

SARC user day 2023

Workshop Probabilistic Damage Stability with PIAS

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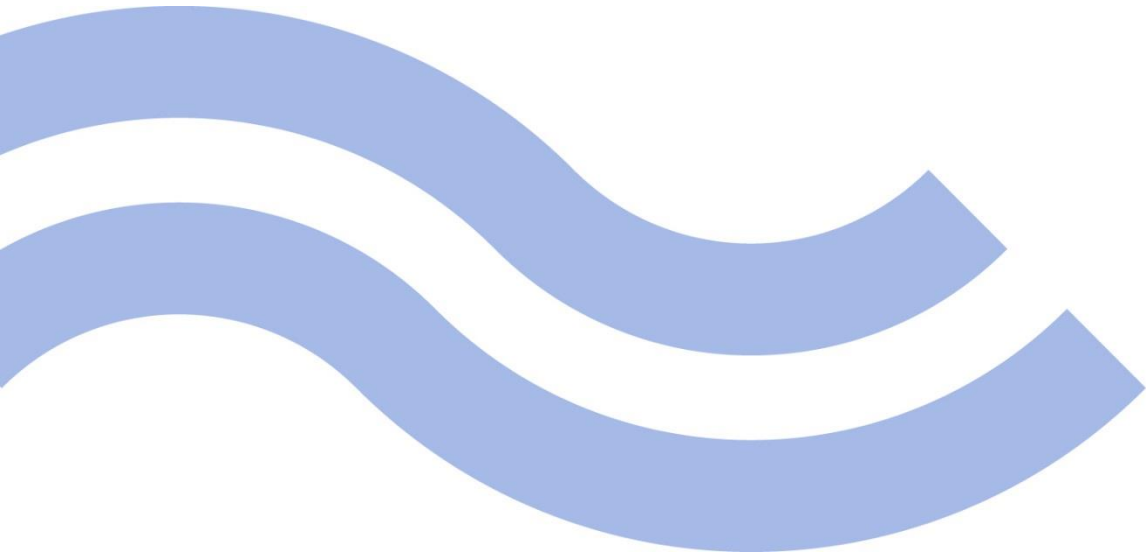


Probabilistic Damage Stability

Topics:

- Increased complexity of probabilistic damage stability and calculation times.
- Tips and Tricks
- Q&A

Increased complexity and
calculation times.



Increased complexity and calculation times.

Coming from SOLAS 1992, the SOLAS 2009 already meant more aspects to be calculated, thus increased calculation times.

Although the regulations of the SOLAS 2009 (2014 and 2020) haven't changed much, we all experience longer calculation times.

How is that possible?

Implementation and interpretations of the regulations have become more and more strict. Not only by the Classification Societies, but also by our customers and of course here at SARC.

Increased complexity and calculation times

Example: Progressive flooding

7 If pipes, ducts or tunnels are situated within the assumed extent of damage, arrangements are to be made to ensure that progressive flooding cannot thereby extend to compartments other than those assumed flooded. However, the Administration may permit minor progressive flooding if it is demonstrated that its effects can be easily controlled and the safety of the ship is not impaired.

In the past it was generally accepted that a major ballast water pipe was considered but other small pipes (e.g., F.O. piping which connects F.O. tanks with each other through the overflow tank) were 'permitted' without having to demonstrate the effects.

Increased complexity and calculation times

Other examples:

- It was allowed to calculate the stability only 'to the side of heel', now the stability must be calculated to both PS and SB.
- Minor damages were considered in a coarse manner.
- Now we have more advanced ship designs leading to:
 - Asymmetrical models (need to calculate both SB and PS).
 - Sloped bulkheads, added hull forms etc.
 - More detailed drawings are available (which cannot be ignored).

Increased complexity and calculation times

Effect:

- Calculations get more complicated.
 - Lower attained index.
 - The designer must take extra effort in order to gain back the loss in the attained index, by calculation more damage cases, more iterations etc.
- More detailed PIAS models (more frames, frame points, etc.)
- All leading to increased calculating time and effort.

Increased complexity and calculation times

Since we are not only developing software, but we also use it, we are facing the same issues as you.

Luckily, we are lazy people, so we try to keep up and develop new functionalities and mechanisms to be able to calculate these aspects and reduce the time one have to spend on it him/herself.

Let the computer do the hard and boring work.

Increased complexity and calculation times

What have we done to make life easier?

- Ability to define more complex compartment connections.
- Calculation of (damage) stability to both SB and PS.
- (more advanced) automatic generation of minor damages (higher sub-damages).
- Intermediate results can now be reached within PIAS without the need to browse and open the PD0-file with a text editor.

Most of this has been developed as free 'updates'

Increased complexity and calculation times

This has led to enhanced accuracy but unfortunately also longer calculation times.

So, what have we done to reduce calculation times?

- Multi-threaded (dual, octo and viginity) calculation of optimizing damage boundaries.
- Chronology of calculations.
- Multi threaded calculation of stability (general).

Increased complexity and calculation times

Aspects that (likely) have to be considered in the (near) future.

- More detailed ‘progressive flooding’ calculations.
 - Progressive flooding including time calculation.
- Calculation of pressure heights of pipes and closing devices.
- More detailed calculations for ‘cross-flooding calculations’.
 - Not only calculation of cross-flooding times for a selection of critical damage cases but all damage cases with a cross-flooding arrangement.
 - Not only calculation of cross-flooding at the start and end of cross-flooding, but also intermediate stages of cross-flooding have to be calculated, including the calculation of the intermediate s_i values.

Increased complexity and calculation times

At the moment this means extensive ‘manual’ labor to calculate this. The ‘Piping’ module, which we are developing, will be the answer to ‘automatically’ take these aspects into account on a detailed level.

- Now in it’s testing-fase.
- New features keep on coming to be added due to recent comments (such as calculating si values in intermediate stages).

This module will be a major step forward.

Increased complexity and calculation times

Since we are making software not only for our own use but also for you, we are interested in your experiences on increased complexity of probabilistic damage stability.

- Do you face problems like the ones mentioned earlier?
- What are these problems?
- How do you deal with these problems?
- What could there be done to solve these problems?

It is important to let us know. We want PIAS to be able to calculate what is needed.

Increased complexity and calculation times

Since developments like the 'Piping' module will also lead to longer calculation times, we are always trying to find ways to speed up the calculations and to automate the process as much as possible.

Increased complexity and calculation times

Future developments to deal with the increasing calculation times.

SARC is exploring the possibilities to:

- Combining calculation of SB and PS and additional trims, in 'one-go'.
- Possibility to (re-)calculate only one draft (e.g. in case of $A < 0,7R$).
- Showing 'A' during calculations and implementing a setting which stops the calculation as soon as the required index is reached.
- Storing the intermediate results to be printed, when using the 'Reuse of unmodified results from former calculations'.

Increased complexity and calculation times

Again, we would like to hear from you!

- Do you have suggestions to speed up calculation times?

Increased complexity and calculation times



**What can
YOU do???**

**To reduce calculation
time and increase the result.**

Increased complexity and calculation times

What can you do to reduce calculation times and increase the result?

- Make sure that all input data is correct. (more in the T&T)
- Don't 'guess' which G'M-values are needed. (more in the T&T).
- Avoid added hull forms and external defined compartments!!

Increased complexity and calculation times

Avoid added hull forms and external defined compartments!!

- Determining damage boundaries based on coordinates of compartments is fast. There are only a few distinct coordinates which form the boundaries of a compartment
- External defined compartments have a lot more coordinates which need to be considered to determine the damage boundaries.
- Consider to re-model the PIAS-model without external defined compartments and added hull forms.
- With this, we reduced the calculation time from over a week to a day.

Increased complexity and calculation times

What can you do to reduce calculation times and increase the result?

- Make sure that all input data is correct. (more in the T&T)
- Don't 'guess' which G'M-values are needed. (more in the T&T).
- Avoid added hull forms and external defined compartments!!
- Use the 'Re-use of unmodified results from former calculations' functionality.

Increased complexity and calculation times

‘Re-use of unmodified results from former calculations’.

In order to increase the computation speed, this functionality stores quite some results of former calculations in memory. These can be re-used in subsequent calculations.

Damage cases generation including "progressive flooding"	-	Yes
Store intermediate results in spreadsheet file	-	Yes
Re-use unmodified results of former calculations	-	Yes
Orientation damage case plots	-	Portrait
Wind pressure for calculation of heeling moment (kg/m ²)	-	12.23
Passenger moment (tonm)	-	10.00

Increased complexity and calculation times

‘Re-use of unmodified results from former calculations’.

In order to increase the computation speed, this functionality stores quite some results of former calculations in memory. These can be re-used in subsequent calculations.

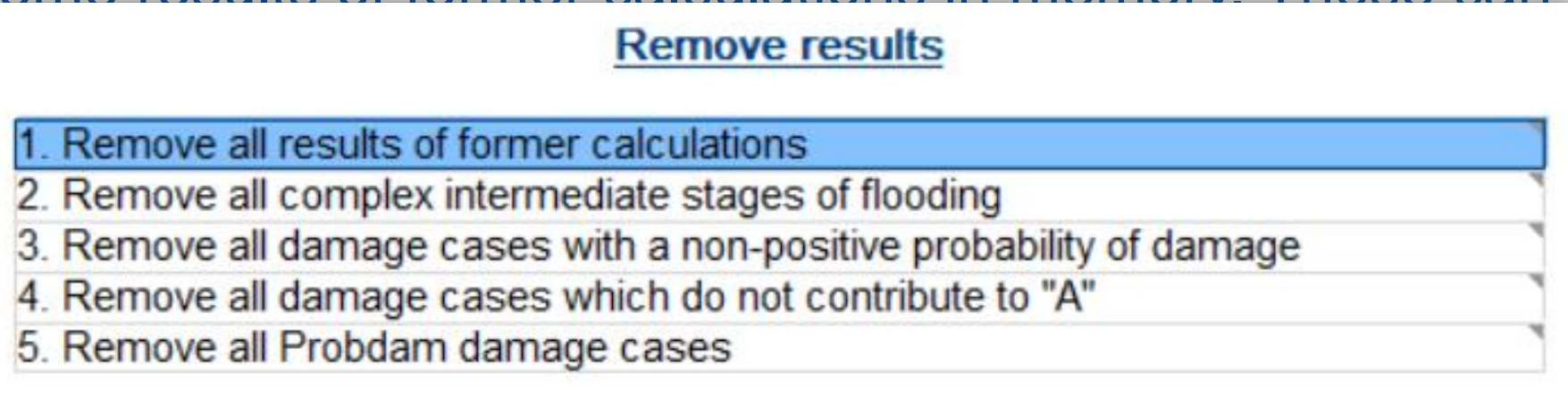
- When this option is used, and PIAS uses the results of former calculations this will be mentioned in the intermediate calculation data. When you require complete intermediate data, this option should not be used or:
- The results of former calculations can be removed explicitly with the ‘Remove all results of former calculations’ functionality.

Increased complexity and calculation times

‘Re-use of unmodified results from former calculations’.

In order to increase the computation speed, this functionality stores quite some results of former calculations in memory. These can be re-used in

- When calculation data should



Remove results

1. Remove all results of former calculations
2. Remove all complex intermediate stages of flooding
3. Remove all damage cases with a non-positive probability of damage
4. Remove all damage cases which do not contribute to "A"
5. Remove all Probdam damage cases

- The results of former calculations can also be removed explicitly with the ‘Remove all results of former calculations’ functionality.

Increased complexity and calculation times

What can you do to reduce calculation times and increase the result?

- Make sure that all input data is correct. (more in the T&T)
- Don't 'guess' which G'M-values are needed. (more in the T&T).
- Avoid added hull forms and external defined compartments!!
- Use the 'Re-use of unmodified results from former calculations' functionality.
- Don't start with too many compartment damages. You can easily add damages later. (more in the T&T).

Increased complexity and calculation times

What can you do...? (Continued)

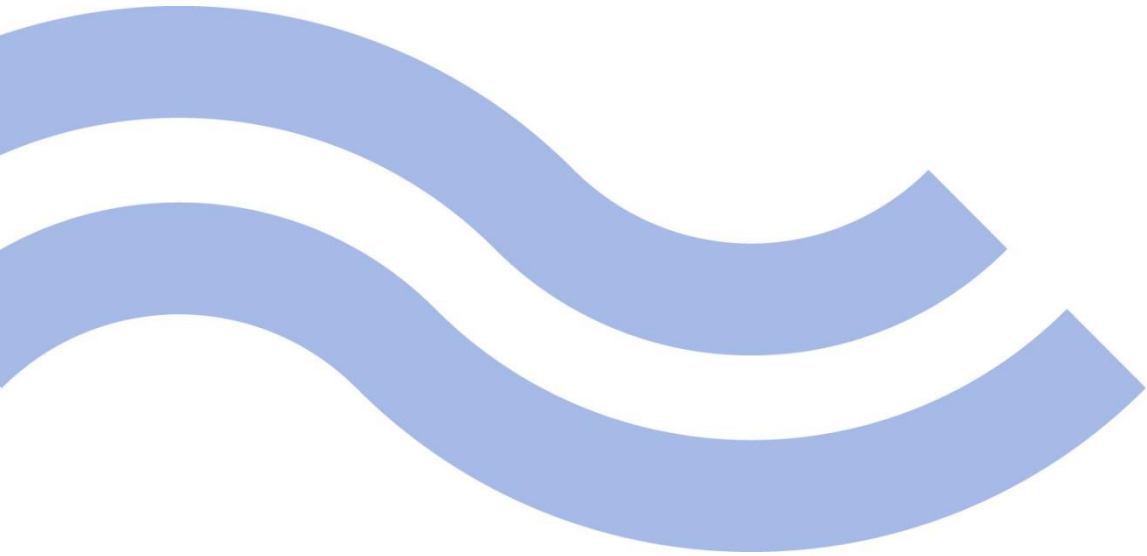
- Preferably: Install the codemeter, files and program-files locally at a dedicated fast computer used for probabilistic damage stability.
- Turn-off Windows updates!
- Try multi-threading (on dedicated hardware).
- When you have the need to perform multiple calculations in a short term, you can rent additional temporary 'Probdam', and/or 'Multi-threading' licenses or consult SARC for extra calculation capacity.

Increased complexity and calculation times

What can you do...? (Continued)

- Try the 'Numerical integration method' for probabilistic damage calculations. (More in the T&T).
 - Easier to implement.
 - Faster.
 - More accurate.
 - Less arbitrary.
 - Less equations and prescriptions.
- Unfortunately, not (yet) commonly used and accepted.

Tips & Tricks.



Tips & Tricks

The following Tips & Tricks are based on:

- Commonly asked questions.
- Recent developments.
- Things I sometimes see users getting wrong.
- ‘Basics’ but important enough to discuss.
- Our own experience, not being said the only truth.

Tips & Tricks

The selection of topics I would like to discuss are:

Preparations:

- ‘Hulldef’.
- ‘Layout’.
- ‘Loading’.

And details of:

- ‘Prodam’

Tips & Tricks

'Hulldf'



‘Hulldef’

- Particulars for SOLAS chapter 2, Part B1.
 - Subdivision length.
 - Fore and aft station.
 - Permeability.
- Vertical escape hatches.

Tips & Tricks: 'Hulldef'

Particulars for SOLAS chapter 2, Part B1

Subdivision length	m	122.050
Position 'Afterterminal'	m	-2.550
Light service draft	m	4.476
Subdivision draft	m	7.300
Permeability damaged compartments according to	-	SOLAS 2009 & 2020
Number of persons with lifeboats provided (N1)	-	12
Number of persons without lifeboats provided (N2)	-	0

Tips & Tricks: 'Hulldef'

Particulars for SOLAS chapter 2, Part B1, Subdivision length

Regulation 2

Definitions

For the purpose of this chapter, unless expressly provided otherwise:

1 *Subdivision length (L_s)* of the ship is the greatest projected moulded length of that part of the ship at or below deck or decks limiting the vertical extent of flooding with the ship at the deepest subdivision draught.

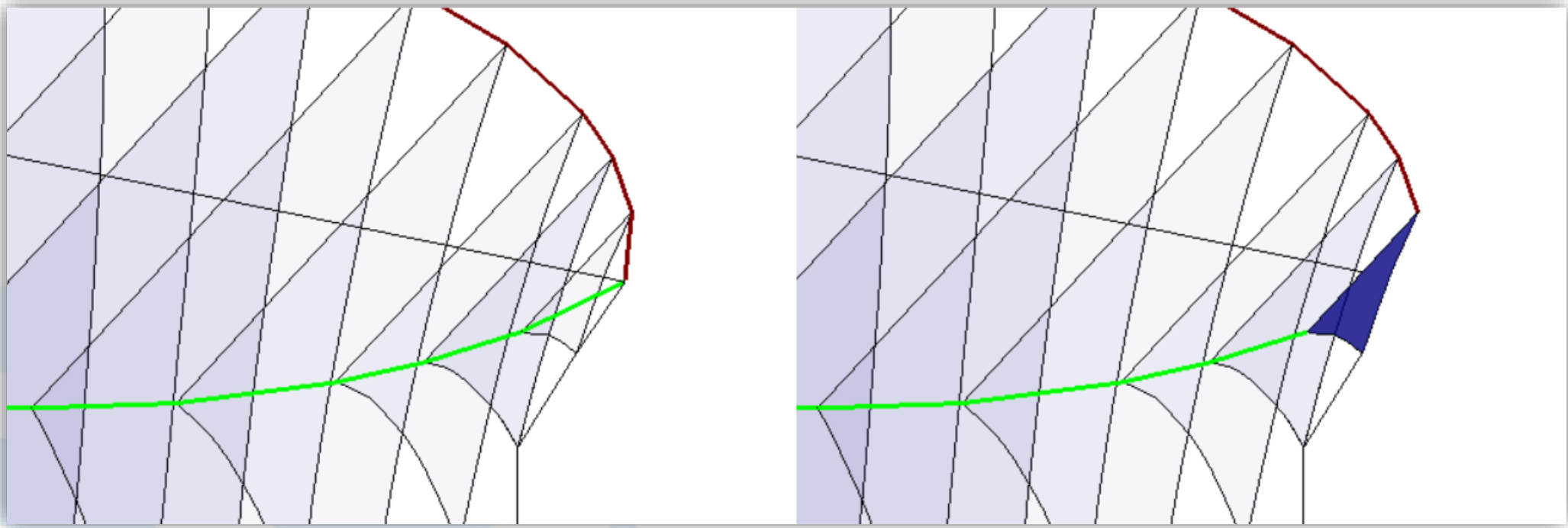
Tips & Tricks: 'Hulldef'

Particulars for SOLAS chapter 2, Part B1, Fore and aft station.

