



Safety & Stability through Innovation in Cruise Ship Design

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ABSTRACT

The guests see one aspect of the operations, which may be the size of the vessel, the features of a restaurant, comfortable staterooms or the amazing architecture of the vessel. But what they do not necessarily see is everything behind this, making it work. Still, it is always there. It is about culture, it is about focus, it is about continuous improvement and it is about working together with the best minds; above all, it is about competence and knowledge – people!

Elevating the expectations, setting the goals and being true to them – every newbuilding project at Royal Caribbean Cruises starts by setting goals towards improving the guest experience. The same process that has created innovative vessels on the guest side has also been applied to the technical side. The result is the most technologically advanced cruise vessels in the world today with the highest levels of stability and safety, a strong focus on the environment and continual energy efficiency improvements.

Keywords: *cruise ship design, safety and innovation, safety culture, life-cycle stability and safety*

1. INTRODUCTION¹

The organisation of Royal Caribbean Cruises Ltd is built around a fleet of 44 cruise vessels, operated by 7 strong brands. The combined capacity of the existing fleet is about 102,000 berths. In addition to that, 8 vessels are on order, boosting the capacity further by 10 per cent during the next few years. The itineraries include more than 480 destinations worldwide. A fleet of innovative and trendsetting vessels is turned into a winning concept by over 60,000 dedicated employees involved in all kinds of different tasks both ashore and onboard – from the chairman, to the naval architects designing the vessels, to the

cabin stewards ensuring that the guests get a good night's sleep in a tidy stateroom.

2. DESIGN TRENDS

Economies of scale have driven the development towards larger and larger cruise vessels. A large vessel opens up new possibilities. When Project Genesis was initiated, eventually resulting in the Oasis class, the design team looked at the advantages of many different sizes, from 150,000 to 250,000 GT. They decided to go for a record-breaking 220,000 GT design. The size was not a means in itself; they just needed an outstanding product, taking the guests' vacation experience to the next level. A large vessel offers more real estate and extended width, allowing new architectural possibilities. It became possible to open up the ship even more and create a substantially wider promenade, which again was regarded as a giant leap.

Compiled by Par-Henrik Sjoström based on discussions with the author and additional interviews with Kevin Douglas, Janne Lietzen, Mika Heiskanen, Clayton Van Welter, and Thomas McKenney



A driving thought throughout the development of Genesis was the concept of neighborhoods – to offer distinct and separate areas for people with different lifestyles, needs and priorities. Step by step over two years of systematic development work the Genesis solution grew up and the contract was signed in February 2006. Now the "MkII"-version of the successful Oasis-class is being built, with delivery of the Harmony of the Seas scheduled for 2016. At about the same time the third vessel of the Quantum-class, Ovation of the Seas, will be handed over. Although somewhat smaller than the Oasis-class, the Quantum-class is said to be the most technologically advanced cruise vessel design in the world. By taking all of the latest collective knowledge and experience across the company and industry, Royal Caribbean has further developed holistic safety and stability elements. For example, the size of Oasis class provided the opportunity to improve the design from the safety perspective as well.

The development towards improved safety on cruise vessels has been driven by the industry. In many cases new, innovative vessel designs have been challenging the existing regulations. As old rules are often not applicable to new designs, the ship designers push the envelope, challenging existing "truths". The result is that new technology is utilized in a much larger extension than before in all areas, including safety. It is no exaggeration to state that the cruise vessel design of today provides a better and safer platform for the operators. Beyond safety, the cruise vessel of today is also more environmentally friendly and fuel efficient. These improvements have been – and continue to be – possible due to hundreds of ongoing initiatives that target not only meeting current rules and regulations, but going above and beyond them.

However, Royal Caribbean and the cruise industry have come a long, and occasionally rocky, way before reaching the status as a major player in the multi-billion dollar vacation

market. The first purpose-built cruise vessel, designed for leisure cruises in warm waters, was developed in the late 1960s. It originated from a Norwegian project for the expanding Caribbean cruise market. It also materialized the dream of Edwin W Stephan, a multi-talented American visionary, who first came up with the idea of a cruise line operating a fleet of high-class, purpose-built new buildings instead of old ocean liners, which were common in those days.

