NTSB Cruise Ship Safety Forum

Safety of Large Passenger Ships

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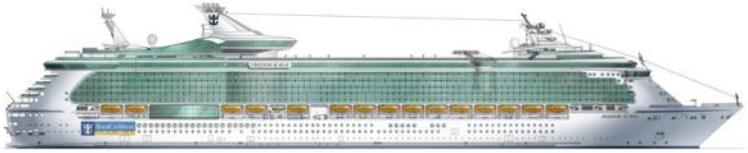
NTSB Cruise Ship Safety Forum
March 25/26 2014

Culture of Innovation and Safety

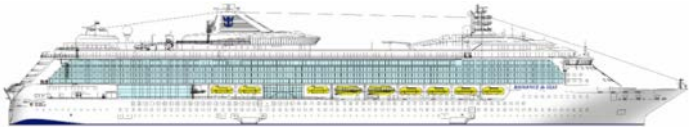
Fleet Evolution

Quantum of the Seas
4,180 D.O. / 167,800 GRT
2014

Oasis of the Seas
5,400 D.O. / 225,282 GRT
2009

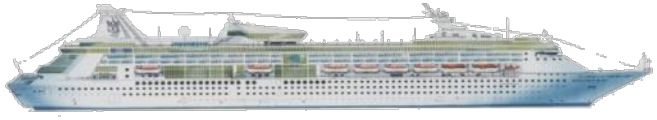


Freedom of the Seas
3,600 D.O. / 154,407 GRT
2006

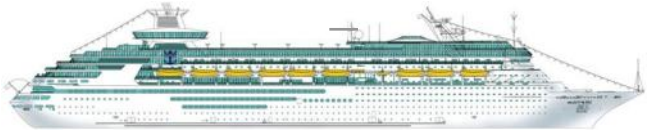


Radiance of the Seas
2,100 D.O. / 90,090 GRT
2001

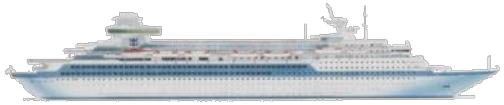
Voyager of the Seas
3,100 D.O. / 137,276 GRT
1999



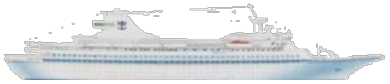
Legend of the Seas
1,800 D.O. / 69,130 GRT
1995



Sovereign of the Seas
2,300 D.O. / 73,192 GRT
1987



Song of America
1,400 D.O. / 37,584 GRT
1982



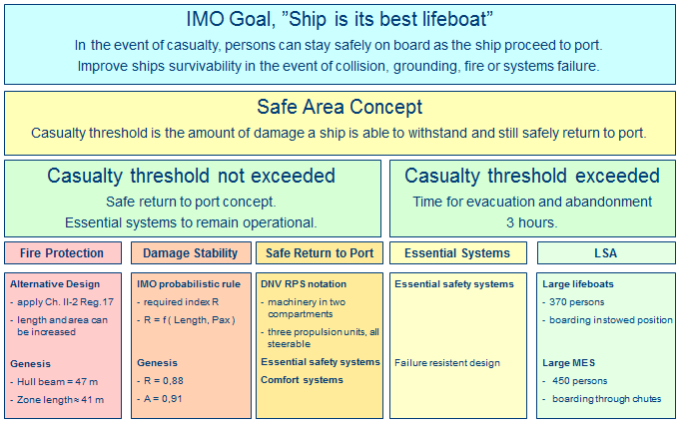
Song of Norway
700 D.O. / 18,000 GRT
1970

RoyalCaribbean® INTERNATIONAL

Oasis Class
The benchmark for the future

"The Oasis Class (2009) is truly an architectural and nautical feat. This is truly the next step in cruise evolution."

- **Biggest commercial shipbuilding design effort ever undertaken**
- **Two million design hours and ten million working hours for construction**
- **Risk-Based Design (first ship designed with a known safety level)**
- **Modern calculations, simulation tools and model experiments**
- **Alternative design process as defined in SOLAS**
- **Extensive Onboard Decision Support System for crisis management**



Oasis Class

The benchmark for the future

IMO Goal, ”Ship is its best lifeboat”

In the event of casualty, persons can stay safely on board as the ship proceed to port.

