Chapter 4: Knowledge Base for Chief Officer

Figures:

4-01 船上不幸的要員

大副在海上是準備要做船長的，要負起船舶操縱，結構強度確保的責任。準備作為船上的一個重要人士，希望對船隻的安全事項，例如貨物裝載，船舶結構的安全，負起責任。**不幸的是有百分之五十的海上事故，是在大副班發生**，這是因為有幾個理由：

⇒ 4 到 8 的航行班，瞭望是最困難的，尤其是使用眼睛，在曙光時期，陽光直接從水平線透過駕駛台的窗戶，照在人的眼睛上。
⇒ 在日出前的一兩個小時，是人體最容易入睡的時刻，也是人精神最不濟的時刻。
⇒ 在港區附近，船隻的交通，在大副班是最繁忙的，因為所有船隻都急著進港裝卸貨，趕上早上 8 點開工的時刻。
⇒ 船長信任大副的能力，可以避免危險，大副可能低估他自己生理跟心理，在當班時的狀態，現在都說是慢性疲勞，疲勞管理也是現在人為因素的主題之一。尤其是在擱淺的案件，慢性疲勞是心力不濟的主因。
⇒ 或是對他個人的瞭望技術，太過自信，事實上，也許不過如此。
⇒ 當班的 AB 在清理駕駛台內外，沒有在從事瞭望的工作。
⇒ 大副將他瞭望的責任交給 A B，就像桑吉輪的三副，將避讓的責任交給漁船一樣。

4 – 01 Key and misfortunate man on board.

A chief officer at sea is to prepare for the position of captain in maneuvering and responsibility. As a key man on board he also be expected to responsible for major safety of ship's cargo and structure. Unfortunately, **more than 50 % of marine incident happened at chief officer's watch** for many reasons:

⇒4 - 8 watch is most difficult to lookout by eyes due to twilight sunshine from horizon.
⇒The hours before the sunrise is most sleepy time of the day.
⇒The vessels traffic are heavy around harbour area as all vessels are eagerly to go alongside for 0800 day gangs to work.
⇒Master trust Chief with his ability to avoid the danger, but chief may underestimate his physical and mental state for the watch.
⇒Over confidence of his skill on watch.
⇒Duty AB is cleaning the bridge rather than doing lookout duty.
⇒Chief refer his lookout duty to AB solely in same logic Sanchi 3/O refer to fishing boat.

4-01 來到繁忙的上海港區

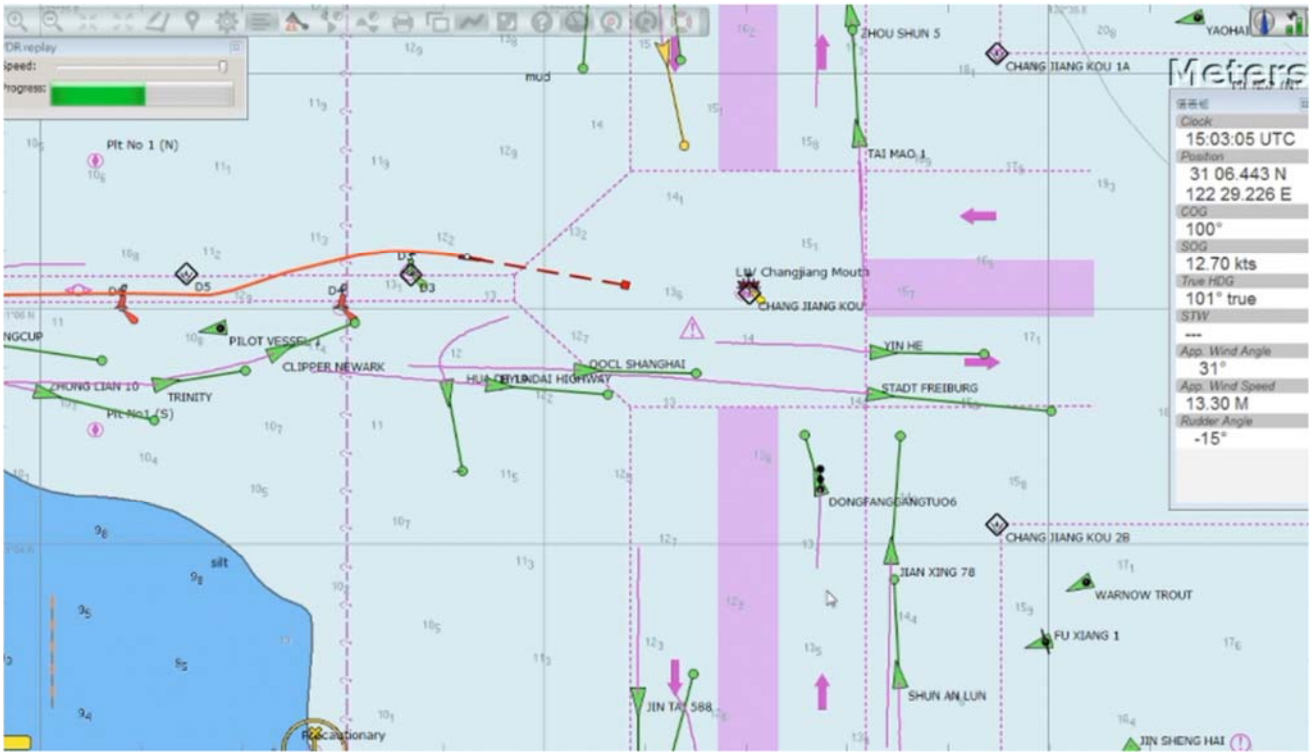
對大副來說，船長會希望他具有應付多重船隻交遇的情況，避碰規則規定了，如果有碰撞危機存在時，兩條船之間的航行規則。在多船隻交遇的情況，就需要尋找沒有碰撞危機的航路，而不是用所有的努力去避免碰撞，這是以後的話題。在 2019 年上海港是世界上最繁忙的貨櫃碼頭，雖然港區週邊的長江口充滿淺灘，跟強勁的流水，以及數不盡的各種各樣的漁船，長江口是的我們知識，技術跟直覺的測試場。

圖形 4-01 紅色的本船接近長江口燈船，航向 100 度，航速 12.7 節。

從本船紅色速度向量線起點的位置，我們看到前面交叉路上的中心點，是在長江口的燈船。

4-01 Into heavy traffic Shanghai.

For chief mate, Captain will expect him have the ability to handle multiple ships traffic situation. COLREG had sort out sailing rules between two vessels when collision risk exists. **In multi-vessel situation, it is better to find no collision risk route (voyage planning) rather than to avoid it** at all efforts (avoid by COLREG). Port of Shanghai is World's busiest container port for 2019 although shallow water and strong tidal current and numerous small boats of all kind around her is our testing ground for knowledge, skill and instinct of collision avoidance.



圖形 4-01 紅色的本船接近長江口燈船，航向 100 度，航速 12.7 節。

In figure 4-01. From position of ownship in red speed vector, we see the cross road ahead is centered by Chang Jiang (Long River) Mouth light vessel.

4-02 在進入繁忙水域之前，大副應該要準備些什麼？

⇒ 兩種有效的瞭望方式，這是最低限度，我可以用的有目視，阿帕，雷達，AIS 等，就像是我們在第三章所討論的。

⇒ 檢查天候風向風速以及流水的流向流速，在淺水跟港口區域，這些不可抗力，會受到地形地理的很多限制，這會造成在我們船舶操縱能力上，很大的影響，當我們最需要控制船隻的動態的時候。

⇒ 檢查在水平線的能見度，是否可以看到水平線，我們的能見距，也許是令人吃驚的短，輕霧或海煙在水面上，或是都市里的空氣污染，都會造成能見度減低。

⇒ 使用 3 公分雷達來探測大型船隻，借由減低本船雷達的增益設定，來消除小型船隻的目標回跡。小型目標的回跡，在 3 公分雷達上，消失掉之後，當值船副可以設定 ARPA 自動擷取功能，自動將大型船隻的動態顯示 3 公分雷達上（大型船隻在螢幕上的回跡顯示比 10 公分雷達小）。

⇒ 我們應該使用 10 公分雷達來探測小型目標，尤其在近距離，因為 10 公分的回跡，比 3 公分雷達大。

⇒ 雨雪雜斑在 10 公分雷達上，可以降低增益的設定來消除。

⇒ 當值船副會需要降低雷達的探測距離到 3 海浬，或是離心來顯示船頭 5 海浬的小型目標，這取決於本船的速度，小一點的探測距離設定，可以放大目標的回跡顯示的尺寸，但是會縮短探測到碰撞的時間，讓當值船副無法提早知道碰撞的時間。

⇒ 當值船副用雷達來探測，在本船附近的小型目標船，目標的速度向量線跟尾跡，應該設到相對運動模式，相對運動的回跡，比較容易找出有碰撞危機的小船。

⇒ 用相對運動模式，對小型船隻的回跡顯示，本船可以找出碰撞危機，利用電子方位線放在目標的回跡，來檢查他的方位變化。

除了這個基本的使用兩部雷達的分別設定，來探測大小船隻，第三種瞭望方法，目視或是船頭的第三部雷達，在這種情形下，都應加以使用，以確保所有的目標，都可以被快速的評估，這是大副最基本的工作。

4-02 What chief should prepare before heavy traffic?

1. Use at least two means of lookout effectively: Visual, Radar, ARPA, AIS for quick reference refer to chapter 3.
2. Check wind and tidal current direction and force now. No matter ownship is at open sea or harbour, these two forces will always work on our ship's body. And it forces will definitely affect our maneuvering ability. To predict its influence and take into consideration are a prudent navigator's routine. In shallow water and port area force majeure (wind and current) are subject to terrestrial influence a lot which will have severe effect on our maneuvering ability when we need most.
3. Check the visibility if horizon is not at scene which may reduce to shocking short due to mist / smog over water or just air pollution from landside before we can verify it in Radar.
4. Use X band radar to detect big vessels only by reducing ownship's radar "gain" setting to eliminate small vessel's target. When small target echo are not seen on X band radar, OOW can set ARPA function "Auto Acquisition" on. (X band 3 cm radar has smaller echo on screen than S band radar).
5. We use S B or 10 cm radar to detect smaller target at close range due to 10 cm echo size is bigger than 3 cm radar.
   - Rain/sea clutter in 10 cm radar can be eliminated by lower Gain setting.
   - OOW will need to reduce the detection range to 3 nautical miles or off centered to allow 5 nautical miles ahead depend on ownship's speed. Smaller range setting enlarged the echo size on screen but reducing TTC time to collision available for OOW to detect.
   - When OOW adjust radar to detect small targets around ownship, target speed vector and trail should set to relative motion. Relative trail is more easily to locate small boat with collision risk.
   - With relative motion mode for small target. ownship can detect collision risk by put Electric Bearing Line on target's echo to check its bearing change or not.

Beside these two basic settings with two radars, another lookout means by visual or third radar on foremast should be used in these situations to ensure all targets are properly evaluated by Chief.

4-03 額外的甲板燈光來說明本船的視角

在準備好了雷達的設定，讓我們考慮一下避碰規則 20 條，航行燈的設定，

在日落到日出之間，其他的燈光不應該外露，除了這些燈光不會被誤認為本規則所指定的航行燈，不會影響到航行燈的能見度，跟他的燈光特性，或是干擾到適當的瞭望。

額外的燈光開啟在甲板上，是允許的，只要它們不會被誤認為航行燈。所以船長應該決定，在甲板上有什麼樣的燈光，或是住艙燈光，可以用來協助本船視角的辨認，就像在第一章的附錄，作者建議使用，在甲板貨櫃下面的走道燈，或是相同位置的其他燈光，來協助本船的視角，可以使他船，更容易的識別本船的大小。

我也注意到，在路上跑的公車，都外側至少有四盞側燈，在同一時間閃爍，一條 300，400 公尺的船隻，至少應該要有三十，四十盞燈，每隔 10 公尺一盞燈光，在同時開啟，或在轉向時閃

爍，來表明本船的位置與動態，這是建議。平常應該有些固定燈光，來顯示本船的視角如何？是左舷還是右舷？輔助的舷燈，不可有太強的燈光強度，去照到其他船隻。

什麼樣的燈光？可以做這些用途，應該是由船長來決定，選擇好的輔助燈，應該在船隻開航之前，就決定了。船長選好了以後，這些補助燈光可以另外做記號，瞭望人員只需要把這些做過記號的補助燈光打開，同時也方便其他駕駛台人員知道，這些是已經通過船長授權的補助燈。桑吉輪跟長鋒水晶輪並沒有使用甲板燈光，來幫助其他船隻瞭解其長度跟視角的確認，額外的甲板輔助燈光，可以幫助其他船隻更容易區分本船，與其他數不清的漁船與近洋船。這是在遠東的海域附近，我建議這樣做，在碰撞風險高或是高速船隻上面使用，以降低風險。

圖形 4-01 紅色的本船接近長江口燈船，航向 100 度航速 12.7 節

4-03 Extra lights on deck to assist visual aspect of ownship

After preparing for Radar, let's consider COLREG Rule 20 navigation lights application*:*

during such times no other lights shall be exhibited, except such lights as cannot be mistaken for the lights specified in these Rules or do not impair their visibility or distinctive character, or interfere with the keeping of a proper look-out. Extra or more lights on deck is allowed as long as it *cannot be mistaken for the lights specified in these Rules and etc.*….. So, master should decide what lights on deck or accommodation can be used to assist visual aspect of ownship. As the annex in 1st chapter, I had suggested to use alleyway lights under containers on deck or similar construction to assist in ownship's aspect be readily visible to other vessels. I had noticed that a bus with 50 seats have at least 4 side light on one side, all flashed at the same time. A 300 or 400 meters long vessel has only one side in one side and five lights around its whole body is unimaginable to any other industrials. Year and year passed by we still see no remedy for visual lookout as visual skill is not a selling merchandize to other stockholders beside seaman. These assisting side lights should not have strong reflection or interfering lookout duty on board. Right now, the decision of which lights should be used and selected for assisting lookout should be done before sailing by senior OOW and marked by mark pen or tape or some sort of similar effect. After that, lookout just need to switch on these auxiliary lights and adjust it brightness by marks already set. SANCHI and CF Crystal did not have deck lights to help its length identification. Extra deck lights can help other vessel to easily distinguish big vessels from numerous fishing boat especially in Far East coast. It is recommended to do so for high collision risk area or high-speed vessel. LED light tripes moderate to show synchronized light and specified pattern to reflect vessel's heading and turning rate are advisable in modern technology.