In 1968 Edwin W Stephan travelled to Oslo to meet with Norwegian owners. He presented his idea and got the support of I M Skaugen and Anders Wilhelmsen. Together with a third partner, Gotaas-Larsen, they established Royal Caribbean Cruise Line A/S in 1969, and the rest is history. Edwin W Stephan was the cruise line's president from 1969 to 1996, when he became vice chairman of the board of directors. At various times he had served as general manager, CEO, president and vice chairman.

Edwin W Stephan had a vision and was extremely focused on materializing it. This pioneering spirit has been present in the company ever since. It began with a total of three sister vessels being ordered from Wärtsilä Helsinki shipyard. It is said that it was a bargain for the owner, as the shipyard was desperately searching for a way to enter the cruise market.

These references could not have been better ones. The vessels to be named Song of Norway, Nordic Prince and Sun Viking are still today regarded as exceptionally innovative in their technical design and layout. Introducing many interesting features, the Song of Norway drew much attention. The vessel had a large pool deck and was the first ship in the world designed specifically for warm-weather cruising. It is not an understatement to say that she revolutionized the cruise industry, as previous ships were usually built with far less open space on deck.



Edwin W Stephan's vision also included what was to become a distinctive feature on Royal Caribbean's ships – the glass-walled cocktail lounge cantilevered from the funnel. Had he not been quite headstrong this might not have been the case today. When he first told the naval architects he wanted something like the Space Needle in Seattle, they were skeptical. A rival cruise line even predicted such a construction would shake right off the funnel.

The 18,000 GT Song of Norway made her maiden voyage from Miami on November 7, 1970 and became an instant success. She also made most of the existing cruise fleet feel old fashioned overnight. The Song of Norway was a purpose-built cruise ship, while the bulk of the cruise fleet was formed by former ocean liners, built in the 1950s, made obsolete on their original routes by the booming transcontinental air traffic.

The development since Song of Norway has been amazing. The Song of Norway class was followed by the twice as big Song of America in 1982. Just five years later the 73,192 GT Sovereign of the Seas entered service. Under Richard Fain's leadership and vision, who became the cruise line's Chairman and CEO in 1988, the culture of innovation and transformational ship design continued. Royal Caribbean has taken a place in the forefront of cruise ship development, introducing a row of trendsetting vessels, each generation with new features, of which many have been adapted by the whole industry.

Perhaps the most transformational and influential ship in the entire cruise industry is the 137,276 GT Post-Panamax cruise vessel Voyager of the Seas, originally known as Project Eagle. Delivered in 1999 by Kvaerner Masa-Yards in Turku, Finland (which after several changes of ownerships is now working under the name Meyer Turku), Voyager of the Seas became the lead vessel of the Voyager class, totalling five ships.

In 1995 Project Eagle took a new course when Harri Kulovaara joined Royal Caribbean. His experience from innovative ship design work in the ferry company Silja Line influenced the project in a positive manner, which in that stage more resembled a much larger version of the Sovereign class than something really ground breaking.

A unique feature was the huge horizontal atrium Royal Promenade, which was for the first time introduced on a cruise vessel. The "prototype" for the Royal Promenade can still be seen onboard Silja Line's cruise ferries Silja Serenade and Silja Symphony, built in 1990 and 1991.

The Voyager class marked a real turning point for Royal Caribbean, placing the company in a league of its own with respect to creativity and new innovations.

One such innovation was introducing the first ice rink at sea, another entertainment medium that further solidified Royal Caribbean's place at the forefront of cruise entertainment. Its integration into the ship design, placed amidships on the neutral axis with minimum motions, further emphasized the focus on safety, not just for guests, but also for the crew.

Voyager of the Seas was regarded as a unique cruise vessel that mixed elements from the US cruise industry and Scandinavian ferry technology. But there was more to come. Probably the most amazing floating structure built so far is the Oasis class, a record-breaker in almost every aspect. Project Genesis was the largest commercial shipbuilding design effort ever undertaken, breaking totally new ground. The vessels were built with a larger Royal Promenade than the Voyager class and the updated Freedom class. The width of the vessel enables two parallel superstructures between which is a park with over 12,000 living plants and trees, Central Park, and the Boardwalk, inspired by Atlantic City.



The latest class of Royal Caribbean ships, the Quantum class, is not only a technological masterpiece; it once more introduces new experiences for the guests. A unique feature is North Star, an observation capsule, which is telescopically lifted to a height of 90 metres. Even the inside cabins have a view as they are fitted with an 82 inch video wall, serving as a virtual balcony with real-time images of the sea, offering the same view as the outside cabins.

