



Analisa Risiko Lalu Lintas Kapal dan Bahaya Navigasi dalam Rencana Penetapan Alur-Pelayaran

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FGD Penyusunan Juknis Penetapan Alur-Pelayaran di Tersus/TUKS

Outline



- 1. Peraturan yang Relevan
- 2. Sistem Rute berdasarkan IMO
- 3. Formal Safety Assessment
- 4. Identifikasi Bahaya: Tubrukan dan Kandas
- 5. Pemanfaatan data AIS
- 6. Penilaian Risiko dengan IWRAP
- 7. Dampak Lingkungan: Tumpahan Minyak
- 8. Perencanaan AtoN/SBNP

Peraturan yang Relevan



- Peraturan Menteri Perhubungan Nomor PM 129 Tahun 2016 tentang Alur-Pelayaran di Laut dan Bangunan dan/atau Instalasi di Perairan sebagaimana telah diubah dengan Peraturan Menteri Perhubungan Nomor PM 40 Tahun 2021
- Peraturan Menteri Perhubungan no. 25 tahun 2011 tentang Sarana Bantu Navigasi-Pelayaran
- International Convention for the Safety Of Life At Sea, 1974 (SOLAS) Chapter V Regulation 10 tentang Ships' Routeing
- IALA Guideline G1078 The Use of AtoN in the Design of Fairways and Channels

Kriteria Desain Sistem Rute berdasar IMO

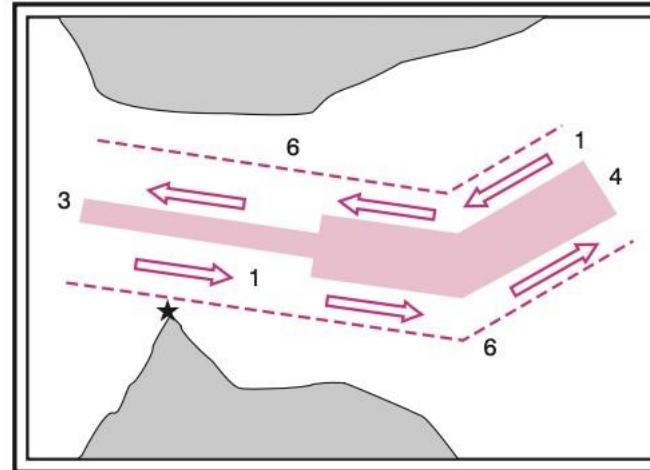


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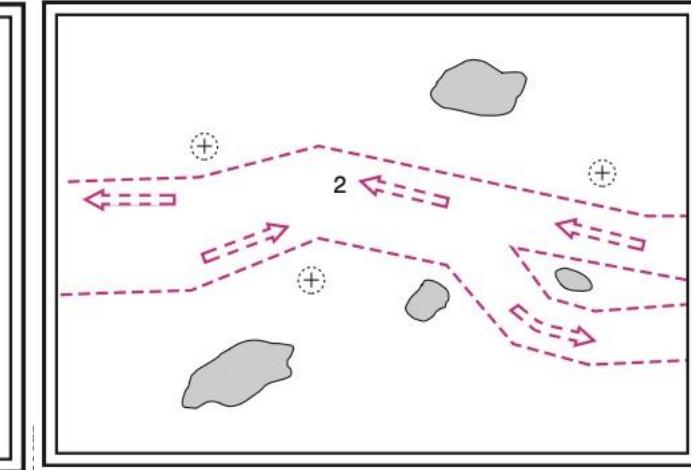
- Rute sebisa mungkin mengikuti pola alur pelayaran yang sudah ada di lokasi tersebut dan dapat ditentukan melalui *traffic survey*
- Perubahan arah sepanjang rute harus dibuat sesedikit mungkin dan harus dihindari saat mendekati area konvergensi dan persimpangan rute atau di mana lalu lintas penyeberangan diperkirakan akan padat
- Jumlah area konvergensi dan persimpangan rute harus dibuat sesedikit mungkin dan dibuat saling berjauhan
- Rute harus dirancang untuk mengoptimalkan penggunaan alat bantu navigasi di wilayah tersebut, dan alat bantu navigasi yang ada di kapal

Jenis Sistem Rute menurut IMO

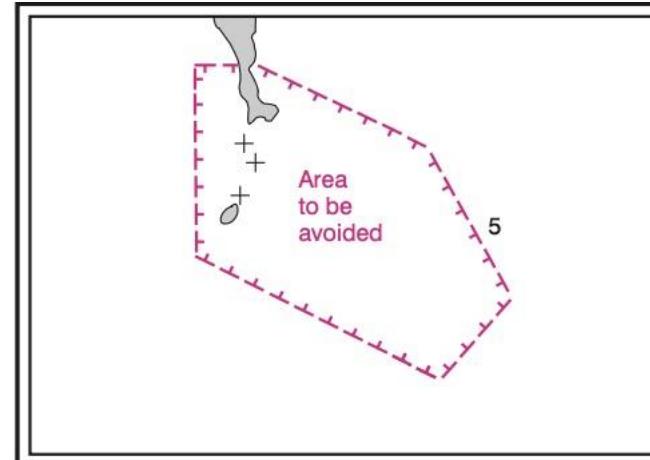
1. Traffic separation schemes
2. Two-way routes
3. Recommended tracks
4. Areas to be avoided
5. Inshore traffic zones
6. Roundabouts
7. Precautionary area, and
8. Deep-water routes



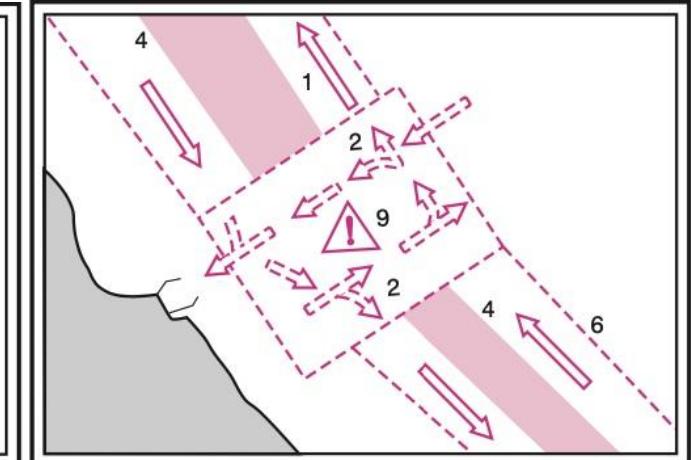
(1)



(2)



(4)



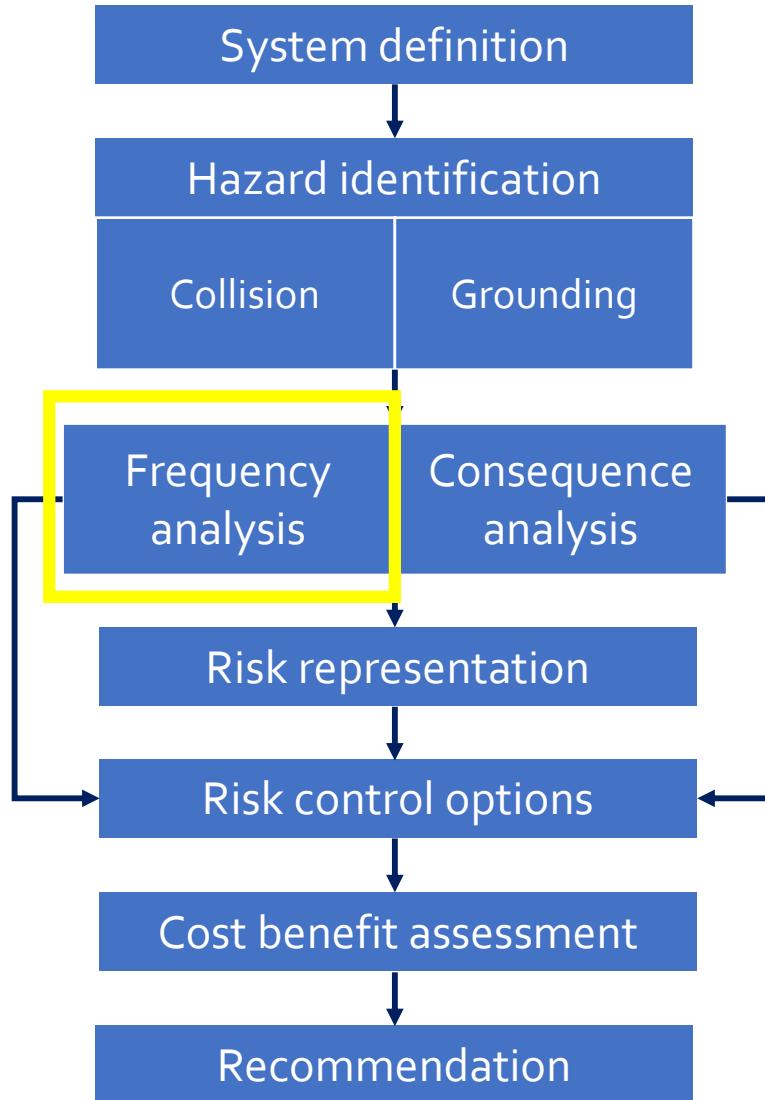
(7)

