Chapter 6: Knowledge Base for Master

Figure

6 – 01 Grounding with no collision risk: Add one more effort in your routine

6-01 "one critical minute" unknown to most of us

Junior OOWs need to have knowledge, skill and instinct to handle one target encounter situation in 2-4 nautical miles range and avoid close quarter situation. Senior OOWs need to have knowledge, skill and instinct to handle multi-ship in close quarter situation (1-2 nautical miles) and familiar with best aid to collision avoidance. Masters need to have knowledge, skill and instinct to handle "Crash Astern", "rudder cycling" and "emergency maneuvering" situations within 0.5 to 1.0 nautical mile in multi-ship situation within a narrow channel or crowded anchorage or pilot station. The challenge for Junior OOW is knowledge base: target vessels is conducting normal navigation watch with steady speed and course. The challenge for Senior OOW is skill appliance: target vessels are conducting navigation watch within coastal waters while vessels come in many shape and size, some with unsteady speed and course. The challenge for master is endless in instinct reaction: target vessels are conducting varied speed and course within restrict visibility or narrow strait or harbour entrance, the briefing from OOW is not reliable or not correct, the evaluation time of situation may reduce to 30 seconds or 1 minute.

We said in last chapter there is "one critical minute" in ship's handling. When this critical minute will appear in middle of our efforts or mess to solve the case is unknown to most of us? We can only image from closely related scenes and cultivate from vague clues we had to summarize something might be useful in ownship. In mid of those maneuvering periods, our anxiety, tension, pressure and fear accumulated from one source: uncertainty, not knowing what is right or wrong, what will happen next, have I met or imagined of this scene before? These things won't happen in our every day's work. Some captains are preferring to observe cloud pattern change above sky or high low pressure interchange in weather chart which are fascinating and charming. Few of them can summarize a low pressure system triangle to predict the weather. It's like teas and flowers on our table, easy to grasp, good in taste and smell, even colorful and elegant.

When we review again what had happened in Sanchi case, in OOW level they can easily overlook a simple situation. In senior OOW level, they don't know full set of visual lookout skill and have no idea of what is best aid to collision avoidance. We are Captain who been look upon by the crew to handle all risks at sea for them. It is life or death matter. How can we ignore the call from the duty? When you think you are enough, be prepared, here comes more for Captain.

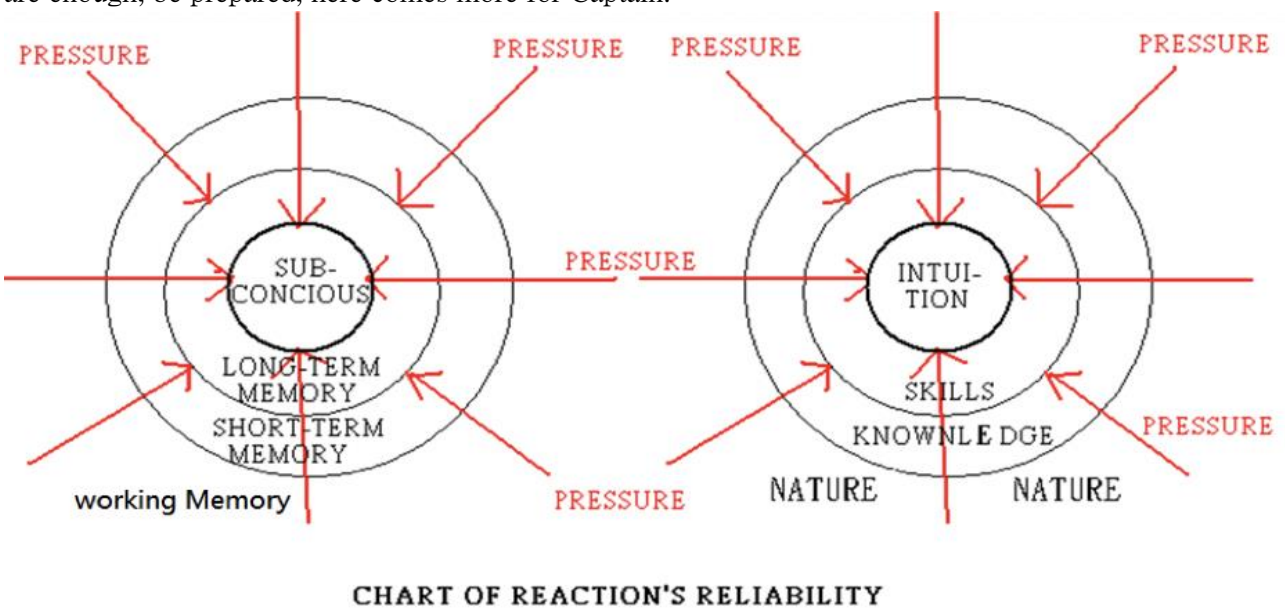

Figure 6-01: Memory structure and their response to pressure

6-02 "lapse of mind" in turning

After all these years' sea times we thought ourselves are competent captain. All of a sudden, we felt something is wrong but how to change it immediately is unknown. No action is never a choice. Wise man sailed, only fool stopped. Stop engine is the last option for many a case which C/E insisted. Everybody knows we are human not machine. Actually, we are not so much difference from machine. Our reactions in daily routine is mostly habitual unconscious not rational decision and more often is an emotional feeling. This conclusion is derived from our short term memory limitation as figure 2-11 working memory test. Habits is unconscious when we are walking we did not think about how to move the legs. Knowing the shortest route to office is our rational decision. But we cannot help to detour to Botanic Garden route just to feel the Spring in the air. Who care about lost time and sore legs we would have. This is our unpressured or little pressured life. When something is wrong with some penalty to pay we feel depressed and like to have some way to change.

Our pressure comes from many ways: physical, mental or situational. Seaman's life follows the cargo flow. Many ship types are designed to quick turn around to save owner's capital cost like containers ship, car carrier, ferry boat and feeder vessel. These services may work around the clock cause seaman physical burden and accumulated day after day, chronic fatigue: *is a disorder characterized by extreme fatigue or tiredness that doesn't go away with rest and can't be explained by an underlying medical condition*. Common cause for seaman chronic fatigue are sleep deprivation, not enough sleep interval by routine works or extra overtime due to vessel's condition worsen. Our mental burden may come from our boss, works, studies or family far away. If we feel the pressure we can cope with it by our continuous improvement process. When we are young we thought pressure are normal to life. The symptom of chronic distress slows us down in our daily watch. In real case, most amazing accident is unconscious "lapse of mind" when everything seems under control. Suddenly the habitual reaction lost, sea is the sea and ship is the ship, everything is irrelevant anymore. We have no feeling of the work at hand everything around us are just like an afternoon tea party with flowers, cakes and peace. The lapse time may last 5 or 10 seconds only. We just go blank in mind. Our routine job suspends and ignore risk sign we sought.

Vessel go aground outbound: One experienced Captain disembarked pilot just before Break water entrance. Mr. pilot advised captain" there is no vessel inbound. Just turn starboard at break water entrance to align with the outbound channel. Good Bye Captain". 3/O lead pilot the way to pilot station and report his disembark. Captain conned the ship approaching break water entrance then forgot to give rudder order. The smart 3/O also carried away by something else without reminding captain of the turn. After vessel passed B/W entrance, captain realized something is wrong. What captain can do in this situation? Should he execute crash astern? Not sure about where vessel will end inside the harbour. Can he drop anchor now? Without knowing turning basin diameter, is he capable of stopping or full rudder turn or rudder cycling to slow down the vessel or turn her 180 degrees? There is another break water entrance ahead with smaller channel connecting to outside of the harbor. Captain succeeded in this tight turning and go through this narrow break water entrance. But vessel go aground in this channel due to its for fishing boat use with less water depth which is not designed to navigate by Cargo ship. Captain had called this port many years without fail. If he has not forgot to turn it will be another smooth voyage. What should be his normal reaction with his experience did not support him in barely one minute is "lapse of mind", lost long term memory without obvious cause. Vessel grounded here and block the aircraft landing route near the harbor. Airport is close for 8 hours before this vessel removed from shallow water area.

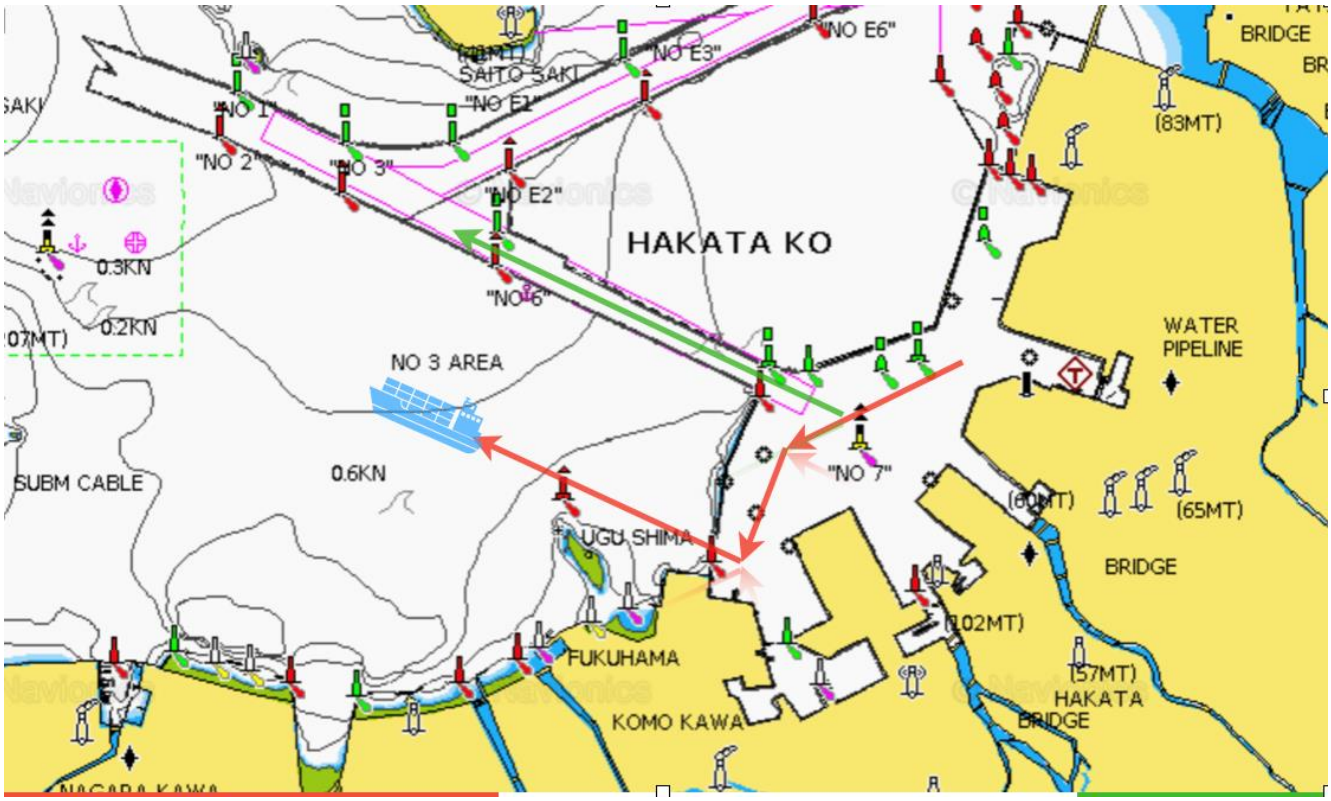

Figure 6-02: Lapse of mind in experienced Master

6-03 refer to authority in turning

In next example as figure 6-03, Vessel go aground inbound while pilot navigate with pilot boat leading the way. Before the turn of river, pilot give rudder order "Starboard 15" at 17:23:33 hours UTC to start the turn in wheel over position (left upper picture) and "Hard Starboard" at 17:25:25 hours UTC when the turn is approaching (left lower picture). All of a sudden, pilot found pilot boat leading the way ahead did not turning but going straight ahead because pilot boat did not see "south cardinal buoy" there (which is drifting away to northeast position, not shown at her charted position as our figure 6-03). Ship's heading is still 342^0 degrees(T) at 17:25:25 hours, not turning yet after 2 minutes wheel over. Pilot still remember his starboard side turn and order rudder angle to "Hard Starboard" to increase the turn. But pilot boat did not turn to starboard side who should I trust at this time? The straight going pilot boat did not have any confirmation with Mr. pilot or himself who had given two correct rudder orders and familiar with the turn here is to be trusted? The instinct of pilot is to trust others. Maybe pilot had these unconscious mistakes or carried away sometimes before and saved by pilot boat's help? Maybe it is still OK pilot use counter rudder "Hard Port" to stop the turn at 17:26:29 hours UTC (middle upper picture). The starboard turn is checked at 354^0 degrees(T) at 17:27:11 hours UTC (middle lower picture). Vessel go around after 2 minutes 17:29:02 Hours (right lower picture). At the bridge ship's Captain and OOW did not notice when pilot hesitated at his rudder order. They did not notice either when counter rudder is ordered while the turn is not finished yet. It is quite normal to have "Hard Port" rudder order to stop starboard side turn initiated by "Hard Starboard" rudder. The "Hard Port" is used when the turn is about to finish at second stage of turning. No one challenge pilot's timing of Rudder order or suspect his intention to stop the turn. This confused situation can be solved by one look at ECDIS or looks outside the bridge for other buoys position or OOW is smart enough who had detected one buoy had missing well before ownship approaching this turn. Nor OOW nor master nor pilot nor pilot boat are in the mood of navigation in this critical minute. It is a good day to sail, for a sailor.

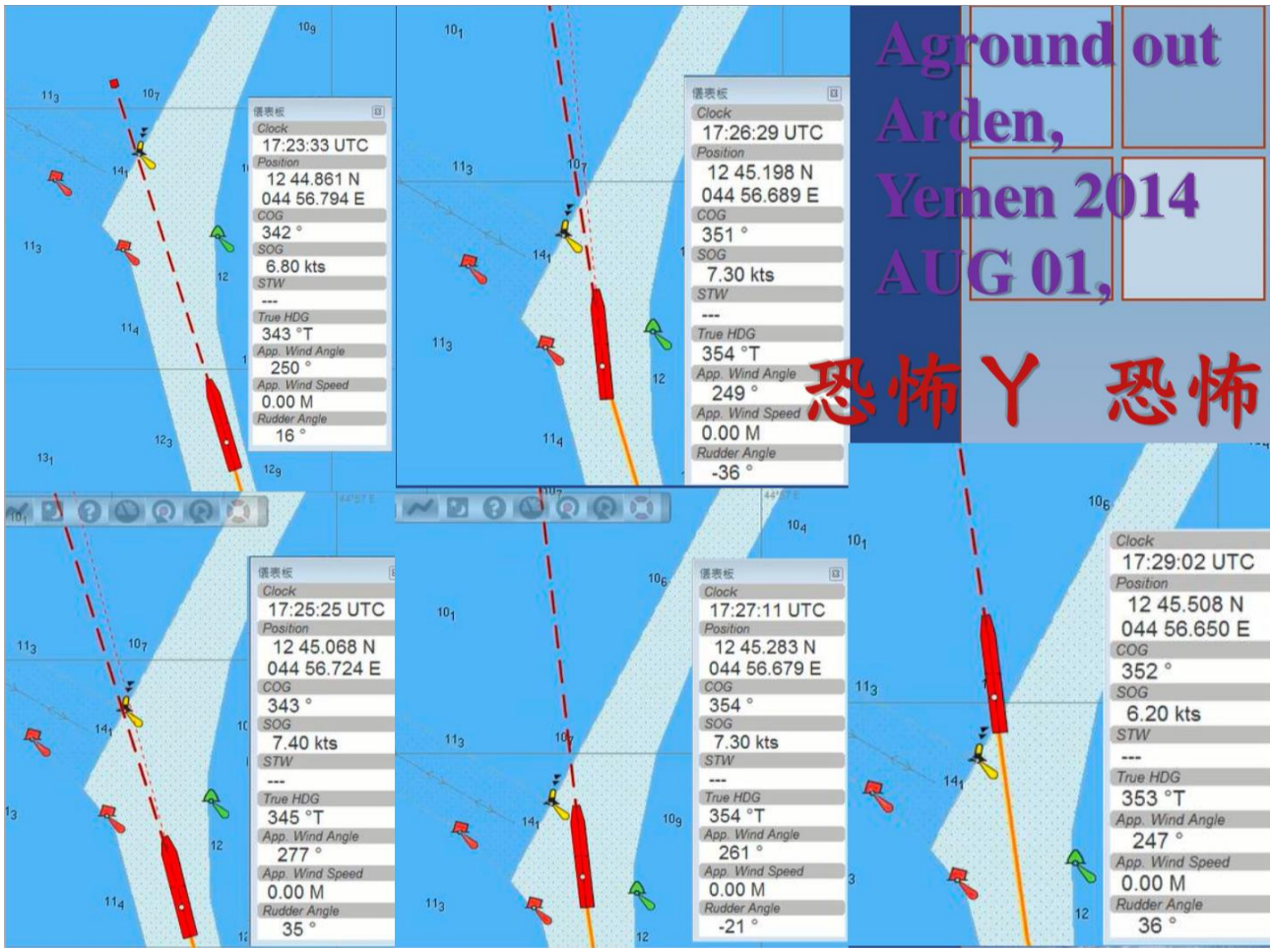

Figure 6-03: Who should we trust at this time?

6-04 refer to OOW in sailing

"Lapse of mind" is not only happen to elder but young man too. The most painful incident to OOW is The Exxon Valdez grounding and oil spill occurred in Prince William Sound, Alaska, March 24, 1989 which bring 6 sigma management system into shipping industrial whether it is suitable or not. In this incident, "*The master asked the third mate whether he felt "comfortable" about what he was supposed to do, and the third mate replied that he did. The third mate testified that he had determined by radar that there was a distance of about 0.9 mile between Bligh Reef and the ice floe and that it would be possible to pass around the ice once Busby Island Light was abeam (green line on chart is planed route to pass ice floe). The master left the bridge about 2352.*" Captain left the bridge at 2352 when vessel is heading South (original course is 215^0 (T)) and "The third mate failed to properly maneuver the vessel *(to pass around the ice floe once Busby Island Light was abeam at 2355, 3 minutes later). At 23.55 hours 3/O plots a fix abeam Busby Island but he does not order a turn. For another 5 minutes he continues to take Exxon Valdez on her southerly course.*" This is lapse of mind from 2355 to 0001.5 hours, 6 minutes long when he failed to turn to port side 217^0 (T) back to southwest bound channel even vessel is heading South into the rocks. *At midnight the lookout reports Blight Reef light buoy broad off starboard bow. 3/O now orders 10 degrees right rudder. Two minutes later, at 00.02 3/O orders 20 degrees right rudder and at 00.04 hard (35 degrees) right rudder. At 00.07 (point 9) Exxon Valdez strikes Blight Reef at a speed of approximately 12 knots ripping open 8 of 11 cargo compartments.* Those Glacial Ice are hard to estimate its length, width or thickness by vessel passed by. These uncertainties have to overcome by 3/O. He will have to alter course to 210^0 (T) at least when he saw the red sector light of Busby Island light at 2358 hours no matter what damage those Glacial Ice may scratch off ownship's bow. This is the bottom line OOW should check Busby Island light from time to time to ensure ownship's position is on correct lane.

6-05 Add one more effort in your routine: No fix sailing

This is one of Captain's skill: No fix sailing which means sailing with no time to fix due to narrow channel or congested traffic area. It may use one look at land mark outside the bridge or radar to know ownship's

position is OK or not, even exact position is not so sure. Captain or OOW on the bridge should check red sector light in Busby Island light. Like using parallel index skills or Variable range ring to keep in safe area. The green line on figure 6-04 is parallel index expected by 3/O, 0.9 nm distance to Bligh reef and course along TSS. The red line on figure 6-04 is parallel index set along Busby Is. Light. The green one is monitored by radar unit and red one is monitored by visual. One more checking on watch keeping is one more ritual to our instinct which will help OOW automatically. 3/O had checked vessel's position at 2355 hours but he has no clue this is the position where new course should begin. 3/O had testified possible ice floe passage he saw in Radar. But this route had not set on chart nor set on radar with parallel index line. After he fix ship's position there are no new course line on chart nor parallel index line on radar to remind him turning point is arrived. At 0058 hours when ownship had sailed inside red light sector of Busby Island light he did not look back to check the sector light's color is OK or not? His mind failed him in turning point, he didn't feel anything strange or missing. Inside red light sector, he may not prepared yet how to check ownship's safety by Busby Island light color. His mind is not there even *lookout reports Blight Reef light buoy broad off starboard bow.* If we check on the chart Blight Reef light buoy is always broad off starboard bow since 2355 hours when 3/O fix ship's position. Why lookout knows something is wrong or feels strange about Blight Reef light buoy's position at 0001.5 hours? (we might learn something from his wisdom.) He reported to 3/O. Maybe lookout's report is not clear enough. 3/O takes action slowly. Starboard 10 at 0001.5 hours. Two minutes later, at 00.02 3/O orders starboard 20 and at 00.04 hard (35 degrees) starboard. Delayed from last chance 2358 hours to 0001.5 hours in turning cause all the damage of the environment.

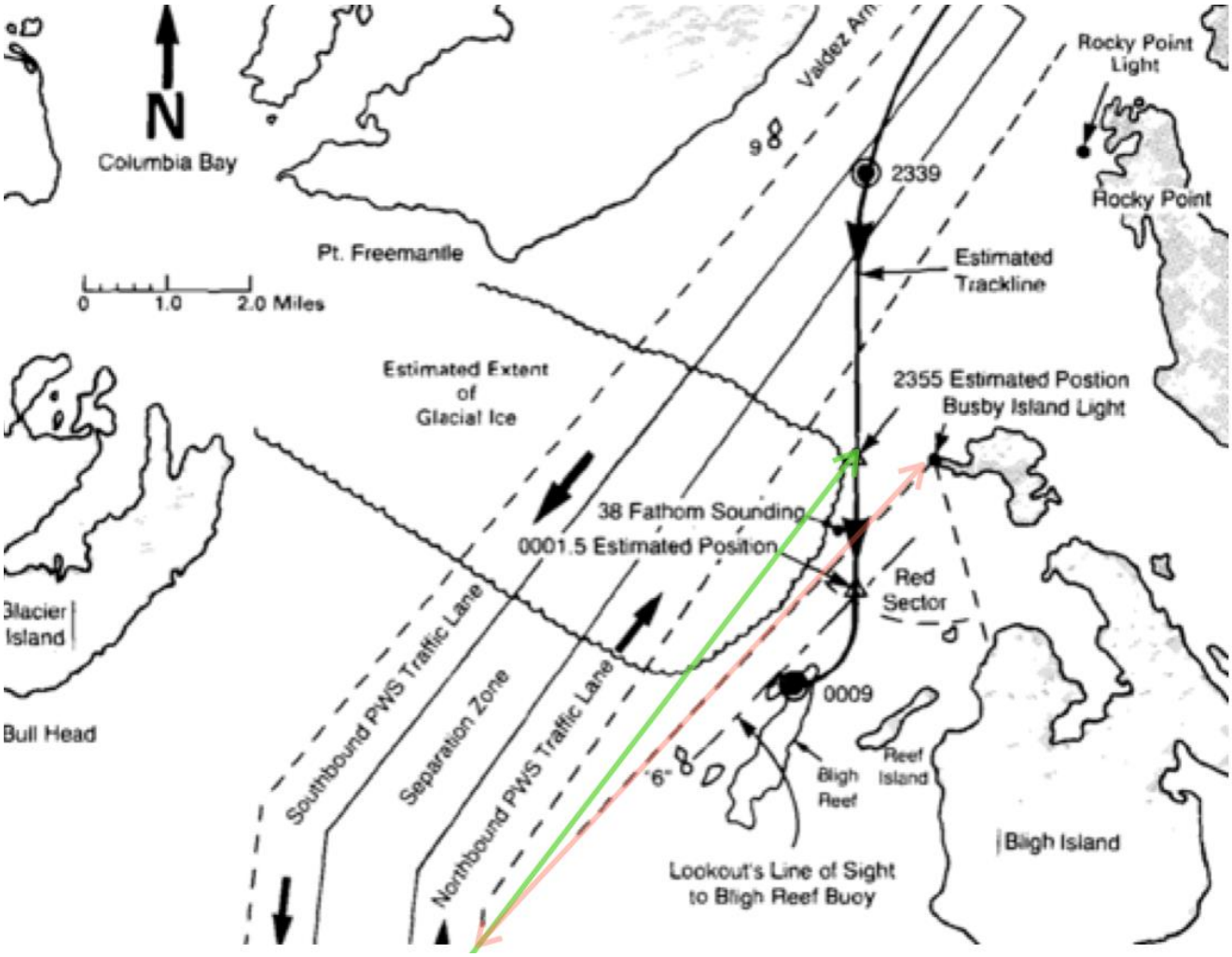

Figure 6-04: Parallel index: When or where to turn ownship back to channel again?

All our memories and knowledge, skills and experiences are compressed by pressure we had at that one critical minute as figure 6-01. Only those most familiar things in our subconscious can work without pressure. The actions we take at extreme pressure are our intuition without second thought. When everything

is familiar without pressure we have "Lapse of Mind" set in. Life is never easy at sea or at all because this is human element. In these chapters to come, captain will feel extreme pressure or disgust when reading unprepared without knowing exactly what to do. It is to cultivate our knowledge, skill and intuition before the real incident when we need it, pressured or not. Old saying "Sweating at practice is better than bleeding at war".

Grounding and collision are two major causes of marine claims. Collision may have some interaction with other vessels. Collision ratio is about 10 times of grounding. Our industrial use BRM to cope with our collision risk. Grounding is solely decided by ownship's mental ability, that is our knowledge, skills and instinct. But grounding claims amount is 10 times of average collision case. Our industrial use HELM human element leadership and management to cope with lapse of mind. For a competent Captain we have to master these two categories at sea without fail.

6 – 02 Grounding with collision risk: change situation from danger to safe

Avoiding ship or avoiding collision position

We know collision risk is created by two vessel's speed vectors or course line crossed each other. These cross points of course lines are common on turning point of entrance to TSS, fairway or land capes. If two vessels happen to arrive same position at same time they will collide. In OOW stage, we concentrate to avoid the collision with 3 minutes speed vector advance distance (space ship status) which represent the maneuvering restrictions of ownship and allowance for ownship's huge dimensions on water. We also learned collision point is moving as ownship's heading and bounce forward if ownship reduced speed. Many times, we learned to avoid collision by avoid target vessel's speed vector or her stern as OOW level. In master stage, we need to check collision position before any avoidance action been taken because Captain is expected to avoid collision in restricted area. Collision position may in close proximity to other navigational hazards like shallow water or outside TSS or close to fishing farm or inside narrow channel as COLREG Rule 2: Responsibility

(a) … of the neglect of any precaution which may be required by … the special circumstances of the case.

