



**Smart Cruising: smart technology applications and their diffusion in cruise tourism.**

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## Smart Cruising: smart technology applications and their diffusion in cruise tourism.

### STRUCTURED Abstract

#### \* Design/methodology/approach (limit 100 words)

Information Communication Technologies (ICTs) advancements and smart tools revolutionise interactions and affect all transactions, transforming the cruise experience. Gradually a Smart Cruise Ecosystem emerges by incorporating all technologies available and involving cruise passengers, who as smart actors interact dynamically with stakeholders, creating value before, during and after the cruising experience. The COVID19 pandemic outbreak stressed the need for touchless and digital interactions as well as real time information, fast-tracking the deployment of smart technologies. The diffusion of ICTs in the cruise industry is multi-faceted and dynamic, resulting to a number of smart-technology use-cases.

#### \* Purpose (limit 100 words)

This paper explores and discusses the impact of digital innovations from a business ecosystemic perspective. Key smart technology application themes in the cruise industry are extracted and synthesised in a "Smart Cruise Ecosystem" framework.

#### \* Findings (limit 100 words)

Smart technology constitutes a comprehensive smart ecosystem to manage all actors, controls, devises and systems in order to optimise ship operations and management, whilst co-creating value for with guests and crew in an effective way. The multiplex Smart Cruise Ecosystem (SCE) proposed is enabled by digital technologies including object detection, IoT, satellite communications, Big Data, automation, robotics, AI, Cloud Computing, AR, VR, collect, access and process big data dynamically. A range of interoperable and interconnected supporting systems form the basis of the smart ecosystem.

#### \* Originality/value (limit 100 words)

The proposed framework offers a holistic perspective of the smart-cruising domain, highlighting innovations, interfaces, dependencies, along with the corresponding key limitations and challenges. The synthesis and conceptual structure provided serve as a topology for guiding and connecting further research in smart cruising.

**Keywords:** smart • cruise(s) • tourism • information technology • ships • innovation

## Introduction

Cruising has been dramatically gaining popularity as a leisure and travel activity. Up to the COVID-19 pandemic crisis, the global cruise sector grew from 21.3 million passengers in 2013 to 28.5 million in 2018, reaching the 30 million mark in 2019 (CLIA 2018; 2019; 2020a). The ocean cruise capacity reached 537,000 passengers, carried by 314 vessels and, by 2020, 37 new-builds were planned, adding 99,895 lower berths to the worldwide passenger capacity and \$11.7 billion in annual revenue to the ocean cruise industry. The three major competitors that dominate the global cruise industry, include: the Carnival Corporation & Plc. (abbr. CCL), Royal Caribbean Cruises Ltd (abbr. RCCL) and Norwegian Cruise Line Holdings Ltd. (Cruisemarketwatch, 2018). Although the threat to these corporations from new entrants is limited, competition within the market is intense (Lester and Weeden, 2004). The cruise sector continues to grow, particularly in Asia. In 2017, there were more than 50 mega cruise ships operating in Asia, indicating a growth of around 25% per year. By 2030, China was predicted before COVID19 to become the world's second-largest cruise market after the US (Allianz, 2021). The Chinese cruise market is emerging rapidly, seeking quality and pursuing luxury experiences (Hung *et al.*, 2020).

At the core of the cruising experience is a new, dynamic and demanding customer base demanding the transformation of cruising to a safer, more sustainable and transformative experience. The emergence of a younger, increasingly active and connected clientele (Generation Y and Z) calls for the adaptation of marketing strategies as well as the reengineering of the products and services offered on board. Demographic-based segmentation requires appropriate tools for targeting specific groups of cruisers. An evolving consumption culture and demographic structure is calling for innovations, digitalisation and a more activity-focused experience portfolio and a close coordination between multiple stakeholders, before, during and after the actual cruise. This includes: the port and the destinations; local, regional and national governments; cruise companies; ground handlers; suppliers; cruise travel agents and distributors (Di Vaio, *et al.*, 2018; CLIA 2018). Papathanassis (2022) illustrates the 'bright side' of cruise tourism (growth and the emergence of 'floating destinations'), the 'dark side' (sustainability and corporate social responsibility); and the 'grey side' (regulations, health and safety and working conditions).

Resuming sailings in the post-COVID19 era confronts the cruise sector with radically transformed regulatory-, demand- and operational-environments. This new context acts as a catalyst for the accelerated adoption of smart technologies, which in turn is a key enabler for the business continuity of the sector (Papathanassis, 2017a:115). Smart tourism accelerates the development of technology empowered business ecosystems (Buhalis, *et al.*, 2019; Assiouras *et al.*, 2019). Smart tourism poses a paradigmatic challenge for tourism scholarship (Buhalis, 2020) and can benefit from 'practical research' and from adopting a wider, supplier-focused perspective (i.e. beyond destination-specific cases) (Mehraliyev *et al.*, 2020, p.88). This paper aims at exploring the application and potential of smart technologies in the cruising industry. It aims to derive a conceptual framework to synthesises current smart-technology applications and their interdependencies. The paper maps smart cruising developments and inspires innovations in the cruise tourism domain.

### Cruise tourism as a complex system and "smart-technology" potential

"Cruise tourism is a socio-economic system generated by the interaction between human, organizational and geographical entities, aimed at producing maritime-transportation-enabled leisure experiences" (Papathanassis and Beckmann, 2011). This combines socio-psychological and business perspectives, whilst incorporating research and paradigms from the humanities, environmental studies, maritime transportation, hospitality and tourism.

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2  
3 Managing an information-intensive cruise experience and coordinating the corresponding  
4 supply chain implies considerable information and communication challenges.  
5

6 *Managing an evolving cruise customer experience and supply-chain ecosystem value creation*

7 The UN (2010) defines cruise passengers as “tourists or overnight visitors” on-board and  
8 “same-day visitors or excursionists” on-land (i.e. ports of call), exposing the challenging nature  
9 and fluid competitive boundaries of the cruise market. Market maturity is evident in the  
10 concentration of the industry and the accompanying investment in ever-larger all-inclusive  
11 ships, offering an extensive range of facilities and on-board sports, health and wellness  
12 amenities (Weeden *et al.*, 2011). Intense competition in the cruise sector has highlighted the  
13 need for highly sophisticated and information-intensive marketing practices, aimed at dealing  
14 with the challenges of:  
15

- 16 • Information intensity of on-board and ashore revenue management,
  - 17 • Diversity of consumption profiles,
  - 18 • Reliability of demand forecasting,
  - 19 • Impact assessment of competitive pricing and sales promotions.
- 20  
21  
22

23 The cruise industry’s growth calls for a modernisation of the sector’s image (Papathanassis,  
24 2020, 2022). The cruise guest demographic and consumption profiles are evolving. First time  
25 cruisers tend to be younger and prefer a resort style cruising. They differ in terms of their  
26 expectations related to the duration of cruise vacation, the composition of the cruise itinerary,  
27 distance of destination attractions from cruise ports, and the influence of cruise online  
28 reviews and environmental friendliness of cruise lines on their booking decision (Bahja, *et al.*,  
29 2019). Cruise guests’ participation is critical in the co-creation of positive experiences (Fan *et*  
30 *al.*, 2020; Kang, 2020; Risitano, *et al.*, 2020; Wu *et al.*, 2021). The relationship between  
31 passengers and crew determine the perceived value attributed to a cruise experience (Jeong  
32 and Hyun, 2019). Personalisation and multilingual interaction between tourists and crew  
33 enable passenger participation and engagement, resulting to more satisfying cruise  
34 experiences. Domènech and Gutiérrez (2020) illustrate that the extent of cruise tourists’ port  
35 activity and expenditure depend on a range of factors, such as the travel party, the age of the  
36 visitors, the length of stay and the tourists’ activities in the city; ultimately reflecting their  
37 satisfaction with the visit. Aside from the negative global publicity attributed to the cruise  
38 sector’s crisis management during the onset of the pandemic, other health and safety issues,  
39 such as norovirus outbreaks (accidents (Papathanassis, 2016) and crime at sea (Klein, 2016;  
40 2019; Klein and Poulston, 2011; Wittlinger and Papathanassis, 2019), have long existed. Cruise  
41 passengers also need protection from becoming victims of criminal activities aboard a cruise  
42 ship or suffer from illness or medical conditions either on board or related to landside  
43 excursions (Vogler, 2022). Experiential value and value co-creation determines the brand  
44 prestige and loyalty for cruisers (Kang, 2020).  
45  
46  
47