Formal Safety Assessment (FSA)

IMO MSC-MEPC.2/Circ.12/Rev.2



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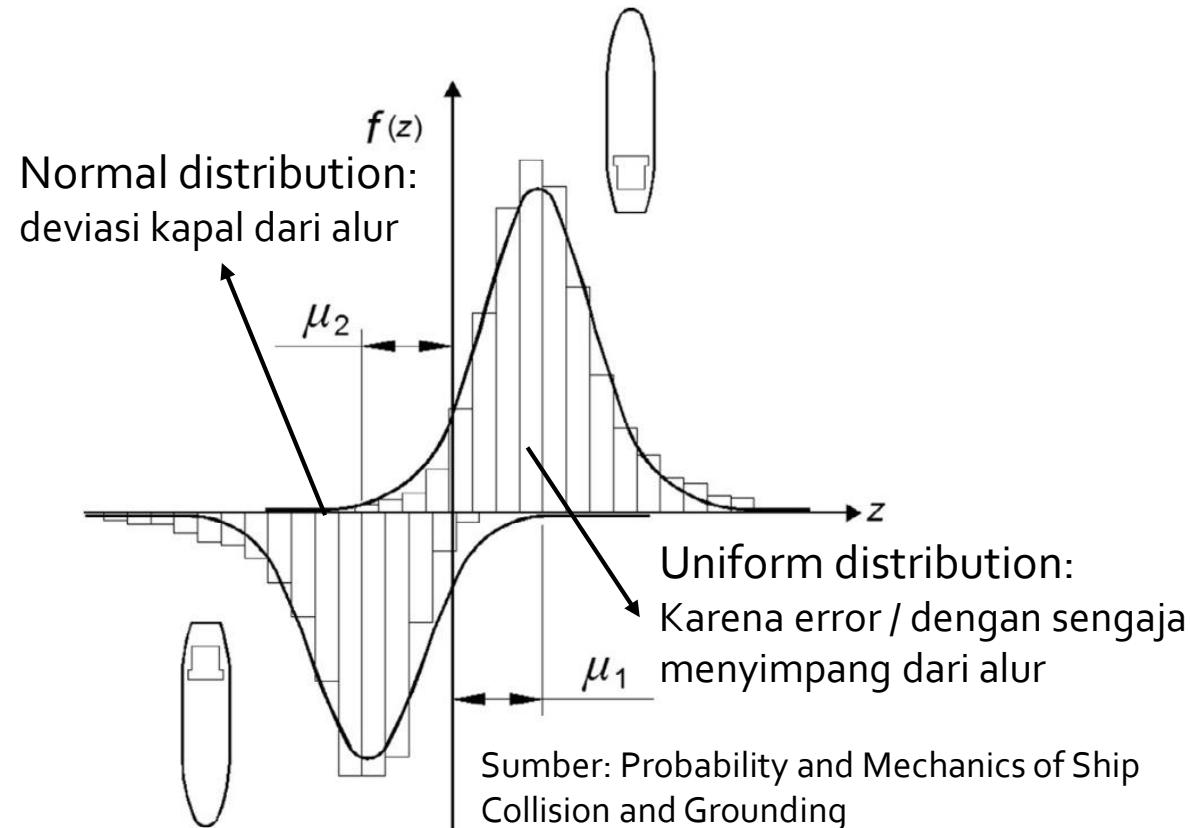
1. Pendefinisian sistem yang akan dianalisa → koordinat area yang akan dianalisa, data traffic, kondisi lingkungan (batimetri, hidro oseanografi, angin), histori kecelakaan, dll.
2. Identifikasi bahaya
Collision → collision along the route and crossing each others
Grounding → powered grounding and drifting grounding
3. Frequency analysis → IALA Waterway Risk Assessment Programme (IWRAP)
4. Consequence analysis: structural damage, environment, fatalities, etc.
5. Pendefinisian langkah mitigasi untuk mengontrol risiko (mengontrol frekuensi atau mengontrol konsekuensi)
6. Cost benefit assessment dilakukan untuk menilai RCO mana yang menghasilkan keuntungan tertinggi dengan biaya terendah
7. Pemberian rekomendasi kepada pembuat keputusan

Identifikasi Bahaya: Tubrukan

1. Collision along the route

- a. Head-on collision
- b. Overtaking collision

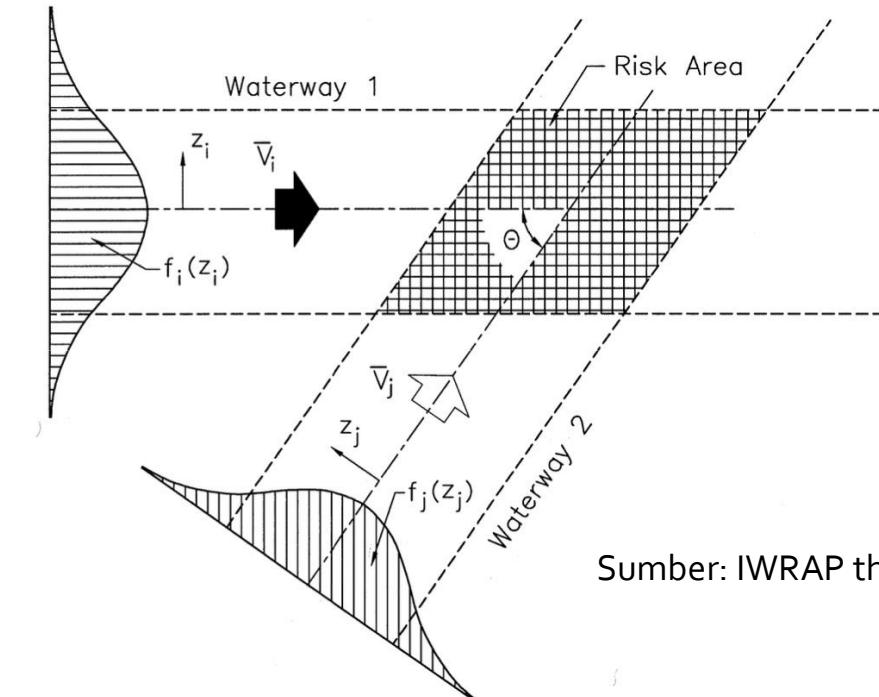
$$N_G^{\text{head-on}} = L_W \sum_{i,j} P_{G i,j}^{\text{head-on}} \frac{V_{ij}}{V_i^{(1)} V_j^{(2)}} (Q_i^{(1)} Q_j^{(2)})$$



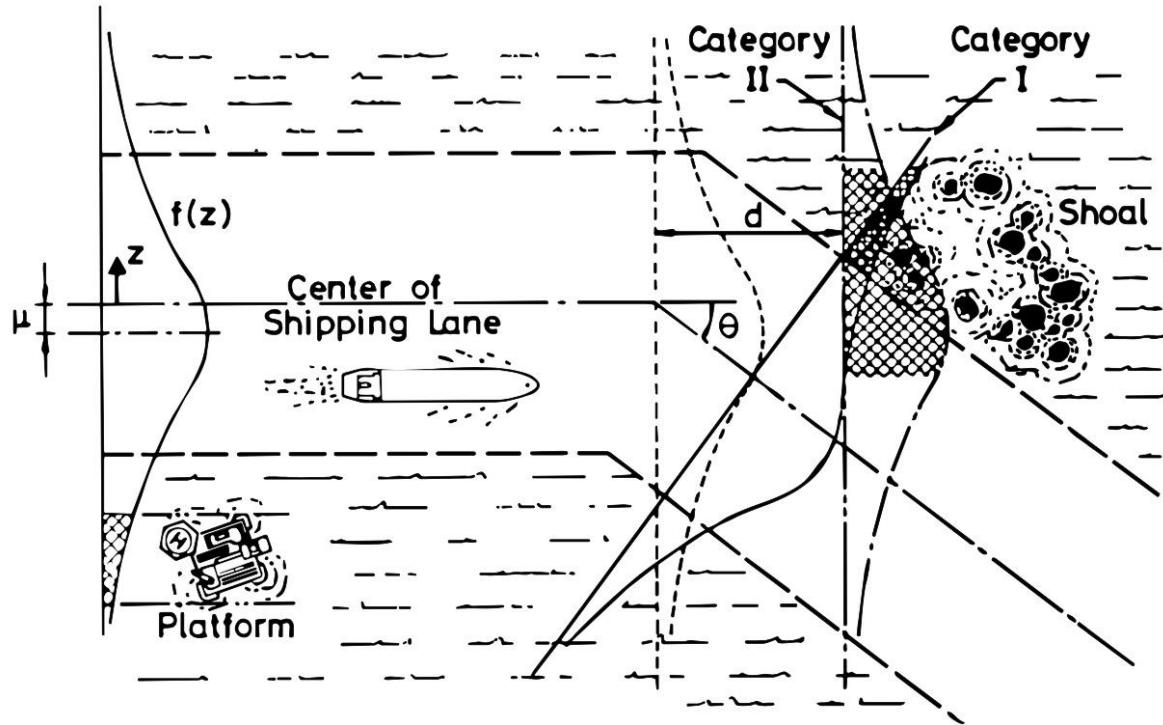
2. Collision when two routes crosses each other

