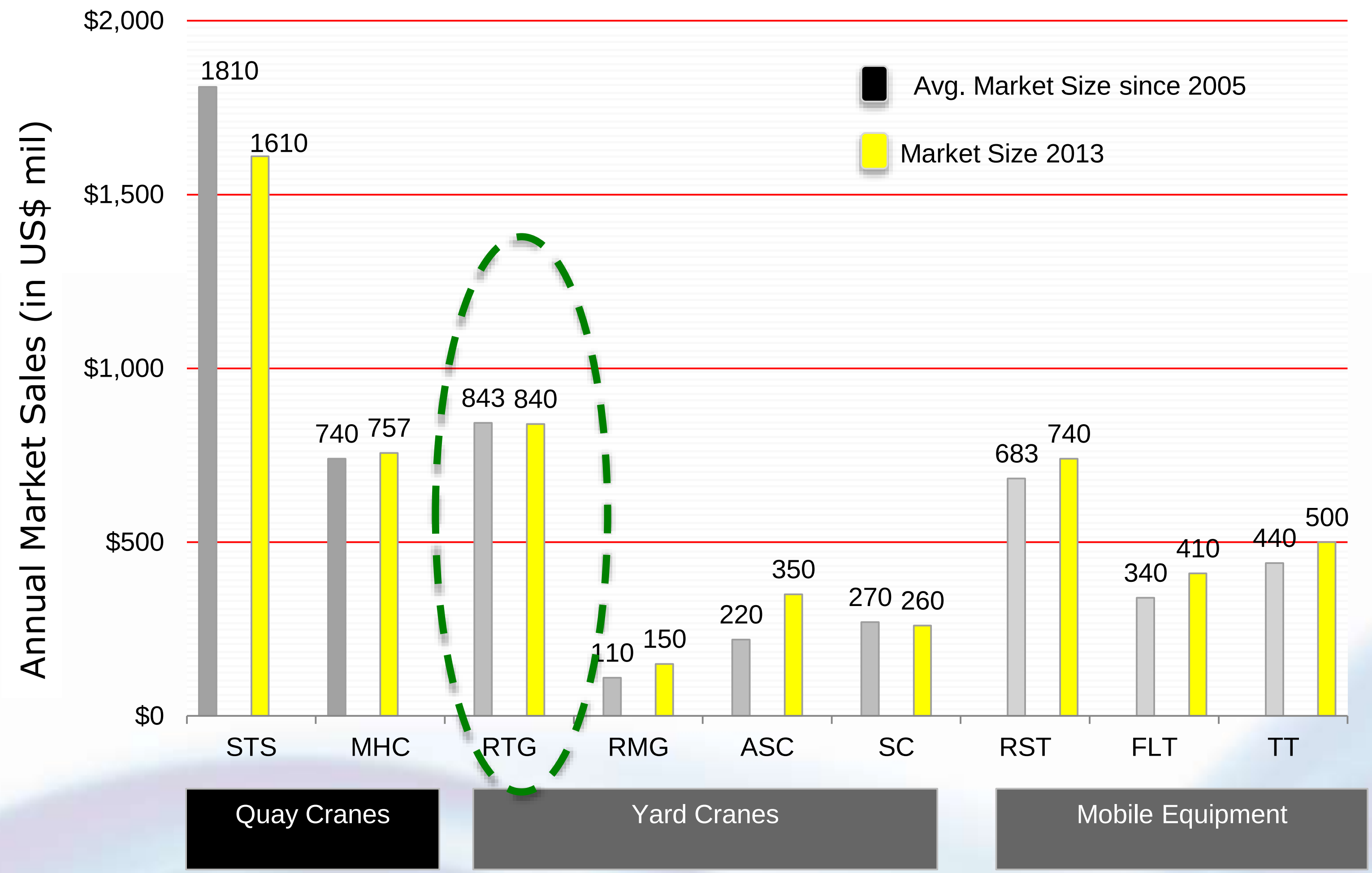
- The three determinants of yard capacity are area, density and dwell time.
- KPI: throughput per acre.
- Transhipment cargo is less demanding on the yard than gateway cargo
- Different stacking equipment achieve different storage densities
- The dwell time that the containers spend in the yard is probably the most important factor affecting yard capacity



Market for Port Equipment - 2013



RTGs Deliveries by OEM / Region
993 units: 2012 - 2014 (2Qtr)