Improve ships survivability in the event of collision, grounding, fire or systems failure.

Safe Area Concept

Casualty threshold is the amount of damage a ship is able to withstand and still safely return to port.

Casualty threshold not exceeded

Safe return to port concept.

Essential systems to remain operational.

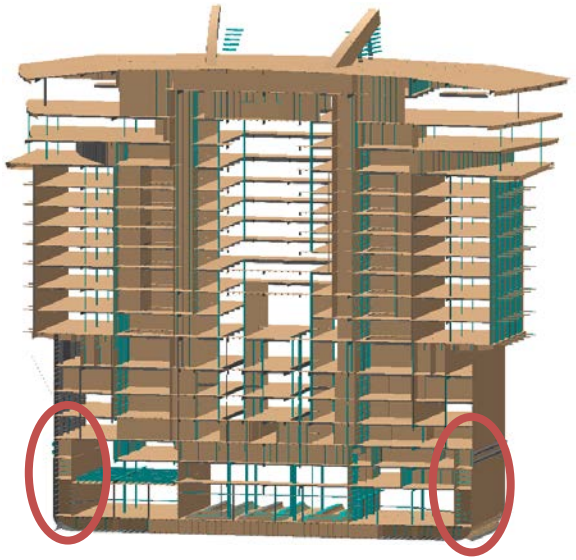
Casualty threshold exceeded

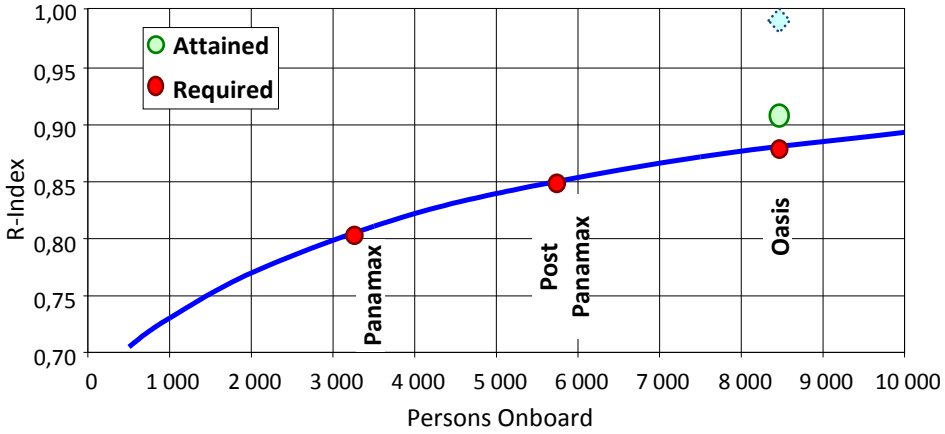
Time for evacuation and abandonment

Fire Protection	Damage Stability	Safe Return to Port	Essential Systems	LSA
Alternative Design - apply Ch. II-2 Reg.17 - length and area can be increased **Genesis** - Hull beam = 47 m - Zone length ≈ 41 m	**IMO probabilistic rule** - required index R - R = f (Length, Pax) **Genesis** - R = 0,88 - A = 0,91	**DNV RPS notation** - machinery in two compartments - three propulsion units, all steerable **Essential safety systems** **Comfort systems**	**Essential safety systems** Failure resistent design	**Large lifeboats** - 370 persons - boarding in stowed position **Large MES** - 450 persons - boarding through chutes

Safety
Damage Stability

- **IMO probabilistic rules applied ahead of time**
- **Machinery spaces protected by double hull**
- **Two years of R&D on Oasis Class Stability**
- **Extensive simulations and model test verification**