After the turn of the millennium the trend towards a lower average age of cruise passengers has accelerated. A new market is formed by families travelling with children. The latest generations of cruise vessels are designed to fit the expectations of a much more heterogeneous market than 45 years ago when the Song of Norway-class was delivered. Now there are cruise passengers of all ages and with many different social backgrounds.

Today Royal Caribbean Cruises is the second largest cruise company in the world. The cruise industry has evolved from a niche to a major player in the vacation market. As it all started in the Caribbean, this area has maintained its position as the most important cruise market in the world. However, the Caribbean has become a mature market. The growth has moved to Europe and during the last years there are huge growth expectations for the Far East with China as the driving force.

Key features for the cruise industry of today are very high guest satisfaction and great value for money. As a product on the vacation market a cruise is superior. Innovation has been driving the experience and service level far above what you can expect ashore. The convenience of a cruise is outstanding: a high-standard floating hotel, providing excellent service and entertainment, moves along with the guest and offers interesting new destinations almost every day along the cruise.

The cruise industry is about a never-ending quest to provide the best vacation to the guests.

It is driven by consumer demands while economies of scale provide cost advantages and opportunities. Royal Caribbean has been in the business since the beginning of the modern era of the cruise industry. The lesson learnt during the past decades is that there is no shortcut to success. There is no silver bullet; it is all about culture and process. The success is built upon an innovative mind-set and the cornerstones for Royal Caribbean's activities are guest experience, environment, energy efficiency, and most importantly safety.

Everyone is asking: 'what is the one thing going on?' The answer is that there are several hundreds of initiatives going on. It is not just one thing, it is a mass of things, it is a way of thinking, a process.

3. SAFETY IS THE CORE

In the same way Royal Caribbean is pushing the cruise vessel architecture to its limit the company is driving the technical design, always with highest priority on the extremely important sectors of safety and environment. The foundation of the cruise industry is to ensure the safety of the guests in all conditions, including possible emergency situations.

Safety is indeed the core of all activities within the company. The guests shall feel the safety culture onboard and feel that they are well taken care of – even if something exceptional would occur. Knowing this, everything is set for an enjoyable and relaxing holiday onboard.

In general, safety is no doubt the most important issue at sea, no matter what kind of vessel we are talking about. On a cruise vessel, with several thousand passengers and crew onboard, it is absolutely crucial. The policy of Royal Caribbean has, for decades, been a proactive one – to take safety to a limit far above and beyond compliance. The vessel should remain floating as a priority and new



technology and design tools have contributed to great progress, driving better and safer rules for damage stability. Ultimately it is about just that. If the design cannot withstand extensive damage, the game is over when an accident occurs – as was the case with the Titanic in 1912.

Safety is a complex and vast field, containing much more than built-in damage stability requirements. Redundancy, for example, is essential in the modern way of thinking, where the ship should be the safe haven even if a serious accident should occur.

Royal Caribbean has pioneered redundancy. In 1995 the so called half ship concept was implemented with the Vision class, based upon separate engine rooms mainly for fire division. In practice this means, that in case of an engine room fire the vessel would still have capacity left to generate enough power not only for propulsion, but also for all the vital functions in the hotel part of the ship.

In 1999 double hulls in engine rooms and two totally independent engine rooms were introduced in the Voyager class to reduce the risks of flooding of these vital spaces if the hull would be penetrated by grounding or collision. Since 2007 Royal Caribbean has built its ships by the principles of Safe Return to Port along with enhanced guest comfort requirements. In 2013, additional divisions were included between engine rooms to improve damage stability in addition to building them within the double hull. Extensive 3D-topographic simulations have been completed to verify configurations, along with consequence studies and safe return to port simulations.

Royal Caribbean has been pioneering many other sectors for enhanced safety and security as well. In an early stage the company took a robust approach towards the adoption of paperless navigation, including an internal approval process above and beyond that of regulation. An enhanced bridge layout, focusing on human-centred design, was

introduced with the Voyager class. The utilization of electronic mustering systems was taken to the next level in the Oasis class, leveraging this technology to further enhance evacuation and accountability.