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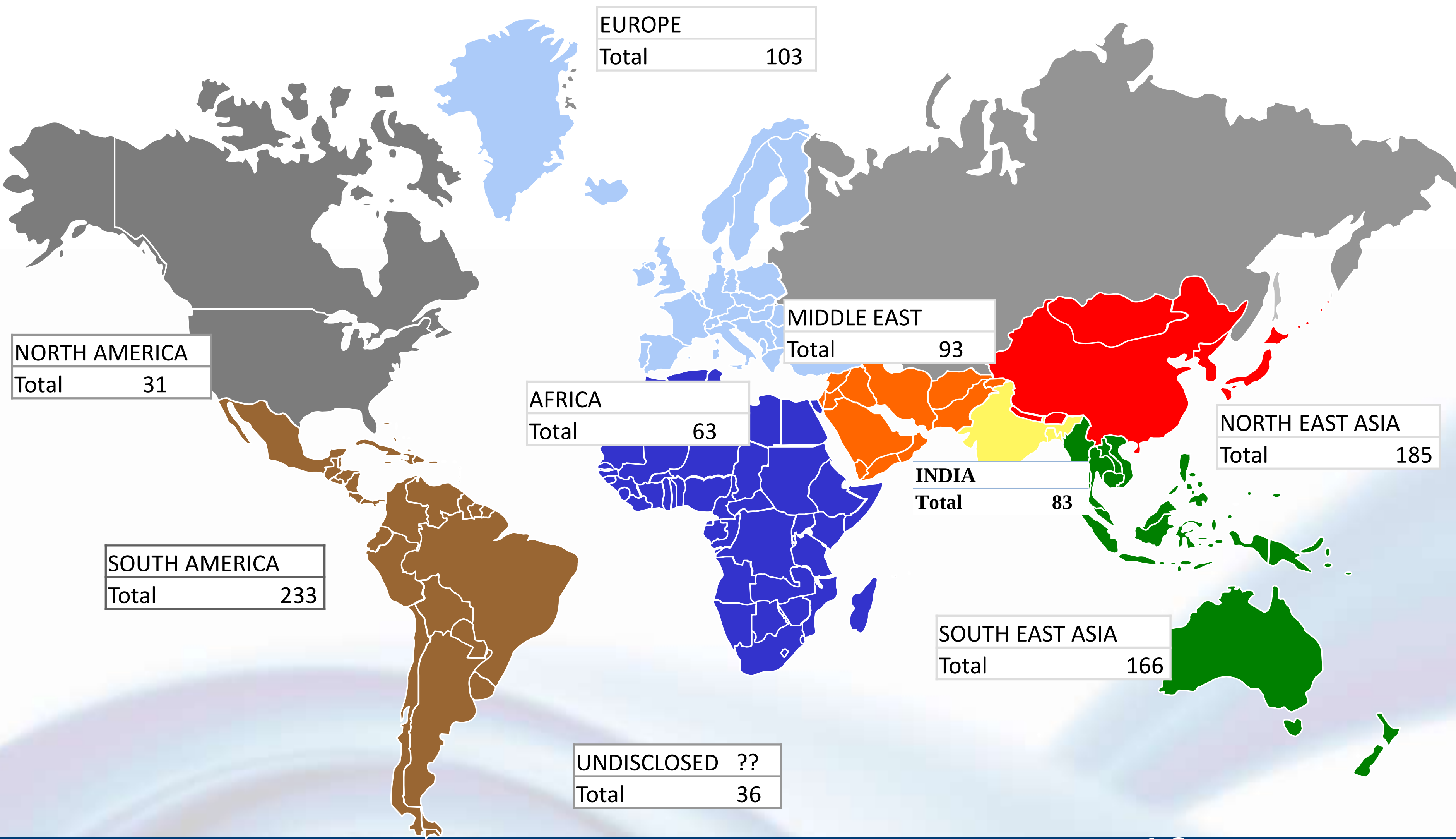
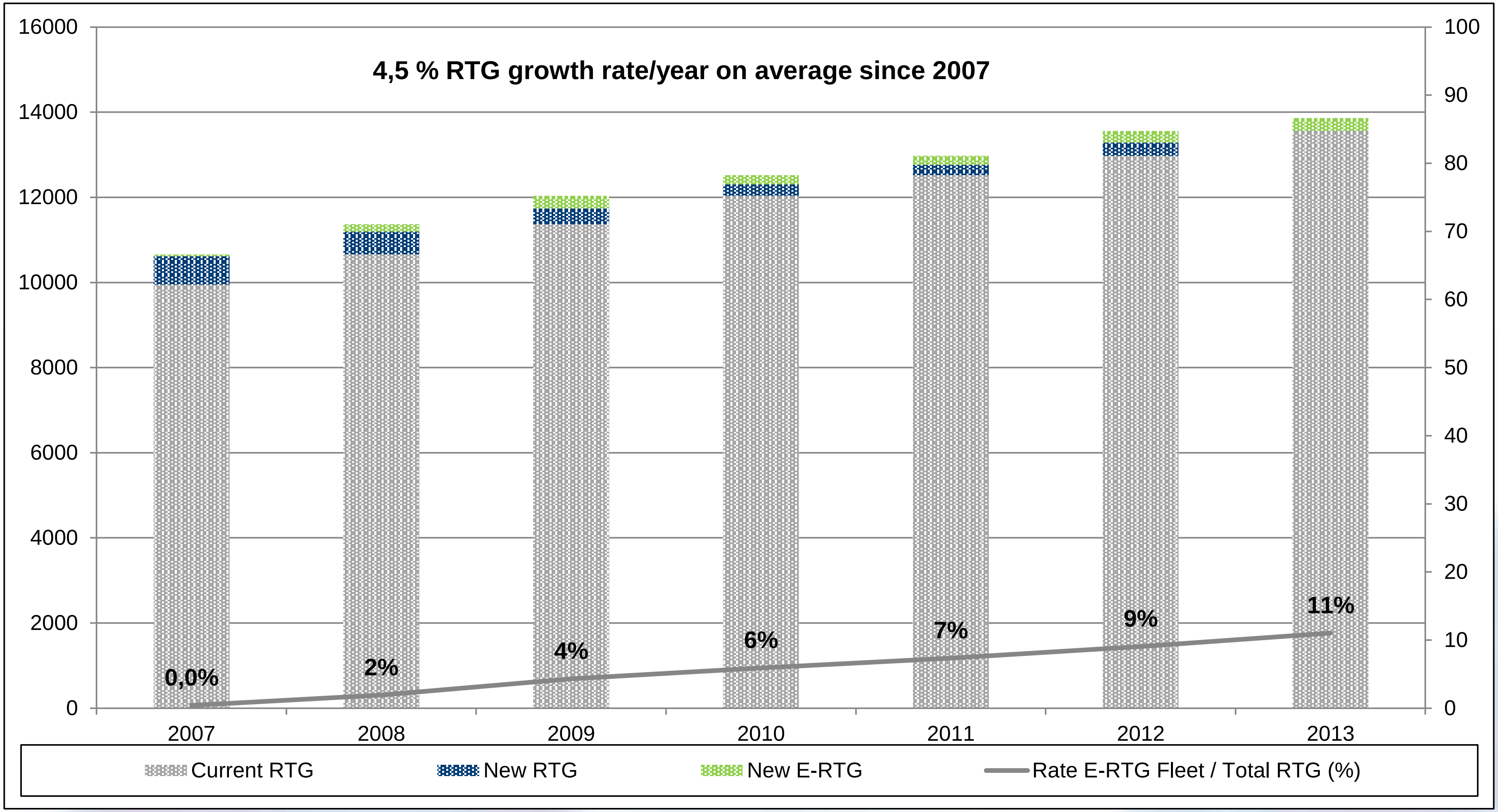
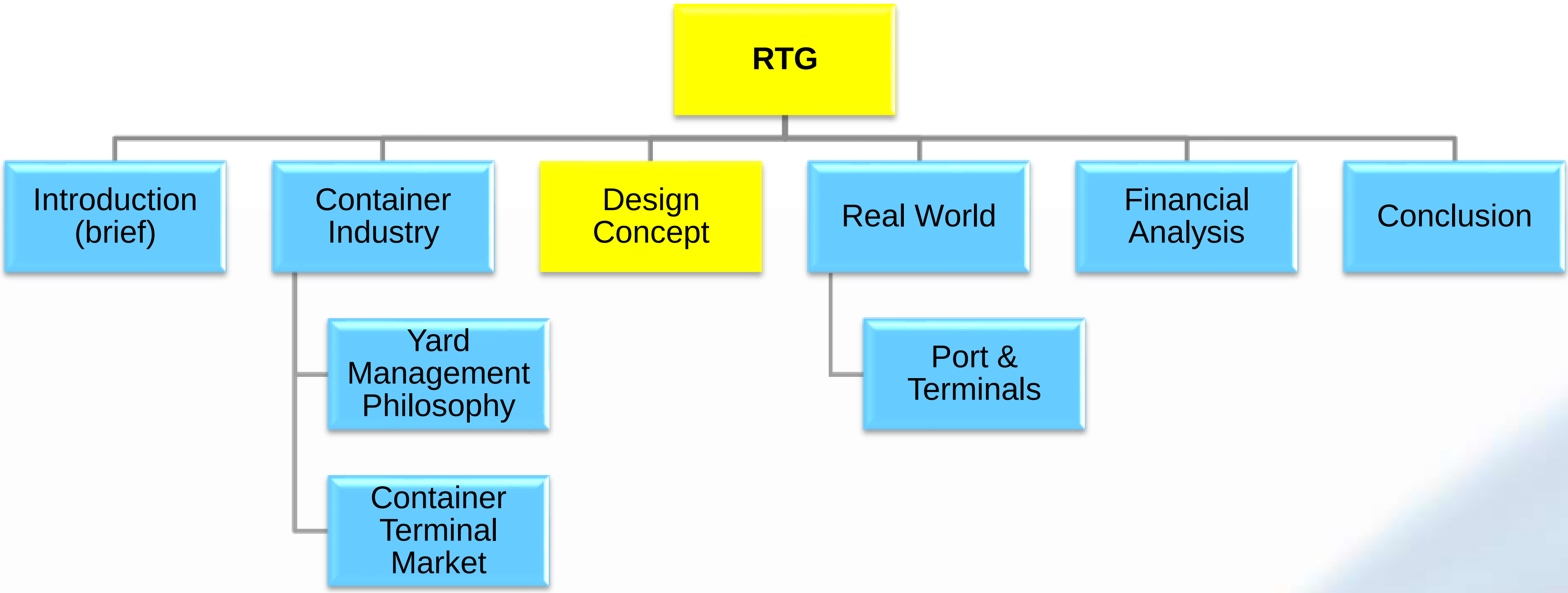


Conventional Wisdom is leading to e-RTGs



- RTGs becoming more Electrofied representing **11%** of the 2013 Fleet from less than 1% in 2006.
- Around 75% of all converted and newly supplied E-RTG systems are electrified by conductor rails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Facts + Figures / Effects

Facts + Figures

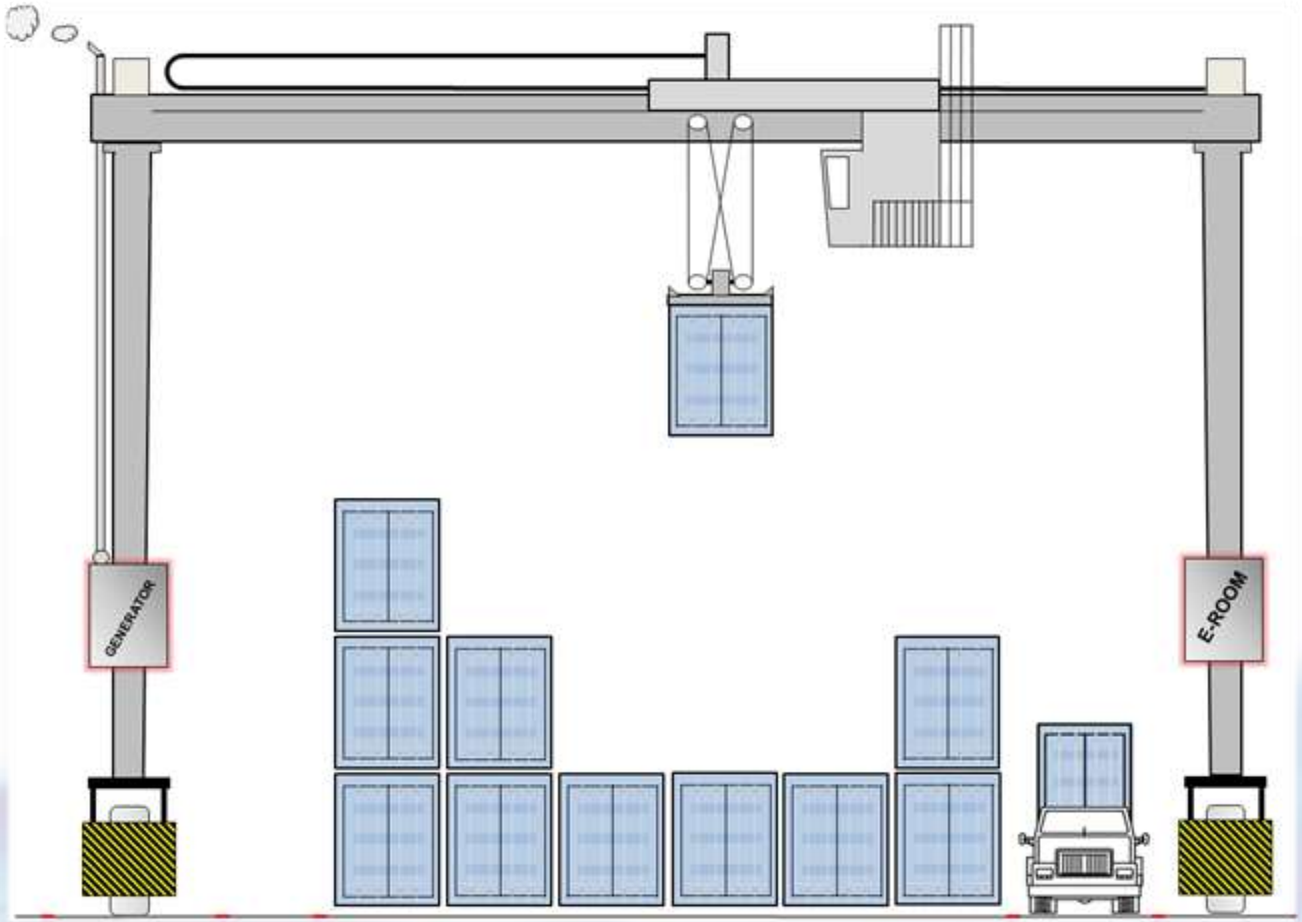
- Diesel engines are the main source of RTGs
- Container handling increases
- At the same time diesel prices increased rapidly
- In some cases RTGs account for 50 % of a container terminals‘ diesel consumption