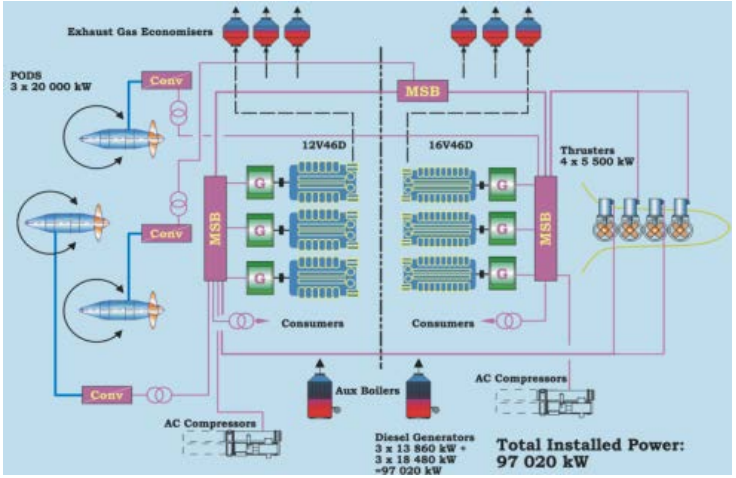




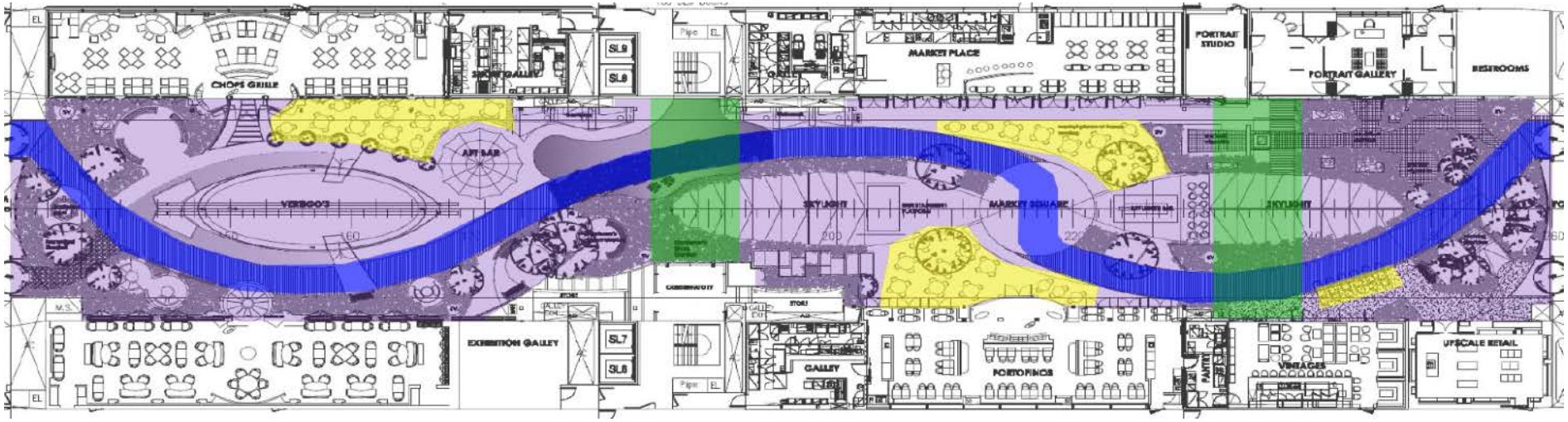
Safety
Redundant Systems

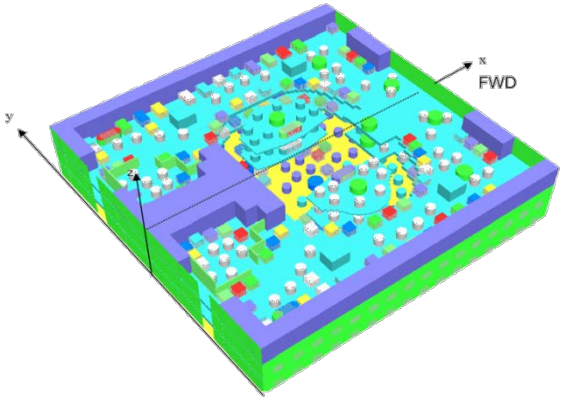
RCL has adopted

- **1995 → half-ship concept with separate engine rooms**
- **1999 → double hulls in engine rooms and two totally independent engine rooms**
- **2007 → principles of SRTP along with enhanced guest comfort requirements**
- **Extensive 3-D topographic simulations to verify configuration**