An essential part of safety is also good manoeuvrability. Manoeuvring calculations, simulations and model tests have been incorporated both onboard and in shore-based training. The result is that every new generation of vessels has presented improved manoeuvrability, regardless of size. There are also innovative utilization practices for dynamic positioning systems within operation.

Project Eagle, resulting in the Voyager class, is a good example of ground breaking thinking regarding safety. The dramatic increase in size was driven by experience, also leading to giant leaps in safety. The alternative design principle was extensively used for the development of the horizontal atrium, the Royal Promenade. Such a large space as the Royal Promenade presented a real challenge for fire safety, not only for the designers, but also for the shipyard and the classification society.

In the Voyager-class, double engine rooms and advanced safety simulations were also adapted. The advanced integrated navigation systems, originally developed for demanding navigation of large cruise ferries in narrow archipelago fairways, soon found their way to Royal Caribbean's cruise vessels. Equipment and ergonomics of the bridge on Voyager of the Seas was state-of-the-art, and probably the most advanced on a cruise vessel at the time.

The Oasis of the Seas was the first ship designed with a known safety level, based upon the Risk-Based Design methodology. For crisis management an Onboard Decision Support System was adopted.

Technology made it possible to take such huge leaps in ship design without compromising safety. It had become possible



to simulate virtually everything on a cruise vessel during the very early phases of design: strength, stability, logistics, passenger flows, evacuation routes, damage stability, obstructed views in the theatre, manoeuvring in port, etc. It was now also possible to visualize the interiors of the vessel during the early stages. Simulation technology made it possible to design vessels that are progressive in all areas regarding customer satisfaction, operational advantages, energy efficiency and overall safety.

A main goal during the project was to design a vessel with improved levels of safety. The latest technology was utilized in all areas. The large number of passengers provided an opportunity to improve new evacuation routines and routes, including on-line registering of passengers at assembly stations.

Computational fluid dynamics calculations were used for optimizing the hull and its details. This process improved detail design and eventually created substantial energy savings. The machinery solution was adapted from Voyager and Freedom with two totally independent engine rooms and doubled systems.

The Solstice and Oasis class did in advance fulfil the principles of the coming regulations for “safe return to port”. In addition, the design of both classes helped shape the Safe Return to Port regulations by being used as examples during detailed analyses. Based upon a Casualty Threshold concept, where this defines the amount of damage the vessel is able to sustain and still safely return to port, a large 3D-computer model was created, including all channels, valves, cables and components. Numerous simulations took place, testing what would happen if a section was lost, analysing optimal routing for cables, etc. Part of the tools and the technology was developed exclusively for the Oasis-class and used for the first time to a greater extent.

Mainly due to the increased size of Oasis, there was a requirement to develop novel concepts in multiple areas including life-saving. Without compromising the design and safety of the vessel, several innovative designs were developed including optimized evacuation of the 8,500 passengers and crew, the largest lifeboats installed on a ship so far with a capacity of 370 persons each, and a large Marine Evacuation System (MES) for 450 persons each, designed for boarding through chutes.

Due to the configuration and novel design an alternative design process was extensively applied, including extensive fire simulations as per SOLAS Alternative Design and Arrangements. Alternative means of fire division was carried through in the form of roller shutters, enabling longitudinal and transversal fire breaks.

Royal Caribbean also pioneered a feature called the Safety Command Centre on the Solstice and Oasis class. Since the 1990s Royal Caribbean vessels were equipped with a safety desk on the bridge, evolving into the separate space on Celebrity Solstice in 2008 and Oasis of the Seas in 2009.

If a serious accident occurred the Safety Command Centre is manned, acting as a centre for resource allocation. Command, communication, evacuation and incident management all have dedicated resources that are specialized. The true power of the space is the potential to leverage the allocated resources through design and technology. Committing to a larger footprint allows objective-oriented teams to focus on their work stream. The team leader supports the command more effectively due to optimal span of control, thereby having a more ideal number of responsibilities and resources to manage.

This concept was further developed on the Quantum-class by dividing the Safety Command Centre into three pods. On the port side is the Evacuation & Command Pod, on the



starboard side the Incident Pod and amidships the Command Pod.

4. SAFETY LIFECYCLE

The philosophy of Royal Caribbean is that safety is not only about how a newbuilding is designed but also concerning virtually everything that takes place over the life cycle of the vessel. One important issue is how to train the ship operators and how to set the standards for the operations. The operators have to know exactly which tools are provided to monitor the stability in operations and also how to understand them. They have to understand a possible damage situation in a very complex manner, using the technological tools provided.