- Define the position of the most aftward station (Ls) and make sure you have defined a frame at this position.
- Make sure you also define the most forward frame at Ls.

Tips & Tricks: 'Hulldef'

Particulars for SOLAS chapter 2, Part B1, Fore and aft station.



Correct

Incorrect

Tips & Tricks: 'Hulldef'

Particulars for SOLAS chapter 2, Part B1, Permeabilities.

Only for 'Loading' and 'Hydrotables', in 'Probdam' it is the default

Particulars for SOLAS chapter 2, part B1

Subdivision length	m	122.050
Position 'Afterterminal'	m	-2.550
Light service draft	m	4.476
Subdivision draft	m	7.300
Permeability damaged compartments according to	-	SOLAS 2009 & 2020
Number of persons with lifeboats provided (N1)	-	12
Number of persons without lifeboats provided (N2)	-	0

Permeability damaged compartments according to

- Fixed permeability
- SOLAS 2009 & 2020
- IMO A.265
- SOLAS 1992

Tips & Tricks: 'Hulldef'

Particulars for SOLAS chapter 2, Part B1, Permeabilities.

Number of persons with or without lifeboats provided (N1 & N2).

Subdivision length	m	122.050
Position 'Afterterminal'	m	-2.550
Light service draft	m	4.476
Subdivision draft	m	7.300
Permeability damaged compartments according to	-	SOLAS 2009 & 2020
Number of persons with lifeboats provided (N1)	-	12
Number of persons without lifeboats provided (N2)	-	0

Tips & Tricks: 'Hulldef'

Special points: 'Vertical escape hatch'.

Type of point of "vert. escape test Em"

- Watertight
- Weathertight
- Open
- Margin line
- Point of horizontal evacuation route
- Non-watertight opening (V-line)
- Watertight door
- Buoyancy point
- Emergency exit
- Vertical escape hatch
- Watertight TNO

Tips & Tricks: 'Hulldef'

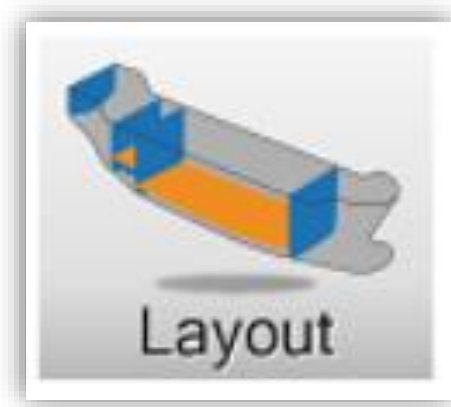
Special points: 'Vertical escape hatch'.

In the intermediate results the minimum clearance to evacuation route (horizontal and vertical) is printed.

```
- - - - - Results for portside- - - - -  
Equilibrium angle of heel = -7.16 degrees  
Maximum GZ = 0.963 m  
Range = 65.37 degrees  
s = 1.0000  
Wind heeling moment (Mwind) = 51.17 tonm (contour "wind contour")  
Heeling moment (Mheel) = 51.17 tonm  
s(mom) = 1.0000  
Evacuation route clearance = 3.325 m  
Results for starboard
```

Tips & Tricks

'Layout'



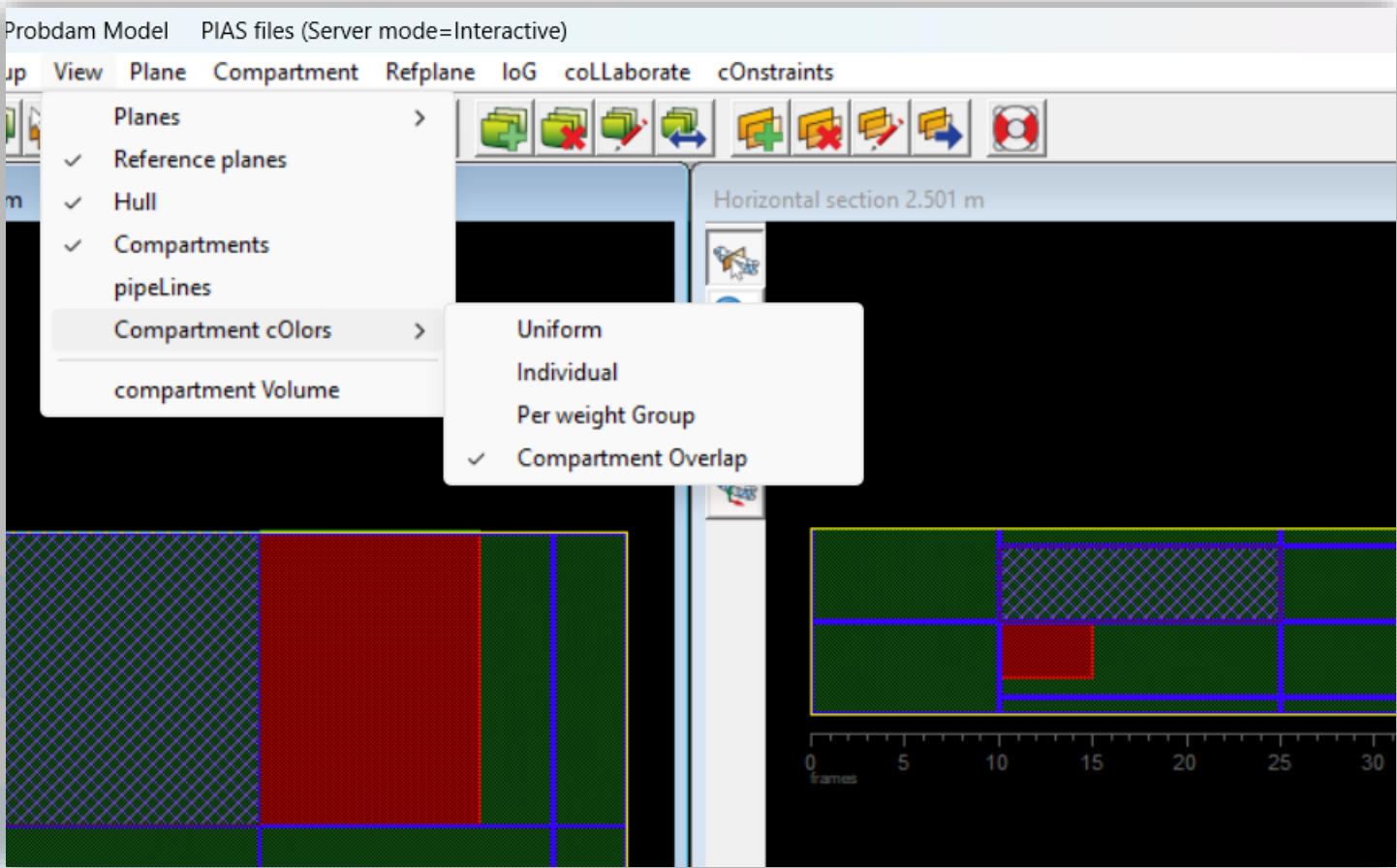
‘Layout’

Make sure you have defined compartments correctly without overlap or missing parts. Use the correct permeability

- View overlapping compartments.
- Compare internal and external geometry
- Type of space for SOLAS 2009 / 2020 (permeability)

Tips & Tricks: 'Layout'

Overlap of compartments.



Tips & Tricks: 'Layout'

Internal and external geometry.

Design and utilization of the ship's layout

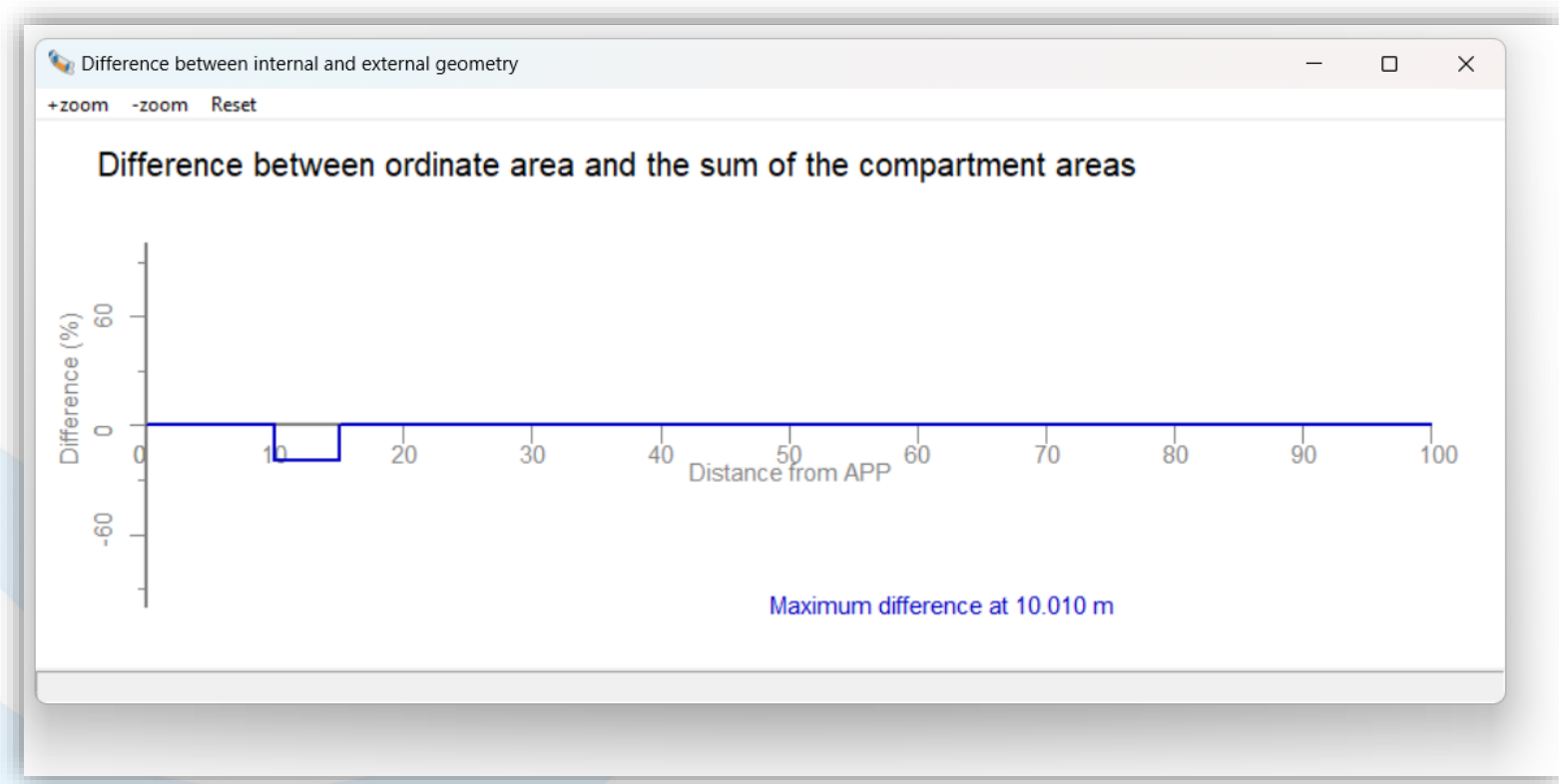
1. Graphical User Interface of planes and compartments
2. Compartment list, calculation and printing of tank tables
3. Pipe lines and piping systems
4. Other lists, and program settings
5. Threedimensional presentation
6. Subdivision plan
- 7. Print compartment input data**
8. Conversion, and import and export of subdivision data
9. File and backup management

Print compartment input data

1. Print input data of selected compartments
2. Three-dimensional views of selected compartments
- 3. Difference between internal and external geometry**
4. Define views/sections of compartment plan
5. Draw compartment plan

Tips & Tricks: 'Layout'

Internal and external geometry.



Tips & Tricks: 'Layout'

Select 'Type of space SOLAS' for correct permeability for probabilistic damage stability.

The screenshot shows a software interface with a table of parameters. The table has a blue header 'Data for specific regulations'. The row 'Type of space SOLAS0920 prob.damstab. (uniform)' is highlighted with a red box, and the value 'Machinery space' is also highlighted. A dropdown menu is open below this row, showing a list of options: Unspecified, Stores, Accommodation, Machinery space (selected), Void space, Liquid supplies, Dry cargo, Container cargo space, RoRo cargo space, Timber cargo space, and Wood chip space. A red arrow points from the 'Machinery space' value in the table to the 'Machinery space' option in the dropdown menu.

Data for specific regulations	
Compartment is an open hopper	No
Is a hold with a RoRo-deck (STAB90+50)	No
Type of space SOLAS0920 prob.damstab. (uniform)	Machinery space
Type of tank for oil outflow calculations	No oil tank
Tank is at underside adjacent to	N.a.
Overpressure of inert gas system (kPa)	00
Compart	
Automatic inclusion in loading condition	es
Is part of watertight ship's layout	es
Computation script	ult
Output script	ult
Fr 75-90 SB Low	
Volume 73.500 cubic meter	

- Unspecified
- Stores
- Accommodation
- Machinery space
- Void space
- Liquid supplies
- Dry cargo
- Container cargo space
- RoRo cargo space
- Timber cargo space
- Wood chip space

Tips & Tricks: 'Loading'

'Loading'



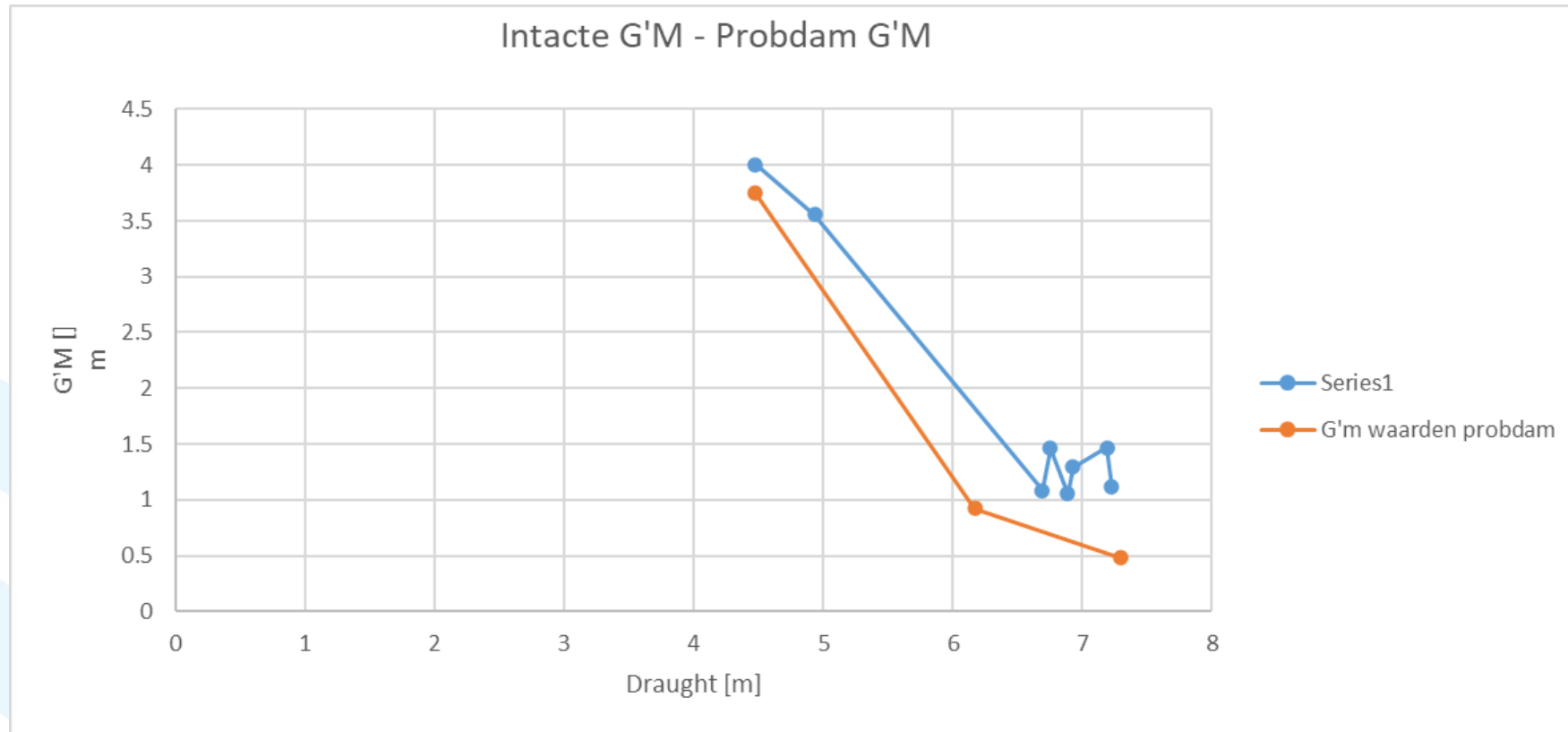
Tips & Tricks: 'Loading'

'Loading'

- Determining G'M values to be used.
- Create Tlight, Tpartial and Tdeepest for investigating certain damage cases.