4-04 雷達的調諧 增益跟雜斑抑制，反應出你的專業

圖形 4-02 詳細的雷達設定

雷達就我們所知，應該是在永遠不停搜尋的模式，畢竟它是用來代替我們的人眼，要看出碰撞危機，我們也不可能只看一個地方，就不做搜尋的動作。同樣雷達的觀測設定，是從大範圍大角度來回尋找目標的一個過程，而不是等待雷達自動呈現目標，與我們所需要的資料。

請看雷達螢幕的左邊，我們以此型雷達做一講解。

調諧 tune 是調整回波的頻率來跟發射器震盪的頻率一致，來增強回波的強度。

⇒ 這個回波需要調諧的理由，是要配合 3 公分，10 公分雷達的發射頻率來接收，就是本船發出的雷達波，由本船的調諧好的接受器來接收，這樣才不會與其他船隻的雷達波混淆。

⇒ 實際上，雷達發射使用的頻率範圍是在 8 到 12 的 GHz，這表示發射波長的範圍是 3.75 到 2.5 公分，這是對於 3 公分雷達來講。

⇒ 所以自動調諧的線路，會調整接收器的頻率，來配合每一次發射的脈波 8.0 到 12.0GHz 的頻率，這樣子接收器配合發射頻率的不同而改變，是不可能使用人工作業的，因為這是電光石火的事，人力無法勝任。

⇒ 這代表的意思，就是本船需要調整接收器頻率，到剛剛發射的脈波頻率，我們不可能人工調節到每一次脈波的不同頻率，只有使用自動的調諧模式。

我們看到這裡的增益設定，是人工控制，這是 OK 的。

⇒ 增益是用來放大接收的回跡強度，以適當的區分目標與雜斑，這是我們做一切目標識別，最重要的方法，在搜尋模式裡面，也要常使用的。

⇒ 因為是人工控制增益，當值船副應該注意，是否有目標回跡的消失，這是他瞭望的例行工作。他應該經常調整增益的設定，不時多多少少的來探測目標的回跡顯示，是否能從海浪雜斑裡面呈現。雷達所能接受到的回波，也就是不停的調整增益的大小，來區分大小目標的回跡。

⇒ 更多的增益，就會有更多的雨雪雜斑，可能會吞掉大型目標的回跡，使螢幕上一片白光。

⇒ 太多的雨雪雜斑抑制設定，會消除掉大小目標的回跡，使螢幕上一片漆黑。

⇒ 太多的增益設定，使大型目標的回跡混在雨雪雜斑裡，太多的雨雪雜斑抑制，讓大型目標回跡與雨雪雜斑一起消失。一片空白或一片黑暗，過猶不及。

⇒ 我們並不推薦，在使用自動模式去抑制雨雪雜斑。特別是在惡劣天氣的狀況，目標的回跡很可能被抑制的太多，也就是失去小型目標的回跡。

⇒ 在雷達上失去目標的回跡，在我們的航行當值中，是不適任的。如果大副沒有注意到，發生回跡的消失，也沒有視覺的接觸，大副可能根本不知道，現場還有其他船隻的存在，就像桑吉輪的案子。

要訓練當值船副使用人工調整增益的設定，跟雨雪雜斑抑制來做搜尋的目的，這是船長的責任。船長要負責教導當值船副，如何使用雷達的設定，大副應該對這樣的指導工作，也要很熟悉，每一次大副或是是船長來到駕駛台，都應該檢查資淺船副的雷達設定，是否正確？

⇒ 雨雪雜斑的設定是人工的，這是 OK 的，雨雪雜斑的設定，也應該經常的調整。

⇒ 要確保雨雪雜斑的抑制，不會太多，小型船隻的回跡，不會因此而消失。

⇒ 雨雪雜斑的設定，同時也反映了我們當班時的海象狀況。

- 天氣好的時候，雨雪雜斑週邊的邊緣，會出現在一兩海浬的距離，也就是說雨雪雜斑的調整是從本船的中心開始，向外抑制到一兩海浬 。天氣好的時候，雨雪雜斑的外緣是在一兩海浬的距離。
- 天氣不好的時候，雨雪雜斑外緣可能會到 3，4 海浬的距離遠，也就是說，在這三四海浬的距離內，小型漁船回跡，很可能都混在雨雪雜斑裡面，在雷達螢幕上面，在這三四海浬的距離內，都是一片白光。
- 在天氣惡劣的時候，雨雪雜斑的外緣距離，可以到 5，6 海浬遠，也就是表示，在這 5，6 海浬裡的小型船隻的雷達回跡，很可能都被雨雪雜斑所掩蓋了。

當值船副有很好的理由去擔心，小型船隻的雷達回跡，在惡劣天氣裡面，在一兩海浬的距離內都無法顯示，如果雷達設定不良，雨雪抑制太高，很可能就沒辦法找到小型漁船的回跡。如果是船頭的雷達，可能好一點。補救措施就是要用目視瞭望來看。

⇒ 不同廠牌的雷達製造商，他的目標回跡呈現的形狀，可能具有不同的邏輯，依照他們的主要用戶的喜好，好像早期船上用到美國的軍用雷達廠牌，所有的回跡，都給你顯示成四方形。這當然是方便阿兵哥識別敵情，但對於船上來講，就很不實際。

⇒ 當值船副應該要瞭解本船的雷達設定，才能夠適當地執行他的航行瞭望職務。

⇒ 雷達螢幕上，如果看不到任何雨雪雜斑的顯示，就應該降低雨雪雜斑抑制的程度，讓螢幕上可以顯示些微的雨雪雜斑週邊，來確認我們的設定，不會遺失海上任何的目標。

我們在第三章桑吉輪的雷達上，已經看過因為抑制不當，目標回跡的消失。在圖形 4-02 雨雪雜斑抑制的是 40 %人工設定，這已經是太高了，因為大船長峰水晶輪的回跡，看起來就像一條小

船。在桑吉輪的增益設定是 67 %，在緊急的時候，三副並沒有時間去調整雨雪雜斑的設定，熟練的使用雷達，是適當的目視瞭望外，所必須的步驟，應該由大副船長來確保。

圖形 4-02 詳細的雷達設定

4-04 Radar tune, gain and clutter setting reflect your competence

圖形 4-02 詳細的雷達設定

Radar as we knew should always use in searching mode. Look on right upper side of Radar screen,

⇒ we see **the Tuning setting is automatic** which is OK.

- Tune is tuning the receiver frequency to accord with on board transmitter oscillator frequency.
- The reason for this tune is the frequencies generated in X band or S band is not fixed frequency.
- The actual frequency range used are floating between 8.0 – 12.0 GHz which means Wavelength range are changing from 3.75 to 2.5 cm for X band Radar.
- The automatic tuning circuits adjust the receiver frequency to each transmitted pulse in 8.0 – 12.0 GHz frequency which is impossible to be tune by manual.

It means ownship's receiving frequency is tuned (or chasing) to the frequencies ownship had just transmitted. It is impossible to duplicate this procedure using manual tuning for each pulse.

⇒ we see **the Gain setting is manual** which is OK:

- use Gain amplified receiver echo strength to properly distinguish target from sea rain clutter is the only and most important way in searching mode.
- Because it is manual **OOW shall beware of target echo lost as part of his watch routine**,
- he shall adjust the GAIN setting more or less from time to time to detect target echo from sea clutter ownship radar had just received.

- More Gain setting comes together with more sea/rain clutters which may swap target echo inside these fluctuate clutter.
- More sea/rain clutters depress setting could reduce target's echo at the same time.
- Too many Gain setting immerse target echo into clutters white noice. Too many sea/rain clutters setting depress target echo into blank (balck) screen.
- If these two settings had not adjusted properly in searching mode target echo will become either too white or too dark (lost) in screen.
- Using sea/rain clutter in AUTO mode is not recommended especially in rough sea condition where target echo is likely to be depressed too much by land technician's judgement who is not at scene.
- Lost target echo on radar is not competent to his navigational watch if chief mate cannot notice this mis-adjustment had happened.

To train OOW to manual adjust radar setting of Gain and Sea/Rain Clutter for searching purpose is the responsibility of Captain. Chief officer should be capable of this mentor job too. Each time chief or Master come to bridge should check the Radar setting by Junior OOW are correct or not.

⇒ Sea Rain clutter setting in manual is OK:

- Sea and Rain clutter setting should adjust periodically.
- to ensure it won't set too much so as small target's echo were eliminated by it.
- Sea/Rain clutters also reflect the sea condition during our watch. In good weather, Sea/Rain clutters outer limit appear in 1 to 2 NM range. In bad weather, Sea/Rain clutters outer limit appear in 3 to 4 NM range. In rough days, Sea/Rain clutters outer limit appear in 5 to 6 NM range. Generally speaking, small target inside half the distance of these outer limit will easily missing. That is to say sea clutters can be seen in 6 NM rough sea state small target within 3 NM distance to ownship might be detect by OOW.
- OOW have very good reason to worry about small target might lost in 1-2 nm range in rough days if Radar setting is not properly.
- Each brand Radar manufacturer may have different logic in its echo presentation according to their own preference. OOW should familiar with Radar setting on board to properly carry out his navigational watch.
- One general rule accepted by industrial is to see an echo shown at same place on screen three times in 6 consecutive antenna rotations. This is due to sea clutter shown on screen is jumping all the time. If one echo remained stable on screen it might be a small target. This is also a skill can only be mentored on board the ship by management level.

Each time the radar screen did not have any clutter appear OOW should reduce the Sea rain clutter setting to let the clutter re-appear a little on screen to make sure our setting cannot miss anything at sea. We see target lost in SANCHI radar in Chapter 3. In figure 4-02, the sea clutter setting is 40 percent manual which is too much cause the echo of a big vessel CF Crystal appeared as a small vessel although Gain setting in Sanchi is 67 percent and 3/O did not have time to adjust sea clutter setting in emergency time.

Figure 4-03 detection range reflect traffic density

圖形 4-03 探測距離應該配合船隻密度

4-05 雷達的距離設定，反應出船隻密度

⇒ 目標的數量很多時，我們需要降低雷達畫面顯示的距離到比較小的範圍。

⇒ 在圖形 4-03 的左邊，我們看到距離設定是 6 海浬，目標還是很多。

⇒ 如同圖形 4-03，當雷達畫面設定是 6 海浬的距離，目標的數量太多的時候，我們應該把雷達的距離降低到 3 海浬，如同右圖。

⇒ 如果 3 海浬的目標數量，還是太多，我們就應該減到 1.5 海浬來顯示。

這種情形之下，誰能告訴我，哪一個目標是最危險的？6 海浬經常是資淺船副，應該採取避碰行動的距離。

⇒ 你現在是個大副，應該有能力處理 2 到 4 海浬距離範圍，具有碰撞危機的目標。

⇒ 如果船長看到三副使用三海浬的距離設定來做雷達瞭望，會感到生氣，是否三副知道如何去避免大型目標，可能會使本船沉沒的大船，如果他沒有做長距離的掃描。

⇒ 你是否具備有在三海浬做瞭望的能力，瞭解避免碰撞的程式，這就是為什麼，我們必須討論資深船副瞭望的程式，跟資淺船副不同的地方？

⇒ 聯合國海事組織對於阿帕的性能要求，是可以同時測繪 20 個目標，如同圖形 4-03 的左邊，我們不必做這麼多的目標測繪，或是需要這麼多測繪目標的資料，我們的短期記憶，沒有辦法處理所有目標的細節。

最好把我們的工作負荷，改成兩類：大型船隻跟小型的漁船。

⇒ 在長距離，3 公分雷達應該用來掃描大型船隻，即使我們的雷達增益設定比較低，還是能夠收到很強的信號回波。

⇒ 我們必須降低增益的設定，來減少小型目標以及雨雪雜斑回波強度，用來區分出螢幕上的大型目標。

⇒ 10 公分的雷達，如同圖形 4-03 的右圖，已經把顯示的距離範圍改成 3 海浬，這是為了小船而設定的。

⇒ 我們可以看到小型船隻的尾跡，在 3 海浬的距離顯示內，是比較清晰可見。

⇒ 這兩種雷達畫面都是離心顯示，目的是為了有更多的顯示距離，在本船前進的方向。

⇒ 這反映了當值船副的想法，在本船後方的目標，具有比較少的碰撞危機，相較於在我們船頭的目標。

⇒ 10 公分雷達的設定，是不希望遺漏近距離的小型目標。

⇒ 我們看到在右邊的 3 海浬雷達，小型船隻螢幕上非常清晰的顯現，調諧的設定是自動模式，增益大約是 30%，海浪的抑制是 20%，下雨的抑制是零，沒有開啟。右舷的拖船長度是 40 米，這是可以簡單容易的，在雷達螢幕上辨識出來。

⇒ 在 3 海浬的距離顯示，目標的數量是可控制的，但是目標的動態並不清楚，因為我們還沒看到右船頭這些目標的速度向量線。
⇒ 為了補償沒有時間去擷取近距離的小型目標，這一部雷達應該設定目標的尾跡功能，使用相對運動模式，這樣可以快速的參考他的碰撞危機。
⇒ 這個錯誤的理由，是集中注意力在 6 海浬的大船，又沒時間照顧小船。
⇒ 小船在近距離，並沒有被追蹤或擷取，雷達螢幕的工作分配，是分開監控小型與大型的目標，如果沒有分成兩部雷達來運作的話，就容易顧此失彼。

不要相信你在任何事物上面的經驗，即使是船長，也不一定能夠有雷達瞭望的技巧，就像我們上一章所討論的，這麼簡單的錯誤，在你航運事業的後期，就會引起碰撞的意外，只因為早年雷達瞭望的訓練，並不適當。

4-05 Radar range setting reflect traffic density at the time.

⇒ If the target number are many, we need to reduce screen display range to smaller area.
⇒ If target number too much in figure 4-03 left when range setting is 6 nm we should reduce radar range to 3 nm (right side). This will also reduce our TTC time to collision to be aware on radar lookout. SO, here is the in charging region of chief mate or Master as they are more experienced.
⇒ If 3 nm has too much targets we should reduce range setting to 1.5 nm to display.
- In figure 4-03 left we see range setting is 6 nm and the target are numerous which is impossible to handle it all at once. Also, it reduce the target's echo size for our reference.
- Who can tell me which target is dangerous? 6 nm usually is the action range for junior OOW.
- You are C/O now. You should be able to handle target has collision risk at 2-4 nm range.
- If Captain see 3/O use 3 nm range for radar lookout he may upset about this. Did 3/O know how to avoid big target which can sink ownship within this 3 nm range?
- Are you capable of 3 nm mile lookout and collision avoidance procedures is not depend on you're ARPA training certificater? This is why we have to discuss Senior lookout procedure separated from Junior one.

⇒ It is over 20 targets of IMO ARPA performance requirement in figure 4-03 left. We don't need so much target traced or target data. Our short-term memory cannot take care of all these.
⇒ It is better to separate our work load into two categories (big targets and small fishing boats).
- In long range, X band radar should be used to scan big vessel echo (strong echo with lower gain).
- We need to lower the GAIN level to reduce all small target and sea rain clutter together to distinguish big vessel at screen.
- S band radar as right picture of figure 4-2 had set the display range at 3 nm for small targets.
- We can see small vessel's trail are visible in 3 nm range setting screen.

⇒ These two radars are all set off-center to have more display distance ahead ownship.
⇒ This reflects OOW's thought: target behind ownship has less collision risk than those ahead.
⇒ S band radar setting is not to leave small target unseen at close range.
- We see at right side 3 nm radar screen small vessel is very clearly presented on screen. The tune is auto. The gain is about 30%, the sea clutter is 20% and the rain clutter is 0% setting. The starboard side tug boat length of 40 meters is easily identify in radar screen.

⇒ In 3 nm range display the target's number are controllable but the target's movement is not clear as we did not see speed vectors of those two targets at starboard bow.
- To compensate for no time to acquire small target at close range this radar should set target trail function on to relative motion for quick reference.

⇒ The reason of this mistake is because Master concentrated on big vessel at 6 nm range.
⇒ Small target at close range did not be traced or acquired by ARPA.

The job assignment to Radar screen for monitoring small or big targets is not separated with two Radar as we recommended. Don't trust your experiences in everything. Captain may not be able to master the skill of radar lookout as last chapter. This simple mistake caused the incident of collision in later stage due to radar lookout training is not appropriate.