Training is essential in the safety lifecycle. The operational standards and levels of training are enhanced to fit for purpose and rigorous technology qualification. The company has a safety culture program that stresses the necessity of efficient emergency response procedures and training.

Royal Caribbean talks about the safety lifecycle of a ship, containing four phases: Ship Design (Design and NB phase), Strategic Stability Management (operational life cycle), Operational Stability Management (per voyage) and Emergency Stability Management (emergency situations).

The design of the ship is setting the bar. Over the life cycle of the ship several modifications are done. They can either impact the construction negatively or positively. With deeper knowledge of the vessel it is possible during a refit to enhance the stability by applying new types of watertight doors, adding ducktails, removing weight up high or splitting tanks. Through this process it is possible to improve the vessel stability, despite the fact that the original design has been modified. If no measures are taken, the ship will gain weight and the stability will be impacted.

Already in the design and newbuilding phase there is greater collaboration between partners such as the Cruise Ship Safety Forum (CSSF), the world's leading shipbuilders and designers, academic institutions, authorities, technology suppliers and the Cruise Lines International Association (CLIA).

The CSSF has become a very active unit, where the majority of cruise lines, shipyards and classifications societies are represented. The forum is collectively working on several topics and has been pushing the envelope in a positive manner. Developing thoughts and giving recommendations to cruise lines, shipyards and even to the International Maritime Organization (IMO).

In the design phase the regulations are to a great extent providing the basis. But it is of course, as in the case of Royal Caribbean, possible to go above and beyond that.

The stability, and hence the safety of the vessel, does not remain unchanged through the entire operational life cycle. It is therefore important that it is constantly monitored to make sure that the vessel lives up to the initial design aspects and elements. This is called Strategic Stability Management. It starts with stability analytics that utilizes a shore-side stability analytics program for tracking and trending fleet stability parameters.

This process also includes a deadweight management system to better optimize both hull efficiency and stability. The potential exists for more robust policies and procedures, which can result in positive change with minimal cost.

Operational Safety Management is how a vessel is operated during each voyage. It is about how all the technological tools are applied and used to determine the stability and loading conditions. It includes control of water tight doors and deadweight management.



For example watertight door exemptions have been objectively assessed in an effort to strategically reduce opening times and thereby increase vessel survivability. These experiences are encouraging. Going beyond the requirements laid out by Class and authorities on two different ship classes, watertight door opening hours have been reduced from 40 to 80 percent.

Emergency Stability Management aims to prepare the operators for a critical situation. The key is training – it has to be the best training with the best procedures if the ship is damaged.

Royal Caribbean is also a step ahead in this field. For example, SOLAS has mandated fire and life boat drills on a weekly and monthly basis. But SOLAS has not mandated any damage control drills. Royal Caribbean started mandating damage control drills a couple of years ago on a few ships and now they have adapted the practice fleet-wide. Their ships do not only have fire drills and lifeboat drills, but they also have proposed through IMO that damage control drills be completed on a regular basis. For all RCCL brands there is a monthly damage control drill frequency in policy. The two newbuildings of Quantum class have also been delivered with Damage Control Plans updated to incorporate Damage Response.

The life cycle of a cruise vessel is like a journey itself. The trick is to make sure that all the competence and knowledge is transferred in a meaningful manner to the operators via training and tools. When new knowledge and new competence is found, there becomes ways to improve existing ships with relatively small modifications.

An important issue is the impact of Stability Management on Safety. Compliance serves as the clear baseline for safety while the actual ship design sets the bar. Stability management systems and procedures for a vessel in operation can raise, maintain or lower that bar.

Royal Caribbean continues towards enhanced Stability Management. Based upon a holistic approach, linking Strategic, Operational, and Emergency Stability Management, the aim is to ensure better understanding of existing ships as well as the impacts of lightship growth and reduction of stability.

The measures taken should initiate actions to improve both physical changes and operational practices. These measures will increase knowledge and understanding of specific ships, creating possibilities to develop even more efficient training processes and procedures to reduce risk of progressive flooding. An important part of the follow-up process is benchmarking and sharing best practices with the industry through the CSSF and to develop an industry-wide approach.