Tips & Tricks: 'Loading'

Determining the G'M values to be used (e.g. in Excel)



Tips & Tricks: 'Loading'

Using 'Advice' to create Tlight, Tpartial and Tdeepest in Loading for investigating certain damage cases.

Weight items of loading condition: light service draft

Name	ComList	Type	%	Weight	VCG	LCG	TCG
Empty ship		aggregated LS		1100.000	4.000	50.000	0.000

Advice

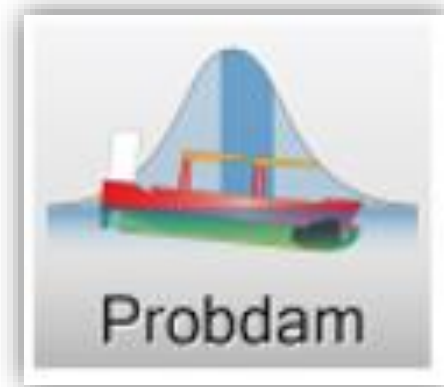
Specify draft and trim

Enter the mean draft relative to the baseline.
 With the given draft and trim the displacement will be calculated.
 The difference with the displacement of the loading condition will be displayed.

Draft mean	6.5 m
Trim	0.000 m
G'M	1.25 m

Tips & Tricks

'Probdam'



‘Probdam’

- Applied regulations.
- Calculation method probability of flooding and configurations.
- Probability of damage never negative. Yes, or no?
- Maximum damage length and number of damaged compartments.
- Drafts, trims and G’M values.
- Compartment connections
- New damage cases menu

Tips & Tricks: 'Probdam'

Applied regulations.

<u>Calculation method and other configurations</u>	
Applied regulations	SOLAS 2020
Ship type	Passenger vessel
Calculation method probability of flooding	1 damage per compartment

Tips & Tricks: 'Probdam'

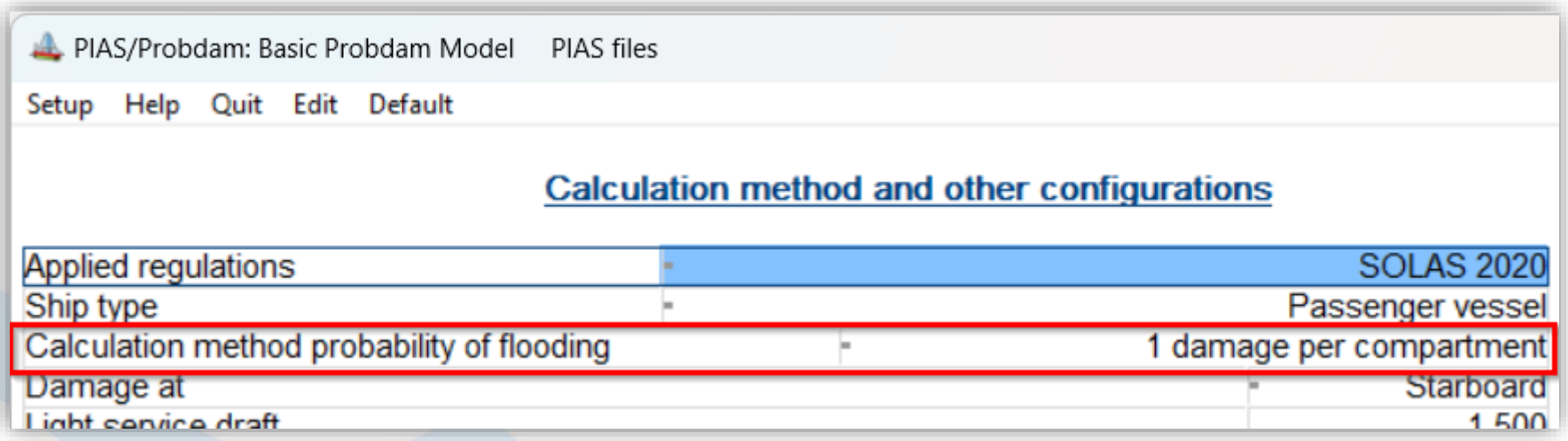
Applied regulations.

Changes

- SOLAS 2020.
 - Most significant change: raise of damage stability requirements for passenger vessels and RoRo vessels.
 - In case of cross-flooding arrangements for cargo vessels the SOLAS 2020 does now introduce intermediate stages.
- SPS-code.
 - Does not state 'as amended' anymore but uses the formula to calculate the required index as used in the SOLAS 2009.

Tips & Tricks: 'Probdam'

Calculation method probability of flooding.



Tips & Tricks: 'Probdam'

Calculation method probability of flooding.

I would like to give a (simplified) explanation on:

- 1-damage per zone.
- 1-damage per (sub)compartment.

And:

- Numerical integration method.

Tips & Tricks: 'Probdam'

Calculation method probability of flooding.

One damage per zone:

A zone, whereas a zone is a portion of the vessel between two longitudinal boundaries (e.g. transverse bulkheads). The use of the zonal concept forces the subdivision model into regularity, thus avoiding certain pitfalls of a more refined subdivision. However, the zone-model is artificial; it is an abstraction of the actual subdivision, and as such will produce a less accurate result.

Tips & Tricks: 'Probdam'

Calculation method probability of flooding.

One damage per zone:

It is funny to see that the zonal concept is rather popular, although it is not even mentioned in SOLAS 1992 (however, it is mentioned in the explanatory notes). In SOLAS 2009 the terms 'zone' and 'compartment' are entangled, however, the 'zone' is not defined at all.

Tips & Tricks: 'Probdam'

Calculation method probability of flooding.

Regulation 7-1 - Calculation of the factor p_i

General

- 1.1 The definitions below are intended to be used for the application of part B-1 only.
2. In regulation 7-1, the words "compartment" and "group of compartments" should be understood to mean "zone" and "adjacent zones".

Tips & Tricks: 'Probdam'

Calculation method probability of flooding.

One damage per zone:

- Zonal boundaries must be defined manually.
- In general, this will be a rough layout.

Tips & Tricks: 'Probdam'

Calculation method probability of flooding.

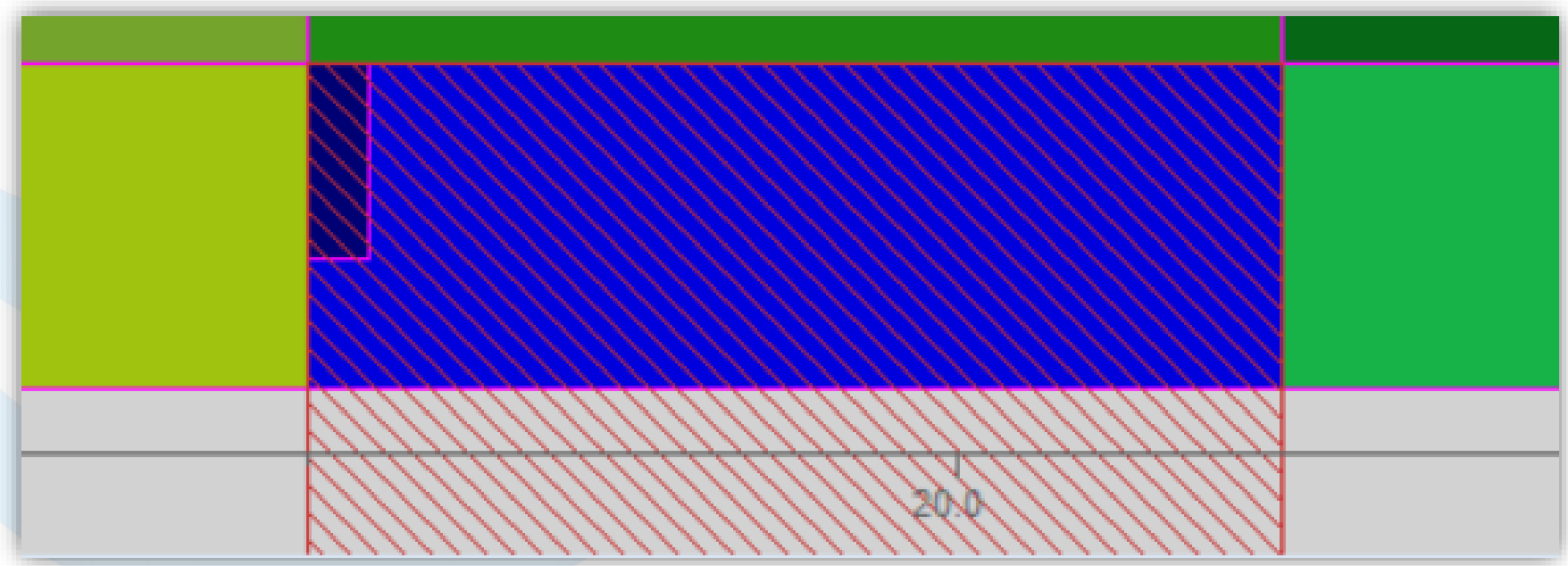
One damage per (sub)compartment:

- With this mechanism, PIAS uses the boundaries of compartments to automatically determine the layout of the vessel.
- If one would define all the boundaries of compartments as zonal boundaries, both mechanisms will have the same result. (more or less)

Tips & Tricks: 'Probdam'

Calculation method probability of flooding.

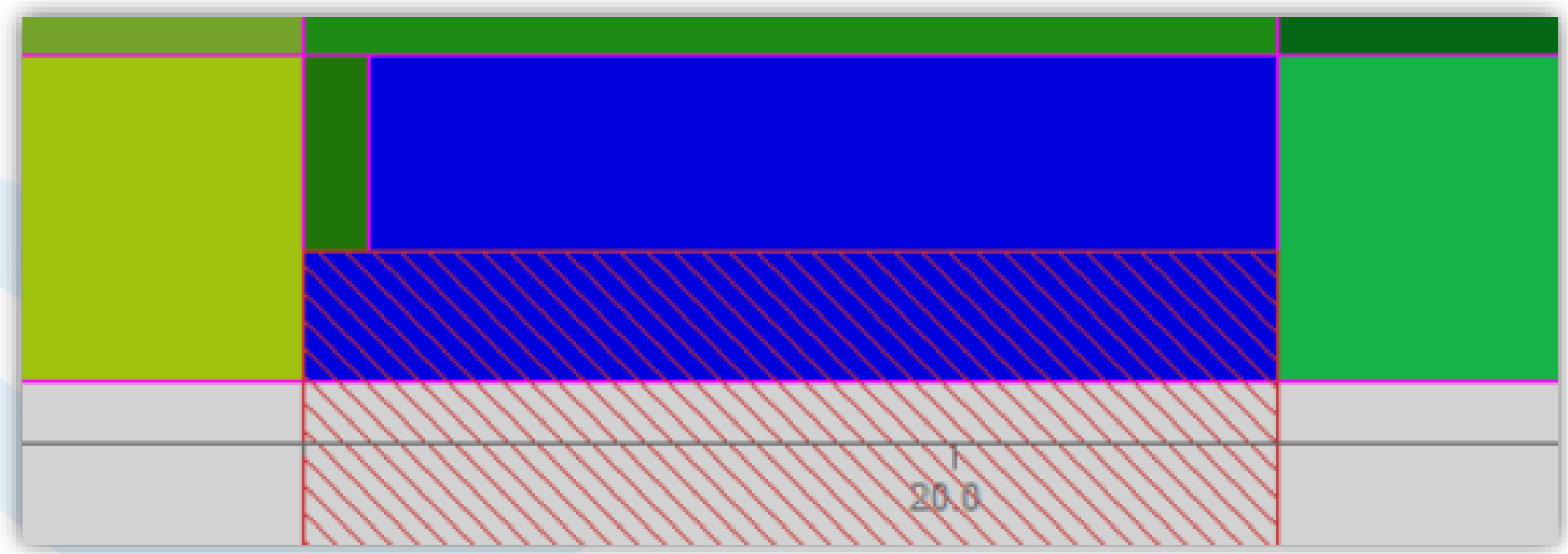
Example of one damage per zone:



Tips & Tricks: 'Probdam'

Calculation method probability of flooding.

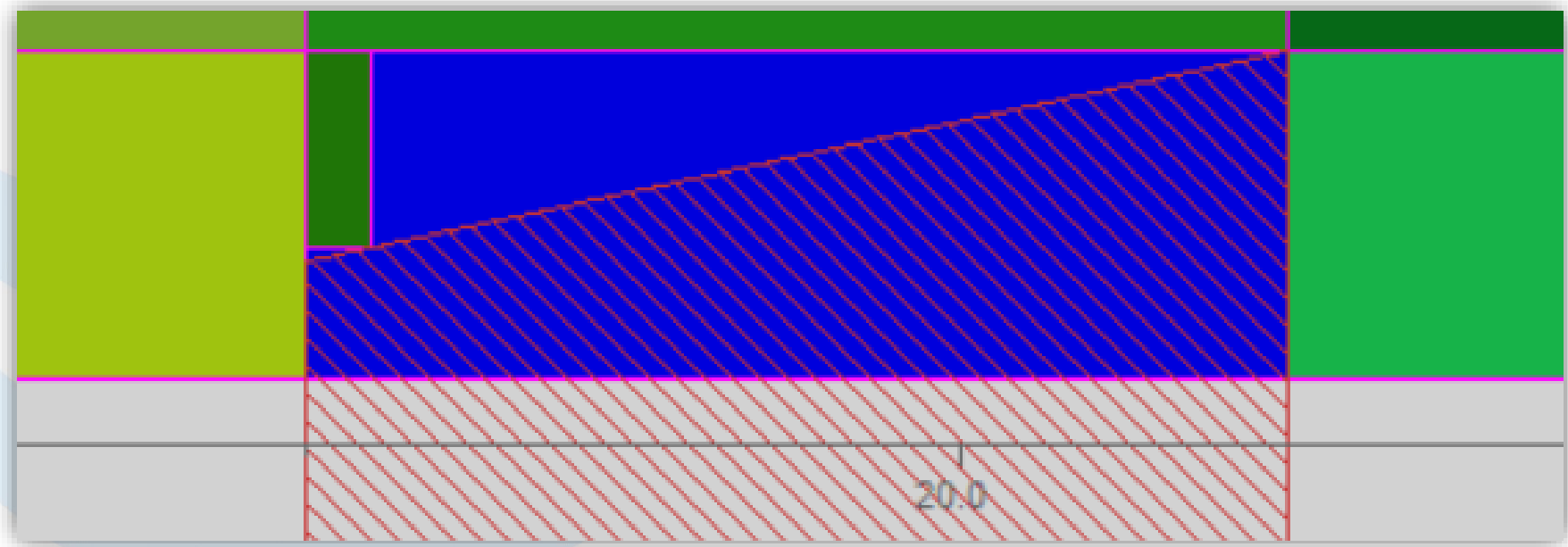
Example of one damage per compartment (before optimizing damage boundaries:



Tips & Tricks: 'Probdam'

Calculation method probability of flooding.

Example of one damage per compartment (after optimizing damage boundaries):



Tips & Tricks: 'Probdam'

Calculation method probability of flooding.

As you hopefully understand, the one damage per (sub)compartment does not differ much from the zonal method.

- The layout is determined automatically.
- Higher accuracy.
- Thus, a higher attained index.

In general, we use the one damage per compartment method

Tips & Tricks: 'Probdam'

Calculation method probability of flooding.

For your own benefit:

- Please don't just switch to the zonal method if Class Societies don't understand the mechanism.
- With the earlier mentioned explanation, you should be able to convince them it is a valid calculation method.

Tips & Tricks: 'Probdam'

Calculation method probability of flooding.



Tips & Tricks: 'Probdam'

Calculation method probability of flooding.

- Numerical integration method.