48 For destinations / ports, the direct economic impacts of cruise tourism are determined by: the  
49 total number of cruise tourists and crewmembers embarking/disembarking, the average  
50 expenditure per cruise line and passenger, and the number of cruise lines attracted (Chen *et*  
51 *al.*, 2019). Ecological concerns, particularly in fragile and insular environments, are also a key  
52 issue (Lamers *et al.*, 2015; Van Bets *et al.*, 2017). However, harsh economic realities, supply  
53 chain power struggles, and the sheer diversity of ports and islands, all render stakeholder  
54 coordination for sustainability planning and regulation control highly complex (Lester and  
55 Weeden, 2004). Many shore excursions and attractions are highly dependent on cruise lines.  
56 Sustainability aspects, ranging from environmental impacts to overcrowding, have been  
57 reluctantly accepted as the price local communities have to pay to economically benefit from  
58 cruises (Thurau *et al.*, 2013; Larsen and Wolff, 2019; Navarro-Ruiz *et al.*, 2020).  
59  
60

Cruise passengers can possibly return and spend a longer holiday at a port once having 'sampled it' through a cruise (e.g. Klein, 2009; Larsen *et al.*, 2013; MacNeill and Wozniak, 2018; Larsen and Wolff, 2019). The macro-economic contribution of cruise tourism varies greatly amongst ports, being significantly lower for visiting ports of call (compared to turnaround/home ports) (Chen *et al.*, 2019). A closer look at the annual CLIA's reports on the sector's economic impact reveals that shipbuilding and cruise line purchases account for approximately 70% of the cruise sector's economic contribution (Papathanassis, 2019a). Such activities primarily benefit the economies of passenger-sourcing countries, rather than smaller destination economies. Engaging customers with information on shore activities and ports can generate benefits (Thyne *et al.*, 2015). Using smart solutions enhances customer experience and supports citizen behaviour (Fan *et al.*, 2019, Assiouras *et al.*, 2019). Informational-, behavioural-familiarity, and visit arrangement (organised excursion vs. independent visit), determine the length of stay ashore as well as satisfaction and cruise tourist behaviour (Sanz-Blas *et al.*, 2019). Satta & Vitellaro (2022) suggest that "the success of cruise-port destinations and the sustainability of cruise tourism are expected to benefit from the involvement of public, private and hybrid entities in the development of cruise port and related tourist activities".

#### *Smart-technologies for cruise tourism*

The multidimensionality characterising a cruise experience, requires ICT-diffusion and the digitalisation of both business and consumer processes (Buhalis, 2020). This poses challenges to establishing a fertile ground for the effective application of 'smart technologies' in the cruise sector. Technological disruptions revolutionise and transform service industries (Buhalis *et al.*, 2019). The adoption of innovative technologies (smartphones, tablets, computers, laptops, gadgets, wearables) empowers end-consumers by enabling real-time decision-making and by enriching experiences (Buhalis and Sinarta, 2019; Buhalis and Foerste, 2015; Buhalis and Inversini, 2014). ICTs can support cruise businesses and operators towards achieving their key goals, namely: cultivate loyalty, raise customer value, innovate for competitive differentiation and foster collaboration in new ecosystems. Technology is a key driver for cost reductions, management-effectiveness, sustainability, safety improvements and market penetration. "Smartness" includes customer experience, Business Ecosystems and Destination (Buhalis and Amarangana, 2014; Gretzel *et al.*, 2015a; Gretzel *et al.* 2015b). 'Smartness' in hospitality places tourists in the middle of the ecosystem (Buhalis and Leung, 2018). Different ICTs systems (or hard smartness), including: the Internet of Things (IoT), Cloud Computing and End-User Internet Service Systems, orchestrate the co-creation of customer experiences (Buhalis *et al.*, 2019; Zhang *et al.*, 2012; Wang *et al.*, 2013). The combination of 'soft smartness' (i.e. application-innovation, human and social capital employment) and leadership within a 'Service Dominant' logic ecosystem structures, result in value co-creation for the wider network of stakeholders (Neuhofer *et al.*, 2014, 2015).

Combing all systems, through ambient intelligence and ensuring interoperability and interconnectivity empowers smart digital ecosystems and ambient intelligence (Buhalis, 2020). Interoperability refers to the ability of data, information and knowledge-sharing between disparate systems (Maheshwari and Janssen, 2014). Interconnectivity and dynamic interaction, rather than individual technological advances, assist the co-creation of experiences through optimisation of subsystems and operational and marketing practices (Buhalis and Leung, 2018; Höjer and Wangel, 2015, Gretzel *et al.*, 2015b). Digital technologies on board raise new opportunities and challenges for customers, cruise companies and stakeholders. Operational efficiency and control as well as reliable information and transparency regarding passengers' movements and activities determine health, safety and disease-control on board. Connectivity and real-time information are key-enablers for

managing the cruise vessel's interface with ports and attractions. Failure to manage these interfaces may undermine the safety on board and ultimately jeopardises a complete cruise holiday experience (i.e. with land excursions and port visits) (Vogler, 2022).

**Research methodology: Thematic analysis of cruise-related smart technology application**

A literature search on smart tourism addressing the cruise domain, revealed a potential research gap. Conducting an advanced bibliographical search for literature containing the keywords: "smart", "cruise" and "tourism" in their title, abstract and/or keyword list, yielded no results. The absence of a conceptualisation for smart-technology diffusion in the cruise tourism, underlines the relevance and need for a thematic framework to facilitate the mapping and scoping future research efforts. This qualitative approach involved the thematic analysis of secondary sources (i.e. professional and sector publications) and searched for keywords: "innovation", "smartness", "smart", "information and communication technologies (ICTs)", "big data", "internet of things", "value co-creation", "future(s)", "trends", in conjunction / combined with: "cruise(s)", "maritime", "cruise ships", "tourism", "destination". Each search result was reviewed and selected sources informed the thematic analysis.

In addition a comprehensive search was undertaken on the homepages, statements, social media and published reports including

- Cruise and hospitality associations: The annual publications of the Cruise Lines International Association (abbr. CLIA) as well as HORWATH's reports
- Smart technology suppliers: Three leading organizations (ACCENTURE, WARTSILA, XEVO), plus the annual reports of ALLIANZ (2021), to summarize the current smart services offered in the marketplace.
- Smart Applications Analysis of Cruise operators: Comprising a coverage of the top six cruise corporations amounting to 13 cruise brands (i.e. Carnival Cruises, Princess Cruises, Holland America Lines, Costa Cruises, Aida Cruises, Cunard Seaburn, Royal Caribbean Intl, Celebrity Cruises, Norwegian Cruise Line, Regent Seven Seas Cruises, Disney Cruise Line, Crystal Cruises and MSC Cruises).

