SIGNIFICANT IMPROVEMENT OF CURRENT OPERATIONAL PERFORMANCE LEVELS AT TERMINALS IS FEASIBLE. A MAJOR EVOLUTION IS TAKING PLACE IN SOME OF THE CURRENT CONCEPTS DRIVING OPERATIONAL PLANNING, CONTROL AND EXECUTION PRACTICES. THESE CHANGES WILL REQUIRE NOT ONLY TECHNOLOGY BUT ALSO NEW PROCESSES AND COLLABORATION ACROSS THE INDUSTRY THAT WILL SHAPE THE FUTURE OF HOW TERMINALS WORK AND ENGAGE.
Terminal Productivity: Optimizing the Operational Front Line

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In the media and at the 2015 TPM conference in Long Beach, ocean carrier leaders have amplified their frustration with the terminal industry over the lack of improvement in berth productivity in line with the bigger ship sizes. Where, they ask, is the maritime equivalent of the airline industries double-decker passenger jetway that has increased the rate of unloading/loading passengers onto and from mega-sized aircraft?

Ocean Carrier Demands

What are ocean carriers asking for? In the case of Maersk Line, it is a reduction of port stay from 18 to 12 days on the Asia-Europe round-trip routes. Imagine a mega-vessel on an Asia-Europe loop with a call size of 8,000 moves at a terminal with 6 hour shifts. Assuming the quay crane operation is concentrated on 25 of the 46 bays typical of a Triple E, therefore 320 boxes per bay, and 7 cranes per shift working at 25 gross gang productivity (GGP), the operation will be complete in just over 45 hours.

If GGP can be improved to 35 moves per quay crane, then operations would be complete in about 32 hours, thus saving 12 hours and achieving the carrier stated goal of a total of 12 days in port. It seems simple enough to understand, but when working on the operational frontline, it is less easy to execute. Besides, having more productive solutions on the quay side will not address the overall problem if the entire system is not performing accordingly.

We believe better integration between technology, processes and people can move terminal operations forward in terms of practical results on operational productivity, reduced port-stays and operational costs. In this technical paper we highlight the available solutions and comment on the necessary changes that could impact not only technology but processes and culture, conceptualising the maritime supply chain as a system and covering processes both for shipping lines and terminals.

“There has been little progress in carriers’ and terminals’ ability to get these ships quickly worked and sent back out to sea, resulting in delays to cargo and added costs for carriers”

- Soren Skou, MAERSK CEO, Feb 2015
Areas of a port that have an effect on the maritime supply chain, as illustrated above, include:

**Carrier stowage planning center:** Where carrier stowage coordinators perform vessel loading and discharge plans for each vessel call across the whole port rotation, implying an intense EDI data exchange for vessel planning with inherent dynamics that include changes and contingencies.

**Vessel voyage:** Vessel sailing and calls to different ports included in the port rotation pattern. Capacity sharing, vessel utilization and operational cost minimization are the targets, with a focus on micro-managing berth buffers at different ports and extra-costs due to contingencies.

**End-to-end port operations:** Beyond the vessel operation time at terminals, there is a big portion of time allocated for a vessel calling at one port. This includes steaming-in, piloting, mooring and steaming-out after operation completion. The focus in reducing port stay from a holistic perspective is quite important and vessel visit management and berth scheduling are key areas of focus.

**Quay at terminals:** For terminals the way they manage the assignment of resources and the performance of quay equipment determines the overall terminal performance in terms of productivity and cost.

**Yard at terminals:** Highly important for terminals is to have complete operational control for getting maximum throughput from the yard feeding quay operations including horizontal transportation and dwell time to allow terminals to meet their annual goals on potential volumes.

**Operations planning and control center at terminals:** A fundamental focal point for providing responsive planning, proactive monitoring and effective troubleshooting is the demand for qualified people and software tools that apply an analytic approach to manage terminal operations, making good use of available operational data. This is made significantly richer with process and equipment automation.
“The industry is stuck at 25 to 30 moves per crane, per hour. We haven’t had any breakthrough development that can get that to 40 to 50 moves per hour”
—Soren Skou MAERSK CEO, Feb 2015

Progression
Below are four areas in which there is room for improvement:
1. Berth productivity
2. Terminal automation
3. Carrier-terminal cooperation and visibility
4. Operations monitoring, business intelligence and process excellence

1. BERTH PRODUCTIVITY
There is still potential for quay crane productivity to rise above the current levels by improving quay crane cycles, promoting real-time interaction and visibility and using more software intelligence that takes a holistic approach to align quay crane operations, horizontal transportation and yard production.