There are several issues on the agenda: Damage Control Response Plans (along with stability computers), damage consequences, decision identification and simulation support tool, attained index live on bridge based on watertight door status and linking/improving communication between the Engine Control Room and Safety Command Centre. The vision is to provide a further benchmark in the passenger ship and maritime industry, not just for cruise ships.

The CSSF continues working very actively on these improvements and even developed papers and practices for IMO, with recommendations such as damage control drills.

5. PROBABILISTIC DAMAGE STABILITY

When designing the Oasis- and Solstice-class vessels Royal Caribbean made a decision to utilize the probabilistic damage stability requirements ahead of time for safety. At that time the deterministic calculation model was still in use, calculating if the ship survives damage to any two of its compartments.



The probabilistic damage calculation methods were developed more than 10 years ago, supported by an ever increasing level of computing power.

The index required by SOLAS for the Oasis of the Seas is approximately 0.88. This means that Oasis could survive 88 per cent of the defined damage situations deriving from accident statistics without losing the ship. The actual calculated index for Oasis of the Seas, the attained index, is 0.91. When calculated in the project stage, Royal Caribbean was already informed that due to the simulations made they had a reason to believe the actual capability of the ship was much better. The simulations indicated that Oasis of the Seas could actually survive 98 per cent of all damages.

By then it had become clear that the calculation methods, which are demanded by SOLAS are conservative thus giving a very conservative view of the ship safety level. Since then a lot of work and research has been completed by the company and its associates that has verified that the presented calculations for the Oasis of the Seas were correct.

We feel strongly that the cruise ship industry, academia and regulators now urgently need to start focusing on improving the calculation methods to better indicate the true safety levels of a vessel. The rules are simplified and give a very conservative estimate of the situation. For example, longitudinal bulkheads in engine rooms protect better against raking side damage, but do not impact the attained index (meaning you don't get credit for it). This is why designing to a standard above the rules is desired, especially in areas that the rules do not directly address. Royal Caribbean is also working towards improving safety in this field. Simulations are used to enable a much higher standard of safety to the ships, making these simulations exceptionally important.

The use of the simulations allows us to better understand the likely consequences for

the myriad of different damage scenarios. With that knowledge the ship's operating team can be trained and educated so that they are more likely guided to a successful outcome in the event of progressive flooding.

Once more, this reiterates the need to go beyond the current rules while also identifying the conservative nature of the simplifications made in the rule calculations. Simulations are critical for training and understanding. These findings will be shared with the industry and the ship designers so that they collectively, as an industry, can work towards better regulations.

We have always had a gut feeling that the actual safety levels of our cruise ships exceeded the results of the calculated methods. The simplified calculation method does not give credit to the actual built-in safety. The probabilistic regulations have been very important; they have helped us to improve the safety of ships. However, through simulations and model scale work we have found out that they give a conservative look and now we hope that the industry starts really working on putting down research in order to get even better results in this respect to redefine the regulations.

Today there is a wide spread opinion in the industry that it is necessary to further enhance the probabilistic damage stability regulations to more accurately reflect the actual improved safety levels. Having all this information, it is asked if the probabilistic method really does advance safety. There is a great opportunity to advance and improve safety, along with more realistic regulations, by looking for long-term solutions and benchmarking cruise industry practices to all passenger vessels and the maritime industry as a whole. Continuing research on the entire life-cycle and on existing ships as well as further development of advisory, support and training tools is critical for the success of continual improvement in safety and specifically damage stability for all vessels.



6. THE FUTURE AND NEED FOR INNOVATION

The tremendous success behind cruising is the sum of a number of factors, such as high service, innovative ships offering many activities and experiences for the guests, a pristine environment, interesting destinations and cost effective operations.

Effective operations through economies of scale have enabled large scale cruising. In the early days it was a vacation form for the wealthy. Today cruising is available for a large spectrum of consumers in a large number of countries.

Future trends in cruise ship design and operations show a continuing growth in the average ship size as larger vessels replace smaller aging vessels. Still, it is unlikely that the maximum size will increase significantly in the foreseeable future compared to the largest vessels of today. When talking about the super large ships, like the Oasis class, we believe that it will be some time before going beyond that size. The reason for the ultra large size of these vessels is, to a great extent, architectural, they were designed wide enough to really be opened up in the centre.