(b… due regard shall be had to all dangers of navigation and collision and to any special circumstances, …

Been a captain, we need not only predict collision position. We also need the ability to dissolve it with our action, not only avoid it with all means. We need the ability to change the situation from danger to safe. Our ability is learning from our past mistakes. One more case of grounding.

6-06 Grounding after collision avoidance

Case Study: MAIB Report on the investigation of the grounding of No. 2/2010

*A UK registered container ship, ran aground on Monggok Sebarok reef in the Singapore Strait on September 2009. **It is likely that the master went into a state of shock** and reacted instinctively by putting the engine to full astern. While this may be understandable in the circumstances, an effective bridge team would have ensured that the master was prompted to use the grounding checklist.*

- *The vessel had altered her course to starboard to give way to three vessels exiting Jong Rong Channel.*
- *This caused her to head towards the reef and block his intention of altering course to port and resuming her original planned track after passing astern of the third vessel.*
- *Despite warnings from Singapore Vessel Traffic Information System (VTIS),*
    - *the vessel did not reduce speed or*
    - *alter course in sufficient time to prevent her from grounding.*
- *Substantial damage was sustained to the fore part of the vessel. However, there were no resulting injuries and no pollution.*

The following decisions and actions taken by the bridge team contributed to the vessel running aground:

- *The movement of the engine telegraph from full ahead manoeuvring to half ahead had no effect on the engine speed; neither the master nor the chief officer appreciated this at the time.*
- *The master's assessment of the situation and decision to alter course to starboard were based on his observation of true vectors and relative trails of the radar targets; no trial manoeuvres were carried out.*
- *The master and chief officer misinterpreted the information received from VTIS in respect of which three vessels it had referred to.*
- *The master and chief officer became irritated by the frequent interventions by VTIS, which resulted in important information from VTIS being missed.*

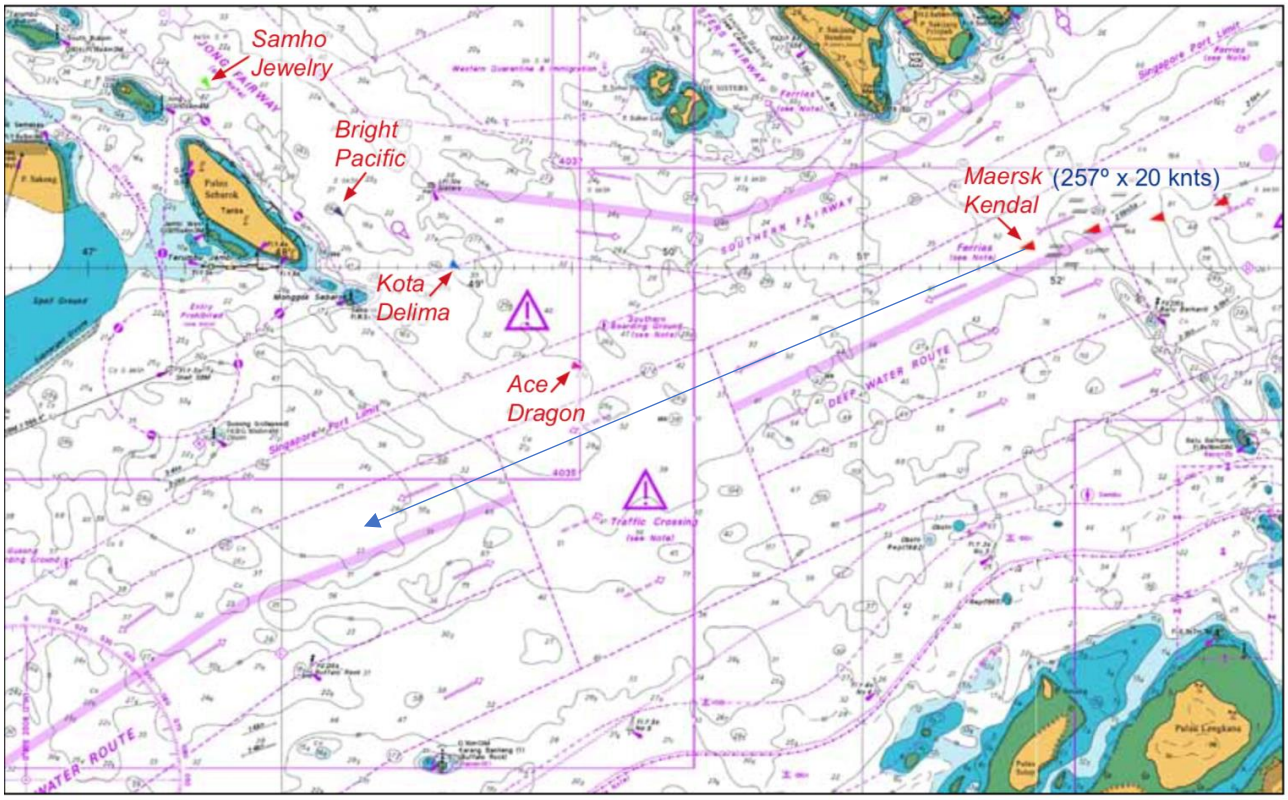

Figure 6- 05: 11 min. before grounding at 0703 hours,

If master can handle collision risks with these three vessels by speed vectors the grounding could be solved easily. In this investigation report, speed vector is not available. For those read this book from the beginning this is unimaginable but this is the truth at sea. We have to solve this case by another way. To avoid the collision ownship have to take care of collision location especially a Master level as captain have to take care safe distance to surrounding grounds more precisely than OOW when we react to collision risk. In figure 6-05, we can see ownship position colored as red triangle sharp end suggest possible heading at that times.

At 0703 hours, ownship 257^0(T) x 20.7 knots just come back from opposite lane of TSS.

- Why ownship wondering outside southwest traffic lane? When general direction of TSS lane is 246^0 (T) ownship heading is 257^0 (T). This heading breaks second safety rule in group convoy: keep same direction with another vessel.
- Ownship heading toward starboard side of TSS lane, our collision position will shift to starboard side also.

⇒ *VTIS called ownship and advised: 'Container ship, require you to slow down, require you to slow down. Three ships coming out of the Jong channel'. –*

- Good advice as speeding reduce our reaction time and increase our collision risk in all cases.

⇒ *VTIS also advised ownship to exercise caution, which was acknowledged by the chief officer, and the master who set the telegraph to half ahead. –*

⇒ *The movement of the engine telegraph from full ahead manoeuvring to half ahead had no effect on the engine speed; neither the master nor the chief officer appreciated this at the time.*

- Maybe the investigator did not understand the restrictions of their Main Engine M/E program.
- 20.7 knots is her sea speed which may need Load Down program to reduce speed from Full to half ahead in the sequence of load down program to protect M/E from deform or crack from undue thermal or structure stress and strain.
- Speed reduce according to Load Down program: I minute per RPM. Very Slowly as I remember if not override by OOW or engineer on watch.
- To override load down program, OOW have to ring telegraph order below half ahead which will have the effect of overriding load down programme and reduce the rpm quickly (reduce speed by cut fuel oil injection amount as crash astern program) to the required setting. Different M/E design and program may need different telegraph order to cut off fuel oil supply.
- Or, Load down programme could be overridden at any time by pushing the 'limits cancel' switch (or something alike) on the telegraph control panel.
- Master or chief officer understood "Load Down programme" is in operation when they move telegraph to "half ahead" position.
- Why they don't override load down program? Maybe the situation is not so critical in the beginning or they don't want lost steerage because no engine output,…etc.

⇒ If AIS data is available target vessel's speed can be used to predict collision position. 1/3 speed target bearing is 1/3 of $60^0 = 20^0$. Three target vessel's speed estimation from figure 7 of MAIB investigation report.

⇒ "Ace Dragon" outbound speed is about 10 knots, ½ of ownship. Her SRB should be 30 degrees about. As figure 6-05 we see "Ace Dragon" relative bearing is 8 degrees to ownship's starboard side. It is far less than her SRB 30 degrees. If ownship steer 245^0 (T) traffic lane general direction she will pass ownship head without problem.

⇒ "Kota Delima" outbound speed is about 10 knots, ½ of ownship. Her SRB should be 30 degrees about. As figure 6-05 we see "Kota Delima" relative bearing is 20 degrees to ownship's starboard side. It is still less than her SRB 30 degrees. If ownship steer 245^0 (T) traffic lane general direction she will pass ownship head at close range.

⇒ Kota Delima" outbound speed is about 6 knots, 1/3 of ownship. Her SRB should be 20 degrees about. As figure 6-05 we see "Kota Delima" relative bearing is 23 degrees to ownship's starboard side. It is more than her SRB 20 degrees. If ownship steer 245^0 (T) traffic lane general direction, ownship will pass her head at close range.

⇒ SRB skills care about target vessel's speed which is irrelevant to target vessel's distance. It can give Captain a rough idea of collision situation will be. Actual situation when two vessels meet will depend on each vessel's speed course change.

6-07 Load up and Load down program

To increase speed from full ahead manoeuvring speed to full sea speed, the telegraph was pushed forward to Navigation Full. This activated a load up program which took approximately 2 minutes to increase one rpm to reach desired RPM setting. *When reducing speed from full sea speed (navigation Full) to full ahead manoeuvring speed, telegraph was moved back to full ahead position. This activated the* load down programme, which took about 1 minute to decrease 1 rpm to reach the required setting. Regardless of any movement of the telegraph from full ahead manoeuvring speed to half ahead speed, the engine was designed to continue to reduce the rpm in accordance with the load down programme. *Any movement of the telegraph below half ahead had the effect of overriding the programme and reducing the rpm normally to the required setting. Alternatively, the programme could be overridden at any time by pushing the 'limits cancel' switch on the control panel.*

- Ship's speed cannot reduce immediately because telegraph is put in "Half ahead" position. This did not notice by Master and Chief is because work load of VHF communication with VTIS and evaluation of target vessels' movement and ownship heading control already compressed their memory capacity as figure 6-01.

⇒ *The vessel's course and speed over the ground were recorded as 257° (T) and 20.7 knots respectively.*

- General direction of traffic lane is 245^0 (T).
- Captain pay no attention to this as he keeps this course for 4 minutes with no intention to steer back to 245^0 degrees(T).
- Captain had not set parallel index line for southwest bound TSS lane. Captain may not aware his vessel already inside correct lane. Chief did not remind captain of own ship's position is OK now.
- With the ECDIS and GPS's help Captain only need take one look at ECDIS screen he can realize ownship's position now. Because it is so easy Captain did not worry about ownship's position. So, Captain had not checked ownship's position at 0703 hours.
- Captain did not know ship's position. He did not change his course back to 245^0 (T).
- Ownship's collision position is always on our heading. If we heading outside the traffic lane we will have collision point outside the lane. This is not the route where ownship should go in normal sailing.
- Ownship should seek for the chance to go back to normal traffic lane which general direction of traffic lane is 245^0 (T).

⇒ *The master then began to assess the traffic situation using the vessel's starboard automatic radar plotting aid (ARPA).*

- Target's speed vector is not available because captain did not save VDR data in hard disk.
- Even the ARPA data are saved target's movement is hard to predict as their speed and course are under continuous change inside a harbour area with pilot on and off.
- Once again, what the COLREG asked one to give way and another is to keep speed and course is useless here just like Figure 5-05: collision of VLCS and VLCC in Singapore strait.
- Using Visual Relative Bearing may be workable in close range as long as we can take target's horizontal angle augmentation into consideration.

⇒ *The ARPA was set to display target true vectors with relative trails.*

- Ture vectors to monitor target's speed and course over ground is good.
- If ownship knows how to use true motion speed vectors to identify collision position, time and distance it will help to improve our situational awareness.
- Relative trails are for small target use to monitor her collision risk immediately.
- In these outbound vessels, they should use true trails to make their course change immediate visible to ownship.

6-08 Identify wrong vessel to give way

⇒ *He identified the Kota Delima, Bright Pacific and Samho Jewelry, which he concluded were the vessels referred to by VTIS. Ace Dragon, which was almost right ahead of ownship, was discounted.*

- VTIS advised: 'Three ships coming out of the Jong channel' not including coaster vessel "*Samho Jewelry*". "Ace Dragon" had passed ownship's bow at heading *257° (T).*

⇒ ***Ace Dragon, which was almost right ahead of ownship, was discounted.***

- This could be monitor at ECDIS with target's AIS signal overlapped.
- Wrongly assuming coaster vessel "Samho Jewelry " as last vessel outbound the harbour who will not cross TSS as other vessels.
- However, vessel Samho Jewelry's intention is not predictable by ARPA's help.
- VTIS's instruction is right but did not mention last ship's name "Bright Pacific" or the first one name is "Ace Dragon" for ownship reference.

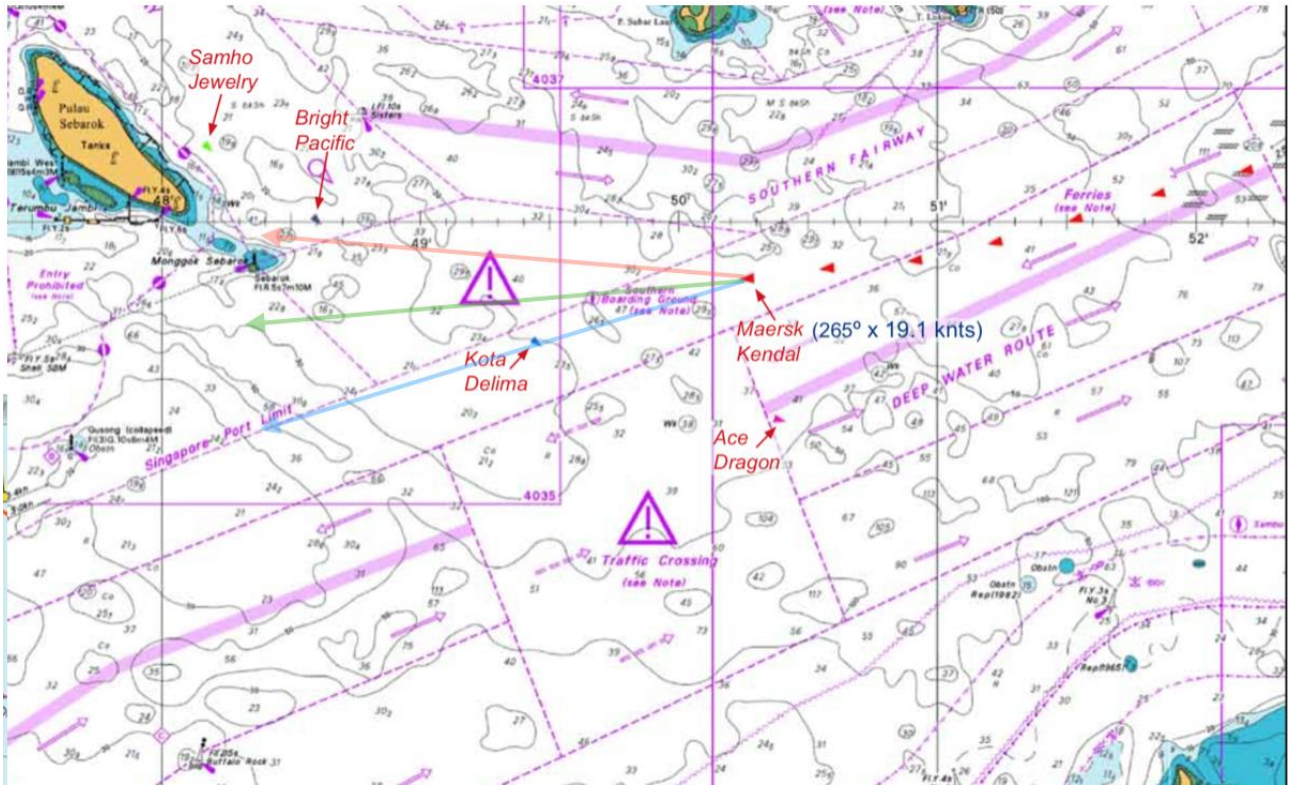

Figure 6- 06: 6 min. before grounding at 0708 hours,

The critical minute comes at 0708 hours, ownship 265^0(T) x 19.1 knots.

6-09 Considering navigational hazards while give way

Ownship speed is not reduced very effectively from 20.7 knots to 19.1 knots, almost unnoticeable to all parties. At 0708 hours 5 minutes later, Ownship's position is already outside the TSS and should seek every opportunity to go back to ownship traffic lane as prudent navigator.

⇒ Actually, three or two minutes before at 0706 hours is our first opportunity to go back to course 245^0 (T) when first vessel "Ace Dragon" crossed our traffic lane.

⇒ Ownship did not take chance to go back to 245^0 (T). Instead, ownship alter course to port side 265^0 (T) to give way to second vessel "*Kota Delima".*

⇒ At 0708 hours is our second chance to alter course to 253^0 (T) to go around second crossing vessel "Kota Delima" (as blue course line on figure 6-06).

⇒ If reader measure two outbound vessel's distance is exactly 1 nm between first vessel "Ace Dragon" and second vessel "*Kota Delima". It is also 1 nm distance between second vessel* "*Kota Delima" and third vessel* "Bright Pacific". Last coastal vessel "Samho Jewelry " may have no pilot which is not regulated by VTIS. Her distance to third vessel "Bright Pacific" is not 1 nm apart.

⇒ Captain want to know two outbound vessel's distance is want to know the safety to sail between these two vessels.

"Is ownship capable to go around safely" is the awareness of Master.

VTIS called ownship and advised to reduce speed as speed was still high and ownship was about to enter port limits.

⇒ *This message was acknowledged by the chief officer, and the master set the engine telegraph to slow ahead.*

⇒ *Course and speed over the ground were recorded as 265° and 19.1 knots.*

- Captain is comfortable with course 265^0 (T) (green speed vector) to give way to "Kota Delima" which is at ownship's port bow already.
- Course again to 245^0 (T) has not come to Captain's mind. Why? Complacency or lapse of mind.
- 5 minutes time, ownship had reduced speed from 20.7 to 19.1 knots which is too slowly for collision avoidance.

- Captain's tension in maneuvering can release by Slower Speed always. Whenever captain feels nerves about the collision reduce speed is always work.

6-10 Safety procedures to avoid grounding changed in ECDIS time

- *The master then ordered a further alteration of course to starboard and steadied the vessel on a course of 273°(T). (at 0708 hours)*
  - This is course 273°(T) (color red speed vector) given way to "Bright Pacific" third crossing vessel already put ownship in danger after 6 minutes as red speed vector pointed at shallow water in figure 6-06.
  - This common practice for junior OOW to go around target vessel's stern at open sea is not suitable for narrow channel in Master level.
  - Captain is impossible not to aware shallow water around Paula Sebarok island in this moment.
  - Ownship's safety in narrow channel are ensured by frequent position fix in old time (if Captain did not have No fix sailing skill like parallel index line) and change to correct heading in time.
  - Fix ship's position work is replaced by ECDIS. When fix ship's position is not a job with punctual interval but a look at ECDIS. We forget safety function to fix ownship's position with enough frequency, 3 minutes a fix, is to avoid grounding.
  - After ownship's position is fixed on chart OOW may recommend course to steer to master or let master know ownship's heading once again.
  - The safety concern of grounding needs one OOW man power to fix ship's position had not reduced by ECDIS but change to another routine to monitor ownship's position from time to time by Master himself before ECDIS screen.
  - In another words, extra OOW to fix ownship's position is reduced by ECDIS real time ownship position displayed on ECDIS screen. The worry of grounding has no OOW to remind Captain on bridge. Captain himself will responsible to check ownship's position from time to time if there are not so much traffic around. OOW's role on bridge change to VHF correspondence if VTIS is full of enthusiasm to call passing vessels in his territory to announce something may not very clear.
  - Captain's grounding and maneuvering concern may interfere by collision concerns like this case.
  - In the old times, grounding case will look into the fix interval is adequate or not. The chart without any ownship's fix on it is unimageable to owner's manager. No extra OOW posted in narrow channel is also unacceptable. Now with ECDIS and VDR in place, nobody knows who had check ship's position and at what interval and where ship's position is looked upon. I wonder which company will insist of Extra OOW in narrow channel.
  - ECDIS has the function to monitor cross track error or safety depth/contour to avoid grounding. In coastal area these functions need more sophisticate setting to make it workable to Captain. Judging by ship's route from beginning which just come back from opposite traffic lane these safety setting monitored by ECDIS will sound too many times in this ship when Captain like to use quick changing heading to avoid danger.
  - To set proper routine to carry out grounding lookout without fail and how important it is to make sure ownship's position in narrow channel ECDIS should have a fix bottom. Each time Captain or OOW check ownship's position and route on ECDIS they should push the button and leave a fix mark on ECDIS for later reference. This is like BNWAS Bridge Navigational Watch Alarm System , part of human element.

Without traditional job function we lost traditional awareness altogether.

6-11 Our venture at sea and streetwise to cope with

- Chief Mate may know ownship's position and danger of grounding by one look but he did not inform Captain of grounding risk in 6 minutes. Our estimate time of grounding is observed from 6

minutes speed vector on ARPA or ECDIS. Using speed vectors to predict ownship's position is no mystery but a situation awareness in shiphandling skill.

- If go around "Bright Pacific" is necessary, master have to ensure ownship can course again within 6 minutes otherwise ownship will aground.
- Actually, ownship have to take risk to cross "Bright Pacific" head and back to ownship's traffic lane. This is our venture at sea. To choose the least danger one is our instinct. We have to understand this before we are fit to be a Captain and in charge of lives and property on board.
- There are many reasons for this decision: These are our streetwise in making our decision.
  1. The distance between two outbound vessels had measured already, 1.0 nm.
  2. The distance between ownship to "Kota Delima" is about 0.8 nm.
  3. The distance between ownship to "Bright Pacific" is about 1.8 nm.
  4. "Bright Pacific" is moving out very slowly.
  5. Her position is so close to Sebarok reef which is not likely to go to eastbound lane in TSS. This is next chapter's topic.
- After give way to second crossing vessel "Kota Delima" ownship should course again slowly by go around "Kota Delima" stern to course 255^0 (T) (light blue speed vector), then 245^0 degrees (T) as general direction of traffic lane.
- If we try to sail through the gap of "Kota Delima" and third vessel "Bright Pacific" we should know the distance between these two vessels is 1.0 nm. If we check again the distance between 1st crossing vessel "Ace Dragon" and 2nd vessel "Kota Delima" is also 1 nm. These outbound vessels sailed with one nautical mile distance.
- Ownship should able to sail between these 1 nm space. But how? Refer to figure 2-10
- If captain cannot transit ahead of out bound vessel "Bright Pacific" stop and wait is only option.
- Captain reduce speed to slow ahead at 0708 hours after VTIS request.

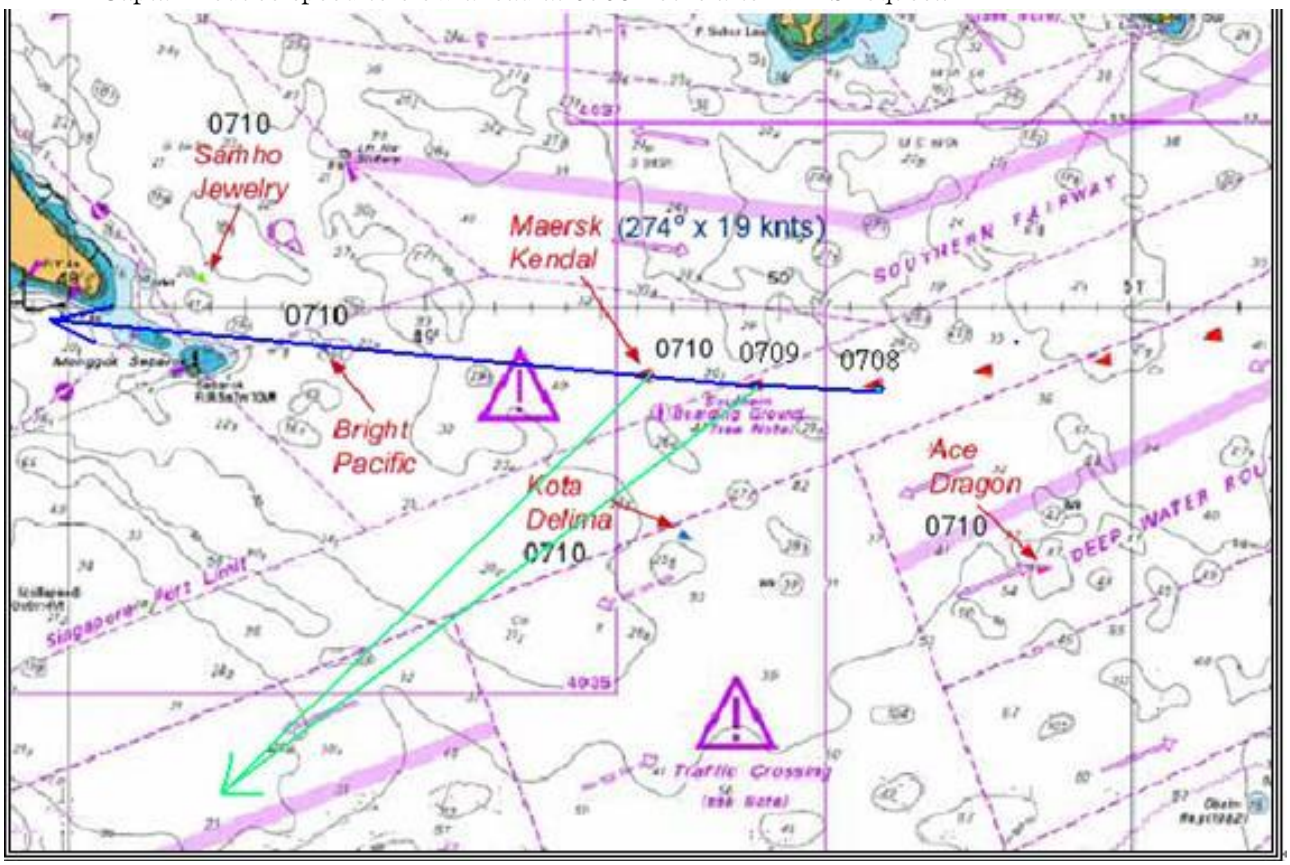

Figure 6-07: Critical minute at 0710 hours, 4 min. before grounding

At 0710 hours, ownship course 274^0 x 19 knots

6-12 Safe Relative Bearing SRB skill in crossing ahead

Ownship is heading into final aground location dead ahead. At this critical point:

⇒ Ownship's slowdown from 19.1 knot to 19 knots still very high after Captain reduced telegraph to "slow ahead" 2 minutes before.