Quay Crane Cycles
Equipment capability is ready to provide duty cycles above 45 cycles/hour. There are however many factors and areas that can constrain quay crane productivity in a live operational scenario: gantry moves (bay changes), waiting times for horizontal transport, driver skills, lashing and vessel conditions etc. Figure 2 illustrates the constraints these factors that can have on quay crane productivity.

Several equipment providers are proposing more controlled quayside environment, with automated hand off between horizontal transport and the cranes, including container flow control using container ID and equipment position information, securing quality in what is discharged and how the vessel is stowed.
“As we see it, intelligent cranes—automated and interacting with TOS—should work on work orders from the TOS to optimize the movements and workload and be able to maintain or even increase the speed of operations.”

—ABB, Fredrik Johansson World Cargo News Feb 2015

Real-time engagement with crane team operations

Beyond improving quay crane cycles with faster cranes and more technology applied for move and remote control, there is huge potential to improve the use of the available time for each shift. There are tools available for crane drivers, hatch clerks and foremen to enable real-time visibility and interaction of stowage plans, bay-views and container lists to effectively manage sequencing and exception handling to optimising labor gang utilisation.

- With the right visibility tools, the different roles including foreman, hatch clerk, checkers and radio-men can play a more active part in operational decision-making to react quickly to re-planning changes.

- New emerging equipment technologies such as remote quay crane operations require a different way for users to work. A driver located hundreds of meters from the physical position of the crane needs visual information from the crane and real-time information on sequence management, container characteristics and information to handle exceptions when they occur.

Figure 3: Real time interaction with crane-operations, Crane Team GUI. Bay-view including container detail.
Different operational decisions are normally related to each other, so the best way to support decisions is always to review the whole decision chain across all the optimizers. This requires users to stop thinking about optimizers in isolation and for software to be cognizant of related activities.

- Start with planning decisions: It’s important to understand how stowage positions are decided for load containers and how yard positions are decided for discharge containers.
- The key role of scheduler components is to make the best possible operational decision.

Responsibilities include:
- Move time generation
- Work assignment for each type of equipment
- Moves injection for other non-productive but opportunistic moves: For example re-handles in the yard, pre-positioning or house-keeping. Closer to the execution timeframe, software components such as Equipment Dispatcher and Transfer Zone Decker to help with executing what is scheduled, and take into account real-time feedback for managing congestion and addressing balance across all operational zones.
- Closer to the execution time-frame software components such as Equipment Dispatcher and Transfer Zone Decker to help with executing what is scheduled, and to take into account real-time feedback for managing congestion and addressing balance across all operational zones.

Figure 4 illustrates the roles of the different scheduler components with mutual dependency between each other and the decisions they are driving.

In summary, there is still potential for quay crane productivity to rise above the current numbers by using more software intelligence and by taking a holistic approach to align and harmonize quay crane operations, horizontal transportation and yard production.
2. TERMINAL AUTOMATION

The use of automation at container ports and terminals remains a practiced and accepted method to improve productivity, primarily for larger container terminals. Terminal automation and its decision-making capability are held out as the ‘promised land’ for terminal operations. This is the area where traditional boundaries to operational performance are being pushed out by using software to systematize terminal operations. Automation is built on the following ideas:

- Equipment, systems and people can be coordinated with a holistic approach
- Operations can be made more predictable within a well-organized system
- Improved efficiency and flexibility for operational decisions can be enhanced through software
- Greater safety for staff and better environmental performance can be achieved
- Software can provide user-friendly interfaces and pro-active decision support for users monitoring and managing operations from control centers.

For automation to deliver on its promised potential there are some key areas for terminal operators to consider:

**Terminal design and optimization**

The figure below shows four of the possible combinations of terminal topologies and equipment configuration in use today. Each design depends on the requirements for traffic pattern and modal split, vessel types and berthing, capacity and performance and cost per move assumptions. We are still in an experimental phase of automation where there is no one clear terminal design winner. New equipment types and new automation concepts are still coming.

