Introduction to SRtP

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Outline

• Introduction
• SRtP requirements
• SOLAS approach
• Geometric Model
• Systems Modeling
• Analysis
• Results
Introduction

The term SRtP refers to

- a ship design concept

- the IMO regulations loosely based on the SRtP concept
Introduction

Passenger ships

Improvements in safety requirements
Introduction

A ship is often referred to as “the safest place to be at sea”!

In the case of a damaged ship, sustaining fire or flooding casualty, this can only be true if

• …following the casualty the ship should proceed to the nearest port, or …
• …should unable to sail she may await rescue and assistance.
• Only if the ship’s survival is in doubt she must be abandoned.
Regulations on System Design

• IMO Regulations
  • Safety of Life at Sea (SOLAS)
    • General Requirements on Systems
    • Safe Return to Port regulations
  • MSC Circulars (Guidelines and Interpretations)

• National Regulations

• Class Rules and Guidelines
  • Class Rules on System Design
  • Additional Class Notations (e.g. Redundant Propulsion)
  • Guidelines and Interpretations

• National and International Standards (e.g. DIN, ISO)
• Guidelines/Requirements of Owner Association (e.g. CLIA)
SRtP requirements

Safe return to port

Casualty threshold not exceeded

- Indefinite survivability (vessel afloat and upright)
- Fire contained within casualty threshold
- Operability of essential systems to support safe areas and recovery of the vessel

Safe and orderly abandonment

Loss of a single MVZ

- [3]* hours survivability for abandonment
- Fire contained within MVZ
- Operability of systems to support evacuation and abandonment

* Required Safe Abandonment Time
SRtP requirements

Outline of the assessment process

• Evaluation of residual functionality of Ship’s Systems in Damage Scenarios
  • Minimum capabilities
  • Allows for abandonment

• Lengthy / Complex process
  • Many Systems
  • High interdependency
  • Many potential scenarios
  • Large volume of data
Safe Return to Port – essential systems according to IMO MSc.1/Circ. 1214

- Propulsion
- The ship’s electrical-generation systems and their auxiliaries
- Steering systems and steering control systems
- Systems for filling, transferring, and the service of fuel oil (duplicated or added with a supplement)
- Internal communication between the bridge, engineering spaces, safety centre, fire fighting and damage control teams, and as required for passenger and crew notification
- External communication
- Fire main system
- Fixed fire extinguishing system
- Fire and smoke detection system
- Bilge and ballast system
- Navigation systems
- Systems intended to support safe areas
- Flooding detection systems
- Other systems required
# SRtP requirements

*List of essential systems as defined in SOLAS II-2 Regulation 21-4 and 22-3*

<table>
<thead>
<tr>
<th>ID</th>
<th>System</th>
<th>SRTP Reg. 21-4</th>
<th>EAA Reg. 22-3</th>
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<tbody>
<tr>
<td>1</td>
<td>Propulsion and necessary auxiliary systems</td>
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<td></td>
</tr>
<tr>
<td>2</td>
<td>Steering systems and steering-control systems</td>
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<td></td>
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<tr>
<td>3</td>
<td>Navigation systems</td>
<td></td>
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<tr>
<td>4</td>
<td>Systems for fill, transfer and service of fuel oil</td>
<td>X</td>
<td></td>
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<tr>
<td>5</td>
<td>Internal communications system</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>6</td>
<td>External communications</td>
<td>X</td>
<td>X</td>
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<tr>
<td>7</td>
<td>Fire main system</td>
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<td>X</td>
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<tr>
<td>8</td>
<td>Fixed fire-extinguishing systems (gaseous and water)</td>
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</tr>
<tr>
<td>9</td>
<td>Fire and smoke detection systems</td>
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<tr>
<td>10</td>
<td>Bilge and ballast systems</td>
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<td>X</td>
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<tr>
<td>11</td>
<td>Power operated watertight and semi-watertight doors</td>
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<td></td>
</tr>
<tr>
<td>12</td>
<td>Systems intended to support “safe areas”</td>
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<tr>
<td>13</td>
<td>Flooding detection systems</td>
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<tr>
<td>14</td>
<td>Other systems vital to damage control efforts</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Lighting along escape routes, at assembly stations and at embarkation</td>
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<td>X</td>
</tr>
<tr>
<td></td>
<td>stations of lifer-saving appliances</td>
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<td></td>
</tr>
<tr>
<td>16</td>
<td>Guidance systems for evacuation</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
Safe Return to Port Requirements

Source: Brookes Bell
Safe Return to Port – Minimum Requirements for Safe Areas

- Alternative designs and arrangements;
- Safe areas and the essential systems to be maintained while a ship proceeds to port after a casualty, which will require redundancy of propulsion and other essential systems;
- On-board safety centres, from where safety systems can be controlled, operated and monitored;
- Fixed fire detection and alarm systems, including requirements for fire detectors and manually operated call points to be capable of being remotely and individually identified;
- Fire prevention, including amendments aimed at enhancing the fire safety of atriums, the means of escape in case of fire and ventilation systems; and
- Time for orderly evacuation and abandonment, including requirements for the essential systems that must remain operational in case anyone main vertical zone is unserviceable due to fire.
Safe Return to Port – Minimum Requirements for Safe Areas