4-06 小型船隻的尾跡，我們需要注意什麼樣的特徵

⇒ 在圖形 4-03 的左圖，雷達尾跡並沒有開啟，或者是設定時間太短，還沒有辦法立即可見，船長沒有辦法，在第一眼就分辨出碰撞危機，就像圖形 2-19 能做到的。

⇒ 相對運動的尾跡，有時候會非常長，因為非常高的相對速度，造成其他目標的回跡被遮蔽。

⇒ 真運動的尾跡，當我們立即需要目標動態資訊的時候，是比較好用。

⇒ 大部分的漁船是靜止不動，當我們接近非常密集的漁船區域。為什麼不動？打漁的人也會非常擔心，跟其他的海上漁船發生碰撞，他們只有兩個選擇，第一個就是停留在原地，第 2 個就是全部以同樣的方向跟速度來移動。這是對漁船群群來說。

⇒ 真運動的尾跡，會降低不動漁船的威脅，只要我們有雷達螢幕的尾跡設定。

⇒ 真運動的尾跡，可以很容易的分辨出，具有不同方向與速度的船隻，**當目標與跟其他的漁船不同方向與速度，這很可能是一條大型的遠洋船隻**。

⇒ 在 3 海浬雷達畫面的右邊，雷達的尾跡長度設定是 3 分鐘的真運動尾跡，這就比 6 分鐘的速度向量線長度設定要短。

⇒ 船長這樣子設定目標的尾跡長度，是要利用尾跡來指示過去的動向，就是去核對在過去的 3 分鐘，該船是否轉向。

⇒ 船長也可以利用擷取的速度向量線，來指示目標的航向航速。

⇒ 我的建議是使用尾跡長度的設定，跟速度向量線的時間長度設定一樣（6 分鐘）。

⇒ 設定尾跡的時間跟速度向量的時間長度一樣長，可以立即參考目標的動態，如果螢幕上的目標，不會混淆的話。

在緊急的時候，我們不必去，或者不希望重複核對尾跡的時間長度設定，船長應該要求當值船副如何速度向量線時間長度，使用同樣的時間長度的尾跡，這樣就不必再花時間去核對尾跡的長度設定。這在船隻眾多繁忙的時候，可以節省一點寶貴的時間。

⇒ 尾跡的長度跟速度向量線設定一樣長，那或許有可能的目標在減速，或是加車的時候，我們能夠有一點的概念，可以監控船速的改變，會來得更為輕鬆，測量他尾跡的長度跟速度向量線長度來比對。

⇒ 小型船隻的速度向量線，如果還沒設定，可以在心裡預期，如果當值船副將尾跡的時間長度，設定的與速度向量線同樣的時間。

⇒ 這些回跡的設定是非常有用的，當目標船隻在過去幾分鐘改變了航向，我們可以立刻知道目標船隻過去的航向改變，在我們設定的時間長度內。

如果小型目標的航向改變，沒有在阿帕上面擷取的圖形或是數位化的顯示，那就只有尾跡，能夠為我們解決這個難題。

4-06 What trail property of small vessel we are looking for?

⇒ In figure 4-03 left picture, radar trails of target had not turned on or too short to be readily visible to OOW. So, captain cannot tell collision risk at first glance as Figure 2-19 can do.

⇒ Relative motion trails sometimes can be very long due to high relative speed so as to obscure another target's echo.

⇒ True motion trails are preferable when we need instant information of target movement.

- Most fishing boat are stationary when we approaching a very dense concentrated fishing group. No movement, why? Because in this concentration fisher are also very worried about collision to other fishing boat at sea, they will have two options:

        - first is staying where they are,
        - second is all moving in same direction and speed.
    - By fishing group moving or stop together. It will give us some option to go around them more easy by proper lookout or estimation.
    - True motion trial will reduce the threat of stationary fishing vessel by one look.
    - True motion trial can easily identify which target has different course and speed than other fishing vessels, probably a big ocean-going vessel who know if we cannot distinguish them from small target's echo in close range.

⇒ In right side 3 nm radar picture the radar trail set to 3 minutes true motion which is shorter than speed vector setting to 6 minutes true motion.

- Captain set target trial in this manner is to use trial to indicate the past movement of target, that is to check does target had alter course or not in past three minutes.
- Captain use acquired target speed vector to indicate target's course and speed right now.
- For those targets had not acquired will have problem to estimate their true course and speed. But, their COG and SOG will be readily visible by their true motion trail setting.
- Our suggestion is to use trail length setting same as speed vector time setting, 6 minutes in this case.
- For immediate reference of target movement, it is better to set trail timing same as our speed vector so we can know target vessel reduce speed immediately by comparing speed vector and trail's length.
- We don't need to (or want to) double check trail time setting at emergency if Captain had asked OOW to follow this procedure in heavy traffic watch-keeping standing order.
- The speed vector of small targets if not set yet can be projected mentally if OOW use same time setting in trail.
- These trail setting is very useful when target vessel changed course in last few minutes. Ownship can monitor target vessel past course within the time interval we had set.
- Course change of target has no indication on ARPA graphically or digitally, only trail can do this trick.

4-07 小小的設定不同，就是造成碰撞的潛在因素

⇒ 船長高估了，在右船頭的這兩個目標，或是我們應該說，船長沒有這兩個目標速度的概念，因為沒有速度向量線與尾跡的顯示。

⇒ 不用任何的航向航速的改變，本船就能夠安全的通過這兩條小船的船頭，而不會有任何麻煩。其中的一條還是拖著駁船的拖船。

⇒ 因為船長沒有設定目標的尾跡來使用，與沒有設定速度向量線，使用同樣的時間長度。他就沒有能力，去比較本船的速度向量線與目標船的尾跡，來正確的估計目標船未來的位置，相對於本船的操縱，當他必須對是否轉向做出決策的時候？沒有參考的東西可以核對或支持自己的看法，只能憑直覺，沒辦法核對。事實證明，他的直覺是錯的。

⇒ 經過雷達瞭望的訓練，可以用來估計這兩條小船未來的位置，與本船未來的位置，只要他有適當的尾跡長度設定，這種想法，並沒有進入船長的腦海，他沒有受過這樣子的訓練。

如果船長沒有辦法知道，他是否能夠通過這兩條小船的船頭？（利用小船的雷達尾跡，或是這兩條小船的速度向量線）在這之前的選項（資淺船副的選項），他就只有往這兩條船，也就是向目標船的船尾轉向，這我們在第二章資淺船副的標準避讓程式中談過。

⇒ 更危險的目標，已經在右舷等著他，這個突然的決策，造成一個無法抹滅的傷疤，在他的事業裡。

⇒ 當小船的數量很多時，他們的尾跡就是我們所需要的東西，當我們的目視瞭望也有困難，去確認目標與本船之間的距離。

不論我們雷達設定的多好，瞭望的優先順序，永遠是目視第一。雷達瞭望有太多的設備參數要設定，即使我們非常熟悉如何在雷達螢幕上做搜索跟擷取的程式，我們對雷達瞭望的經驗，可能會被新的品牌，或是雷達的不同構造所挑戰，經過這麼多年的海上生涯，如果我們改變服務的船隻，在一個合同之後，雖然你現在已經是一個大副，是否能試問自己，能夠用雙眼的視力，來分辨出目標的距離，如果你對你的目視瞭望，還沒有信心，你現在就應該多加練習。

4-07 Small difference in setting is exactly the hidden cause of collision.

Captain overestimated two targets speed at starboard bow or should we say Captain has no idea of these two targets' speed without speed vector.

- Without any course and speed alternation, ownship can pass safely ahead these two small vessels without any trouble. One of it is a tug boat with tow.
- Because Captain had not set target trial with same time interval as speed vector he has no ability to compare ownship's speed vector with target's trial to correct estimate target vessel future position related to ownship when he had to make decision to alter course.
- Captain has no ability to know or predict exactly target's future movement together with ownship's speed vector.
- Captain is not a rookie. 24 years consecutive sea time and 7 years master and madam voyage captain of company biggest new ship.
- Captain's seniority can only reflect one serious fact of "How poor current seaman's skill in radar lookout?".
- The training of his cause him cannot estimate these two small vessels' future position (or speed vector) together with ownship position (or speed vector) by proper trail length setting has not come to his mind. (no knowledge caused no skill)
- If he has no way to make sure whether he can pass ahead of these two small vessels by radar trail (second choice) or speed vectors (first choice) he has to go around (alter course to targets stern) as we taught in Chapter 2.
- Even more dangerous targets are waiting him in the starboard side. This jump-out decision had leaved an unforgettable scar on his career.
- When captain reported to office after this incident for BRM training I asked him what lesson he learned? He said 24 years sea time with no incident cannot guarantee in next year, 25 year you will be OK.

When numbers of small target are many their trail is needed when our visual lookout have trouble to identify target's distance from ownship. No matter how good we are at radar setting. **The priority of lookout is visual first.** Radar lookout has too many limitations even we are very good at their searching and acquiring procedures. Our experiences of radar lookout may face challenge from new brand or layout of Radar year after year if we change service vessel after one contract. Even you are a chief mate now, you should ask yourself "Can I decide the target's distance with my bare eyes?". If you did not have the confidence in your visual skill you have to make it up now.

4-08 雷達速度向量線的設定，反應出當時的碰撞危機

⇒ 在這一部雷達上，速度向量線的設定是 6 分鐘，這容易用電子海圖來交叉參照，

⇒ 速度向量線的設定在 6 分鐘，方便我們觀測未來 6 分鐘的碰撞危機。

⇒ 速度向量線的長度，就像探測距離的設定，目標多的時候，就必須減低速度向量線時間的間隔，來減少有問題的目標數量。

⇒ 當目標數量不多時，我們可以把速度向量線，設在比較長的時間間隔，找出其他船隻的可能碰撞危機。

⇒ 3 分鐘的速度向量可以認為是雷達瞭望的最低的需求，這是因為本船改變航向避碰的能力，受 3 分鐘的轉向時間所限定。

圖形 4-04 探測碰撞危機的金手杖，在 2230 時

4-08 Radar speed vector setting reflect collision risk at the time. In figure 4-04

- The speed vector setting is 6 minutes in this Radar, true motion is easier for ECDIS cross reference.
- The speed vector setting 6 minutes means we can detect collision risk in future 6 minutes time.
- The speed vector length is like range setting. When targets are many we need to reduce speed vector length to shorten time interval to reduce target numbers in question.
- When the targets are few, we can set longer time period to find out possible collision risk with other vessels.
- 3 minutes speed vector is considered minimum requirement for radar lookout as ownship’s ability of alter course to avoid collision is limited by its 3 minute advance.

圖形 4-04 探測碰撞危機的金手杖，在 2230 時

4-09 為什麼船長不願意浪費時間，使用阿帕去擷取目標

在上一章我們知道探測碰撞危機的魔杖，就是我們的速度向量線，速度向量線的長度應該隨著碰撞危機的不同而改變，速度向量線的時間設定比較長，可以得到早期的碰撞警報。速度向量線設的比較短，可以找到最危險的目標，尋找可能的選項，可以採取最佳措施來避免碰撞。

在圖形 4-04 的左圖，雷達距離設定只有 1.5 海浬，這使得本船的速度向量線看起來非常的長，本船的速度向量設定是 6 分鐘，但是目標船沒有速度向量線，沒有速度向量線顯示，就是缺乏雷達瞭望的訓練，所以我們將橫越船的速度向量線開啟，在右圖使用紅色的箭頭，代表對地的航向跟速度，這些對本船並不重要，因為當值船副根本就沒有時間去知道這麼多，我們只希望知道這條船是不是能夠安全通過？這就是為什麼船長不願意浪費時間，去使用阿帕去擷取目標。但是沒有速度向量線顯示，我們不知道有沒有碰撞警報？

⇒ 有一個紅色的碰撞點，在 6 分鐘的行駛距離之後被發現，本船與目標船，都大約在同時到達這個碰撞點。

⇒ 電子方位線可以用來標記目標的方位，在雷達上的方位圈上的紫色圓點，或是使用蠟筆來標注在雷達的方位圈上，這裡的讀數是 127 度的真方位。

⇒ 我們不必記得方位的讀數，但是有一個蠟筆的記號，在紫色的圓點上，有兩個用處：可以知道

- o 第一個，稍後的方位變化

- o 第二個，如果目標方位沒有改變，我們需要知道這一個方位，來做操船避碰時航向的參考。

⇒ 碰撞的時間是 6 分鐘後，在速度向量線上面所讀到的碰撞位置。我們需要確認，也就是用眼睛找出這一個目標。

⇒ 6 分鐘後目標的距離，可以用本船的速度向量線來做估計，現在本船 6 分鐘的速度向量線的距離，就是 1.54 海浬。

知道 1.54 海浬的碰撞距離，以及 6 分鐘的碰撞時間，我們可以把這個情況，分成兩個種：

⇒ 第一種是近洋船隻，他的迴旋圈比較小，他能夠在下面的五分鐘之內，轉向來避免碰撞，要確認他是哪一種船隻，跟他的意圖，我們可以使用目視瞭望來確認，這是否是條近洋船隻。

⇒ 第二種是遠洋船隻，這些船我們有國際避碰規則的限制，限制本船，也限制的他的行動，如果在這個橫越的情勢中，再一次，如果他用轉向來避免碰撞，在未來的幾分鐘內，這也是使用目視瞭望，會立即明顯可見他的轉向，比阿帕的測繪方便。

⇒ 如果要用阿帕的測繪來確認他的轉向，還不如使用尾跡的設定，更為便捷。

如果他減速或停車來避碰，在這個時候，我們必須使用更多的時間，在我們的目視技巧上，從他的相對方位的增加，才能夠知道他的速度改變。也許他的船尾浪，能夠提供我們一些線索，不過這個都是看運氣，如果他是深吃水吃船隻的話，也不會有多大的船尾浪。阿帕對於他船速的改變，可以提供立即的資訊，也就是他的速度向量線會變短，但是我們要剛好他在變短的過程中看到，如果只是偶爾看一眼的話，也是很難分辨他的速度向量線，是否正在變短。

避碰規則 8，如果有充足的水域，單獨的改變航向，可能是最有效的行動，來避免近接的情況，橫越船的相對方位會增加，如果他減速或是停車。換句話說，他會通過我們的船尾，如果他減速或是停車，本船會提前通過碰撞點。在這 6 分鐘的時間，有什麼選項是蠻重要的。

⇒ 經過航向 37 度的右轉，到 127 度的真航向，對橫越船是可用的選項。

⇒ 減速到一半的速度，在 3 分鐘的時間內，也是可用的。

⇒ 本船現在是在長江口燈船的注意區域，目標船（小船）也許會對本船讓路。

到碰撞的距離，就是本船 6 分鐘的速度向量線跑的距離，也就是 15.4 節的十分之一等於 1.54 海浬，或是我們可以從雷達的畫面，利用計算固定距離圈有幾圈？在這有六圈才會到達碰撞點的距離，碰撞距離就是每圈 0.25 海浬乘 6 等於 1.5 海浬，從現在的位置算起。

圖形 4-05 偵測碰撞位置的魔杖，2233 當地時間

4-09 That's why Captain don't want waste time to use ARPA to acquire target

In last chapter we know collision detection tool is our speed vector. The length of speed vector should be varied by OOW to detect different situation in collision risk. Set speed vector timing longer to get earlier warning of collision. Set it shorter to most dangerous target and find how many possible choices ownship can have to avoid the collision.