The analysis of reports and use cases revealed commonalities, differences as well as interconnections (Yin, 2016) between current and anticipated developments in cruising. Key themes extracted, including trends, risks, challenges and best practices were grouped based on their demand- and supply- related 'smartness' potential.

## RESULTS AND DISCUSSION

### **'Smart-Cruisers': Cruise-demand trends and smart technology potential**

Tourism demand is rapidly moving towards smart tourists that engage with a range of technologies to maximise their value (Femenia-Serra, *et al.*, 2019; Fan *et al.*, 2019; Gajdošík, *et al.*, 2020). An analysis of the reports illustrate key trends and demand-driven motivators for change. Table 1, summarise these future trends, namely: Customer segment diversity; Experience-innovation; Service digitalisation; value-based consumption illustrating the 'Cruise Management – Smart Technology' Potential.

Customer segment diversity drives service diversification and digitalisation. Cruising has become more affordable and accessible than ever before, offering excellent value for money and a diversity of destination experiences. This democratisation of cruises as a holiday form has rendered cruising accessible to a wider, less affluent consumer base. The "Silver-Ager" segment, loosely defined as the total economic activity of the 50+ population is expanding rapidly (Zsarnoczky, 2016). They tend to be experienced travellers and often travel in larger, multi-generational family groups (e.g. with their grandchildren). A relatively younger generation of cruisers is also emerging, including 'Working Nomads' who combine work with leisure time; 'Going Solo', who travel alone either by choice or by necessity; Gen Y (born between 1982 and 1998), who seek interaction and exploration; Gen Z (born between 1996 and 2010) who prefer authentic experiences over material items (McCrinkle and Wolfinger, 2014).

Different market segments with different needs, expectations, requirements and critical satisfaction paths, experience cruise holidays differently and yet often share the same vessel and itinerary. This heterogeneity of customers traveling on a cruise, especially for cruise ships carrying 1000 passengers or more, implies a need for increased operational flexibility and tailor-made services in a large scale. Mass customisation and personalisation of services at this scale is only possible by context-based digitalisation (Buhalis and Foerste, 2015). The need for customisation and personalisation of services is greater than ever. Under this premise, conventional loyalty schemes (e.g., loyalty cards and points, discounts) are expected to decline. Loyalty will increasingly be based on value co-creation, enabled by digitalisation and technology-enriched experiences, facilitated by mobile apps, online portals, gamification, and other data-based innovations (Neuhofer *et al.*, 2015; Xu *et al.*, 2017).

Seeking experiences drives innovation and value-based consumption. CLIA expects that the next evolution of cruise travellers will be one dominated by a focus on healthy lifestyle and the demand for 'transformational experiences'. Consumers engage with people and places seeking transformational value and emotional involvement, rather than material things. They have an active role in shaping their vacation, preferring to co-create experiences rather than being passive recipients of pre-fabricated animation and entertainment activities. Story-telling, content crowdsourcing and enrichment support co-creation add value to the entire ecosystem. Cruise companies acknowledge a shift from 'storytelling' to 'individual discovery'. They offer itineraries where tourists can engage in authentic experiences, deeply rooted in the local context. Providing targeted information, based on location and context-based services, allows passengers to build their own unique experience throughout their itinerary. While in the past, a standardised itinerary would be sufficient, there is a drive for facilitation of individualised and personalised experiences on board and ashore.

Table I: Future trends in tourism and in cruise industry

Key Theme	10 Tourism Megatrends (HORWATH HTL 2015)	Cruise travel report 2018 (CLIA 2018)	Cruise trends and industry outlook 2019 (CLIA 2018)	Cruise Management – Smart Tech Potential
Customer Segment Diversity	<ul style="list-style-type: none"> <li>• Growing middle class</li> <li>• Silver Hair Tourists</li> <li>• Generation Y and Generation Z</li> </ul>	<ul style="list-style-type: none"> <li>• All budgets will cruise</li> <li>• Skip-gen cruising: grandparents with grand-children</li> <li>• Millennials (Gen Y) and River cruising</li> </ul>	<ul style="list-style-type: none"> <li>• Female-centred cruising</li> <li>• Singles Segment,</li> <li>• “Going Solo’</li> <li>• Working-Digital nomads</li> <li>• Gen Z (iGen) and Sea Cruises</li> </ul>	<ul style="list-style-type: none"> <li>• Granular segmentation</li> <li>• Individualisation of marketing measures</li> <li>• Provision of customised services</li> <li>• Improved preference and behavioural tracking</li> </ul>
Experience innovation	<ul style="list-style-type: none"> <li>• Emerging destinations (Middle East and Asia)</li> <li>• Political issues and terrorism. Risk for destinations</li> </ul>	<ul style="list-style-type: none"> <li>• Travelers warm to chilly destinations (Canada, Alaska, and Antarctica)</li> <li>• Transformational cruise experiences (cultural immersion, voluntourism, extreme adventures)</li> </ul>	<ul style="list-style-type: none"> <li>• Off-Peak Adventures, including once-in-a-lifetime experiences during the colder months</li> <li>• Achievement over Experience</li> <li>• Access is the new luxury, for unreachable destinations by plane</li> </ul>	<ul style="list-style-type: none"> <li>• Story-telling and content enrichment</li> <li>• Targeted information</li> <li>• Location and context based services</li> <li>• Experience co-creation</li> <li>• Safety and security targeted information</li> </ul>
Service Digitalisation	<ul style="list-style-type: none"> <li>• Technological (r)evolution (SoMo – Social and Mobile)</li> <li>• Dominance of digital distribution channels</li> <li>• Loyalty V.X.0 (digital integration of loyalty programmes into the overall tourists’ journey)</li> </ul>	<ul style="list-style-type: none"> <li>• Smart travel technology (wearables for seamless and personalised experience on-board)</li> <li>• Steady demand for travel agent services</li> </ul>	<ul style="list-style-type: none"> <li>• On board with Smart Tech</li> <li>• Instagrammable cruise travel</li> </ul>	<ul style="list-style-type: none"> <li>• Digitally-enabled process and data- integration</li> <li>• Usability and seamless technology</li> <li>• Individualisation of marketing measures</li> <li>• Contextualisation of information</li> </ul>
Value-based Consumption	<ul style="list-style-type: none"> <li>• Sustainability (Socio-cultural, environmental)</li> <li>• Health and healthy lifestyle</li> </ul>	<ul style="list-style-type: none"> <li>• Sustainability (Sustainable practices on and off board from recycling and waste management to popular voluntourism initiatives)</li> <li>• Healthy doses (health and wellness services)</li> </ul>	<ul style="list-style-type: none"> <li>• Conscious travel, by implementing innovations that decrease the environmental footprint of cruise travel</li> <li>• Total restoration offering the latest in fitness innovations</li> </ul>	<ul style="list-style-type: none"> <li>• Content reliability and transparency</li> <li>• Responsible digital engagement</li> <li>• Adoption of Social responsibility related to ports and destinations</li> </ul>

Source: Based on HORWATH HTL and CLIA



### ***Cruise Ship size drives Smart logistics: Passenger and hospitality supply management***

Digitalisation is also reinforced by the size and capacity of cruise ships. The sheer volume of passengers and crew on board, as well as the coordination of all logistics from both customers and supply chains force digitalisation. At least 50 mega-ships with capacity over 4,000 passengers, plus crew, put pressure on port authorities to expand their infrastructure to accommodate larger cruise ships, as well as to ensure safety, health and security to the cruisers (Papathanassis, 2017a and 2022; Cheng *et al.*, 2016). At least 10 ships carrying nearly 10,000 passengers were stranded at sea after having been turned away from their destination ports (McCormick, 2020, Bennett *et al.*, 2020). At this scale, raising hospitality service standards on board and satisfying an increasingly demanding guest-base, stumbles on logistics and crowd-management. For example, offering quality excursion experiences for 6000 passengers, who must board and disembark efficiently and safely within a limited timeframe, needs precise orchestration and choreography, allowing practically no room for error. Not only does the organisation of the cruise ship adhere to a tight schedule, but each passenger needs to follow this schedule quasi-religiously, especially during port visits, to avoid delays. Delays result in missing flight connections, missing passengers, and disturbances leading to dissatisfaction, compensation, financial loss and reputation damage (Vogel, 2022). The quest for uniqueness and novelty extends to all the components of the cruise bundle; from the vessel itself to the ports-of-call.