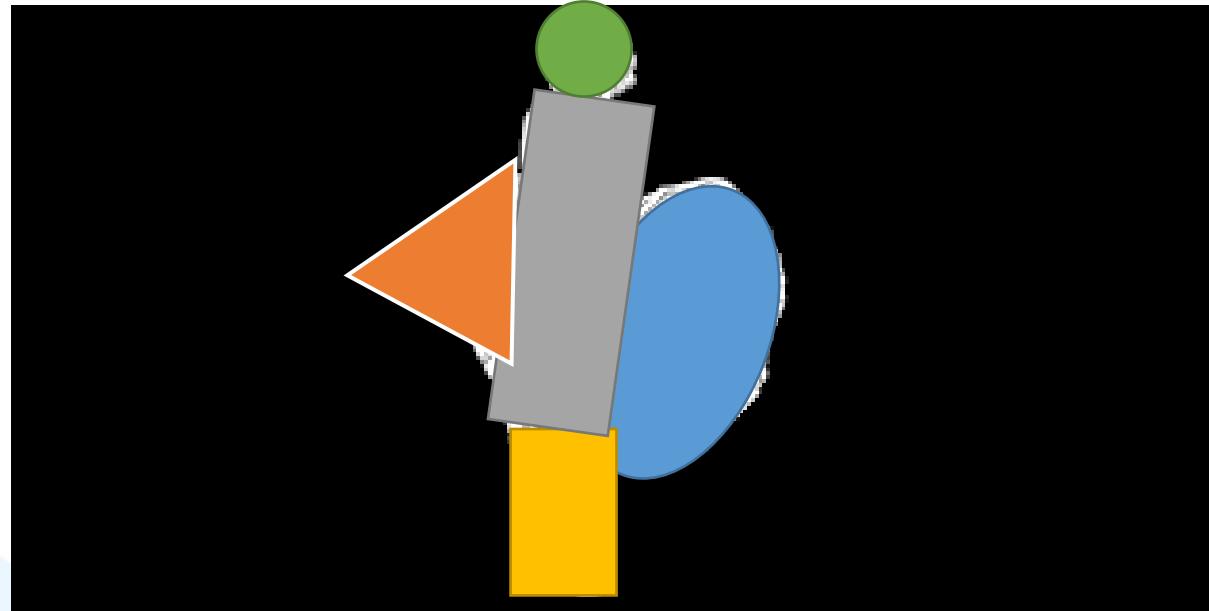
The area of a 2D figure

Suppose we are faced with the daunting task of determining the area of this Marilyn Monroe picture



Then we can choose between (at least) two methods

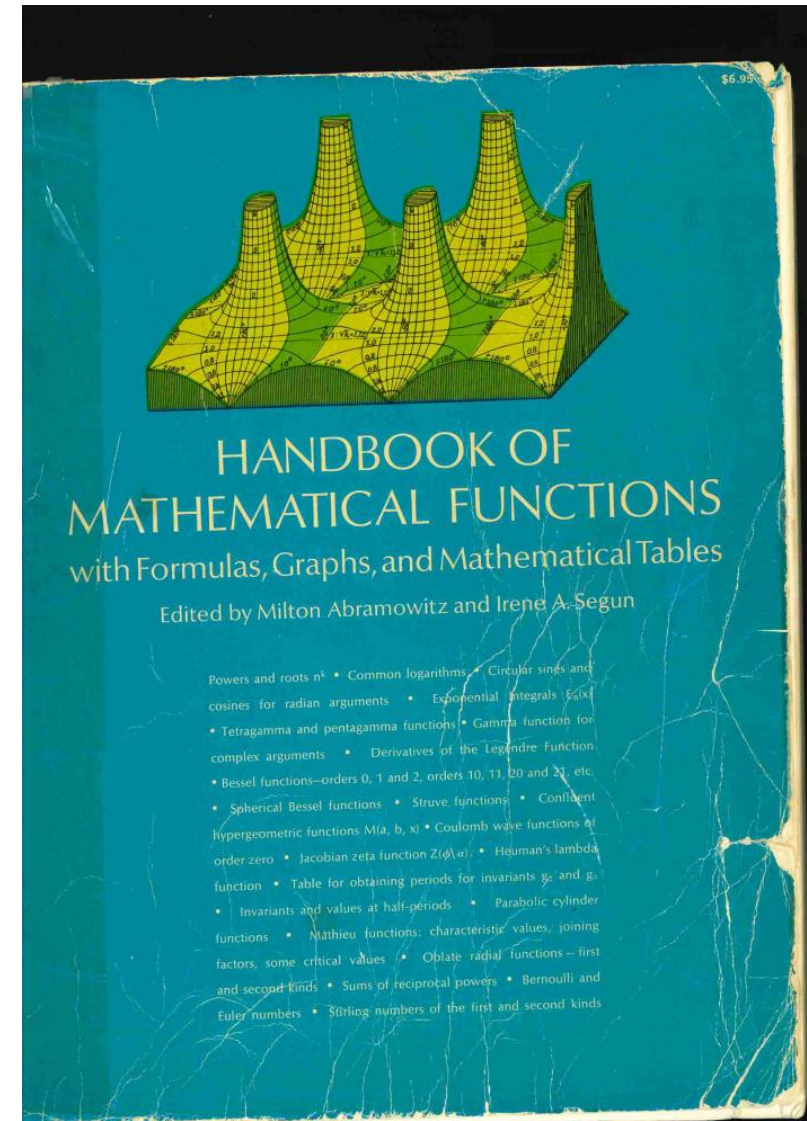
Method 1960



Simplification and arithmetic

Simplification and arithmetic

1. Subdivide the figure in five areas (“zones”):
 - A circle.
 - A triangle.
 - A rectangle.
 - An inclined rectangle.
 - An ellipse.
2. Find a handbook with formulas of areas from these elementary shapes.



3. Elaborate detailed rules on mapping these shapes on the figure, e.g.:
 - The inclination of the torso zone may not be more than 12.3° .
 - The B/H ratio of the triangle should be between 0.65 and 1.70.
 - The ellipse and the rectangle may at maximum overlap for 4%.
4. Tediously write a computer code which scales and locates these shapes over the picture, still matching these mapping rules.
5. Determine these shape parameters, and compute areas from the equations of the 2nd step.

Method 2006



Method 2006

1. Count non-black pixels.



```
N_black_pixel = 0
```

```
For row = 1 to number_of_rows
```

```
  For column = 1 to number_of_columns
```

```
    If pixel[row,column] is not black then
```

```
      N_black_pixel = N_black_pixel + 1
```

```
Area = N_black_pixel * Bpixel * Hpixel
```

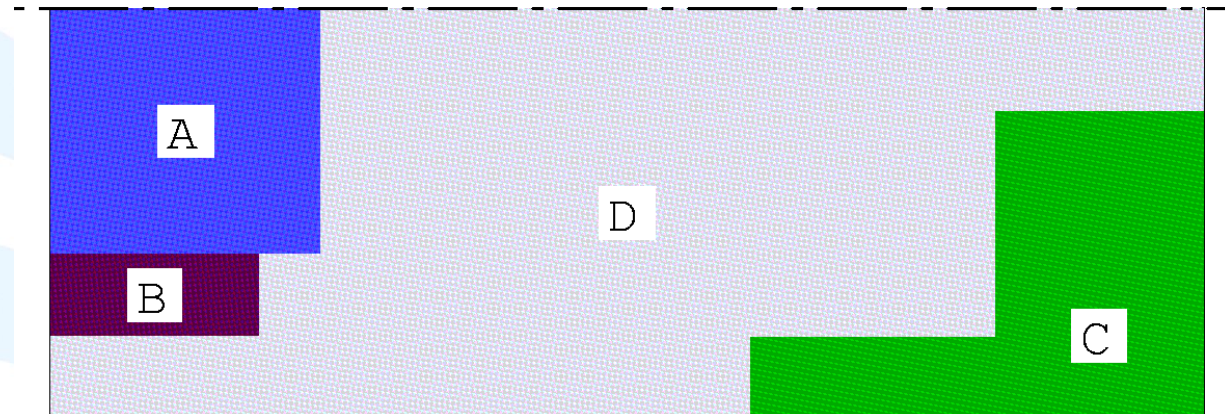
Numerical integration

- Numerical integration = repeated additions
- Pros:
 - Easier to implement.
 - Faster.
 - More accurate.
 - Less arbitrary.
 - Less equations and prescriptions.
- Cons:
 - ?



Fixed damage limits

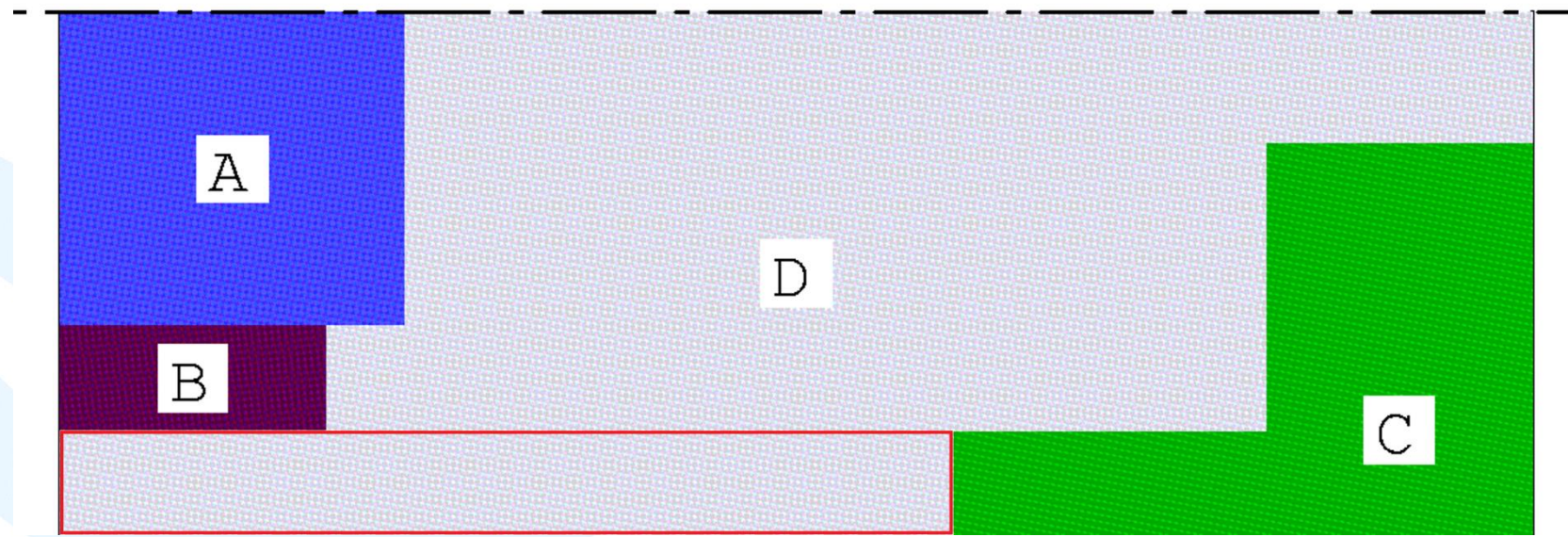
- Fixed damage limits:
 - Aft
 - Forward
 - Penetration from WL (with inclined inner boundary).
 - Upper.
- With **one damage** per compartment (or zone).
- However, what about:



In reality

Presuming a rectangular damage shapes, compartment D can be hit by **three** distinct damages:

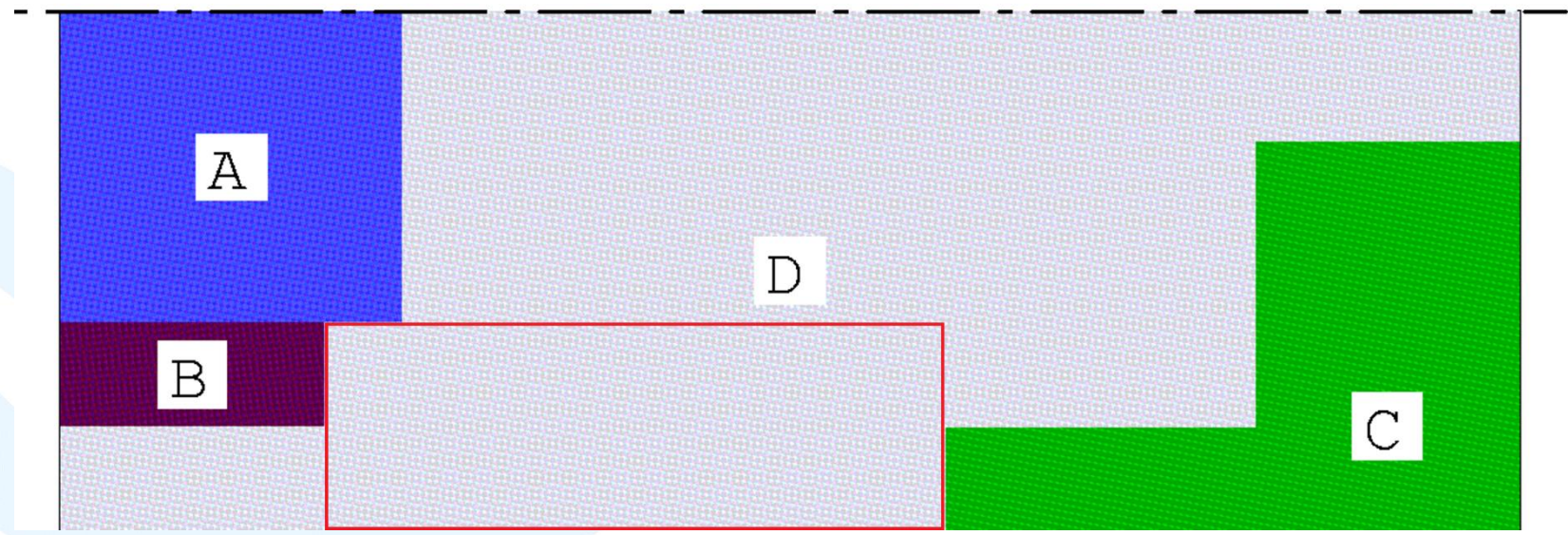
- Outside B.



In reality

Presuming a rectangular damage shapes, compartment D can be hit by three distinct damages:

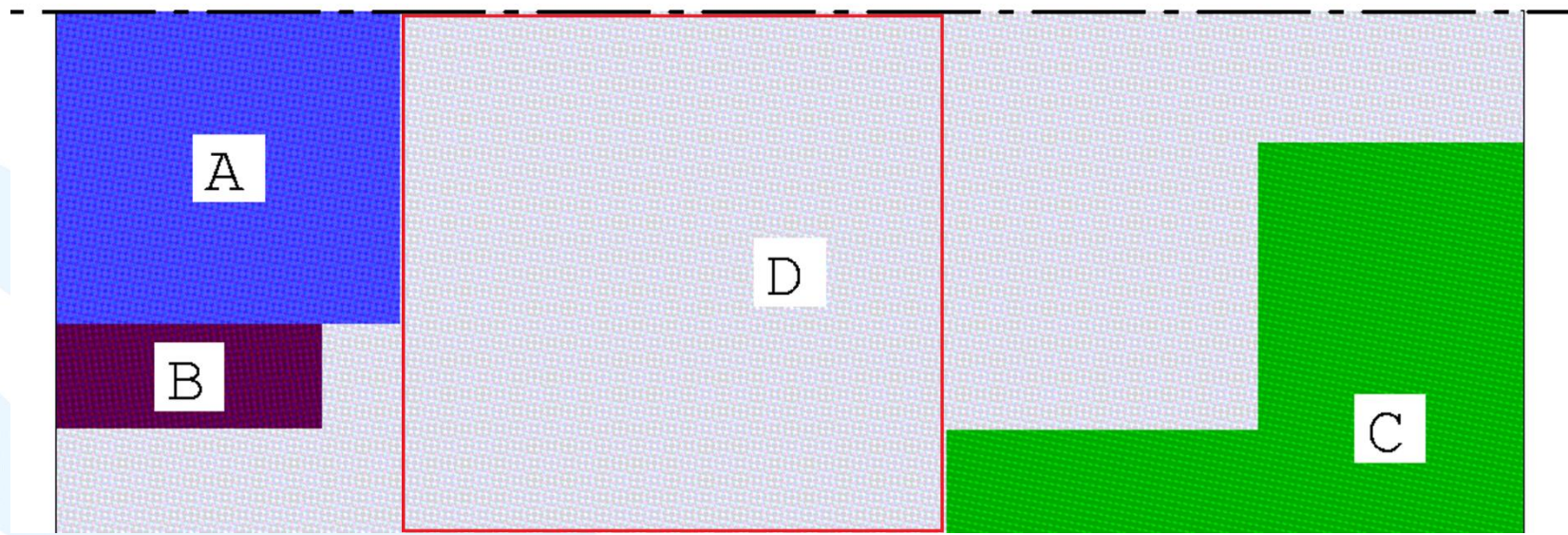
- Outside A, just in front of B.



In reality

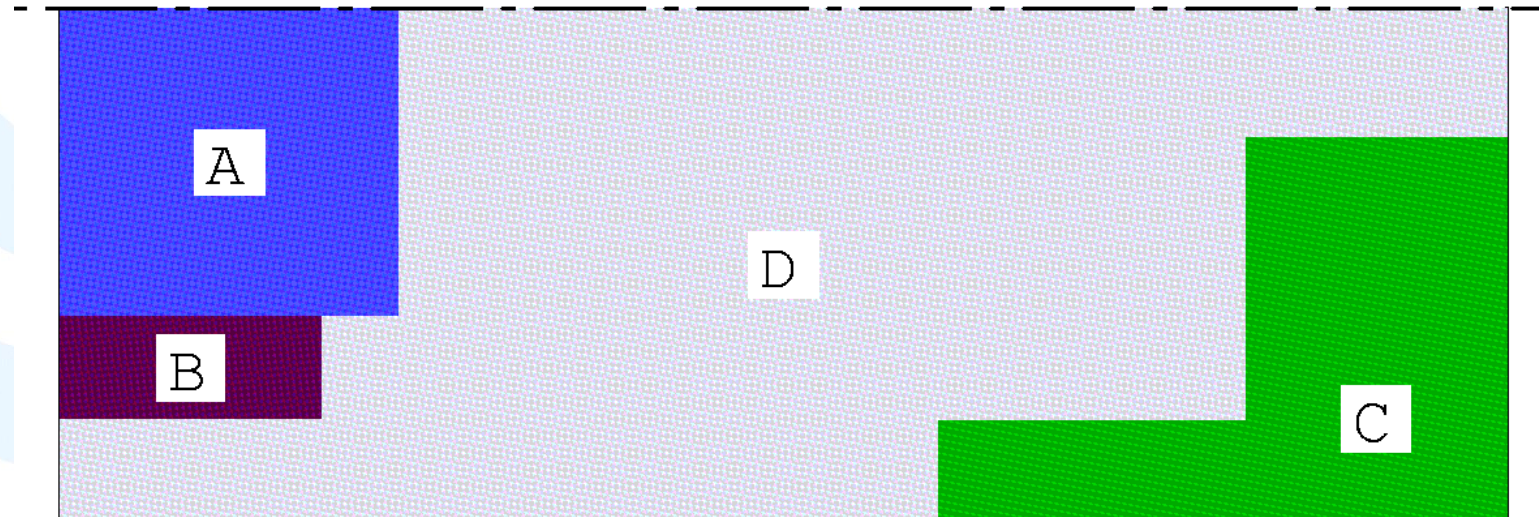
Presuming a rectangular damage shapes, compartment D can be hit by **three** distinct damages:

- To CL, from the front of A to aft of C.