- a. Crossing collision
- b. Merging collision
- c. Bending collision

$$N_G^{\text{crossing}} = \sum_{i,j} \frac{Q_i^{(1)} Q_j^{(2)}}{V_i^{(1)} V_j^{(2)}} D_{ij} V_{ij} \frac{1}{\sin \theta}$$



Identifikasi Bahaya: Kandas



Sumber: IWRAP theory

$$N_I = \sum_{\text{Ship class, } i} P_{c,i} Q_i \int_{z_{\min}}^{z_{\max}} f_i(z) dz \quad N_{II} = \sum_{\text{Ship class, } i} P_{c,i} Q_i \exp(-d/a_i) \int_{z_{\min}}^{z_{\max}} f_i(z) dz$$

$$N_{\text{grounding}}^{\text{drift}} = N_{\text{ship}} \int_{\psi=0}^{360} P_{\text{wind}}(\psi)$$

$$\sum_{\text{All segments}} P_{\text{blackout}}(L_{\text{segment}}) \int_{x=0}^{L_{\text{segment}}} \int_{\text{All } v_{\text{drift}}} P_{\text{no repair}}(t_{\text{ground}} | \mathbf{Z}) P_{\text{no anchoring}}(t_{\text{ground}} | \mathbf{Z}) f(v_{\text{drift}}) dv_{\text{drift}} dx d\psi$$

- Category I: Kapal mengikuti alur pada kecepatan normal. Kandas dapat terjadi karena human error atau permasalahan pada propulsi / steering system
- Category II: Kapal gagal merubah course pada turning point di dekat *obstacle*
- Category III: Kapal bermanuver menghindari *obstacle* pada jarak pendek
- Category IV: *Loss of propulsion*

IWRAP

- Powered grounding: mesin kapal menyala
- Drifting grounding: mesin dalam keadaan mati dan kapal hanyut

IALA Waterway Risk Assessment Program (IWRAP)



IWRAP merupakan software untuk menghitung frekuensi tabrakan dan kandas yang direkomendasikan oleh IMO yang tercantum dalam IMO SN.1/Circ.296 year 2010.

General

$$\text{Risk} = P \times C$$

IWRAP

$$\text{Collision Freq } (\lambda) = P_c \times N_g$$

Pc = causation factor, Ng = geometric number of collision candidate

Traffic Volume Distribution Editor - North Bound																
Data Item:		Traffic Volume Distribution: TD_100														
		Crude oil tanker	Oil products tankers	Chemical tanker	Gas tanker	Container ship	General cargo ship	Bulk carrier	Ro-Ro cargo ship	Passenger ship	Fest ferry	Support ship	Fishing ship	Pleasure boat	Other ship	Sum
0-25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
25-50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
50-75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
75-100	0	7	0	0	0	0	3	0	0	0	0	0	0	0	10	
100-125	0	19	0	0	0	0	4	0	0	0	0	0	0	1	24	
125-150	0	1	0	0	0	0	3	0	0	0	0	0	0	0	4	
150-175	0	1	0	0	0	0	1	0	0	0	0	0	0	0	2	
175-200	0	25	0	0	0	0	0	0	0	0	0	0	0	0	25	
200-225	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
225-250	0	4	0	0	0	0	0	0	0	0	0	0	0	0	4	
250-275	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
275-300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
300-325	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
325-350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
350-375	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
375-400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
400-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Sum	0	57	0	0	0	0	11	0	0	0	0	0	0	1	69	

Traffic volume distribution pada Leg 63



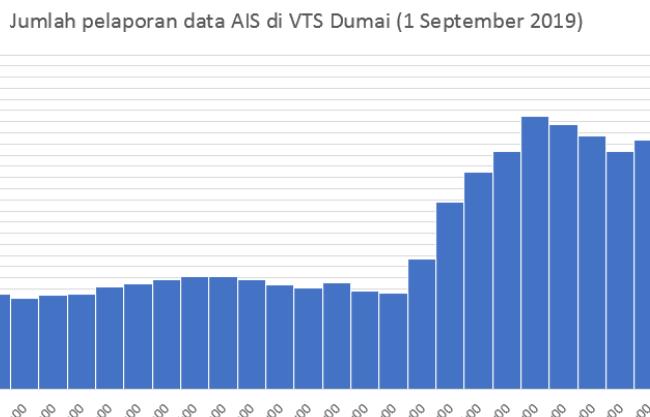
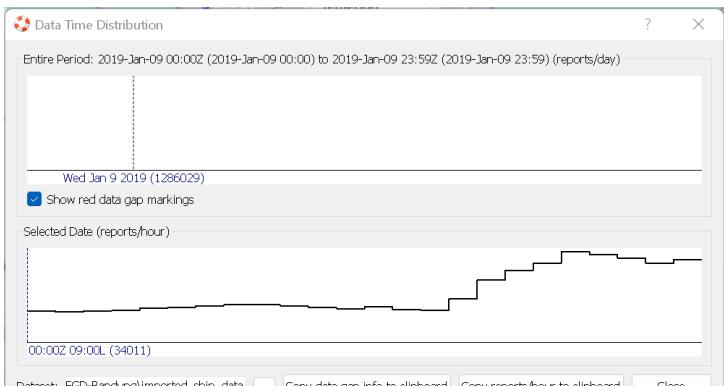
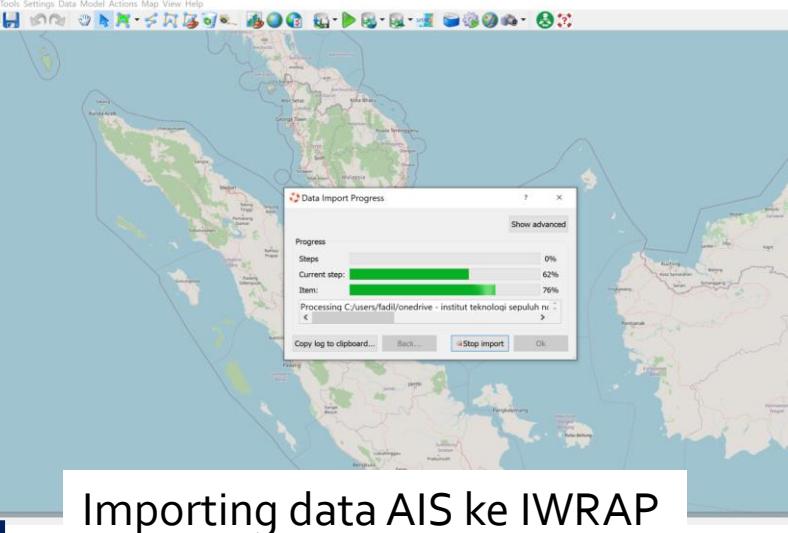
Mendefinisikan leg di IWRAP