⇒ If this is not the load down program sequence, there must be something wrong in the Bridge *overriding* Control of the Engine. "*Any movement of the telegraph below half ahead had the effect of overriding the programme and reducing the rpm normally to the required setting."*

⇒ "Bright Pacific" has no speed vector on 0710 hours figure which proceed 1.5 cables in 2 minutes. Her speed is about 3-5 knots by comparing her distance run in 0708-0710 hours.

- At maximum of ¼ of ownship speed = 5 knots, her SRB is 15 degree.
- By 3 knots speed, her safety relative bearing SRB is 3/19 x 60 = 9.5 degrees.
- In this speed, if it is not for disembarking the pilot it is reducing speed for ownship to pass her bow.
- In either case, this is a wide berth to pass between 2nd crossing vessel "Kota Delima" and 3rd vessels "Bright Pacific".

⇒ Ownship have many chances to go back to west bound traffic lane. Port bow vessel "Kota Delima" is not a problem if ownship alter course to port side at 0708 hours.

⇒ Ownship still can alter course to 220^0 degrees(T) at 0710 hours (54 degrees relative bearing to "Bright Pacific" true bearing 274^0 (T)).

⇒ "Bright Pacific" will be on ownship's starboard side 54 degrees which is greater than her SRB 9.5 - 15.0 degrees at speed 3-5 knots.

⇒ If we have "Bright Pacific" speed vector, it will be clearer that ownship can safely pass ahead her without any collision point is 3 minutes speed vector is displayed. Reader may simulate this situation in plotting sheet or bridge simulator about our SRB and speed vector statements.

6-13 Senses of speed which Captain can feel, see and hear

VTIS called the vessel to confirm if the master was on the bridge, to advise him that the vessel had already entered Singapore port limits, and to request the vessel to slow down.

⇒ *vessel had already entered Singapore port limits:* this is a serious violation of port state's authority usually accompanied with penalty if Captain is lucky or civil/criminal proceedings end up in jail if Captain is in bad luck. Chief mate may or may not know "*if the master was on the bridge"* is *already* an announcement of violation. *Don't be a fool.*

⇒ Captain knows what will be ahead of him (heavy penalty) if he cannot justify his violation is an emergency measure.

The master responded by advising VTIS: 'Listen I am slowing down all the time, I have two ships out ahead and will pass astern of both of them, no problem.'

⇒ Strong words with bold attitude are signs of extreme pressure, not confidence.

⇒ Captain may not aware ownship speed had not slow down at all in these 2 minutes from 0708 hours to now and in the past 7 minutes from 0703-0708 hours with no reducing effect.

⇒ Aware of speed reduction don't need to use any special instrument like Doppler or GPS.

⇒ It is a sense of speed which Captain can feel, see and hear from everything around bridge, seas, wind, passing waves, vessel noise or vibrations of the hull. If all these senses are quenched it is a sure sign of extreme pressure, not dumb. Please refer to figure 6-01.

The performance data supplied to the vessel recorded a turning circle of 0.48nm to port, with an advance of about 0.47 nm at 20.1 knots.

⇒ Captain had not noticed there are no sea room *astern of both of them. (*no sea room to accommodate *advance of about 0.47nm)*

⇒ Captain had not leave 3 minutes maneuvering time to alter course back to TSS. (distance is too short for 3 minutes turning)

⇒ Captain don't aware ownship will go aground after 4 minutes.

⇒ No checking of ECDIS and RADAR may imply Captain rely on visual only and lost aground awareness.

VTIS then immediately advised: 'Chemical tanker, chemical tanker, the name is Samho Jewelry Samho Jewelry is a, is a piloted tanker. She is not leaving Singapore she is not leaving Singapore'

⇒ VTIS have given vessel name and her intention but not clearly indicated which one is the "*Samho Jewelry".*

⇒ VTIS conveyed his massage in this communication. Captain has to receive awareness of:

- First is to inform outbound ship's name "*Samho Jewelry"* to approaching vessel.
- Second is to inform pilot on board "*Samho Jewelry"* usually this massage implies "pilot had not disembarked yet. She will sail with slow speed and will not increase speed for a while, either it is for disembark or other reason. Approaching vessel can use this slow steaming time to do you maneuvering."
- Third is to inform massage implied in second massage: why "*Samho Jewelry"* have not increase speed? "*She is not leaving Singapore she is not leaving Singapore"*

The chief officer responded: 'Got the name of the tanker – Samho Jewelry. Thank you'

⇒ *Got the name of the tanker – Samho Jewelry, Thank you'*. Good command in English.

⇒ Thank you implied no more talking "over".

⇒ VTIS did not know "Does this vessel received second (pilot on board) and third massage (slow steaming now)?". VTIS added

VTIS replied: 'Thank you, it appears that you are heading towards her. Over'

⇒ Ownship is heading toward "Bright Pacific", not "Samho Jewelry"

⇒ VTIS divert ownship's attention to collision avoidance with 4th vessel outbound not grounding risk ahead.

⇒ No body on bridge mentioned about anything of grounding. No situational awareness and leave no room for Master to maneuver.

⇒ VTIS also Thank you means I speak to the "Thank You" man on board (Chief), not the "Listen" one before (Captain).

⇒ This curtesy on VHF communications release the tension before. It is also released the question VTIS had in mind?

and then made a further broadcast at about 0711 hours: 'All ships standby, all ships standby. Maersk Kendal warning to you. Ahead of you is Samho Jewelry, Samho Jewelry, What is your intention over?'

⇒ *All ships standby.* This area is under my control. It is a dominance announcement to bring out all parties' attention.

⇒ Actually, VTIS only want Maersk Kendal's attention*. "warning to you" then answer my question What is your intention over?*

6-14 Cross reference situation: forged and unshakable by conversations exchanged

The chief officer replied that ownship would be passing astern and would make an alteration to port after that.

⇒ Chief Officer's reply because his observation of Captain steadies her heading on 274^0 (T) now.

⇒ Once chief officer replied, Captain has no option but to follow otherwise the VTIS may be offended. VTIS will call again.

⇒ Chief Officer may not notice there are no sea room *astern of both of them.*

⇒ Chief Officer don't know ownship will go aground after 4 minutes.

⇒ So, this is a cross reference situation. You ask me to pay attention to *Samho Jewelry* and I will pay attention to *Samho Jewelry*. We are talking the same thing and at same page. That's all. We are fine to each other.

⇒ Captain is wrong to give way to a vessel "Bright Pacific" outside the traffic lane.

⇒ Any collision position outside TSS lane is a wrong assumption.

⇒ Captain's priority is bringing ownship track back to TSS lane immediately. It is wrong to sail inside a harbor area.

⇒ This mistake is forged and unshakable by conversations exchanged between Chief Officer and VTIS.
⇒ Ownship has collision risk with "Bright Pacific" is because our heading is wrong.
⇒ Our heading should be same as other vessel at westbound lane 245^0 degrees(T), not 274^0 degrees (T).
⇒ Ownship can course again anytime from 0708 hours or 5 minutes earlier from 0703 hours, see figure 6-05.
⇒ This 30 degree course difference (245^0 degrees(T), not 274^0 degrees (T)) can outweigh any vessel speed under 9.5 knot (half speed of ownship) as we learnt from SRB.
⇒ To go back to TSS, it is no shame if ownship alter course to 180 degrees (T) to cross 3rd or 4th outbound vessel's bow as 2nd outbound vessel "Kota Delima" bearing is 170^0 degrees (T) now.
⇒ Captain might mistake VTIS intention is asking him to give way to all vessels outbound.
⇒ VTIS's duty is actually only warning crossing vessel of any vessels outbound. Collision risk inside a harbor area is not a normal case especially a transit vessel. VTIS only need to ask transit vessel keep out of his harbour, not to mitigate collision risk with vessel rush inside. If transit vessel keeps her route outside his harbor there will be no collision risk inside it. Collision is always on our course line.
⇒ After all these VHF communications, Captain should manage to take all speed out for safety reason and keep their promise to VTIS. *Ownship would pass astern and make an alteration to port after that.*
⇒ We now know rudder cycling can be used to reduce speed and maintain control of ownship's heading. But, first turn to which side if you are the Master at 0710 hours? What is the pros and cons?

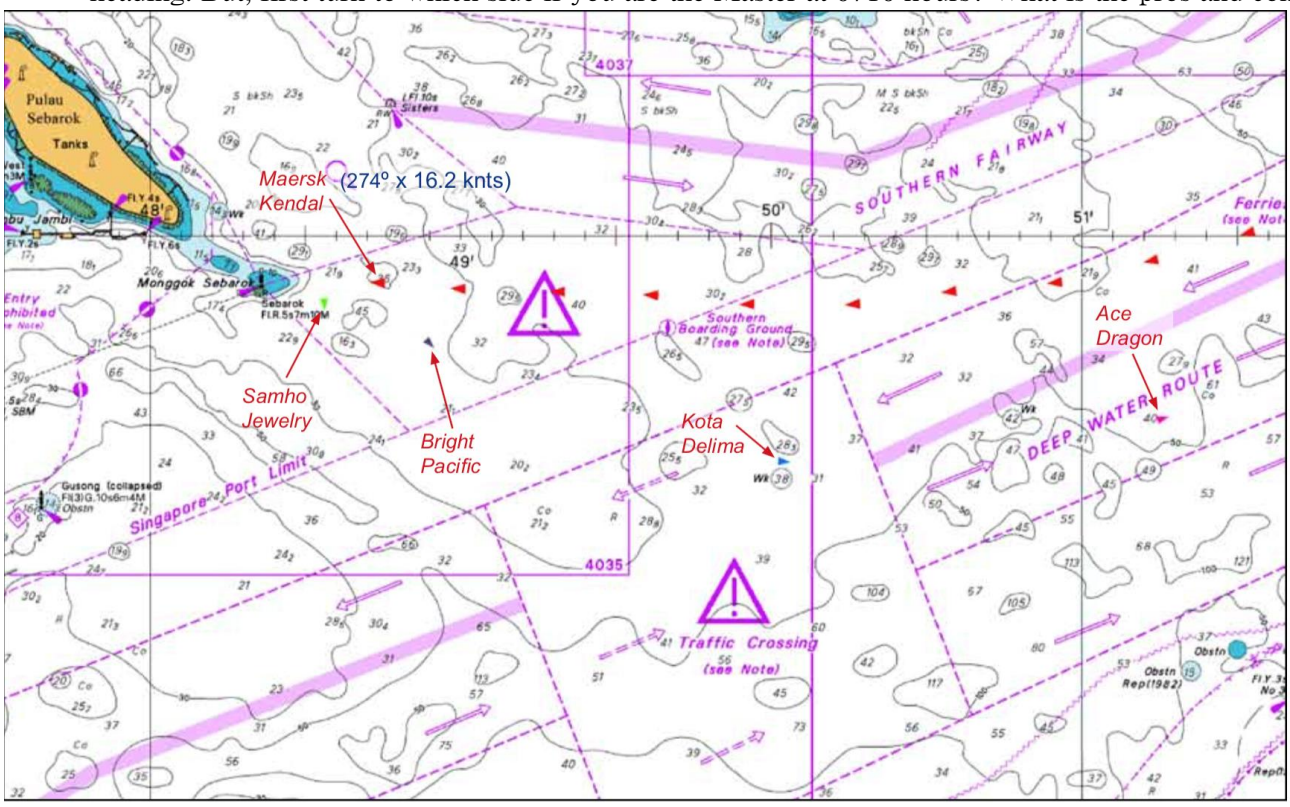

Figure 6-08: Point of no return at 0713 hours, one min. before grounding

At 0713 hours one minute before grounding (Figure 6-06),

6-15 Former generation's wisdom had not stipulated and explained.

Ownship still on a course of 274° and now at a speed of 16.2 knots, reducing rate 1 knots per minute. VTIS advised: 'Container vessel, shallow water ahead of you, shallow water ahead of you.' The chief officer replied "OK sir".

⇒ One minute before grounding is not enough for vessel to change course. VTIS may not know this but we do.
⇒ Ownship did not stop engine three minutes before and take all means to reduce it effectively.

⇒ If ownship had set the speed vector 3 minutes length we will have ability or awareness to predict what position ownship will be after 3 minutes.

⇒ No imagination on speed vector's length and direction as space ship status (as Figure 2-15) will not have awareness of safety contour when we need.

⇒ If ownship (Chief or Captain) had space ship aware at 1710 hours there will urge to go back to main channel.

After "Samho Jewelry" had crossed the bow of ownship, the master started following the stern of the other vessel to port. His initial helm order was 'port 10', followed by 'port 20' and then 'hard-a-port'.

⇒ Lack of ship maneuvering knowledge or awareness.

⇒ Lack of visual and radar distance awareness training.

⇒ *The course change should begin earlier before 0713 hours.*

Lack of basic knowledge and training is inevitable in TV game generation when everything speed, course, position, collision or grounding seems have a solution on some kind of machine. But, we are human had limited short term memory to handle all instruments in the same time. Deep roots of this deficiency are originated from academic learning objective had not included human element and former generation's wisdom had not stipulated and explained to new generation.

He then went onto the starboard bridge wing to assess whether the vessel would clear the beacon on Monggok Sebarok reef. As he returned to the wheelhouse, the vessel ran aground on a heading of 246° (T) and at a speed of about 14.2 knots.

⇒ One minute turn from 274^0 (T) to *246° (T), rate of turn is 28 degrees per minute,* speed reduce from 16.2 to 14.2 Knots*, reducing rate 2 knots per minute.*

⇒ *This* vessel's response to rudder and speed is very good if Captain has the chance to master it earlier.

6-16 Why grounding still happen?

Bridge Resource Management (BRM) as adopted by the maritime industry can be described as:
'The use and co-ordination of all the skills, knowledge, experience and resources available to the ship's team, to accomplish or achieve the established goals of safety and efficiency of the passage.'(from Wiki)
Navigators have all skills, knowledge, experience and resources available to avoid grounding. Why grounding still happen? Groundings in most cases are human element caused by unconscious mistake like fallen asleep (black out), lost feeling to do (turn at B/W entrance) or lost feeling to fear (heading into shallow water). This grounding case is interacted with other ship and VTIS in the middle of collision risks. The basic reason of grounding is lost aground awareness throughout. Collisions and groundings have one thing in common: the location. To avoid collision, we should identify where is collision position first then see what we can do to avoid and what is its danger around this position. Every ship has her course and speed to go if we can predict where is her possible position after 3 minutes by his speed vector we will be able to predict her space ship status. By avoiding her space ship status ownship can sail safely in between. The ability to predict target's relative movement is what we are trying to work so hard over last chapters. First is to categorize targets by their speed to estimate their SRB. For targets outside its SRB it is safer to across his bow by giving more margin than actual needed (i.e. using more relative bearing to cross her bow than calculated SRB). For target inside their SRB it is better to go around her stern to avoid any confuse. If there are no space to go astern of target stop and wait her to pass is wiser. Reduce speed is always good but have to be effective otherwise it will cause more danger than alter course. This basic concept will help us in reducing unnecessary collision risk.

6 – 03 Collision position Study

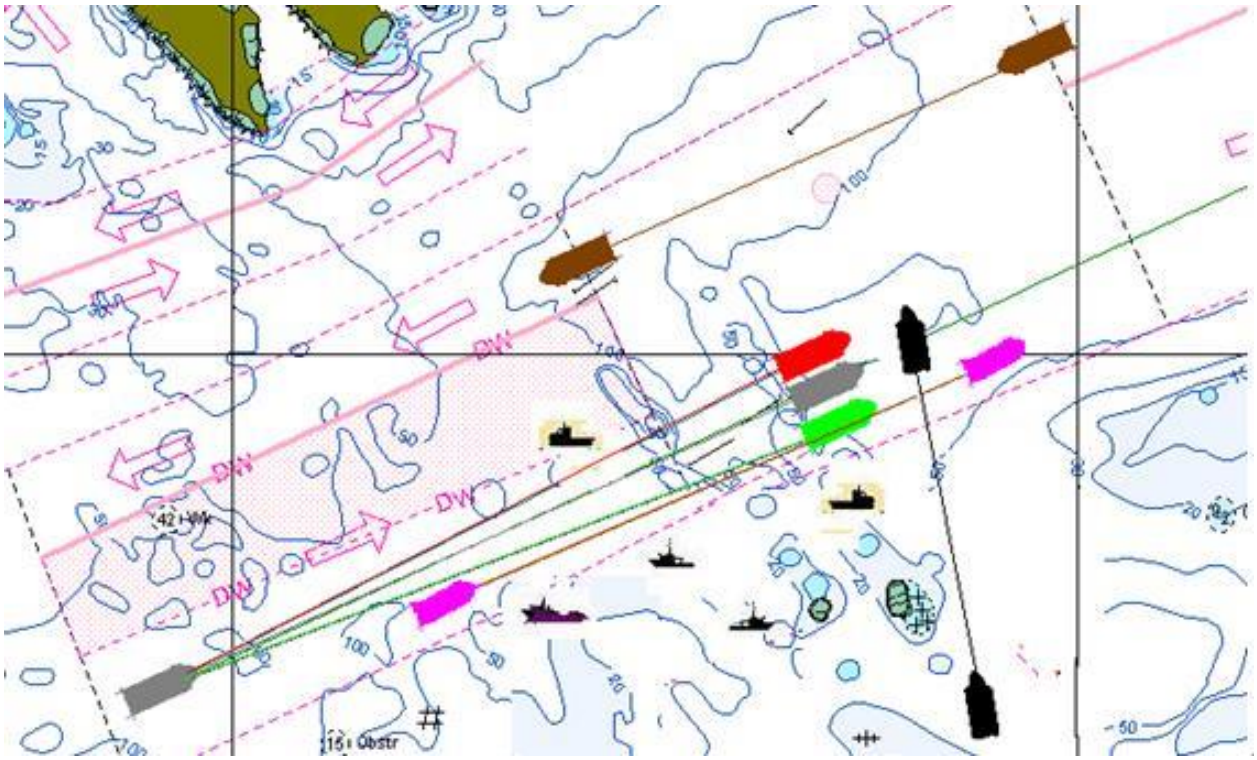

Figure 6-09: What ownship can do by alter course 3 degrees in 6 minutes ahead

6-17 How can we give way in such narrow channel without grounding:

Collision position properties:

- Collision position is always on our heading ahead.
- Ownship change course our collision position will change course accordingly.
- Ownship reduce speed our collision position will moving ahead.
- Ownship reduce speed can reduce collision position at the same time.
- Ownship follow course line inside of traffic lane our collision position will happen inside.

Two vessels arrive same place at same time will have collision. In other words, if ownship can do these things below collision risk will disappear immediately.

- Avoid arriving in same collision position, or
- Avoid arriving collision position in same time, or
- Change heading to what direction have no target vessel, or
- Reduce speed to arrive collision position later than another target vessel, or
- Have different course line to make the passage.

If ownship suddenly faced a collision risk with target vessel in close range from any reason, ownship speed is 18 knots, course 064^0 degrees(T), speed vector in 6 minutes length as grey course line, black vessel north bound crossing the TSS lane.

1. How can we give way in such narrow channel without danger of deviate our course line outside TSS and have risk of grounding as 0703 hours ownship meet "Ace Dragon" situation in figure 6-05 ?
   - ⇒ In restricted sea room, collision position must make sure first then Captain can decide what to do next.
   - ⇒ If collision position is not sure Captain should use ARPA or Radar to detect target vessel's speed vector to make sure collision position.
   - ⇒ If AIS data is available target vessel's speed can be used to predict collision situation. 1/2 speed target bearing is 1/2 of $60^0 = 30^0$.
     - Target with 1/2 of ownship's speed: if her relative bearing is 30 degrees she is about to arrive collision position with ownship in the same time.
     - Target with 1/2 of ownship's speed: if her relative bearing is 40 degrees ownship will arrive collision position earlier than target vessel.

- Target with 1/2 of ownship's speed: if her relative bearing is 20 degrees target vessel will arrive collision position earlier than ownship.

6-18 His navigation looks always nice and easy without any surprise

In figure 6-08, Ownship collision situation is about to hit Black vessel's midship section after 6 minutes as grey ship if ownship keep original course 064^0 (T) and speed. This is situation 1 when ownship hit target vessel midship section.

⇒ The collision position is within traffic lane.

⇒ Ownship alter course to starboard side, the collision position will move to starboard side too.

⇒ We know from blossom effect that target vessel in close range will have greater horizontal angle.

⇒ If captain can read from speed vectors and know ownship will head into target 's midship section 6 minutes before, ownship can alter course 064^0 degrees(T) to 067^0 degrees(T) as green course line/vessel. This is situation 2.

- 18 knots run for 6 minutes and course change 3 degrees = 18 knots x 1852 x sin (3^0) x 6 min = 174.5 meters which is half length of 349 length over all vessel. If situation 1 is to hit target in midship section, 3 degrees course change in 6 minutes will change the situation from 1 to 2. Shift collision position one half target vessel's length 174 meters distance from target vessel's midship section to her astern as situation 2.
- Coastal vessel usually less than 200 meters. Ownship change course 3 degrees 6 minutes before can create 174 meters abeam distance to original collision position.
- If ownship steering course 067^0 (T) three degrees to starboard our position after 6 minutes is still within traffic lane. 174.5 meters = 1 cable. Usually TSS lane is 0.5 nm = 5 cables in width.
- But the crossing situation had change due to this 174.5 meters (1 cable) abeam distance from our original course line. Ownship will face black crossing vessel's stern in situation 2.

⇒ Captain can estimate the passing distance and relative bearing change of target's stern to decide what course to go with easy in situation 2.

⇒ Captain apply some leeway to compensate for current or setting inside traffic lane is usual.

⇒ If Captain apply 3 degrees course change to give way to crossing vessel change situation 1 to situation 2, OOW on bridge may not know this 3 degree course change is to give way.

⇒ When ownship approaching crossing vessel from port side (give way side) OOW just saw target vessel's stern and OOW did not know captain had given way already.

⇒ To an OOW on bridge he did not know captain's maneuvering with quarter master in hand steering had changed situation from no.1 to no. 2 as green vessel's route.

⇒ OOW only notice rudder order and course had changed frequently but he did not know the reason why captain did these changes.

⇒ When this Captain is in charge the navigation looks always nice and easy without any surprise.

⇒ But some captain's navigation looks always nervous and panic with many difficult meeting situations.

6-19 His navigation looks always nervous and panic with many difficulties

Could it possible that Ownship steered 3 degrees more to 067 degrees(T) course 6 minutes ago and found ownship is still heading into target vessel's midship section with difficult steering to handle?

⇒ Well, it is possible. Originally, 3 degrees course change from 064^0 (T) to 067^0 (T) is enough to create 174 meters abeam distance. Why ownship had changed course but still in situation1? Main reason for this kind of trouble is captain's estimation of collision position (not situation) is not correct or Captain had no idea of what will happen after 6 minutes.

⇒ If the meeting situation is no. 1 after ownship already applied 3 degrees to give way to crossing vessel ownship's original heading is heading into target vessel's bow, not her midship section.

⇒ For example, in figure 6-09 ownship's original heading is 061^0(T) as the red vessel. Captain apply 3 degrees starboardside as grey vessel steered in 064^0(T) as grey vessel. The result is like what we see grey vessel head into Black vessel's midship section in figure 6-09.

⇒ Collision position's estimation is very simple which always moves with ownship's heading and target vessel's speed vector, on ownship's head and moving along target vessel's speed vector.

⇒ When our original course is 061^0(T) the collision position is at target vessel's bow. When ownship changed to 064^0(T) the collision position moved to target vessel's midship section.

⇒ Ownship can always change our heading to avoid unfavorable collision (or collision position) like the case in figure 6-07. Captain stick to course 274^0(T) the collision risk in 274^0(T) will never disappear unless he realizes his course is wrong and alter course to eliminate collision risk.

⇒ In harbor area, every ship is under constant course and speed change. Ownship should have the ability to estimate other vessel's movement either by her speed vector or by Captain Visual lookout skills.

Navigation is nothing but to predict ownship and target vessel's position and adjust accordingly.

6-20 How to make transit plan between many outbound vessels

⇒ If Captain can correct estimate target's movement by his skills he will be able to find easy chance to get back to original traffic lane.

⇒ In Master's level, we should be able to verify which meeting situation will be with target vessel.

⇒ Our precision in collision situation prediction have to reach target vessel's ship length level.

⇒ If collision risks inside traffic lane seems unavoidable like three vessel's outbound Singapore harbor and ownship have to transit through these vessels.

- The time ownship arrive collision position TTC and target vessel's TTC should be decided precisely with help of speed vectors of both vessels.
- Collision position is where target vessel's course line intersects with ownship's course line, it should be within Traffic crossing area of harbour's doorway as figure 6-08 marked with a purple triangle.
- If collision position is not inside traffic crossing area ownship course is not the same as general direction of traffic flow. Ownship should alter heading to general direction of traffic flow and check the collision position and TTC again.
- The spacing between these vessels should be measured by comparing with ownship's speed vector. With a divider beside the ARPA or with your finger. This is situational awareness of Master.
- In last case, the spacing of two outbound vessels are 1.0 nm. For a 20 knots vessel 1.0 nm is 3 minute distance run. For vessel with maneuvering full speed 15 knots 1.0 nm is 4 minutes distance run. Ownship need to make best use of this 4 minutes time gap to transit Traffic crossing area.
- As we discussed before when we have speed vectors on ARPA or Radar screen which target vessel has real collision risk with ownship should be decided, i.e. which one will arrive collision position (inside traffic crossing area) at the same time as ownship.
- In last case we did not have Speed vector available. We use SRB concept and target vessel speed value may get from AIS data or her trail length to compare with ownship's speed vector to get rough ratio to ownship's speed.
- In last case, first two outbound vessels have 30 degrees SRB. Their relative bearing for first one is 8 degrees to starboard side only this one will pass ownship without problem.
- Their relative bearing for second one is 21 degrees to starboard side this one will pass ownship's bow at close range.
- Before we decide how to transit we should take a look of third one with speed 4-5 knots only. For same 1.0 nm distance spacing outbound this vessel will have 12 minutes time gap instead of 4 minutes time gap between first two vessels (both in 10 knots speed). Her SRB in

5 knots is ¼ of ownship speed = 15 degrees. Now it relative bearing is 23 degrees to ownship which means she will not pass ownship's bow unless increase her speed. Even third vessel increasing speed she should not over 10 knots speed to reduce 1.0 nm spacing distance of outbound vessels. At least 4 minutes time gap for ownship to transit.