In figure 4-04 left picture, our radar range setting is 1.5 nm only which make ownship's speed vector very long. Ownship speed vector setting is 6 minutes but target vessels had no speed vector. No speed vector is lack of radar lookout training. So, we add speed vector on crossing vessel at right side picture with red arrow. The course over ground or speed over ground of this target are not important as OOW did not have time to know. We only want to know "is it safe to pass?". That's why Captain don't want waste time to use ARPA to acquire target's digital data but speed vector prediction in graphical mode is what we are teaching here. After we add red speed vector for small target,

⇒ One collision spot (red spot) was found after 6 minutes run, ownship and target vessel will arrive about the same time.

⇒ Electric Bearing Line EBL can be used to mark target's bearing on radar (green line) or with a crayon pencil to mark the bearing in radar's azimuth circle. (the reading is 127 degrees (T)).

⇒ We don't need the reading of the bearing but one crayon mark at purple point of azimuth can serve two purposes:

- for later bearing check.
- If the target bearing did not change, we will need this bearing to inform AB or remind ourself go around her stern.

⇒ The collision time is 6 minutes later by reading collision position at speed vector.

⇒ **We need to identify (find out) this target by graphical presentation on radar now.**

- Target's distance can be estimated from ownship's speed vector = 1.54 nm in 6 minutes run. Use a divider or your finger's span to set on our speed vector then compare it with target's distance from ownship's center (for the time being when you are not familiar with distance estimation by your eye). Target's distance is about the same distance as our 6 minute's distance run.
- With 1.54 nm distance and 6 minutes to collision, we will divide the situation into two categories:
    - Coastal vessel: with smaller turning characteristics, it could alter course within next 5 minutes to give way. One way to make sure his nature and intention is by Visual lookout.
    - Ocean going vessel: He has COLREG binding his movement while he is stand-on in this crossing situation. Once again, **if he alters course to avoid the collision in next few minutes it will be more readily apparent to visual lookout than ARPA plotting.** If he reduces or stop engine in this moment, we will need more time in our visual skill to verify his relative bearing is increase to notice his speed change (target vessel in collision risk reduce speed means he will arrive collision point later. So, its relative bearing will reduce to zero). In the contrast, ARPA can provide immediate data of her speed over ground even the speed vector setting is not so obvious in speed reduction process.
    - That's why COLREG **rule 8(c)** *If there is sufficient sea-room, alteration of course alone may be the most effective action to avoid a close-quarters situation.* Because altering course in close range need at least 6 times ship's length advance to be effective.

Crossing vessel's relative bearing will increase after he reduce or stop the engine. In another words, he will pass our stern if he reduces or stop engine. Ownship will pass collision point first.

⇒ In this 6 minutes' time what options we had is important.

- Alter course 37 degrees to starboard side to 127 degrees(T) is available for crossing vessels.
- Reduce speed to half speed is also available to us in 3 minutes time.
- Ownship is now in precautionary area of Chang Jiang Mouth L/V. Target vessel may not give way to ownship.

⇒ Distance to collision is 6 minutes run of speed vector (one tenth of 15.4 knots speed) = 1.54 nm. Or we can read it from radar picture counting the range rings number, there are 6 rings to reach collision spot distance to collision DTC is 0.25 nm x 6 = 1.5 nm from current position.

圖形 4-05 偵測碰撞位置的魔杖，2233 當地時間

4-10 碰撞點隨著本船速度向量而移動

碰撞危機是于 2230 時確立，3 分鐘後，船長並沒有採取任何行動，但是情勢已經改變，也許船長已經注意到，目標船正在改變航向。在雷達的螢幕上，也是有出來些線索，作為我們的參考。在圖形 4-05 我們還能確認方位 127 度的目標轉向了，算是幸運的。這要感謝早先設定的 3 分鐘的真運動尾跡，使我們對他的轉向有所感覺。試著想像此時的螢幕，如果沒有目標的尾跡，我們怎會知道他是否要轉向，來避讓本船？

⇒ 本船正在接近碰撞位置，在這 3 分鐘的時間。
⇒ 碰撞點也就是航線的交叉點，正從我們速度向量線的端點，向本船移動，如果目標沒有改變航向，如同綠色的速度向量線。
⇒ 碰撞點也就是兩條船的速度向量線的交叉點，沿著本船的速度向量線前面，向本船接近。
⇒ 當目標船轉向到我們的船尾，這時是紅色的速度向量線，碰撞點就移動到本船船尾。
⇒ 隨著這兩條船未來位置的改變，就現在來講，新的碰撞點，已經沒有碰撞危機，對這兩條船來說，這兩條船會經過這一個新的碰撞點，在不同的時間。
⇒ 本船現在就正在經過新的碰撞點，目標船已經轉向，目標船還需要 4，5 分鐘以後，才會到達本船現在的位置，這 4，5 分鐘的時間差，通過的時間不一樣，就是我們的安全範圍。

我們不知道漁船航向改變的多少？這不重要，但是我們確實知道，碰撞點現在已經移動到我們的船尾，也就是本船現在沒有安全的顧慮，沒有碰撞危機。

4-10 Collision point move along ownship’s speed vector

The collision risk is established at 2230 hours. After 3 minutes, Captain did not take any action but situation is changed. Maybe Captain had noticed target vessel is changing her course now. It is also having some clue in radar screen we can pick up for our reference. In the left side of Figure 4-05, it looks like something is missing. We now know it speed vector missing. It is lucky that we can identify the target at bearing 127 degrees (T) had alter course. Thanks to the setting of 3 minutes true motion trail let’s have the sense of altering. Try to image the screen without trial of target. Is her course altering can clear ownship?

- Ownship approach to collision position is in 3-minute time.
- The collision (crossed) point is very close to ownship if target had not altered course (green speed vector).
- The collision (crossed) point moves along ownship’s speed vector from ahead to ownship stern direction because target had altered course to our stern (red speed vector).
- Collision point actually is moving along ownship speed vector from ahead to astern direction.
- The collision position is in ownship’s current position now as indicated by red speed vector.

- This collision point no longer has collision risk as two vessels will pass at different time now.
- Ownship is passing collision point now due to target vessel alter course already.
- Target vessel need 4-5 minutes more to arrive ownship's position now. This is our safety margin, 4-5 minutes time difference in passing collision point.
- We don't know how much course had changed by target vessel (it doesn't matter to ownship) but we do know collision point is at our position (or stern) now.

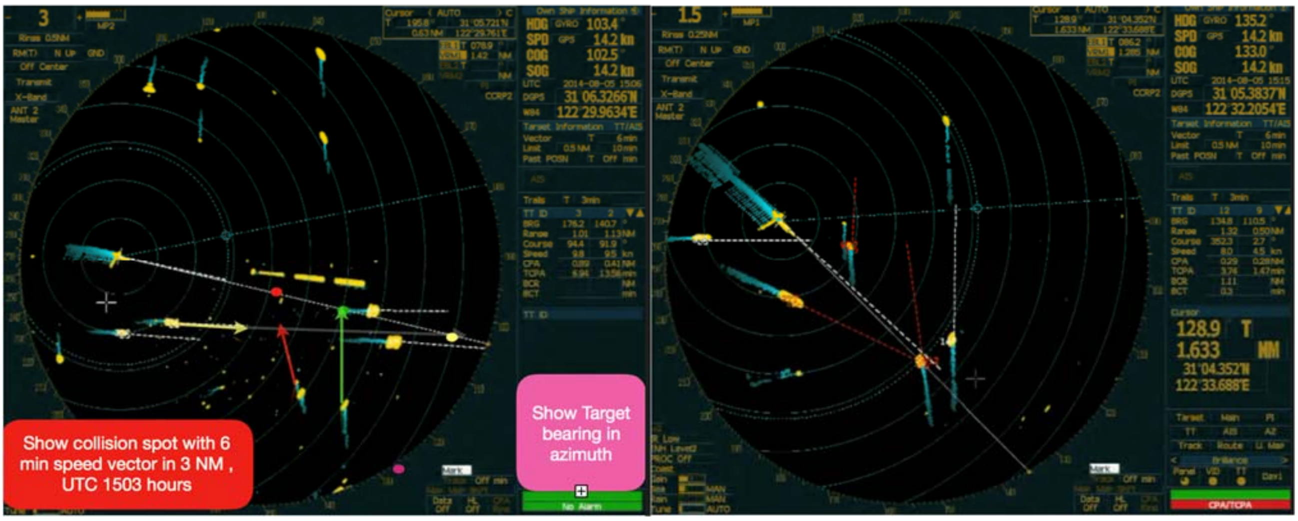
4-11 碰撞點移動的基本概念

⇒ 如果目標船沒有改變航向，碰撞位置對本船，是離現在 3 分鐘之後。對漁船來講，大約是 4 分鐘之後，這是由他綠色的速度向量線來做的判讀。
⇒ 漁船轉向後，它的方位增加，如果你有檢查它的方位，利用方位線，或電子方位線。
⇒ 相對方位變大，表示他會通過本船的船尾。
⇒ 他的相對方位變大 15 度，就像紫色的點，在方位圈上向後移動的度數。
⇒ 知道這個小船的航向改變了多少度，在一海裡的距離，是否足夠避免碰撞？
⇒ 我們看到在這 3 分鐘的時間，游標是停留在雷達螢幕上沒動，這可以協助瞭望的工作，也就是游標是代表過去 3 分鐘的位置。
⇒ 使用游標來標注目標的方位，需要額外的時間去比較回跡的位置，在這麼關鍵的時間，是比較沒效果，再慢 3 分鐘，就要碰撞了。
⇒ 如果我們需要更多的時間來分析方位變化，與其分析游標的位置，使用電子方位線來標注目標的方位，是比游標有效。
⇒ 對小型目標在 0.75 海裡的距離，如果有 15 度的方位改變，由我們在第二章所討論的正橫距離公式，離原來的碰撞位置是 1852 x 0.75 x Sin (150) = 395.5 公尺
⇒ 是的,這條船已經讓路 395.5 公尺給本船，也就是將近本船的全長長度。

圖形 4-06 讀出可能的碰撞位置在 2306 時與 2315 時

4-11 Some concepts of Collision point movement

- If target vessel did not change her course the collision position will be three minutes from now for ownship and about 4 minutes for target vessel (read from green speed vector).
- Target vessel's bearing had increased if you check on bearing or EBL line from last figure 4-04.
- Relative bearing getting bigger means she will pass ownship's astern.
- This relative bearing change will be more vivid in visual then Radar screen by its bearing resolution limitation.
- Her Bearing changed 15 degrees as the purple point moved backward on azimuth circle.
- Did you know how many course changes for small vessel in one nm distance will be enough?
- We saw the cursor was left on radar screen untouched in these three minutes to help in radar lookout job by shipboard master.
- Use the cursor to mark target's bearing need extra time to compare target echo's position which is not effective in this critical point (3 minutes to collision, no time already).
- However, we need more time to analyses the situation by using cursor. Using EBL to mark target's bearing is more effective than cursor.
- Using visual skill will be more effective than EBL setting as the target vessel is small (as well as her blossom effect).
- For small target at 0.75 nm distance with 15 degrees bearing change we said in chapter 2 the abeam distance away from collision position is 1852 x 0.75 x Sin (15^0) = 395.5 meters.
- Yes. This vessel had give-way of 395.5 meters beam distance for ownship. It's about one ship's length of ownship and may be 5-6 times of her length.



圖形 4-06 讀出可能的碰撞位置在 2306 時與 2315 時

4-12 最低的速度向量時間設定

可能的碰撞位置，PCP 是兩條船航線在海上的交點，要找到兩條船航線的交叉點，使用速度向量線是非常容易的事，本船與所有的橫越船隻，都有交叉點，只有少數的交叉相遇船隻與本船有碰撞危機，我們要如何從這些交叉點，找出碰撞危機？

⇒ 不論航線交叉的角度是多少，碰撞可能呢永遠是在我們的船頭方向，這在碰撞前是幾乎不變的，都在我們的船頭之前。
⇒ 在桑吉輪的案子，他的右船頭被撞，在碰撞之前，可能的碰撞位置，也是在桑吉輪的船頭方向。
⇒ 如果兩條船的航線互相交叉，他們就會產生一個可能的碰撞位置。
⇒ 這些可能的碰撞位置，經常發生在分道航行制的入口，或狹窄水道的出入口，因為很多船隻的航線都會這些位置，互相交叉
⇒ 船的速度向量線代表我們船頭方向一部分的航線，所以兩條船的速度向量線的交叉點，就是可能的碰撞位置。
⇒ 速度向量線的交叉點，可以用來找尋：
  - o 確認可能的碰撞位置
  - o 知道你離碰撞點的距離有多遠
  - o 知道你離碰撞的時間有多久
⇒ 速度向量線的長度設定，代表我們探測碰撞危機的時間長度，應該對現在的交通密度，做一個合適的設定。
⇒ 瞭望時，速度向量線是一個很有用的工具，我們叫它魔杖，調整我們設定的時間，可以確認本船轉向的彈性與可能性。
⇒ 我們認為 6 分鐘的速度向量線設定，是評估碰撞危機最低的需求。
⇒ 我們認為 3 分鐘的速度向量線設定，是避碰操作時，最低時間設定的需求

4-12 Minimum requirement of speed vector time setting.

Possible Collision Position PCP is crossing point of two vessels at sea. It is very easy to find out with speed vectors crossed. Ownship have crossing points with every crossing vessel. Only few of them have collision risk with ownship. How to find out collision risks from crossing points?

⇒ No matter what angle of blow the collision may be, Possible Collision Position PCP is always at our heading direction before collision.
⇒ Even for SANCH case, we see her starboard bow been collided. Before the collision the PCP is ahead of Sanchi's heading. Only after one of these two vessel had arrived this collision point her collision point change to her side (Sanci) and the one arrived later still has its collision point at bow (CF CRYSTAL).

⇒ If two vessel's course line crossed each other there will have a possible collision position.
⇒ These possible collision positions are common at entrance of Traffic Separation Scheme or narrow channel because many ship's course lines crossed each other at there.
⇒ Ownship's speed vector represent part of our course line ahead. So, crossing point of two ship's speed vector is possible collision position too.
⇒ Ownship's speed vector can be used to:
- search Crossing Point or collision point
- identify a crossing point as a possible collision position PCP.
- know Distance to collision DTC
- know Time to collision TTC

⇒ The speed vector length setting is the detection range and time OOW decided for current traffic usage.
⇒ Speed vector is a powerful tool in Radar lookout we called it **collision line** to represent its usage in collision avoidance.
⇒ We considered 6 minutes speed vector setting is the minimum requirement to access collision risk.
⇒ We considered 3 minutes speed vector setting is the minimum requirement to avoid collision risk.