Minimum requirements as given by MSC.1/Circ. 1369

• Size of area (return time > 12 h) 2 m² / person
• Sanitation 1 toilette / 50 persons
• Water 3 l / person and day
• Food
• Alternate space for medical care
• Shelter from the weather
• Means of preventing heat Stress and hypothermia 10°C < Temp < 30°C
• Light
• Ventilation 4.5 m³ / person and hour
• Access to LSA
Safe Return to Port – Benefits for Safety and Operation

• Systems will remain operational in case of
  • Local fire and flooding incidents,
  • Internal system failures (mechanical, electrical, ... )

• Journey may be finished without any affects on passengers and crew.
• In case of system failure SRtP capabilities might help to prevent collision and grounding.
• More efficient and flexible operation with additional system capabilities (e.g. manoeuvrability, speed, ...) and
• More reliable operation due to design benefits.
• Lower probability of loss of vessel.
Conventional Ro-Pax Design

Source: TNA
Ro-Pax Design comply with SRtP regulations

Source: TNA
SOLAS Approach

1. Ship Description
   - Operational area / requirements
   - Layout (GA)
   - System Layout
   - System Functionality

2. Overall assessment of ship systems
   - Determine the impact of damages on systems
   - Determine which are ‘critical’

3. Detailed assessment of critical systems
   - As required based on Step 2.
   - Determine solution to critical failures (crew actions)
Requirements for the assessment tool

• Model of Ship
  • Layout of spaces
  • Definition of damages
  • Definition of MVZ, Safe Areas, Watertight compartments

• Model of Systems
  • Layout / topology
  • Functions of components
  • Functionality of System

• Calculate the effect of a damage
  • Failure of functionality
  • Individual component failures

• Detailed overview of failure mechanism
  • Allow for fixing of the system
Ship Model

- Generated from 3-D Model
  - NAPA export

- Displayed as decks

- Preserved WT and A-class subdivision

- Relative location stored in DB
  - Help pipe routing
  - Damage generation
Ship Model - Rooms

- Room
  - Smallest iSys location
    - Name
    - Deck
    - Fire Origin
    - Fixed Fire Fighting

- Space Names
  - Group of Rooms
  - Define the WT, A-Class, MVZ, Safe Area
  - Damage Generation
  - Reporting
Ship Model - Zones

• Four Zone Types
  • Watertight (WT)
  • A-Class (ACL)
  • Main Vertical Zone (MVZ)
  • Safe Area (SA)

• Closely Related to Spaces
  • Generate one from the other

• Zones Are Defined Visually

• Used in Calculation to determine criticality
  • Assessment Criteria
Ship Model - Damages

• Damages
  • Defined as a collection of rooms
  • SRtP Prescribes Damages
  • Custom Damages Possible

• Analysis
  • Assume all components in a damage are unavailable
  • Possible to change vulnerability of components

• Generation
  • Create in Interface (like Zones)
  • Generate from Space Names
    • Will determine ‘spread’ for threshold fire damages
Modelling Approach

• Ultimate Goal
  • Define essential system functionality

• Essential Systems
  • Breakdown into sub-systems
  • Define function of sub-systems
  • Essential System relies on multiple sub-system functions

• Any function can be described as being dependent on availability of
  • Components
  • Connections (cables and pipes)

• Components / Cables
  • High technical detail
  • Low abstraction

• Functions
  • Low Technical Detail
  • High abstraction
Modelling Approach
Systems categories

• Essential Systems
  • SRtP ones loaded by default
  • Delete / Rename as required
  • Add New ones

• Subsystems
  • Belong to an ES
  • Multiple Subsystems in an ES
  • One person may edit a subsystem at a time
  • Subsystems can be connected
    • Cross Connections
    • Repeated Components
Physical Systems

• Requirements
  • Locations of Components
  • Routing of Cables

• Model as a Diagram
  • Components – Blocks
  • Connection – Lines

• Location aware
  • Location from GA

• Damages
  • Check Location
  • Check Vulnerability
  • Set Unavailable
Physical Systems - Components

• Components
  • Physical components
    • Engines, Tanks etc.
    • Single Location

• Store Information
  • Sub-system
  • Name, Type, Description
  • Vulnerability
  • Diagram Symbol
  • Location
  • Review Status, Editor, Creator
Physical Systems - Connections

• Connections
  • Physical link between components
    • Cables, pipes
    • Multiple locations

• Store Information
  • Sub-system
  • Connecting blocks
  • Name, Type, Vulnerability,
  • Locations
  • Review Status, Editor, Creator
Physical Systems – Special Components

• Valves and Circuit Breakers (Switches)
  • Can have On/Off status as well
  • When off, cause a break