- The choice is very clear to Captain to transit between No.2 and No.3 target with 245^0 (T).
- All discussions of transiting plan are based on 245^0 (T) course line which is general traffic direction of traffic flow, please refer to Figure 6- 05: 11 min. before grounding at 0703 hours.
- Use the blue course line of 245^0 (T) to do all evaluations of transit with SRB and relative bearing, otherwise you will make same mistake as Captain here.
- Once we make the decision to transit after outbound vessel No.2 stern. We should monitor closely and adjust ownship' s position close to her stern as a prudent navigator.

⇒ If the spacing is sparse like figure 6-5 three vessels spacing by one nautical mile. This 1 NM distance must be the result of proper controlled by VTIS inside the harbor.

⇒ Captain should be able to navigate through 1 nm between two vessels if he had not made wrong assumption which one to pass.

⇒ Then these vessels should be handled one by one precisely. Not like OOW handle multi target situation in open sea treat three vessels as a big ship and passing last ship's stern. That is not a Master level skill.

⇒ If three vessels spacing is very crowded like three cables distance each we should consider safe or reduced speed to let them all pass ahead of ownship. Keep ownship on correct course line even stop engine to wait outbound vessels to pass.

6 – 04 Visual skill for Master

6-21 Visual skills captain had is his last resort in all dangerous situation

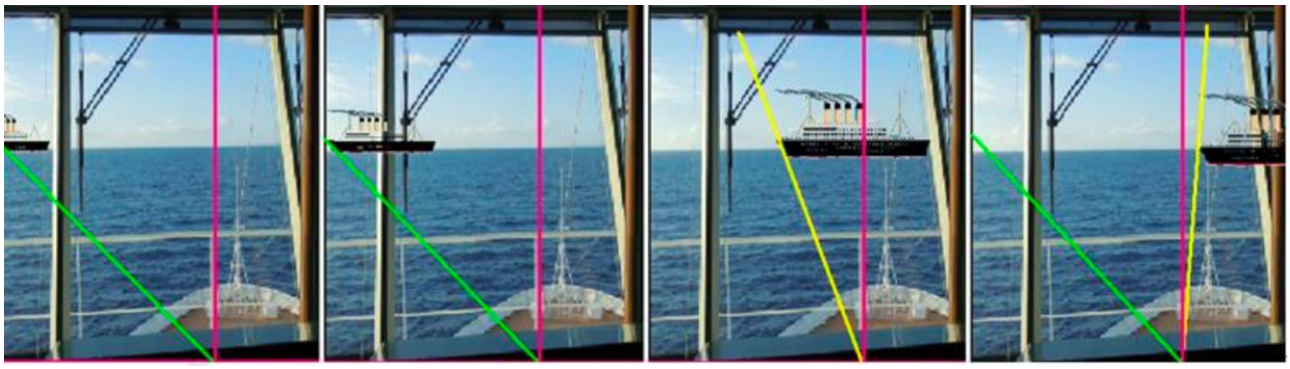

Figure 6-10: Target stern passed all clear from ownship bow

Collision position could be identified by speed vector in radar or relative bearing change in visual. This is our basic training. If you don't know how you are not qualified as a master yet. See Figure 5-3: Situational Awareness of angle of blow. When we are a junior OOW we use visual and radar lookout in ample distance away while targets are treated as a point on radar or a point where we use to take visual bearing reference on deck. When we are a Chief mate we use speed vector length to estimate space ship status taking account of vessel's maneuvering requirement and considering target vessel's horizontal angle augment into visual lookout skill.

Be a captain we have to consider each vessel as three parts, bow, stern and pivot point.

In figure 6-09 we discussed about 3 degrees difference in heading will change collision spot of target vessel. For a target vessel to pass ownship's bow we need to make sure target's stern bearing are cleared like figure 6-10. Target vessel horizon angle increased as approaching but her stern still has time to clear ownship's bow. Use target vessel stern bearing to access collision risk will take blossom effect into our action plan. If we have monitored bearing change of target's stern we don't need to worry about her blossom effect. This is very important as instinct reaction from visual skills captain had is his last

resort in all dangerous situation while RADAR ARPA echo may suffer interference from sea/rain clutter or undue setting as we seen in Sanchi's case.

6-22 Master need relative bearing most when we practice visual skills

All bearings mentioned in COLREG are compass bearings which measured from Earth meridian (due North), not ownship's heading. When ownship alter course to avoid collision target vessel's compass bearing did not change appreciable in the beginning. The effect of alter course to avoid collision is only effective after ownship had gained some sea room from Earth when we can see target vessel's compass bearing changed at third stage of turning. Where is North or Meridian we don't know we need an equipment (gyro, ECDIS or RADAR/ARPA) to remind us where is prime meridian we can use to take compass bearing to evaluate our collision avoidance actions. It is not our nature and indirect to our instinct. In Junior OOW level, there is no harm with this precaution when substantial action in ample time and enough sea room is the norm for avoidance actions in open sea mostly. In Senior OOW level, using compass bearing to avoid collision already has its limitation if we considering horizontal angle augment in close range. For example, in figure 6-10, we use target vessel's stern to evaluate bearing change for collision avoidance. If we take compass bearing of this target vessel from RADAR or ARPA did you think we will get same result of her compass bearing change to compare with her relative bearing change from a dumb compass card? It will have some difference because the reference point we take from same vessel to decode compass bearing and relative bearing may not the same. Actually, to measure compass bearing of a very close target is very inaccurate because the horizontal angle can cover up 10 degrees in 1.0 nm distance. *It's about 10 degrees horizontal angle for a target length 300 meters. 1852 m x 1 nm x Sin (θ^0) = 300 meters (chapter 2-08).* *Θ=9.32 degrees.* We need relative bearing most when we practice visual skills in Master level.

6-23 Why relative bearing change is not the same as compass bearing change?

In COLREG rule 7 Risk of collision: (d)(ii). such risk may sometimes exist even when an appreciable bearing change is evident, particularly when approaching a very large vessel or a tow or when approaching a vessel at close range.

- ⇒ *approaching a very large vessel or a tow: appreciable bearing change* is because blossom effect of target which we can overcome by using target stern bearing to make sure target's actual collision risk.
- ⇒ *when approaching a vessel at close range: how many distance is close range this rule means?* This close distance is determined by ownship's turning diameters.

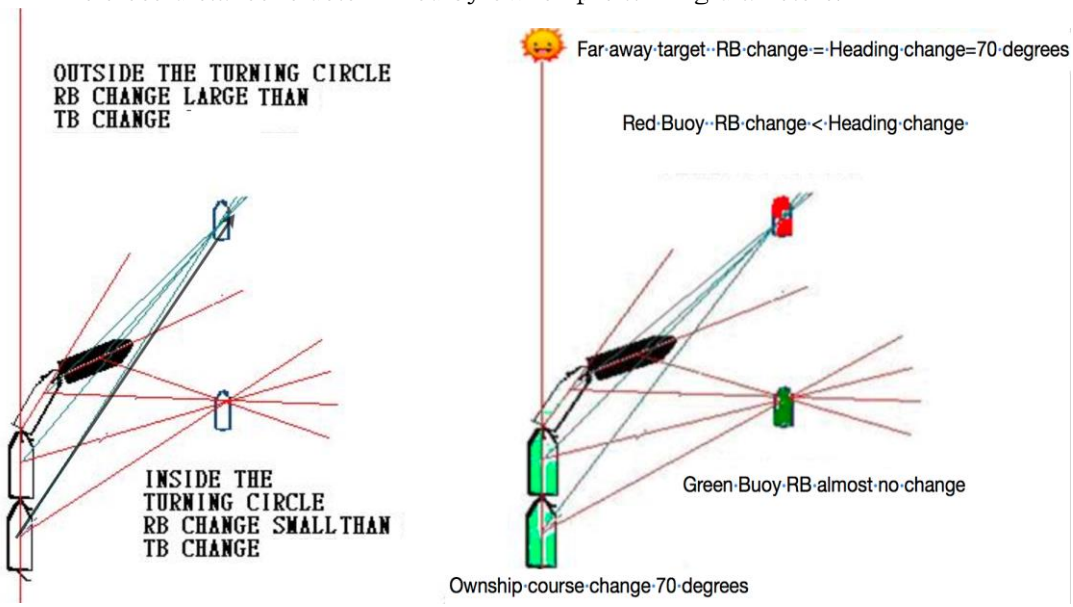

Figure 6-11: Target relative / true bearing change and heading change

In figure 6-11 left drawing,

1. Case 1: One target outside ownship's turning circle (upper one, green bearing line): its Relative Bearing RB change (from starboard side to port side) is larger than its True Bearing TB change (still at 033^0 – 045^0 (T)) when ownship is turning toward it. This target had passed ownship's bow after turning. Even its compass bearing change is not obvious in ownship's turning first two stages its compass bearing change will become more *appreciable* after ownship had steady in new course in third stage. Although TB change is not immediate available (*appreciable*) to ownship its RB relative bearing change could be used to access collision risk if RB change is continuous. Relative Bearing change first them true bearing also change, no collision risk. If relative bearing changed but true bearing did not change *appreciable* there will be a collision risk. See figure 6-12 left picture, target vessel is dead ahead three minutes before collision judged from her 3 minutes trail on ownship's heading. At time of collision, target vessel's compass bearing is about the same at ownship's southeast direction but her relative bearing had changed from ownship's bow to our starboard quarter. In this case, collision comes when target vessel's Relative Bearing changed in the beginning then stopped change while ownship turning. RB unchanged in the last minute happened collision in case 1.
2. Case 2: One target inside ownship's turning circle (lower one, red bearing line): its Relative Bearing RB change is almost unchanged while ownship's turning pass abeam of her. However, its True Bearing TB change is *appreciable* when ownship is turning toward it. This target distance still close to ownship and collision risk is not dissolved. Even its compass bearing change is very obvious when ownship's turning her collision risk is still there. Although TB change is immediate available (*appreciable*) it is useless for collision avoidance purpose. To avoid collision with target inside our turning circle, TB change is no use RB change is necessary. If relative bearing did not change at all there will be a collision in case 2. See figure 6-12 right picture, in SANCHI case both compass bearing and relative bearing had not changed.
3. That why *In COLREG rule 7 Risk of collision: (d)(ii). such risk may sometimes exist even when an appreciable bearing change is evident.*
    I. In case 1, *appreciable relative bearing change* but compass bearing did not change. Collision happened when Relative Bearing stopped change in last minute.
    II. In case 2, *appreciable* compass *bearing changes* but relative bearing had not changed. Collision happened when Relative Bearing had not changed at all.

We know all cases end when collision happened. In both cases 1 and 2 above, relative bearing whether it had changed or not by ownship>s maneuvering in the beginning, when relative bearing stopped change there will be a collision. It is common case for ownship alter course to give way to crossing vessel as case 1 above (This target outside ownship's turning circle). So, we see more collision case of Relative Bearing change but True bearing did not change.

6-24 Why Captain should use relative bearing change to access collision risk?

In figure 6-11 right drawing, if ownship use relative bearing to access collision risk,

1. One target very far away from ownship: her relative bearing change amount is same as ownship's heading change. If ownship just turn our heading away collision risk with it will dismiss immediately.
2. One target outside ownship's turning circle (red one, green bearing lines): its Relative Bearing RB change is from starboard side to port side when ownship is turning toward it. The result is this target will pass ownship's bow. Even its compass bearing TB change is not obvious in ownship's first two turning stages but its relative bearing RB change is immediate *appreciable*. We know target vessel outside ownship's turning circle is more often when we meet other vessel at sea. If Master use RB to access collision risk with target outside ownship's turning circle, relative bearing change is more efficient than compass bearing for collision avoidance assessment. The collision risk with this target vessel is not dismissed after her relative bearing had changed while ownship is turning. Ownship

need to continue observe its relative bearing change to make sure her collision risk after ownship's turning.

3. One target inside ownship's turning circle (green one, red bearing line): its Relative Bearing RB change is almost unchanged while ownship is turning. However, its True Bearing TB change is *appreciable* when ownship is turning toward it in all three stages. However, captain is not the man taking bearing while maneuvering in close range. His short term memory is used to remember ownship's course not target's bearing. Even its compass bearing change is very obvious in ownship's every turning stage her collision risk is still there. Use TB change to access collision risk is dangerous in this situation as we knew. Captain's attention can only be used in target vessel's relative bearing change to access collision risk. Luckily, target inside ownship turning circle is rare case at sea and COLREG had warned "*such risk may sometimes exist even when an appreciable bearing change is evident".* Both bearings change may be useless for collision avoidance purpose. The key point in collision is last minute's relative bearing change. If Master use relative bearing to access collision risk while ownship is turning or not they will be no mistake even in close range, in or out of ownship's turning circle. However, this is Master level's skill and instinct we need.
4. Some thoughtful Master will challenge: not all targets at sea are fixed objects, no speed or course to go. That's right. In master level, we should know better that Target is alive before collision. When collision happened target vessel is only an huge object at collision position. Master's crucial ability is to predict target vessel's position (or collision position) where collision might happen. We are to avoid collision position no matter she has what course or speed before collision. If we can take actions to avoid original collision position by change course or reduce speed collision risk at original position will be avoided by our action.

6-25 Does relative bearing change can be used to determine collision risk?

In COLREG, two vessels have collision risk is based on "*such risk shall be deemed to exist if the compass bearing of an approaching vessel does not appreciably change".* From the discussion above, we know when ownship go straight or alter course toward a target vessel has collision risk her compass bearing will not change. Only when ownship's turning had reached third stage or ownship's hull had left original course line target vessel's compass bearing will begin its change. In figure 6-12 left picture these two vessels have collision because their *compass bearing does not appreciably change*. we see ownship has abeam distance at third stage and collide with target vessel off original course line. The proximate cause of his collision is ownship's turning. The hidden cause is Captain's knowledge of turning characteristics is not enough, don't know how to estimate ownship's turning circle. I think most of us also forget here. It is our space ship status or 3 minutes speed vector to represent it.

However, in COLREG " *Such risk may sometimes exist even when an appreciable bearing change is evident …".* In another words, by COLREG along had concluded *compass bearing appreciably change* is not enough to judge this target has collision risk or not. Now We have a question here "If one target's *relative bearing does not appreciably change* should collision risk be deemed exist? In another words, does relative bearing change can be used to determine collision risk?

If we judge by the figure 6-11: Target relative / true bearing change and heading change.

- For a remote target like Sun on the sky, it relative bearing change is exactly the same as compassing bearing change if ownship is turning to starboard side 70 degrees. Faraway target has no collision concern.
- For a target outside ownship's turning circle its relative bearing change (about 55 degrees) is smaller than ownship's heading change like the red buoy at ownship's port side after ownship altered course 70 degrees to starboard side. If ownship steady on new heading 070^0 (T) before collision target relative bearing will increase and pass ownship's stern. If collision happened before ownship finish the turning this red buoy's relative bearing will not *appreciably change* which can be used as an indication of collision risk.

- For a target inside ownship's turning circle its relative bearing change is almost no change after ownship heading change 70 degrees to starboard side like the green buoy at ownship's starboard side. If collision happened when ownship's turning had not finished yet this green buoy's relative bearing will not *appreciably change* which can be used as an indication of collision risk.
- It is like we had found something in common: Relative bearing had not *appreciably change* which can be used as an indication of collision risk. Once again, these discussions had indicated one thing important. Knowing ownship's turning characteristics.

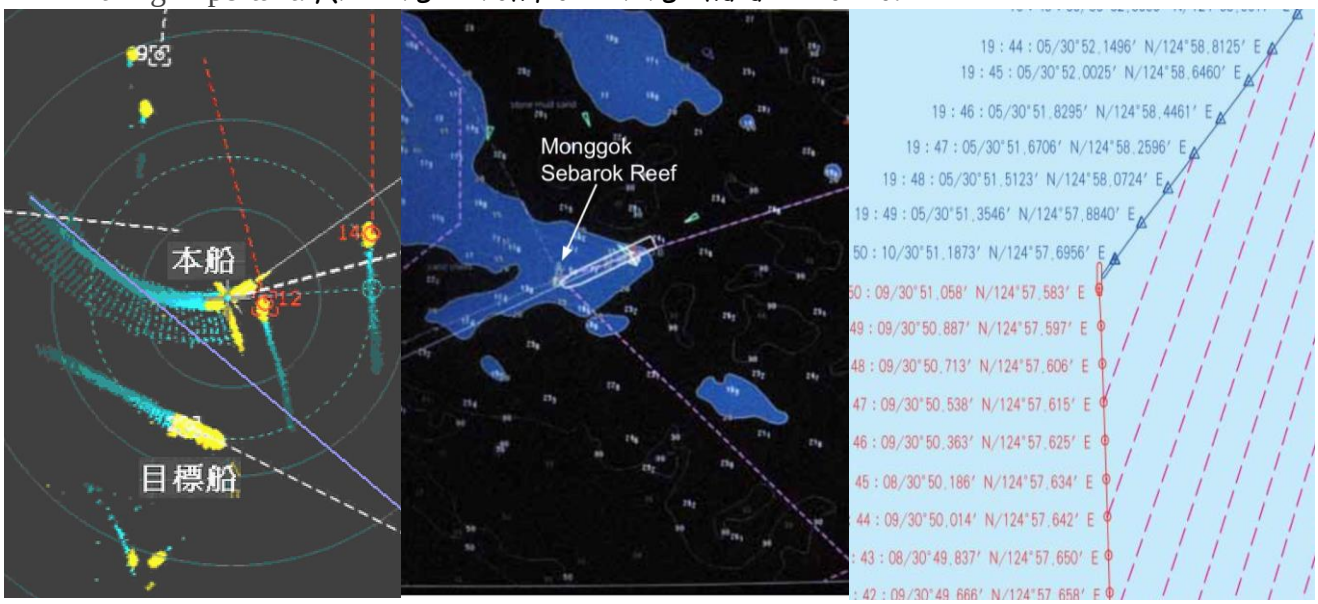

Figure 6-12: Target relative / true bearing change and heading change

6-26 Challenges to COLREG definition and its application

Should the COLREG 7 amended to "*such risk shall be deemed to exist if the **relative bearing** of an approaching vessel does not appreciably change*" instead of "*compass bearing*" ?

Both buoys are at close range why their bearing change in relative bearing and compass bearing is so different? It is because these two buoys are at different side of ownship turning circle while ownship is turning.

- Green buoy relative bearing unchanged is because it located inside ownship's turning circle. So, when target are inside ownship's turning circle its compass bearing changed cannot used as an indication of safe passage. Instead, we should use her relative bearing change to decide her collision risk.
- Red buoy located outside ownship's turning circle relative bearing had changed in the beginning. However, if ownship cannot finish the turning before the distance getting too close collision will happen. When target outside ownship's turning circle has collision her relative bearing will not increase any more.
- It looks like relative bearing is more suitable for collision risk reference than compass bearing whether ownship is on steady course or under different turning stages.

If this is correct we should concentrate on relative bearing observation instead of compass bearing observation from gyro repeater card or radar screen (not determinate and waste time to remember it). May be the collision definition should be defined by two vessel's distance become Zero (by using their speed vectors to decide the distance) instead of their compass bearing had changed or not? If COLREG defined the collision risk as "two vessels approaching each other so as their distance to each other will become zero" what actions can be used to avoid a collision case? Increase two vessels' distance should be the answer. But how to increase two vessel's distance? If OOW mind is set in "to increase distance between two vessels to avoid collision" then alter course and stop engine all become part of options to keep safe distance. We will more conscious to lookout safe distance instead of bearing change which is not so efficiencies in close range as we had discussed.

6-27 Relative bearing change when turning in close quarter encounter

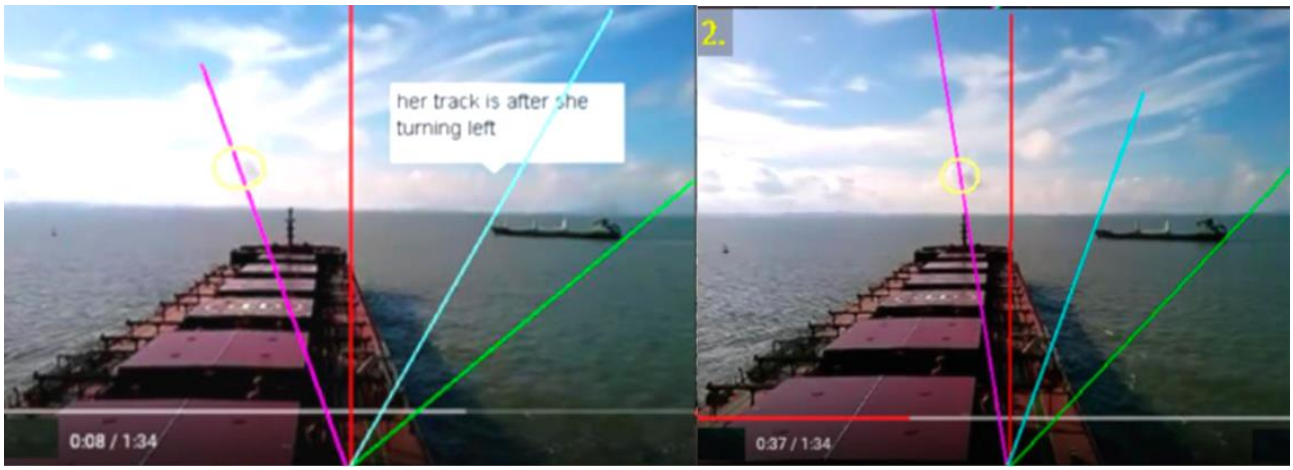

Figure 6-13: Ownship turn port side in first stage and target distance close in

Now we had some discussions of target relative bearing changed when ownship is turning. In figure 6-13 left picture we have

- far away target the cumulus cloud (black patch in yellow circle) on the sky is our reference of ownship's heading change marked with purple line on port bow.
- Ownship heading is red line at break of forecastle.
- Target vessel's bow bearing is light blue line.
- Target vessel's stern bearing is green line

Ownship is turning to portside right now. At port side we saw a buoy passing by or closing in?

From 0:08 times to 0:37 times, ownship may be in first stage of turning.

⇒ Relative bearing of the cloud had decreased 11 degrees from port side 20 degrees at 0:08 times (picture 1) to port side 09 degrees at 0:37 times (picture 2). This means ownship's heading had changed 11 degrees to port side.

⇒ Relative bearing of Target vessel's bow (should increase when ownship is turning to port side) had decrease 10 degrees from starboard side 30 degrees to starboard side 20 degrees.

⇒ If ownship had not altered heading to port side 11 degrees target vessel's bow will be starboard side 09 degrees at 0:37 times.

⇒ Relative bearing of Target vessel's stern (should increase when ownship is turning to port side) had decrease 05 degrees from starboard side 50 degrees decreased to starboard side 45 degrees.

⇒ Target vessel's horizontal angle is 20 degrees at beginning then 26 degrees after 30 seconds at 0:37 times which is a sign of closer distance between two ships. Horizontal angle increases 6 digress.

⇒ In this interval 0:08 to 0:37 times (29 seconds), ownship is turning to port side 11 degrees and target vessel's bow relative bearing decrease 10 degrees which is 11+10 = 21 degrees if ownship is not turning. Her stern relative bearing had decreased 5 degrees which is 11+5 = 16 degrees if ownship is not turning. Plus half of her horizontal angle augment (increases 6 digress), her stern relative bearing may have decrease 16+ 3 = 19 degrees.

⇒ We can see Target's bow relative bearing decrease is 21 degrees if we deduct 3 degrees of her horizontal augment, actual relative bearing change will be 21-3= 18 degrees if ownship did not turn. And, her stern decrease is 19 degrees (as calculation above) if ownship did not turn.

6-28 Visual clues whether target vessel can pass our bow

This target will pass collision position earlier than ownship for her bow relative bearing is decreasing.

If there is a collision ownship will collide his port side if collision happened in ownship's 1st stage of turn.

⇒ Judging the collision situation from target's bow relative bearing change is difficult. Judging the collision situation from target's stern relative bearing change is easy for we don't need to worry about horizontal angle change.

⇒ Relative bearing of Target vessel's stern had decrease 5 degrees means **target vessel's stern had the chance to pass ownship's bow** even ownship is turning to port side now.

⇒ Her stern decrease is 19 degrees actually plus 11 degrees ownship's turn and 3 degrees horizontal augment and her original relative bearing is 50 degrees to starboard side (19 off 50 degrees). If ownship did not turn she has very good chance to pass ownship's bow.

⇒ The key point here is her distance to ownship. Is it enough time to wait her stern to pass?

6-29 Estimate target vessel distance by her length over all

Horizontal angle of this target is 20 degrees. If we assume this target is 150 meters in length, by the calculation of Horizontal angle:

- 1852 m x ? nm x Sin (θ^0) = 150 meters. θ=20.0 degrees, ? = 0.237 nm = 438 m. (See Figure 2-09 horizontal angle augment of approaching vessel) Sin (20^0)=0.342
- 1852 m x ? nm x Sin (θ^0) = 150 meters. θ=26.0 degrees, ? = 0.185 nm = 342 m. Sin (20^0)=0.438

This target' s distance to ownship is about 438 meters (2.37 cables) if she is 150 meters long estimated by horizontal angle. 438 m to 342 m = 96 m in 29 seconds, ownship is making 6.22 knots. TTC is 4.57 minutes. Her stern relative bearing changed 19 degrees in 29 seconds and TTC is 4.57 minutes. If ownship did not turn she has very good chance to pass ownship's bow.

Although we now estimate her distance from horizontal bearing and ship's length, it is possible to judge the distance by our experience or radar.

