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Science for Transport

A research group of CIMNE

EXCELENCIA SEVERO OCHOA

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Fire Hazard Management of Cargo Distribution Supported by a Risk Assessment of the Units Based on Historical Data

Francisco Rodero
ITS Project Manager

Background

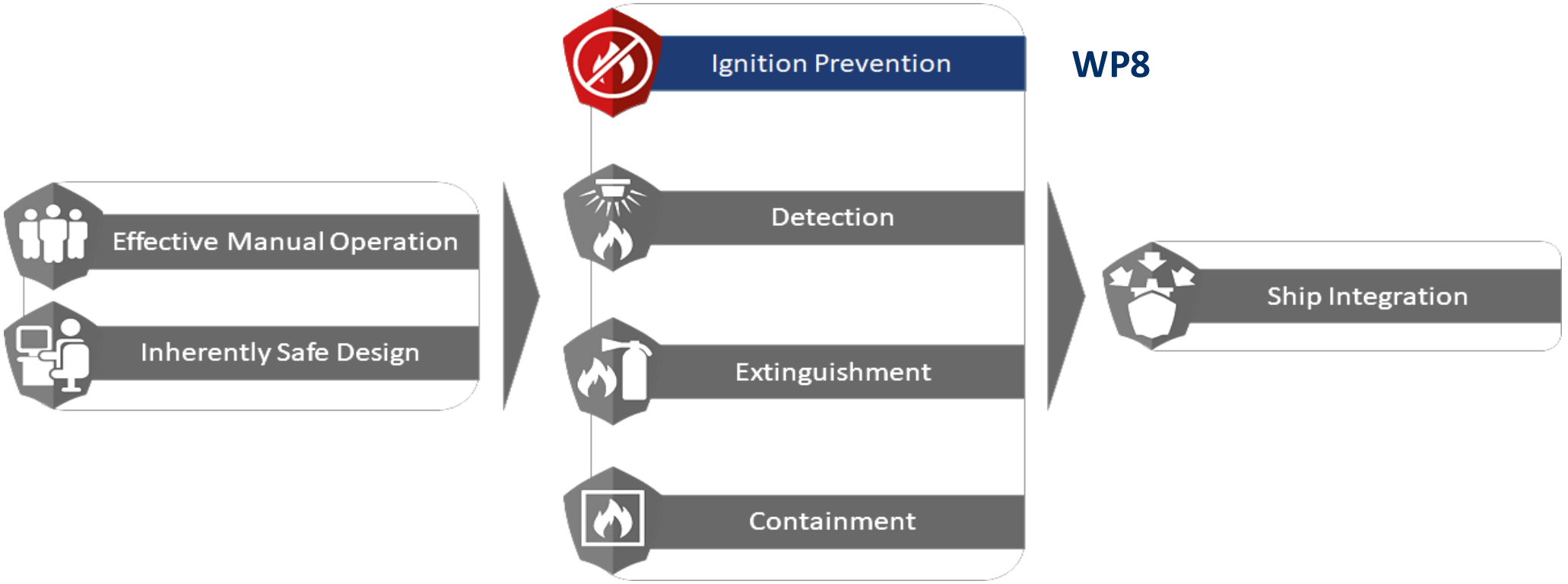
Legislative Assessment for Safety Hazards of Fire and Innovations in Ro-ro ship Environment

LASH FIRE

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement nº 814975

"To provide a **recognized technical basis** for the revision of international **IMO regulations**, which greatly **enhances fire prevention** and **ensures independent management of fires** on ro-ro ships in current and **future** fire safety challenges."

Background



Significant reduction of the most probable **ignition sources and improved management of fire hazards in ro-ro spaces**, including provision for automatic screening and risk-based loading support

Background

Ignition Prevention

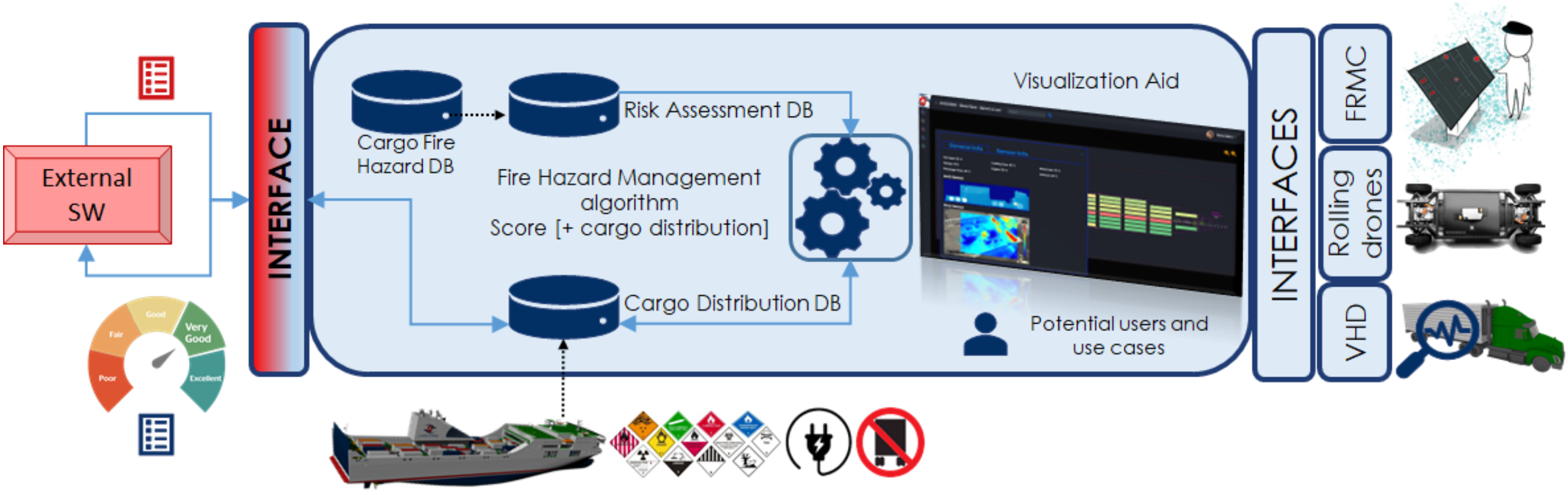
8-A Automatic screening and management of cargo fire hazards
8-B Guidelines and solutions for safe electrical connections
8-C Fire requirements for new ro-ro space materials

- 90% of all ro-pax fires originate in cargo (vehicles and cargo units).
- Cargo is everything from brand new to poorly maintained, rebuilt or unsafe.
- Fire hazards are not screened.
- Except Dangerous Goods, cargo is not loaded considering potential hazards