4-13 在 2306 時雷達瞭望的情境感知

我們在這裡提到的東西，如果你已經讀到這裡，讀者應該多多少少有些印象。如果我們回頭去看看前面的章節，就能夠找到一些線索，來支持現在這些敘述。這一本書是著眼于建立我們的長期記憶，所以重要的事情我們會說三遍，在不同的章節都提一下，順便可以檢查一下，我們記得是對還是錯？好現在，我們看看圖形 4-06 的左圖，速度向量的設定是 6 分鐘，在 2306 時本船在長江口的燈船前面 6 分鐘的水路。兩條小船在右船頭，當值船副並沒有在阿帕上面，擷取這兩條船，我們放上兩條速度向量線來解釋這個情況。

⇒ 紅色的速度向量是一條拖船拉著駁船慢速前進，當然它是比本船慢。
⇒ 本船的速度向量在 6 分鐘的時間內沒有交叉點，雖然有兩條船正在橫越。

如果我們將速度向量的時間長度設為 9 分鐘，那就會在我們的船頭方向，產生一個交叉點（也就是圖上的紅點），我們在船頭方向，就會找到一條目標船的速度向量線，通過本船的速度向量線。

不必做任何的計算，我們已經知道碰撞的時間不少於 6 分鐘，但是也不會多於 9 分鐘的時間。因為我們把本船的速度向量長度，從 6 分鐘改為 9 分鐘，就這麼一個動作，我們就知道碰撞的時間是在 6 到 9 分鐘之間。

如果在其他的情況時，碰撞的時間是由碰撞點在速度向量線上的位置，來決定碰撞的時間。在這一個例子裡面，碰撞的時間 TTC Time To collision ,大約是 9 分鐘的時間。

碰撞距離就是本船 14.2 節跑 9 分鐘的 2.13 海浬。這是由 14.2 節乘上 0.15 的得來的。

⇒ 綠色的速度向量線是一條慢速漁船的，我們與他的碰撞點，也是在我們的船頭的某一點上面，在圖上是綠色的點，
⇒ 由本船的速度向量線時間，判斷碰撞點大約是在 6 分鐘後，大約 12 分鐘後，就是紅點與我們的碰撞時間。
⇒ 本船離這個碰撞位置是大約是 4.26 海浬，這個就是綠點在我們船頭方向的位置。
⇒ 在這個 2306 時的情勢感知，並不需要我們的想像力？本船呢只需要用阿帕來擷取這兩個目標，來設定他們的速度向量，就可以參考到他們的碰撞點，碰撞時間跟碰撞距離。

如果放大尾跡的時間設定到 6 分鐘的時間，這樣呢我們可以更好地瞭解他們過去的動向，萬一不幸速度向量又遺失了，那這個尾跡的長度跟方向，可以提供我們更快速地預測他未來 6 分鐘的位置，當然這是需要經過一點訓練，所以呢這是大副要具備的技能。

⇒ 東航的船隻，在同樣的方向，當值船副已經擷取。但是橫越船隻並沒有擷取，那這是雷達瞭望不力的地方

⇒ 利用分析紅色與綠色速度向量線，我們可以知道拖船拉著駁船是我們安全的主要顧慮，我們也許需要避讓 200 公尺長的距離，來清爽的離開拖船跟他的駁船。

⇒ 無論如何向右轉 10 度，應該足夠讓這條拖船與他的駁船清爽。(1852 x 2.13 x Sin (100) = 685.0 meters) 所以新的航向呢應該是 100 度加上 13.4 度等於 113.4 度，這樣應該就 OK 了。

4-13 Situation awareness in 2306 hours radar lookout

What we mentioned here are more or less recognized by reader if you had read this far. As we go back to chapters before we can find some clues to support these statements. This book is aimed to establish our long-term memory so important things we will say three times in different chapters. Let's check on figure 4-06 setting first. The speed vector setting is 6 minutes. In left picture at 2306 hours, ownship is 6 minutes ahead of Chang Jiang Mouth racon. Two vessels crossing from starboard side OOW did not acquire these two by ARPA. We put two speed vectors on to explain the situation.

⇒ Red speed vector is a tug boat with tow in slower speed (than ownship).

- Ownship speed vector had no crossing point with her in 6 minutes time.
- She is crossing. There has a cross point at ownship's heading (or course line).
- If we increased the speed vector setting to 9 minutes length, we will find a collision point ahead with this target (red point). Verify this by your knowledge now or read this chapter from beginning.
- Without any calculation, we already know collision time is not less than 6 minutes then no more than 9 minutes by changing ownship speed vector length to 9 minutes.
- What time is collision time depends on collision point position at speed vector. In this case, collision time TTC is about 9 minutes.
- The Distance to Collision DTC is 9 minutes run of ownship speed 14.2 knots. DTC = 2.13 nm = 14.2 knots x 0.15

⇒ Green speed vector is a fishing boat in slower speed.

- The collision point is on the heading mark somewhere (green point).
- Judging by ownship speed vector time to collision point TTC is about 6 minutes x 2 = 12 minutes. For this fishing vessel, her TTC is 6 minutes.
- Target vessel distance to collision DTC is about 4.26 nm as read from green point located on our heading mark.

This situation awareness in 2306 hours don't need our situation imagination. Ownship need to acquire these two targets by ARPA to set up their speed vectors for later reference and enlarge the trail time setting to 6 minutes as better understand their past movement. These adjustment are our skill in using radar from our previous knowledge learned. Eastbound vessels in same direction had acquired by OOW. But, crossing vessel has not acquired is not a good practice of radar lookout. By analyses of red and green speed vectors we know tug boat with the tow is our prime concern of safety which might need two hundred meters long distance to clear her tow. Anyway, 10 degrees to starboard side would be enough for this tug and tow (1852 x 2.13 x Sin (10^0) = 685.0 meters). New course 10^0 + $103^0.4$ = $113^0.4$ degrees should be OK as nearest target is at 135^0 degrees bearing. One of the way to estimate collision risk with other vessel is to rotate our heading to starboard side where ownship speed vector won't touch starboard side vessel's yellow speed vector. (Alter course to 120 degrees will be fine as my judgement)

4-14 安全速度或是慢速進入口袋戰術

圖形 4-06 的右邊是 2315 時的雷達畫面，速度向量線是 6 分鐘，本船的對地航向是 135 度，這是在 2306 時從 103 度轉向的，對地速度是 14.2 節，其他的船隻保持同樣的航向航速，只是情況已經不一樣了。

⇒ 這一條紅色的拖船拉著駁船，在我們的左船頭，已經轉向到 000 正北的方向，因為他本來就是要向北航行，左轉只是想要通過本船的船尾，本船大角度的轉向之後，他就回到原來正北的航向。本船跟這一條拖船，已經沒有碰撞的時間跟碰撞的距離，因為本船已經轉向了。

⇒ 本船的船首向已經改變，並且已經完全清爽了這條拖船的速度向量線，對著對的他的船尾前進。

⇒ 有一條船在我們的右船尾，航向 090 度，與我們的船首輝線有碰撞點，請看圖形 4-06 的右邊。碰撞時間對這兩條船來講，大約有 5 分鐘的差距，本船呢會通過他的船頭，在 1 分鐘之後，速度向量線就不會有交點，就是 1 分鐘後沒有碰撞危機了。

⇒ 任何橫越船隻在本船的航線上，都會有一個碰撞點，如果在我們的船首輝線上，他已經通過了本船的船頭，就沒有碰撞危機，他通過本船船頭的時間，就是船頭橫越時間，Bow CROSSING TIME ,BCT。

⇒ 一條船在本船的右舷，方位在正南，航向航速未知，與本船有碰撞危機，因為這兩條船到達碰撞位置，是在相同的時間。他的速度向量線是紅色的，請看圖形 4-06 的右邊螢幕。

⇒ 碰撞時間是 6 分鐘，速度向量線上的距離是 1.42 海浬，是 14.2 節的 10 分之 1，現在我們已經有了一些對於碰撞點的概念。

目標船的航向航速並不重要，因為我們沒有時間去記這些東西，**碰撞點在本船速度向量線上的位置，能夠決定碰撞的時間跟碰撞的距離**，這才是我們需要關心的，而不是目標船的航向航速。

⇒ 碰撞點會隨著本船的航向改變而改變。

⇒ 哪一條船先到達碰撞點，就會先通過碰撞位置。

⇒ 兩條船必須在同一時間到達碰撞點，才會發生碰撞。

使用速度向量線的輔助，碰撞的情勢比較容易確認，請再仔細的看看圖形 4-06 的右圖，在 2315 時你會如何做？來避免碰撞危機。

目標的距離只有 0.5 海浬，很明顯的安全速度或是減速，對我們比較有利，因為本船呢現在已經在一個口袋戰術裡面，前後左右都是船。

4-14 Safe or slow speed in a pocket trap

In the right side of the figure 4- 06 is radar screen at 2315 hours, speed vector is still 6 minutes, ownship COG 135^0 degrees which had altered from 103^0 degrees at 2306 hours, SOG 14.2 knots, the vessels around are still the same with different situation.

⇒ The red tug boat with tow on our port bow had altered course to 000^0 degrees (course again for north bound vessel) now.

⇒ Ownship has no collision point (or risk) with this Tug boat for ownship altered course already.

⇒ Ownship's heading had changed from her bow to stern already and passed her speed vector completely. We head into her stern direction now.

One vessel at ownship starboard quarter course 090^0 degrees has collision point in our heading mark. (figure 4-06 right screen)

⇒ Time to collision point of these two vessels are different about 5 minutes. Ownship will pass her bow at one-minute time then speed vector will not have crossed point any more, no collision risk after one minute.

⇒ Any vessel at ownship bow will have a collision point in our heading mark. No collision risk will exist when she could cross ownship bow earlier or later with sufficient time interval (3 minutes is preferable). Her time to arrive this crossed point is her Bow Crossing Time BCT. (crossing ownship's bow)

⇒ One vessel at ownship starboard side, bearing about due south, course and speed unknow has collision risk because two vessels arrive collision position at the same time (speed vector is red). (figure 4-06 right screen)

⇒ TTC is 6 minutes from now as speed vector setting is 6 minutes. DTC = 1.42 nm = 14.2 knots x 0.1. Now we begin to have some ideas of the collision point.

- Target vessel's course and speed is irrelevant as we have no time to remember it.
- The position of collision point at ownship's speed vector can decide how many collisions time and distance from now on (TTC and DTC).
- Collision point changed as ownship's course changed (that is at our own will/decision).
- Collision point moves along both vessel's speed vector.
- The one take action first changed her collision point, DTC and TTC at his own will.
- No collision point, no collision.
- Which vessel arrived collision point earlier will pass collision point first.
- Two vessels have to arrive collision point about the same time to have a collision.

With the help of speed vector, collision situations are easier to define. Take one more thoughtful look at figure 4-06 right screen. What will you do to avoid collision risk in 2315 LT? Target distance is about 0.5 nm only. It is obvious safe speed or slow speed is preferred now as ownship is trapped in a pocket.

4-15 為什麼 3 分鐘的速度向量設定，是最低的需求以避免碰撞

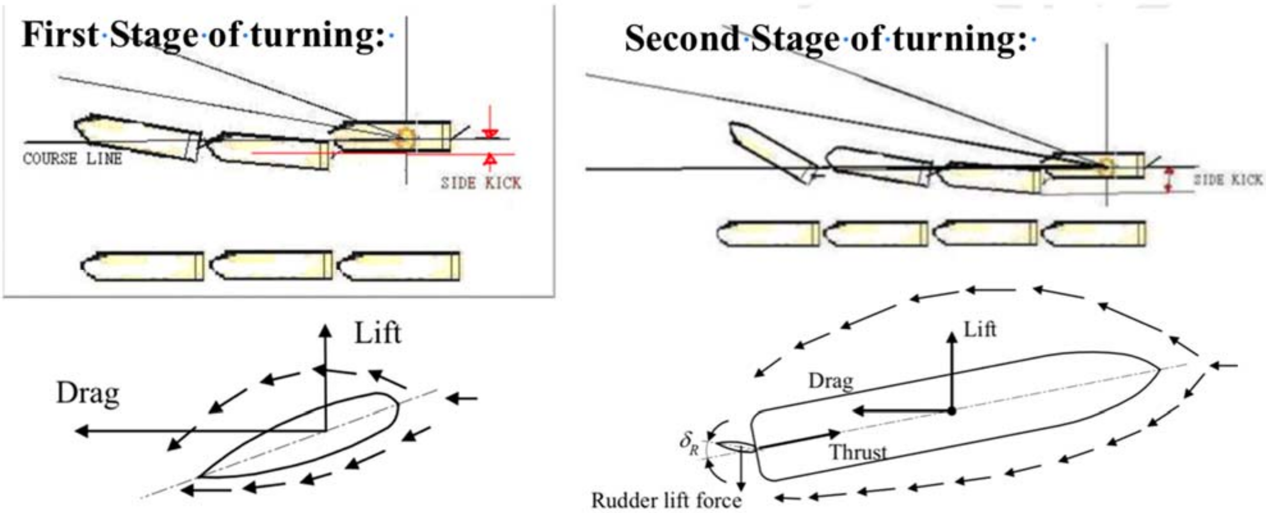
在第二章圖形 2-15 阿帕雷達畫面，3 分鐘的真運動向量線，以及我們的口號，“如果看到很多船的速度向量線與本船的速度向量有交點，請打電話請船長上駕駛台，如果你還沒有準備好”。

我們現在是大副，我們應該有能力靠自己來解決，這些海上的疑難雜症。我們必須將速度向量線減到 3 分鐘，降低本船速度向量線上面交叉點的數量，3 分鐘是本船回轉的最低需求時間。但是回轉有三個階段，我們現在必須仔細研究，船隻 3 個回轉階段的程式以及回轉的機能，我們還沒有完全的討論過，所以這就是我們現在要做的。

圖形 4-07 瞭解船隻回轉的階段

4-15 Why 3 minutes speed vector setting is the minimum requirement to avoid collision

In chapter 2 Figure 2-15: ARPA screen, 3 minutes True motion speed vector together with the motto “If we saw lots vessels speed vector have cross point with ownship's speed vector, call the master if you are not ready.” We are chief now, maybe we should solve the mystery at sea by ourselves. We have to reduce speed vector to 3 minutes to reduce crossing points in ownship speed vector. 3 minutes are minimum requirement to maneuver ownship's turning because vessel turning need 3 minutes and in three stages. We now have to go details of vessel's four stages turning process. The machinic of vessel turning had not discussed fully as we did here.



圖形 4-07 瞭解船隻回轉的階段

4-02 回轉的四階段(英文已經改版)

4-16 回轉的第一階段，舵板工作

轉舵位置：船隻將作舵板放到需要角度的船位。轉舵位置是在海圖上所畫的轉向點之前，1.5 到 2 倍船隻長度距離的位置。在這個階段，只有舵板具有橫向推力，推著本船的船尾，因為舵板與水流的方向，成了一個角度，擋住螺旋槳的排出流跟船體下面的水流，所以在船尾會產生橫向的推力。

⇒ 在圖形 4-07，我們可以看到水流在舵板上有兩種力量，在舵板前面的水流，直接推在舵板上面，在舵板後面的水流，被舵板阻擋了，所以快速流入補充，造成部分的真空，因為舵板後面的水壓，比舵板前面的水壓低很多，兩邊的壓力差，造成舵板向後移動，也就對船隻的船尾產生橫向推力。

⇒ 舵板的面積比較于船邊的側面積，只有 3%到 5%，利用這麼小一片的舵板在船尾水線下，就能使整條船的船體轉動，這真是一個奇跡，但是它卻是真實的發生，而且是實際可用的。

⇒ 舵板的側推力是累積性的，從開始轉舵的位置，越向航行前進，舵板的側壓力呢，就累積得越來越大，它需要一些時間跟距離，來累積足夠的側行動量，在船尾產生作用。

⇒ 當船尾開始向側邊移動，船頭呢並沒有受到影響，舵板不是作用在船頭，船頭呢只會留在原來的航向線上。

⇒ 舵的側推力，將船尾從船隻原來的航線上推開。

⇒ 舵板上的側壓力，工作在船尾需要的距離是 1.5 到 2 倍船長的距離來做工，然後才會有第二種的力量，開始主導船隻的回轉。

⇒ 在第一階段船頭不會離開原始的航線，只有船尾會慢慢離開。

⇒ 在第一階段船隻的船首向，也就是整條船的前後中線會改變 10 到 15 度，與原來的航線相比，因為船尾已經不在原來的航線上，產生了轉向的角度。

⇒ 一旦本船的船頭方向跟原來的航向不一樣，水流往船體兩邊的流量就不一樣，船體兩邊的水壓，就會不平衡。

⇒ 一舷的船邊，面對前面來的水流，會有比較多的水壓力。

⇒ 另外一舷面對船尾，有海水的吸力，因為前面來的水流被船體阻擋，就像舵板一樣。

⇒ 但是水流呢，不是第二階段的主導性力量。

⇒ 第一階段的回轉，經常在人員落水的操演中使用，使用滿舵，目的是要將船尾，從人員落水的一側推開。

4 – 02 Four stages of vessel turning: first in space ship status

4-16 Ship Turning consist of four stages: In first stage only Rudder plate working on our stern

Wheel over position: vessel put rudder plate over to required angle in wheel over position need about 1.5 to 2.0 ship's length over all distance ahead of charted turning point.