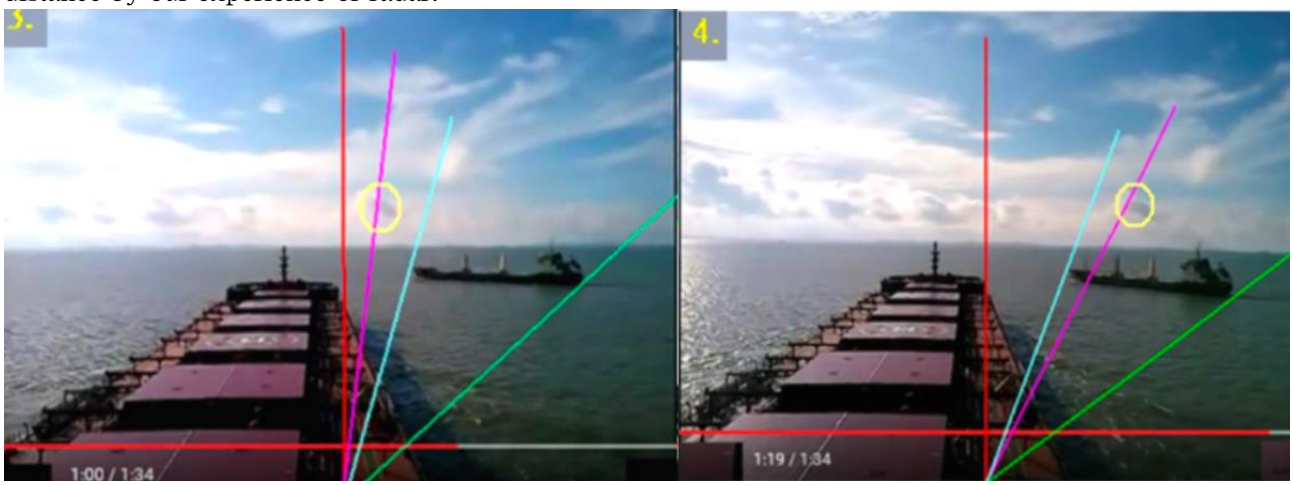

Figure 6-14: Ownship turning port side in second stage and target distance steady

At 1:00 times, ownship is in second stage of turning. Judging by the degrees had turned 27 degrees. Relative bearing of the cloud had changed from port side 20 degrees at 0:08 times (picture 1) to 07 degrees starboard side at 1:00 times (picture 3), Rate of turn is 36 degrees per minutes. In 1:19 times (picture 4), Relative bearing of the cloud had changed to 27 degrees. Rate of turn is 20 degrees in 19 seconds. Bulk carrier is a round ship.

⇒ Relative bearing of Target vessel's bow had decrease 3 degrees from starboard side 19 degrees decreased to starboard side 16 degrees at 1:00 times in figure 6-14 (picture No.3). Target's bow crossed ownship's bow very slowly.

⇒ Relative bearing of Target vessel's bow had increased 4 degrees from starboard side 16 degrees decreased to starboard side 20 degrees at 1:19 times hours in figure 6-14 (picture No.4).

If target vessel's bow relative bearing had not changed much in starboard side target's bow will hit ownship starboard side hull because these two vessels is approaching to each other in close range. If collision happened ownship will be hit by our starboard side in ownship's 2nd stage of turning to port side.

⇒ Target vessel's bow had increased 4 degrees is a good sign of been overtaken by ownship.

⇒ Relative bearing of Target vessel's stern had increased 15 degrees from starboard side 35 degrees to starboard side 50 degrees at 1:00 times in picture No.3 is a good sign of been overtaken by ownship.

⇒ Relative bearing of Target vessel's stern had increased 05 degrees from starboard side 50 degrees to starboard side 55 degrees at 1:19 times in picture No.4.

⇒ Relative bearing of Target vessel's stern had increased means target vessel's stern had the chance to pass ownship's stern.

⇒ Ownship is turning to port side at rate of turn 36 degrees per minute target vessel's bow and stern bearing increased still very slow. Collision risk is still imminent.

6-30 Estimate target vessel collision risk by her distance

Target vessel' s horizontal angle is 34 degrees at picture 3 compared with 35 degrees at picture 4 which is a sign of distance between two ships had not changed.

⇒ If the collision is defined as "two vessels' distance close to zero" as we discussed before the collision risk is no longer exist at this stage because "two vessels distance remained the same".

At this stage two vessel is standstill at sea although both are moving with continuous changed speed and course, judging by two vessels' distance.

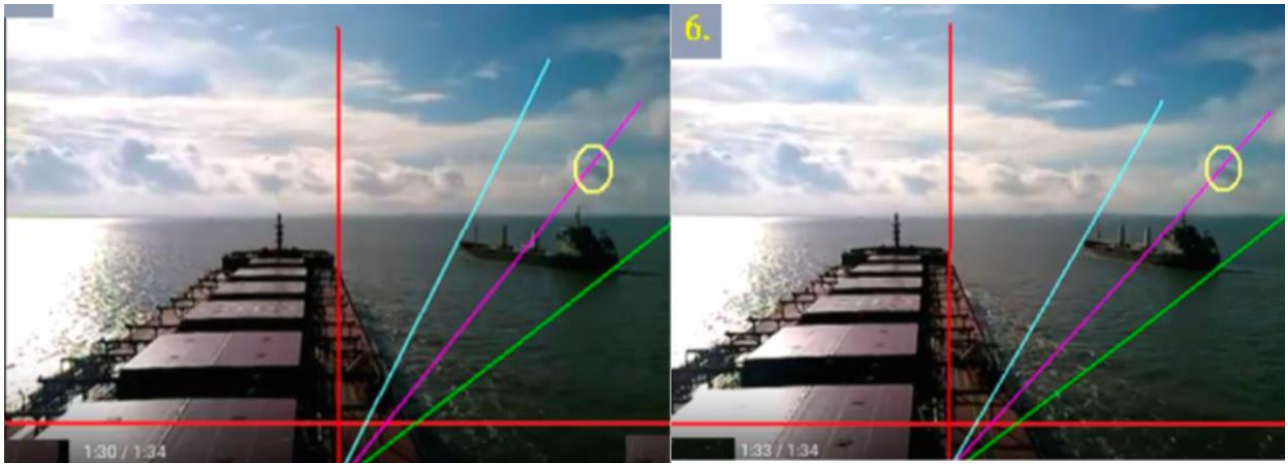

Figure 6-15: Ownship turning port side slowly and target stern approach

6-31 Target vessel horizontal angle decreased means safe

From 1:19 times to 1:30 times, ownship is in 3rd stage of turning.

Relative bearing of the cloud had changed from 27 degrees in 1:19 times (picture 4) to 41 degrees in 1:30 times (picture 5). Ownship had turned 14 degrees in last 11 seconds. Rate of turn is over 60 degrees per minutes. From figure 6-15 1:30 times to 1:33 times (picture 6), ownship had slow down the turning.

⇒ Relative bearing of Target vessel's bow had increased 5 degrees from starboard side 20 degrees to 25 degrees at 1:30 times in figure 6-15 picture No.5.

⇒ Relative bearing of Target vessel's bow had increased 5 degrees from starboard side 25 degrees to starboard side 30 degrees at 1:33 times in figure 6-15 picture No.6.

Target vessel's bow relative bearing increased very fast means target vessel's bow is away from ownship, whatever the reason. The reality is Target vessel's bow is turning to his own starboard side (turning away from ownship's starboard side).

⇒ Relative bearing of Target vessel's stern had increased 02 degrees from starboard side 55 degrees decreased to starboard side 57 degrees at 1:30 times in figure 6-15 picture No.5.

⇒ Relative bearing of Target vessel's stern had not changed from 57 degrees at 1:33 times in figure 6-15 picture No.6.

Relative bearing of Target vessel's stern had not changed means target vessel's stern had closed to ownship.

⇒ Ownship is turning to port side at rate of turn 60 degrees per minute target vessel's bow and stern relative bearing changed still very slow. Collision risk is still imminent.

⇒ Target vessel's horizontal angle is 35 degrees at picture 5 then 27 degrees at picture 6 because target vessel had altered course to starboard side, not because two ship's distance had increased.

⇒ Target vessel's horizontal angle has decreased by his turning is a good sign and her stern relative bearing is unchanged is a bad sign.

⇒ At least these two vessels are about to sail in parallel course which is a good sign of relieve.

Target vessel's horizontal angle has decreased means two things: 1. Her distance increased or 2. Turning away.

6-32 Judging collision risk by relative bearing of target vessel's stern change

In this paragraph, we had studied the relative bearing change of target vessel's bow, stern and her horizontal angle. Ownship had alter course to port side and target vessel had alter course to starboard side. The collision is near miss.

⇒ Target vessel's horizontal angle give us a sense of her approaching distance is closing or not.

⇒ When horizontal angle increased target vessel distance decreased like a great wall which ownship should try to parallel with her heading if possible.

⇒ Target vessel's relative bearing of bow is decreased when she had not altered course to starboard side yet. This is a sign of target vessel's bow will arrive collision point earlier than ownship. Ownship have to judge her distance change by using horizontal angle augment of target vessel. If her distance is running out very quickly the collision risk is imminent.

⇒ Later, target vessel's relative bearing of bow is increased slowly. This means target vessel's bow is away from ownship by her course altering to starboard side or ownship increased speed.

⇒ Target vessel's relative bearing of stern had not so much change. Had decrease 05 degrees to starboard side 45 degrees at 0:37 times. Had increased slowly 10 degrees to starboard side 55 degrees at 1:00 times and steady in that direction after her course change. The distance to target vessel's stern is reducing when her relative bearing had not changed.

⇒ It is obvious that although two ships had conducted avoidance action, target vessel vessel's relative bearing of stern had not changed much. The distance of vessel's stern is getting closer and closer.

⇒ The avoidance actions of both ships are not so effective because the distance is too close to each other (less than 3 cables if we are right).

⇒ Ownship have three options.

- First, Slow down let target vessel's relative bearing of stern decrease slowly and passing ahead ownship (judging by ownship's stopping ability) or
- Second, keep altering course to port side and let target vessel's relative bearing of bow increase until two vessels are in same course (judging by ownship's turning ability).
- reduce speed and alter course at the same time by rudder cycling (judging by ownship's rudder cycling skill).

After all 6 pictures, we can see **target vessel's relative bearing of stern did not appreciable change the collision risk should deem exist.**

6-33 Avoiding collision actions is decided by ownship's turning characteristics

In the beginning, target vessel's bow and stern relative bearing is decreased which means target vessel arrive collision point earlier than ownship.

⇒ If ownship stop engine to avoid collision here target vessel bow and stern relative bearing will be decreased fast which means target vessel may pass ownship's bow quicker than before.

⇒ If ownship alter course to starboard side to avoid collision ownship have to make sure target vessel is outside ownship's turning circle. (our estimation 3 cable distance for a vessel with 7 hatches is not enough)

⇒ To make sure target vessel is outside ownship's turning circle is to check target vessel's distance is greater than ownship's 90 degrees turning advance distance.

⇒ The skill to visual estimate target distance is enough or not for ownship's turning advance distance is a valuable skill here.

⇒ This skill is also needed when Captain maneuver his ship around pilot station or anchorage with other vessels anchored nearby.

⇒ Ownship had altered course 60 degrees to port side which is dangerous move if Target vessel had not altered course to starboard side in last minutes.

⇒ Ownship alter course to port side shift collision position from ownship's bow to ownship's port side where target vessel is going. Ownship is chasing after target vessel's position.

⇒ Captain should bear this in mind (don't chase target vessel) to protect ownship when take actions to avoid the collision.

⇒ If ownship can reduce speed effectively by rudder cycling it will be a most valuable means to avoid collision in close quarter situation.

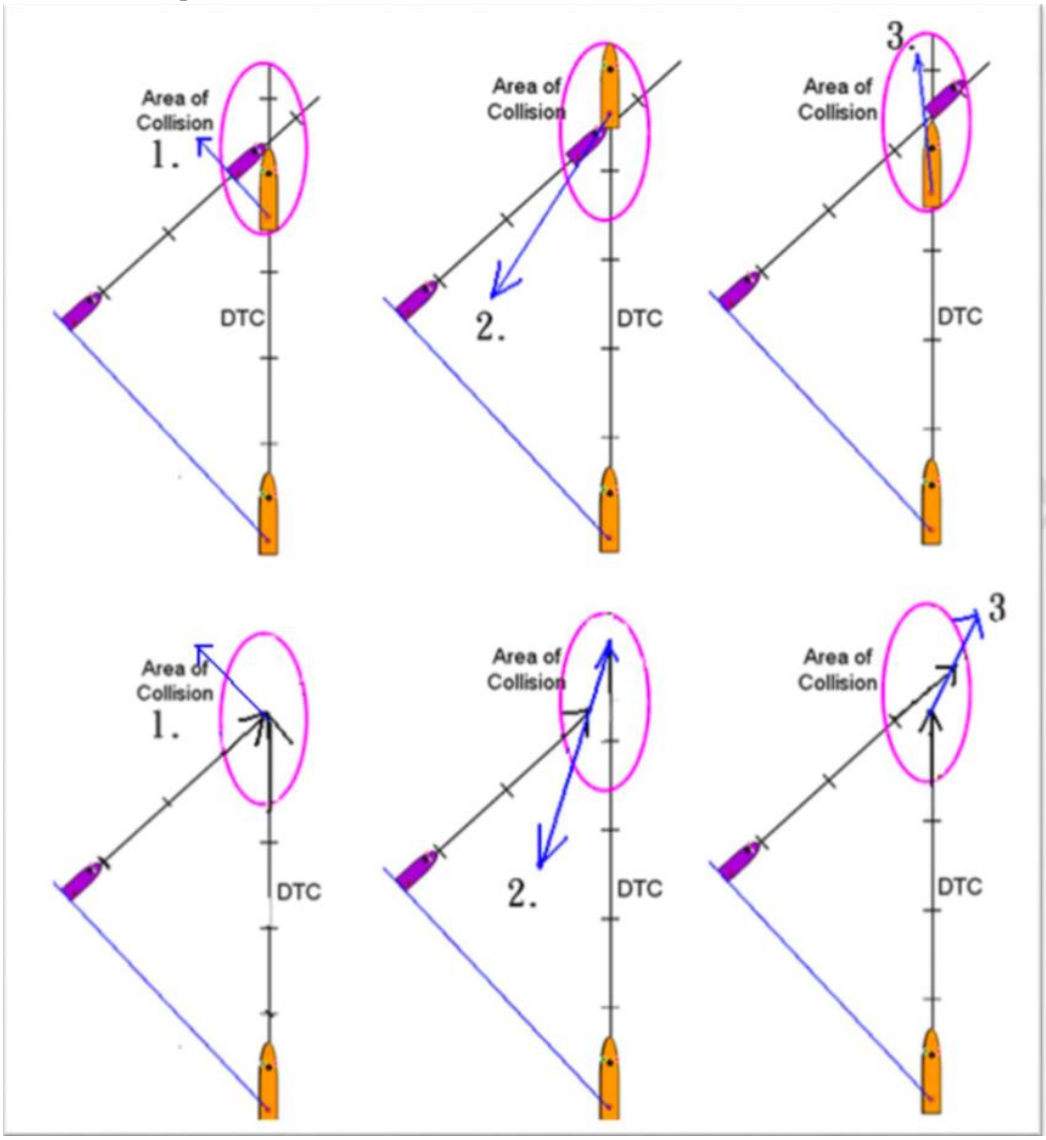

Figure 5-03: best aide action to avoid the collision by speed vector

6-34 Judging angle of blow by visuals

Let's review figure 5-03 again, as a captain we expect he has ability to verify the situation will be in collision. To know meeting situation in collision is not only best aide to avoid it. But, it is also best aide to protect ownship and crew. It is necessary to judge angle of blow by visuals. Visual check relative bearing change of target's stern or bow is needed when Radar/ARPA target echo are not available in close range as we discussed in Sanchi's case. Visual check is the only way we can use to estimate how these two ships will collide. Radar/ARPA/AIS data can provide earlier collision warning as we always know but Mariners didn't know we can have "Angle of Blow" earlier warning too.

Ownship can take more correct actions to avoid collision if we can read angle of blow from radar true speed vectors layout. The speed vector length can set to 3, 6, 9, 12 minutes if we cannot find crossed point of these two vessels' true speed vector. No matter how many minutes length setting of speed vector is. The last three minutes speed vector is the critical part in collision avoidance as FIGURE 2-14: ARPA, 6 minutes tm speed vector and 3 minutes collision risk area. If we can read speed vector head layout as figure 5-03 lower part we can get early warning of angle of blow massage 3, 6, 9, 12 minutes before collision. The visual relative bearing change can also be used to verify our radar lookout skill. Verify relative bearing change by visual is to cultivate our instinct in collision avoidance. We have been trained to take target's

compass bearing in OOW time as a point at sea. We are Master now. We should train ourselves to feel relative bearing change of target's bow and stern separately. In figure 5-03 there are three cases.

⇒ Case 1: Target's relative bearing of stern unchanged or increased a little (due to horizontal angle augmentation). Both vessels arrive collision position at same time. Best aide to collision avoidance is decided by Target's relative bearing (or approaching bearing or target's speed) which will be explained in figure 6-16. For fast speed vessel relative bearing near ownship's beam position is to stop our speed. For slower vessel relative bearing near ownship's bow is to alter ownship's course.

⇒ Case 2: Target's relative bearing of stern increased to ownship's quarter. This target has the tendency to pass ownship's stern. Ownship can help her by altering course away from her to increase her relative bearing change.

⇒ Case 3: Target's relative bearing of stern decreased. This target has the tendency to pass ownship's bow. Ownship can help her by altering course to go around her stern.

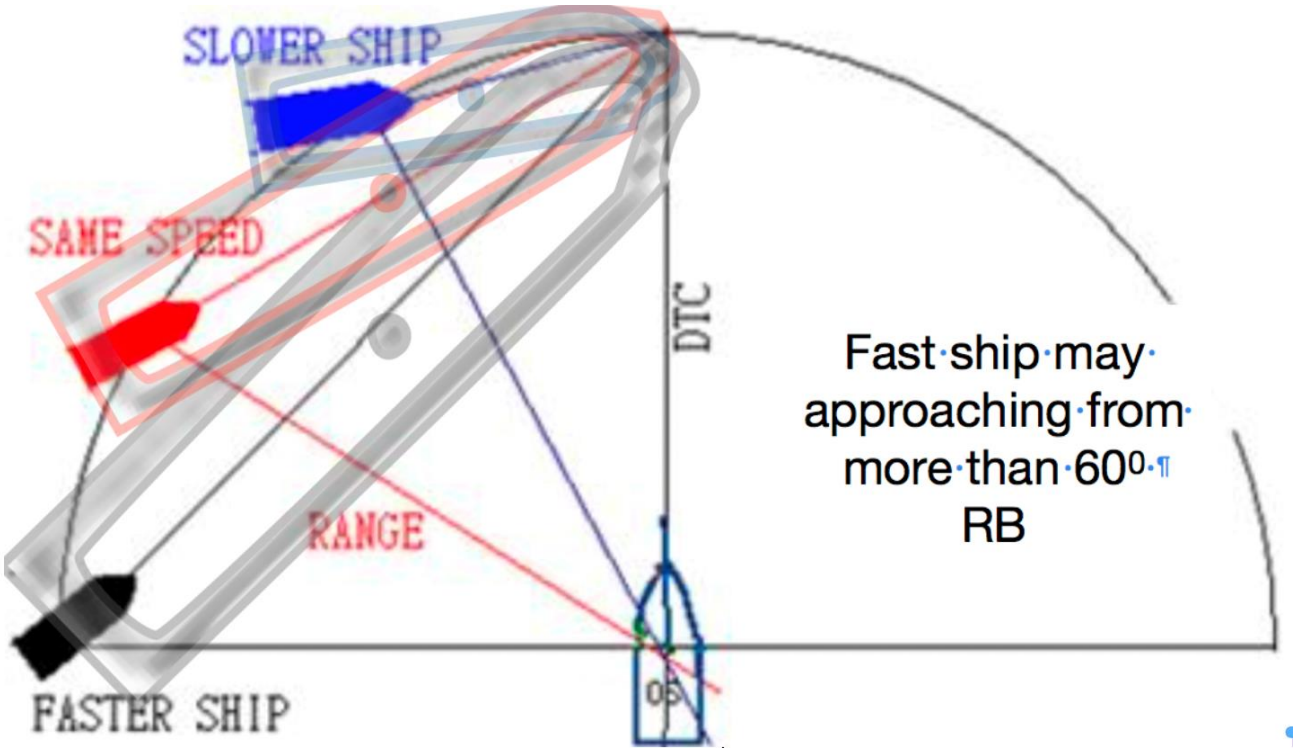

Figure 6-16: Best aide to collision avoidance is decided by Target's relative bearing

6 – 05 Best aide to collision avoidance

6-35 Best aide to collision avoidance when no visual contact with target vessel

When ownship has no visual contact with target vessel at fog (restricted visibility) our avoidance actions are decided by Target's relative bearing. We have three cases as figure 6-16:

⇒ Target is slower than ownship. So, she has SRB safety relative bearing which can be estimated by Master when we know target's present speed already.

Sometimes it is better to cross his head than her stern like the example of figure 6-06.

We know what target or danger are before her bow and we can properly estimate and decide what we should do to keep safe. But, sea room or other targets behind her stern is unpredictable especially in narrow channel or TSS. What if she suddenly stops engine (or alter course to give way to other small vessel) and there is no room in her stern as figure 6-06 which cause ownship to go around? Whether to pass ahead or astern ownship have to make sure where is collision position first. If the collision position is not inside TSS or narrow channel ownship should consider going back to correct traffic lane first to avoid unpredictable dangers as prudent navigator. If Captain want to pass ahead of target vessel he should know what is her SRB to pass?

⇒ Target has same speed as ownship. Her approaching bearing is up to 60 degrees. It is a very tired work to go around her stern to 60 degrees more. Captain should know how to avoid collision by

avoiding collision position with her. If target vessel arrives collision position first ownship should reduce speed to let her pass first. If ownship arrive collision position first and ownship increase speed is unavailable to avoid the collision we should alter ownship's course to parallel with target vessel. When ownship's course had paralleled with target vessel we should find the way to communicate with target vessel to discuss how to solve the case. Or, it is better to reduce ownship speed with rudder cycling skills (if Captain knows how to do it) to let target vessel pass first.

⇒ Target is faster than ownship.

- It is very likely she is an overtaking vessel. Ownship should maintain course and speed if possible. Suddenly reduce ownship speed will create some forms of stern wave which will easily push ownship's course away to block overtaking vessel's way.
- If she is not overtaking but crossing vessel our avoidance action should decide by ownship's speed.
  - If ownship speed is below 5 knots it is better to alter course to same heading as target vessel. Because reduce speed can create safe distance if ownship speed is very low ownship reduce speed have very little effect to make enough safe distance. This consists of two reasons: first is speed difference is little and second is vessel can drift ahead in slow speed longer than we expect unless Master had use astern telegraph to reverse the revolution of propeller.
  - If ownship speed is between 5-10 knots ownship may try to rudder cycling to reduce speed more effectively if situation does not allow to alter course.
  - If ownship speed is over 10 knots stop engine immediately is recommended.

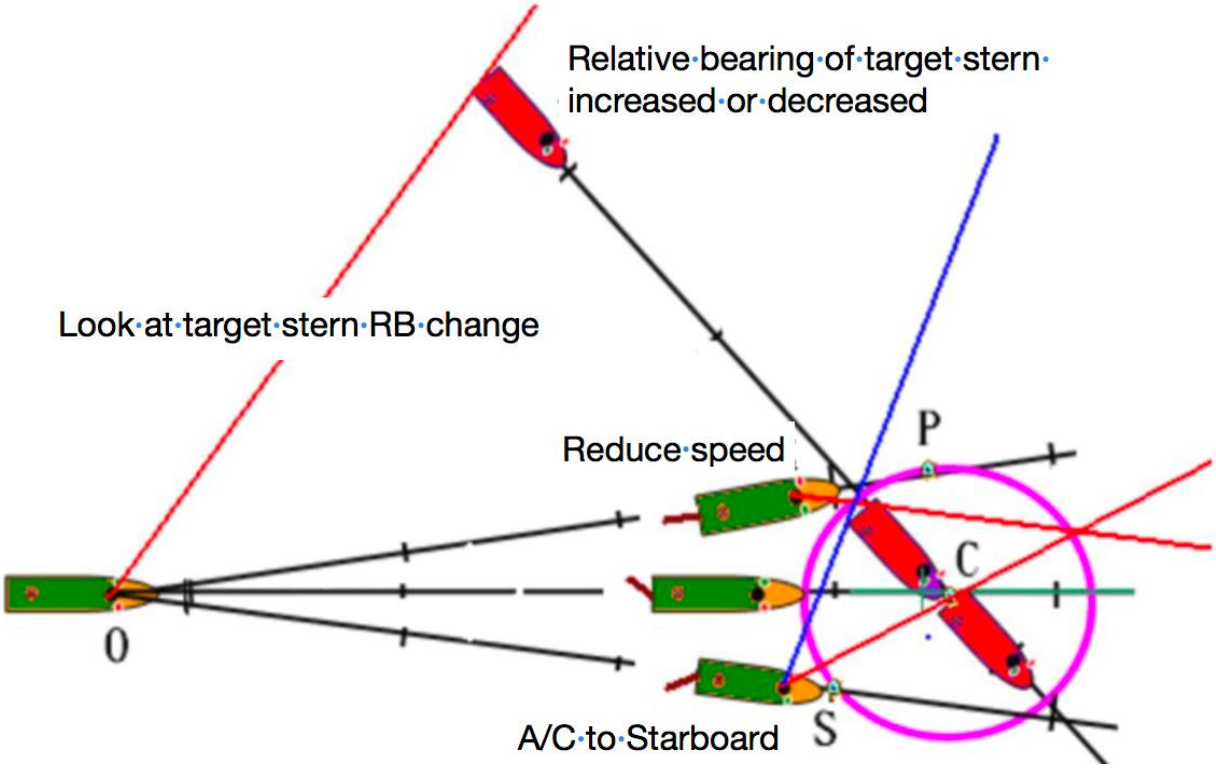

Figure 6-17: best aide action to avoid the collision by visual

6-36 Best aide to collision avoidance when some targets may not track or notice before

In radar lookout we can decide TTC time to collision of both vessels to know which ship will arrive collision position earlier. The one arrives collision area earlier is more danger than the other as Sanchi's case shown. If ownship is give-way vessel it is no doubt we should take avoidance actions earlier. If we are stand-on vessel we may use our decision to take avoidance actions before give-way vessel did. The understand of SRB and possible collision area are important when ownship decide to take actions along to avoid collision. As a Master, when we transit narrow channel or crowded harbour area or near pilot station

navigate with caution is a must-be. However, some targets may not track or notice before it become a close quarter situation.

⇒ Verify her distance by visual or radar first. This requirement has one prerequisite: positive identify the target. The setting of target's trail in radar can help to identify if targets' number are few. If targets are many her relative bearing should be readable by Master immediately using those visual skills we practiced so many years already. Target's distance is to know does ownship have time to alter course to avoid collision or not? Identify the target in question on radar and acquire it by ARPA to have her speed vector available for our quick decision.