Effects

- High fuel consumption & costs
- High dependecy on fossil fuels that have unpredictable prices
- High cost in larger size Genset service (- USD 20k / year)
- Environmental; carbon emissions, air and noise pollution

Full Electric RTGs: eRTG

Principle Function:



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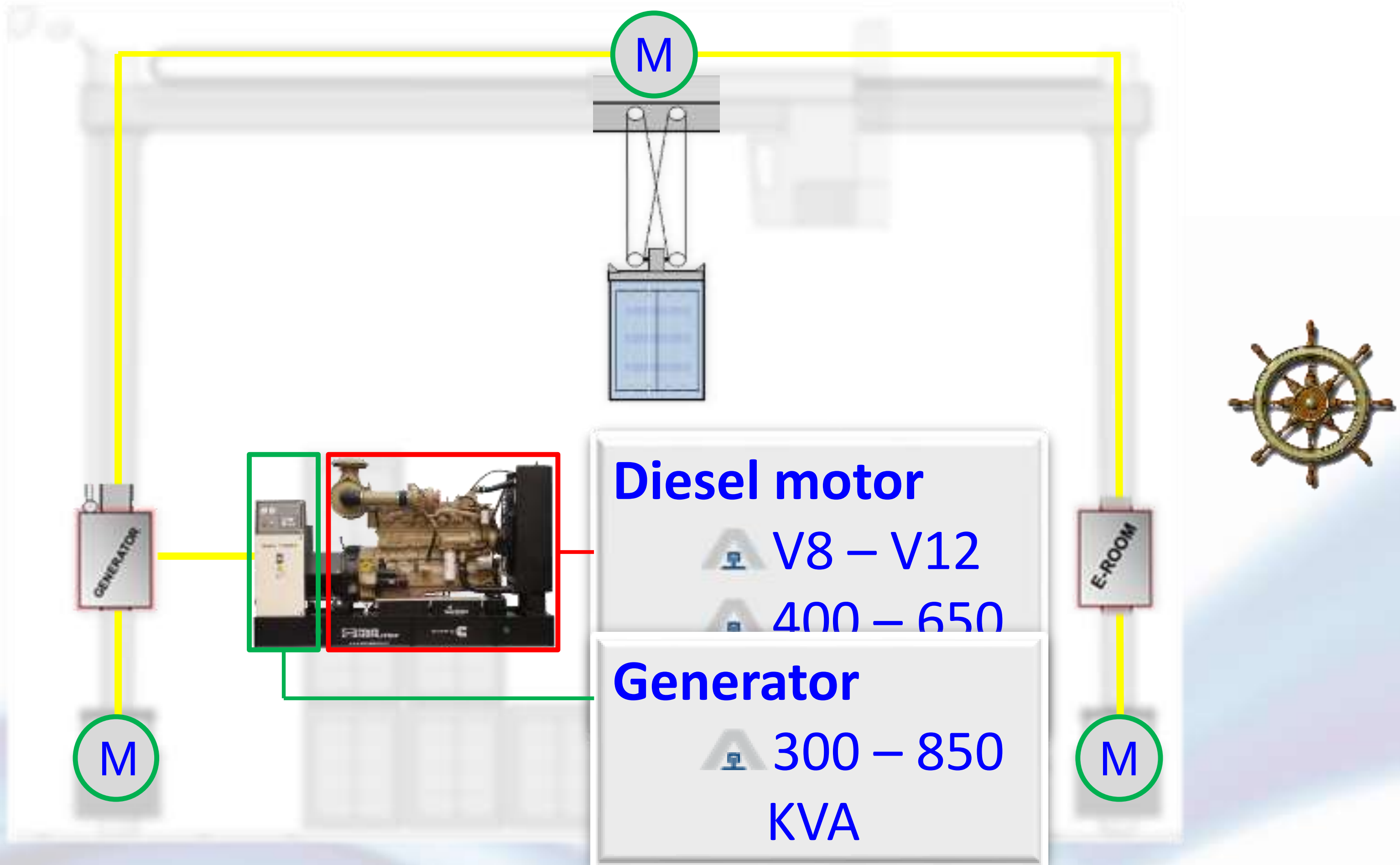

Full Electric RTGs: eRTG

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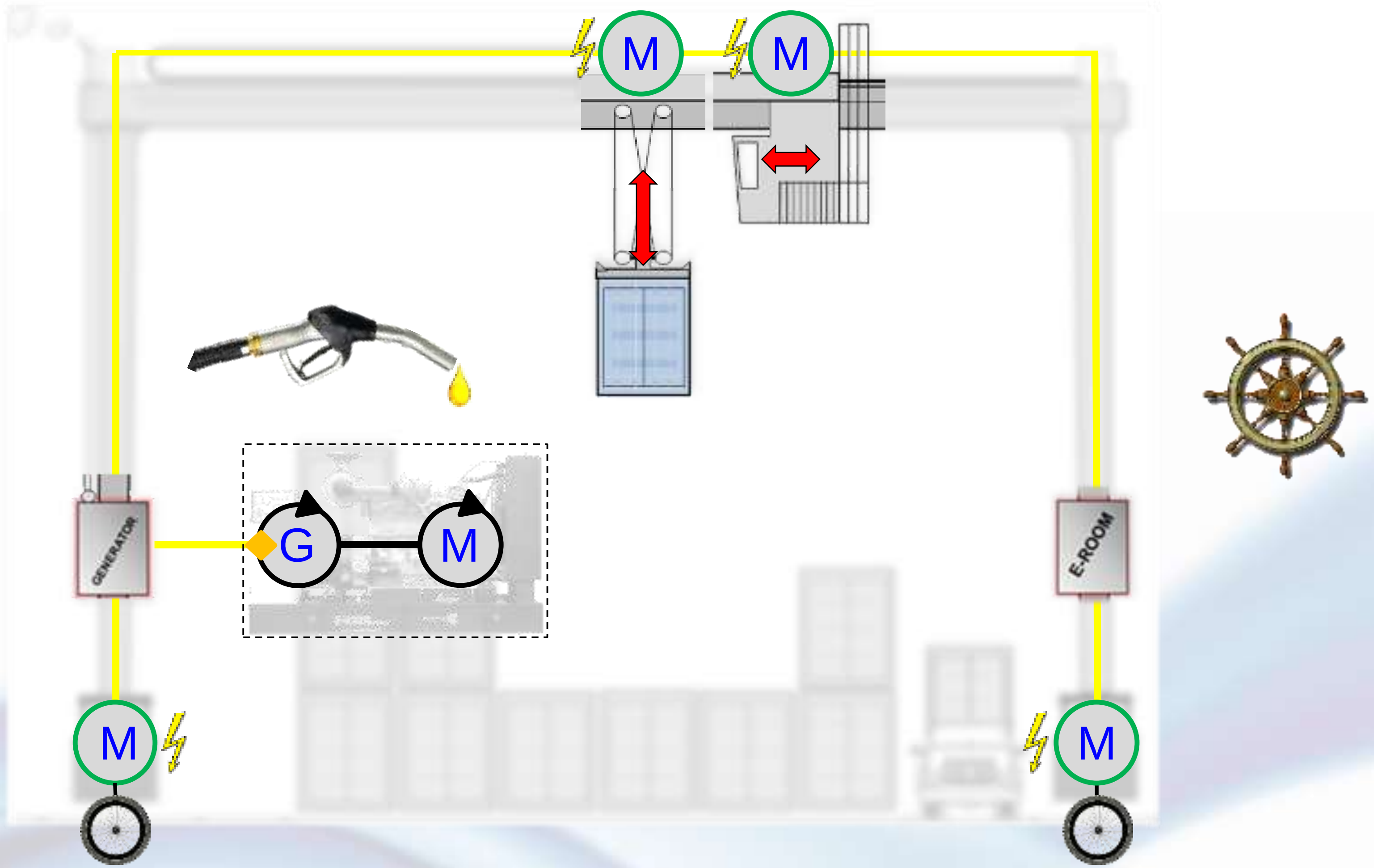
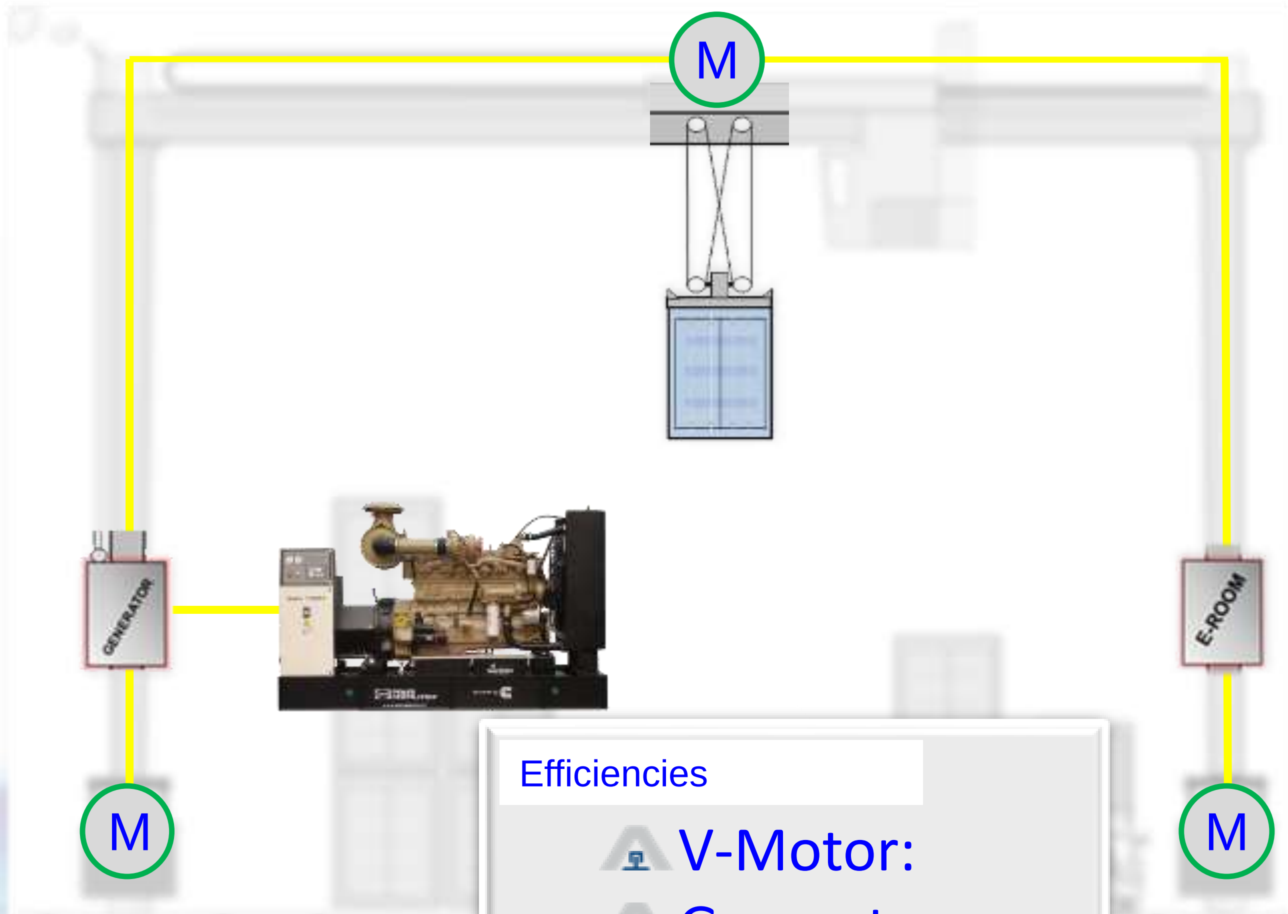