Safety
Fire Protection

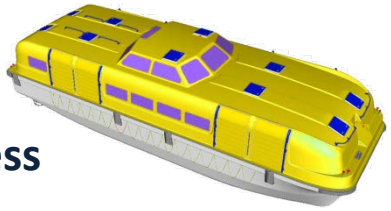




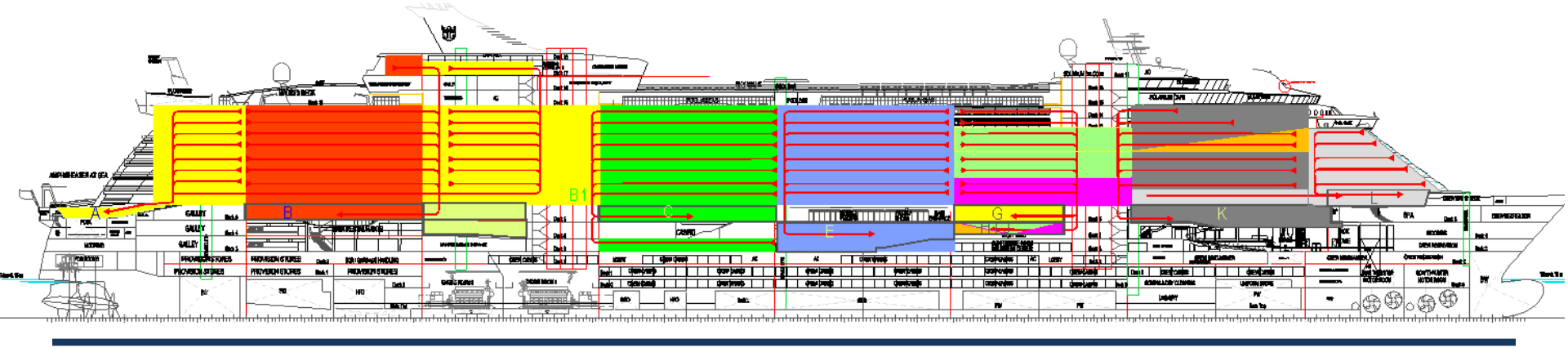
- Furnished areas
- Other areas
- Longitudinal fire break (>3m)
- Transversal fire break (ca.6m)

- **Due to ships configuration and novel design an alternative design process has been extensively applied**
- **Extensive fire simulations as per SOLAS Alternative Design and Arrangements**
- **Alternative means of fire division in the form of roller shutters**

Safety
Evacuation and Life Saving



- **Optimized evacuation as an integral part of the iterative design process**
- **SOLAS equivalent safety approach applied for life saving appliances**
- **Pioneered design for large lifeboats (370 persons each)**
- **Improved utilization of Marine Evacuation System (MES)**



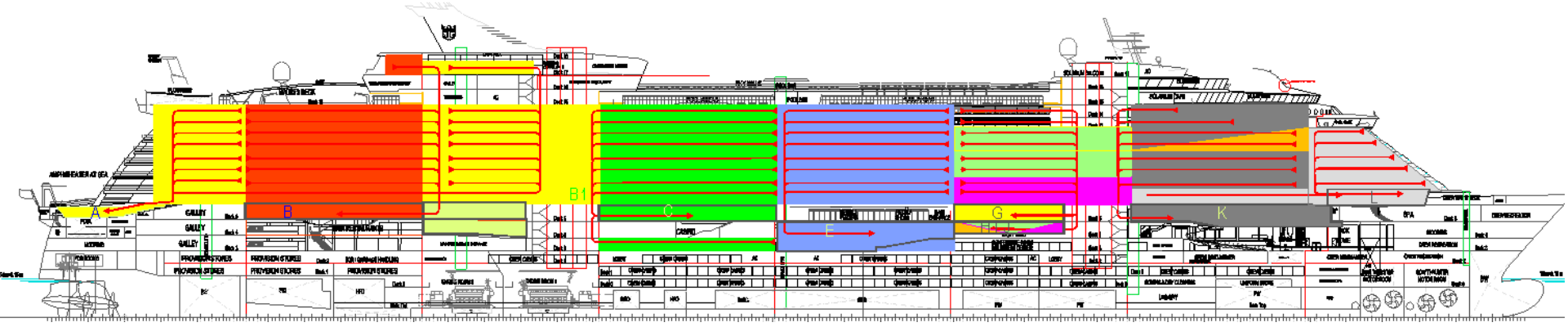
Safety
Evacuation and Life Saving

Extensive work carried out in order to optimize evacuation as an integral part of the iterative design process