⇒ Lookout for Target vessel's stern relative bearing change to decide the action plan. Follow her stern's original tendency will be more effective for collision avoidance. Knowing her stern movement is also part of our awareness of collision position and collision situation. Another reason why ownship should beware of her stern's movement is the sea room available for avoid collision usually is very limited in this congested area. If Captain did not have this ability to visual verify target vessel's movement his career is in danger. We may give-way and give-way again but collision or grounding happen at last. Nothing is more sad for a Captain to have this kind of wrong setting procedures. We have to said to evaluate target's stern movement in close range need strong mental stability. However, this stability in mind is based on our instinct from long times practice and experiences in correct situation awareness.

⇒ If target vessel's stern relative bearing decreased and close to ownship's bow, any actions can help target vessel stern's relative bearing continue decrease will be useful like reduce speed or turning toward her if distance is enough (you should know her distance or SRB already before alter course).

⇒ If target vessel's stern relative bearing reduced to ownship's bow, go around her stern if we need safety distance.

⇒ If target vessel's stern relative bearing increased slowly ownship should evaluate the chance we can pass her. If the distance is so close and she has the chance to hit ownship's side and sink us, make sure her intention first. If proper communication cannot be established ownship should give some warning in VHF, whistle or ALDIS flash lights at night to her if we have the time. If no response from target vessel ownship should reduce speed, stop engine drastically or alter course to parallel her for safety and find other solution if available. If VTIS or pilot is present in this area ownship should seek their proper assistance if collision time is sufficient.

6-37 At 4 NM distance away, A/C 15 degrees of collision course to achieve CPA = 1 nm

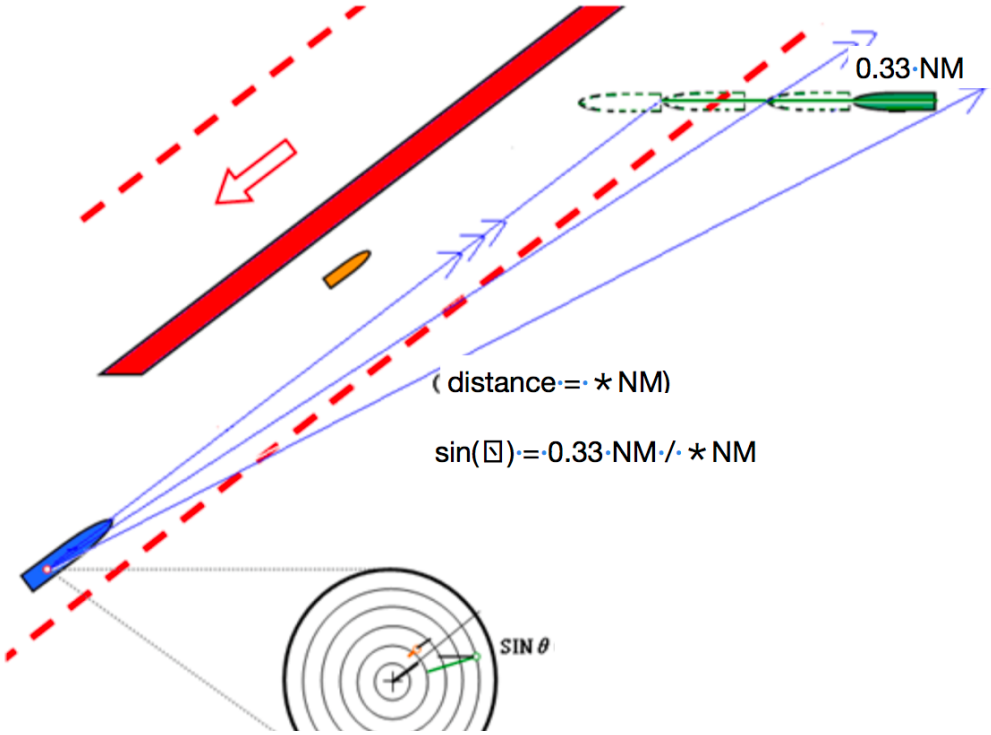

Figure 6-18: Ownship should alter course how many degrees to give way 1/3 NM

In chapter 4 we had reached conclusion as above. If these target vessels are inside the Singapore harbour or Suez Canal the distance controlled by VTIS is one nautical mile apart. Ownship want to keep one nautical mile distance from other vessels is a joke if captain want OOW to keep. If ownship can avoid first target vessel by 1 nm we will collide second vessel who were instructed to keep 1 NM distance after first one. The principal for junior OOW to keep 1 NM CPA is not applicable to a Master in coastal area.

Anyway, if target vessel has collision risk with ownship the collision position should be verified first.

If ownship want to keep CPA to 1/3 of one NM we need to alter course to 5 degrees at 4 nm distance away.

- ⇒ Sin(θ) = 0.33 NM / 4 NM , the θ is 4.73 degrees
- ⇒ At 4 NM to A/C 5 degrees to give way one third NM (1/3 nm, 620 meters: about two ship's length, one ship length for target and one ship length for ownship). Only for Master the safe distance CPA is 0.33 nm to comply with real world requirement.
- ⇒ Here, we must understand this course alternation 5 degrees is to alter the collision course: the course that ownship will reach collision position at same time as target vessel. For example, if Sanchi in course 358^0 (T) will have a collision 358^0 (F) is collision course. $358^0 + 5^0 = 003^0$ (T). 003^0 (T) is the course to keep CPA 1/3 nm.
- ⇒ What if ownship want to give way 1/3 NM in 2 NM distance away? Sin(θ) = 0.33 NM / 2 NM , the θ is 9.49 degrees, or easy to memory: 10 degrees
- ⇒ What if ownship want to give way 1/3 NM in 1 NM distance away? Sin(θ) = 0.33 NM / 1 NM , the θ is 19.3 degrees, or easy to memory: 20 degrees. These are Captain's golden rule:

At 4 NM to A/C 5 degrees to give way 1/3 NM (620 meters)
At 2 NM to A/C 10 degrees to give way 1/3 NM (620 meters)
At 1 NM to A/C 20 degrees to give way 1/3 NM (620 meters)

1/3 nm or 620 m is about two ship's length for most case. Alter the collision course 5 degrees in 4 nm distance away to achieve 1/3 nm CPA. Please refer to Figure 6-18: Ownship should alter course how many degrees to give way 1/3 NM.

6-38 At 4 NM distance away how many degrees is 400 meters target's horizontal angle?

In chapter 2, we also summarized augmentation of horizontal angle as follow:

For vessel of 400 meters length over all at 4 nautical mile distance the bearing taken by horizontal angle is

- ⇒ 1852 m x 4 nm x Sin (θ^0) = 400 meters. Θ=3.095 degrees:

this is what we see a 400 meters vessel in 4 nautical miles distance away his profile takes about 3.095 degree of horizon angle.

For vessel of 400 meters length over all at 2 nautical mile distance the bearing taken is

1852 m × 2 nm × Sin (θ°) = 400 meters. Θ= 6.20 degrees
1852 m × 1 nm × Sin (θ°) = 400 meters. Θ=12.47 degrees
1852 m × ½ nm × Sin (θ°) = 400 meters. Θ=25.59 degrees
1852 m × 1/4 nm × Sin (θ°) = 400 meters. Θ=59.76 degrees

Imaging this 400 meter target is at 1/8 nm her horizontal angle in front of ownship is 120 degrees. If ownship want to alter course to avoid collision with this target where we can go? There are only 180-120= 60 degrees before ownship abeam and we have to make the turn to find it when target's horizontal angle is growing like a Monster bigger and bigger. Mission impossible at 1/8 nm = 231.5 meters away (to avoid a 400 meters target vessel) which is less than one ownship's length if you are ocean going vessel.

6-39 How many distance away to avoid 400 meters target by alter course?

Now, let's use our knowledge of vessel turning characteristics to examine the time to clear these horizontal angles.

⇒ At 2 nm distance away, ownship need to alter course 6.2 degrees. This can be done with auto pilot heading setting function by one minute time. Course change can be done in first stage of ownship's turn.

⇒ At 1 nm distance away (1852 m), ownship need to alter course 12.47 degrees. Ownship need to finish 1st stage of turn which need advance distance about 2 times of ownship's length (600 meters for 300 m long ownship) and 1 minute time to complete the turn. Target's distance is 1 nm = 1852 m and ownship alter course needs advance distance 600 m. 300 m Ownship alter course to avoid 400 m target vessel at 1 nm distance away the distance reminded is 1852 m – 600 m = 1252 meters or 2/3 nm.

⇒ At ½ nm distance away (926 m), ownship need to alter course 26 degrees. Ownship need to finish 2nd stage of turn which is 4 or 3 times of ownship's length (1200 or 900 meters for 300 m long vessel) and 2 minute time. Target's distance is 1/2 nm = 926 m and ownship alter course needs advance distance 900 m. 300 m Ownship alter course to avoid 400 m target vessel at 1/2 nm distance away the distance reminded is 926 m – 900 m = 26 meters or 0 nm. It is obvious that to avoid collision by alter course in ½ nm distance is almost impossible for two VLCC or CLCS. ½ nm is 1.5 minutes run for a 20 knots vessel.

⇒ If target vessel is 200 meters long, at ¼ nm distance away (463 m), ownship need to alter course 30 degrees. Ownship need to finish 2rd stage of turn which is 3 times of ownship's length (450 meters for 150 m long vessel) or 2 minute time. 300 m Ownship alter course to avoid 200 m target vessel at 1/4 nm distance away the distance reminded is 463 m – 450 m = 13 meters or 0 nm. It is obvious that to avoid collision by alter course in 1/4 nm distance is almost impossible for two coaster or working vessel.

For two vessels over 300 meters long, it is almost impossible to avoid collision by Alter course along when their distance is less than 1/2 nm.

And we confirmed once again: why we need at least 1.5 minutes to avoid collision by altering course along.

6-40 How to reduce speed effectively?

We have estimated how many degrees course change in 4 nm is enough to keep away 1/3 NM. If we use same target vessel's size to estimate collision avoidance effect by speed reduction;

- Target vessel 400 meters length over all
- 3 minutes is the time we had to reduce speed

to reduce how many knots to create 400 meters difference in approaching distance should be

1852 meters x ? knots x 3 / 60 minute = 1452 meters. The answer is 15.68 knots

This means with 15.68 knots average speed one vessel can cover 1600 meters distance in 3 minutes run. If ownship original speed is 20 knots, with 3 minutes we can travel one nautical mile (1852 meters), then how many speed ownship should have if the distance run in 3 minutes is 1452 meters (1852-400=1452 meters)?

- 1852 meters x ? knots x 3 / 60 minute = 1452 meters. The answer is 15.68 knots

- 15.68 knots + 4.32 knots = 20.00 knots
- 4.32 knots is the speed to run 400 meters in 3 minutes and 15.68 knots is the speed to run 1452 meters and 20.0 knots is the speed to run 1852 meters.
- Original speed is 20 knots. This 20 knot is average speed. New average speed required 15.68 knots. 15.68 knots = (20 knots + ? knots) / 2. Last speed =11.36 knots

Ownship have to reduce to 11.36 knots in one minute to create 400 meters safety distance.

If ownship original speed is 10 knots who have to reduce speed to create 400 meters distance from collision point then what is last speed will be? The logic is the same.

- 10 knots average speed run in 3 minutes is 926 meters.
- 4.32 knots is the average speed to run 400 meters in 3 minutes and 5.68 knots is the average speed to run 526 meters. Last speed =11.36 knots
- Original speed is 10 knots = 4.32 knots for 400 m + 5.68 knots for 526 m in 3 minutes.
- 5.68 knots = (10 knots + ? knots) / 2. Last speed =1.36 knots

It seems these two cases are the same to reduce 4.32 knots in 3 minutes. Actually, it is not. This 4.32 knots is an average speed.

- For original speed 20 knots, ownship's speed have to reduce to 11.36 knots (20-(4.32 x 2) = 11.36 knots).
- (20 + 11.36) / 2 = 31.36 /2 = 15.68 knots.
- If original speed is 10 knots ownship speed should be reduced to 1.36 knots to create an average speed of 5.68 knots.
- If original speed is 5 knots, in 3 minutes run = 463 meters. 4.32 knots for 400 m + 0.68 knots for 63 m in 3 minutes. 0.68 knots = (5 knots - ? knots) / 2. Last speed = -3.64 knots, initial speed 5 knots, average speed 0.68 knots.

For a prudent navigator, the common sense is

20 knots vessel reduce to last speed 11.36 knot within 3 minutes is possible.
10 knots vessel reduce to last speed 01.36 knot within 3 minutes is almost impossible.
5 knots vessel reduce to last speed 0.68 knot within 3 minutes is impossible

From the discussions here, we can summarize as:

Faster vessel reduce speed is more effective than slower vessel.

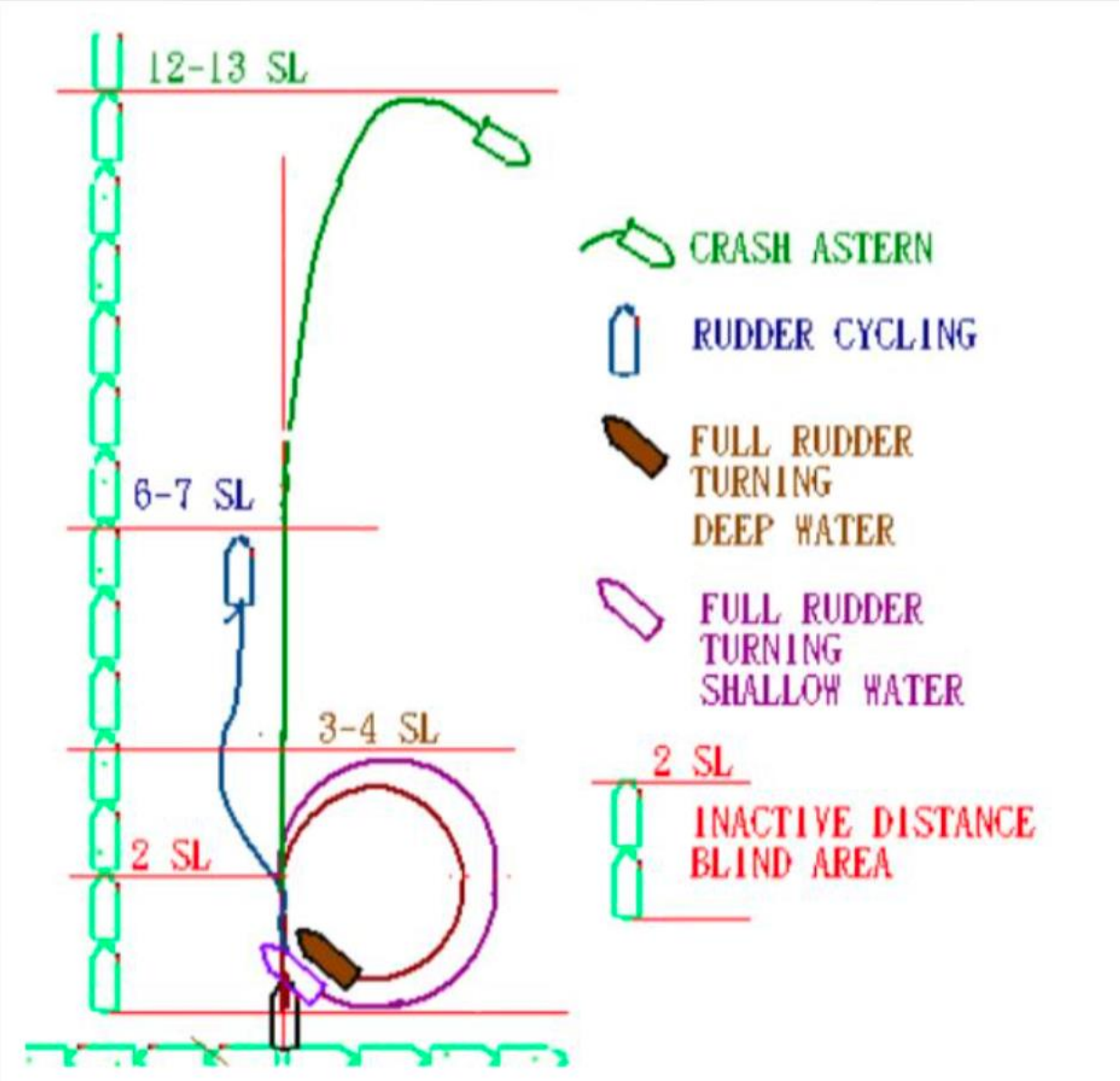

Figure 6-19: Emergency maneuvering

6-41 conclusions of collision avoidance action efficiency? Smaller or slower vessel

Speed reduction to create 400 meters to avoid collision is not so effective within 3 minutes for slower vessel. The operational speed range is from 20 knots to 10 knots. Course change to create 400 meters difference, operational distance range is from 1 nm to 0.5 nm. Our calculation based on Very Large Vessel with 400 meters length over all to avoid. For smaller vessel 200 meters long, speed reduction may workable to 5 knots vessel and course change may workable to range 0.25 nm. We can estimate the limitations we may have to know our deadline in every maneuvering we have, no need to worry or confuse as we know nothing at all. Before we prepare ourselves for these last resorts knowing obligation in COLREG is a must-be. After all, that was what they convict you in the future.

The speed reduction needs to be very quick and bold to be effective

as it's not like alter course can monitor by eye and vessel has more momentum/less resistance to carry forward than it turning into sideward.

If we combine the speed and course workable range for a 400 meters vessel, 20 knots in 1 nm distance is 3 minutes. In radar, a simple way to represent this limitation we had in maneuvering to avoid collision is very vessel's 3 minutes speed vector.

Once we know meeting situation in collision the choices to avoid it are three:

1. Alter course: if ownship have more than 3 minutes TTC (time to collision, read it from ownship' s speed vector) in open sea.

2. Reduce speed: if ownship have more than 6 minutes TTC in open sea.
3. Rudder cycling: if ownship have no more than 3 minutes TTC in open sea or confined waterways.
4. Don't forget reduce speed is effective for faster vessel to avoid collision. Fast ownship reduce speed will have better chance to avoid collision compare with course change. In another words, slower vessel reduce speed is less effective than faster vessel.
5. The advance distance created by altering course to avoid collision is less effective for a small ownship because its effect is measured by ship's length.
6. Small vessel creates less distance difference in collision avoidance.
7. Image one 150 meter vessel had reduced 3 times ship's length 450 meter to avoid collision but this 450 meter is not enough to clear one 400 meter vessel who had not taken any avoidance action. Her 400 meters length ship hull occupied original collision position which ownship cannot avoid by 3 times of ownship's advance length.
8. For a small vessel to alter course to avoid collision is to parallel with oncoming vessel's course not to create more distance. In another words, smaller or slower vessel avoid collision is waiting big vessel to pass not try to get away by course change or speed reduction.
9. It is very important for bigger or faster vessel knowing your present at scene. If bigger or faster vessel did not know ownship is there any small course change of her will make ownship very hard to escape by alter course or reduce speed.

6-42 Manoeuvring characteristics: some fundamentals

Quoted from EXPLANATORY NOTES TO THE STANDARDS FOR SHIP MANOEUVRABILITY MSC/Circ.1053

- *At a given engine output and rudder angle δ, the ship may take up a certain steady motion*. In general, this will be a turning motion with constant yaw rate ϕ, speed V and drift angle β (bow-in). Ownship may make a turn at steady rate of turn ϕ in certain speed V and drift angle β.
- *This particular ship-rudder angle configuration is said to be "dynamically stable in a turn".*
- *Most ships, perhaps, are "dynamically stable on a straight course" (usually referred to as simply "dynamically stable") with the rudder in a neutral position close to midship*. Most ships are stable on a straight course, sharp vessel, VLCS.
- *In the case of a single screw ship with a right-handed propeller, this neutral helm is typically of the order δo = -1° (i.e., 1° to starboard).*
- *Other ships which are dynamically unstable, however, can only maintain a straight course by repeated use of rudder control*. Other ships can only maintain a straight course by repeated use of rudder control, round ship, VLCC.
- *The motion of the ship is governed mainly by the propeller thrust* (main engine power to go ahead) *and the hydrodynamic* (water resistance push vessel backward) *and mass forces acting on the hull* (momentum to carry vessel hull forward when turning). *During a manoeuvre (* turning*), the side force due to the rudder is often small compared to the other lateral forces.* When ownship begin the turning use rudder force to change it is small.
- *However, the introduced controlling moment is mostly sufficient to balance or overcome the resultant moment of these other forces.* (Although Rudder force is small, it is enough to overcome the resultant moment of main engine, water resistance and eccentric force of turning if we have time to wait for it act. Otherwise this vessel is unmaneuverable, is useless without a tug boat assistant. No class society will grant it construction or give her seaworthiness certificate, safety construction S/C certificate.)

- *In a steady turn there is complete balance between all the forces and moments acting on the hull*. It is in third stage of turning as we study on VLCS. VLCC may have small accelerate rate of turn in third stage.
- *If a manual helmsman takes over the heading control, a further steering lag could result but, in fact, he will be able to anticipate the swing of the ship and thus introduce a certain "phase advance". Various studies suggest that this phase advance may be of the order of 10° to 20°. At present there is no straightforward method available for evaluating the phase margin from routine trial manoeuvres.* At first, he said helmsman will have a steering lag to course change compare to autopilot. Then, in fact helmsman can predict the vessel overshoot amount and apply "phase advance" rudder angle 10^0 to 20^0 degrees to overcome it. Thirdly, at present this phase advance ability of helmsman is not available by auto pilot. This is the value of hand steering although it depends on helmsman's experiences in steering.
- *Obviously the course-keeping ability will depend not only upon the counter-rudder timing but also on how effectively the rudder can produce a yaw checking moment large enough to prevent excessive heading error amplitudes.* If Captain want to maneuver his own vessel the timing and amount of counter-rudder angle can stop rate of turn to prevent excessive heading error while turning are very important. In master lever, we expect Captains can know these knowledges and have these experiences automatically without further discussions.
- *It follows from the above that a large dynamic instability will favour a high "turning ability" whereas the large yaw damping, which contributes to a stable ship, will normally be accompanied by a larger turning radius.* A large VLCC round ship, dynamic instability vessel, can initial the turn very easily with less turning diameter to compare with a large VLCS sharp ship, dynamic stable vessel, will have trouble to initial the turn with a larger turning radius.
- *Hard-over turning ability is mainly an asset when manoeuvring at slow speed in confined waters. However, a small advance and tactical diameter will be of value in case emergency collision avoidance manoeuvres at normal service speeds are required.* A large VLCC round ship is easier to maneuver in slow speed and confined space and collision avoidance.
- *The "crash-stop" or "crash-astern" manoeuvre is mainly a test of engine functioning and propeller reversal. The stopping distance is essentially a function of the ratio of astern power to ship displacement. A test for the stopping distance from full speed has been included in the Standards in order to allow a comparison with hard-over turning results in terms of initial speed drop and lateral deviations.* The "crash-stop" or "crash-astern" manoeuvre is mainly a test to compare parameters with hard over rudder turning. Actually, it is not so much useful. In some cases, Captain is obliged to stop or crash astern ownship to avoid excess legal liabilities in COLREG.

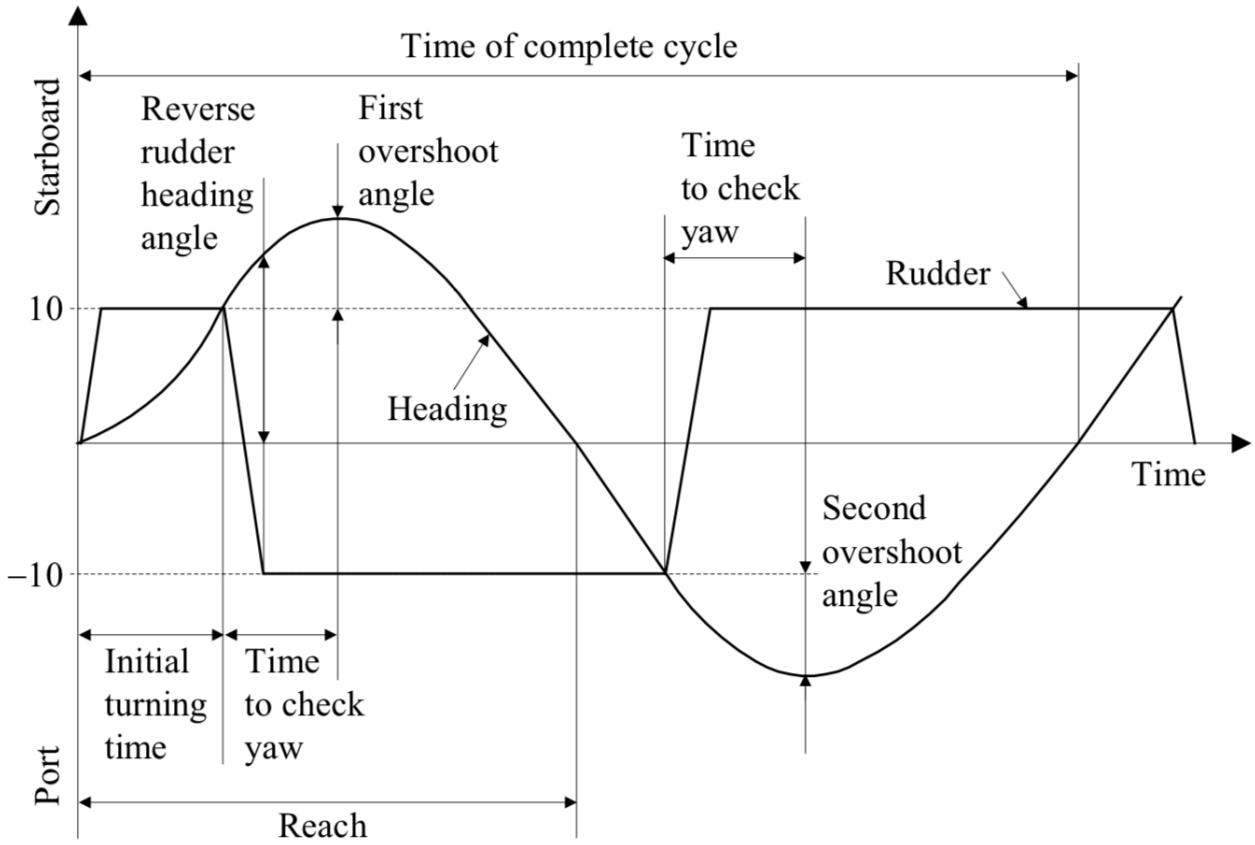

Figure 6-20 turning elements in ZIG ZAG test

6 – 06 Emergency maneuvering to collision avoidance

6-43 Emergency maneuvering: full rudder turning

As a captain we have to handle a lot of emergency case, sometimes it is not emergent like go aground. The Earth or the Pier will always wait for ownship to collide only the maneuvering space is limited due to some reasons. To handle normal situation in a restricted way is an emergency. In emergency case, we have three ways to handle the situation to solve the situation as Figure 6-19. Full rudder turning and crash astern are test by IMO standard and post of wheel house wall but rudder cycling had not. We will study further to understand the difference in application.