• Cross Connections
  • Allow pipes to pass between systems
  • Fuel flow from
    • ES 4 – Systems for fill, transfer and service of fuel oil
  • To
    • ES 1 – Propulsion and necessary auxiliary systems

• Repeated Component
  • Component in more than one system
  • Original component stores all information
  • Repeated component acts as link

• Junctions
  • Allow pipes and cables to join
  • Defines what happens at the intersection
Functionality

- Defined physical system
  - Need to assess system availability

- Require to define functionality
  - Essential functions
    - Define the functionality of a sub-system
    - “Transfer of fuel”
  - Functions
    - Define a part functionality
    - “Transfer fuel from tank 1”

- Essential System availability
  - Rely on all essential functions
Functionality

• Functions rely on components
  • May be 1000’s of components in one system
  • Becomes difficult to define

• Define functionality at component level
  • Inputs
  • Internal Dependencies
  • Outputs

• Connections ‘transport’ functionality
  • Link Inputs and Outputs

• Complexity of essential functions massively reduced
  • Simply rely on output of single or couple components
  • e.g. ES 1 – Propulsion simply rely on output of propulsion unit
Functionality - Component

- Components
  - Inputs
  - Outputs

- Outputs rely on inputs

- Pump Inputs
  - Flow_In
  - Power_In

- Pump Outputs
  - Flow_Out

- Flow Out
  - Relies on both Flow In and Power In
Functionality - Connectivity

- Defined Individual Functionality
- Need to link outputs->inputs
- Connections Define Connectivity
- HFO_TANK_1
  - FUEL_OUT
- Valve_2_1
  - FUEL_IN
- FAIL HFO_TANK_1[FUEL_OUT]
- FAIL Valve_2_1[FUEL_IN]
- ‘Knock On’ effect
Define Function

- Define as AND/OR of component outputs

- Define Type
  - Ship Wide
  - Main Vertical Zone etc.

- Assessment Scope
  - SRtP vs Abandonment

- Automatic dependency
  - Component Functions
  - Connectivity

- Component Damaged
  - All output fails

- Connection Damages
  - Link between inputs and outputs fails
  - Input fails (no longer available)
Assessment of Systems

• Defined
  • damage scenarios
  • system connections / dependencies
  • functionality

• Create BDD of system
  • Express connections and functions as Booleans
  • Apply damages (damage components in spaces)
  • Output results

• Analyse results
Restoring of Systems / Containment

• BDDs allow for restoring
  • Damage a System
  • Determine how to restore a function

• Restore Essential Functions
  • Only if Critical
  • Consider Valves and Circuits
    • Open / Close

• Containment Actions
  • Valves to close

• Create Crew Actions
Results

• View in Software

• Report Generation
Interface Walkthrough
Basic Assessment

- In iSys the systems are embedded in ship geometry (through explicit “placement” of the systems’ components within the ship model)

- The system failures can be either
  - a result of direct damages (components affected by a casualty due to their location) or indirect, or ...
  - ...caused indirectly, through the functional dependency on directly affected components, systems or functions

- Given the usual complexity of the models and relationships between the systems the assessment require powerful algorithm to evaluate all the assignments
Quantitative Assessment

- Formally, SRtP compliance is based on qualitative assessment and the regulations are deterministic - they do not built on probabilistic framework (e.g. for damage stability).

- However, the post-casualty availability is a concept intrinsically linking systems functionality and topology with ship design, layout and structural arrangement...

- ... and as such it utilises fact that internal spaces have non-uniform exposure to flooding or fire risks.

- Neglecting this evidence prohibits safe, rational and efficient systems design.
Quantitative Assessment

- The advanced models of the systems used in availability assessment contain already information about systems' structure and interconnections.

- This information can form a foundation for rapid development of physical models allowing for quantitative assessment of energy networks (i.e. thermo-hydraulic network integrated with electrical and control layers).

Such form of assessment can be, for instance, employed in decision support for crises management and emergency responses.
Quantitative Assessment

- Quantification of the models allows also for employing the inferences available through the Boolean assignments.
- This makes the models a powerful tool for optimisation of systems’ design, topology and operation.
- Finally, the robust and detailed representation of the ship systems modelled within the ship’s arrangement will be essential in evaluation of the active means of improving damage stability (and safety in general).
System Vulnerability and Availability for Existing Cruise Ships

- System vulnerability and availability assessment for existing passenger ships can increase the safety and reliability significantly.
- It requires owners willingness to invest in safety and availability.
- SRtP principals and interpretations serves as sound basis for any assessment of existing vessels.
- The results may also be used to train the crew how to intervene in case of any fire or flooding incident.
Concluding remarks

• Old concept but relatively new legislation

• Everything discussed so far, i.e. hydrodynamics, sea-keeping and stability is closely related to SRtP

• Met with (understandable) reservation by the industry but becoming more and more appreciated

• Will become more and more important
Thank you