Planning Ahead for Automated Terminals
Presentation to AAPA Facilities Engineering Conference

Dan Johnson, P.E. – November 18, 2009
Agenda:

1. Introduction to TBA
2. Critical Background: History and Continuous Change
3. Planning approach used in Portsmouth for APMT (and elsewhere)
4. Example Focus study: Waterside transport
Headquartered in Delft (Rotterdam)

World’s largest dedicated simulation firm

75 engineers working full – time

8 out of top 10 Global Terminal Operators are customers.

Active in more than 25 countries

Completed over 100 terminal projects

TBA supports port and terminal operators during all stages from concept to realization and thereafter in operations.
**Study:**
- Simulate capacity, strategy, CAPEX studies, e.g. vessel deployments: TRAFALQUAR
- Full-terminal simulation, peak shift and multi-day (e.g. handling strategy tests): TIMESQUARE

**Test, Train, Tune:**
- Full system emulation: Simulation plus direct connection to TOS and equipment systems: CONTROLS

**Operate:**
- Optimization modules for real-time control in conventional and automated container facilities: POSCH
- Automated transport control software (e.g. AGV system operation): TEAMS
Selected portfolio for support of container terminal conceptual design (2003-2009):

DPW:
- Antwerp Gateway
- London Gateway
- Fisherman’s Island
- Jebel Ali CT 2, CT3 & CT4
- Rotterdam World Gateway
- Southampton extension

HPH:
- ECT barge terminal, Rotterdam
- Tercat - Barcelona Muelle Prat
- Euromax Rotterdam
- Thamesport extension

APMT:
- Maasvlakte II terminal
- Portsmouth, VA
- Algeciras extension
- Tanjung Pelepas extension

PSA:
- Voltri Terminal Europe extension
- Transnet: Nquga & Durban extensions
- Others: (many are secret)
  - Northport, Malaysia extension
  - Port of Gothenburg extension
  - Packer Avenue, Philadelphia

HHLA:
- Burchardkai extension
- Tollerort extension
Summary Project Portfolio

- **Optimization** of existing facilities (layout, TOS, operations):
  - DPWorld Port Botany, West Swanson (2006 - 2008)
  - Durban Container Terminal (2007)
  - **APMT Rotterdam** (2007 – 2008)
  - TSI Vancouver (2008)
  - Ocupa Manzanillo (2008)

- **Performance assessment** of equipment specifications
  - NTB (2004, 2006)
  - **Euromax** (2005)
  - APMT-PTP (2006)

- **TOS Optimization** (CONTROLS):
  - **DPWorld Pusan Newport** (2006)
  - APMT Portsmouth, Rotterdam, Algeciras (2006 - 2008)
  - Eurogate Hamburg (2007)
  - **DPWorld Antwerp Gateway** (2008 - 2009)
  - Gothenborg Havn (2009)

- Delivery **Automated Equipment Control Systems** (TEAMS)
  - CTA (Hamburg, 2002)
  - Euromax (Rotterdam, 2008)
  - Antwerp Gateway (2007)
Terminal Automation is...

- Complex
- Expensive
- Time-consuming to implement
- Unique, each time
- Environmentally friendly?
- Leveraged?
- Cost-effective?
- “Inflexible”? 

Typical Questions:

- Is it right for my facility? When?
- What mode?
- What are implications for me if a nearby terminal automates?
What is the Relative Popularity of Automated Yard Cranes?

End-loaded stacking cranes are most popular more now for primarily import export terminals.

[Diagram showing the popularity of automated yard cranes with specific years and locations labeled]
The Drivers for Terminal Automation are Compelling

- Cost control
- Reduction of labor dependency
- Logistic control – centralized control & optimization
- Reliability and predictability of operations
- Safety
- Reduction of environmental impact (noise, light, emission)
- Reduction of maintenance
The History: Recent Terminals to Go Live

Terminal Simulation HPH - Euromax (2003 → 2009)

Terminal design APMT - Portsmouth (2003 → 2009)

Terminal design DPW - Antwerp (2005 → 2009)
Four Terminals have Yard and Transport Automation

- 4 sites in Operation:  Automated  Automated
  Yard Crane  Transport

- ECT, Rotterdam  ASC  AGV
- Altenwerder, Hamburg  ASC  AGV
- Patrick, Brisbane  N/A  Automated Strads
- Euromax, Rotterdam  ASC  AGV
ECT, Rotterdam - 1993
Reduce labor dependencies – labor costs

Notes: Original Automated Terminal, ONE ASC PER RUN, strads used for valet gate service, low ship productivity.
Notes: Successful but sub-par ship productivity. ASC + AGV; 2 asc per run, 1 over 4 ASC; second QC hoist is automated.
Note: sub-par ship productivity, unable to sell second site on concept, low density. However, exceeding design throughput capacity is part of what hurts ship productivity.
Euromax, Rotterdam - 2008
Reduce labor dependencies – labor costs
Eight Terminals have Yard Crane Automation