Simulation tools are helpful to test initial assumptions about terminal design and productivity targets but these virtual exercises cannot reflect the impact of system integration and complexity of the real algorithms driving terminal equipment in production. Thus simulation tools cannot provide reliable predictions on actual operational capacity and performance especially around operational dynamics and the inherent variability for fundamental parameters such as crane production rates and yard position assignments.

### Figure 5: Various layouts and equipment configurations for terminal automation decisions

<table>
<thead>
<tr>
<th>Perpendicular</th>
<th>Parallel</th>
<th>Auto</th>
<th>Auto</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASC + (A)HT</td>
<td>C-ASC + TT/AHT</td>
<td>Straddle Carriers</td>
<td>RTG + TT/SC</td>
</tr>
</tbody>
</table>

Automation is here to stay, and represents the future approach for operational performance, but it is challenging and complex to implement and the industry is still learning how to capitalize on automation’s potential.
In addition, the range of automation design possibilities provide software developers with a challenge to create an optimization platform and framework to accommodate the model, workflow engines and algorithms. In addition, they need to be extensible and configurable enough to support any selected operational concept design. Fortunately, most of the layouts and equipment configurations have not needed fundamentally different approaches to optimization but each variation does impact project implementation. Any new operational concept still has to be prototyped, tested and implemented and this adds time and risk to any automation project.

**Time to value versus system integration efforts**

Technical integration for automated terminals is complex and impacts equipment, systems and people and in turn, impacts implementation. In automated terminal projects, it is not uncommon to have more than 35 interfaces between different software systems. To improve deployment predictability and time to value requires streamlining the functional design process upfront and improving deployment processes.

From a technical integration perspective, one area where there is significant room for improvement is around standardizing the interface between the TOS and the different Equipment Control Systems (ECS). In the market, the TOS and ECS represent the ‘spinal cord’ for automation where critical information is exchanged to manage the movement of containers through the terminal.

From a technology perspective, ECS software providers are starting to take a step forward on interfaces, but the maturity of existing solutions is not where it needs to be having been largely project driven. ECS software developers are now focusing on increasing their software efforts in design, architecture, testing and deployment practices and we are seeing initiatives to standardize and reduce future integration complexity and cost.

The terminal automation software and equipment industry is aiming for standard and generic integration patterns on interfaces and interactions but for now there is still a significant amount of customization and configuration for each project, depending on layout configuration and equipment specification. Only with a clear definition for interfaces and solution modularity to handle this ‘automation puzzle’ between different software applications will automated terminal projects be implemented in a similar time-frame to more manual terminal projects.

—PEMA FORUM, TOC EUROPE 2014
Figure 6 describes the basic interaction for Automatic Stacking Cranes (ASC) between ECS and TOS:

- The communication protocol is based on working instructions from a TOS to an ECS (orders) and real-time (events) information from an ECS to a TOS.
- Next, the low level communication between an ECS and the PLC software level to handle, for an ASC in this case, all related interactions regarding gantry, move control and collision-avoidance.
- For quay cranes, rail cranes or horizontal transportation, the related interactions follow the same pattern.
“There is no doubt that big ships are driving the need for automation at container terminals in major gateway ports such as Rotterdam, New York-New Jersey and Los Angeles-Long Beach. Terminals that handle 1 million 20-foot container units, or more, per year must provide consistent, reliable and uninterrupted performance and only machines can meet those qualifications.” —Henk De Groot, APMT MV2 COO, April 2015

Performance requirements for mega-vessels

One of the measures of success for automation will be demonstrating that terminal automation is a reality for getting the required efficiency for mega-vessels at large scale terminals (>2M TEUs) in a sustainable form, with improved productivity and lower costs per move. Shipping lines are pushing for terminals to match the economies of scale of larger vessels with increased speeds of performance.

Although not every terminal needs to handle mega-vessels, larger vessels are cascading across trade lanes and terminals will need to prepare for providing higher throughput. This in turn will drive process changes with a change in mindset.

Terminal operators will increasingly look at their business as a system and set of processes to be centrally managed and monitored by highly skilled technical operatives.