TraffGo simulations were based on MSC Circular 1033, representative passenger demographics were used

11 Assembly stations total; 10 located inside

Scenario	Assembly Time	Limit
Night	44:51	60 minutes
Day	33:38	60 minutes

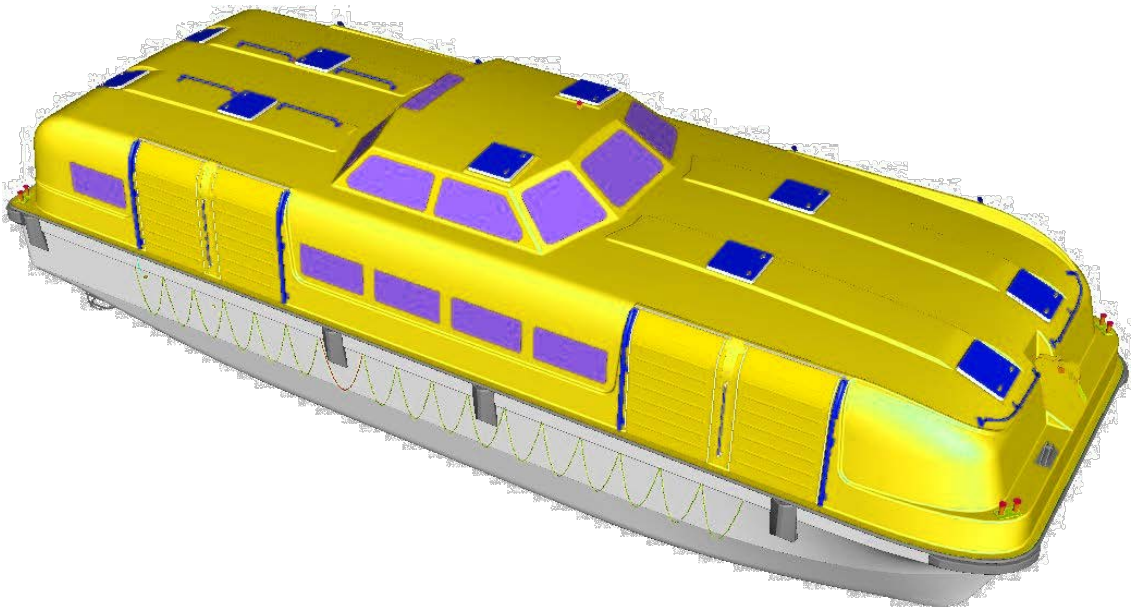


Safety
Evacuation and Life Saving

SOLAS equivalent safety approach applied for life saving appliances

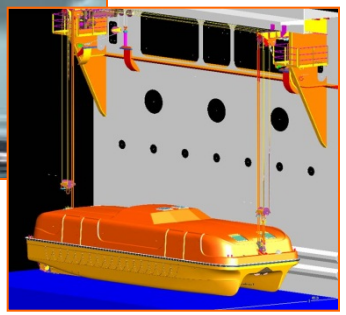
Germanischer Lloyd led the Design Team effort

Equipped with 18 lifeboats (Rescue Vessels) for 370 persons each, two fast rescue boats and four MES stations for 450 persons each