Conventionally

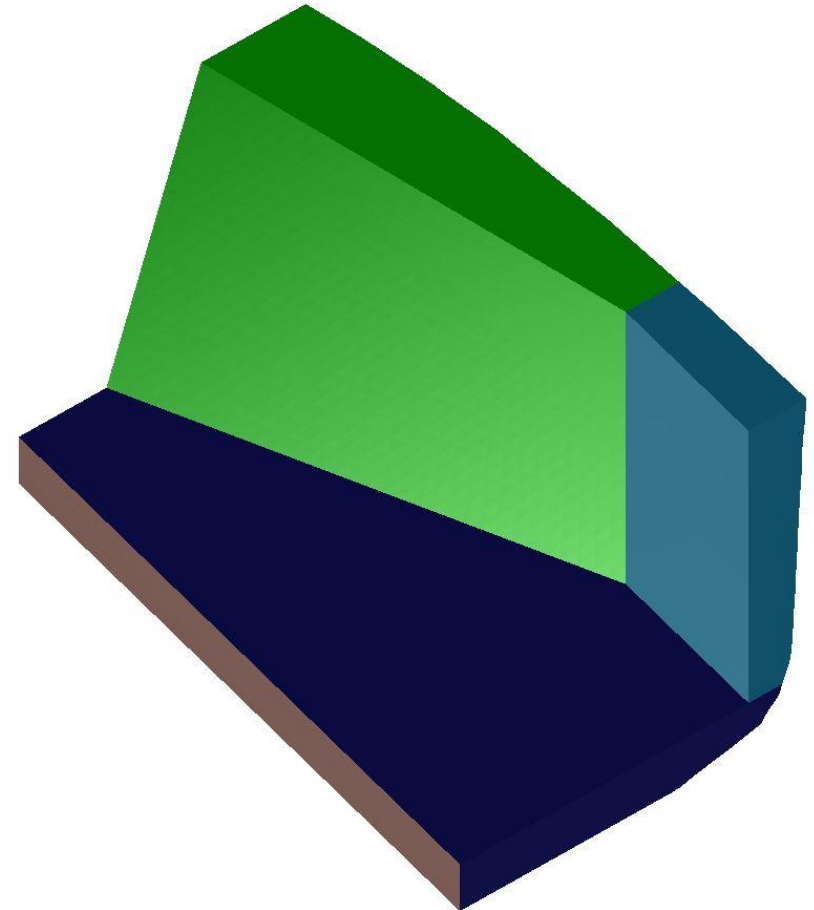
- The conventional (SOLAS) method only allows one of these damages.
- Not very realistic, and artificially reducing computed probability of survival.



Conventionally

What is here for the green compartment:

- Aft boundary
- Forward
- Penetration from WL?

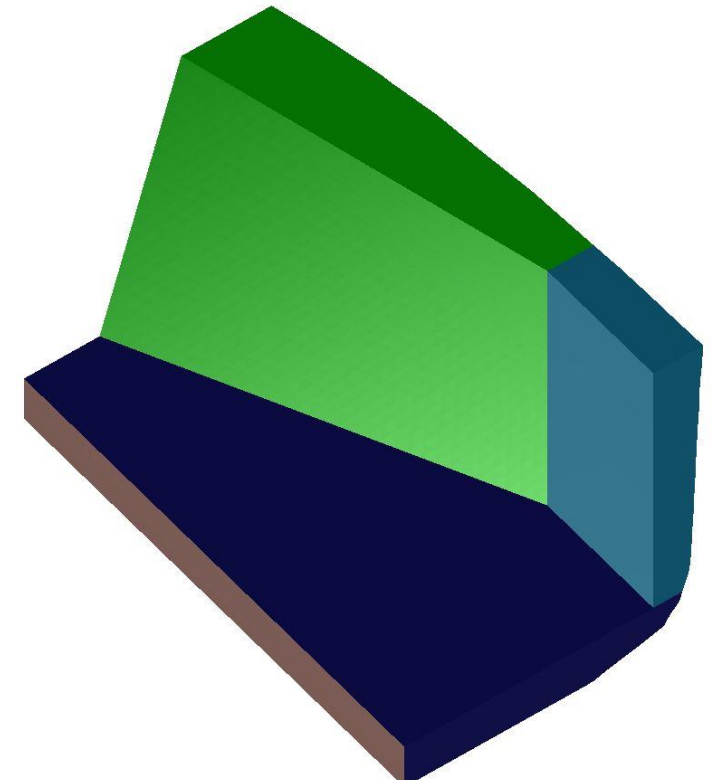
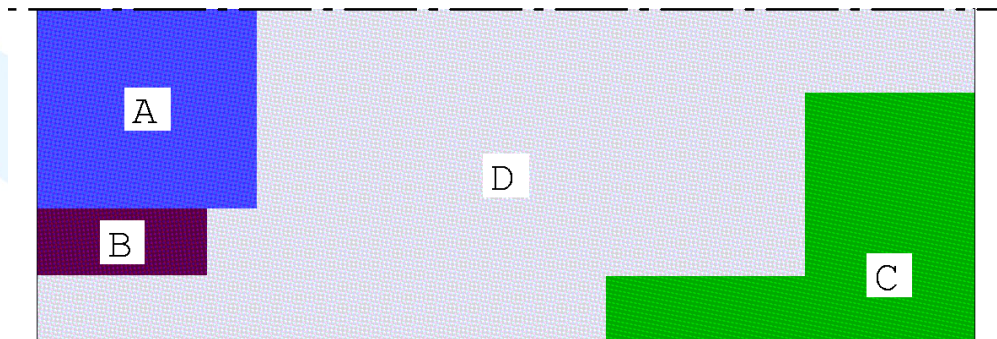


Solution: numerical integration



Thousands of mini damages

- Divide the compartment into thousands of cuboids (“voxels”, in analogy with the pixels of Marilyn Monroe).
- Matches the compartment shape accurately.
- No presumptions on damage shapes.
- More accurate computation.
- Matches IMO’s damage statistics fully.



Article

Statutory and Operational Damage Stability by a Monte Carlo Based Approach

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Abstract: The paper describes the extension of a Monte Carlo based damage stability simulation method for the generation of approval documents for both statutory and operational damage stability. The intention of this development is that the advantages of the Monte Carlo damage stability simulation concept can be used without the necessity to ask for alternative design approval procedures during the statutory approval by the classification society. This means that the same damage stability documentation must be generated as by the conventional damage stability calculation. To generate the required approval documentation, the individual probabilities for each damage case have to be determined and the different damage cases have to be sorted into so called damage zones,

in two conferences.

www.sarc.nl/publications/.

Stefan Krüger (TUHH). He
ation”.

[10/jmse11010016](https://doi.org/10/jmse11010016) (2023).

3. Monte Carlo Realization

The Monte Carlo simulation principle for damaged ship problems was proposed by Koelmann [2] for damage stability problems and by Kehren [9] for the oil outflow problem of the MARPOL regulations. In 2015, Bulian et al. [3] applied that principle also to grounding problems with further and deeper research into that problem in 2020 [3]. In 2019 Bulian, Ruponen et al. [4] refined this approach to a general damage stability concept. Ruponen et al. [7] and Dankowski [10] have combined a Monte Carlo simulation with a time

And now?

Status quo

- Readily available in PIAS, fully documented.
- For a regular subdivision numerical integration yields the same results as conventional zonal-based computation. Which is no surprise.
- For more complex (non-regular) subdivision with numerical integration the attained subdivision index (A) will be somewhat higher. Because this method is more accurate and realistic.
- At SARC we use this method for quick design studies. While afterwards presenting the results to the classification society with the compartment or zonal method. Accepting reduction in A.

Future?

- Some Classification Societies may be inclined to accept this method as alternative arrangement.
- For this purpose, at SARC the development of material to show methodological and numerical equivalence has once been converted into a student graduation project. Unfortunately, this student left without finishing the job.
- Still lying on the shelf, although SARC will only invest time in collaboration with one or two (potential) users.

The choice

Either:

- Choose for predictability, comfortable discussions with the Classification Societies and a somewhat lower attained index. Then stick with the conventional approach.

Or:

- Choose for innovation, higher accuracy, less hocus-pocus and a faster computation method. Then contribute to the acceptance of the numerical integration method.

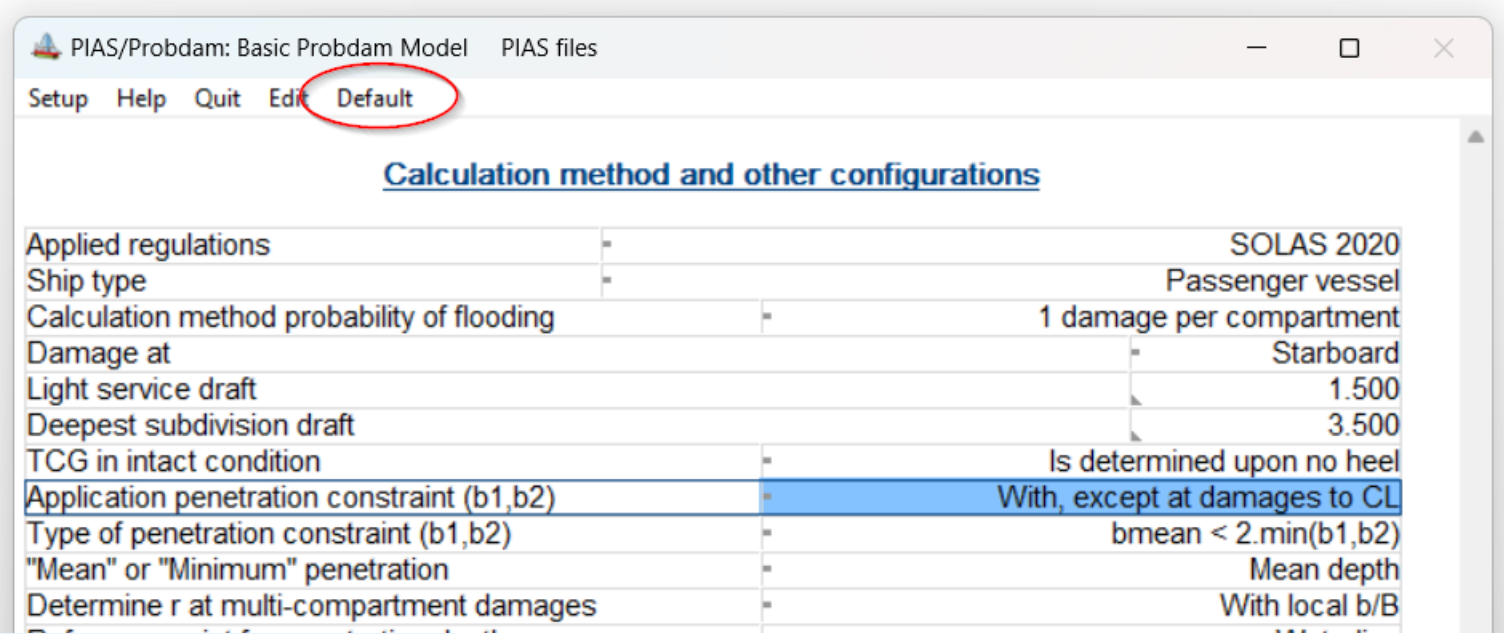
1960 or 2023?



Tips & Tricks: 'Probdam'

Configurations.

Unless you have reasons to deviate from the default settings, use the default settings which can be set with the button 'Default'.



Tips & Tricks: 'Probdam'

Setting: 'Probability of damage never negative'. Yes, or No?

Reference point for penetration depth		Waterline
Damage penetration over CL	-	Yes
Probability of damage never negative	-	No
Including intermediate stages of flooding	-	Yes
Maximum damage length for damage case generation		40 000

Tips & Tricks: 'Probdam'

Setting: 'Probability of damage never negative'. Yes, or No?

The formulae in the SOLAS, to calculate the probability of a damage, can lead to a negative probability. How to deal with this?

Tips & Tricks: 'Probdam'

Setting: 'Probability of damage never negative'. Yes, or No?

Options:

- Set to 'Yes' (which simply turns every negative probability to zero).
- Set to 'No' (which can lead to damages with a negative probability) and take no further actions.
- Set to 'No' and remove the damage cases with non-positive probability of damage.

Tips & Tricks: 'Probdam'

Setting: 'Probability of damage never negative'. Yes, or No?

Set to 'Yes'.

- This simply turns every negative probability to zero.
- Questionable whether this mechanism is in line with the SOLAS (Though negative probabilities should not be possible).
- Only one calculation needed.
- Higher attained index compared to calculations with damage cases with non-positive probability of damage.

Tips & Tricks: 'Probdam'

Setting: 'Probability of damage never negative'. Yes, or No?

Set to 'No' and take no further action.

- Damage cases with non-positive probability of damage can (and likely will) occur.
- According formulae of SOLAS.
- Only one calculation needed
- Lower attained index

Tips & Tricks: 'Probdam'

Setting: 'Probability of damage never negative'. Yes, or No?

Set to 'No', execute the calculation and remove damage cases with a non-positive probability of damage.

Remove results

1. Remove all results of former calculations
2. Remove all complex intermediate stages of flooding
- 3. Remove all damage cases with a non-positive probability of damage**
4. Remove all damage cases which do not contribute to "A"
5. Remove all Probdam damage cases

Tips & Tricks: 'Probdam'

Setting: 'Probability of damage never negative'. Yes, or No?

Set to 'No', execute the calculation and remove damage cases with a non-positive probability of damage.

Since one is free to calculate any damage that he/she wants, one may remove the damage cases with a non-positive probability of damage.

Because the probability of damages, also depends on the probability of other damage cases, a re-calculation is necessary.

Tips & Tricks: 'Probdam'

Setting: 'Probability of damage never negative'. Yes, or No?

- Damage cases with non-positive probability are deleted.
 - Tip: Use 'Remove all damage cases with a non-positive probability of damage'.
- (Several) re-calculations are necessary to obtain the maximum result.
 - Tip: Use 'Re-use unmodified results of former calculations' for faster re-calculations.
- According regulations of SOLAS.
- Higher attained index

Tips & Tricks: 'Probdam'

Maximum damage length and number of damaged compartments.

Damage penetration over CL	-	Yes
Probability of damage never negative	-	No
Including intermediate stages of flooding	-	Yes
Maximum damage length for damage case generation	\	30.000
Maximum number of damaged compartmenten per damage case	\	6
Damage cases generation including horizontal subdivision	-	Yes

Tips & Tricks: 'Probdam'

Maximum damage length and number of damaged compartments.

- Don't start with exceptional long damage length or high number of damaged compartments.

Tips & Tricks: 'Probdam'

Maximum damage length and number of damaged compartments.

- You can always create additional damage cases later if it turns out that the most-compartment damage cases still contribute to 'A'.

The screenshot shows a dialog box titled "Generation of additional damage cases". It contains four input fields and two buttons. The first two fields are for the "Aft boundary" and "Forward boundary" of the generation area, with values -0.000 and 100.000 respectively. The next two fields are for the "Minimum number of damaged compartments" (7) and "Maximum number of damaged compartments" (9). The "OK" button is on the bottom left and the "UNDO" button is on the bottom right.

Parameter	Value
Aft boundary of the generation area for additional damage cases	-0.000
Forward boundary of the generation area for additional damage cases	100.000
Minimum number of damaged compartments	7
Maximum number of damaged compartments	9

Tips & Tricks: 'Probdam'

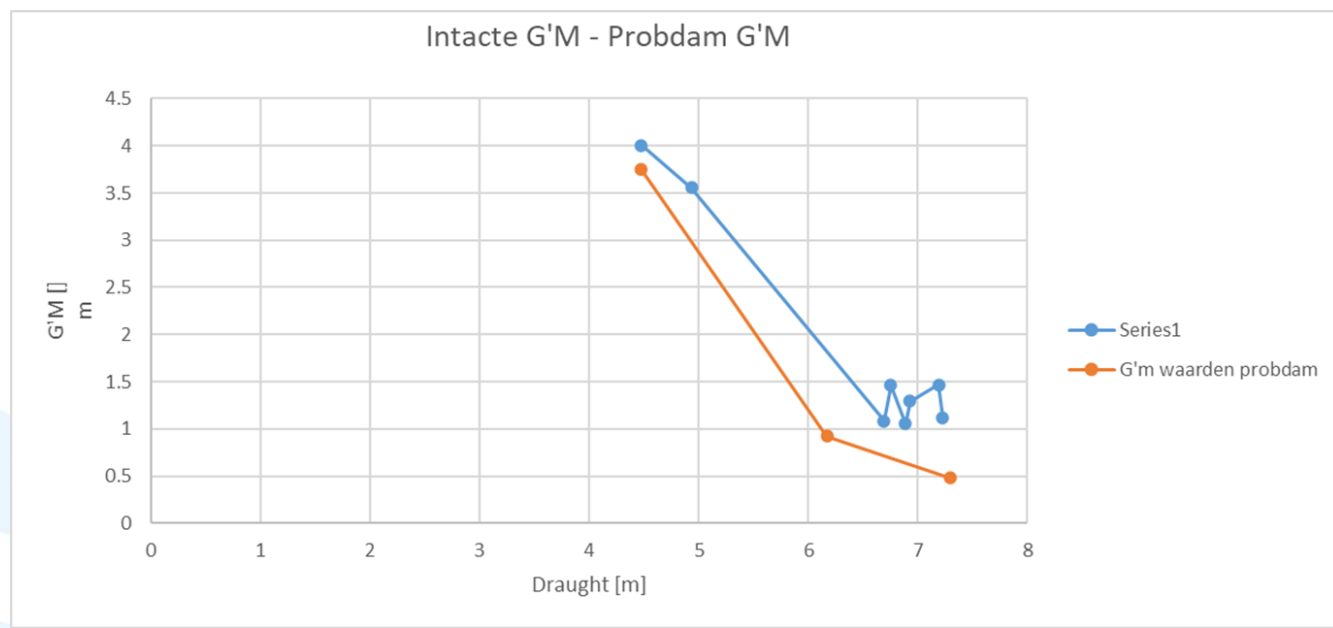
Drafts, trims and G'M values.