Traffic Data: AIS data

Data AIS adalah data yang krusial

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Data AIS format NMEA

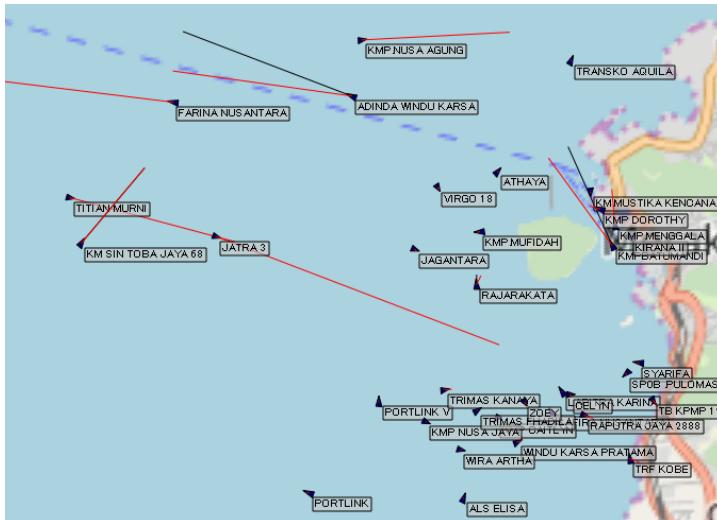
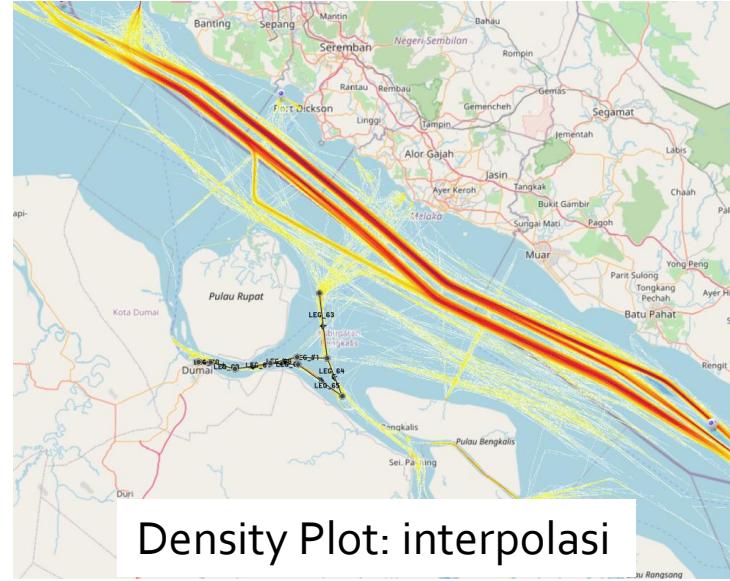
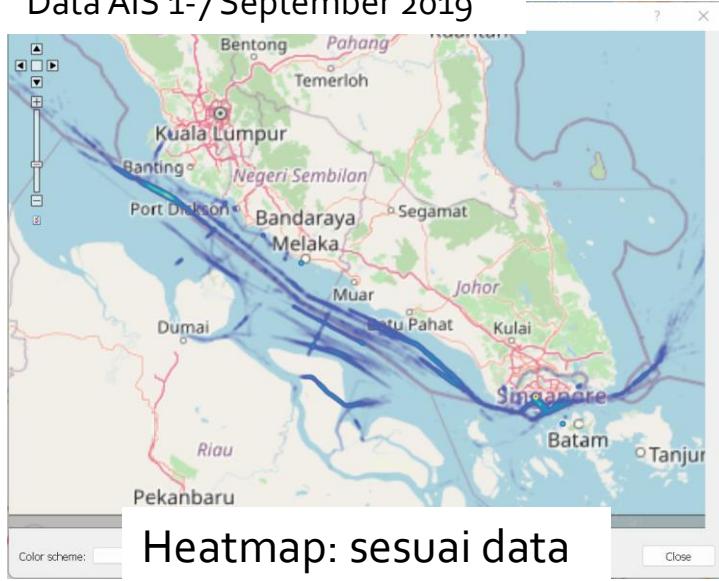


FGD Penyusunan Juknis Penetapan Alur-Pelayaran di Tersus/TUKS

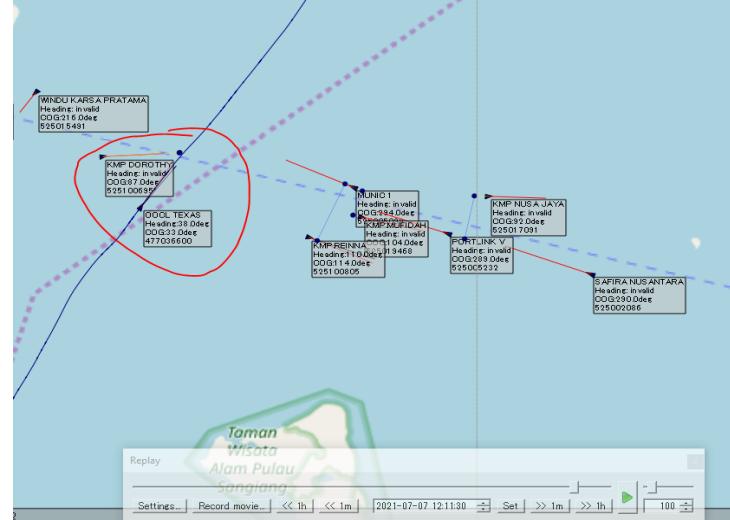
AIS database	
Static data	
1) MMSI	
2) Vessel name	
3) Vessel type	
4) Callsign	
5) Gross tonnage	
6) Deadweight tonnage	
7) Length	
8) Breadth	
9) Draught	
10) Flag	
11) Year built	
12) Classification society	
Dynamic data	
1) Timestamp	
2) Latitude and longitude	
3) Rate of turn	
4) Speed over ground	
5) Course over ground	
6) Heading	

Traffic Data: AIS data

Data AIS 1-7 September 2019



Vessel trips #1



Vessel trips #2

Data yang bisa diekstrak:

- Vessel information
- Vessel categories
 - Panjang kapal
 - Tipe kapal
- AIS Data gap
- Rute kapal
- Jumlah kapal/jumlah trip
- Vessel encounters



Penentuan leg
dan waypoints

Metodologi Penilaian Risiko

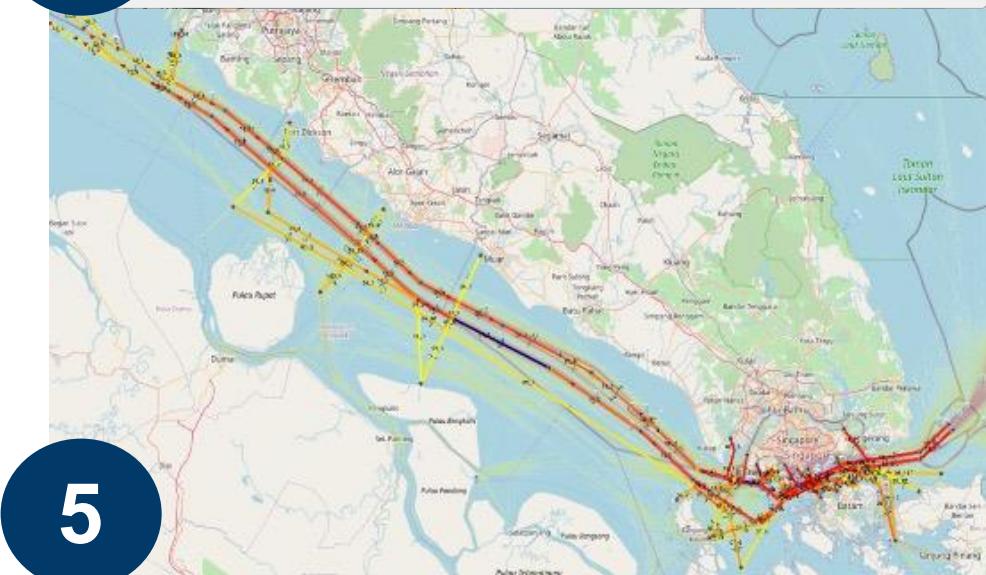
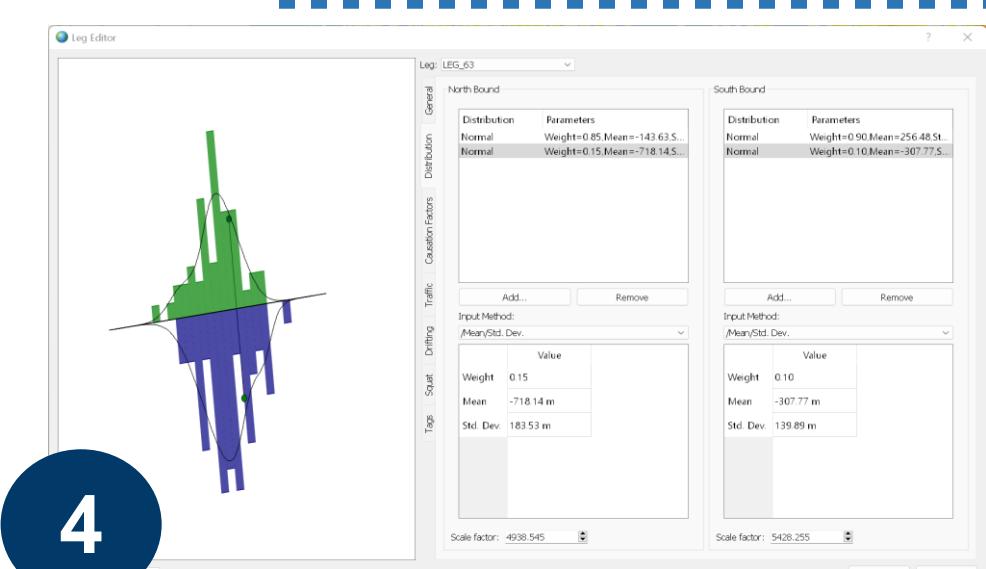
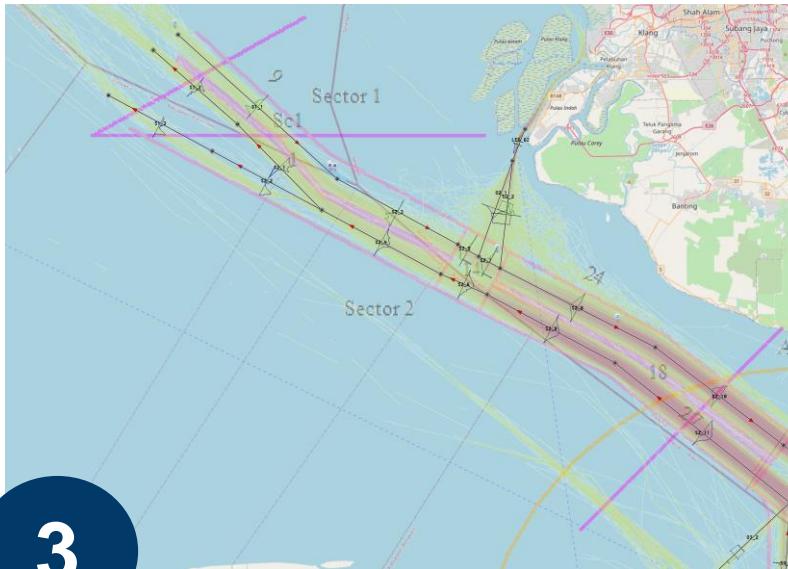
1
Traffic Data