Background

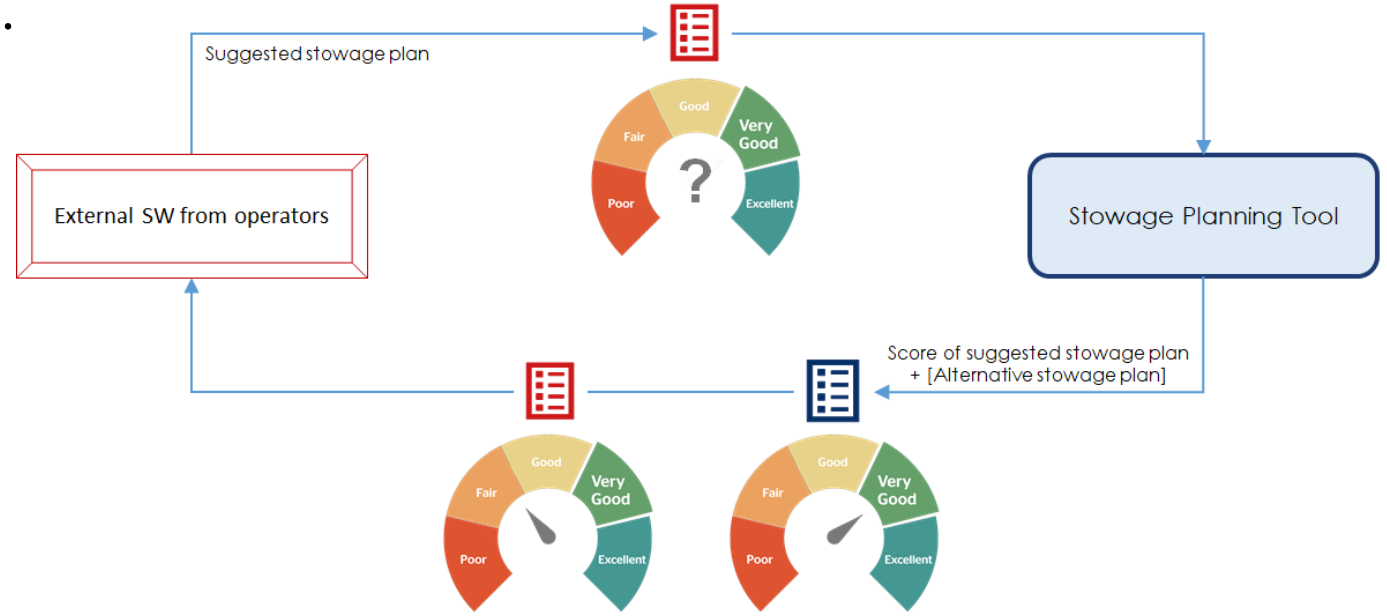
- Hazard identification and database construction
- Assessment of cargo identification technologies
- Assessment of sensors for fire ignition prevention identification
- Fire hazard matching and mapping
- **Stowage planning tool and visualization aid**
- Appropriate placement of monitoring systems based on hazard map and screening methodologies
- Integration with firefighting control Centre

Overview

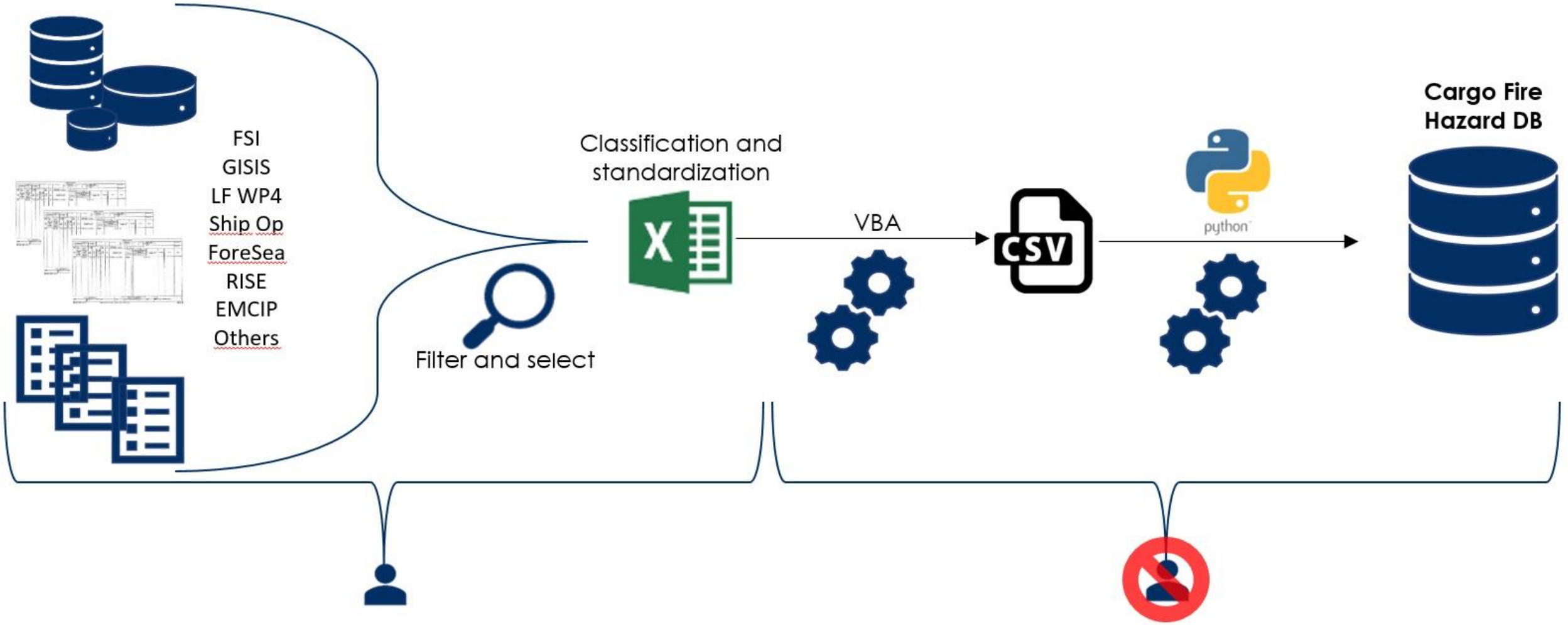

External SW
INTERFACE
Cargo Fire Hazard DB
Risk Assessment DB
Fire Hazard Management algorithm
Score [+ cargo distribution]
Cargo Distribution DB
Visualization Aid
Potential users and use cases
INTERFACES
FRMC
Rolling drones
VHD
Poor
Fair
Good
Very Good
Excellent

Stowage Planning Tool (SPT)

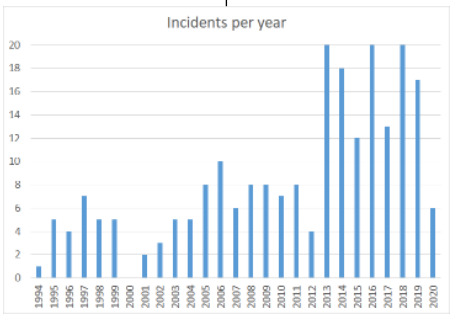
- The SPT is the software component that implements all the features described in this presentation:
  - Scoring: Taking advantage of the risk assessment based on historical data, a risk score value is assigned to every single cargo unit.
  - Cargo Distribution: Algorithm supporting fire hazard management that proposes an alternative placement of the units in order to reduce the overall risk (according the score value).