“APS Terminals MV II is clearly a game-changer port in the shipping industry.”
- Kim Fejfer CEO APM Terminals

“A skilled longshoreman at a gateway port can produce 30 container moves per hour at his or her “best time of the day.” However, as the day wears on, productivity can erode somewhat due to fatigue or other factors. An automated crane may likewise do 30 moves per hour, but will perform at that level throughout the day. APM’s goal for its cranes is to beat the manually-operated cranes’ average performance by 50 percent.”
—Henk De Groot, APMT MV2 COO, April 2015
3. CARRIER-TERMINAL COOPERATION AND VISIBILITY

When a carrier and terminal do something concrete to collaborate, it has a significant impact on vessel turn-around times and adaptability to operational changes. This has been proven at DP World Jebel Ali, DPW Southampton and with the Maersk Hub partnership with APMT Algeciras and Tangiers. Take vessel stowage, the sooner a terminal can get the stowage plans, the better they can optimize the use of their resources. If this data is consistent and reliable (by doing better planning) the terminal pre-planning exercise is expedited.

Maximizing the use of terminal resources is a benefit for the users of that terminal as much as it is for the terminal itself and the carrier network. Removing short term thinking and taking on a paradigm shift in thinking about carrier-terminal collaboration can reduce port stay by between 20% and 30%.

Operations Dynamics: data quality, flexibility and berth management

Certainly there are inherent dynamics to container operations which demands flexibility and interaction across the planning process, sometimes with really exigent times on the terminal side, ending in unplanned costs due to contingencies. To improve the planning process with better carrier-terminal collaboration includes:

- **Data quality**: A focus on accurate cargo information and inventory control of the equipment (containers) would help shipping lines keep better track of the containers scattered across different terminals and vessels.
- **Flexibility**: Carriers are also demanding flexibility to handle inbound-outbound container planning changes, especially for contingency management using response and integrated systems that are able to react to those planning changes.
- **Berth management**: Better control on berthing management and tools to improve decisions for berth allocations and resource assignment will positively impact vessel operational performance and costs.

![Figure 7](image)

Figure 7 describes what shipping lines and terminals need from each other in order to achieve the mentioned operational goals.
Stowage and vessel planning processes

Shipping lines focus is to have a reliable productivity and berthing window compliance. From a terminal perspective the focus is on what the carrier can do to help the terminal to deliver the requested productivity. The whole planning process needs to be managed in a different way in order to respond to the requirements of shipping line alliances and the increasing pressure on operational performance, especially with the onslaught of mega-vessels.

Stowage planners at the shipping line focus on the following areas:

- **Reduce shifting / re-stows and increasing ‘crane split.’** With direct impact on bunker consumption and terminal/port cost reductions.
- **Reduce the gap between a vessel’s real capacity and nominal capacity,** to increase vessel utilization.

For vessel planners at the terminals, the focus is on:

- **Maximizing berth productivity,** by optimizing gang productivity and multi-lift ‘ratio’.
- **Minimizing operational cost,** by maximizing productive moves and gang productivity.
- **Keeping an operational balance,** a huge challenge because to do so they need to:
  - Balance buffers on berth utilization
  - Control yard congestion and dwell time
  - Manage machinery stress and maintenance

Figure 8 describes the areas for stowage and vessel planning where better collaboration could bring large performance improvements.
With each day of real operations there is a growing treasure trove of data for process excellence. A team comprised of experts in IT and operations will be working continuously through every performance failure logged in the systems to find the root cause and fix it.

—MAERSK Post 2015, APMT MVII and Process Excellence department

4. OPERATIONS MONITORING, BUSINESS INTELLIGENCE AND PROCESS EXCELLENCE

Fixing traditional problems with data accuracy and availability, alignment on strategic and operational KPIs and adopting analytical tools will help support continuous improvement of operational performance at terminals.

The focus on practices and techniques, such as process excellence, real-time control and business intelligence have been successful practices adopted in other industry sectors to improve operational performance including airports, manufacturing and warehousing.

Process Excellence and Business Intelligence

Beyond business intelligence adoption at container terminals, terminal operators are focused on creating Process Excellence (PEX) teams who have the responsibility to develop plans to implement assigned process optimization programs at the terminal level or in selected business processes.

Our industry faces some constraints such as data quality and operational predictability which makes the adoption of new tools and methods really challenging. We are experiencing a ‘learning period’ in which we will learn how the industry can address inefficient processes supported by new intelligence tools.