2
Traffic Density Plot

3
Define Legs/Waypoints

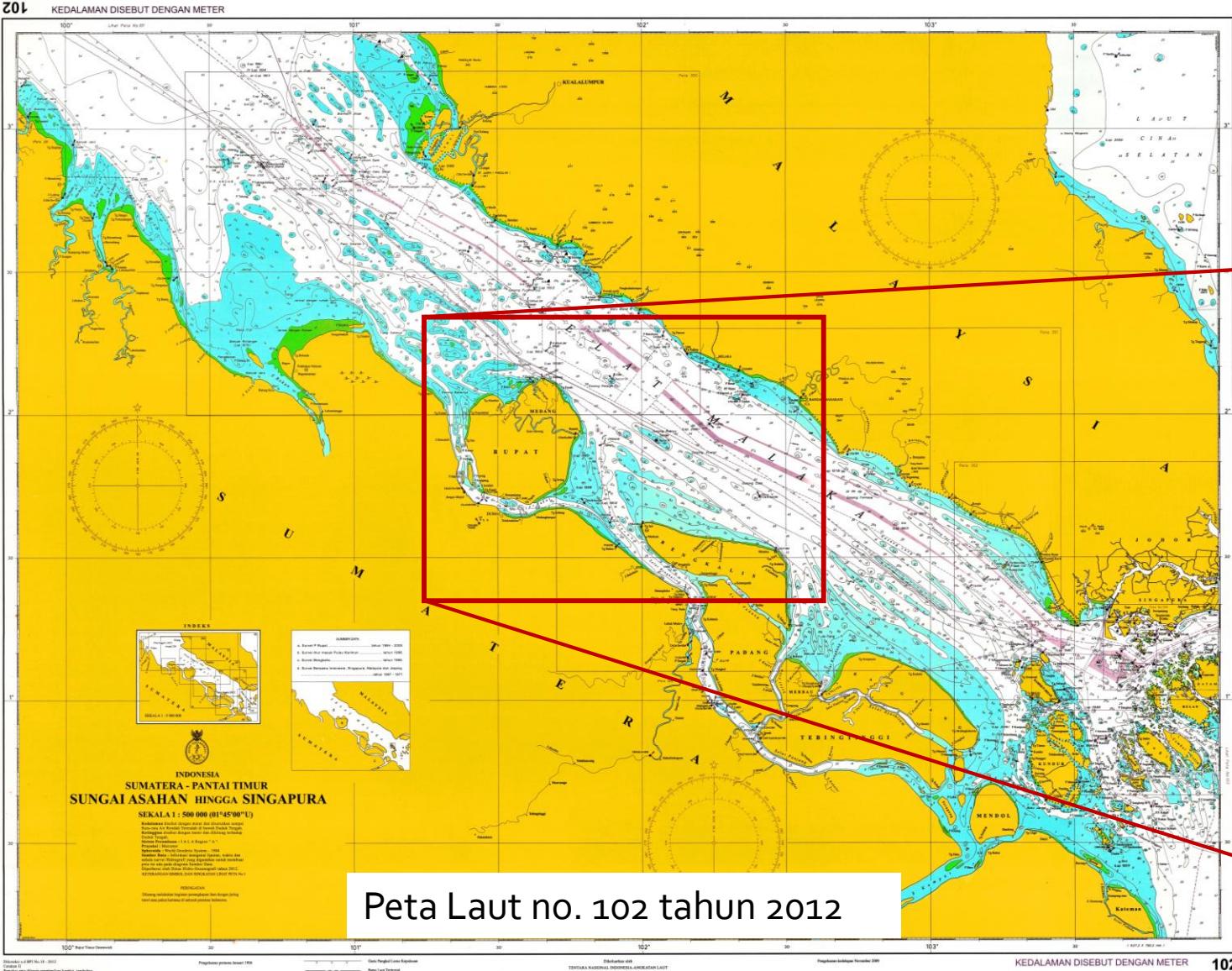
4
Lateral Distribution

5
Collision Frequency assessment

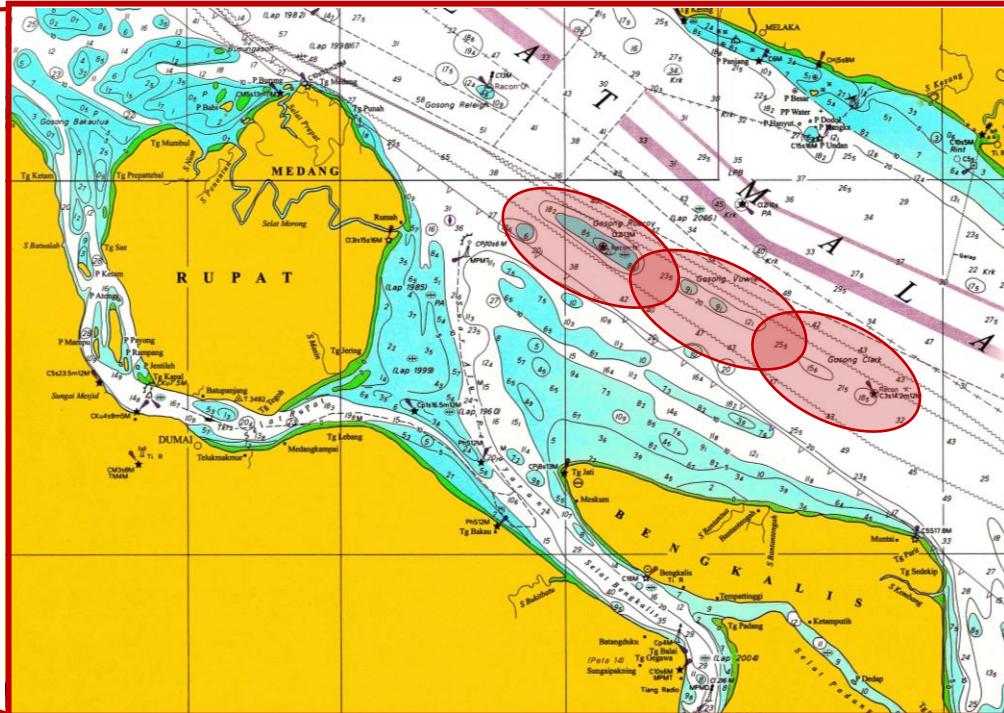


Bahaya Navigasi di Peta Laut

Segala hambatan pada perairan yang dapat membahayakan dan mengganggu kapal untuk bennavigasi, antara lain bangunan dan instalasi di perairan, kerangka kapal, karang, gosong, dan ranjau (PM no. 129 tahun 2016).