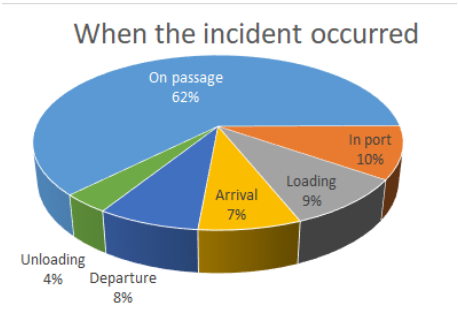


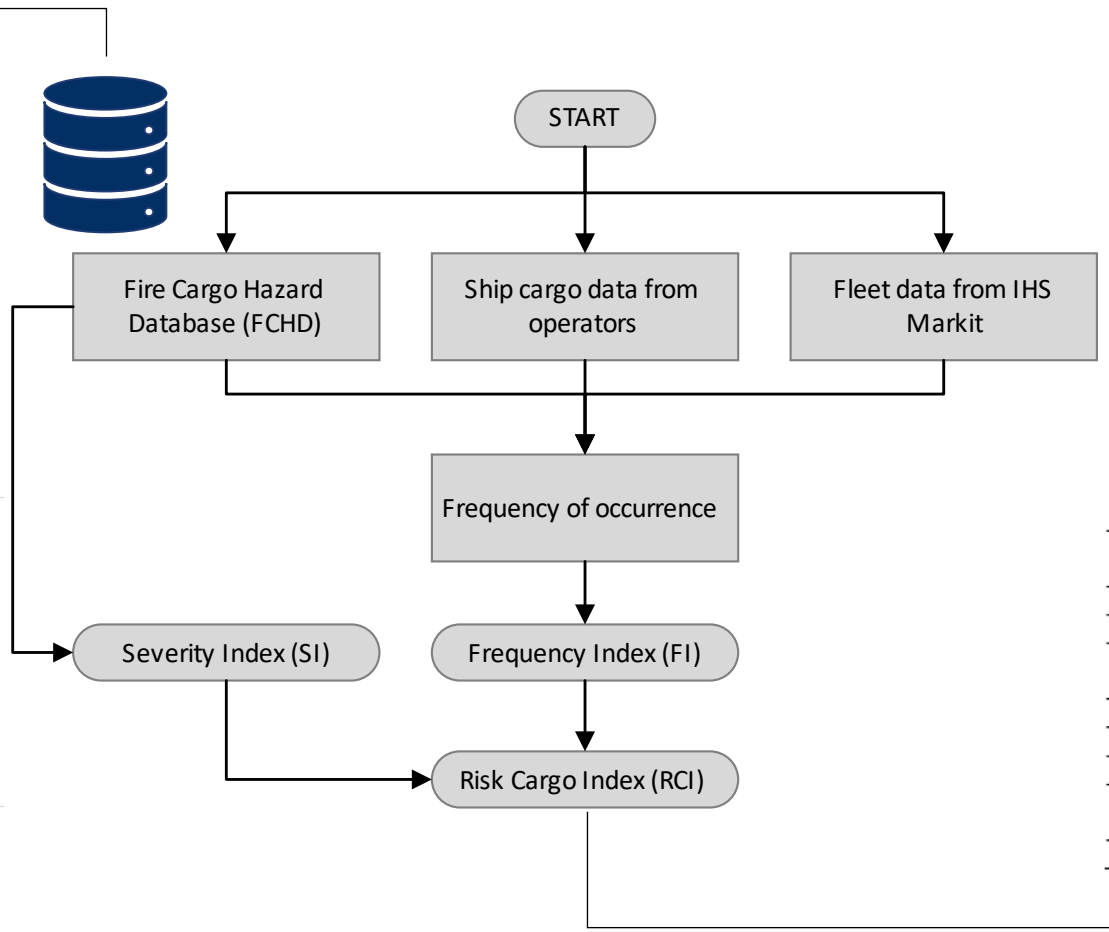
Cargo Fire Hazard Database



Risk Assessment



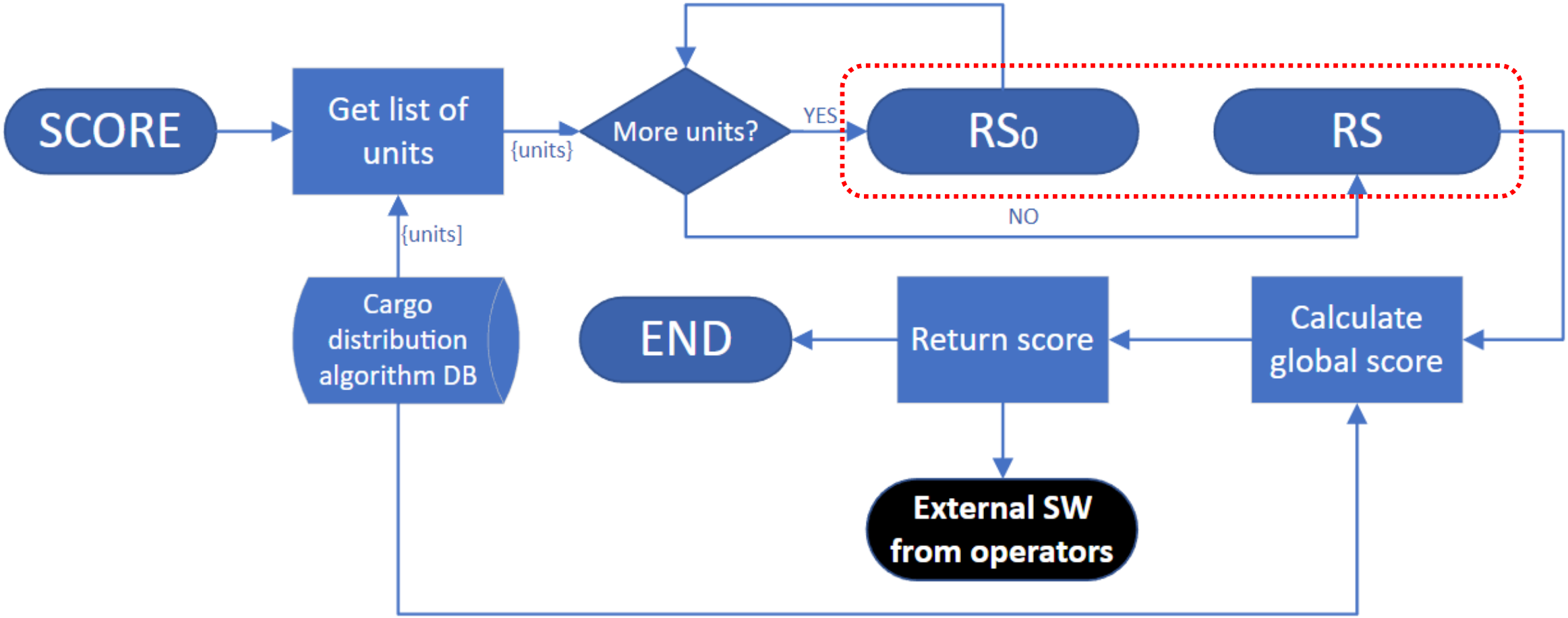




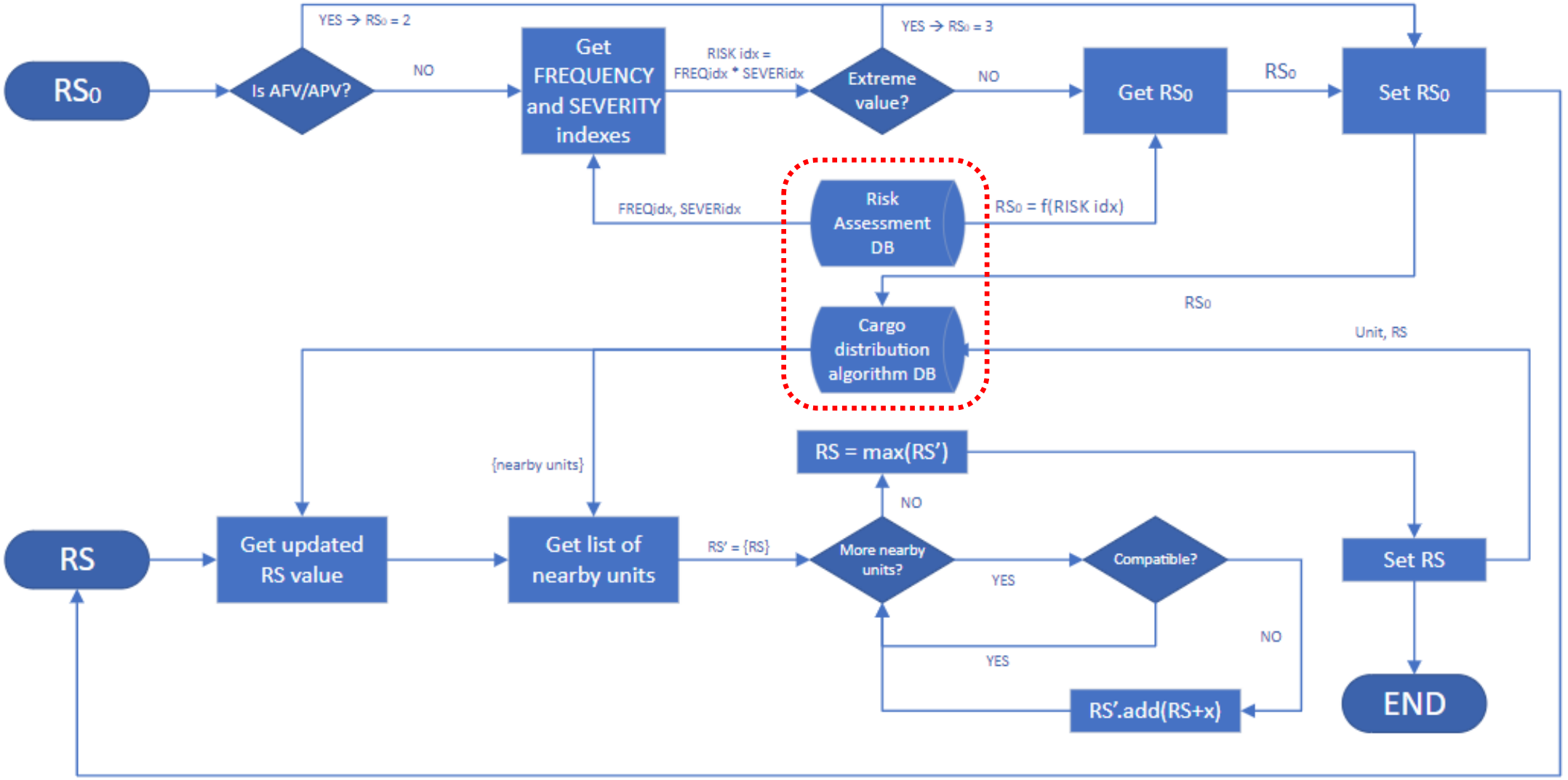
Dangerous goods units*	Frequency index	Severity index	Cargo Risk Index
Dangerous goods Flammable solid	4	2	8
Dangerous goods Flammable liquid	3	2	6
Dangerous goods Miscellaneous dangerous substances and articles	3	1	3
Dangerous goods Corrosive substances	3	1	3
Dangerous goods Explosive	3	1	3
Dangerous goods Gas	3	1	3

Cargo unit	Frequency index	Severity index	Cargo Risk Index
Reefer unit	4	2	8
Conventional Vehicles – Bus	3	1	3
Conventional Vehicles - Truck	3	2	6
Special Vehicles -RV	2	2	4
Conventional Vehicle – Car	2	2	4
Special Vehicles - Tractor	1	1	1
New energy vehicle – Electrical vehicle	1	1	1
Special Vehicles - Trailer	1	1	1