Full rudder turning: **full rudder turning is most effective to avoid the danger** as it is shortest, lost most speed and create more abeam distance than other two methods which is its advantage.

- ⇒ The disadvantage is: **Full rudder turning** has the risk of lost control if the rate of turn is over ownship's limitation to handle effectively as we seen in Figure 5-24: collision happened at third stage of full rudder turn 1519 hours. That is a case of sharp vessel or fast Vessel in figure 5-24. The vessel like VLCC round vessel has more trouble to stop the vessel once the turning is started hence her trouble of lost control is more serious than VLCS.
- ⇒ Nevertheless, full rudder angle should be used to initial the turn in first stage even ownship is not intended to take full circle turning.
- ⇒ Steady ownship as fast as we can is a prudent navigator but it does not mean we have to use small rudder angle in the beginning.
- ⇒ Now we know it better, hard over rudder in first stage is to create eccentric force in ship hull to make the turn in second stage.
- ⇒ After ownship has 10 degrees heading change to our original course line the momentum in original course line will carry on the turn to against water resistance ahead of pivot point.
- ⇒ Vessel will not lost control in first stage because only rudder plate pushing the stern.
- ⇒ If ship's momentum added in turning we will have trouble to control it by rudder angle in second stage. It is because hard over rudder force is no compare with eccentric force once the momentum started.

⇒ Once ship have turning momentum we need to think what time and angle of counter rudder should be applied?

⇒ One critical factor in ship's maneuvering of turn is "time to check yaw" or as we said "time to check rate of turn" which is the time when helmsman start to apply reverse rudder to stop original turn till the rate of turn reduced to zero as figure 6-20 turning elements in ZIG ZAG test.

⇒ For a round ship VLCC it is obvious time to check yaw need more time than sharp vessel VLCS. The counter rudder needs for VLCC to stop the yaw are more. In real sea, what we see VLCC doing is their heading changed quickly and hard to coming back. Their track over ground is not steady as a VLCS can do.

⇒ If master is giving rudder order to maneuver ownship's heading the so called "phase advance" rudder angle have to estimate by master. This information is not included in wheel house poster. We just apply double counter rudder angle to stop the turn initialed by original rudder angle. For example, it we start the turn with "Starboard Ten" we will use "Port Twenty" to check the yaw or stop the turn. If we start the turn with "Starboard fifteen" we will use "Hard Port" to check the yaw. As the time to check the yaw is not a constant it depends on many factors like wind/current force and direction, our loading or trim, water depth and shore proximity… etc.,

⇒ The turning momentums have two indications:

⇒ first is drifting angle in turning which we can see it in RADAR or ARPA screen between COG course over ground and our heading. Drifting Angle = heading – COG. In first stage of turning, drifting angle is almost unnoticed. In second stage of turning, the drift angle increased to 10-20 degrees. COG is the direction ownship's momentum want to go. Heading is the direction pushed away by water resistance ahead (or *hydrodynamic as they said).* The

⇒ second one is rate of turn (or *yaw rate as they said)* which displayed at steering stand or wheel house indicator panel. Usually, we see rate of turn is under 10 degrees per minute in first stage, under 20 degrees at second stage, above 20 degrees is in third stage of tuning. Rate of turn is larger in VLCC than VLCS which could reach 30-60 degrees more per minute depend on ship's hull.

⇒ Captain should know at what rate of turn or drifting angle ownship will have trouble to steady and turning back to original course even we use full counter rudder?

⇒ While ownship is turning the heading and the course over ground are not the same at most time.

⇒ It is then very important to know what we want? If we are turning to target vessel's stern to give way some overshooting angle (heading change over what we want) to target vessel's stern bearing will be OK. If we are turning to parallel with target vessel's course or a pier or berth drifting angle (overshooting) may have some trouble to steady ownship in time and cause the collision.

⇒ To midship the rudder in each stage of turning and let ownship to turn by its own is a very good practice to know ownship's maneuverability when we need precise heading control of ownship.

⇒ *This test (*To midship the rudder in each stage of turning) *gives a simple indication of a ship's dynamic stability on a straight course. If the ship is stable, the rate of turn will decay to zero for turns to both port and starboard. If the ship is unstable, then the rate of turn will reduce to some residual rate of turn. The residual rates of turn to port and starboard indicate the magnitude of instability at the neutral rudder angle.*

⇒ Watch out rate of turning or drifting angle while turning to decide the time and how many rudder angle or counter rudder should be used to keep ownship's turning under control.

⇒ Never forget vessel will continue turning or overshooting even counter rudder had applied already.

⇒ In this over-shooting period it is prudent if Master can check on indicator whether rate of turn had decreased or not? Who knows helmsman may had use wrong side of hard over rudder in this critical moment.

6-44 Emergency maneuvering: Crash Astern

Another option of **Crash Astern** also has the problem of lost control when rudder effect is no longer available.

- ⇒ Crash astern can stop the vessel but her advance distance may be two nautical miles already with prolonged time of no control (no rudder effect in slow ship speed and engine expel current to kick ahead).
- ⇒ To avoid the collision, reduce speed is effective in high initial speed vessel as we discussed in last paragraph.
- ⇒ If we image the distance run of crash astern 12 x 300 m ship's length = 3600 meter (ownship is at speed of 20 knots) the time to reach 2 nm is 6 minutes for a 20 knots vessel.
- ⇒ By the order of crash astern, ownship have to go through stop engine (by cutting fuel oil injection to main engine) period of one minute at least.
- ⇒ After engine stop one minute (in real sea, it decides by propeller's RPM which had reduced to dead slow ahead revolution) compress air injected into cylinder of main engine to stop the revolution to 0 RPM).
- ⇒ After 0 RPM of main engine, compressed air injected into cylinder to start reverse revolution of Main engine propeller.
- ⇒ After reverse revolution is established main engine can offer real braking power to ship's hull in water. At this time vessel may still have ahead speed which we can check on wash current come out of reversed turning propeller is reaching under bridge or not?
- ⇒ Crash Astern need 2 nm (6 minutes at least) to take effect. It is OOW level skill.

6-45 Emergency maneuvering: Rudder cycling

Rudder cycling combine the advantage of speed reduction and heading control seems a more promising way in emergency but not so much reference to study.

- ⇒ But captain should understand all emergency maneuvering measures have its application time limitation.
- ⇒ In collision avoidance, an OOW competence in his work needs at least 6 minutes before to take action.
- ⇒ In captain level, the time to avoid collision may reduce to 3 minutes before. This is not the Captain's choice but the reality.
- ⇒ This is so called space ship status as we said in early chapter 2 for junior office as Figure 2-15: ARPA screen, 3 minutes True motion speed vector is same as imaginary collision risk area (space ship).
- ⇒ 3 minutes is the time believed enough to start a turning maneuvering in its 1st, 2nd and 3rd stages for VLCC, not enough for a VLCS. However, the time to steady the vessel after course change within 3 minutes depends on Captain's understanding, skill and instinct at the scene as the environment condition is not always the same.
- ⇒ Turning maneuvering as we discussed have its limitations: For two vessels over 300 meters long, it is almost impossible to avoid collision by Alter course along when their distance is less than 1/2 nm.
- ⇒ But less than 0.5 nm distance away may be enough for two smaller vessels to avoid collision by alter course along.
- ⇒ **Rudder cycling** need 3 - 4 minutes to finish its maneuvering. This is time limitation in its application. Imagine ownship have to finish 3 hard over rudder order in 2nd stages of turning.
- ⇒ We mariner are more aware of target distance than time to collision. The distance to conduct rudder cycling is 6 to 7 ownship's length to stop ownship.
- ⇒ However, the speed reduction may have some effect even when ownship can only conduct first hard over rudder and the counter hard over rudder before ownship actually lost all speed.

⇒ With hard over rudder turn ownship can finish 90 degrees turn within 3 minutes. With rudder cycling ownship may be still in its halfway process at half ahead and has some beam distance to our original heading. Please refer to Figure 5-21: Rocking ship in the pocket at 1515 hours, Rudder Cycling.

⇒ Halfway of rudder cycling in about 3 ship's length at 2nd full counter rudder stage as Figure 6-19: Emergency maneuvering. This is most effective stage to reduce ownship's speed.

Rudder cycling principal is to use water resistance working on ownship's hull as a big dragger to reduce ownship's speed over ground or even stop ownship.

⇒ Please refer to figure 4-08 different size container vessel turning with hard over rudder. In second stage three force working together: the stern is pushing sideward by rudder, water resistance pushing backward on ship's bow and ship's momentum pushing ship body ahead.

For best collision avoidance purpose ownship should decide which side full rudder should be used first? In figure 6-19 ownship had used "Hard Port" rudder first for illustration.

⇒ First hard starboard or hard port rudder depends on the navigational hazards around. If we use chapter 5 example "Aftermyth of Container ship collided with fishing boat 2014" to demonstrate the difference of full rudder turning and rudder cycling.

⇒ In this case many targets are at ownship's port side we should use "Hard Starboard" first as ownship may suffer no control after three minutes at port side (see Figure 5-24: collision happened at third stage of full rudder turn 1519 hours). This collision happened because ownship did not use counter rudder "Hard Starboard" in 1517 hours. See Figure 5-22: First stage of full rudder turn at 1517 hours.

⇒ If ownship use "Hard Port" rudder to rudder cycling first we will close to port side one ship length abeam distance as figure 6-19. It is too risky for rudder cycling if we use "Hard Starboard" rudder too late in Figure 5-22: First stage of full rudder turn at 1517 hours and trying to go back to starboard side in time.

⇒ Ownship should use "Hard Starboard" rudder first in 1515 hours to initial the turn and expect ownship's position will remain in starboard side during whole rudder cycling maneuvering.

⇒ Starboard side has the real target "OOCL Shanghai" ownship want to avoid. However, her beam distance to ownship is 0.3 nm compare with no beam distance small vessel ahead. 3 cables beam distance is 555 meters only very close to own ship but still it is better than small vessel dead ahead now.

⇒ Ownship should use "Hard port" rudder in 1517 hours to counter the initial turn to Starboard side if ownship course had changed 10 degrees to starboard side (from 135° to 145° (T) degrees, first stage of turn). See Figure 6-20 turning elements in ZIG ZAG test

⇒ Maybe the overshooting will reach 155° (T) in first stage of rudder cycling. Whether the overshooting is OK or not depends on rate of turn is decreased or not. If Captain can make sure ownship's rate of turn is reduced to zero it will help to demonstrate ownship is under control and expect ownship position will not mingle with port side small vessels.

⇒ What is our guarantee to avoid the collision with "OOCL Shanghai" by rudder cycling? The answer is the same as other cases: same speed or same course.

⇒ Can ownship speed reduce to 9.4 knots as "OOCL Shanghai" from 14.3 knots original speed? In first stage of rudder cycling it is impossible as ownship course had change 10 degrees only and not yet in second stage of turning.

⇒ The speed reduction is about 2 knots from 14.3 to 12.3 knots as figure 5-23. 12.3 knot is still fast than "OOCL Shanghai" 9.4 knots. The collision risk is still not solved yet.

⇒ The solution is to keep same course with "OOCL Shanghai" 115° (T) as soon as possible. But now ownship is at starboard side of original course line at heading of 155° (T) (overshooting from 145° (T)).

⇒ It is a slow process from 155^0 (T) to 115^0 (T). If the rate of turn to starboard side had reduced to zero and ownship 's heading had turning to port side we can stop engine to further reduce the speed.

⇒ In second stage of rudder cycling it is possible to reduce from 14.3 knots to 9.4 knots if we have time to wait.

⇒ Rudder cycling did not necessary to as big as 10 degrees to each side. Very small zig-zag manoeuvre VSZZs 5 degrees to each side which recommended by IMO is used to reduce ownship's speed by many cycle than normal zig zag maneuvering.

⇒ *VSZZs consists of a larger number of cycles than a conventional zig-zag, perhaps 20 overshoots or so, rather than the conventional two or three, and interest focuses on the value of the overshoot in long term.*

⇒ In "OOCL Shanghai" case, ownship can use two alternative form. First is Very small zig-zag manoeuvre: 5 degrees to each side. Second is imbalance small zig-zag manoeuvre: 5 degrees to starboard side in first Hard Starboard turn then 10 degrees course change to port side with second Hard Port counter rudder. Bear the rate of turn in mind and always beware of overshooting amount.

6-46 Situational Awareness in Rudder cycling

Our situation awareness in rudder cycling is not only the degrees of course change but the environment factors has on vessel 's maneuvering and angle of blow consideration. Which side is the upwind/stream side? Is this side rudder had more effect to turn and harder to stop? Is the time to check the yaw of Portside need to be earlier than Starboard side? Our attention on these details: timing and rudder angle required affect ship hull response to our maneuvering.

⇒ In Figure 5-03: Situational Awareness of angle of blow, there are three cases may need different precautions in rudder cycling.

- Case 1: Target's relative bearing of stern unchanged. In this case, target vessel arrives collision position same time as ownship.
- Whether to reduce ownship's speed or increase CPA with target depends on ownship's speed: if ownship is a fast ship reduce ownship's speed will have very good effect.
- Or, ownship is a round ship which can start the turn very easy ownship should try to parallel with crossing vessel then reduce speed as a choice.
- Only if ownship is a sharp ship with slow speed in very close range ownship have no time to avoid the collision. We need to think how to execute rudder cycling to avoid the collision.
- Reduce speed need some time 2 or 3 minutes at least to accumulate the distance difference to avoid the collision. Reduce speed by rudder cycling need large heading change in its turning cycles from each side if possible.
- In figure 5-03 case 1, if target vessel comes from port side and no other traffic in our starboard side ownship can initial the turn with "Hard Starboard" rudder to starboard side and come back with "Hard Port" rudder order.
- If other target vessels on ownship's Starboard side ownship should use less degrees to starboard side and check the yaw rate earlier than normal. If best aide to avoid collision by rudder cycling is to stay away target vessel's side and stay away longer in another side, like figure 5-03 case 1, ownship should parallel ownship's course with target vessel i.e. first Hard Starboard rudder to starboard side then check rate of turn in maneuverable range with counter rudder "Hard Port" until reach the course of target vessel if target is at port side.
- Case 2: Target's relative bearing of stern increased. This target has the tendency to pass ownship's stern. To reduce speed may not be a very good choice. Ownship can help her by alter course away from her (i.e. First full rudder to starboard side if target is at port side, then staying on starboard side longer than normal case).

- Case 3: Target's relative bearing of stern decreased. This target has the tendency to pass ownship's bow. Ownship can help her by reducing speed with large heading change (to starboard side first) by rudder cycling after her stern.

As we study the figure of rudder cycling the first turn with Hard over rudder will create a track of ownship close to first turn side, i.e. first Hard Port rudder will create a track in the port side of ownship's original track. If the target vessel is coming from port side ownship alter course toward her will reduce the beam distance with target vessel which is very unwise. The general rule for rudder cycling is using "opposite side hard over rudder where target vessel is located" which is opposite to man overboard maneuvering. The exception is the example of chapter 5 Figure 5-21where both side are full of targets ownship have no option but to use smallest degrees each side in rudder cycling or zig-zag maneuvering more. The best try is not to try, reduce speed or stop the engine when too many vessels ahead which formed a envelop waiting to swallow the reckless captain in it.

6-47 Seeing big vessel overtaking: visual bearing change fore and aft

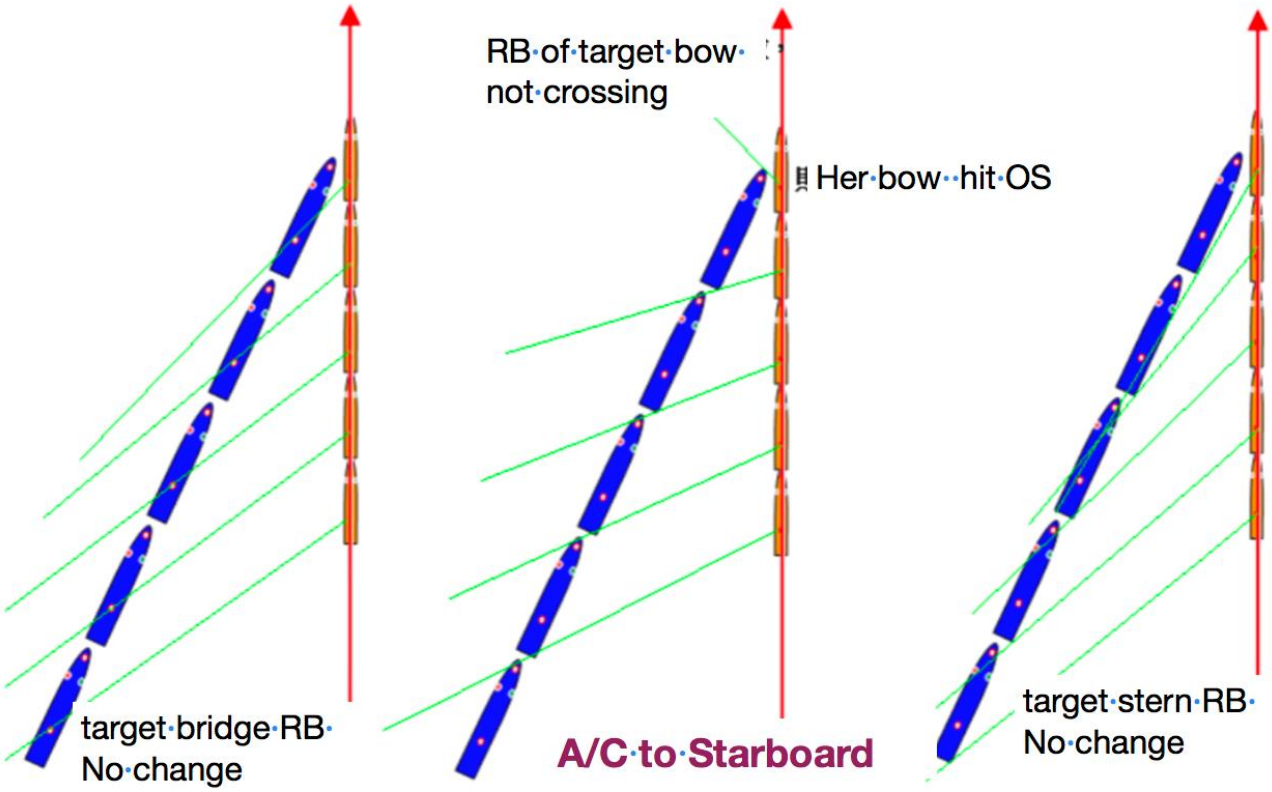

Figure 6-21: Target vessel as three different moving parts, bow, stern or bridge

One big vessel overtaking from behind, for some reason, he had not taken actions to avoid collision. This is a tricky situation for ownship (small one, vulnerable and fragile) especially when traffic is heavy around harbour area. Ownship is mingle with small supply vessels and fishing boats all inside the fairway with different speed and course (not in general direction of traffic flow). Like Figure 6-21 above, these three drawing are in exactly same collision situation. Target vessel's bow will hit ownship's port side. High speed vessel approaching fast than ownship we do not know her attention and collision risk with other vessels. If this vessel is overlooked earlier (had not acquired earlier in ARPA) by ownship we have to use our visual lookout to determine his collision risk.

⇒ What we can see by visual is target vessel's bridge and bow relative bearing had changed a little as left and center drawing.

⇒ This accord to our observation in figure 6-13/14/15. Target vessel's bow relative bearing may decrease or increase a very small amount but not enough to dissolve the collision risk.

⇒ This very small amount of relative bearing change: may less than horizontal angle augmentation

1852 m × 2 nm × Sin (θ^0) = 400 m length. Θ= horizontal angle= 6.20 degrees

1852 m × 1 nm × Sin (θ^0) = 400 m length. Θ= horizontal angle= 12.47 degrees

1852 m × ½ nm × Sin (θ^0) = 400 m length. Θ= horizontal angle= 25.59 degrees

1852 m × ¼ nm × Sin (θ^0) = 400 m length. Θ= horizontal angle= 59.76 degrees

⇒ This is bad luck for ownship. ½ nm distance for her 20 knots speed may take only 1.5 minutes time to collision. Her bow may stab inside ownship's port side causing serious damage.

⇒ Ownship will need to alter course to starboard side. But how?

⇒ If ownship alter course too late and swing ownship stern to target vessel we may expose ownship's stern to target vessel which is a deadly move.

⇒ It will cause substantial damage to ownship and our crews and subsequent impact to environment in coastal area.

⇒ Reduce or stop ownship's speed is preferable in this situation. But she is fast ship ownship's speed make very small space for her to pass safely. Like we said before our 3 ship length distance difference of 450 meters only can spare one ship length for her.

In close quarter situation, to decide angle of blow of two vessels by visual is almost impossible in collision avoidance.

Any actions take to avoid collision should have correct judgement of angle of blow in collision. Angle of blow will need correct observation of target vessel's relative bearing change of bow, stern and her bridge.

⇒ **If ownship have to use so much time and efforts to predict her movement it is better to alert her our present and ask her to take action to spare our life.**

⇒ In Sanchi case, 3/O don't want give way to small vessel is a very dangerous move if this small vessel has nobody on bridge and take actions to save their own life.

⇒ Target vessel's intention in overtaking process should closely monitor by OOW with AIS or ARPA to avoid unnecessary risk if overtaking vessel had alter course to starboard side to pass ownship's stern.

⇒ In figure 6-21 we can see the relative bearing change of target's bow and stern is not obvious in the beginning but horizontal angle increased very quickly (expand the relative bearing range quickly) in close range.

6-48 Seeing big vessel overtaking: rudder cycling

Another case of high speed overtaking vessel is like figure 6-22.

⇒ Target vessel's bow relative bearing has crossed ownship's bow.

⇒ His stern relative bearing is decreased too but cannot reduce to zero (cross ownship's bow).

⇒ Ownship have to take actions to best avoid collision risk.

⇒ Reduce or stop ownship's speed is also preferable in this situation if ownship will arrive collision position later than target vessel.

⇒ In this range ownship have to take action large enough to be readily apparent to another vessel.

⇒ **Rudder cycling to starboard side, three minutes before collision**

- "Hard Starboard" rudder to initial the turn
- "Midship or Hard Port" rudder when ownship turning is initialed
- "Steady on xxx degrees" where xxx degrees is target vessel' s course.

In this example our conclusion conflicted with what we had did in figure 5-03. The reason is different ship's type in these two cases. For a small vessel to go around a big vessel's stern is hard to achieve in this example. Smaller vessel should wait for big vessel to pass like in this case ownship keep same course as big vessel. For a big vessel in high speed to go around small vessel in figure 5-03 is easy. If we think about the horizontal angle of big vessel close by these choices seems more reasonable. However, the best aide to avoid the collision is the feeling of collision risk. We don't need to know all the reasons why and why we are discussing here.

But without basic knowledge and training of close range lookout we will never have any idea of what will happen and what we should do next. In Figure 6-22: Rudder cycling to starboard and Steady on target's course, Captain need to know at least three things: reverse rudder angle to stop the turn, time needed to stop

the turn and first overshooting angle ownship will have. Please refer to Figure 6-20 turning elements in ZIG ZAG test.

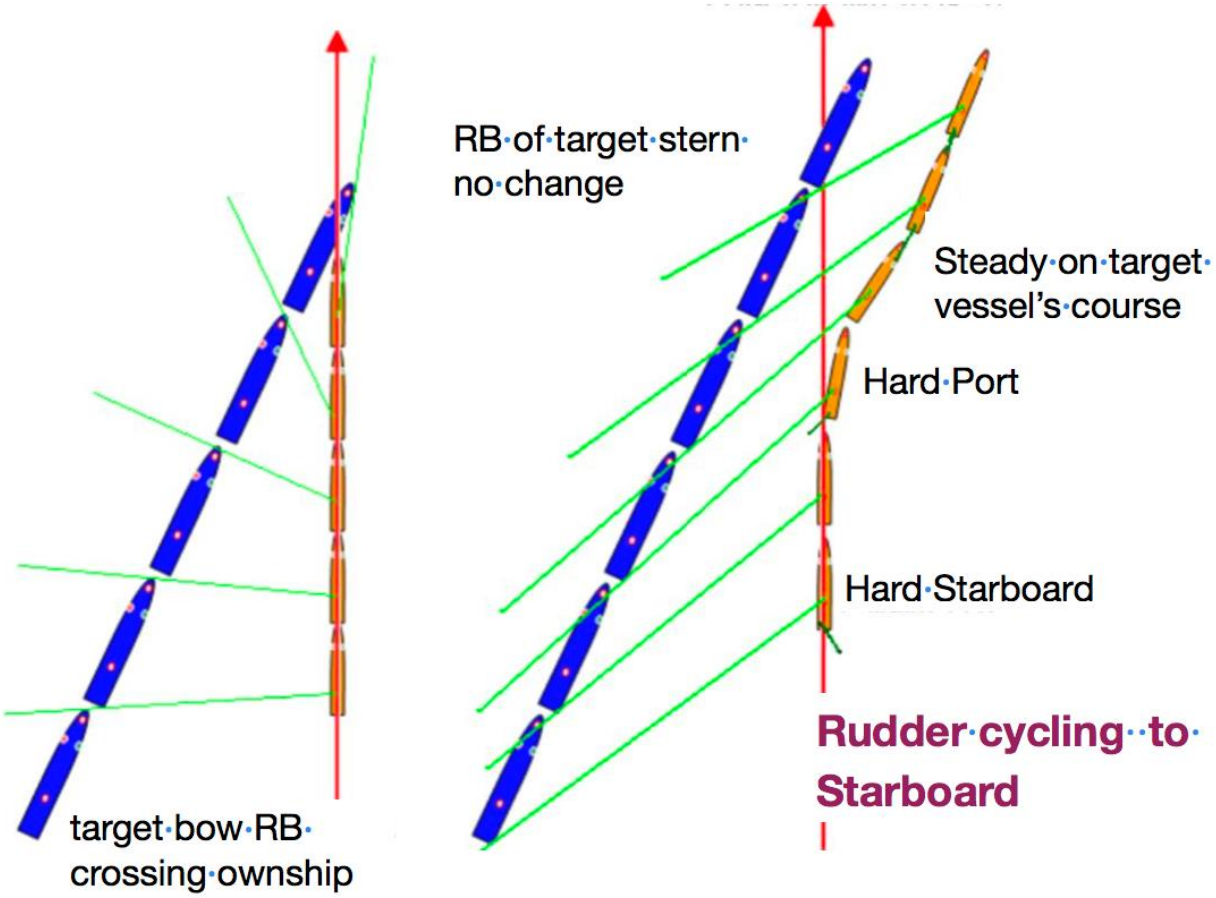

Figure 6-22: Rudder cycling to starboard and Steady on target's course

6-49 Man overboard is also a rudder cycling maneuvering.