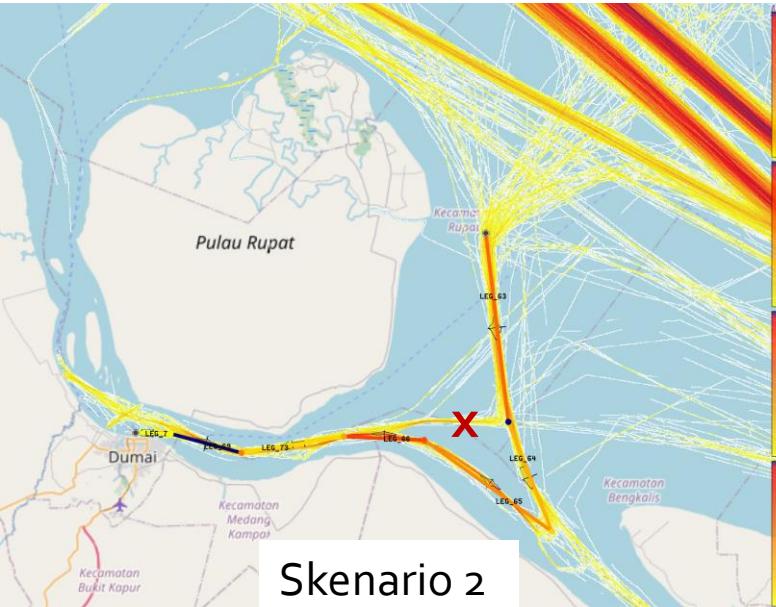
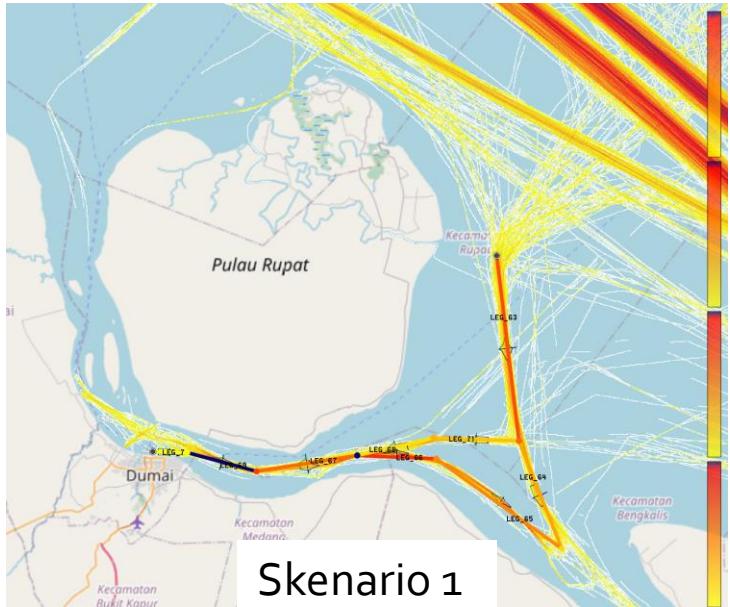


Peta Laut no. 102 tahun 2012



Gosong Robroy, Vowler, dan Clark

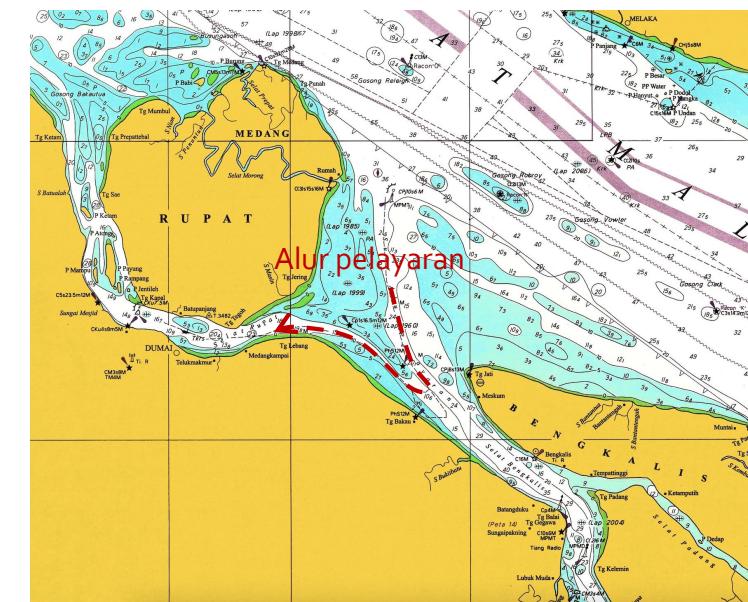
Risk Assessment dengan IWRAP MK II



Collision type	Annual frequency
Head-on	1.9376E-05
Overtaking	3.2064E-06
Crossing	9.7549E-08
Merging	4.0264E-07
Bending	6.5639E-06
Total	2.9646E-05

Collision type	Annual frequency
Head-on	1.7569E-05
Overtaking	2.5444E-06
Crossing	-
Merging	-
Bending	3.4054E-06
Total	2.3519E-05

Menghilangkan traffic di persimpangan (Leg71) dapat menurunkan frekuensi total tubukan sebesar 20%.