- **8 Sites Operating:**

<table>
<thead>
<tr>
<th>Automated Yard Crane</th>
<th>Manual Transport</th>
</tr>
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<tbody>
<tr>
<td>DPW Antwerp</td>
<td>ASC</td>
</tr>
<tr>
<td>APMT, Virginia</td>
<td>ASC</td>
</tr>
<tr>
<td>Thamesport, UK</td>
<td>ASC (side &amp; end)</td>
</tr>
<tr>
<td>Pasir-Panjang, Singapore</td>
<td>Bridge Crane</td>
</tr>
<tr>
<td>Wan-Hai, Tokyo</td>
<td>C-RMG</td>
</tr>
<tr>
<td>Evergreen, Kaohsiung</td>
<td>C-RMG</td>
</tr>
<tr>
<td>DPW – Antwerp</td>
<td>ASC</td>
</tr>
<tr>
<td>Tobishima, Japan</td>
<td>RTG</td>
</tr>
</tbody>
</table>
Successful concept: ASC + manual shuttles like APMT VA; Just went live, RMG stacks still under-utilized.
Successful in concept: ASC + manual shuttles RMG stacks still under-utilized, good ship productivity; aggressive financing required a more fully-utilized terminal, APMT now negotiating with VIT to share use. Ship: 40 Moves/hr, ASC gantry speed 300 m/min; 6 QC, 30 ARMG
fairly successful, side and end loading; Navis SPARCS ship planning
Layout and Equipment Selection is just a Small Part of the Work

- Design of terminal
  - Equipment Requirements
  - Layout definition in detail - E.g. reefer facilities, transfer zones
- Design control rules for TOS
  - Automated grounding decisions
  - Automated ASC dispatching rules
  - Control mechanisms and collision control rules for ASCs
- Testing and tuning TOS control rules with Emulation is ongoing

Example: APMT – Portsmouth, Virginia:
What is Simulation?

(future) Reality

Simulation model

Experiments

Validation

Real terminal

Virtual terminal
- New approaches, equipment, operating logic, site size, etc..
- Obtain non-intuitive results: E.g. Is a buffer required for Automated shuttle
- Board members need convincing argument to spend $$$
- Accurate ROI, OPEX, CAPEX calculations
- Accurate engine hours/emissions estimates
- Decide on waterside transport
**Definition of operational scenarios**

- Conceptual layouts
- Capacity calculation
- Assessment of alternatives under dynamic conditions (simulation)
- Sensitivity analysis (simulation)
- Design of transition trajectory
- Cost analysis (OPEX & CAPEX)

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**Typical project approach:**

*The steps in designing a terminal meeting the targets*

<table>
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<tr>
<th>DESIGN DECISION</th>
<th>QC concept: Conventional</th>
<th>Stack orientation: Parallel</th>
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<tr>
<td>Throughput per quay:</td>
<td>2,500 TEU/m quay</td>
<td></td>
</tr>
<tr>
<td>Throughput per area:</td>
<td>35,000 TEU/ha</td>
<td></td>
</tr>
<tr>
<td>QC productivity:</td>
<td>50 mph (gross)</td>
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<tr>
<td>Vessel productivity:</td>
<td>300 mph</td>
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<td>DS waiting &gt; 8h:</td>
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<tr>
<th>CONSTRAINT/ASSUMPTION</th>
<th>Terminal dimension: Quay length 3,200m, Apron depth 600m</th>
<th>QC work hrs: 5,000</th>
<th>Filling rate: 85%</th>
<th>Dwell time: 5.3 days</th>
<th>Overall peak: 1.15</th>
<th>ASC capacity: 16 bx/h (WS), 14 bx/h (LS)</th>
<th>T/S = 67% (DS, feeder &amp; barge)</th>
<th>Gate / Rail: 20%/day &amp; 7%/hr, 15%/day &amp; 5%/hr</th>
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<tr>
<th>RESULTS</th>
<th>QUAY</th>
<th>YARD</th>
<th>EQUIPMENT</th>
<th>GATE/RAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume:</td>
<td>8.6 M TEU</td>
<td>No. of modules:</td>
<td>90</td>
<td>LS Peak load:</td>
</tr>
<tr>
<td>WS peak load:</td>
<td>1,057 bx/h</td>
<td>Dimension (L x W):</td>
<td>35 x 8 TEU</td>
<td></td>
</tr>
<tr>
<td>Stack height:</td>
<td>5</td>
<td>Stack height:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land use:</td>
<td>~66%</td>
<td>Throughput:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Throughput:</td>
<td>2,700 TEU/m</td>
<td>Throughput:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Throughput:</td>
<td>107,000 TEU/ha</td>
<td>Throughput:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**Equipment**