Principle Function:



Efficiencies

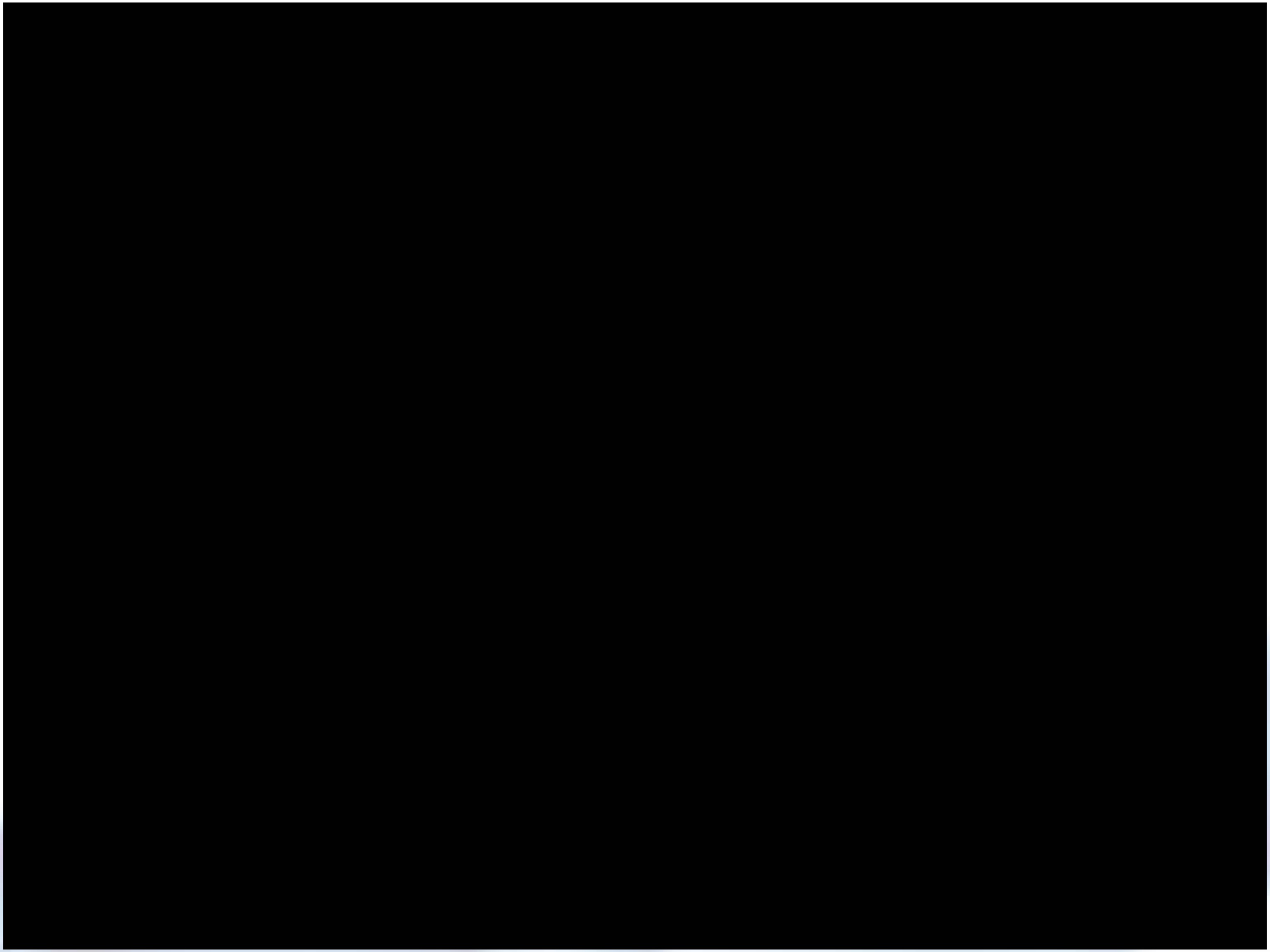
- V-Motor:
- Generator:

Aisle Eletrification System in a Container Yard

- space saving due to vertical arrangement
- electrification of two aisles from one steel structure
- lightweight and robust tubular steel structure
- minimized moving wear parts (3 rollers only)