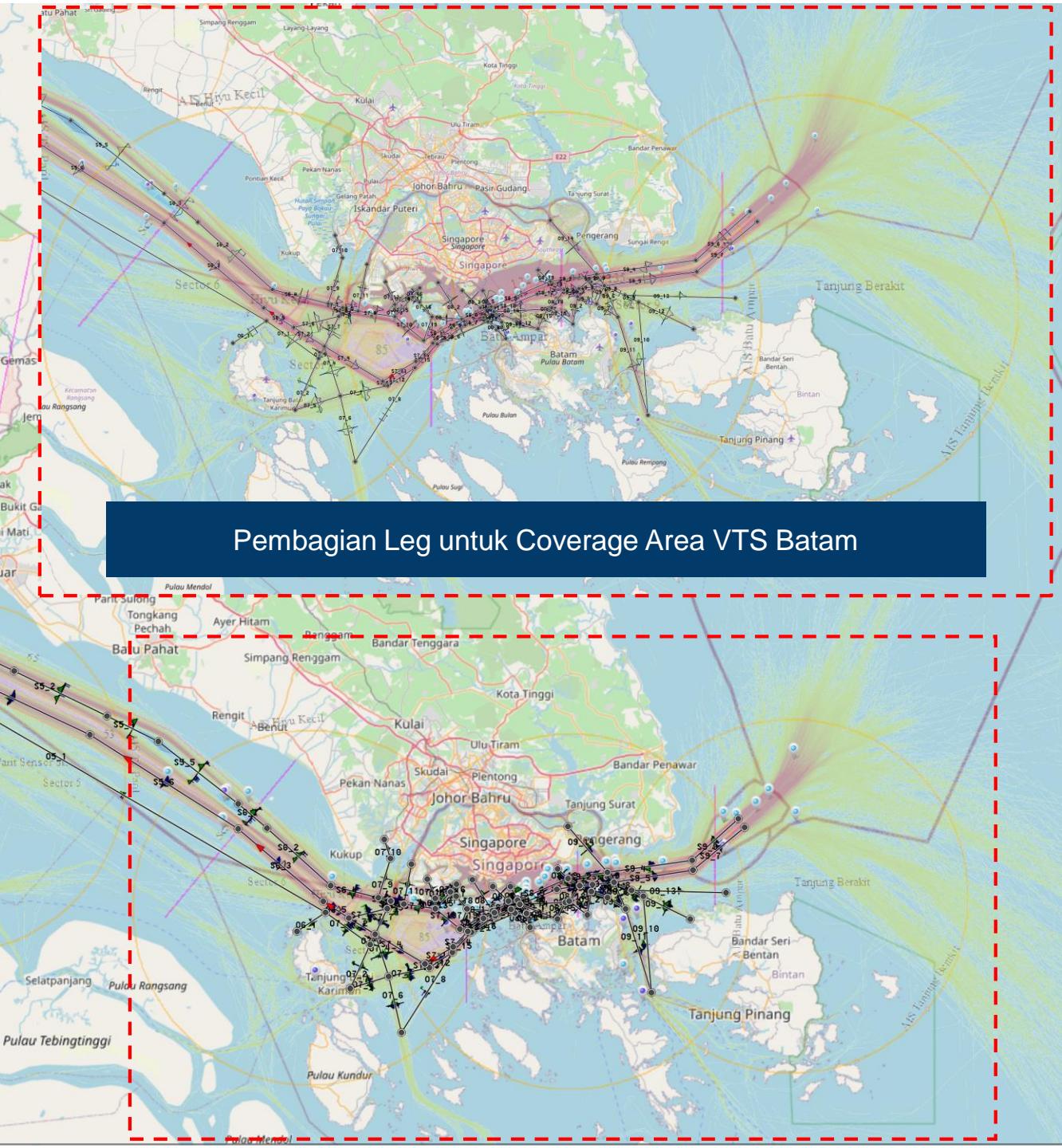
Collision Risk Assessment

AIS Data : 01-14 September 2019

Coverage : VTS Dumai dan VTS Batam

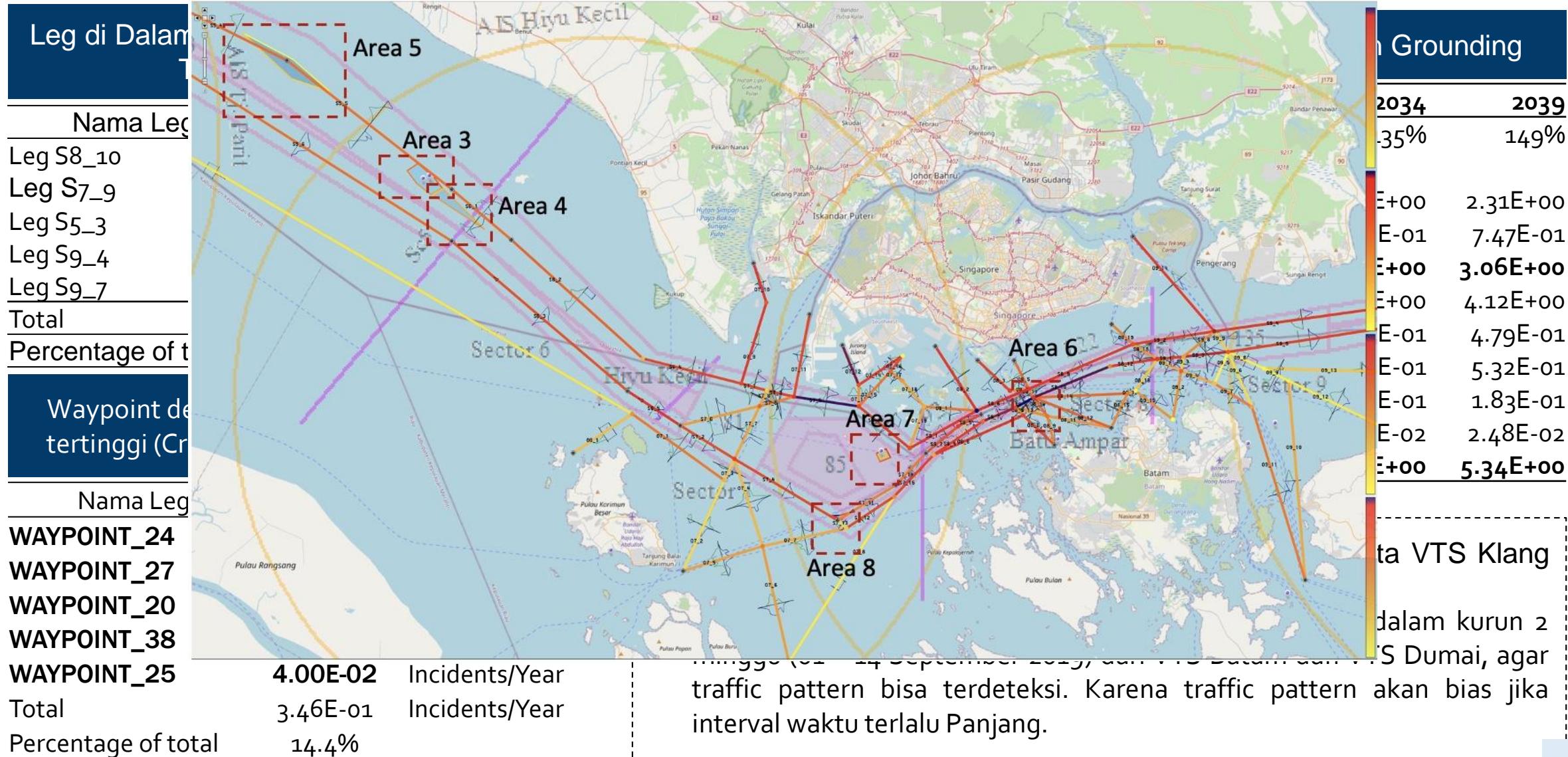


Pembagian Leg untuk Coverage Area VTS Dumai dan Batam



Pembagian Leg untuk Coverage Area VTS Batam

Risk Assessment dengan IWRAP MK II



Risk Assessment dengan IWRAP MK II

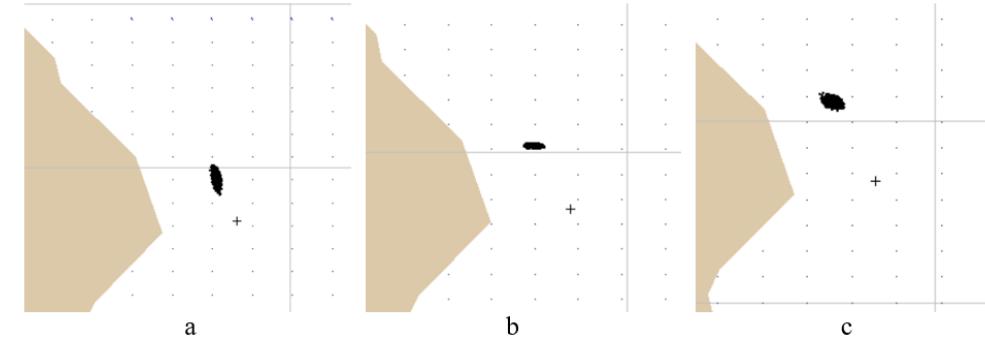


Dampak Lingkungan: Tumpahan Minyak

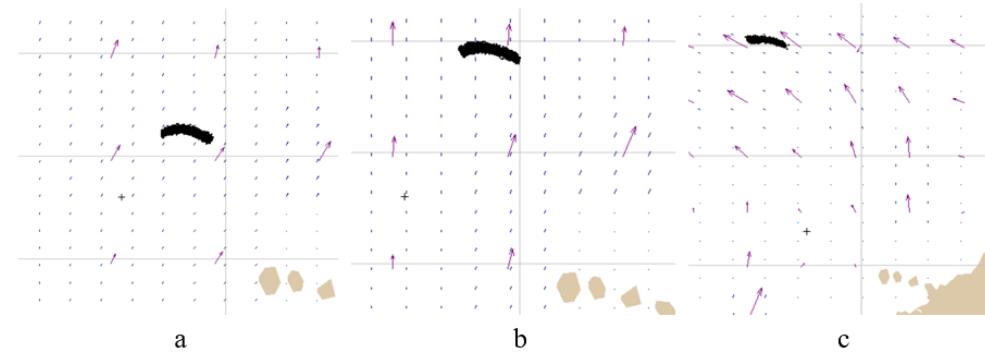
Faktor yang mempengaruhi persebaran tumpahan minyak (Hui, 2019):

1. Kecepatan dan arah angin
2. Kecepatan dan arah arus laut
3. Gelombang laut
4. Peleburan partikel minyak dengan air
5. Penguapan minyak ke udara
6. Kecenderungan lapisan minyak untuk menyebar walaupun pada air yang tenang

Simulasi dilakukan dengan software *General NOAA Operational Modeling Environment* (GNOME).



Hasil pemodelan tumpahan minyak dekat Nusa Penida setelah (a) 12 jam, (b) 24 jam, dan (c) 36 jam