⇒ In this stage, only rudder plate has side thrust to ownship stern due to rudder plate turn to an angle blocked expelled current from propeller and water flow along ship's underwater hull.

⇒ In figure 4-07, we can see water flow over rudder plate consist of two forces. In the front side of rudder water pushed rudder plate directly. In backside of rudder water flow is blocked by the plate which cause a suction force due to water pressure lower than surrounding.

⇒ The rudder plate only has 3 to 5 % area compared to ship's side. With such small piece rudder plate astern, we can turn whole ship's body underwater around is a kind of magic. But it did work.

⇒ This side trust on rudder plate is accumulated from wheel over position slowly, moving ownship's stern little by little. It needs some time and distance to accumulate enough sideward momentum on stern.

⇒ While rudder angle worked on sideward ship's bow is unbothered by any side force in its first stage, so ship's bow remains on original course line.

⇒ The side thrust on rudder plate will push ship's stern away from ownship original course line.

⇒ The side thrust on rudder plate worked on ship's stern up to 1.5 to 2.0 times ship's length advance distance before second forces joined to assist ship's turning.

⇒ In first stage ship's bow will not leave original course line only ship's stern will be about one ship's beam width. See figure 4-07

⇒ In first stage ship's heading will alter 10 to 15 degrees to her original course due to the displacement of ownship's stern.

⇒ First stage of turn frequent used in man overboard exercise to push stern away from man overboard side.

4-17 船隻回轉第二階段：動量工作

在第二階段，船體總共有三種力共同作用，

⇒ 船尾舵板被水流的阻力側推，船體的動量在船尾向前推，船頭被水流的阻力往後推，這三種力量在船體上作用，有一個平衡點，就是他的迴旋支點上，這是以後的故事，迴旋支點之前的是船頭，之後的是船尾。

⇒ 舵效減少: 在第二階段回轉的時候，因為水流在船隻的兩側漸漸平衡，舵板的角度，與原來航向的交角變小，與船速的降低。

⇒ 船頭水流的阻力增加，推的船頭往後，往側邊移動，加速船隻的回轉。因為船體沿原來航線的方向前進，與回轉方向的交角越來越大。

⇒ 船體巨大的動量推動船舯跟船尾向前，這是第二階段回轉的主導力量，相較於船頭水流的阻力。

⇒ 在第二階段船隻的船體，看像一塊大的舵板在水中擋水。但是只有在迴旋支點前的船頭在擋水，在迴旋支點後的船尾，卻是往前沖，船體的作用力與船尾的舵板並不一樣。

⇒ 舵板並沒有推動整條船向前的動量，它只有擋水的作用。

⇒ 船隻的動量推動船體向前，往轉向的外側移動，抵抗著水流的阻力，並加速船隻的回轉。

⇒ 船隻的動量向前，是大於向後的水流阻力，所以在第二階段，回轉速率快速增加，比第一階段，只有舵板的工作來的強。

⇒ 當回轉在第二階段，開始加速度的時候，船頭離開了他的原始航線，因為水流阻力把他推開。

⇒ 在第二階段，船體跟船尾還在原來的航線上，因為船隻巨大的長度跟寬度，在這一個階段船尾，還是沒有辦法離開原來的航線。

⇒ 船隻的長度可能達到 400 米長，寬度可能達到 60 米。
⇒ 第二階段需要另外的 1.5 到 2 倍的本船的長度，來完成他的工作。

4-17 Ship Turning in second stage ship momentum working with water resistance

In second stage, three force working together,

⇒ the stern is pushing sideward by rudder, ship's bow is pushing backward by water resistance and ship's momentum pushing ship body and stern ahead.
⇒ Once ownship's heading had changed the waterflow along two side of ship's hull will become unbalanced:
- One side facing ahead have more water flow on it for two reasons: one is water resistance ahead；the other is ship hull has sheer plate on the bow which lies about 20-30 degrees streamline from fore peak (stem plate). Same water resistance worked on aft part of vessel are lost due to stream line of ship's body.
- Other side facing astern have lower pressure from sea water.

⇒ These three forces working on ship hull balanced its side force at vessel's pivot point.
⇒ The rudder effect on turning in second stage is reduced due to water flow is not balanced from ship's both sides.
⇒ Water resistance pushing ship bow back and sideward can accelerate the turning and moving pivot point astern.
⇒ Ship's momentum or inertia pushing ship body and stern ahead has more power in turning compared with water resistance because vessel still moving ahead.
⇒ In second stage ship's hull look like a big rudder in water but its working force is different from rudder plate. Rudder plate is water resistance dominated the side and astern movement. Ship's body is momentum or inertia dominated the forward and side movement.
⇒ Rudder plate did not have the momentum to push the ship astern.
⇒ Ship's momentum push ship body sideward against water resistance to accelerate the turning.
⇒ Ship's momentum ahead is greater than water resistance backward, the turning rate is increasing quickly than turning by rudder plate only in first stage.
⇒ Ship's bow departed from her original course line by water resistance when turning accelerate in second stage.
⇒ Ship's body and stern are still in her original course line in second stage because vessel's massive body length and width (may be 400 meters long by 60 meters width) underwater.
⇒ Second stage may take another 1.5 to 2.0 ownship's length to accomplish.

4-18 船隻回轉的第三階段，水流阻力工作。

在第三階段，這三種力也許取得短暫的平衡，進入定速回轉的階段。

⇒ 水流阻力在船頭增加，因為船首向與原來的航向角度變大，原來的動量還沒改變他的方向，船體側面積變大，增加了水流的阻力，另外一方面也是因為迴旋支點向後移動，造成船頭往後 4 分之 1 船長的面積，都是水流阻力的部分。
⇒ 船隻的動量減少，因為船隻在回轉時，失去了原來的速度，他的速度被水流阻力所降低。
⇒ 舵板上工作的力量，也降低了，因為船隻的轉向，減少了舵板與水流的角度。
⇒ 船隻回轉的合力，在第三階段可能會穩定一陣子，如果我們有一條方向穩定性的船隻，如同貨櫃船一樣，回轉力矩很快就會被抵消，進入定速回轉。方向穩定性的船隻，叫做尖船。
⇒ 有些船隻的流水阻力，永遠也克服不了船隻的原始動量，一些大型散裝船或是超級油輪，回轉速率也許永遠也無法穩定，只會不停的加快，如果我們有一條方向不穩定的船隻。

⇒ 船隻回轉持續，船尾最後終於離開了原來的航向線，而往轉向的一邊移動，這才進入回轉的第三階段。
⇒ 回轉進入第三階段，本船的轉向避碰，才具有實質功效。
⇒ 第三階段的回轉，也許需要額外的 1.5 到 2 倍本船的的距離來完成。
⇒ 一個完整的回轉，也許需要 6 到 7 倍本船的長度來完成，如果我們沒有使用滿舵，來啟動回轉的動作。
⇒ 碰撞危機永遠是在，我們現在的航線上，如果本船的船頭，船身跟船尾，沒有辦法離開原來的航線，就沒辦法解除碰撞危機。
⇒ 此時我們就沒辦法避免碰撞，即使本船全部的船體，都離開了原航線，目標船的船體也可能佔有 300 公尺的空間，在他向本輪接近的過程中。所以在本船船體的兩側，我們需要額外的 300 和 400 公尺的正橫距離（在回轉的第三階段），來遠離所有的碰撞危機。這就是為什麼，3 分鐘的速度向量線設定，是避免碰撞最小的需求。
⇒ 我們能夠檢查圖形 4-08，就可以看出一條大船，可能需要到一海浬的前進距離，才能夠完成回轉，這是對 20 節速度的船隻，3 分鐘的路程就是一海浬。

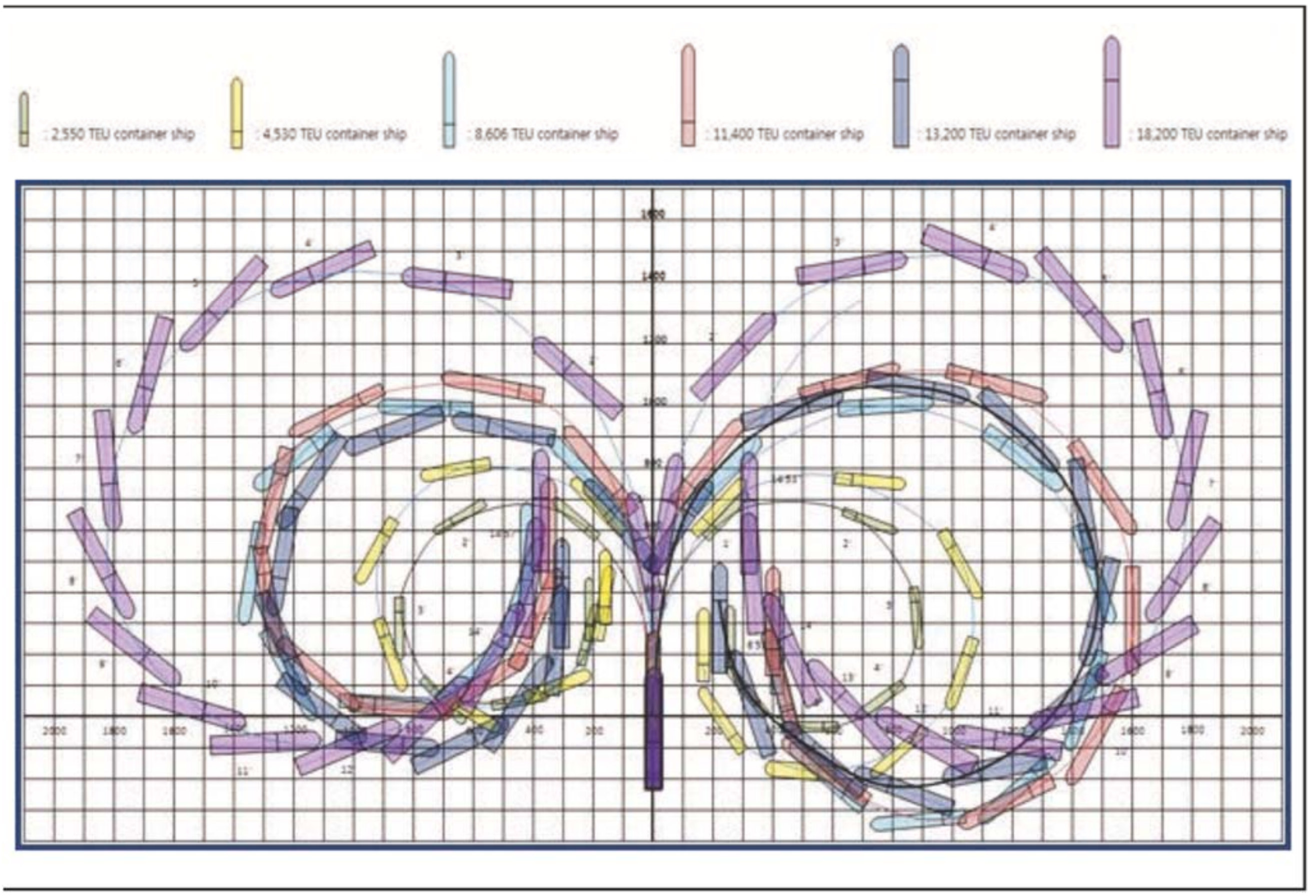
圖形 4-08 大小的貨櫃船使用滿舵回轉

4-18 Ship Turning in third stage water resistance working

In third stage three force may working in harmony for a while or momentum prevail. ,

⇒ Water resistance working on ship's bow increase due heading change increased.
⇒ Ship's momentum reduced due to speed loss and resistance increased.
⇒ Rudder plate working force reduced due to drifting angle reduced water inlet direction to rudder plate.
⇒ Ship's turning rate may steady at third stage for a while if we have a directional stable vessel like container vessel. (vessel will steady on new course)
⇒ Some vessels water resistance force may never equivalent with ship's momentum like some wide beam vessel of very large bulk carrier or VLCC. The turning rate may never steady but increasing quickly if we have a directional unstable vessel. (vessel will not steady on new course)
⇒ Ship's body and stern finally departed from original course line going to sideward.
⇒ Only in third stage, ownship alter course to avoid the collision has its effect.
⇒ Third stage may take another 1.5 to 2.0 ownship's length to accomplish.
⇒ A complete turn may need 6.0 to 7.0 ownship length to accomplish if we are not using hard over rudder to initial the turn.

Remember the collision risk is always in our original course line. If ownship's bow, body and stern cannot leave original course line we cannot avoid the collision. Even ownship's whole body had left original course line target vessel's body may take out 300 meters space in her way to ownship. We need another 300 or 400 meters abeam distance at third stage to clear all collision risk from two sides of ownship's body. That's why 3 minutes speed vector setting is the minimum requirement to avoid collision (which can make 6 times ship's length advance). If we check on figure 4-08 below we can see for a large vessel the turning may need one nautical mile's advance to finish. That's for a 20 knots vessel's 3 minute distance run. (each square is 100 meters in length)



圖形 4-08 大小的貨櫃船使用滿舵回轉

4-19 船隻在第三階段的回轉

想像當值船副發現在正船頭有一個浮標，他想向右舷轉向。如果全船的體積，沒有辦法離開原始的航線，避讓的行動就沒有效果。

⇒ 回轉的第一階段，船隻的船尾離開我們要前往的那一側，舵板的受力，也就是在回轉的第一階段，會離開本船要前往的方向。

⇒ 在第二階段，船體前方的水流產生阻力，船體像是一個巨大的舵板在擋水，全船被推向要回轉的一側，因為水流的阻力，船體沒辦法前進，只能向側邊推出，船體跟船尾是向回轉的外側推出。

⇒ 在第三階段，船頭的阻力跟船尾的動量合成以後，造成船頭的漂流角，就是船體前進的方向跟船艏向的方向不一樣的角度。

⇒ 船隻的回轉，就像是一個高速的汽車在甩尾，前面的輪子吃到地面的阻力（要一腳踩煞車），原來的動量造成後輪失去抓地力（另一腳要踩油門），地面上的漂移使得汽車回轉，海中的船隻，也是同樣的道理，船頭受到水流的阻力，船尾呢受到船體的動量向前，就讓船隻加速回轉，克服船尾側邊水流的阻力。

⇒ 從圖形 4-08，我們看到不同大小的貨櫃船，使用滿舵回轉。船隻的迴旋曲線，或是他的進距，是由它的全長，跟他船隻的形態，吃水，水深等等決定。

⇒ 最近的研究顯示，船隻回轉跟他原始的船速無關。這代表船的回轉曲線，幾乎是相同的，如果我們使用同樣的舵角來開始回轉，與用全速或是慢速開始回轉無關。

⇒ 這表示船隻在回轉時，有他自己一套的規則，不完全是受到前進速度，也就是動量大小的主導。主要還是船隻設計的船型，水線以下的體積，來決定回轉的效率。

⇒ 本船原始的速度，只有使得回轉的速度快一點，或是慢一點。但是他在回轉時的曲線，需要前進的距離，還是維持固定不變，只有轉的比較快，或是比較慢的差別。

4-19 Ship Turning in third stage

Imagine OOW found a buoy dead ahead, he altered course to starboard side. If whole ship's body cannot get away from original course line. His avoidance action is useless.