Drafts, trims and VCG's					
Description	Draft	Trim	VCG'	G'M	Determine so A=R
Light service draft	1.500	0.000	4.156	2.150	No
Partial subdivision draft	2.700	0.000	3.236	1.200	No
Deepest subdivision draft	3.500	0.000	3.481	0.650	Yes

Tips & Tricks: 'Probdam'

Drafts, trims and G'M values.

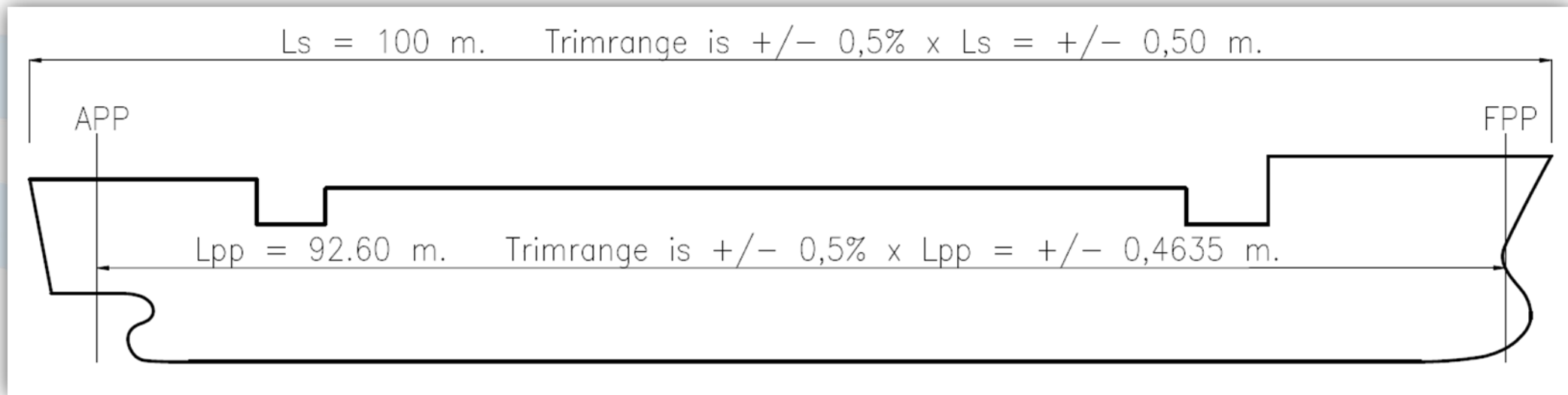
- Determine useful G'M values.



Tips & Tricks: 'Probdam'

Drafts, trims and G'M values.

- Trim in PIAS is the difference between draft fore and aft between perpendiculars (Lpp). Trim as used in SOLAS is between fore and aft station (Ls).



Tips & Tricks: 'Probdam'

Drafts, trims and G'M values.

- Use function: Determine G'M value so Attained index 'A' is equal to the required index 'R'.

Drafts, trims and VCG's					
Description	Draft	Trim	VCG'	G'M	Determine so A=R
Light service draft	1.500	0.000	4.156	2.150	No
Partial subdivision draft	2.700	0.000	3.236	1.200	No
Deepest subdivision draft	3.500	0.000	3.481	0.650	Yes

Tips & Tricks: 'Probdam'

Compartment connections.

Calculation method, configurations and ship parameters

1. Calculation method and other configurations
2. Drafts, trims and VCG's
3. Define hopper stability particulars (incl. pouring in or out)
4. View scheme of standard permeabilities
5. Edit scheme of user-defined permeabilities
- 6. Define compartment connections**
7. Define zonal boundaries
8. Notes (free text)
9. Determine the VCG' for which $A=R$

Tips & Tricks: 'Probdam'

Compartment connections.

In PIAS there are three types of compartment connections:

- 'Open'.
- 'Pipe' & 'A-class bulkhead'

The latter only differ in name.

Tips & Tricks: 'Probdam'

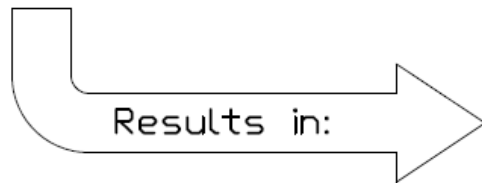
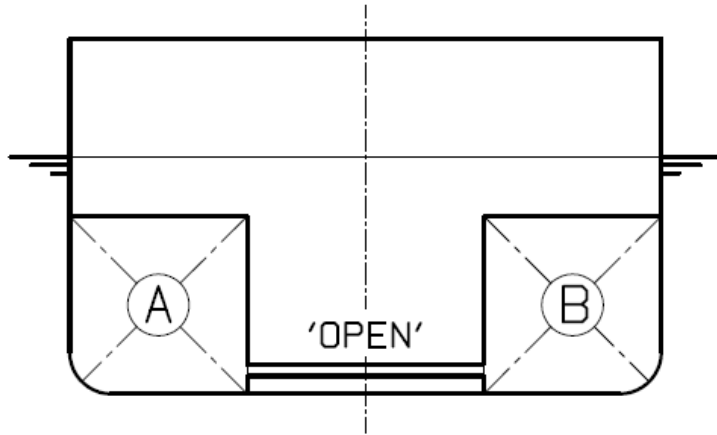
Compartment connections.

'Open' connection.

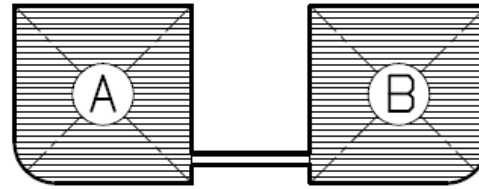
As if there is no resistance in the connection. Progressive flooding is considered to be instantaneous.

Tips & Tricks: 'Probdam'

Connection 'A' <-> 'B'
'Open' w.o. Critical Point

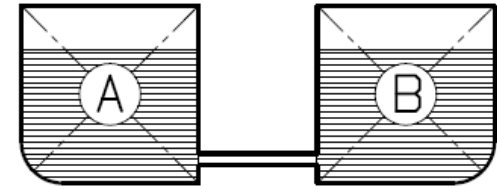


Final Stage of Flooding

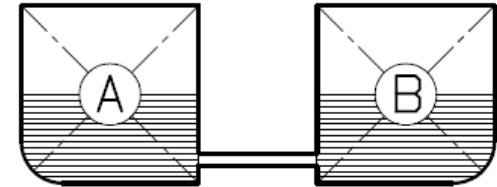


'A' and 'B': 100%

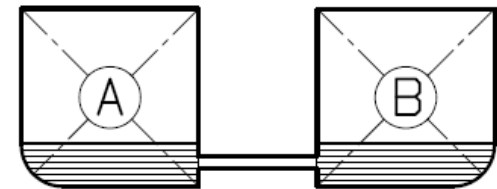
Intermediate Stages of Flooding (if applicable)



'A' and 'B': 75%



'A' and 'B': 50%

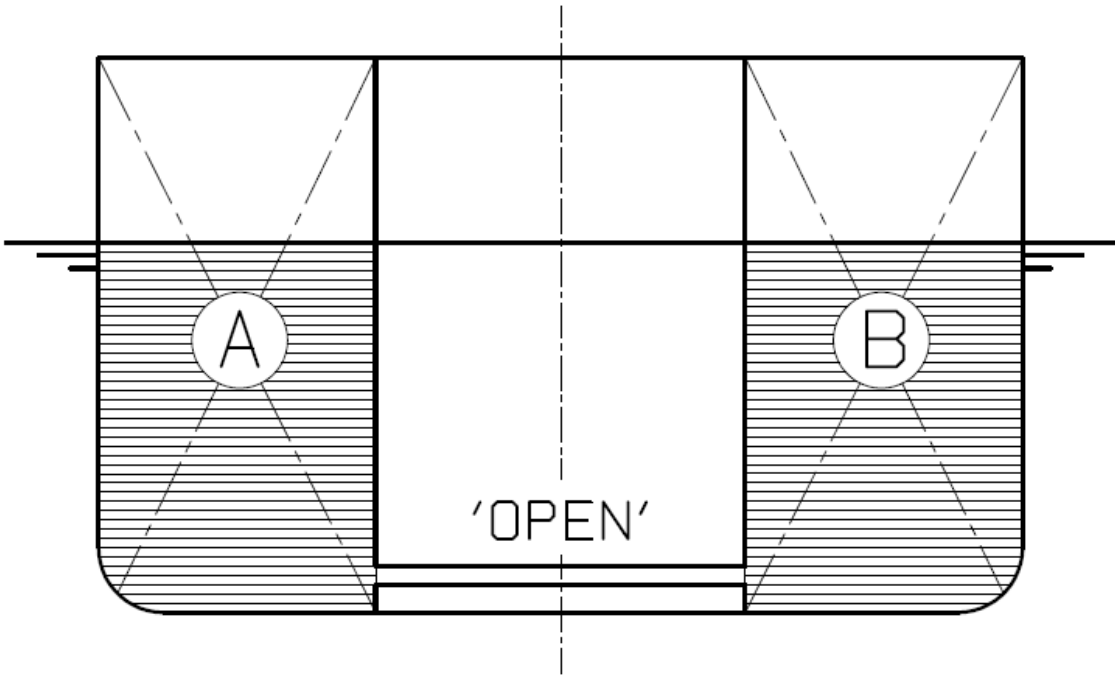


'A' and 'B': 25%

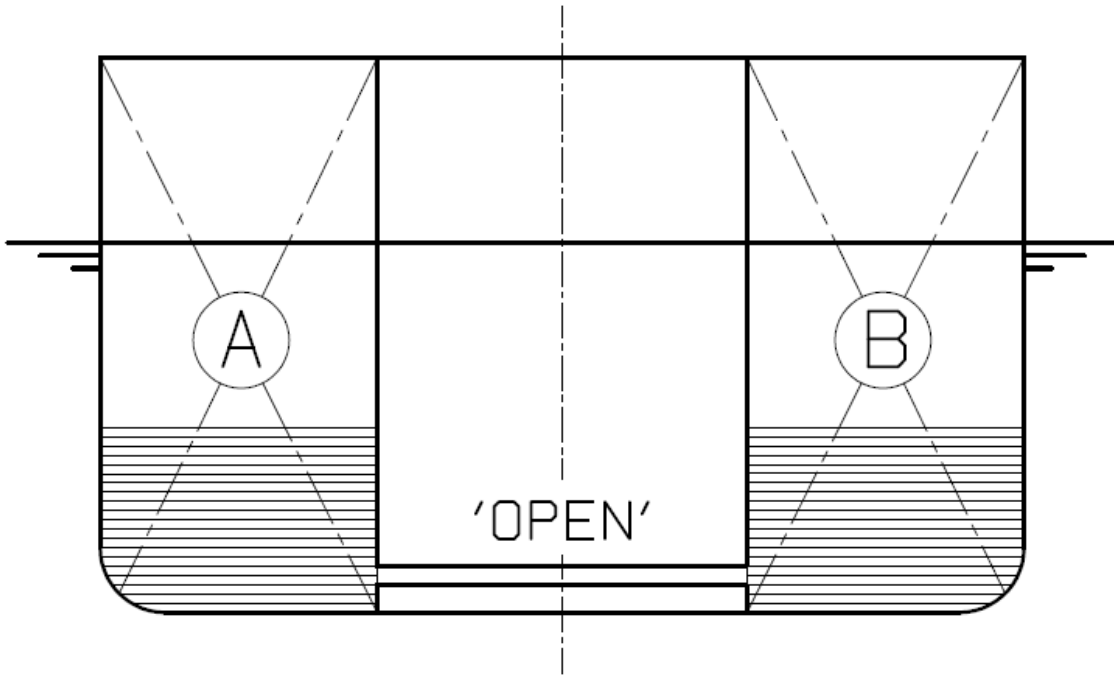
Tips & Tricks: 'Probdam'

Final '100%' and intermediate stages of flooding.

Final stage of flooding '100%'



Intermediate stage of flooding '50%'



Tips & Tricks: 'Probdam'

Compartment connections.

'Pipe' and 'A-class bulkhead' connection.

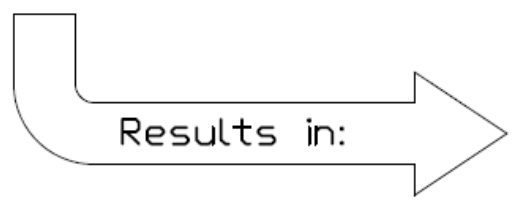
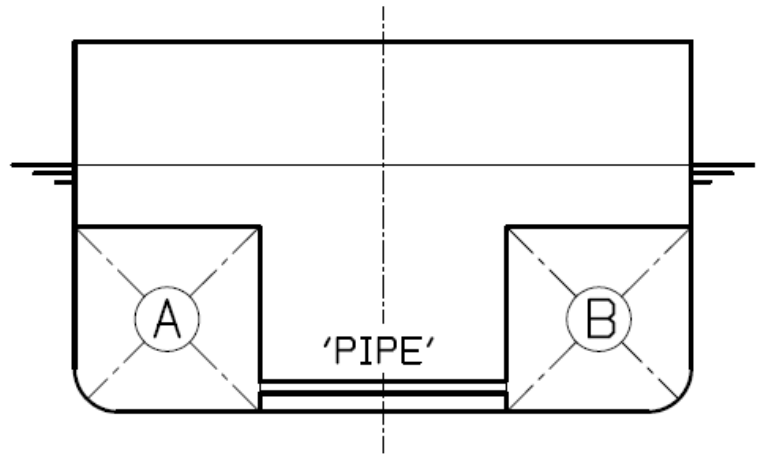
Progressive flooding is considered to may take considerable time.

Therefore, an extra intermediate stage of flooding besides the final stage is generated.

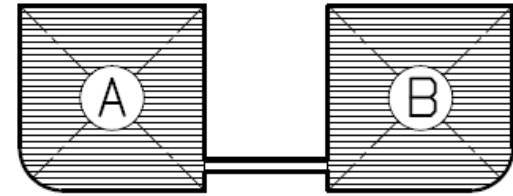
Since the minimum value of s_i for each stage has to be taken, a 'pipe' connection is always the 'worst case scenario'.

Tips & Tricks: 'Probdam'

Connection 'A' <-> 'B'
'Pipe' w.o. Critical Point

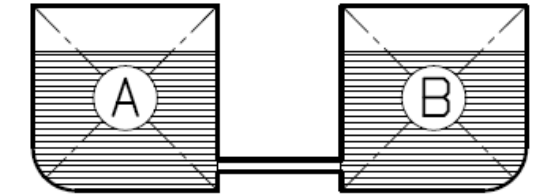


Final Stage of Flooding



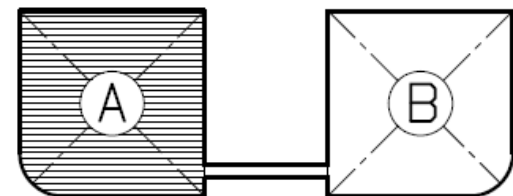
'A' and 'B': 100%

Intermediate Stages of Flooding (if applicable)

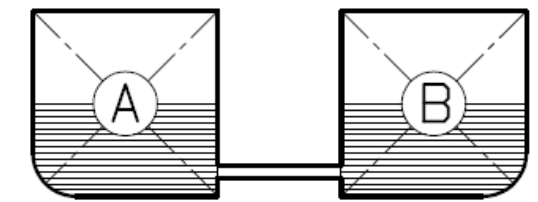


'A' and 'B': 75%

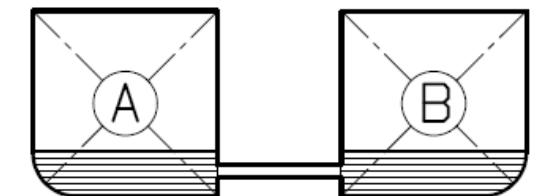
Stage of Flooding #1
Situation before
Progressive Flooding



'A': 100% and 'B': 0%



'A' and 'B': 50%



'A' and 'B': 25%

Tips & Tricks: 'Probdam'

Compartment connections.