PEX teams focus on mentoring processes to create the necessary culture and skills to identify and prioritize continuous improvement projects and manage the deployment of assignments using methodologies such as Lean Six Sigma. These PEX projects have proven to increase operational performance by up to 25%.

“These changes don’t happen in a year, especially when what we’re aiming for is world-class operations. It takes time and will require us, in some cases, to invest in the equipment and processes needed or, if the profitability just isn’t there, consolidate or divest.”

— Martin Gaard Christiansen, Chief Commercial Officer APM Terminals, May 2014
Performance driven mindsets and training
With the increasing pressure on operational performance and the impact on terminal business processes from technologies such as equipment automation or cloud computing, the way container terminals are managed is evolving:

• Organization and profiles of control centers are changing to be more process driven.
• Users are working with highly advanced technologies and applications yet the human brain is still driving the critical decisions and weighing the trade-offs for operational management.
• Tools and software applications need to provide the required engagement to users in order to allow them to be proactive and to be confident with making operational decisions.

Perhaps the biggest challenge is dealing with change itself. Operations management practices and mindsets need to evolve to be process driven and analytically ‘audited’, in order to improve the way container terminals create and deliver value to shipping lines. This can be achieved by:

• Re-defining roles and processes, essential to drive cultural changes on process excellence and performance requirements.
• User training and qualification is important and new methods are being proposed to improve user engagement with new tools and available operational data.
• A ‘learning by doing’ approach with the support of mentors, taking into account a user’s ‘learning curve’ and gradual evaluation has proven to be effective.
• User qualification and knowledge transfer embedded within the operations organization at container terminals is also important.

“We have to move from what we think is the best way to work based on the computer simulations to testing what is the best way to work based on the operational data we’re collecting and analyzing.”
—Patrick Brehmer PEX Operations Expert
“We’re building a system, so we need the system to respond to changes and exceptions on its own and we won’t know all those scenarios on day one. We need to see real operations to know what needs refining and tweaking, which will be continuous until we reach our performance targets.”
—William Rengelink, Manager IT/Automation, APMT Massvlakte II, MAERSK Post August 2014

**Operations monitoring**

With automation, areas where traditional users apply ‘experienced based practices or manual interventions are now driven by system frameworks that are able to analyze a larger amount of operational data and dependencies before making a decision. This approach has been named ‘operations monitoring.’ It is the new way of managing terminal operations. The main guidelines for implementing operations monitoring include:

- The overall view of the terminal as a system and a ‘deviation monitor’ focus, displaying all the relevant information in one view and pro-actively displaying advisories and guidance on actions to take in critical areas, for example alarms on congestion and potential bottlenecks to trigger user attention before issues develop.

- Tools for an analytical and proactive diagnosis including seamless integration with operational procedures for trouble-shooting. Configuration and privileges for different user profiles to focus on different aspects of terminal operations such as real-time monitoring, terminal planning or system health.

- A framework approach that gathers data from multiple systems including TOS, ECS, PDS or OCR in order to facilitate centralized operational monitoring, control and trouble shooting by using modular system architecture and open system interfaces (APIs) to combine systems recorded data with operational processes.

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**Real Time Monitoring**

- **Schedulers**
  - Reports Scheduling information
- **Dispatchers**
  - Reports Dispatching information
- **Decker**
  - Reports Decking information
- **CHE Status**
  - Reports Dispatching information
- **BI Reports**
  - Integration with BI to monitor OPS KPIs
- **Gate**
  - Transactions
  - Appointments

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**Terminal Planning**

- **Vessel/Yard Planning**
  - Planning issues
  - Utilization Distribution
- **Berthing**
  - Berthing, Vessel/Train Visits & Shifts
- **3rd party system**
  - Status of 3rd party systems

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**System Health**

- **N4 Status**
  - Status of N4 Apps and Nodes

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**Terminal Monitoring**

- **API**
- **Analyze data**
  - Alarms Management
- **UI**
- **API**
  - Alarms view

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Figure 9 describes the new Operations Monitoring approach and the initial focus on real-time monitoring, terminal planning and system health areas.

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*Navis*
EXECUTIVE SUMMARY

Many across the industry have known for some time how efficiencies can be gained and waste eliminated through better integration of processes, technology and people. Until recently, the incentives and the will to change core business processes have not been there until recently.