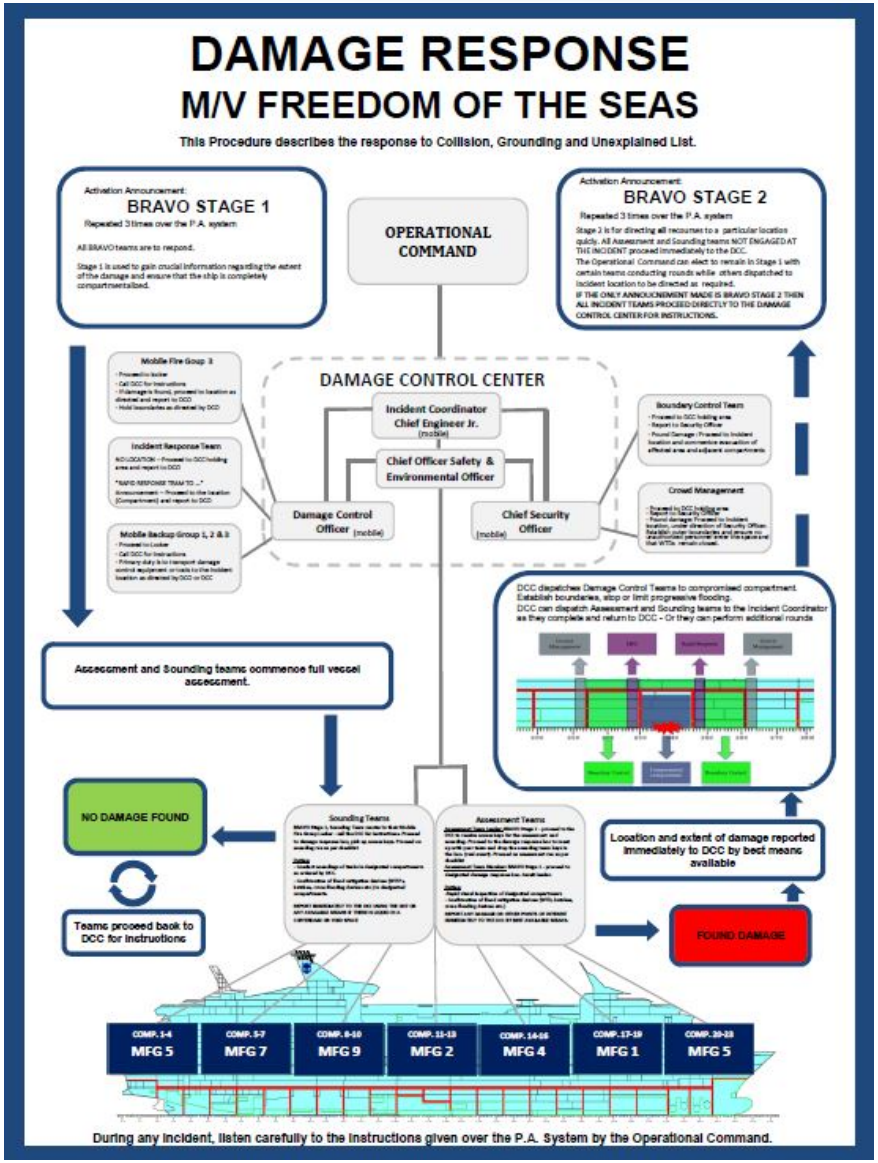
Safety
Large Lifeboats – Rescue Vessels.

- Stowed in embarkation position for simplified launch (one vertical movement) and ease of loading
- Center aisle for ease of embarkation and access to provisions & supplies
- Enhanced maneuvering with 2 independent engines/ rudders
- GPS, PA-system, windows, stretcher locations and toilet facility
- Extensive model testing and reinforcement to accommodate wave loads in extreme seas



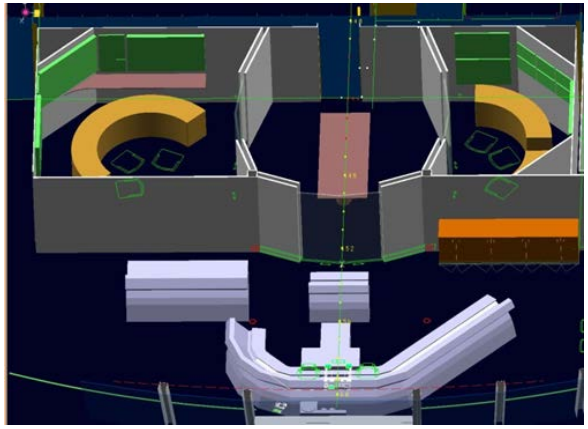
Safety
Damage Control

- A groundbreaking approach to damage control strategy.
- Allowing a ship the size of Oasis to be surveyed and assessed for damage from grounding or collision in only 12 minutes.
- Additional decision support to aid in isolation of compartments in a quick and simple fashion.