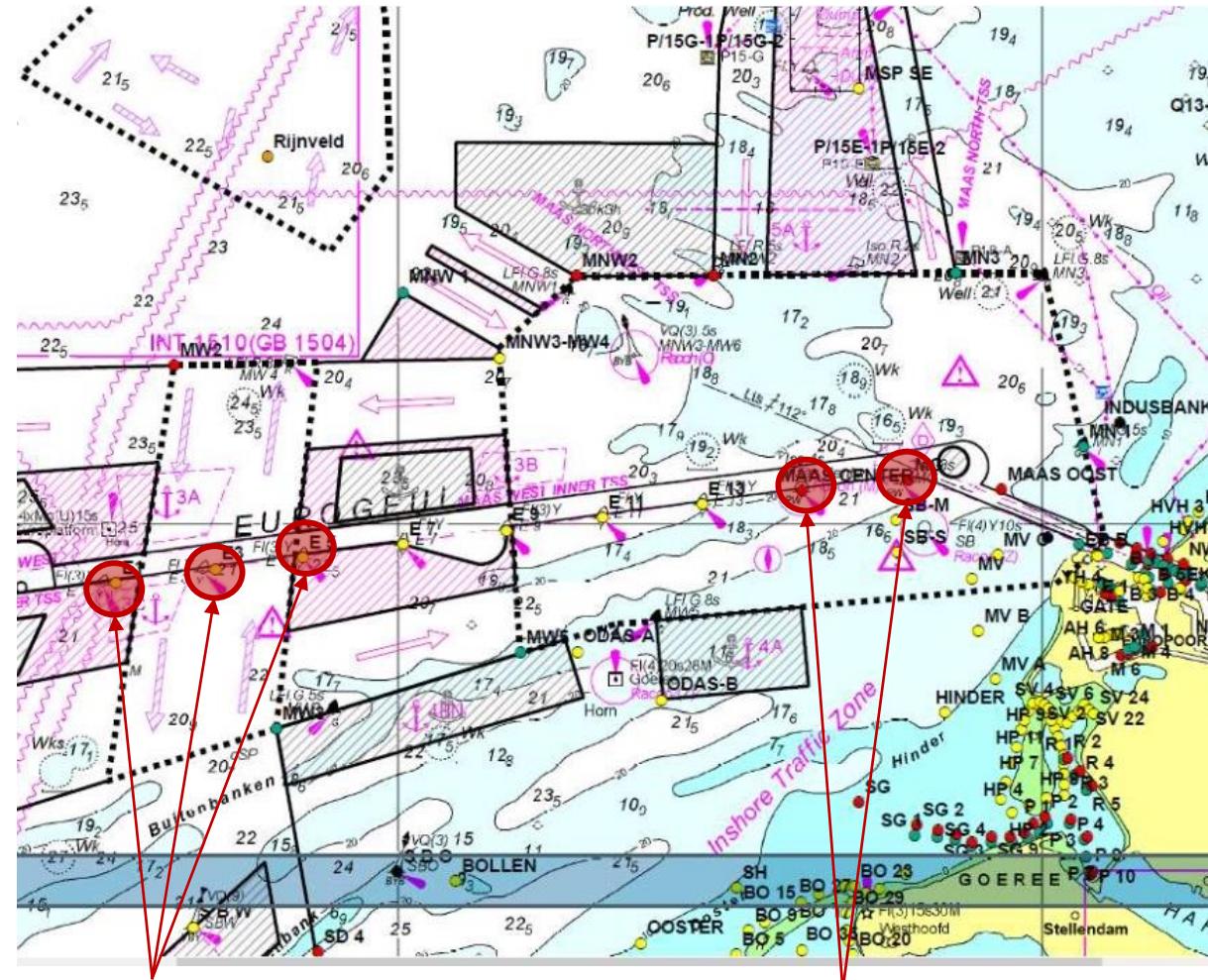


Hasil pemodelan tumpahan minyak dekat Kepulauan Gili setelah (a) 12 jam, (b) 24 jam, dan (c) 36 jam

Prosedur Peletakan AtoN

IALA Guideline G1078 The Use of AtoN in the Design of Fairways and Channels

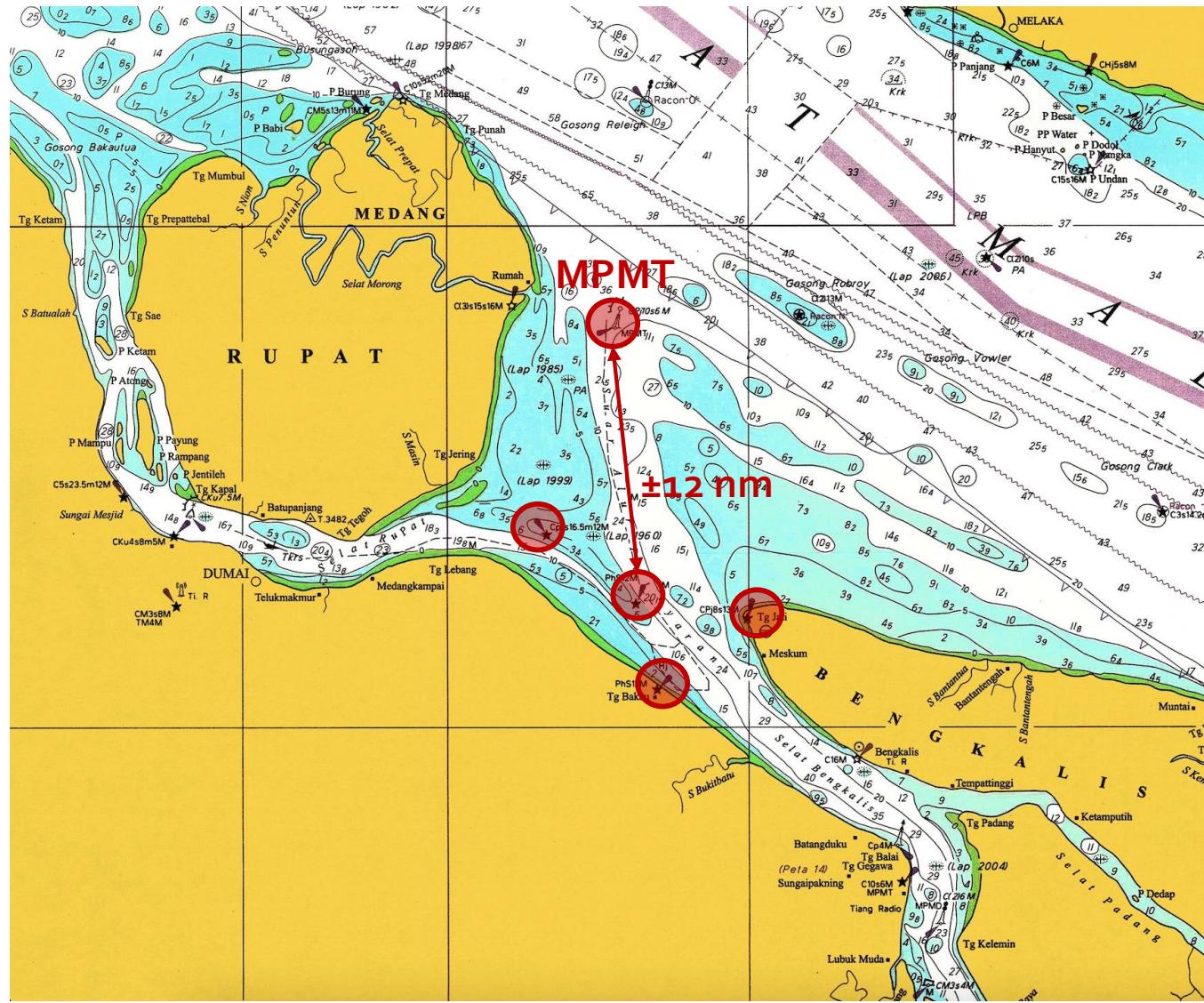
1. Tempatkan sebuah atau sepasang AtoN di awal saat memasuki alur
2. Tempatkan AtoN tambahan di titik-titik ketika:
 - a) Kapal harus merubah haluannya
 - b) Garis batas alur atau garis tengah alur memiliki belokan
 - c) Area kritis yang dangkal dan berbatu, atau bahaya lainnya menjadi batas luar dari alur
 - d) Alur berpotongan atau terpecah
3. Distribusikan AtoN pada titik-titik ini dengan memperhatikan jarak di mana mereka dapat dideteksi dan diidentifikasi
4. Jarak penempatan AtoN bisa berbeda tergantung panjang alur dengan syarat ketika pelaut sedang mendekati sebuah AtoN, setidaknya AtoN yang terletak setelahnya dapat terlihat dengan jelas.



Leading line to the coast of Netherlands
Distance apart: 3 nm

Safe water marks for Maas Center
and Ijmuiden Center

Perencanaan Peletakan AtoN



Geographic range of a light
(observer's height 2m above water level)

Height of the light above water	Geographic range in nautical miles
0m	2.9 nm
1m	4.9 nm
2m	5.7 nm
3m	6.4 nm
4m	6.9 nm

Ref: New Zealand Nautical Almanac (LINZ)

- Jarak dimana AtoN bisa dideteksi, dikenali, dan diidentifikasi disebut sebagai useful range.
- Faktor yang mempengaruhi useful range:
 - Karakteristik AtoN (tinggi, warna, bentuk, dll)
 - Pandangan manusia
 - Kondisi atmosfer (kabut, asap, cahaya)
 - Mencoloknya AtoN
- Useful range seharusnya lebih besar dari jarak antar AtoN

Referensi

- Director of Maritime New Zealand. 2019. Aids to navigation guideline.
- Friis-Hansen, P. 2008. IWRAP MK II Working Document. Technical University of Denmark.
- Hui, G. 2019. 'Modelling Oil Spilling on Water'
- IALA Guideline 1078. 2011. The Use of Aids to Navigation in the Design of Fairways.
- IMO. 2010. Ships' routeing. London: International Maritime Organization.
- Zhang, S., Pedersen, P.T., Villavicencio, R. 2019. Probability and Mechanics of Ship Collision and Grounding. Butterworth-Heinemann.