Safety and security also drive digitalisation. The establishment of new cruising regions and the emergence of novel port-destinations are highly susceptible to political-volatility and safety-related risks (e.g. terrorism). Unexpectedly, COVID19 brought at the forefront the safety and security as several cruise ships were held in quarantine or stranded at sea, highlighting the health risk perceptions in ocean cruising (Holland, 2020). Assuring the safety and security of such amounts of people in a rather confined area, also reinforces the strategic use of technology as a means to detect and deter internal and external threats (Vogler, 2022).

Food and Beverage operations and supply chain management are crucial for the operations and guest satisfaction. Providing hospitality services at sea is a considerable logistical challenge. Smart hotel management technology (Buhalis and Leung, 2018) need to support the hospitality aspects of the cruise ship operations and to integrate its supply chain. To illustrate the magnitude of this challenge, Table 2 outlines the procurement and waste volumes of the Symphony of the Seas catering for 6,680 passengers, accommodated in 2,759 cabins and 2,200 crew members.

**Table 2 Symphony of the Seas procurement requirements and waste management**

- Operator: Royal Caribbean Year of entry into service: 2018
- Number of staterooms: 2,759 Gross tonnage: 228,081
- Number of guests (max.): 6,680 Number of crew (approx.): 2,200
- Food and Beverage Facilities: 23 restaurants and 36 kitchens
- Food and Beverage Consumption:
  - 11 million meals per year prepared by 1085 Food and Beverage professionals
  - 479,314 gallons of fresh water are consumed each day on the ship.
  - 110,000 lbs of ice cubes are made each day.
  - 60,000 eggs consumed per week
  - 9,700 pounds of chicken per week
  - 15,000 pounds of beef per week
  - 700 pounds of ice-cream per week
  - 20,000 pounds of potatoes per week
  - 12,600 pounds of flour per week
  - 2,500 pounds of salmon per week

<ul style="list-style-type: none"><li>○ 2,100 pounds of lobster tails per week</li><li>○ 5,000 pounds of French fries per week</li><li>○ 5,300 pounds of bacon per week</li><li>○ 12,000 pounds of flour tortillas</li><li>○ 2,000 pounds of chicken wings:</li><li>○ 1,500 pounds of coffee per week</li><li>○ 40 different varieties of fruit</li><li>○ 80 varieties of vegetables</li><li>○ 450 cases of Champagne per week</li><li>○ 3,200 slices of pizza per hour</li><li>○ 479,314 gallons of drinking water per day</li></ul>
<b>WASTE GENERATED</b> A ship with 6,000 people on board generates approximately: <ul style="list-style-type: none"><li>○ 2,100 tons of waste water,</li><li>○ 24 tons of wet waste (food waste and bio sludge from wastewater treatment plants) and</li><li>○ 14 tons of dry waste per day (solid burnable waste, plastic, glass, tins and cans)</li></ul>

Source: Ros, 2019

Many port destinations struggle to deal with the disembarkation of so many passengers simultaneously, heading for the same attractions and tourism honeypots. Ports are also unable to provide the quantity and quality of supplies required. Environmental regulations are very strict and the quality standard are very high. Thus, very complex and sophisticated planning process and adaptive operational plans are required. Cruise ships are very susceptible to their external environment, including weather, tornados, safety and security and political situations. Adaptive and resilient plans constantly need to be updated with real time contextual information to reduce disruptions and ensure business continuity.

### Smart cruise ships: Cruise-supply trends and smart technology potential for service

Cruise ships become more sophisticated and technologically-empowered. The concept of 'Smart Cruise ship' provides a constant digital insight into the physical status of a vessel and fully supports its functionality. It consists of multiple layers, such as the product hardware itself, embedded software, connectivity, the product cloud with software services, security tools, and end-to-end integration with existing enterprise systems (Uhlemann *et al.*, 2017). Digital experiences, content co-creation and seamless process integration are essential to effectively addressing a more diverse, competitive and demanding cruise market. The digitalisation and enrichment of co-created holiday content, as well as the electronic integration of company with customer processes enable a seamless flow of information between cruise operators, customers, and other stakeholders such as suppliers and port immigration and security authorities. Contextualising and personalising experiences, support destination management and carrying capacity management.

#### *Smart ship and energy management and navigation*

As generic shipping, smart cruise ships consist of four main features, which are translated into requirements for the various hardware positioning systems on the ship (Van Dijk *et al.*, 2018), namely: 1) Navigation: receiving data from various sensors, which are combined with a Situation Awareness (SA) and a software-based system to create and assess an image of the real world; 2) Guidance to chart the ship's path; 3) Physical ship management to support software-based decision-making; and 4) Control or motion controller that steers the ship in the right direction. Ship management innovations include Augmented Reality (AR) that assists navigation and manoeuvring under extreme ambient conditions, as well as energy savings systems, exhaust gas cleaning systems (ECGS) and waste management.

Sustainability has emerged as a top priority for the cruise industry, fuelling investments in new technologies and cleaner fuels, in order to reduce air emissions and achieve greater energy efficiencies, as well as to address regulatory pressures (CLIA, 2020a). For instance, the "Harmony of the Seas" has all her lighting provided by low-energy LED or fluorescents and motion sensors. The ship is also equipped with an Advanced Emission Purification (AEP) system, which remove about 98% of sulphur dioxide from the engines' exhaust. Improvements in energy efficiency, navigational, and general safety ultimately reduce operational costs for cruise operators. Yet, the primary driver of technological innovation - after comparing a mega-ship with a smart ship - is enhancing customer's holiday experience and not for the human-related cost-reduction (Papathanassis, 2017b).

#### *Smart hospitality on-board*

From a hospitality perspective, a cruise ship is comparable to a resort, offering accommodation, catering and entertainment services at sea. For the post-panamax, mega cruise ships, the term 'floating city' would be more accurate than 'floating resort', and they are subject to unprecedented management challenges. 'Smart Cruising' is critical for developing a critical path analysis and dynamically updating plans with contextual data, in order to maximise resilience and business continuity. Both leading companies, Royal Caribbean and Carnival Corporation, aim at optimising front-office service operations, by improving efficiency and customer service for guests. By reducing the time wasted queuing, waiting for check in, bags to arrive, ordering food, booking activities, and all other activities, before boarding, on-board and ashore, they practically increase the guests' holiday duration. Failure to manage these processes efficiently will result to dissatisfaction, complaints and compensations. Smartness is critical for larger vessels, as it helps manage passengers efficiently.