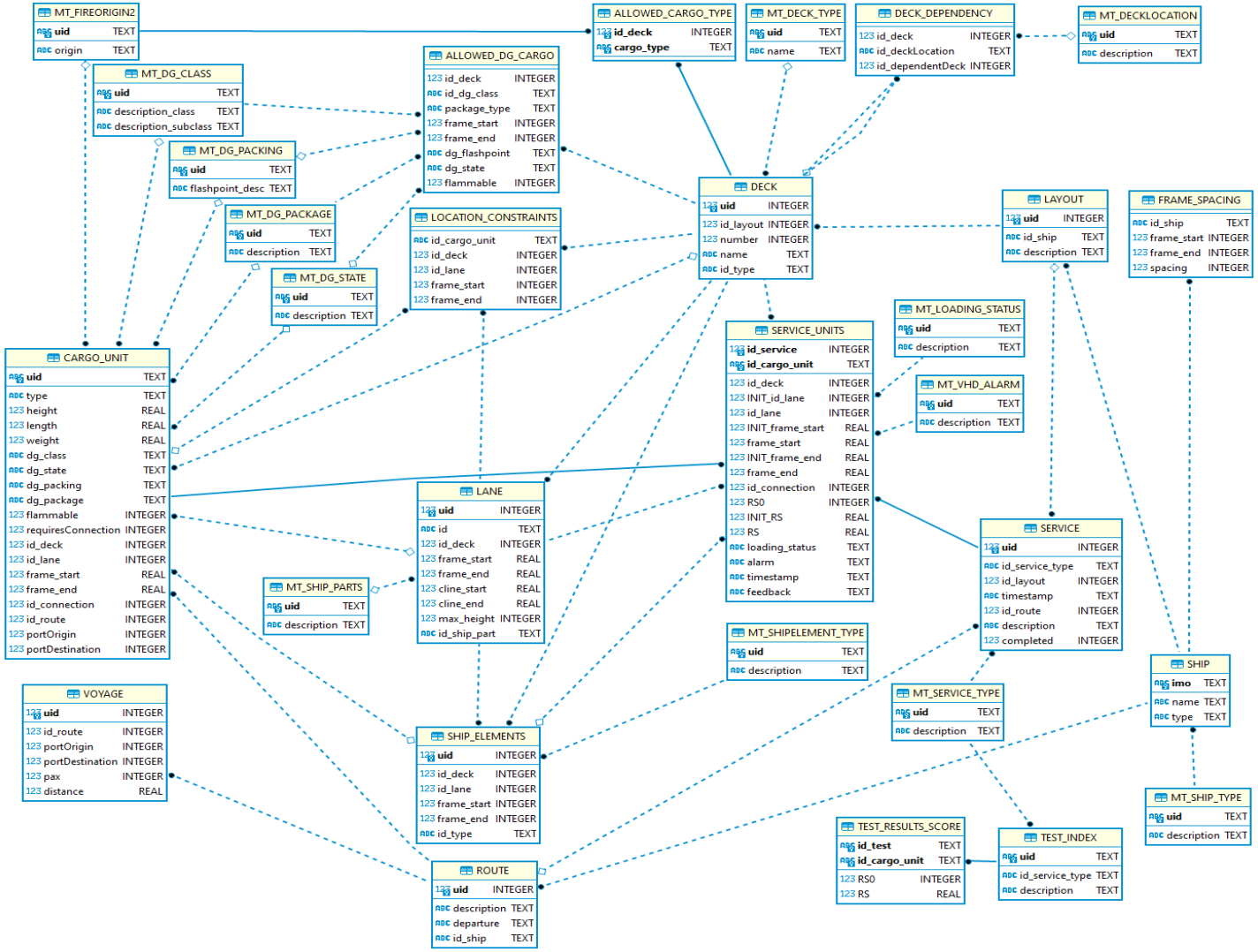
Scoring feature

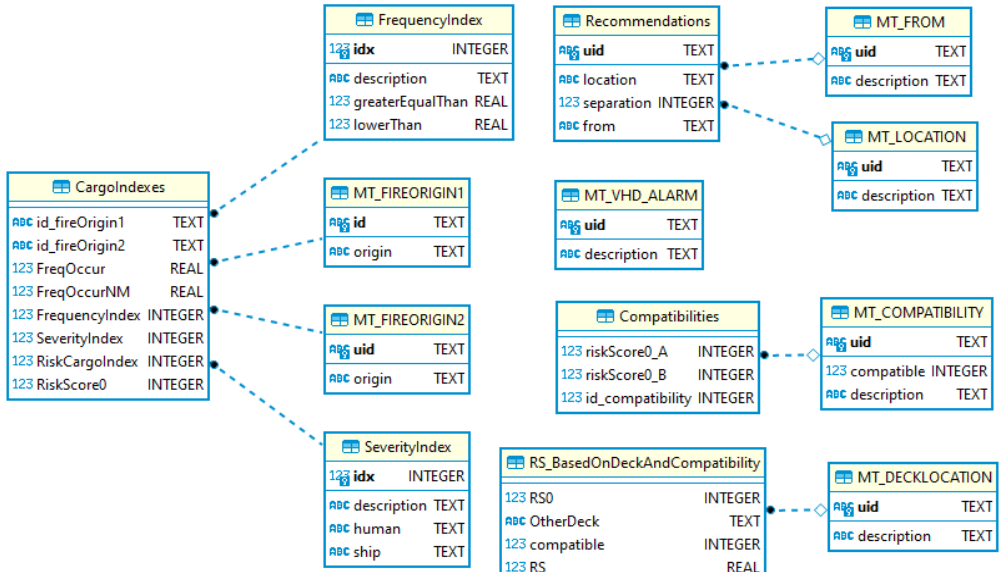


Scoring feature



Data models of underlying databases

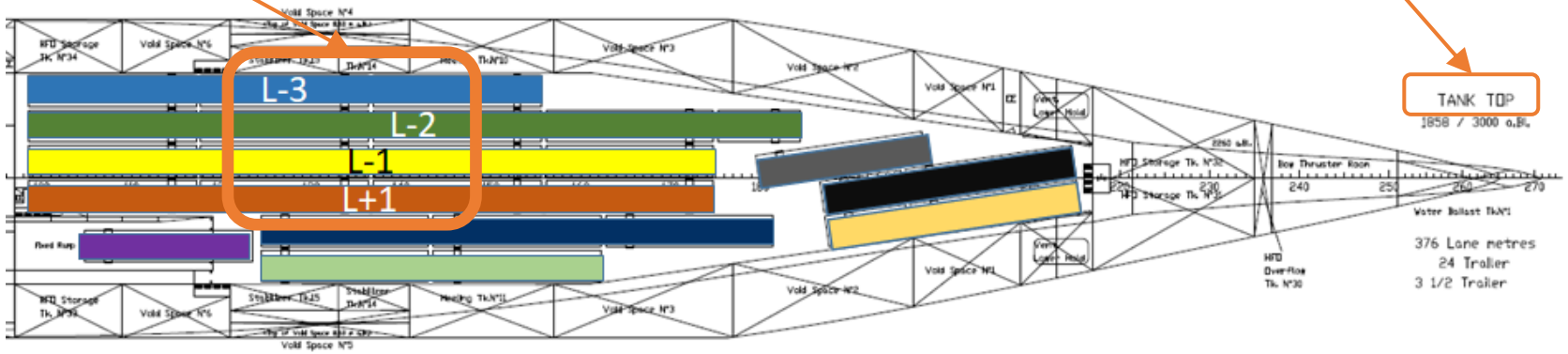




Data models of underlying databases

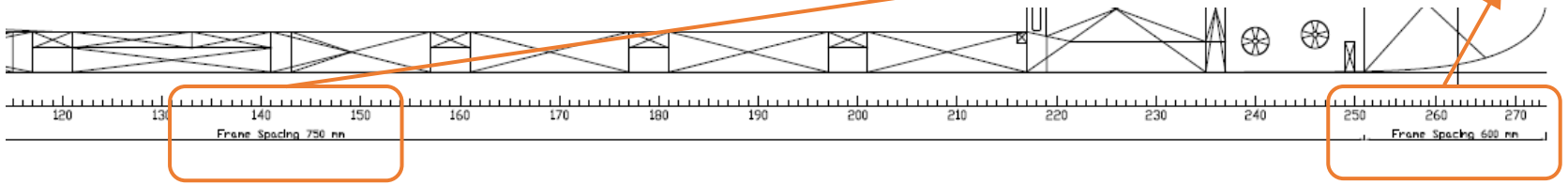
uid	id	id_deck	frame_start	frame_end
1	L-3	1	98	154
2	L-2	1	98	182
3	L-1	1	98	175
4	L+1	1	104	175

uid	id_layout	number	name	id_type
1	1	1	Tank Top	C
2	1	2	Main Deck	C
3	1	3	Upper Deck	O
4	1	4	Weather Deck	W

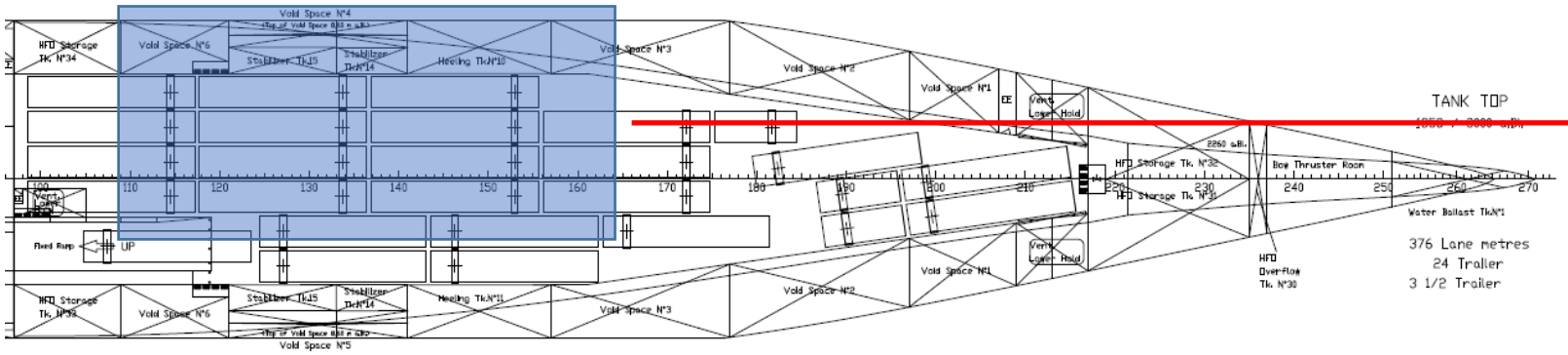


	imo	name	type
1	9417919	STENA Flavia	RO-PAX
2	9259496	DFDS Magnolia Seaways	RO-RO
3	9293612	WALLENIUS Torrens	CC