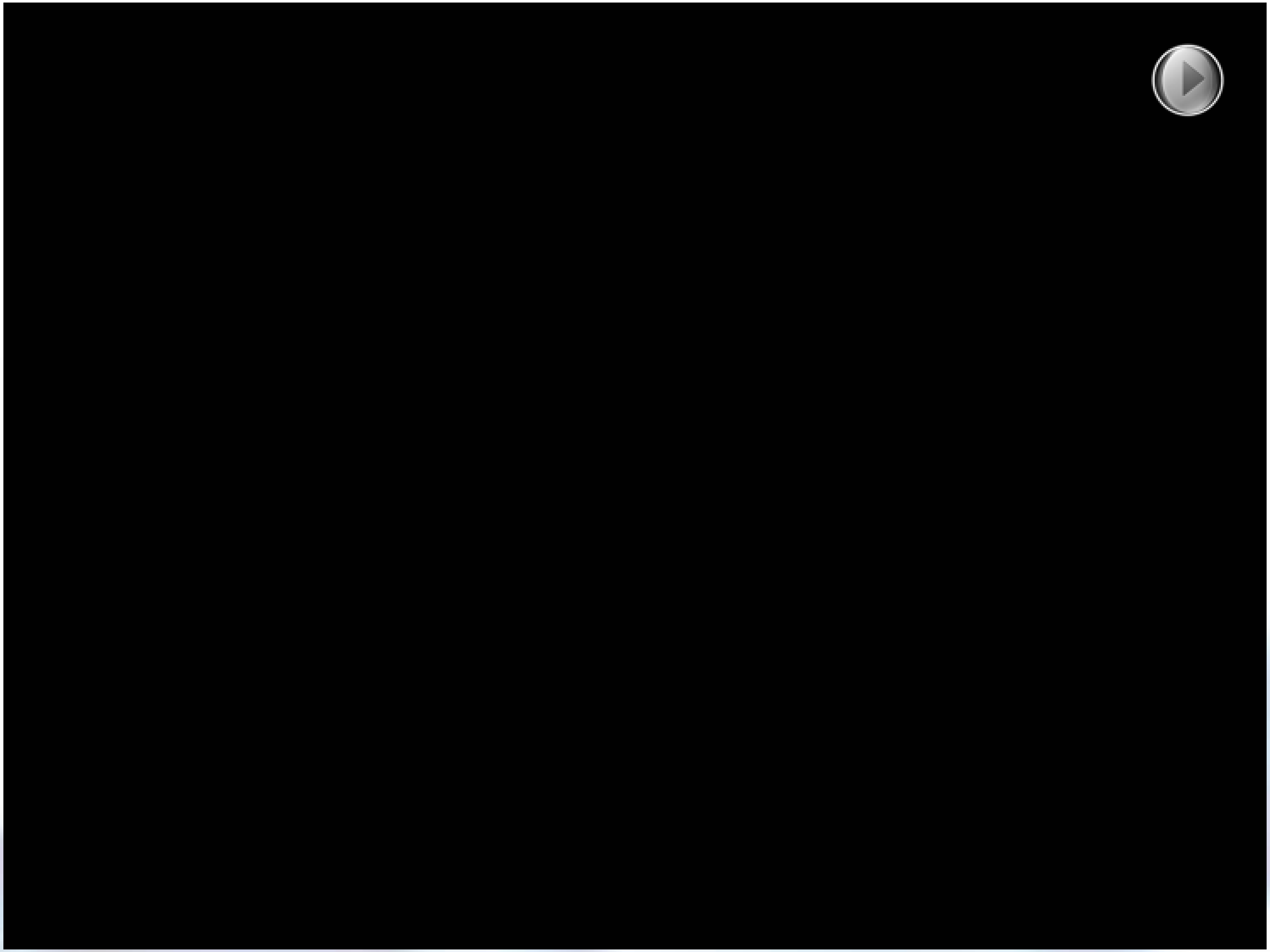
- fully electrical driven, no lifting cylinder
- max. horizontal stroke: 1700mm
- due to modular systems various sizes for particular customer needs
- vertical track tolerances: $\pm$ 200 mm
- reduction of wear parts

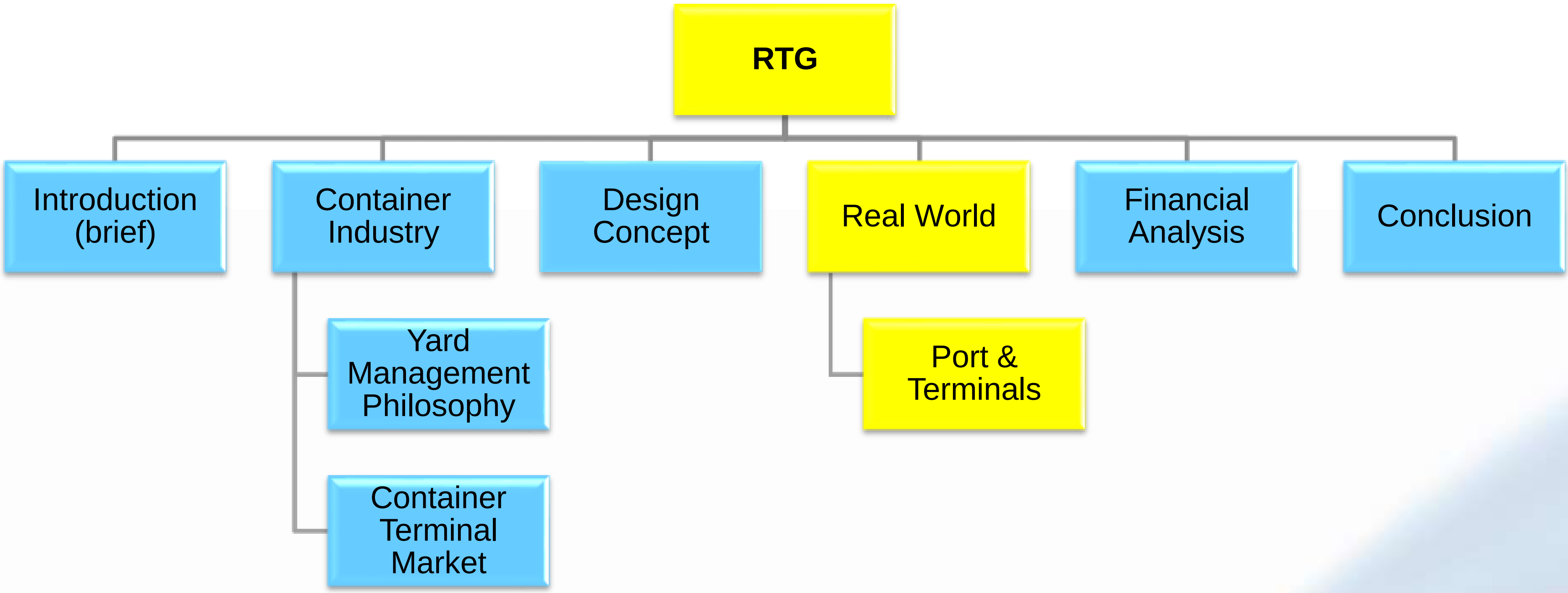
Fully Electric e-RTG



Fully Electric e-RTG

ELECTRIFICATION SYSTEMS

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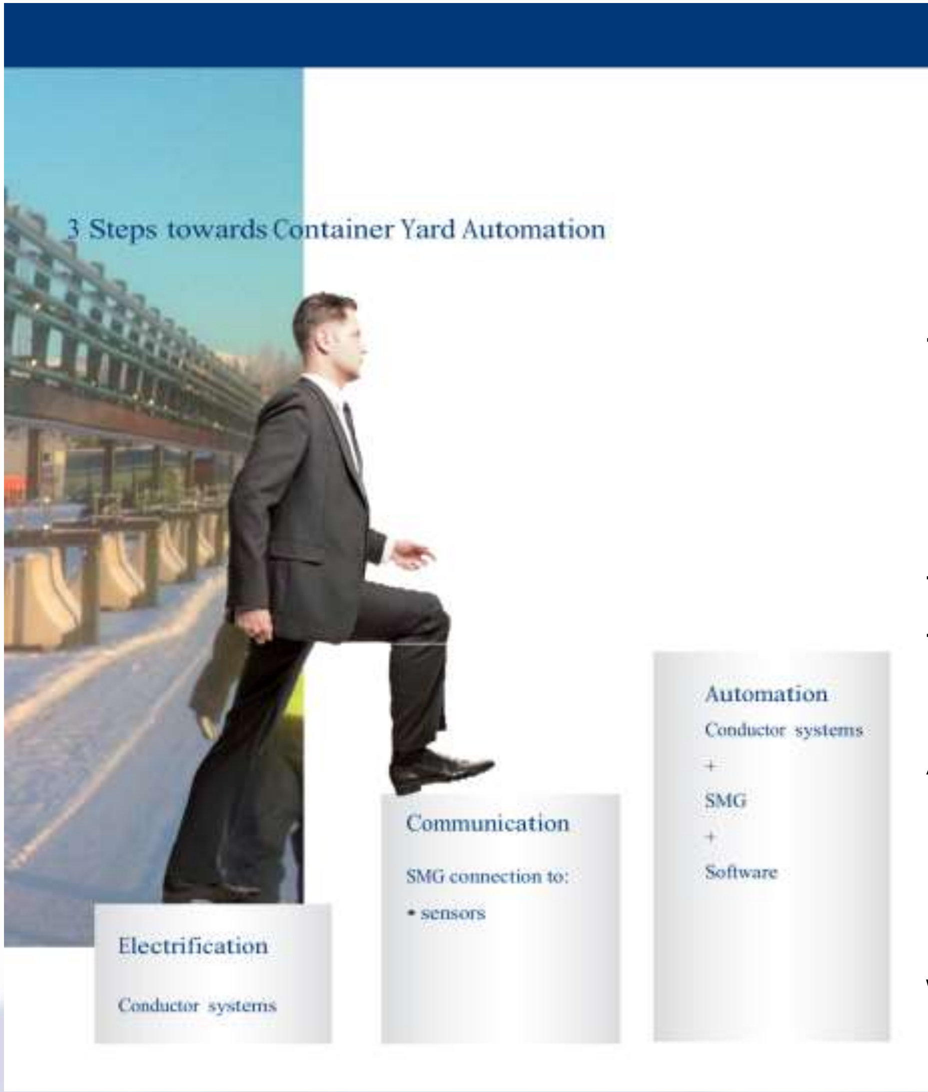

Data communication

Transmit information alongside electricity.

Customers considering low density ‘process’ data being transmitted to the terminal operating system (TOS), a step on the way to full automation of eRTGs?