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3 According to Jay Schneider, Senior vice president of Royal Caribbean Cruise Line, "Waiting is  
4 time stolen from their time off, wasted effort and wasted energy". The company has deployed  
5 a range of technologies aimed at increasing efficiency, such as: RFID Tags (e.g. WOW Band  
6 electronic bracelets); facial recognition technology; and smartphone apps (e.g. Excalibur, Sea  
7 Beyond). They allow guests to embark and disembark seamlessly; follow the progress of their  
8 luggage; automatically access their cabin; adjust lighting and temperature in cabins; sign up  
9 for shore excursions; organize dinner reservations; pay for purchases on board; geo-locate  
10 their children and even order drinks and have them delivered wherever they may be. The  
11 Princess Cruises' 'Ocean Medallion', represented a 'first-of-its-kind' wearable device, which  
12 could be worn in a variety of ways (as a wristband, pendant, clip, or even be tossed in a pocket  
13 or purse), augmenting the entire cruise customer journey. Before the cruise, the company  
14 posts the device to passengers' home. To add personalization, guests can customise their  
15 ocean-themed 'Tagalong avatar' with accessories and stickers.  
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18  
19 Franke and Schreier (2010), find that customers are willing to pay more for self-designed  
20 products, which add more value than standardised products. Beyond its WOW Band  
21 functionality, the system utilises 'nowness' and context-based recommendations. The Ocean  
22 Medallion ecosystem utilises artificial intelligence for tracking guests' service interactions and  
23 offering real-time suggestions for cruisers based on their location, time of day, and activities  
24 occurring at that time. The newest MSC cruise ships provide tailor-made services through the  
25 "MSC for Me" suite; an app with 130 different technological functions (Table 3) (Deloitte,  
26 2018). Norwegian Cruise Line also offers an app, which allows passengers to check-in before  
27 their embarkation and make purchases. 'Smart Cruising' aims to facilitate essential processes,  
28 increase personalisation; facilitate C2C co-creation; reduce time wasted and improve  
29 efficiencies in dealing with the environment both for the individually and collectively with  
30 their party.  
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### 33 *Smart entertainment on-board*

34 Cruise lines are competitive in providing e-technology-based entertaining experiences at sea.  
35 Royal Caribbean focus on innovative experiences and imaginative ways to surprise cruisers.  
36 This trend continues with water parks, surfing and skydiving simulators, the North Star,  
37 roboscreens-video entertainment, digitally transformable public venues, and IMAX cinema,  
38 with six robotic moving screens, while projecting images onto ultra-HD screens (like the  
39 "Wayfinder" interactive LCD touch-screen). Entertaining elements include the X-ray vision  
40 apps, which give the ability to cruisers to 'see' through certain walls interesting places, like  
41 the galley. They also introduced Bionic Bars with robots instead of bartenders and Virtual  
42 dining. Norwegian Cruise Line introduced their 'Freestyle Cruising' for personalised dining  
43 experiences whilst Carnival and Norwegian follow RCCL's example, offering VR and AR  
44 experiences that transform ship spaces into virtual environments and enable active games or  
45 interactive HD screens in public areas. Tech partners, such as Xevo, create shows with live  
46 performers that take on-board entertainment to new heights.  
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Table 3: Smart applications on Smart Cruise Ships-The case of “MSC for Me” App

SYSTEMS	FUNCTION AND PROCESS
MSc for Me App	Comprehensive App to facilitation context based experience co-creation
MSC for Me Wristband	Wearable waterproof device for purchases, bookings and cabin key
MSC for Me Chat	Chat messaging through the app without an internet package
AI Virtual Assistant Bot	ZOE in cabin virtual personal cruise assistant
VALUE	FUNCTION AND PROCESS
Efficient check in and check out	Mobile check-in saves time during arrival and departure
Personalisation	Helps cruisers personalise experience through profile and preferences
Co-creation	Uses digital technology that interconnects the guests, the crew and the ship
Integrated technology	interactive touchscreens around the ship, interactive cabin TV and the app
Languages	ZOE speaks seven languages
Billing and charging	Credit card registration and centralising billing functionality
Navigation	Interactive map helps guests get oriented once on board
Nowness	Real time cruising identifying daily events, activities, and highlights
Bookings	Information and help in booking shows, spas and excursions
Contextualisation	Relevant promotions, offers and events
Family and Friends Locator	Enables cruisers to be independent, while connected with family and friends

#### *Smart guest-services and experience augmentation on board*

Examining the various on-board digital innovations of the main cruise corporations (Table 4), illustrates that the larger cruise companies compete to introduce smart technology to empower cruisers experience. High-tech cruise apps enhance passenger experience, by supporting experiential travel. This also grows ancillary revenues on board, as cruisers spend more on shore excursions, high-speed internet access, and join preceding tech-entertaining experiences. Lusch and Nambisan (2015) emphasize the dual role of technology as an operand resource (facilitator or enabler) in the customer experience and as an operant resource (initiator or actor) in service innovation.

According to Padgett, chief experience and innovation officer at Carnival Cruise Line, the company mission is to deliver entirely new levels of differentiation and personalization by using distributed intelligence in combination with smart sensors worn by passengers. Carnival’s interactive customer experience, named “ICX” (I for the interaction, C for the consumer and X for any band or pass technology) begins for each guest the moment a trip is booked and ends upon guest’s disembarkation. By incorporating the crew interface component - the Crew Compass app - with the guest-experience design, the crew is empowered to even anticipate and respond guests’ preferences, delivering a high-level quality experience. The same technology enables officers to track people during muster drills or, even, during an emergency.