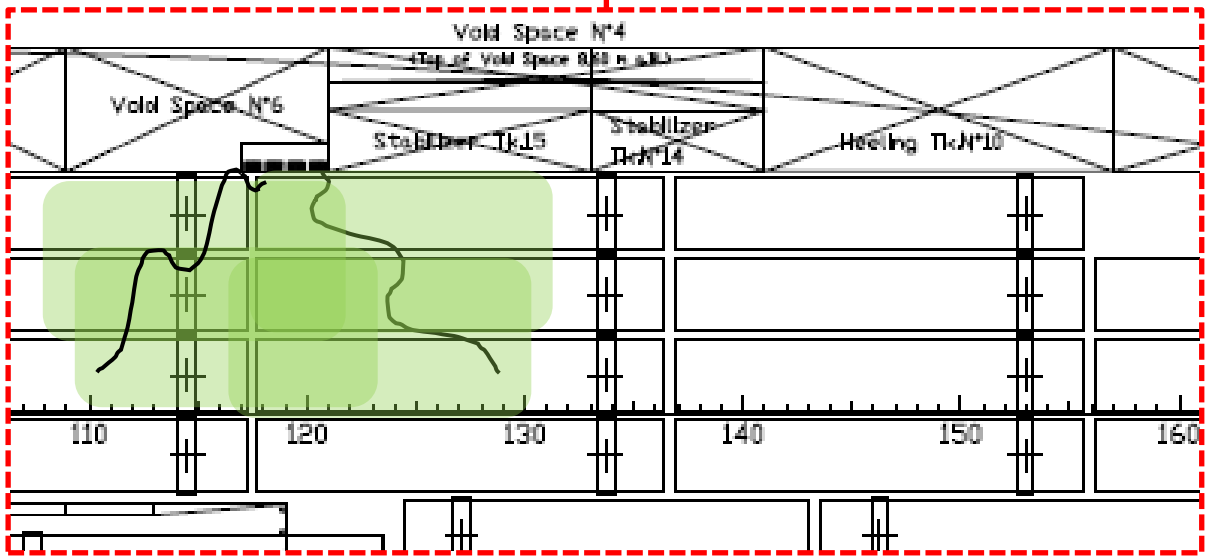
id_vessel	frame_start	frame_end	spacing
9259496	0	33	600
9259496	33	251	750
9259496	251	274	600



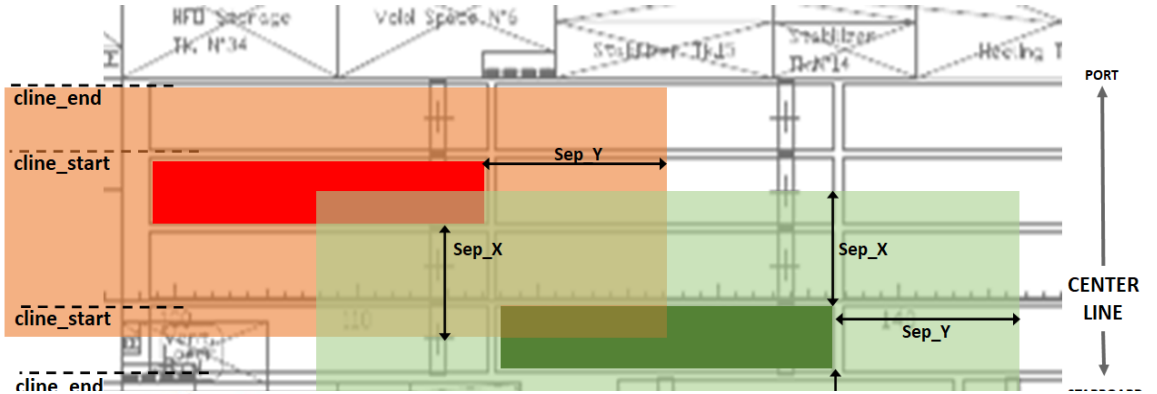
Data models of underlying databases

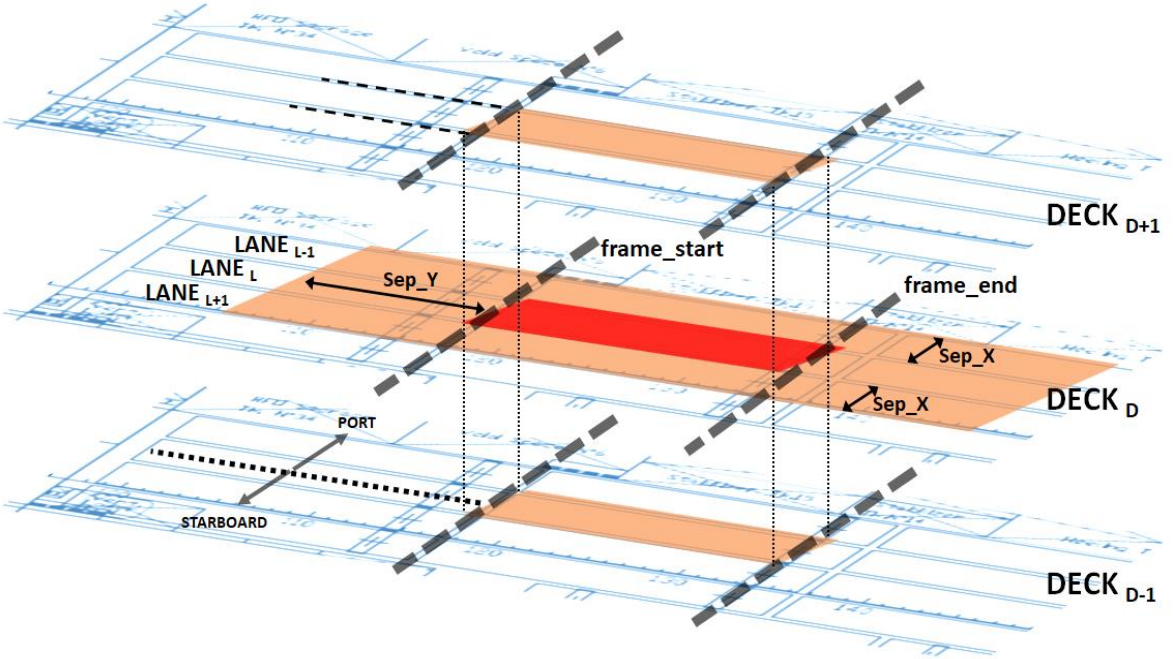


	uid	id_deck	id_lane	frame_start	frame_end	id_type
22	22	1	L-3	99	139	EC
23	23	1	L-3	99	139	EC
24	24	1	L-3	99	139	EC
25	25	1	L-2	100	138	EC
26	26	1	L-2	100	138	EC
27	27	1	L-2	100	138	EC
28	28	1	L-2	100	138	EC
29	29	1	L-2	100	138	EC
30	30	1	L-1	102	135	EC
31	31	1	L-1	102	135	EC
32	32	1	L-1	102	135	EC