A platform for the further development of remotely operated, semi or fully automated eRTGs; position control at a high data transfer rate, around 100 mbps, which can send real, lifelike images to the control room that could enable the eRTG to eventually be driven remotely.

SMG for eRTG

Vahle SMG-System – the components

Antennas (on request with guidance)

RF-cable

Profile

Vahle SMG Transceiver

TESTING

application assignment

- up to three eRTG in every lane
- arbitrary and flexible order
- communication is needed for video signals and PLC signals on the eRTG
- vision: remote control / automating eRTG

Remote Control, Semi – Automation of RTGs

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The world's most advanced RTG crane automation takes efficiency to a new level at Norway's largest freight port.

All-Eletric RTGs can be integrated (either gradually or from star-up) with a range of process automation solutions in such as:

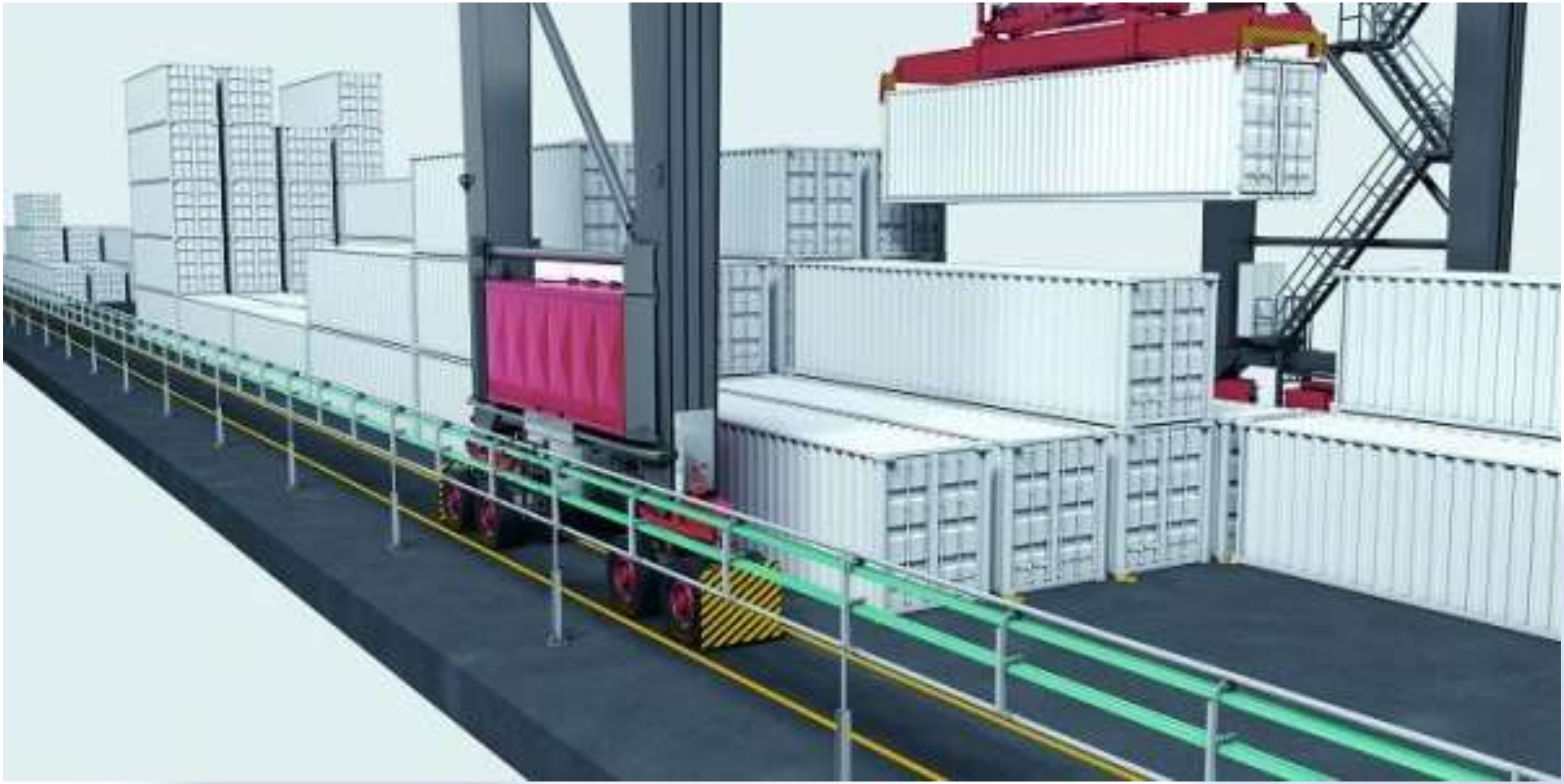
- Automated gantry steering
- Automated job selection
- Real time inventory
- Linked to TOS for control and optimisation
- Safety (stack profiling and anti-truck lifting)

Remote Control, Semi – Automation of RTGs

29 rubber-tyred Gantry cranes (RTGs) at HIT’s Container Terminal 9.

Control Room example for RTGs

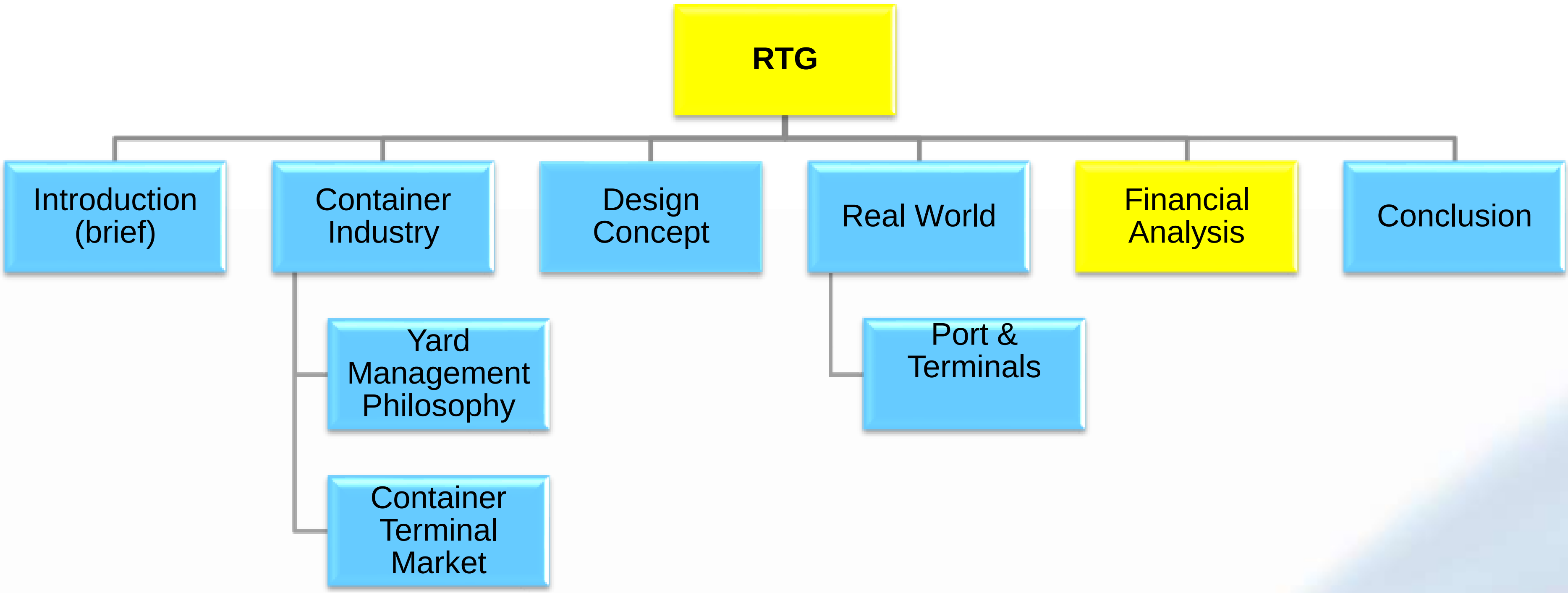
FUTURE: Fully Automated e-RTGs



The Busbar power connection converts the RTGs to fully electric operation. **Image: Konecranes**