Table 4: Cruise operator guests on-board digital innovation

ROYAL CARIBBEAN CRUISE LINES (RCCL)				NORWEGIAN CRUISE LINES (NCL)			
Royal Caribbean International (Quantum class ships)	• VOOM , Wi-Fi connection at sea	Celebrity Cruises	• <i>Eden space</i> , a multi-purpose space whose design is based on a mathematics equation	Norwegian Cruise Line	• App allowing passengers to check in before their embarkation or to make purchases		
	• GPS mapping and Bluetooth for navigation on-board		• Interactive Menus on iPads ( <i>Qsine restaurant</i> )		• Virtual game with virtual ocean views (in widow-sized for interior rooms)		
	• Facial recognition technology		• <i>Edge Access Tour app</i> , a behind-the-scenes 3-D tour using AR		• Virtual mini-golf		
	• <i>Excalibur app</i>		• Luxury " <i>Smart Glass</i> " Shower, using electro chromatic tech		• Epic app, an iConcierge for connecting guests and crew		
	• <i>Sea Beyond app</i> to help customers prioritize their activities		• Digital backdrops in lieu of elaborate sets		• Facial recognition for matching guests to photos captured on board		
	• WDW electronic bracelets using RFID technology	<b>CARNIVAL CRUISE LINE GROUP (CCL)</b>		• Interactive touchscreens for navigating and booking activities			
	• <i>Star Trek</i> -looking digital boards for monitoring the engine			• Interactive digital signage on board			
	• VR Dining	Carnival Cruise Line	• EA Sports Bar using iPads	<b>THE WALT DISNEY COMPANY</b>			
	• AR for steering the ship in low visibility		• Crew Compass	• Magical Porthole, virtual window, showing Disney animated characters together with live ocean view			
	• Virtual balconies using HD LED screens	Princess Cruises	• MedallionNet, Wi-Fi connection at sea	• The Animation Magic Show (Animator's Palate restaurant)			
	• <i>RipCord</i> , virtual skydiving simulators		• <i>Ocean Medallion</i>	• MyMagic+ technology project			
	• <i>Sky Pad</i> , VR bungee trampoline		• <i>Ocean Compass</i> : a schedule of on board activities	• MagicBand No. 2 for additional interactivity			
	• <i>Laser tag battle for planet Z</i>		• <i>Ocean Ready</i> to submit travel documents and go paper free	• MyDisneyExperience app			
• Bionic Bar with two robotic bartenders	• <i>Play Ocean</i> : mobile video games that can be played on or off the ship		• Magic PlayFloor, an interactive floor which blends the latest in gaming technology with Disney-style storytelling				
• <i>iQ app</i> which integrates customers' on board experience with the <i>Cruise Planner app</i> , a tool that helps you pre-plan your vacation	• <i>Ocean Concierge</i> : for purchasing shore excursions, viewing stateroom account and all activities offered on board		• MagicBand bracelets to connect cabin keys, payments and PhotoPass information using RFID, Bluetooth Low Energy (BLE), and Near-Field Communication (NFC) technologies				
• The <i>Wayfinder</i> interactive LCD touch-screen using RealMotion technology	• <i>Ocean View</i> : app offering more than 100 acclaimed "Ocean Original" episodes with compelling experiential travel content		• Skyline Bar, with virtual windows on the bar's walls recreate realistic skyline views of the world's capitals				
• VR mini-golf	• <i>Ocean Now</i> : for personalized guest service on demand		• Two phones for free in each stateroom for internal communication				
• <i>X-ray vision app</i>	• <i>Ocean Casino app</i>	<b>MEDITERRANIAN SHIPPING COMPANY (MSC)</b>					
• <i>GoBe interactive platform</i> offering Virtual shore excursions, tours and activities	Holland America	• Microsoft business intelligence (BI) software / Oracle BI software	• MSC for Me app with 130 different technological functions				
• <i>Two70</i> °, digitally transformable public venues using roboscreens	AIDA / COSTA	• " <i>Pepper</i> " : the first robot which recognizes human emotions and interact with the surrounding environment	• 114 interactive screens (MSC Meraviglia) for booking several activities on-board				
• <i>ARKit and ARCore</i> games to make better use of ship space.	Cunard Seabourn	• Cunard ConneXions, educational and entertainment daily programme of activities	• MSC for Me bracelets / RFID bracelets / Waterproof wristband as ID				
Regent Seven Seas Cruises	<b>GENTING GROUP</b>			• MSC for Me touchpoints			
	• CRM system to track and record guest preferences	Crystal Cruises	• In-room tablets	• Interactive maps to guide guests around the ship			
• <i>Magic Carpet</i> , a floating platform which changes mood, function, and its location	• Mobile app		• For children: interactive game shows, touch screens and 3D printers				

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3 The scope of smart technology diffusion in cruising extends beyond the exploitation of  
4 business potential at the micro-level. Despite the growth of passenger numbers during the  
5 last decade, the first maturity signs in the cruise offer's life cycle were beginning to emerge,  
6 signified by increased competition, decreasing ticket prices and evident cost-pressures (CLIA,  
7 2020b). COVID19 has rendered new source markets and / or new itinerary development (i.e.  
8 geographical diversification) ineffective as growth strategies. Technological innovation  
9 practically remaining the only transformational option (Papathanassis, 2020). As the cruise  
10 industry has accelerated towards a transformational crossroad, smart technologies represent  
11 solutions to a number of long-lingering problems ranging from energy efficiency to safety and  
12 security on board. While such a technological transformation comes with its own risks and  
13 costs, their deployment has become more pressing than ever. The ability and willingness of  
14 different cruise operators to engage in a challenging technological transformation of their  
15 business models may vary, but there is clear evidence for its potential (Papathanassis, 2019b)

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19 Several strategies continue to be explored, such as: "door-to-door" concept (starting from the  
20 time of booking till the return of passengers to their homes), expanded cleaning and sanitation  
21 practices for ships, as well as comprehensive shipboard incident prevention, surveillance and  
22 response measures (CLIA, 2020b). Adopting a holistic approach the cruise industry will engage  
23 in smart technologies to monitor flows of products and passengers. Agility in tracking and  
24 tracing; real time information on ports; collaboration with authorities and ashore will all  
25 require smart technologies and securing the entire value chain and cruise ecosystem.

### 26 27 28 **Synthesis: Towards a Smart Cruise Ecosystem**

29 From a strategic perspective, the cruise industry increasingly relies on digital infrastructure  
30 for its smooth function. The various actors operate independently and competitively except  
31 for certain cases (embarkation/disembarkation process), when they need to jointly  
32 coordinate their actions (Watson and Boudreau, 2011). A range of smart technology  
33 applications synthesise the Smart Cruise Ecosystem landscape, to support this economic  
34 activity and facilitate the experience on-board and ashore.

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37 Before travelling, cruise companies maximise revenues and optimise routes. Machine learning  
38 algorithms and programmatic advertising drive traffic to websites and increase customer  
39 conversion rates by serving dynamic content based on web-user behaviour. Improvements in  
40 data modelling and mining identify new segments with a high propensity for conversion and  
41 optimisation of email-marketing performance. Geo-location and behaviour-based digital  
42 advertising generate sales leads. Using machine learning, cruise companies optimise the  
43 content of marketing emails to support conversion and maximise Revenue Per Available Cabin  
44 (RevPaC). Virtual Reality (VR) and increasingly Metaverse are used extensively to showcase  
45 ship hardware at trade shows and to provide "walk through" for prospective customers. A  
46 large amount of fragmented online data from numerous cruise forums, social network groups,  
47 cruise-portals and blogs are accumulated (Papathanassis *et al.*, 2012).