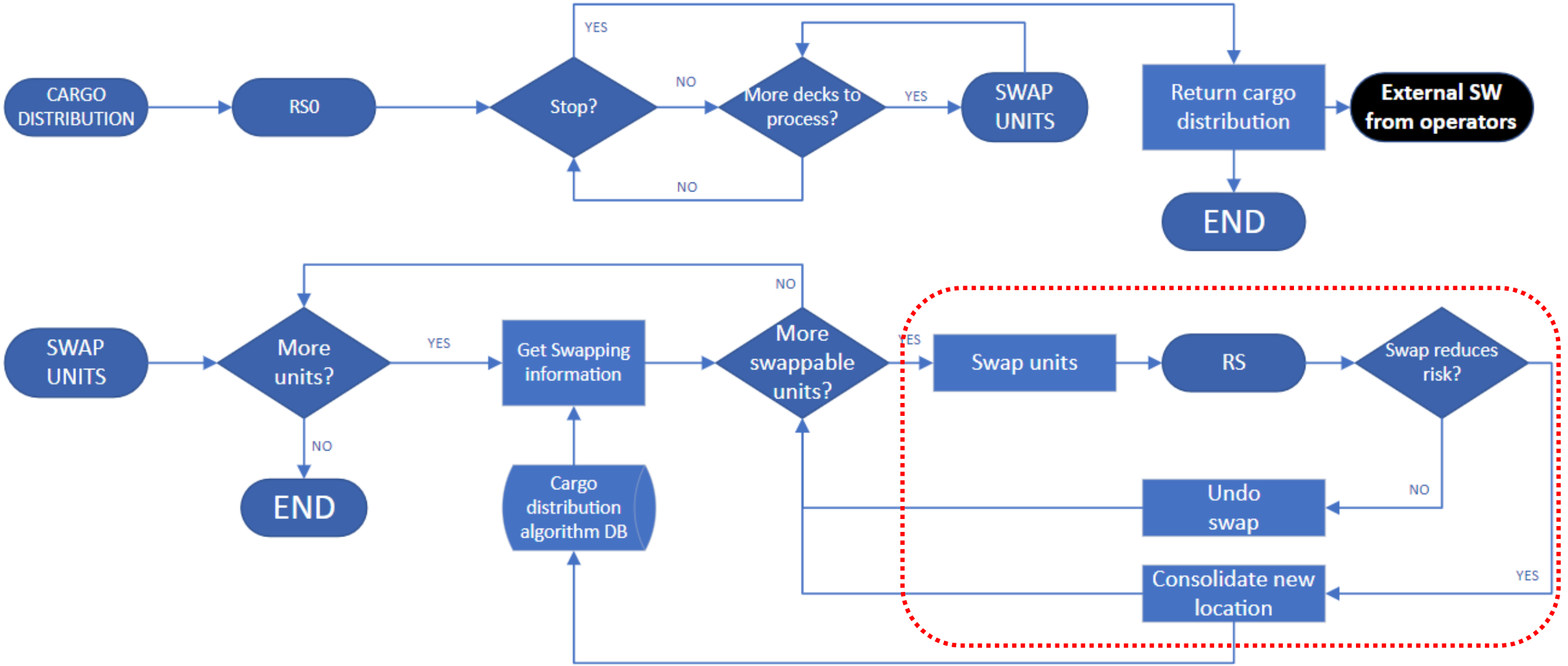


Scoring feature

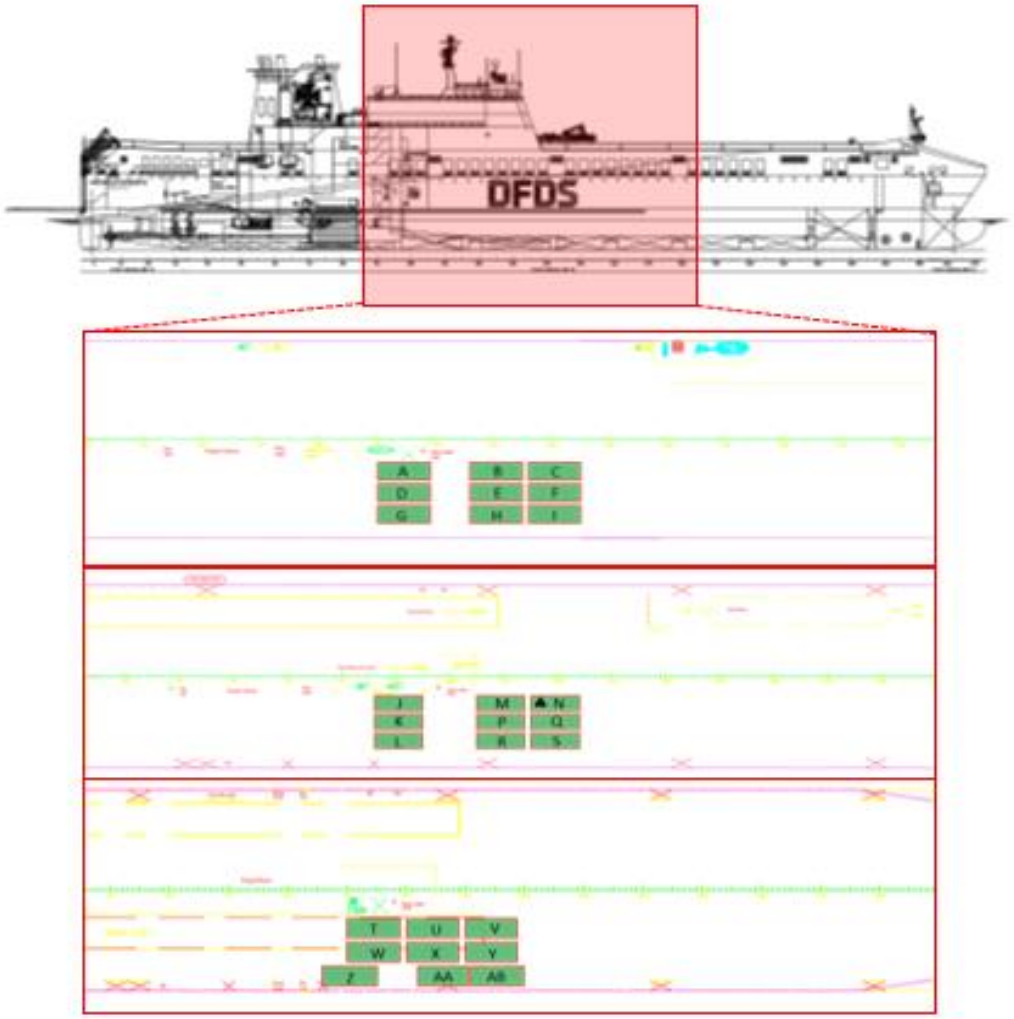




Cargo distribution feature



Cargo distribution feature



	#uid	Type	Deck	RSo	RS
A	4001	TRAILER	4	1	1
B	4002	CAR	4	2	3
C	4003	TRAILER	4	1	1
D	4004	CAR	4	2	3
E	4005	V	4	3	4
F	4006	TRAILER	4	1	1
G	4007	TRAILER	4	1	1
H	4008	TRAILER	4	1	1
I	4009	TRAILER	4	1	1
J	3001	TRAILER	3	1	1
K	3002	TRAILER	3	1	1
L	3003	TRAILER	3	1	1
M	3004	TRAILER	3	1	1
N	3005	TRAILER(2.2)	3	2	3
P	3006	V	3	3	4
Q	3007	CAR	3	2	3
R	3008	TRAILER	3	1	1
S	3009	TRAILER	3	1	1
T	2001	TRAILER	2	1	1
U	2002	TRAILER	2	1	1
V	2003	TRAILER	2	1	1
W	2004	TRAILER	2	1	1
X	2005	TRAILER	2	1	1
Y	2006	TRAILER	2	1	1
Z	2007	TRAILER	2	1	1
AA	2008	CAR	2	2	3
AB	2009	V	2	3	4

Deck		Id Unit RS0		RS
13	4 16	4001 1 1	4002 2 3	4003 1 1
		4004 2 3	4005 3 4	4006 1 1
		4007 1 1	4008 1 1	4009 1 1
13	3 16	3001 1 1	3004 1 1	3005 2 3
		3002 1 1	3006 3 4	3007 2 3
		3003 1 1	3008 1 1	3009 1 1
12	2 14	2001 1 1	2002 1 1	2003 1 1
		2004 1 1	2005 1 1	2006 1 1
		2007 1 1	2008 2 3	2009 3 4