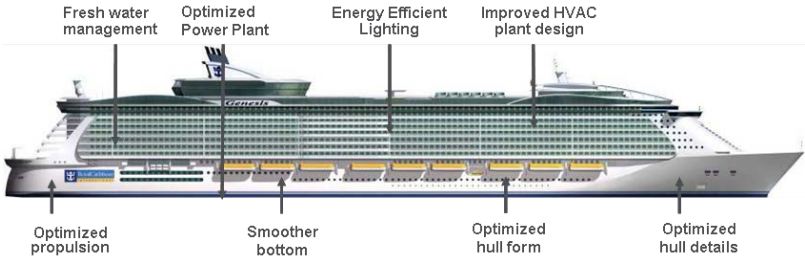
Enhanced Safety and Security

- **Extensive focus on navigation, state of the art technology, cockpit design**
- **Two years R&D on ships maneuverability with world leading authors**
- **Dedicated safety center within bridge** (Improved ability to manage safety and security incidents)
- **Electronic emergency mustering system**
- **Comprehensive digital CCTV system**



Overcoming Complexities
Our Approach

- **Involve ourselves deeply in the design and building process**
- **Strong in-house design and project management capability**
- **Partner with industry leaders, designers, consultants**
- **Follow rigorous design development processes**
- **Rigorous risk assessment process**
- **Third party reviews and Chief Engineer reviews**
- **Utilization of state of the art technical and design technology**
- **Continuous improvement and feedback loop**



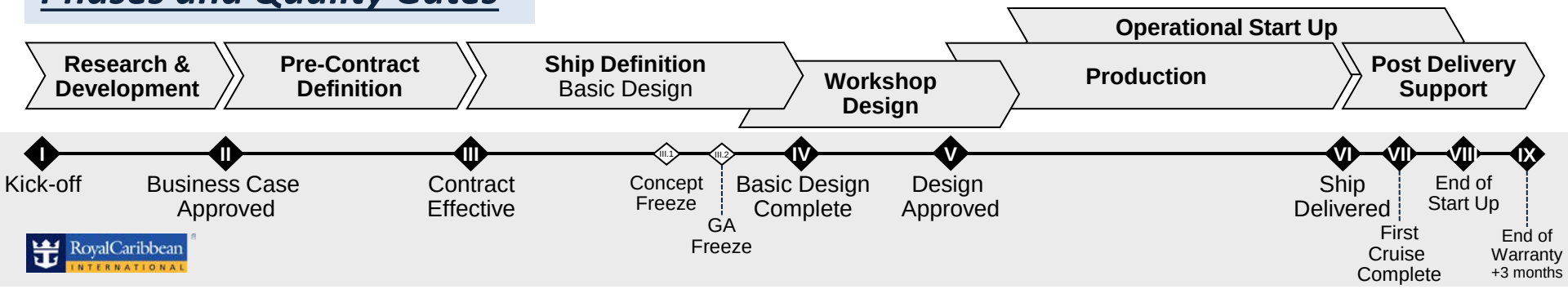
Risk Management
Comprehensive Risk Review

- **Transparent for all safety related aspects**
- **Requires continuous review with experts and close coordination with authorities from concept phase through delivery**
- **Achieved through internal and external risk review processes**
- **Oversight through external Maritime Safety Advisory Board**
- **Process results in large ships that have higher level of built-in safety proven through comprehensive verification through calculations, analyses and model experiments**

Well Defined Processes and Phases

- Seamless collaborative team effort with all partners – “Winning Team”
- Well defined processes
- Follow best practices from other manufacturing industries like aviation and automobile
- Adopt a “Quality Gate” mentality with clear timelines
- It’s all about process, people and collaboration!

Phases and Quality Gates



Lifecycle Safety Management

- **Continuous improvement and learning from ships in operation to newbuildings**
- **Enhance operational standards and levels of training**
- **Fit for purpose and rigorous technology qualification**
- **Lifecycle stability management**
- **Emergency response procedures and training**

Ship Design	Strategic Stability Management	Operational Stability Management	Emergency Stability Management
Design and NB phase	*Operational life cycle*	*Per Voyage*	*Emergency Situations*


“There is no such a thing as perfect Safety, but there is perfect dedication to continuous improvement and Safety, and Royal Caribbean is fully committed to both of them.” – R. Fain
Thank You!