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50 During the cruising experience, there is a large spectrum of smart hospitality applications to  
51 support on-board experiences. Smart innovations are used by marketing departments on  
52 board, supported by robust Customer Relationship Management systems (CRM) to track and  
53 record guest preferences and ; anticipate their needs. Robots, Artificial Intelligence and  
54 Service Automation (RAISA) technologies are increasingly evident in tourism (Ivanov and  
55 Webster, 2019). Customer service Bots, such as ZOE of MSC Cruises (Buhalis and Moldavska,  
56 2021) and robots like "Pepper" of Costa Cruises, provide concierge services about on-board  
57 facilities and shore trips whilst collecting evaluations about the experience. They are available  
58 24/7 to address passenger needs, give information and can customise experiences based on  
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3 individual preferences, using streaming analytics, contextual awareness and machine  
4 learning. Technology innovations also include VR that enables engagement with working  
5 spaces such as the bridge, kitchens or the engines, which are normally not accessible and  
6 visible for cruisers. VR can also enrich physical spaces on board, with virtual aquariums and  
7 other virtual features taking advantage of technology to create attractions in confined places.  
8 By turning walls into digital installations, cruise companies can install interactive virtual  
9 balconies, with high-definition LED screens which show real-time video of the outside the ship;  
10 upgrading the look and feel of inside cabins. The effect is completed by piping in the rhythmic  
11 sounds of calming waves or gentle rain showers, and having a faux sunrise serve as an alarm  
12 clock and the night sky revealed on the concept cabin's ceiling (Locker, 2017). They can create  
13 a space where people can see views of the ocean and skies from inside their cabins, without  
14 having to necessarily go to the promenade of the ship.  
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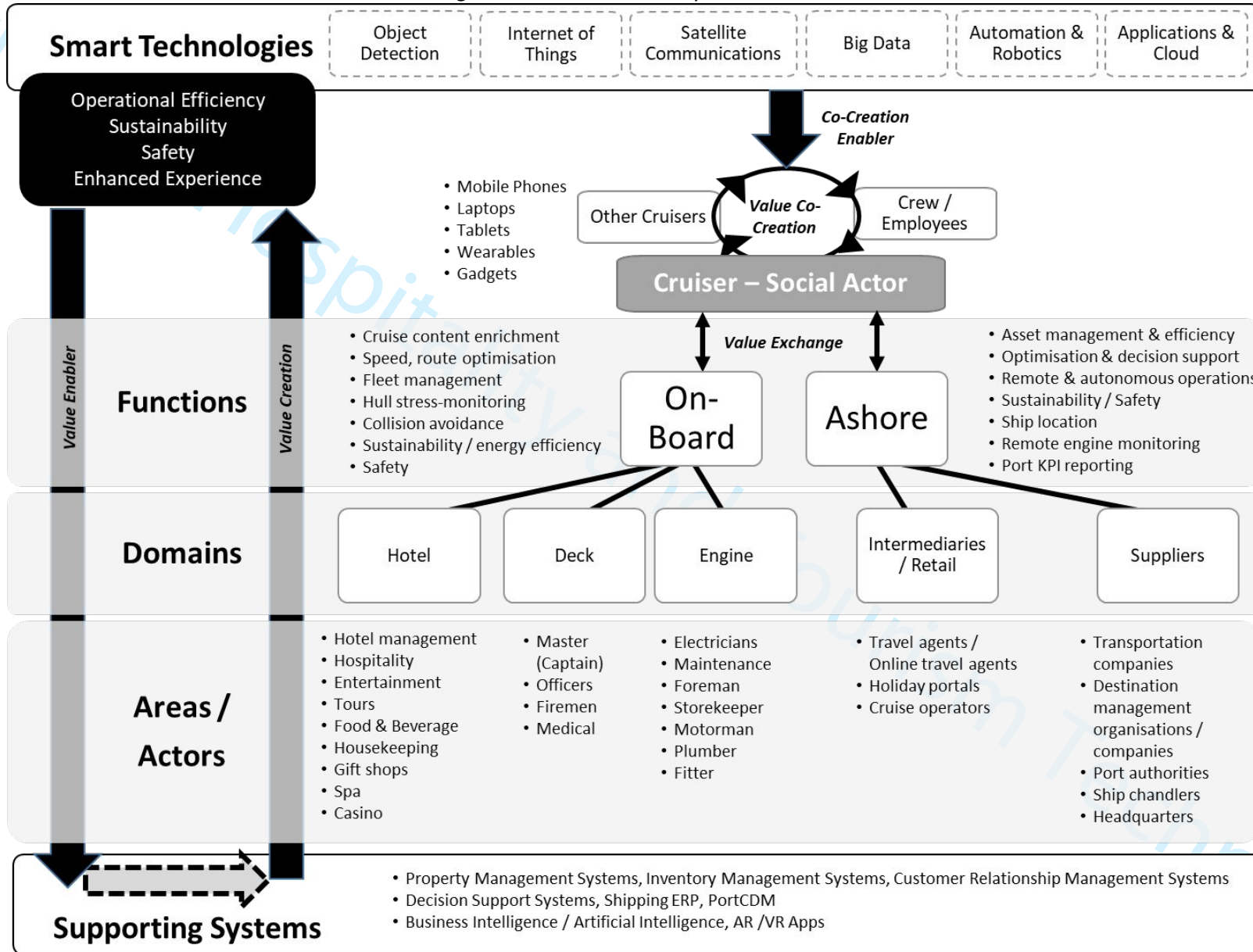
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18 The smart technology constitutes a holistic smart ecosystem to manage all actors, controls,  
19 devises and systems in order to optimise ship operations and management, whilst co-creating  
20 value for with guests and crew in an effective way. The multiplex Smart Cruise Ecosystem  
21 (SCE), illustrated in Figure 1, is enabled by digital technologies implemented by several actors  
22 with different functions, supporting several services. Smart technologies including (amongst  
23 others): object detection, IoT, satellite communications, Big Data, automation, robotics, AI,  
24 Cloud Computing, AR, VR, collect, access and process big data dynamically. These are utilised  
25 on-board for enriching cruisers' experiences and at shore for enabling cruise operations and  
26 asset management. Central to this smart business system is the cruiser as a dynamic smart  
27 actor, interacting with crewmembers and other guests, both on-board and ashore (check-  
28 in/out process, visits in different destinations, etc.), enabling co-creation and value exchange  
29 for all actors. This resides on a seamless coordination between ship- (Deck and Engine), hotel-  
30 and shore-operations, involving the alignment of diverse land-based partners and suppliers  
31 and the mobilisation of intermediaries and retailers. In turn, a range of interoperable and  
32 interconnected supporting systems form the basis of the smart ecosystem.  
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36 Hence, the Smart Cruise Ecosystem can be defined as:

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38 "A cruiser-centric multiprocessing environment, where on-board and port communities,  
39 supported by interconnected digital systems, co-create and exchange value in the form of  
40 enhancing cruisers' experiences; facilitating operational efficiency, safety, sustainability, value  
41 and wealth creation for all stakeholders".  
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Figure 1: Smart Cruise Ecosystem Framework



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3 Smart cruising and digital technologies enrich, customise and personalise cruiser experiences.  
4 Augmented reality apps, integrated with wearable technologies enable seamless navigation  
5 and information on-demand. With AR aggregators, phone apps optimise the experience and  
6 address any unexpected occurrences or personal preferences. From a company's perspective,  
7 real-time data collection and business intelligence (BI) can be used to analyse preferences, to  
8 enhance loyalty and drive revenue-generating performance at the various venues, based on  
9 reliable constructs of guests' behaviours and attitudes. As ships sail between ports, cruise  
10 companies segment their guests, analyse behavioural patterns and dynamically adjust  
11 offerings and programs as to better fit cruisers' preferences (Accenture, 2017). This solution  
12 leads to real time data-driven decision-making, resulting to increased revenues and improved  
13 guests' experiences.  
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17 Smart cruising is not limited to minimising personnel and variable costs on-board, but also  
18 extend to optimising resource utilisation throughout the entire business system. An example  
19 of efficiency includes sea traffic management of "connected ports" using Data-Distribution  
20 Services (DDSs). Unfortunately, in many ports, the necessary data is not shared, preventing a  
21 common Decision Support System (DSS) between the different actors, so coordination is often  
22 poor (Wartsila, 2017). Cruise companies use an Automatic Identification System (AIS) for  
23 designing new digital services, providing raw data to investigate the potential value and  
24 estimate the cumulative benefit of process innovations, such as green routing (the shortest  
25 safe distance) and green steaming (the lowest operational speed to arrive on schedule). The  
26 Port Collaborative Decision-Making (PortCDM) system facilitates the process of collaborative  
27 dynamics for port call coordination (internal collaboration) and port call synchronization  
28 (external collaboration). This optimises port visits by flexibly balancing capacity utilization and  
29 turn-around time, port visit disruptions to a minimum (Lind *et al.*, 2015).  
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33 The future of the maritime complex is also driven by sustainability (TravelPulse, 2016).  
34 Sustainability entails the reduction of marine litter, waste and pollution, the reuse of energy  
35 sources and international regulations, and the recycling of materials and production residues.  
36 The future maritime ecosystem is expected to minimise carbon emissions and reduce  
37 environmental impacts (Accenture, 2017; Wartsila, 2017; Xevo, 2018). The common target is  
38 a 40% reduction of carbon emissions rates by 2030, compared to 2008 (CLIA, 2020a).  
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41 Safety on-board will require the latest GPS technology available for both employees and  
42 cruisers (wearables, gadgets). Operational safety will include preventive maintenance, risk  
43 management, accident prevention, and anti-piracy technology systems On-board safety  
44 technologies include: electronic stability control (ESC), forward collision control and braking,  
45 inside cab facing cameras, over-speed alert systems and electronic logging devices. They  
46 provide direct digital feedback to fleet safety management and enable management practices  
47 dependent on safety technology (Woodrooffe, 2017, Meriteollisuus Finnish Marine Industries,  
48 2016; Van Dijk; *et al.*, 2018).  
49