Cargo distribution feature

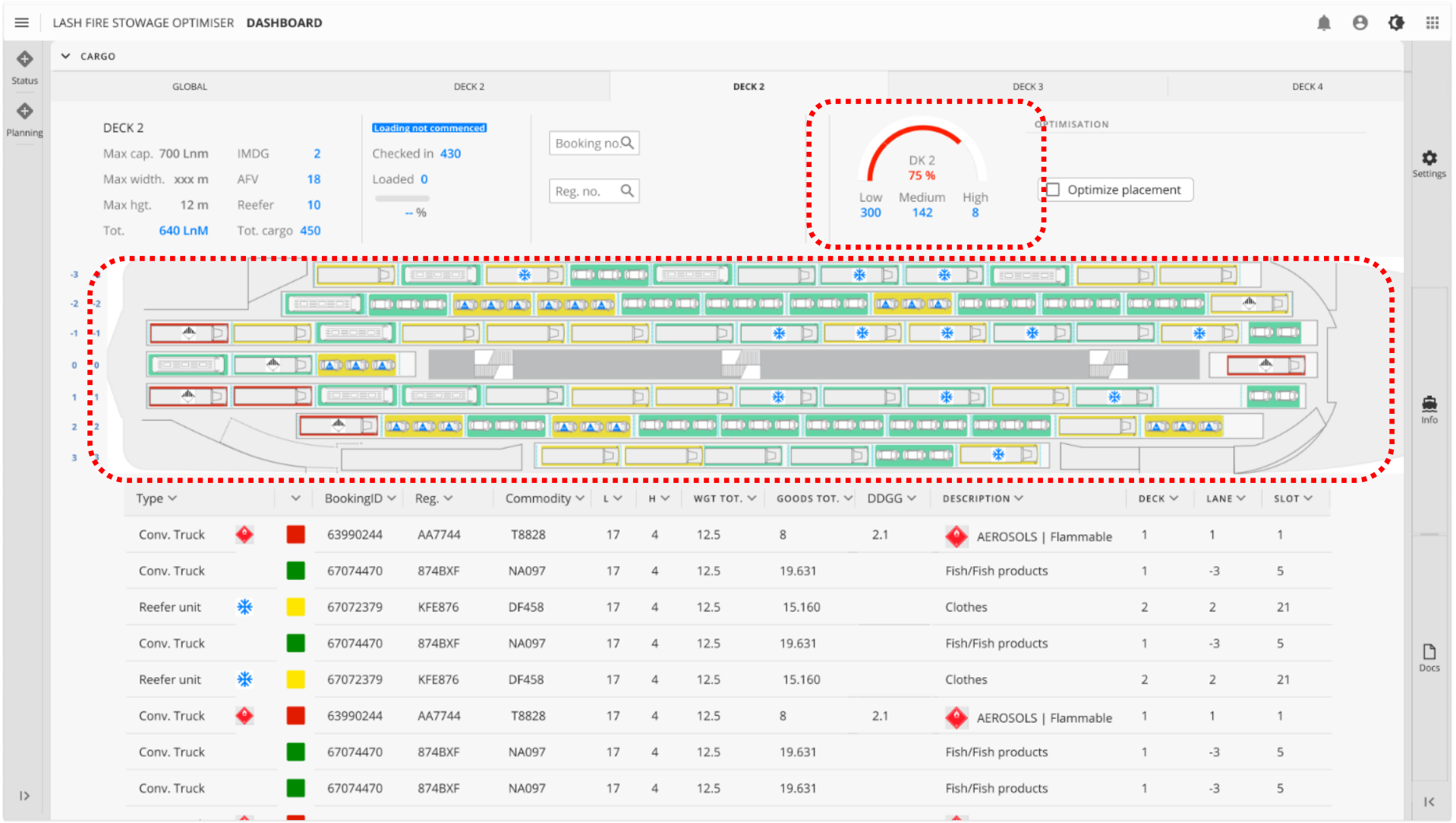
Deck		Id Unit RS0		RS
		4001	4002	4003
		1 1	2 3	1 1
	4	4004	4005	4006
13	16	2 3	3 4	1 1
		4007	4008	4009
		1 1	1 1	1 1
		3001	3004	3005
		1 1	1 1	2 3
	3	3002	3006	3007
13	16	1 1	3 4	2 3
		3003	3008	3009
		1 1	1 1	1 1
		2001	2002	2003
		1 1	1 1	1 1
	2	2004	2005	2006
12	14	1 1	1 1	1 1
		2007	2008	2009
		1 1	2 3	3 4

Deck		Id Unit RS0		RS
		4001	4007	4009
		1 1	1 1	1 1
	4	4006	4003	4004
13	13	1 1	1 1	2 2
		4005	4008	4002
		3 3	1 1	2 2
		3006	3004	3005
		3 3	1 1	2 2
	3	3002	3009	3001
13	13.5	1 1	1 1	1 1
		3003	3008	3007
		1 1	1 1	2 2.5
		2004	2002	2003
		1 1	1 1	1 1
	2	2007	2005	2006
12	12.25	1 1	1 1	1 1
		2008	2001	2009
		2 2	1 1	3 3.25

```
Execution finished in 0.0018203258514404297 seconds
PS G:\TEMP\LASHFIRE\SW> & "C:/Program Files/Python311/python.exe" g:/TEMP/LASHFIRE/SW/la
initialization of module: db
Connection successfully
end initialization of module: db
initialization of module: error
end initialization of module: error
initialization of module: cfg
{'Parameters': {'Service': 'Distribution', 'ServiceDescription': 'Distribution', 'Ship':
ror': 0.4, 'Sep_X': 6, 'Sep_Y': 3, 'IsTest': True, 'timeout': 2000, 'IdTest': 'T3_5'}}
end initialization of module: cfg
initialization of module: input
Read 27 units...
Found 0 invalid units. Units being removed:
Found 27 valid units: 4001 4002 4003 4004 4005 4006 4007 4008 4009 3001 3002 3003 3004 3
2005 2006 2007 2008 2009
setCargoUnits::Transaction executed successfully!
end initialization of module: input
Now accessing entrypoint for use cases...
Implementation of CARGO DISTRIBUTION use case
insertService::Transa
Service: Distribution
Starting RS0 calculat
units read from CARGO
units written to SERV
moveUnitsToServiceUni
Setting RS0 values...
Starting RS calculation stage...
setINIT_RS::Transaction executed successfully!
Loop for deck 2 starts
Loop for deck 3 starts
Loop for deck 4 starts
End of iteration 1
Cargo distribution STOP: timeout expired
INIT_RS: 46.0 --> After cargo distribution: 38.75
updateService::Transaction executed successfully!
Generating output files...
Execution finished in 38.61000466346741 seconds
```


```
INIT_RS: 46.0 --> After cargo distribution: 38.75
updateService::Transaction executed successfully!
Generating output files...
Execution finished in 38.61000466346741 seconds
```

Visual Interface



Conclusions

- The software has been successfully tested when it comes to the implementation of the scoring feature and the subsequent cargo distribution in order to reduce the overall risk in terms of that score value as an application of the risk assessment based on historical data.
- Due to heterogeneous taxonomies and formats of the data sources and lack of public availability, periodic updating of the data that involves the risk assessment is not easy.
- Except for Dangerous Goods, there is a lack of detailed information concerning the cargo, which prevents the development of more sophisticated risk assessment of the units and, therefore, a cargo distribution with less risk.
  - Integration with a fire propagation simulation model
  - Distribution of units so that they create kind of barriers in case of an eventual ignition
- The software can provide accurate information of the location of certain cargo type, which is a very useful information for fire-fighting
- The maximum benefit in terms of risk reduction comes when final cargo distribution matches the loading plan proposed by the software. However, the arrival profile of the units is unknown, situation which drives to continuous changes over the optimum distribution and to a final distribution that probably has higher risk than the initially generated.

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francisco.rodero@upc.edu

Thank you!

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