- No of QCs: 32
- No of ASCs: 124

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**Yard**

- No. of modules: 90
- Dimension (L x W): 35 x 8 TEU
- Stack height: 5
- Land use: ~66%
- Throughput: 107,000 TEU/ha

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**Quay**

- Volume: 8.6 M TEU
- WS peak load: 1,057 bx/h

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**Gate/Rail**

- LS Peak load: 388

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**Results**

- Throughput per quay: 2,500 TEU/m quay
- Throughput per area: 35,000 TEU/ha
- QC productivity: 50 mph (gross)
- Vessel productivity: 300 mph
- DS waiting > 8h: <1%

---

**Targets**

- Vessel productivity: 300 mph
- DS waiting > 8h: <1%
- T/S = 67% (DS, feeder & barge)
- Gate / Rail: 20%/day & 7%/hr, 15%/day & 5%/hr
Typical project approach: The steps in designing a terminal meeting the targets

1. Definition of operational scenarios
2. Conceptual layouts
3. Capacity calculation
4. Assessment of alternatives under dynamic conditions (simulation)
5. Sensitivity analysis (simulation)
6. Design of transition trajectory
7. Cost analysis (OPEX & CAPEX)

Conceptual layouts
Capacity calculation

3 interchange lanes, 2 in gauge, 1 in back reach
Hatchcovers between crane legs

TBA
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Assessment of alternatives under dynamic conditions (simulation)
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**RF QC Performance - RF handling**
Twin Carry ShC - Hoist Speed 60/30 - 25 Reefer Modules - Dedicated Assignment - 18 QCs @ 40 ccph - Gantry Speed @ 4.5 m/s - Gantry Acc. @ 0.3 m/s² - Spreader Acc. @ 0.3 m/s² - Trolley Acc. @ 0.3 m/s² - 408 landside bx/h

<table>
<thead>
<tr>
<th>Number of Reefer Stacks</th>
<th>RF Loading QC Performance (bx/hr)</th>
<th>RF Unloading QC Performance [bx/hr]</th>
<th>Average RF QC Performance [bx/hr]</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>37.8</td>
<td>45.8</td>
<td>42.7</td>
</tr>
<tr>
<td>13</td>
<td>37.4</td>
<td>44.8</td>
<td>42.1</td>
</tr>
<tr>
<td>8</td>
<td>34.7</td>
<td>45.6</td>
<td>41.8</td>
</tr>
<tr>
<td>6</td>
<td>32.2</td>
<td>38.9</td>
<td>35.7</td>
</tr>
<tr>
<td>3</td>
<td>27.1</td>
<td>41.0</td>
<td>33.1</td>
</tr>
</tbody>
</table>

Sensitivity analysis (simulation)
Typical project approach: The steps in designing a terminal meeting the targets

Definition of operational scenarios

Conceptual layouts
Capacity calculation

Assessment of alternatives under dynamic conditions (simulation)

Sensitivity analysis (simulation)

Design of transition trajectory

Cost analysis (OPEX & CAPEX)
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Cost development
ASC 8 wide + Straddle carriers (1 over 2)
Interesting Test Case: Automated Waterside Transport Options

- **Shuttle Carrier (ShC)**
- **Cassette AGV (C-AGV)**
- **Automated Shuttle (ALV)**
- **Lift AGV (AGV_L)**
Results: net QC productivity (Average operation)

QC productivity - Vehicle Comparison
[10 QCs @ 40 ccph, 25 TwinRMG modules, 350 landside bx/h]

Productivity (bx/hr)
AGV  ShC  AGV_Lift  ALV  C-AGV

Total number of vehicles available

Vehicle/RMG Comparison results (rev1.1)
Results: RMG productivity comparison

RMG Productivity per stack module - Compared to previous vehicle numbers for 40 QC mvs/h
[6 QCs @ 40 ccph, 25 TwinRMG modules, 350 landside bx/h]

Vehicle/RMG Comparison results (rev1.1)
Vehicle Order Duration overview - 18 vehicles
[6 QCs @ 40 ccph, 25 TwinRMG modules, 350 landside bx/h]

QC Net. Productivity

Time at QC
Time at RMG
Waiting for Sequence
(De)coupling cassette
Driving laden
Driving with Cassette empty
Driving Empty

QC Net. Productivity

ShC  AGV-L  ALV  C_AGV  AGV
76  75  90  97  87  72
65  93  40  39  86  88
13  14  11  32  35
13  43  44  40  120

Vehicle/RMG Comparison results (rev1.1)
Questions?

For Further Questions:

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