50  
51 Autonomous shipping will be a reality as with all transportation. AI introduces automation in  
52 all functionalities, aiming at the development of autonomous devices, vehicles and vessels.  
53 The latest Rolls-Royce's project in partnership with Google Cloud makes remotely-operated  
54 vessels a reality propelling fully autonomous unmanned ocean-going ships by 2035 (Rolls-  
55 Royce, 2017). Japan's NYK has completed a trial on the world's first autonomous cargo ship,  
56 sailing from China to Japan (NYK Line, 2020). Yara to start operating the world's first fully  
57 emission-free container ship will be in commercial operation from 2022. The vessel's 'virtual  
58 captain' operates in an ecosystem, where decision-making relies on data, smart algorithms,  
59 artificial intelligence, drones, and ongoing process optimisation. Over the next years, remote-  
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3 controlled and autonomous ships, using Intelligent Awareness (IA) systems will reduce the risk  
4 of injury or death for ship's crews and guests, as well as the potential loss or damage of  
5 valuable assets (Rolls-Royce, 2017). The benefits of autonomous shipping to support timely,  
6 safe, environment-friendly and cost-efficient sailing are well-recognised in the shipping  
7 industry (Van Dijk *et al.*, 2018). The absence of human intervention and/or involvement raises  
8 concerns regarding the ability of such technologies to deal with exceptional, complex crisis-  
9 scenarios at sea. The extent to which autonomous or semi-autonomous vessels are capable  
10 of effectively reacting to non-standardised scenarios is questionable and still a long way from  
11 public, political and legal acceptance. Apart from technological challenges, incidents such as:  
12 engine problems fire, and emergencies at sea, render these developments hypothetical; at  
13 least for the cruise sector. Although it is unlikely that cruise ships will become completely  
14 autonomous, smart operations will eliminate a number of work positions on board; with the  
15 remaining crew primarily focusing on customer services rather than shipping.  
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### 18 **Smart cruise technology limitations and risks**

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21 Technological development comes at a cost, with an own set of risks and challenges for all  
22 stakeholders. To address the following threats, advanced crew training, cruisers' awareness  
23 education and back-up systems ought to become an industry-wide standard.  
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26 *Connectivity at sea is challenging as* Internet access at sea still depends on very expensive and  
27 less reliable satellite internet connections. Connectivity bandwidth is limited on board against  
28 an ever-increasing customer expectation for free, unlimited and fast connectivity. To respond  
29 to this challenge, companies use the fastest internet connection via Wi-Fi (like VOOM in RCCL),  
30 offering different pricing packages for passengers and the possibility to even enjoy movies on  
31 Netflix, video chatting on Skype, and playlists on Spotify on-board (Royalcaribbean, 2019).  
32 Edge computing could assist by deploying sensors and mobile data collection devices on-  
33 board closer to where the data originates, reducing latency and server-side network traffic  
34 (Horowitz, 2019).  
35

36  
37 *Cyber-security risks* related to cyber threat, data breach, malicious attacks and ransomware  
38 safety and content reliability, will be more frequent with an 80% of offshore security breaches  
39 as the result of human error. Thus, companies are increasingly looking into cyber-security,  
40 secure cloud and blockchain technologies, as well as standards such as the IMO guidelines on  
41 Maritime Cyber Risk Management and the "Cyber Security On-board Ships" by the  
42 International Maritime Council, to develop recovery plans. Blockchain, as a digital ledger  
43 where virtually everything of value can be recorded (Tapscott and Tapscott, 2017), will find  
44 wide application in the cruise sector, for tackling issues related to vessel maintenance,  
45 overbookings, fraud in refunds and chargebacks, and real-time alerts for data breaches.  
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49 *Data privacy* concerns, security and integrity of data across the ecosystem raises questions of  
50 accountability. Incorrect content, beyond the control of cruise operator and outside the  
51 confines of the cruise vessel, may negatively affect the expectations, satisfaction and even  
52 compromise the safety of the passengers, leading to complaints and refund requests at best  
53 and lawsuits for corporate negligence at worst. The highly fragmented legal framework of  
54 international maritime law, flags of convenience, diverse conventions and standards, poses a  
55 compliance and enforcement challenge in this respect. To overcome this risk, companies are  
56 required to adopt to the standards set by the General Data Protection Regulation (GDPR) rules  
57 and proactively act to ensure compliance.  
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### Conclusion and further research

This paper contributes an analytical Smart Cruise Ecosystem framework, unifying all technology-empowering aspects of cruising and paving further research. The paper conceptualises the application scope and potential of smart technologies in cruise tourism towards enhancing the value co-created for all stakeholders. Technology diffusion and digital consumption have transformed the entire cruise experience to a dynamic ecosystem. Technological innovation and digitally-enabled interactions between cruisers, organizations, and stakeholders drive value co-creation, efficiency, effectiveness, and profitability. Cruisers act as active co-creators of service experiences, generating value for themselves, other cruisers, cruise operators and the communities involved in their trip. This analysis suggests that cruise companies have the common goal of offering innovative personalised experiences.

*Theoretical Implications* reveal a gap for context- and case-specific human-computer-interaction research and refined technology acceptance modelling. The Smart Cruise Ecosystem Framework serves as a roadmap for scoping the corresponding studies, contextualising their relevance, and comparing findings between the various featured user-groups (actors / areas) on-board and ashore (domains). A holistic consideration and the corresponding depiction of the functional-domain interdependencies between the multitude of actors and entities characterising the cruise tourism system, highlights an untapped smart technology research potential for tourism in general and for cruising in particular. It is tempting to reduce the theoretical and research scope of the cruise phenomenon to its various facets (e.g. Accommodation and transport – cruise as a ‘floating hotel’), failing to acknowledge it as a comprehensive experience production system. The evident scarcity of smart-technology research and literature on cruises supports this contention. Providing a comprehensive analytical framework frames and uncovers opportunities for smart technology research in the cruise context.

*Managerial Implications* engage the integration of the technological innovations to provide opportunities for the restarting of cruising. The Smart Cruise Ecosystem framework provides the ‘info-structure’ for optimising cruise tourism. The integration of seemingly isolated smart-technology innovations within an ecosystem strategically interlinks them with organisational actors and support systems. Without interoperability and interconnectivity (‘smartness’), the detached prospect of developments related to internet access at sea, mobile devices, wearables (e.g. RFID Bracelets), AR/VR technologies, and robotics, is one where they serve as guest ‘satisfiers’ or nice-to have ‘exciters’ (Kano *et al.*, 1984). ‘Smartness’ cumulatively augments them to strategic enablers; of process-, resource- and capacity-related efficiency; of service-delivery effectiveness; and of revenue maximisation, and of sustainability, safety and security. Yet, transferring this knowledge to practice lingers between an abstract notion of ‘smartness’ and the specificity of fragmented technological use-cases. The proposed framework provides contextual specificity to the term ‘smartness’ whilst uniting distinct technologies and aligning them to wider organisational objectives. The analysis and the framework serve as a benchmark for assessing individual cruise operators’ degree of technology assimilation (Nolan, 1973) compared to the rest of the sector; aiding the identification of development-project needs and incorporating them into their IT strategies. With the cruise sector facing disruptive decline in the post-COVID19 era, the imperative of organisational transformation and challenge of economic continuity rest upon the evolution of technological smartness to business intelligence.

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