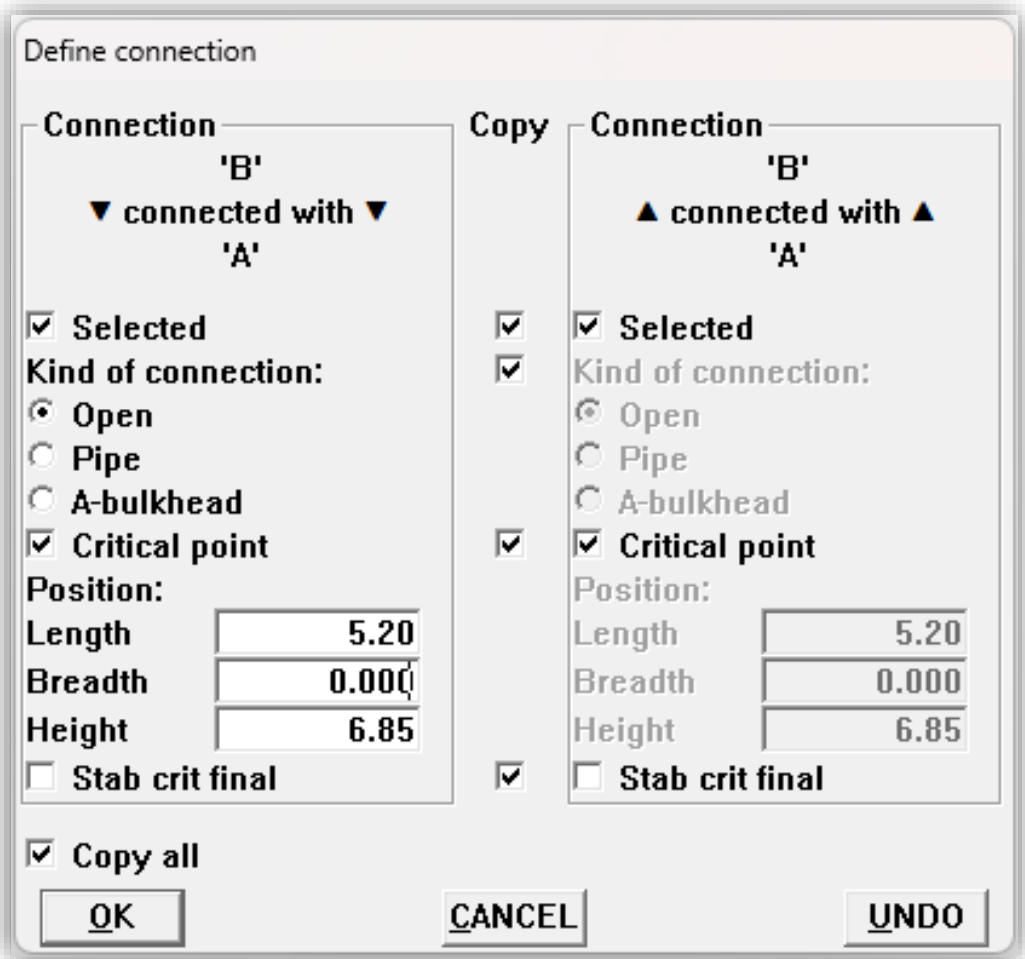
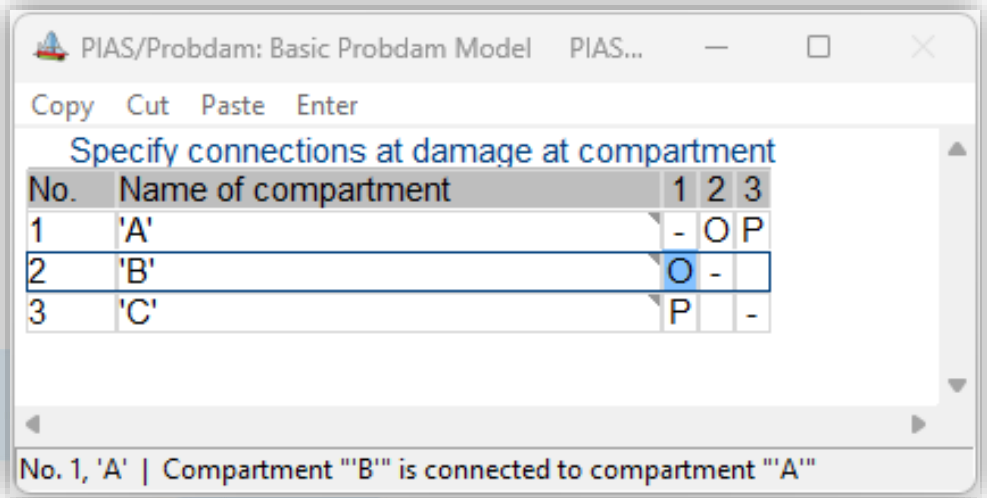
How do you set up a compartment connection?

Calculation method, configurations and ship parameters

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4. View scheme of standard permeabilities
5. Edit scheme of user-defined permeabilities
- 6. Define compartment connections**
7. Define zonal boundaries
8. Notes (free text)
9. Determine the VCG' for which $A=R$

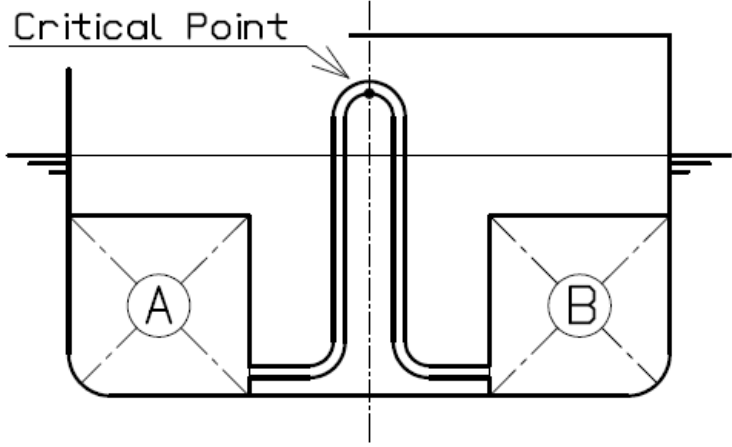
Tips & Tricks: 'Probdam'

Compartment connections.



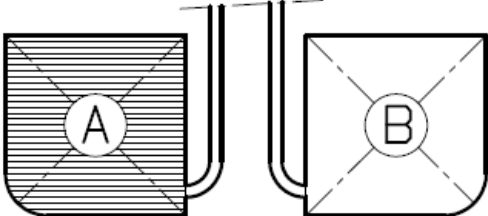
Tips & Tricks: 'Probdam'

Connection 'A' <-> 'B'
'Open' with Critical Point



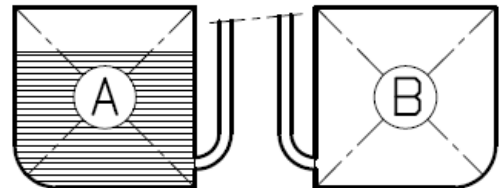
Results in: →

Final Stage of Flooding

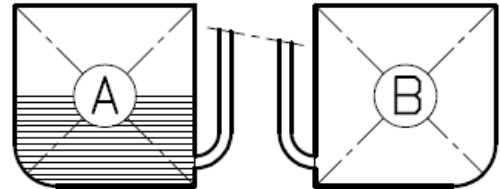


'A': 100% and 'B': 0%

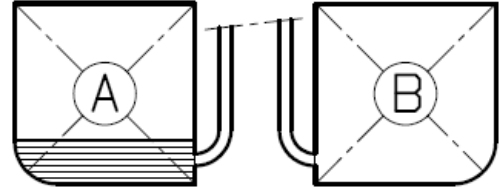
Intermediate Stages of Flooding (if applicable)



'A': 75% and 'B': 0%



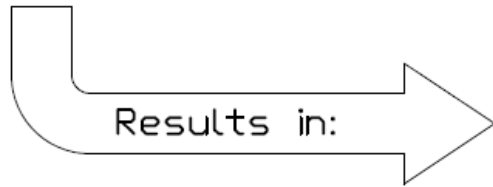
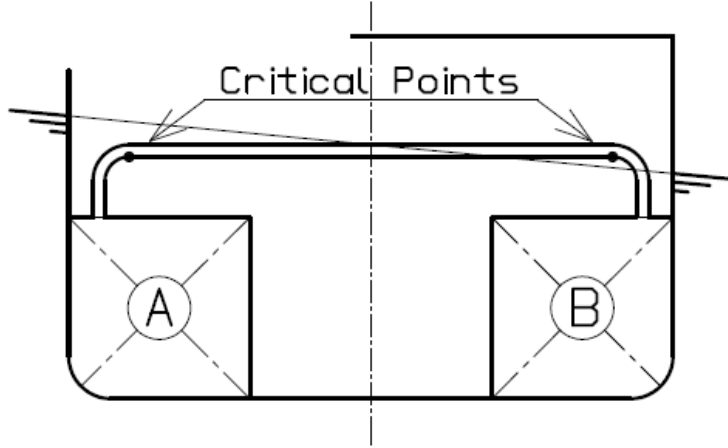
'A': 50% and 'B': 0%



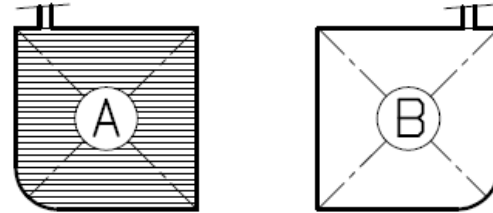
'A': 25% and 'B': 0%

Tips & Tricks: 'Probdam'

Connection 'A' <-> 'B'
'Open' with 2 Critical Points

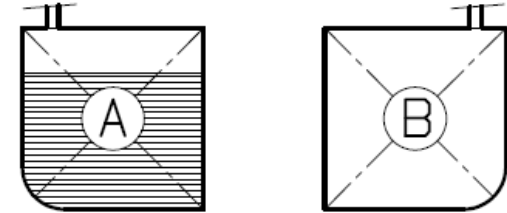


Final Stage of Flooding

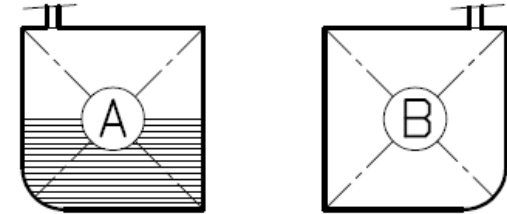


'A': 100% and 'B': 0%

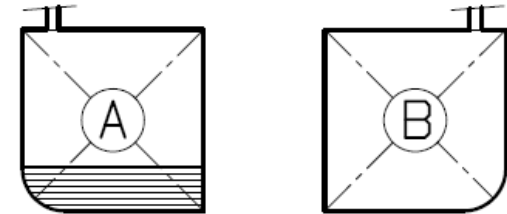
Intermediate Stages of Flooding (if applicable)



'A': 75% and 'B': 0%



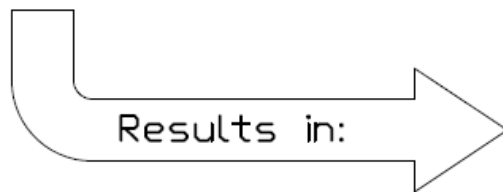
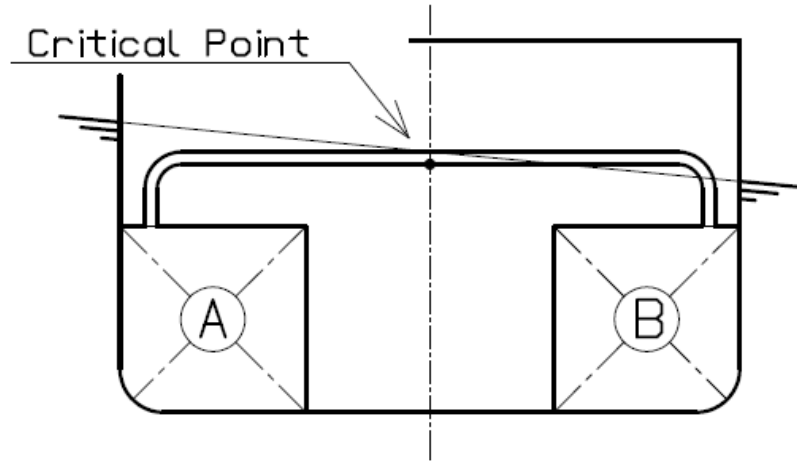
'A': 50% and 'B': 0%



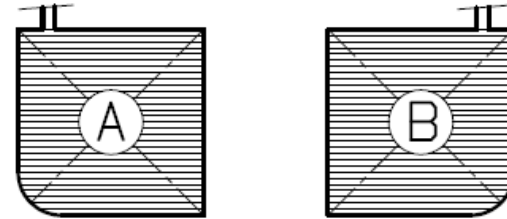
'A': 25% and 'B': 0%

Tips & Tricks: 'Probdam'

Connection 'A' <-> 'B'
'Open' with 1 Critical Point

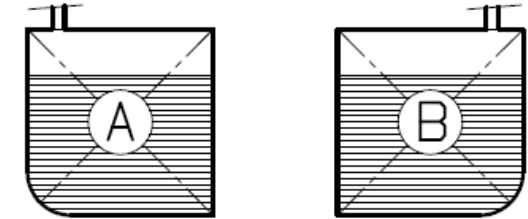


Final Stage of Flooding

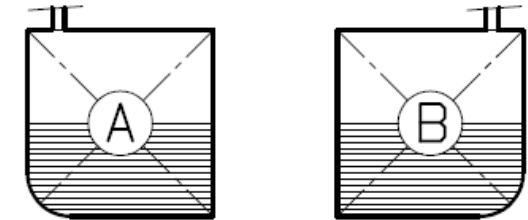


'A' and 'B': 100%

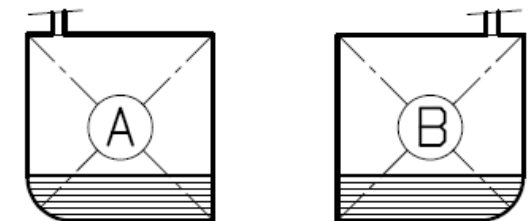
Intermediate Stages of Flooding (if applicable)



'A' and 'B': 75%



'A' and 'B': 50%



'A' and 'B': 25%

Tips & Tricks: 'Probdam'

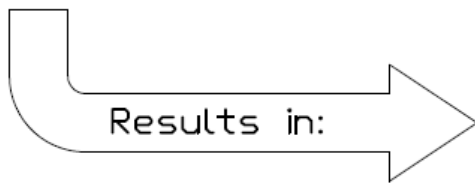
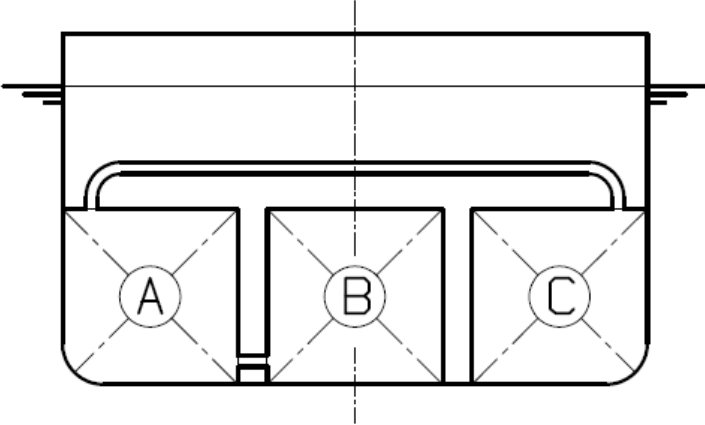
Compartment connections.

Multiple compartment connections.

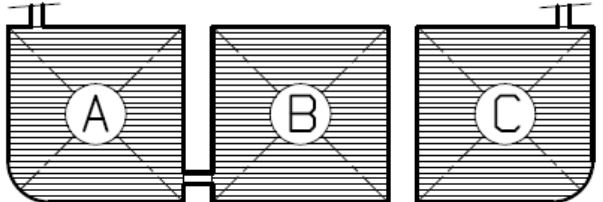


Tips & Tricks: 'Probdam'

Comp. 'A' connected with 'B' and 'C'
'Pipe' w.o. Critical Point

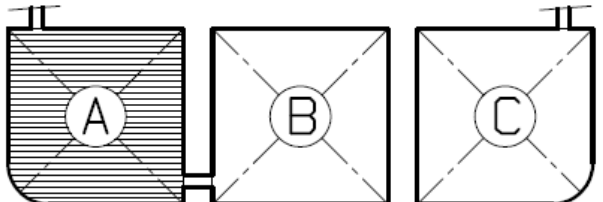


Final Stage of Flooding



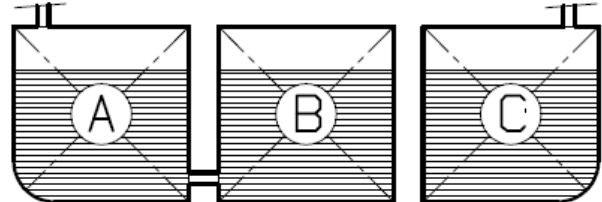
'A', 'B' and 'C': 100%

Stage of Flooding #1

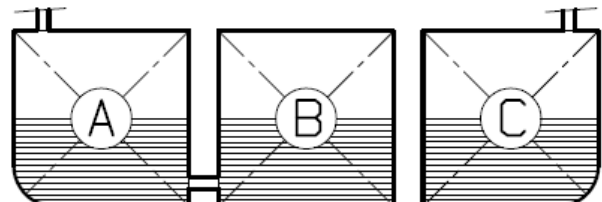


'A': 100%, 'B' and 'C': 0%

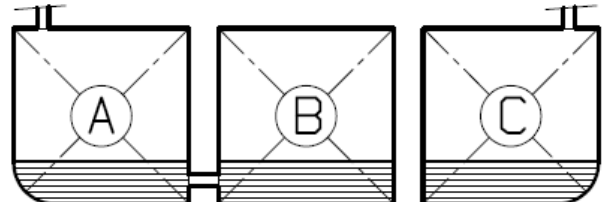
Intermediate Stages of Flooding (if applicable)



'A' and 'B': 75%



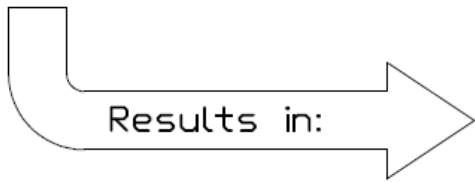
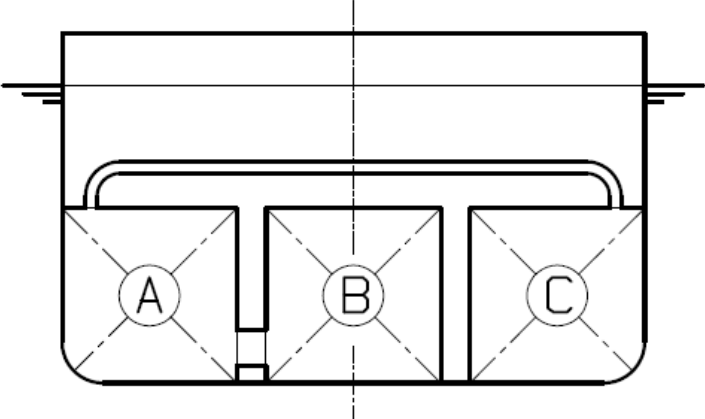
'A' and 'B': 50%