Take early action as required by COLREG is easy to say then to do. Be an OOW we concentrate on collision risk, we use 6, 9, 12 minutes speed vector to detect collision risk in early stage and take early action. Be a Master we concentrate on maneuverable space in harbor area because collision risk is changing all the time. We only concentrate on where is the safe water to sail. The COLREG Steering and Sailing Rules is for reference only because in harbor area every vessel is in close quarter situation and every action can justify as best aide to avoid collision as we see in VLCC and VLCS case (both vessels change course and speed as they thought will best aide to avoid collision). We use three minutes speed vector to judge maneuverable space around ownship (as Figure 2-15: ARPA, 3 minutes TM speed vector is same as imaginary big vessel).

Man overboard is also a rudder cycling maneuvering which aimed to use minimum advance to complete a 180^0 degrees turn to save human life. When master use Hard Over rudder at ownship there are always have the risk of lost control of ship's heading especially for those direction unstable vessel like Bulk Carrier or tanker vessel whether it is big or small (VLCC or round vessels). These vessels are designed to carry maximum cargo weight usually have more fuller ship's hull underwater. These fuller ship hull offer more water resistance ahead and more push momentum astern in turning. Together with these two forces make VLCC initial the turn quickly and stop the turn slowly than those vessels with streamlined ship hull like container ship or ocean liner (VLCS or sharp vessels). Ship hull resistance is the main force to reduce speed when ownship turning with rudder cycling. Direction unstable vessels are easily carried away by excessive rate of turn.

Captain should monitor ownship rate of turn all the time and counter with Hard over rudder in time to steady the vessel.

6-50 Simulate rudder cycling with Man over board turn.

Man overboard does not happen very often but is a good exercise to understand ownship's turning elements. We use 3 minutes speed vector to detect collision risk and steer our way out at dense traffic area. What happen if ownship have collision risk within this 3 minute? In Figure 6-23: Hard over rudder, how many rate of turn you can handle? we compare the advance and beam distance difference of original collision position after 3 minute run of ownship going ahead (speed: 11 cables in 3 minutes = 22 knots, course 000^0 (T)) and rudder cycling to starboard side. What we get from this rudder cycling is like these.

⇒ We can shift ownship position 4 cables (741 meters) beam distance away our original course line as figure 6-23 left drawing after 3 minutes ownship position shift to starboard side 4 cables.

⇒ We reduce 3 cables (556 meters) advance distance from our original ship's position. Increase ownship time to collision TTC one minute time to arrive collision point (New TTC 4 minutes, original TTC 3 minutes).

⇒ Departed original collision position with 4 cables abeam distance (741 meter apart, enough for two ship's length).

⇒ If target vessel approaching from starboard she will arrive original collision position after 3 minutes. If she has same speed as ownship (22 knots = 3 minutes run 11 cables) target vessel will cross ownship's bow about 1 minute before original TTC.

⇒ If she has half speed as ownship (12 knots = 1 minutes run 2 cables) target vessel will cross ownship's bow 1 minute before original TTC.

⇒ Ownship use hard starboard rudder moving ownship position 4 cables to starboard side.

- This is good for starboard side approaching vessel as
- target vessel will pass ownship bow about 1 minute earlier and
- Ownship may cross her course line some time later.
- Target vessel cross earlier and ownship cross her course line later these two effects combined with proper distance away is good.

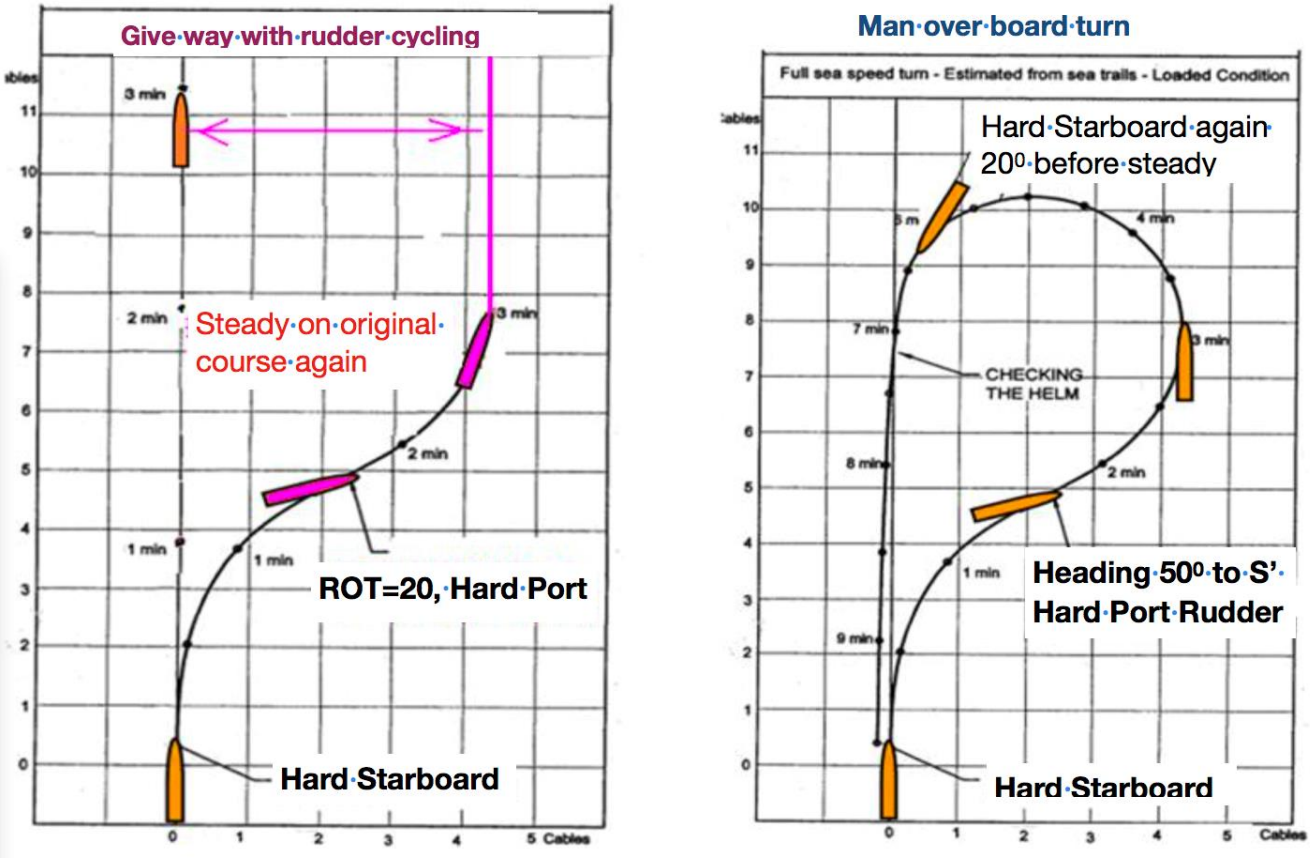

Figure 6-23: Hard over rudder, how many rate of turn you can handle?

If target vessel approaching from port side, ownship use hard starboard rudder moving ownship position 4 cables to starboard side. **This one minute time delay in advance distance is useless when target vessel may also arrive one minute later.**

⇒ Target vessel will arrive new collision position with 4 more cables and

⇒ Ownship also arrive new collision position with 4 more cables.

⇒ Old collision point change with 4 more cables is useless to both vessels.

Once again, we have this lesson" The heading ownship going determine new collision position".

⇒ Always choose our heading carefully before give first rudder order.

⇒ In emergency maneuvering, for a VLCC or VLCS length over 350 meters long to finish a turn with 6 times ship's length is about one nautical mile advance. And,

⇒ The time available to use rudder cycling in one nautical mile is limited to 2 or 3 times.

⇒ One Hard Starboard + One Hard Port + Steady or One Hard Port + One Hard Starboard + Steady, that's all for one nm advance distance.

⇒ Limited times of rudder order available is an important common sense as the times of engine order should not over 7 times to avoid compress air pressure failure to set engine order.

⇒ There are no room for mistake in which side rudder order we choose.

⇒ So, the direction to start the turn and the time to check turning rate are very important.

I believe all Masters will approach with extreme caution and slow speed to cope with the difficulty of maneuvering in harbour area. However, prepare the unprepared, these close quarter situation knowledges will prepare us when we face those emergencies maneuvering unwillingly.

6 – 07 Multi targets situation in confined waterways

We said Captain are to expect to maneuver ownship in confined waterways with multi targets work load. The ARPA which design to reduce the workload of human plotting has one feature of "trial maneuvering" to simulate other target's movement after ownship take avoidance action. However, the philosophy we should beware in trial maneuvering is same as COLREG to aware all target vessel's change in CPA or TCPA. What we need in multi targets situation is general understanding (an instinct) of what will happened to one target once we saw her RM speed vector. To identify most dangerous target before we take avoidance actions in Radar. Or a little

instinct of what we will encounter when ownship alter course or stop engine

This should be a basic ability of Captain to predict what will happen in our new course or speed. A senior captain said "navigation is an art of prediction". If we cannot see what will happen after our avoidance action we will waste very precious time to verify multiple target's CPA or TCPA one by one.

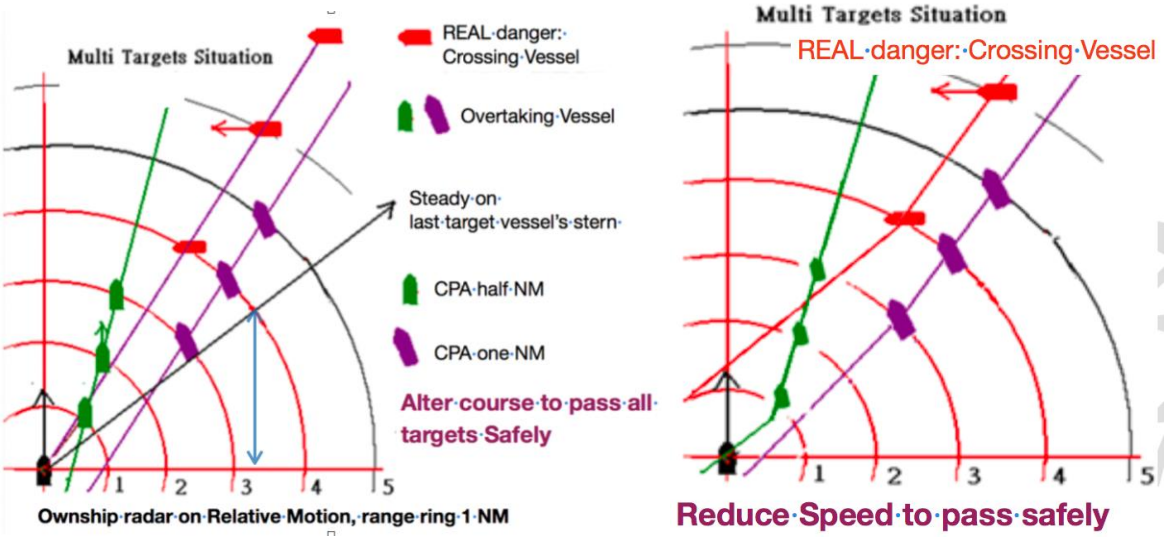

Figure 6-24: Predict Radar target's relative movement after reduce speed

6-51 Go around? How many abeam distance we can have?

In figure 6-24, three small targets on our starboard bow at relative motion, range ring is 1 nm interval, two were overtaken (green and purple) and one was crossing(red). The overtaken vessels have safe distance of CPA=0.5 and 1.0 nm. The real collision risk is the red crossing vessel with CPA=0.

In left side of figure 6-24, how about go around all three vessels? How many abeam distance we can have?

⇒ The left picture is ownship alter course to go around these three vessels. The CPA of these three vessels are 0.5 nm for green vessel, 0.0 nm for red vessel and 1.0 nm for purple. This is an ordinary option to go around but become risky when ownship used in coastal area where sea room is restricted.

⇒ If we did not have ECDIS for our reference, those two overtaken vessels red and purple has slower speed we need go around (change ownship' s position) to our starboard side at least 1.0 nm to keep clear.

⇒ How many degrees course change is needed to go around 1 nm more to our starboard? by theory

At 4 NM distance run, ownship A/C 15 degrees can achieve CPA = 1 nm.

⇒ Judging by figure 6-24, 52.5 degrees course change is needed to go around, red target is only 1.0 nm away. By change ownship course 52.5 degrees starboard side and sail to 4 nm distance (the point of 4 nm range ring and blue line intersected), ownship position will be 3.5 (52.5/15=3.5) nm distance away from our original course line by theory. (from the blue line we see, abeam distance to original course line is about 3.3 nm by figure 6-24)

⇒ Do you feel something strange here? Yes, it is. 3.3 nm distance is too wide a berth in coastal area if we image our route is inside Singapore TSS.

6-52 Reduce speed? All vessels' RM speed vectors will break upward.

In right side of figure 6-24, how about reduce speed? All vessels' **RM** speed vectors will break upward.

⇒ The green vessel relative motion speed vector originally can pass 0.5 nm abeam will catch ownship up and move closer to ownship when ownship reduce speed.

⇒ The red crossing vessel relative speed vector will move to ownship's bow (upward) which means ownship will arrive collision position later than her.

⇒ In summary, when ownship reduce engine to arrive collision position later

- all targets' relative motion speed vectors will move to ownship's bow direction (upward in head up display mode).
- The relative bearing of crossing targets will decrease (pass ownship's bow) more quickly than ownship's original speed.
- New collision risk may merge from those crossing target vessels originally relative bearing is increasing (passed by ownship's stern) safely.
- New collision risk may merge from ownship's stern who are overtaking ownship now.

What happen if ownship reduce speed to give way to red crossing vessel?

All targets' relative motion speed vector will break (change direction) and move to ownship's bow direction once ownship reduce engine. Target vessel has collision risk with ownship originally will pass our bow after we reduce speed. Those target vessels ownship can leave behind now catch up our position (closer to ownship) after we reduce speed. That means ownship have to aware of target vessels originally behind our stern after we reduce speed. This is what ownship can see in our relative motion radar where RM speed vector are only means to determine collision risk with those small targets. What we can expect in True Motion speed vectors radar for large target vessels' lookout after we reduce speed? In TM speed vector radar our concerns are mainly concentrated at collision positions with other vessels. No matter how many speed ownship had reduced target vessels' TM speed vectors are still in same direction and length. Only ownship's True Motion speed vectors length will shorten. Reduce speed in TM speed vectors radar shorten ownship's TM speed vector which reduce collision risk. New collision risk merge from original collision position behind ownship.

6-53 Alter course? All vessels' RM speed vectors will break outward.

In figure 6-25, three targets on our starboard bow with relative motion speed vectors, two were overtaken (green and purple) and one was crossing(red). The one has collision risk is the fast crossing vessel. Ownship want to alter course to starboard side but is afraid too close to overtaking green vessel. In the left drawing ownship imagined alter course to port side, all target's speed vector curve to starboard side. The slow effect

of ownship's turning on target's relative motion line is because vessel's turning had three stages. In the right drawing ownship imagined to reduce speed to let crossing vessel passed ahead first then alter course to port side for green vessel. These relative motion line change is not very correct presented in this figure. Reader should be able to correct it by your knowledge.

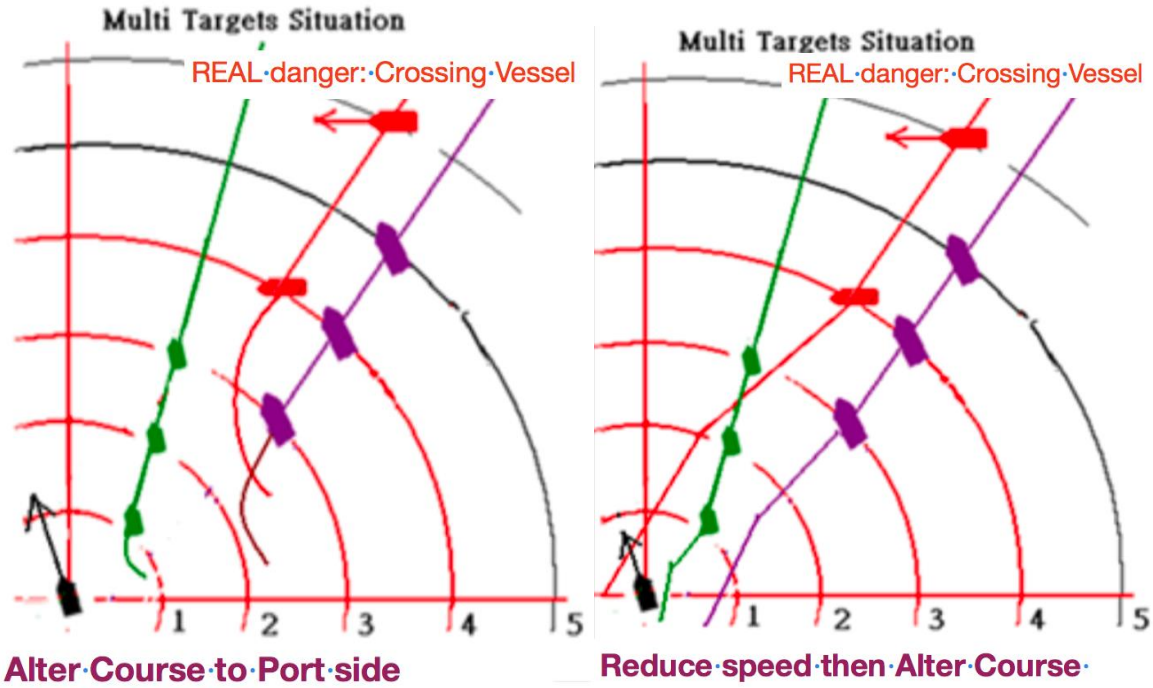

Figure 6-25: Predict Radar target's relative movement after alter course

6 – 08 Narrow channel sailing rules

6-54 Narrow safety margin by using 3 minutes speed vector

In confined waterways like Singapore strait, Suez Canal or Panama Canal, vessel convoyed in one nautical mile distance apart. One nm for 3 minutes run is considered the maneuverable distance for any emergency situation: steering, main engine break down, passing showers or strong sand storm…. etc. As a ship's captain, we have to deal with collision risk within one nautical mile sea room. That is to say if No. 1 vessel has collision risk with ownship No. 2 vessel in same direction will have 1 nm CPA. Ownship have the choice to pass between these two vessels space 1 nm or wait another 1 nm distance away to pass No.2 vessel's stern. If we look at Figure 4-08 different size container vessel turning with hard over rudder (these were all VLCS, sharp vessel), we can summarize as follow:

- for 4500 teu vessel LOA 230 meters turning to 90 degrees advance distance is 800 meters
- for 11400 teu vessel LOA 300 meters turning to 90 degrees advance distance is 1100 meters
- for 18200 teu vessel LOA 350 meters turning to 90 degrees advance distance is 1500 meters

with hard over rudder turn we will need about 4 times ship's length advance.

- How about "Starboard 20" rudder order needs how many distance to finish 90 degrees turn? Is about 5 times ship's length by our estimation.
- How about "Starboard 10" rudder order needs? Is about 6 times ship's length

One vessel with 300 meters LOA use starboard 10 rudder order will need 1 NM advance distance. These are the difficulties to turn experienced by container vessels which is designed to sail ahead with minimum resistance.

⇒ The major problem for container vessel to avoid collision in close range is "not enough advance distance to finish a turn". Ownship response to rudder order very slowly. She needs ample time to start the turn earlier.

⇒ The major problem for VLCC or break bulk carrier to avoid collision in close range is "lost control when the turn started". Ownship check the rate of turn very slowly. She needs make correct choice in her first turn as we discuss in rudder cycling. They are only one choice.

It is obvious ownship should take early action to avoid last 3 minutes avoidance action. To make collision situation easy with 3 degrees course change is possible if Master can correctly estimate who will pass collision position first. The real challenge for a Master is to decide where is true collision position? This also seems easy if we remember the discussion in OOW level for radar lookout: collision position is where two vessels' true motion speed vector crossed each other. To solve the collision risk by Captain is to change ownship's speed vector direction or speed if possible. Be a good OOW in radar lookout is a good fundamental to be a Master who is good at "life or death" decision. The collision position will always exist if two vessels' true motion speed vector have cross point unless ownship go around target which is most safe way as Figure 2-10: SOP for collision avoidance in single target vessel. In confined waterways, master have to narrow his safety margin to just enough for avoidance purpose by using 3 minutes speed vector to detect collision risk and ignore other vessel's movement which has no cross point on our 3 minutes speed vector.

6-55 Called to bridge one minute before collision

If target vessel is in steady speed alter course to port side for starboard side target is not more dangerous than to starboard side

as we saw in figure 4-15 Safety relative Bearing for High Speed Craft. This is well demonstrated by our discussion: stay away where target vessel will be. Been a Master we have to protect ownship with more options, alter course to port side is one of options available for Master. But we don't want to confuse rookie OOW in his early days of watch but to obey Captain's standing order with due diligent and prudent.
When collision situation is not very clear in emergency case when Master is called to bridge one minute before collision. Following suggestions are here to prepare Master for worst scenarios:

1. Knowing the situation:
   - ⇒ Deciding lookout by visual or radar according to daylight or background light of targets.
   - ⇒ Search target vessel from center of ownship's bow then starboard side, port side and astern, from the target vessels have reflections on water at night to while splash/wake current in daylight.
   - ⇒ All target's distance, DTC distance to collision, TTC time to collision should be determined immediately to understand target vessel is inside our turning circle or not.
   - ⇒ For close range targets, make sure whether it is a big or small target by visual? (cannot trust our instinct by radar echo's size)
2. For a small target:
   - ⇒ Reading relative bearing of target vessel with our deck cargo or fittings by our experience.
   - ⇒ Knowing her speed and course if possible by AIS or ARPA after visual checking.
   - ⇒ Is her speed slower than ownship which can be handled by SRB safe relative bearing?
   - ⇒ Estimating her movement by SRB and her relative bearing now.
   - ⇒ If ownship already use "Hard Over Rudder" by OOW, have turning rate check by Master first.
   - ⇒ Ownship need to find a good heading to get away, from her bow or stern.
   - ⇒ Most of time, collision with small vessel is a consequence of lost steerage control out of panic.
   - ⇒ OOW's reaction may be dumb and deaf by the mental pressure accumulated before Master come on bridge.
   - ⇒ If the target vessels are many use ownship's whistle "one long blast" to announce our present.
   - ⇒ Finding ownship's course with patience in radar screen. Relative motion speed vector may provide a quick reference of their collision risk. Ture motion trail may provide their course change if any.
3. For a big target:
   - ⇒ Knowing her speed and course if possible by AIS or ARPA after visual checking.
   - ⇒ Remember same speed and same course are two basic principles in close quarter collision avoidance.
   - ⇒ Identify collision position with these target vessels is reasonable or not? If it is outside the fairway or Traffic lanes ownship should modify our heading to go back our general direction of traffic flow.

⇒ Have the feeling of dangerous target's Bow and stern relative bearing change, moving ahead or astern if distance is one nm away to decide "angle of blow" or who will arrive collision position early. Try to arrive collision position later is always best for ownship.

⇒ When target vessel relative bearing just expands in her fore and aft direction at the same time the distance of target vessel is about ½ nm.

⇒ In figure 6-13/14/15, we should beware of horizontal angle of target is a kind of safe sign to ownship if it is decreased.

⇒ One of these vessels approaching ownship fast has collision risk.

- We have to know is ownship has excess speed in current situation, reduce ownship speed is recommended to clear of all fast moving targets (usually implied big vessel) which have collision risk now.
- Reduce speed can make fast moving target to pass ownship's bow and ownship arrive collision position later. Safer to ownship.
- If the TTC time to collision is too short which side is preferable for rudder cycling should be considered as Figure 5-3.
- Alter course may expose ownship's vulnerable stern portion if ownship lost control of the turn.
- Target vessels speed is fast ownship's avoidance action may be useless. What ownship can do is to minimum the impact area if possible. It is prudent for ownship just to wait her to pass (adjust ownship's heading to parallel with target vessel or go around her stern).

⇒ One of these vessels approaching ownship slow has collision risk.

- Evaluate the collision situation by three minute speed vector of each target as Figure 5-3: best aide action to avoid the collision by speed vector.
- If ownship is faster What ownship can do is to consider give wide berth to target vessel.
- For slower approaching vessels if their speed is available its SRB safe relative bearing can be used to avoid collision.
- If the TTC time to collision is too short consider to parallel target's heading to avoid the collision.

⇒ When the situation is hard to evaluate?

- "Reduce speed immediately" as safe speed is first golden rule.
- When ownship speed reduced all targets' relative motion line will move to our bow direction.
- If any targets' relative motion line is close to ownship from behind ownship should closely monitor when reduce speed. Big and faster overtaking vessel behind is deadly to ownship.
- If traffic situation is confused on both side rudder cycling to less target side is preferable to keep safe distance.
- Rudder cycling with unbalance two side course change degrees (for ex. 5 degrees to port side then 10 degrees to starboard side) or small degrees course change with hard over rudder (5 degrees to both side of original course) all can contribute a little to speed and collision position change.

6 – 09 conclusions

Using relative motion mode in collision avoidance is old fashion. We still discussed here is to cultivate our imagination of relative motion line changed by our avoidance action as we recommended for small target avoidance. More through and precise discussion of true motion speed vectors usage in collision avoidance for ocean going vessels is presented at chapter 8 and 9.

In ancient Chinese warfare history, we have this brave General who can rush himself with his horse into enemy crop seven times to save his Emperor without any harm or had never been defeated in all battles he had attend. This man need not be strong and the killing need not be many as Ramble. He can use least efforts and go into most conflict zone without being hurt and fulfilling his missions. His success is not based on fight but flee. Flee to where we are comfortable and safe. Treat or take the sea as our backyard where we

can relax and comfort, not our battle ground where we have to fight and bleed. We know every captain has his own personality when he conned his ship at bridge. We have armed him with all necessary maneuvering knowledge we know so far. If we don't know how to put it aside with our voyage planning skill we are still but a fool at sea.