In this white paper, we reviewed areas in which the industry can address to raise current performance levels, including:

1. Matching the request of mega-ship owners for berth productivity (above 300 gmp). The challenge ahead is to adopt holistic optimization for supporting and driving operational decisions in an effective and flexible way, minimizing crane wait time and providing balanced zone utilization across the transfer zones in the quay, yard and other areas.

2. User engagement with operational decisions as well as visibility and transparency for real-time interaction. This is necessary to support different users managing operations with equipment and system integration. We mentioned crane team GUI and operations monitoring GUIs as two examples of the evolution taking place.

3. There are areas where shipping lines and container terminals need to work together in order to make the best trade-offs between performance, capacity and costs in an effective way. Better collaboration is possible and the tools enabling visibility and transparency must ensure core sailing and safety requirements are met for shipping lines. This allows terminals to manage operations profitably while not adversely impacting the whole port rotation pattern for the liners.

4. And finally, container terminals need organisation at control centers and cranes to be prepared and qualified to play an active role in planning, monitoring, analysing and controlling highly advanced operations. New tools to do so, and effective training programs to get qualifications ready and mindset aligned with these challenging performance goals is essential.

Significant improvement of current operational performance levels at terminals is feasible by introducing evolution in some of the current concepts driving operational planning, control and execution practices. The changes will require not only technology but also new processes that will shape the future of work at terminals.

Some industry observers have called for a revolutionary change. Currently, there are a number of evolutionary steps that can get performance levels well beyond historic levels. The danger is that if the industry relies only on looking for a magic pill or revolutionary solution, time will be lost actually uniting people, systems and ideas that can deliver faster vessel turnaround times and support a more reliable global supply chain.
About Navis:
Navis provides operational technologies that unlock greater performance and efficiency for our customers, the world’s leading terminal operators. The Navis N4 terminal operating system (TOS) represents more than 25 years of experience and innovation that enables terminals to optimize their operations and move cargo smarter, faster and more efficiently. As an industry leading technology, more than 250 container terminals worldwide have partnered with Navis to improve performance, reduce costs and minimize risk.

The Navis Professional Services team helps customers maximize the effectiveness of their technology investments by aligning operational optimization and new business processes with a terminal’s most important goals. Whether embarking on a new implementation or exploring ways to get more from existing systems, the Navis Professional Services team offers proven best practices that help terminals worldwide gain significant competitive advantages.

As a trusted technology partner, Navis understands that as ships get larger and operational processes become more complex, efficiency and productivity remain an expectation. Advanced and reliable technologies are essential. Navis offers the tools and personnel necessary to meet the requirements of a new, and ever-evolving, global supply chain.

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About the authors
Oscar Pernia, Senior Director of Product Strategy, Navis, San Francisco, USA
Dr. Oscar Pernia is responsible for Navis Product Strategy, with an intense focus on analyzing industry driving forces about operational efficiency and then developing effective operational input to Navis Roadmap. Prior to his current role, he was focusing on Terminal Automation being part of the core team designing, testing and deploying the new N4 3.0 platform. Prior to joining Navis, Oscar worked 3 years for Hanjin Shipping at TTIA, first semi-automated terminal in Mediterranean, leading terminal implementation and optimization: creating a young and talented tech-team which pioneered some integration and operational concepts on systems architecture and control center organizations for automated terminals. Early in his career Oscar spent eight years in IT with Algeciras Bay Port Authority where he held a variety of positions managing projects focused on technology, process optimization and integration.

Andy Barrons, Chief Marketing Officer and Vice President, Navis, San Francisco, USA
Andy Barrons is responsible for Navis Marketing, Product Management, Business Development Partnerships and Corporate Strategy. Prior to joining Navis, Andy was Vice President Marketing for INTTRA, where he created a more customer centric strategic marketing capability for the company, the ocean shipping’s leading e-marketplace. Backed by over 50 carriers and the world’s largest network of ocean shippers, more than 22% of world container trade begins at INTTRA and users can use standardized business processes to manage shipments and do business. Earlier in his career, he spent over fifteen years at the Financial Times, leading marketing and BD for the FT in Europe & North America. In these positions, Andy led key initiatives to expand FT media including the re-launch of the FT in North America.