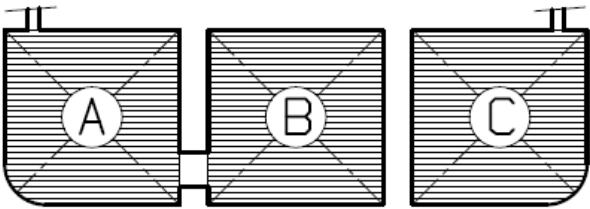
'A' and 'B': 25%

Tips & Tricks: 'Probdam'

Comp. 'A' connected with 'B' and 'C'
 'A' to 'B': 'Open' w.o. Critical Point
 'A' to 'C': 'Pipe' w.o. Critical Point

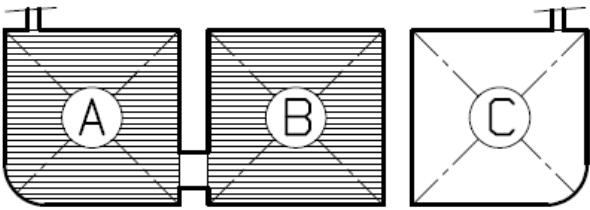


Final Stage of Flooding



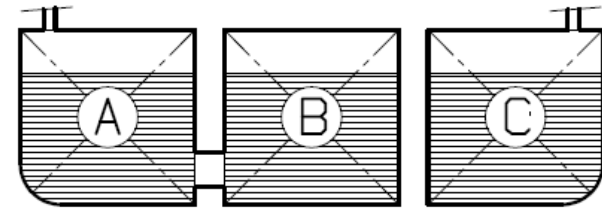
'A', 'B' and 'C': 100%

Stage of Flooding #1

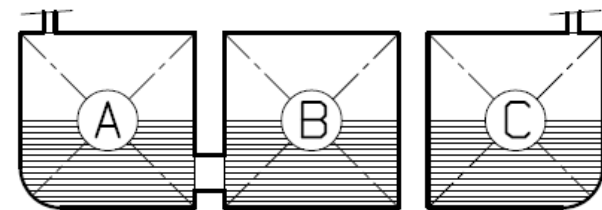


'A' and 'B': 100%, 'C': 0%

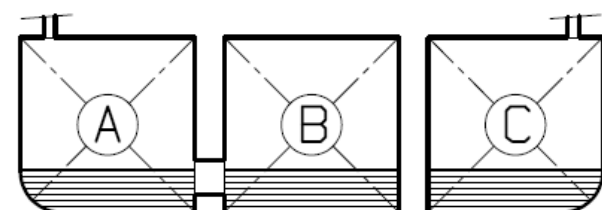
Intermediate Stages of Flooding (if applicable)



'A' and 'B': 75%



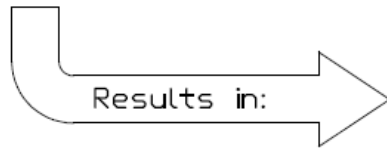
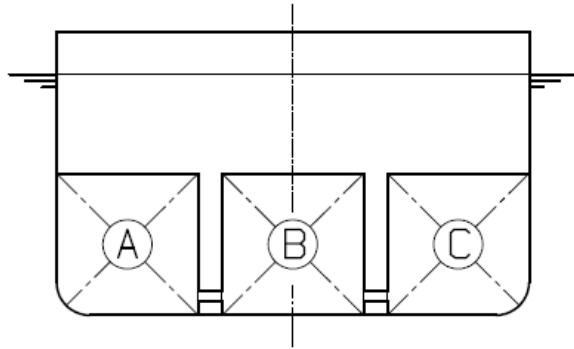
'A' and 'B': 50%



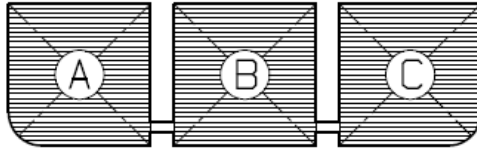
'A' and 'B': 25%

Tips & Tricks: 'Probdam'

Comp. 'A' connected with 'B' and:
Comp. 'B' connected with 'C'
'Pipe' w.o. Critical Point

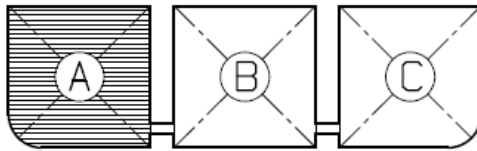


Final Stage of Flooding



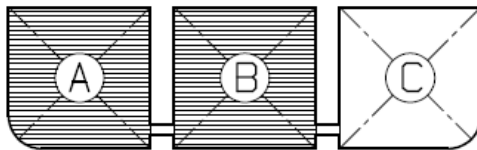
'A', 'B' and 'C': 100%

Stage of Flooding #1



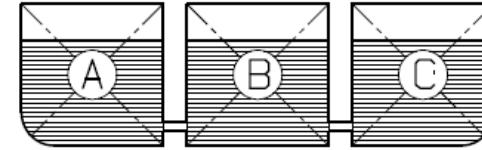
'A': 100%, 'B' and 'C': 0%

Stage of Flooding #2

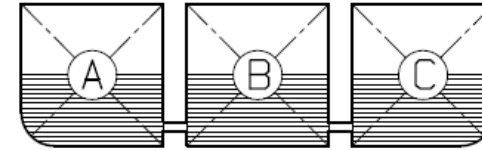


'A' AND 'B': 100% and 'C': 0%

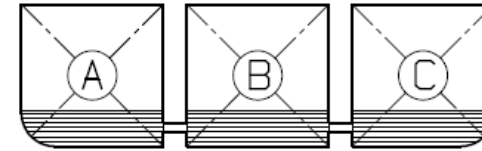
Intermediate Stages of Flooding (if applicable)



'A' and 'B': 75%



'A' and 'B': 50%



'A' and 'B': 25%

Tips & Tricks: 'Probdam'

New damage case menu.

Damage cases													
Slct	Lock	Name	Aft	Fore	Upper	Ainside	Finside	Level interm.	Flood.stages	Higher subd.	Valid Loading	Valid Hydrot.	Valid Probdam
Yes	No	-1;	25.000	50.000	5.000	4.000	4.000	Global sett.	No	Yes	No	No	Yes
Yes	No	-2;	50.000	75.000	5.000	4.000	4.000	Global sett.	No	Yes	Yes	No	Yes
Yes	No	-3;	25.000	50.000	5.000	-0.000	-0.000	Global sett.	No	Yes	Yes	No	Yes
Yes	No	-4;	0.000	10.000	5.000	0.000	0.000	Global sett.	Yes	Yes	No	No	Yes
Yes	No	-5;	75.000	90.000	5.000	4.000	4.000	Global sett.	No	Yes	No	No	Yes
Yes	No	-6;	10.000	25.000	5.000	4.000	4.000	Global sett.	No	Yes	No	No	Yes
Yes	No	-7;	50.000	75.000	5.000	-0.000	-0.000	Global sett.	No	Yes	No	No	Yes

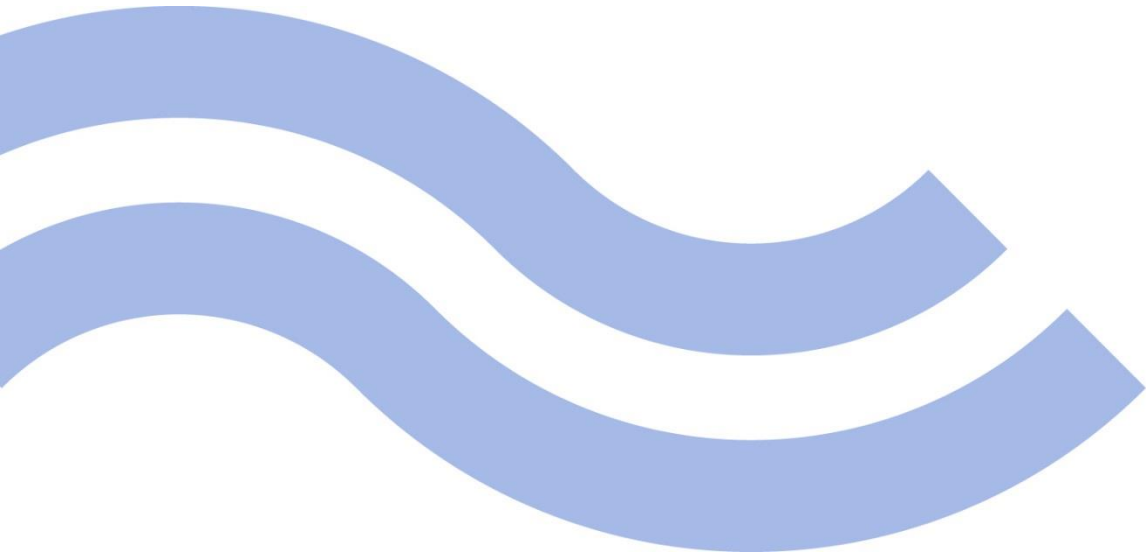
Tips & Tricks: 'Probdam'

New damage case menu.

Damage cases														
Slct	Lock	Name	Aft	Fore	Upper	Ainside	Finside	Level interm.	Flood stages	Higher subd.	Valid Loading	Valid Hydrot.	Valid Probdam	
Yes	No	-1;	25.000	50.000	5.000	4.000	4.000	Global sett.	No	Yes	No	No	Yes	
Yes	No	-2;	50.000	75.000	5.000	4.000	4.000	Global sett.	No	Yes	Yes	No	Yes	
Yes	No	-3;	25.000	50.000	5.000	-0.000	-0.000	Global sett.	No	Yes	Yes	No	Yes	
Yes	No	-4;	0.000	10.000	5.000	0.000	0.000	Global sett.	Yes	Yes	No	No	Yes	
Yes	No	-5;	75.000	90.000	5.000	4.000	4.000	Global sett.	No	Yes	No	No	Yes	
Yes	No	-6;	10.000	25.000	5.000	4.000	4.000	Global sett.	No	Yes	No	No	Yes	
Yes	No	-7;	50.000	75.000	5.000	-0.000	-0.000	Global sett.	No	Yes	No	No	Yes	

- Here you can select damage cases for which higher subdamages have to be generated.
- Here you can select damage cases to be used in 'Loading' or 'Hydrotables'.

Q & A.



Topics and questions raised during the presentation.

If your question is not listed, or if any other question arises, please feel free to contact us for advice!

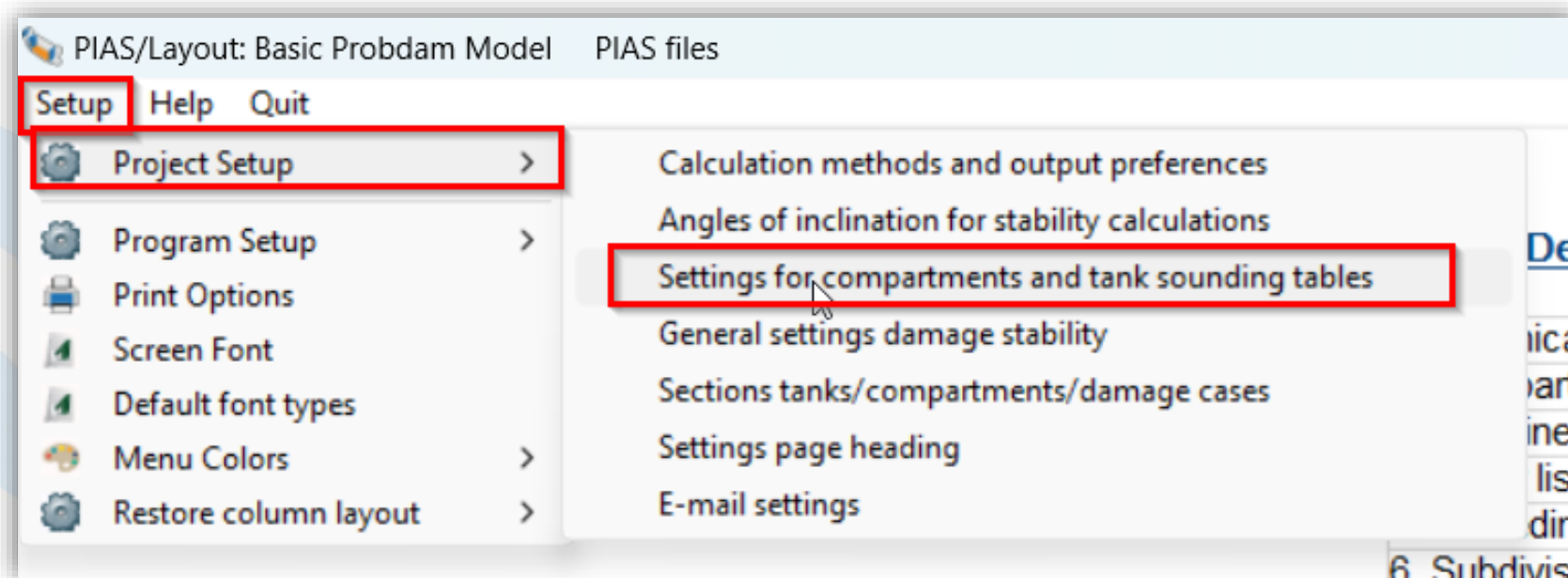
Vertical escape hatch would not be available in the list of openings for all customers.

We are investigating this. If this would be the case, we will fix this.

Please note that a 'vertical escape hatch' cannot be connected to a compartment. Therefore, such point can only be added in 'Hulldef' and not in 'Layout'.

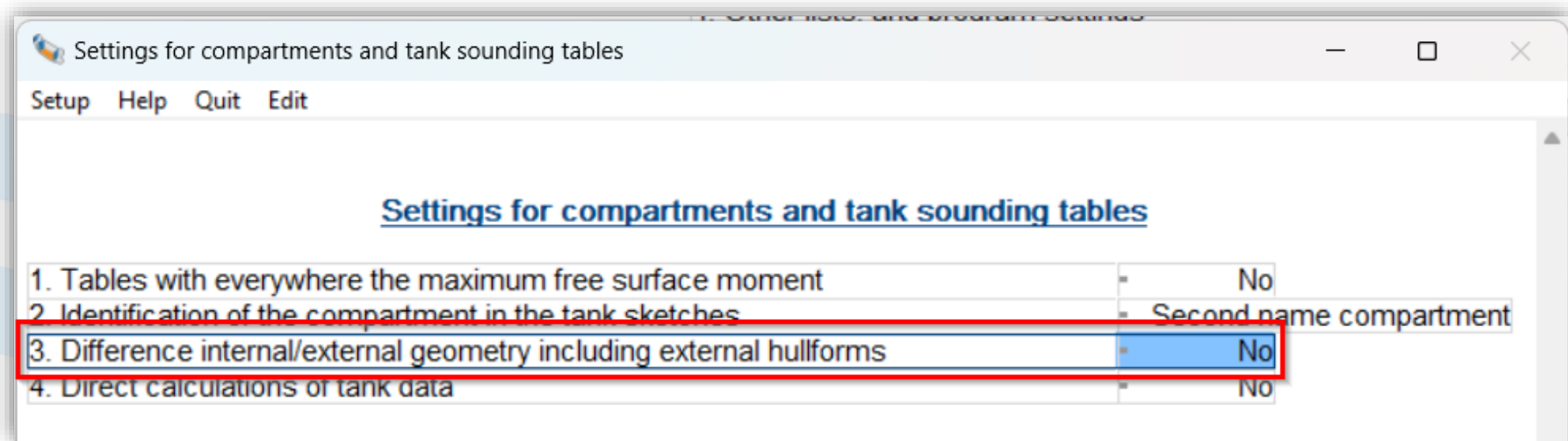
Are external/ added hull forms taken into account when making use of the ‘Difference between internal and external geometry’?

This can be selected by the user via ‘Setup’ (or the ‘Config’-module):



Are external/ added hull forms taken into account when making use of the 'Difference between internal and external geometry'?

→ Settings for compartments and tank sounding tables.



Is the functionality to reduce coordinates of frames (e.g. due to import of dxf etc) also available for PIAS-users?

No. Unfortunately not. The best way to avoid too many coordinates of frames and too many frames in general, is to take this into account when importing a hull-form from dxf/ Rhino. The module we use, does not work flawless and has no manual etc etc and is only used when we can't influence the way a model is imported in PIAS.

If there is a structural need for this module, let us know. Perhaps we can develop this into a module which is suitable to put on our price list.

How to deal with changing designs for the same project?

This is a difficult question to answer without knowing what the design-changes are, and what the wishes are of the client.

- Do you want to be able to work on the model with other modules then Probdam during probabilistic damage stability?
 - In such case it is inevitable to make a copy of the PIAS-files for the probabilistic damage stability. The user must take care to make a new copy of the most recent PIAS-files to be used for Probdam. Since probabilistic damage stability calculations may take some time, we generally use this way of working. Using this way of working it is advisable to set up all the details and settings for probabilistic damage stability first, so you don't have to set this up every time a change has been made and the files are copied for Probdam.

How to deal with changing designs for the same project?

This is a difficult question to answer without knowing what the design-changes are, and what the wishes are of the client.

- Do you want to be able to work on the model with other modules then Probdam during probabilistic damage stability?
 - If not, use the same files.
- In any other situation, please contact us so we can think for the best possible way of dealing with this.

Q&A

If your question is not listed, or if any other question arises, please feel free to contact us for advice!

I would like to thank you for your attention.

SARC user day 2023

Workshop Probabilistic Damage Stability with PIAS

Douwe Plukkel