⇒ In first stage, vessel's stern moving away from the side we want to go due to rudder force. It may not enough to clear this ship's bow away from original course line.
⇒ In second stage, ship's hull act as a big rudder to block water flow. Ship bow is pushed to the side we want to turn by water resistance. Ship's body and stern are pushed away to the side we want to turn. This vessel may hit his stern in this stage.
⇒ In third stage, the resistance ahead and momentum working astern on ship's hull in different direction create drifting angle on the bow. Vessel turning is like a high speed car in drifting (brake on front wheels and momentum get rear wheels lost grip on ground) away the side we want to go but the heading had changed due to this drift.

In figure 4-08, we see different size container vessel turning with hard over rudder. Ship's turning circle or her advance are decided by her length over all and ship's body form, draft, water depth……. Recent studies show vessel turning is irrelevant to her original speed. It means turning circle is almost the same if we used same rudder angle whether we started the turn with full or slow speed. The reason maybe is the hydrodynamic water-body interaction defined turning circle not the force acted upon it. Ownship's original speed only make the turning speed quicker or slower. But. Vessel is turning by her ship's hull drifting inside the water by these multiple forces interaction effect.

4-20 國際海事組織對滿舵回轉的準則

⇒ 本船的長度跟形態，決定了迴旋圈的大小，如同圖形 4-08，而不是船隻的大小。
⇒ 其實就算是同樣長度的船隻，不同的船體，就會有不同的迴旋曲線。
⇒ 不是每一次轉向都是使用滿舵，有時候舵角，只有用到 10 度，15 度或是 20 度，就像圖形 4-09 舵角使用的越多，迴旋曲線就越小。

對於滿舵回轉的回轉能力，

⇒ IMO 的標準是迴旋圈的戰術直徑必須少於 5 倍的船隻全長，
⇒ 迴旋圈的前進距離，在回轉 90 度後，應該少於 4.5 倍船隻的全長。
⇒ 這些準則是在海上試車，回轉時候的規定。
⇒ 在我們每一天的航行班中，我們需要 6 到 7 倍船隻長度的進距，來完成 90 度的回轉。
⇒ 進距取決於多少舵角，我們所使用的。
⇒ 90 度的轉向是用來避免橫越船隻的碰撞，90 度的轉向是戰術直徑的一半。
⇒ 實際的海上，船長最關心的是，與原來航線的正橫距離。
⇒ 在圖形 4-09 的右圖，這項關切是用一個紅色船隻來表示，我們需要創造來船全長的正橫距離，來清爽所有的碰撞位置。
⇒ 紅船是用來提醒資深船副，在做船舶避碰所需要的正橫距離。
⇒ 在避碰中，船長回轉船隻是要創造足夠的正橫海域，如果橫越船不肯改變航向。

4-20 Ship Turning IMO Criteria and Standard in "Hard Over" rudder.

⇒ Ownship's length and type (beam width, draft, trim) define the turning circle as figure 4-08, not the TEUs of vessel.
⇒ Even with same length over all ships different ship type (beam width, draft, trim) will have different turning circle.

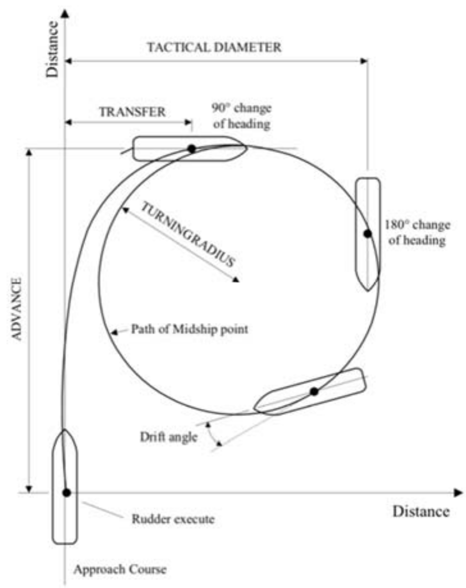
We are not to use full rudder for every turn sometimes rudder angle used are only 10, 15, 20, … as figure 4-09. More rudder angle used the turning circle will be smaller and quickly.

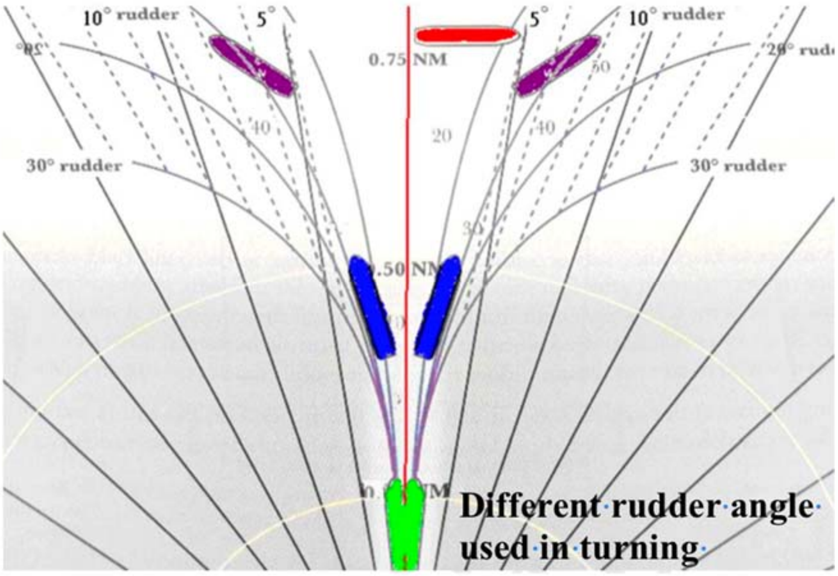
Turning Ability with hard over rudder of IMO Criteria and Standard are as follow:

⇒ TD < 5L = Turning Circle's Tactical Diameter TD should be within 5 times ship Length Over All.

⇒ Ad < 4.5L = Turning Circle's Advance Ad should be within 4.5 times ship Length Over All

These criteria are for "Hard Over" rudder in sea trial. In our daily watch on board, we don't use full rudder to turn as always. **These three stages turning may need 4-6 ship's length advance to finish 90 degrees turning depend on the rudder angle we used.** In real sea, what Captain care most is the transverse distance from original course line. Using 90 degrees turn to avoid collision, 90 degrees position only create half abeam distance of his Tactical Diameter (TD < 5 L). In figure 4-09 right figure, this concern is demonstrated with a red vessel. **We need one ship's length transverse distance to clear from collision position as red ship indicated.** This is the concept needed for Senior OOW collision avoidance. In collision avoidance, Captain turning vessel is to create transverse space for crossing vessel (due to limited space in collision avoidance in restricted waterway or fairway) not to change course widely in open sea as Junioe OOW.





圖形 4-09 舵角使用的越多，迴旋曲線就越小

4-21 資深船副避碰觀念的建立：太空船狀態

⇒ 如果船隻回轉需要 6 倍船長的進距，才能完成。對一個 300 米的船隻來說，就是 1800 公尺的前進距離，這就是幾乎一海浬的進距，才能避免碰撞。

⇒ 我們使用 3 分鐘的速度向量線，當做我們所需要前進的距離。當必須做回轉的時候，3 分鐘的速度向量線在螢幕上的長度，就代表我們轉向的進距所需。

⇒ 我們標注 3 分鐘的速度向量就像一條太空船，來擴大我們碰撞危機的區域。

從單一的碰撞點，在速度向量線上，到碰撞線來探測碰撞危機，再進一步擴大到碰撞面，也就是回轉時，船體會掃過的左右面積，來避免真正的碰撞。避碰規則第五條的(f)(i)

船隻應該採取早期的措施，允許足夠的海域，讓其他船隻安全通過。

⇒ 在前一章，這是一個在操船技術上，適任性轉變的過程，每一條船都有他的太空船狀態，只是我們能不能夠知覺到？我們用這種圖像來視覺化，我們所需要的安全因素。

⇒ 我們應該要像圖形 2-15 一樣，把螢幕上 3 分鐘的真運動速度向量線，當做太空船使用。在我們採取的避碰的措施裡，3 分鐘的速度向量線的太空船，保留了先前的碰撞位置，碰撞時間，碰撞距離等等，與操作所需空間的概念，與更充分的水域，讓其他船隻能夠安全通過。

4-21 Concept set up for Senior OOW collision avoidance: space ship status

If the turning needs 6 ship's length to accomplish, for a 300 meters long vessel, the advance will be 300 m x 6 = 1800 meters. Avoidance action almost need one nm advance to avoid collision.   We use 3 minutes run distance of ownship speed to represent the advance distance we need in avoidance turning. 3 minutes speed vector length on Radar screen represent the distance of advance needed for finish a turn to collision avoidance.

We labeled 3 minutes speed vector as a space ship to enlarge collision risk from single collision point in speed vectors into collision line while turning and finally Possible Collision Area for COLREG rule 5 (f)(i)… *vessel should take early action to allow sufficient sea room for the safe passage of the other vessel.* in previous chapters. It is an evolving competence in our ship handling. Every ship has it space ship status with her. We make this imaginary image to visualize the safety factor we should have as in Figure 2-15: ARPA screen, 3 minutes True motion speed vector. This space ship (represented by 3 minutes speed vector) retains precious property of collision distance, time, position, space for maneuvering and *sufficient sea room from other vessel* we need in collision avoidance.

4-21 快穩住船身的回轉

要開始船隻的回轉，需要一到半分鐘的時間跟耐性，去等待他開始慢慢轉頭。要穩定一個船隻的回轉，穩定在新航向上，要把他回轉的力量，反向操作來達到再一次平衡的狀態，也要有時間跟耐性。有可能開始回轉以後，這些回轉的力量，變得太強大，本船完全沒有辦法或是立刻停止它的回轉。

在這種時候，我們對回轉就失去了控制，為什麼我們需要停止船隻的回轉？我們在啟動回轉的時候，還有耐性，停止回轉的時候就失去耐性，就是當值船副看到新的情勢發生，像是目標船已經改變了航向，與我們的避碰行動不合，或是本船的位置，已經太接近航行的險阻，或是原來沒有注意到的目標，忽然成為危險（在本船的速度向量掃過，或是在回轉的時候）。

在避碰的概念裡，如果本船的速度向量線掃過其他船隻的速度向量線，碰撞危機就可能會發生。在回轉的時候，速度向量線經常都設定的，有一定的時間間隔，在雷達螢幕上，看到兩條船的速度向量線相交，就是在這設定的時間間隔內，有發生碰撞的可能性。

如果本船必須向右舷回轉，本船跟所有右舷的船隻，都可能發生碰撞危機，如果他們是在本船右舷 3 分鐘的航行距離內。也就是說，船向右轉的時候，右邊的所有船隻在 3 分鐘航行的距離內，都有危險，這是碰撞面的概念。

對一 20 節的船隻，這是一海浬半徑的海面。在我們右邊 1 海浬的所有船隻，都變成可能的碰撞船隻。本船的速度向量線是一個麻煩製造者，如果我們不能控制他的行動，實際上課的時候，我都說這是只金箍棒（碰撞線），橫掃千軍找麻煩。相反的，如果船副會用的時候，可長可短，威力無窮。

4-21 Steady ownship whenever you can

To start a turn needs one minute patience to wait for her swing, to steady a vessel to her new course need to reverse those turning forces to reach another balanced status again. The turning force worked on ship's hull is accumulated from her resultant momentum. In some moment, these turning force become too strong that ownship has no way to stop it immediately or at all. In this moment, we lost control of turning (ownship). Why we think we can stop the turn immediately while we have patience in starting the turn? That's when OOW see new situation arise, like target vessel had changed course to against us or ownship's position already too close to a navigational hazard or a new target unnoticed before,… Ownship's speed vector swept while turning. In collision avoidance concept, New collision risk will arise if ownship speed vector crossed another vessel's speed vector in turning. If ownship turning to starboard side we will have collision risk with all starboard side vessel if there are close enough to ownship's 3 minutes speed vector. The speed vector of ownship is a trouble maker if we cannot control its sweeping. The example is in next chapter 5. Another reason to steady ownship's course as fast as possible is for easy reference in visual lookout which need steady course to check relative bearing change. In collision avoidance steady ownship is a constant requirement in anytime. **Senior OOW should beware of rate of turn ROT of ownship and understand how many degrees per minute is ownship's limitation in ROT.** Once turning rate beyond that limit (degrees per minute) ownship may lost control easily and lost the ability to avoid grounding or collision with target close by.