Future development is to a great extent a question about features, activities, experiences onboard and the ability to deliver unique destinations. The designers will continue to develop novelty in architectural design solutions, such as open spaces, large atriums and indoor-outdoor areas. Every new generation of Royal Caribbean's ships have more new attractions and features. The guests want even more diversification regarding activities, features and options onboard. As a target group on the market, families become more and more important, which has to be taken into consideration even more when designing new ships.

The cruise vessels of today reflect the design trends in the land-based leisure industry.

This is especially true regarding restaurants onboard. Cruise ships are cutting edge on the culinary side today, offering many different choices and specialty restaurants. The trends of dining ashore are also the trends of dining on cruise ships.

Furthermore, there is still a focus on smaller ships, which are being designed to satisfy niche markets and deliver smaller and more remote destinations.

The focus will remain strong on safety. Regarding the environment, it will most likely become even stronger. For example, focus will be on advanced emission purification systems, both regarding water and air, as well as improved efficiencies with focus on alternative fuels.

Again, technology is the enabler in every respect. Technology and computing power is helping to design ships in a totally different manner than has been possible before. It is also enabling them to be operated in a totally different manner than in the past.

The design loop for all of the learnings across guest experience, energy, safety is a continuous cycle for newbuilds and the existing fleet, taking lessons learned from each and applying them to the other. For ships that can't be changed from a design perspective, operational aspects are emphasized to better understand the current state of the vessel. All of the challenges that currently face our current and future fleet are very complex and require a structured and innovative process to make continual advancements and improvements. The end result will hopefully be a buried success for safety, as the types of situations that are being protected against are never desired. It is important that complacency is avoided and that innovation is the driver that keeps us moving forward in the direction of continuous improvement.

7. INNOVATION IS THE DRIVER



Designing and operating a fleet of cruise vessels demands a holistic view from every perspective. Key factors during cruise operations, such as guest experience, impacts on the sensitive marine environment, energy efficiency and safety do not live a life of their own, as they are all tightly connected to each other.

It is of utmost importance to understand that one thing does not rule out another. In modern cruise ship design and operation they support each other, from the launching of a newbuilding project to recycling at the end of the life cycle. Technology has become an integral part of design and ship features. Royal Caribbean Cruises has, during all of its existence, been known to be an innovator in the industry. The company has by designing and building ten generations of innovative cruise ships, become trendsetters. This has been made possible by a specific culture, set of values and capabilities and a way of working with the greatest minds of the industry. There is a constant drive to make innovation part of the culture to make it everyone's responsibility and everyone's desire. Sustainability of innovation comes from culture.

The company has strong in-house leadership that collaborates with the best expertise available to nurture innovative solutions. Without this knowledge and experience it would be impossible to innovate. The cornerstone for the approach towards safety is a rigorous risk assessment process and risk centrality, utilizing state of the art technical and design technology. It is a never-ending loop of continuous improvement and feedback. There is always something that can be done better. Royal Caribbean works with the experts in the damage stability field to build better competence and better tools, improving processes and sharing this knowledge with the shipping industry.

This vast competence is applied in every new and existing ship in the Royal Caribbean fleet, aiming at safer designs and safer

operation of existing ships. Technology and tools have been, and will continue to be, a tremendous player in this work.

The goal of continuous improvement in all areas is a journey, and we as an industry are part of driving the technology and tools that facilitate achieving this goal. A successful journey or outcome can be characterized using the simple formula of adding a restless desire, ambition, technology and tools, and the best competence in the industry.

Safety is not just for Royal Caribbean, but the industry as one unified body. There should be no competition when it comes to safety. Sharing and developing passion with others, as we are doing within the CSSF, remains a primary focus for us. Our presence at this Stability Conference exemplifies our willingness to share this point with all the key players.

8. CONCLUDING REMARKS

We will finish this keynote address by using two quotes:

“There is no such thing as perfect Safety, but there is perfect dedication to continuous improvement and Safety, and Royal Caribbean is fully committed to both of them.”

(Richard Fain – Chairman and CEO, RCCL)

“We are constantly working together in order to learn from the operational procedures, how we can apply better thinking, better training and better technical tools into that. We always think about how the use of advanced technology can help the crews to operate the ships more efficiently with less impact on the environment and with the highest possible safety standards.”

(Harri Kulovaara – EVP Maritime and Newbuildings, RCCL)

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