Comparison of Yard Equipment at Felixstowe

Payback Measure for Project	RTG	RisGaRTG	EcoRTG	HW High Wire	CB Cond Bar	RMG	ARMG Automated
Investment (Modified basis)							
Machine Cost		*960 000*	*12 800 000*	*1 950 000*	*1 950 000*	*45 000 000*	*52 500 000*
Infrastructure Cost		0	0	0	0	0	0
Total		960 000	12 800 000	1 950 000	1 950 000	45 000 000	52 500 000
Energy Saving							
Energy Cost	1 979 596	1 328 818	1 076 044	512 282	519 884	574 400	583 459
Saving v RTG		650 777	903 551	1 467 313	1 459 712	1 405 196	1 396 136
Labour Saving							
Labour Cost	7 115 681	7 115 681	7 115 681	7 429 233	7 429 233	5 110 952	1 694 240
Saving v RTG		0	0	-313 552	-313 552	2 004 729	5 421 440
Payback (years) energy only		1,5	14,2	1,3	1,3	32,0	37,6
Payback (years) energy + labour		1,5	14,2	1,7	1,7	13,2	7,7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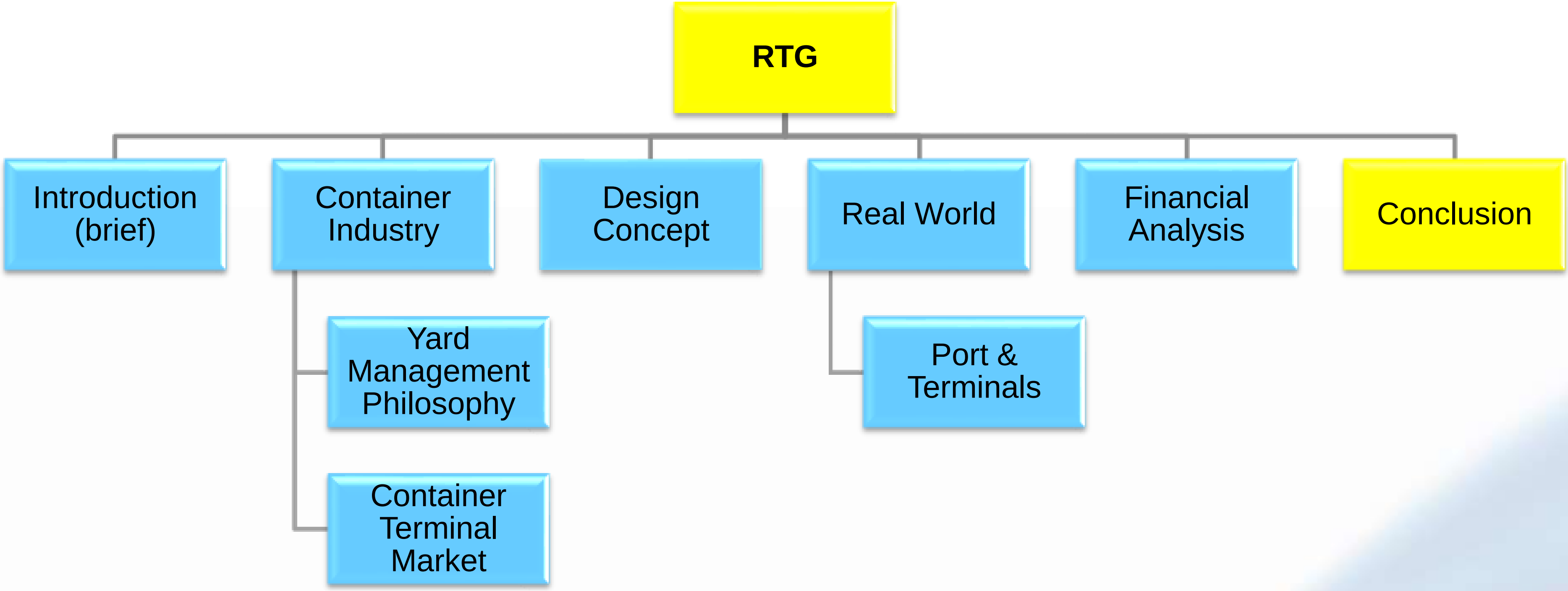
Yard Assumptions for Berth 5&6	RTG All berths ***	RTG	RisGaRTG	EcoRTG	HW High Wire	CB Cond Bar	RMG	ARMG Automated
Productivity								
Average Net Crane Rate mph	11,0	11,0	11,0	11,0	11,0	11,0	16,0	21,0
Total Machine Hours Required	454 242	213 494	213 494	213 494	213 494	213 494	146 777	111 830
Average Gross Crane Rate mph	8,9	9,0	9,0	9,0	9,5	9,5	9,5	9,1
Fleet								
Planned Maint hours per machine year	512	512	512	512	437	400	461	110
MMBF (mean moves between failures)	3 223	3 223	3 223	3 223	3 868	3 868	4 000	4 000
MTTR (mean time to repair in hours)	4,5	4,5	4,5	4,5	4,5	4,5	4,5	0,7
Block Changes per machine/year	1 142	1 142	1 142	1 142	1 142	1 142	0	0
Hours Per Block Change	0,16	0,16	0,16	0,16	0,41	0,25	0,00	0,00
% Idle Off	67,0%	67,0%	67,0%	67,0%	0,0%	0,0%	0,0%	0,0%
Net Utilisation Target (working/total)	75,0%	75,0%	75,0%	75,0%	80,0%	80,0%	55,0%	43,0%
Fleet	69	32	32	32	30	30	30	30
Analysis of Fleet hours								
total hours per year	604 440	280 320	280 320	280 320	262 800	262 800	262 800	262 800
maintenance (planned & unplanned)	42 253	19 639	19 639	19 639	15 822	14 712	16 452	3 691
available hours	562 187	260 681	260 681	260 681	246 978	248 088	246 348	259 109
block changes	12 608	5 847	5 847	5 847	14 047	8 565	0	0
idle hours engine running	31 461	13 642	13 642	13 642	19 438	26 029	99 571	147 279
idle hours engine off	63 876	27 698	27 698	27 698	0	0	0	0
working hours	454 242	213 494	213 494	213 494	213 494	213 494	146 777	111 830
Gross Utilisation (available/total)	93,0%	93,0%	93,0%	93,0%	94,0%	94,4%	93,7%	98,6%
Real Utilisation (working/available)	80,8%	81,9%	81,9%	81,9%	86,4%	86,1%	59,6%	43,2%
Power Assumptions								
Diesel consumption litre per hour work	19,000	19,000	13,000	10,410	0,000	0,000	0,000	0,000
Diesel consumption litre per hour idle	12,580	12,580	5,680	5,000	0,000	0,000	0,000	0,000
Diesel consumption litre per block change	2,000	2,000	2,000	2,000	2,000	2,000	0,000	0,000
Electricity consumption kwh work	0,000	0,000	0,000	0,000	28,000	28,000	40,727	48,109
Electricity consumption kwh idle	0,000	0,000	0,000	0,000	15,000	15,000	15,000	15,000
Average Diesel Consumption	16,3	17,2	11,5	9,3	0,3	0,3	0,0	0,0
Total diesel litres per annum	9 183 979	4 477 913	3 005 833	2 434 049	68 520	68 520	0	0
Total electricity kwh per annum	0	0	0	0	6 269 391	6 368 265	7 471 385	7 589 221
Total carbon tonnes per annum	24 154	11 777	7 905	6 402	2 876	2 919	3 213	3 263
Diesel Costs per Annum	3 673 592	1 791 165	1 202 333	973 620	27 408	27 408	0	0
Electricity Cost per Annum	0	0	0	0	438 857	445 779	522 997	531 245
Carbon Cost per Annum	386 462	188 431	126 485	102 425	46 017	46 697	51 403	52 214
Manning FTE								
Manned	SANT	SANT	SANT	SANT	SANT	SANT	SANT	FALSKT
Drivers	336	158	158	158	158	158	108	0
Engineers (assume 33% RTG related)	59	27	27	27	26	26	26	26
Bowsers	4	4	4	4	0	0	0	0
Technicians	0	0	0	0	0	0	0	16
Pluggers	0	0	0	0	16	16	0	0
Labour Cost								
Drivers	12 571 410	5 908 562	5 908 562	5 908 562	5 908 562	5 908 562	4 062 137	0
Engineers	2 374 904	1 089 155	1 089 155	1 089 155	1 048 815	1 048 815	1 048 815	1 048 815
Bowsers	117 964	117 964	117 964	117 964	0	0	0	0
Technicians	0	0	0	0	0	0	0	645 425
Pluggers	0	0	0	0	471 855	471 855	0	0
Capital Cost Build								
Cost per Machine	£900 000	£900 000	£930 000	£1 000 000	£965 000	£965 000	£1 500 000	£1 750 000
Fleet Cost	£62 100 000	£28 800 000	£29 760 000	£32 000 000	£28 950 000	£28 950 000	£45 000 000	£52 500 000
Infrastructure Cost	£0	£0	£0	£0	£0	£0	£0	£0
Machine Life Years		25	25	25	25	25	25	25
Infrastructure Life Years		25	25	25	25	25	25	25
%Machine ECA		0%	80%	80%	80%	20%	20%	20%
Yard Layout	< reflecting any requirement to alter layout							
Blocks	20	12	12	12	10	10	15	15
Rows	100	90	90	90	92	92	42	42
Width	7	7	7	7	7	7	10	10
Height	5	5	5	5	5	5	5	5
Stacking Capacity (exc shuffle slots)	62 000	33 480	33 480	33 480	28 520	28 520	28 980	28 980
Annual TEU Capacity	4 114 545	2 221 855	2 221 855	2 221 855	1 892 691	1 892 691	1 923 218	1 923 218
Yard Density		72%	72%	72%	84%	84%	83%	83%
Blocks per Fleet Machine	0,29	0,38	0,38	0,38	0,33	0,33	0,50	0,50

*** This column assumes whole port (not berth 6 & 7) to check equipment methodology and results only. Not used in financial analysis

VAHLE
ELECTRIFICATION SYSTEMS

The VAHLE Solution
Financial benefits - Example

Cash flow and ROI statement				
BENEFIT DRIVERS	YEAR			
	0	1	2	3
Improved operational time (less down time)		**25 000**	**25 000**	**25 000**
Reduced energy cost due to less running time		**50 859**	**50 859**	**50 859**
Reduced Maintance cost			**9 180**	**9 180**
Fewer accidents, resulting in less workers' compensation		**10 000**	**10 000**	**10 000**
Diesel replacement avoided 150,000 / 7 years		**21 429**	**21 429**	**21 429**
other…				
Total annual benefits		$107 288	$116 468	$116 468
Implementation filter		**90%**	**95%**	**100%**
Total benefits realized		$96 559	$110 645	$116 468
Costs	**Year 0**	**Year 1**	**Year 2**	**Year 3**
Total	$250 000	$0	$0	$0
Benefits	**Year 0**	**Year 1**	**Year 2**	**Year 3**
Annual benefit flow	-$250 000	$96 559	$110 645	$116 468
Cumulative benefit flow	-$250 000	-$153 441	-$42 796	$73 672
Discounted benefit flow	**Year 0**	**Year 1**	**Year 2**	**Year 3**
Discounted costs	$250 000	$0	$0	$0
Discounted benefits	$0	$96 559	$110 645	$116 468
Total discounted benefit flow	-$250 000	$96 559	$110 645	$116 468
Total cumulative discounted benefit flow	-$250 000	-$153 441	-$42 796	$73 672
Initial investment	**Year 0**	**Year 1**	**Year 2**	**Year 3**
Initial investment	**$250 000**	**$0**	**$0**	**$0**
Implementation costs		**$0**	**$0**	**$0**
Ongoing support costs	**$0**	**$0**	**$0**	**$0**
Training costs	**$0**	**$0**	**$0**	**$0**
Other costs	**$0**	**$0**	**$0**	**$0**
Total costs	$250 000	$0	$0	$0
ROI measures				
Cost of capital	**6%**			
Net present value	$37 355			
Return on investment		39%	83%	129%
Payback (in years)	2,37			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Case for e-RTG: Economy, Efficiency & Environment

Comparisons on Fuel Consumption

RTG Type	Conventional RTG	EcoRTG	EcoRTG w/supercapacitors	eRTGs
Fuel / Energy consumption (15 moves / hour)	5,52 gal/hour	3,45 gal/hour	1,8 gal/hour	35kWh
Energy costs: Diesel $3.13 / kWh: $0.09	$17,28	$10,80	$5,63	$3,15
Operating hours 3600, cost / year	$62 199,36	$38 874,60	$20 282,40	$11 340,00

Additional savings for reducing maintenance costs associated with diesel generators:

- Maintenance costs per operating hours ($2.55 / hour) : $9 180 per yr.
- Tier 4 Diesel replacement @ 25000 hours ($6 / hour) : $150 000

***Reference: I nnovation for future generations conference, ''GPA's eRTG demonstration project", Aug. 5-7, 2012.**

Solutions: Electrification to reduce fuel and maintenance for achieving savings of up to 85%

Comparison of Yard container handling equipment

VAHLE ELECTRIFICATION SYSTEMS

Comparison of the operating performance of different types of handling equipment			
ITEM	RTG	E-RTG	RMG
Mobility	Average	Average	Poor
Safety	Average	Average	Good
Operating system integration method	Wireless transmission system	Wireless transmission system	Fiber transmission system
Stability of Signal	Unstable	Stable with SMG	Stabe
Stable Breakdown frequency	Average	Average	Low
Mechanical method	Hydraulic	Hydraulic / Electric Control	Electric control
Repair and maintenance time	Average	Average	Short
Energy source	Diesel	Diesel/Electric	Electric
Maintenance cost	High	High	Low
Air pollution	Severe	Zero	Zero

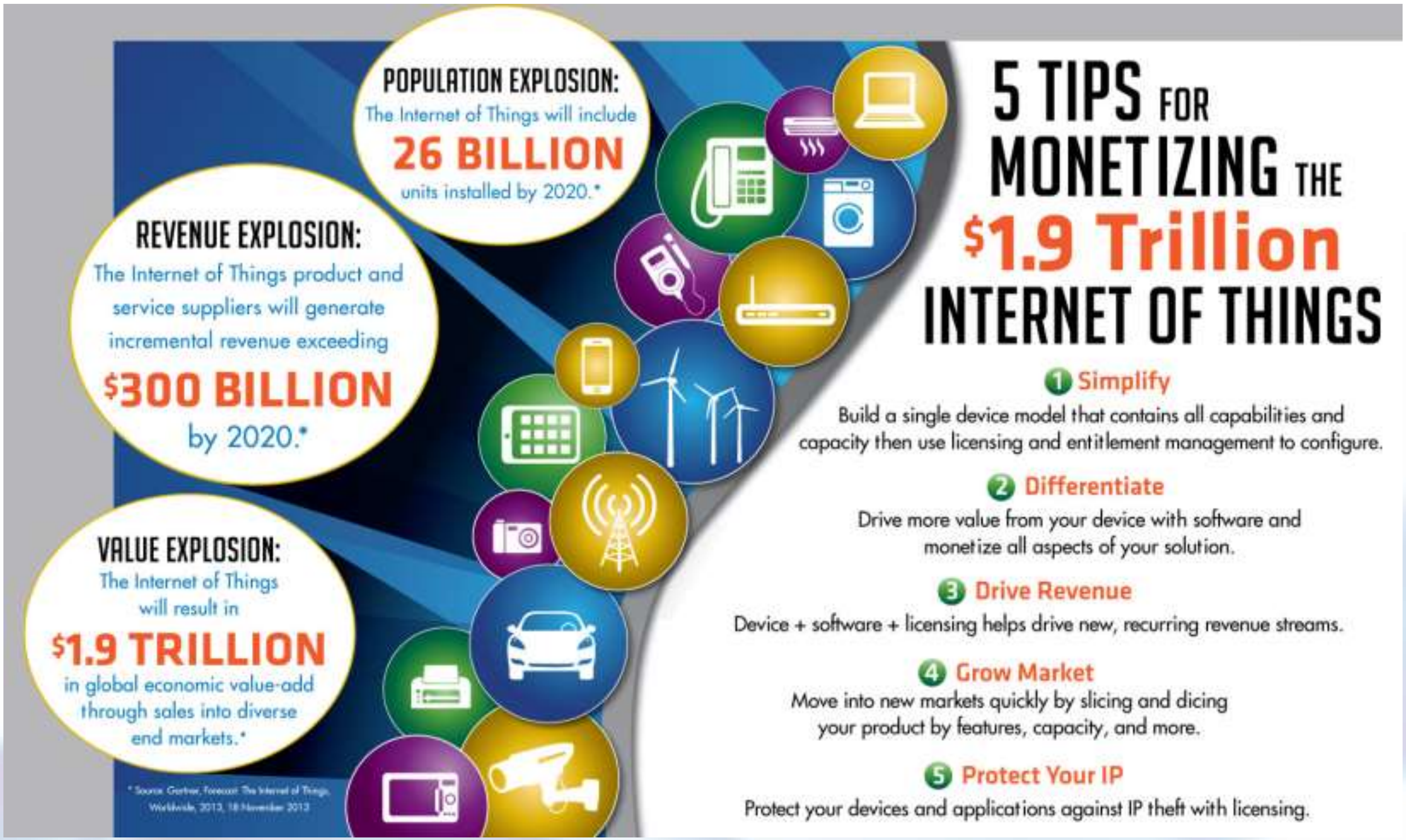
REFERENCE: Yang, Y-C and Chang, W-M, 2013. Performance Analysis of Electric- Rubber Tired Gantries from a Green Container Perspective, In the Proceedings of the Eastern Asia Society for Transportation Studies, Vol 9., 2013

Conclusion

- Energy costs are increasing
- Ports are having to load / unload containers faster and more reliable
- Dozens of eRTG projects completed or in progress
- Main three characteristics are: **cost effective, efficient and ecological**

Pointers for the future

- Automation is fast becoming a standard in various ports and terminals, with recent interest in semi-automating and even full automating RTG.s
- SMG – Slotted Microwave Guide, is a data transmission technology for transmitting and recieveing data to eRTGs, which can improve yard container handling.


POPULATION EXPLOSION:
The Internet of Things will include
26 BILLION
units installed by 2020.*
REVENUE EXPLOSION:
The Internet of Things product and service suppliers will generate incremental revenue exceeding
$300 BILLION
by 2020.*
VALUE EXPLOSION:
The Internet of Things will result in
$1.9 TRILLION
in global economic value-add through sales into diverse end markets.*
5 TIPS FOR MONETIZING THE $1.9 Trillion INTERNET OF THINGS
1 Simplify
Build a single device model that contains all capabilities and capacity then use licensing and entitlement management to configure.
2 Differentiate
Drive more value from your device with software and monetize all aspects of your solution.
3 Drive Revenue
Device + software + licensing helps drive new, recurring revenue streams.
4 Grow Market
Move into new markets quickly by slicing and dicing your product by features, capacity, and more.
5 Protect Your IP
Protect your devices and applications against IP theft with licensing.

Questions?

Thank You