4-22 在船上的迴旋支點，並不是在固定位置

這些不同回轉的力量，在船上的前後中線上的一點，達到平衡，它也不向左，也不向右移動，只是沿著船隻的拋物線移動，我們叫 Pivot Point PP 迴旋支點，它位於船隻的前後中線上，不向船隻回轉的外側，也不內側移動。

⇒ 迴旋支點的位置，在船上並不是固定的，作用在船身的阻力跟動量，也是隨時在變，基本上，在迴旋支點之前的力量，海水的阻力將船頭往後推，在迴旋支點之後的力量是本船的動量，也就是慣性由船隻原航向帶動的，再加上螺旋槳向前面推的力量（永遠推著船體向前作用，我們都把它加在船隻原始的動量，一起討論）。

在高速的時候，迴旋支點位於船頭往後面量出來的四分之一或是三分之一船隻的全長的位置 。當船隻剛剛在水中啟動時的位置時，迴旋支點位於船頭往後 8 分之 1 船隻全長的位置。

圖形 4-10 船隻需要不同的進距，才能夠穩定在新的航向上

這圖表明，要穩定在一個迴轉的方向，在不同的時候，也許需要不同的進距，不同的迴旋曲線，不同的舵角，在不同的潮汐狀態中，如果船員不知變通，船隻就是直接擱淺。

操船的人或是領港，也許需要很多的解釋，才能證明他的船隻操縱，是正當的。

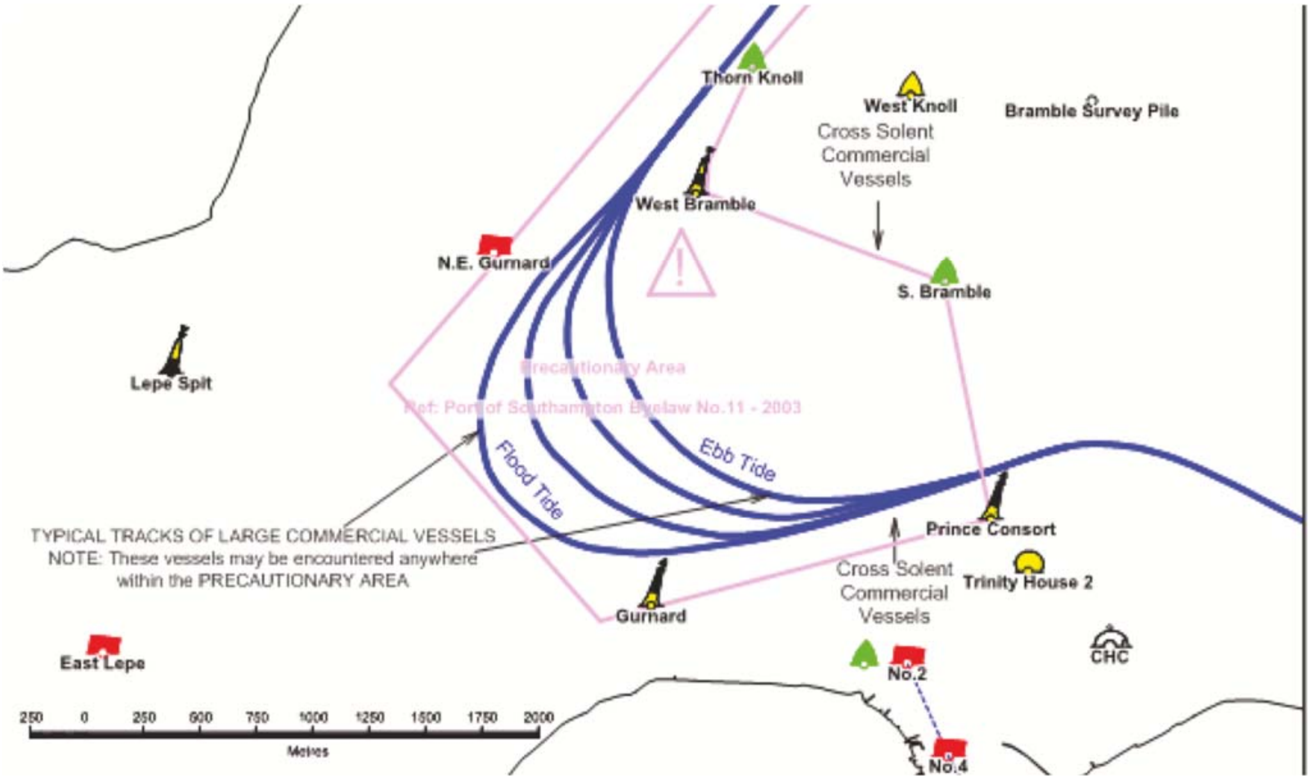
這個圖形解釋了，為什麼在船上迴旋支點不是一個固定的點，在有潮汐的水道，潮水會幫助或是減慢船隻的迴轉速率，這個在我們每天當值的大海中，並沒有辦法明顯的感覺到。當船隻在狹窄水道操縱困難的時候，尤其是有強大的水流影響的代價，就是擱淺，讓本船在轉彎處擱淺。就在 2020 年，今年 5 月 10 號在新加坡海峽的南岸聖約翰島，造成的雙重的擱淺，可以說是一個墨菲定律：「任何事情可能會錯，結果就是發生錯誤」

立刻穩住本船是一個全時性的需求，也就是你操船的船藝，一艘船操縱穩不穩，值班的船副應該注意船隻的迴轉速率是多少？也就是 Rate Of Turn, ROT 並且瞭解多少度的迴轉速率，是本船的極限？一旦回轉速率超過這個極限，也就是每分鐘轉向超過多少度？本船可能很容易失去控制，失去避免擱淺與碰撞的能力，尤其是近距離有其他目標。

4-22 Why Pivot Point PP is not a fixed point on board

Those turning forces reach balance in one point where every turning force is zero called Pivot Point PP. Pivot Point is a point on a vessel's fore and aft central line which remains fixed as bow and stern swing around it. The position of Pivot Point on board is not fixed because those turning forces are not fixed. The force working before the PP is sea water resistance pushing backward. Working force after PP is momentum of ship from initial speed and propeller pushed ahead by her continue expel current. PP located at about 1/4 or 1/3 ship's length from ship's bow when in high speed. PP located at 1/8 ship's length from ship's bow when vessel just started moving in the water while water resistance had not created yet. Figure 4-10 vessel need different advance distances before she can steady on new course. This figure illustrated that steady a vessel turning may need different distance ahead, different turning circle, different rudder angle applied in different tidal condition otherwise the vessel just goes aground. Ship handler or Mr. Pilot may need many explanations to justify his maneuvering to OOW. This figure explained why vessel turning is not in a fixed track. In a tidal current waterway, current will help or slow the turning rate. This is not aware of in our daily watch in open sea. **When turning is difficult in narrow channel or fairway with tidal current influence, the cost is grounding ownship at the turn.**

The flood current is coming from SW to NE. If we refer to longest route used in flood tide we can see vessel cannot turn directly from 295 degrees inbound to 040 degrees because the rudder effect against current is not enough to create necessary turning rate to starboard side in time (or never larger than current pushing power). Big vessel in this route have to turn upstream to 255 degrees first (toward the incoming tide) because it is easy when 3/4 ship's length aft help pushing by current. This is a general rule and golden rule to remember always **turning to upwind or upstream is easier than turning away from it.** Turning to upstream first can easily accomplished around Buoy Prince Consort into 255 degrees. If the flood tide is stronger big vessel will have to make sure her heading had reached 255 degrees already without any other sideward momentum working on ship's body. That's why big vessel has to steady on 255 degrees longer than ebb tide. Then vessel can start the turning downstream from 255 degrees to her final heading 040 degrees. This is a 145 degrees turn from 277 to 040 degrees which almost like a tactical diameter's turn is sea trial. It is easier than original turn from 295 to 040 degrees turn because the starting direction is different. 255 degrees is heading to current and 295 degrees is 40 degrees against flood current. Vessel has 40 degrees against strong flood current may have trouble to maintain her course already which make her turning to downstream even more difficult than usual.



圖形 4-10 船隻需要不同的進距，才能夠穩定在新的航向上

4-23 使用其他船隻三分鐘速度向量，來類比他的太空船狀態

⇒ 我們使用 3 分鐘速度向量當作太空船，來代表它可能的碰撞區域，因為考慮船隻在回轉時，需要的進距與本身長度。

⇒ 本船的 3 分鐘速度向量，不應該橫越其他船隻的速度向量，每一條船都有他自己太空船的大小，我們無法知道，其他船隻在回轉時的限制是多少？其他船需要的回轉長度是多少？**只能使用其他船隻的 3 分鐘速度向量，來類比他的太空船狀態**。

⇒ 如果我們可以操縱本船 3 分鐘的碰撞線，不要接觸到其他船隻的 3 分鐘速度向量，碰撞就能夠避免。

⇒ 在資淺船副的階段，當值船副需要採取及早，實質明確的行動來避免目標船，以保留足夠水域，這是為了安全起見。

⇒ 在大副的階段，目標船的數量太多，如果我們採取早期行動來避免碰撞，我們的速度向量會掃過太多其他接近本船船頭和附近的目標船，造成更多新的碰撞危機。

⇒ 我們想像本船必須採取避碰行動，在圖形 4-06 的左邊雷達畫面，在 2306 時船首向是 103 度，9 分鐘後在圖形 406 的右邊雷達螢幕 2315 時，本船已經轉向到 135 度的真方位，這個航向的改變，產生了多少的碰撞危機，跟右舷的 5 到 7 條船。
⇒ 在近距離或是船隻眾多的時候，使用 3 分鐘的速度向量來作為避碰的決策依據，比較容易。就像圖形 2-15 想像的大型船隻，這些細節，會留給船長在以後的章節來學習。

4-23 Use other vessel's 3 minutes speed vector to simulate her space ship status.

We used 3 minutes speed vector as a space ship to represent the possible collision area due to vessel's advance distance in turning and allowance to clear ownship's length (sometimes 300 meters long). **Ownship's 3 minutes speed vector should not cross another vessel's speed vector.** This is basic requirement. Every ship has its own space ship size. We cannot know other vessel's limitations in turning or her length exactly. We just **use other vessel's 3 minutes speed vector to simulate her space ship status.** If we can maneuver ownship's 3 minutes collision stick carefully not to touch any vessel's 3 minutes speed vector the collision can be avoided clearly. In Junior OOW stage, OOW is required to take early and substantial action to avoid **target vessel** with wide sea room preserved for safety. In Chief Officer stage, the vessels number just too much. If we take early, substantial action to avoid collision our speed vector will sweep over too many targets close by and create too many new collision risks. If we image ownship have to take avoidance action with figure 4-06 left radar screen 2306 hours (heading is 103 degrees(T)). 9 minutes later in figure 4-06 right radar screen 2315 hours, ownship had altered course to 135 degrees (T). Course change from 103 to 135 degrees create many collision risk with starboard side vessels. Use 3 minutes speed vectors to make decision for collision avoidance is much easier in short distance or heavy traffic situation as figure 2-15: imaginary big vessel. These details will leave to Master to study in chapter to come.

4-24 多少的航向改變，才足以避碰？

就像避碰規則 8（c）：*如果有足夠的水域，單獨改變航向是最有效的行動，來避免近接的情勢，只要轉向是在足夠的時間，角度夠大，不會引起另外一個近接的情形。*

⇒ 我們可以使用船隻 3 分鐘的速度向量，來達到這個目的。
⇒ 單獨改變航向時，也許是最有效的行動：如果本船有 3 分鐘的時間去改變航向，我們的速度向量可以改變方向，來避免直接的碰撞。

轉向多少度？才足以避免碰撞。

⇒ 任何目標在四海浬的距離遠，5 度的轉向，能夠產生 645 公尺(1852 m x 4 nm SIN(5)= 645 m)。
⇒ 任何目標在兩海浬的距離，10 度的航向改變，會產生 643 公尺(1852 m x 2 nm SIN(10)= 643 m。
⇒ 任何目標在一海浬的距離遠，20 度的航向改變，可以 633 米的正橫距離(1852 m x 1 nm SIN(20)= 633 m)。
⇒ 5 度的航向改變，在四海浬的距離是簡單的，如果我們需要同樣的正橫距離 643 公尺，在目標 2 海浬的時候，我們需要轉向 10 度。
⇒ 643 米是大約船隻兩倍的長度，作為避碰的目的，或是當作充足的水域。
⇒ 對一條 300 公尺長的船，643 米是大約 0.35 海浬的距離，本船是 0.35 海浬遠離可能的碰撞區域 PCP（使用四海浬距離之前，改變 5 度的航向）。

在圖形 4-06 的右邊雷達畫面，本船是 14.2 節，3 分鐘速度向量的距離是 14.2 乘 1852 成上 0.05 等於 1315 公尺。對於 300 米長的船隻來說，1315 公尺大約是 4.5 倍的船長。4.5 倍船隻的長度的進距，對一個滿舵的回轉是足夠的，如果使用更小的舵角來回轉，進距就不夠。

⇒ 一般當值船副只轉向 5 度時，是沒有信心避讓的，當他是一個資淺船副時，這與避碰規則的要求不同。如果每個人都遵守船長的值更命令，保持來往船隻最少 1 海浬的 CPA，在四海浬的距離，船副需要轉向 15 度， 1917 公尺約等於一海浬。

⇒ 同樣的 CPA 的要求，一海浬。當值船副就必須在兩海浬遠的時候，轉向 30 度，這是當值船副仍然做得到的事情（因為進距夠）。

⇒ 現在我們知道轉向避碰，目標在 4 海浬遠，對一個資淺船副需要一海浬的 CPA，他必須轉向 15 度。

⇒ 對一個大副避免碰撞，在四海浬，只需要轉向 5 度來避免目標，然後他就可以具有 645 公尺的 0.35 海浬的足夠水域。

圖形 4-10 船隻需要不同的進距，當流水改變時

4-24 How many course changes is enough for collision avoidance?

As COLREG rule 8 "(c). *If there is sufficient sea-room, alteration of course alone may be the most effective action to avoid a close-quarters situation provided that it is made in good time, is substantial and does not result in another close-quarters situation.*"

⇒ *sufficient sea-room:* we use vessel's three minutes speed vectors for this purpose.

⇒ *alteration of course alone may be the most effective action:* If ownship have three minutes time to change course our speed vector can change direction to avoid collision directly. If TTC time to collision is not enough for 3 minutes turning we need other avoidance actions rather than just alter course only.

⇒ How many course changes is enough for collision avoidance?

- Any target at 4 nm distance away 5 degrees course change will create (1852 m x 4 nm SIN(5)= 645 m) abeam distance.
- Any target at 2 nm distance away 10 degrees course change will create (1852 m x 2 nm SIN(10)= 643 m) abeam distance.
- Any target at 1 nm distance away 20 degrees course change will create (1852 m x 1 nm SIN(20)= 633 m) abeam distance.

⇒ 5 degrees course change is easy at 4 nm distance away. If we need same transverse displacement 645 meters ownship have to alter course to 10 degrees if target is 2 nm away.

⇒ 645 meters is about 2 times ship's length for 300 meters long vessel, enough for collision avoidance purpose or *sufficient sea-room*.

⇒ 645 meters is about 3.5 cables distance, ownship is 3.5 cables away from possible collision position PCP by changing course 5 degrees at 4 nm distance ahead.

⇒ In figure 4-06 right radar screen ownship is 14.2 knots, 3 minutes speed vector distance is 14.2 x 1852 x 0.05 = 1315 meters.

⇒ 1315 meters is about 4.5 ship's length for 300 meters long vessel.

⇒ 4.5 ship's length advance is good for a "Hard Over" rudder turn, not enough for smaller rudder angle turning.

Usually, OOW had no confidence to alter course 5 degrees only when he is a junior OOW. If everyone followed Captain standing order: keep minimum CPA 1 nm. Junior OOW will have to alter course 15 degrees at 4 nm = 1917 meters (one nautical mile). For same CPA requirement: minimum CPA one nm, OOW will need alter course 30 degrees at 2 nm which is still manageable by Junior OOW. Now we know

⇒ Alter course 4 nm away from target, for a junior who need 1 nm CPA have to alter course 15 degrees.

⇒ For a Chief Mate to avoid the collision at 4 nm he needs alter course no less than 5 degrees to avoid target and he will have *sufficient sea-room* more than 645 meters (3.5 cables).

4-25 6 分鐘的速度向量設定是評估碰撞危機的基本要求

在這個例子中，3 分鐘的時間，大約是 4.5 倍船隻的長度， 3 分鐘的速度向量是我們的生命線。我們不能允許它被其他船隻所橫越，如果兩條船的 3 分鐘速度向量產生交點，他就會製造另外一個近接的情勢，我們不能等待目標接近到我們 3 分鐘的速度向量，去造成無法解決的近接情勢，我們需要早期的碰撞警報，或是早期近接狀況的警報。我們需要比 3 分鐘更多的瞭望，因為碰撞不是只有一條船，那麼簡單。**6 分鐘速度向量線設定，是評估碰撞危機的基本要求**，目標數目不多，我們就會自動的鬆懈，使用正常的速度向量設定，在搜尋的模式，就像是熟練的航海家，可以發現早期的碰撞警報。

4-25 6 minutes speed vector setting is minimum requirement to access collision risk.

Three minutes time is reserved for 4.5 ship's length advance as this example. Three minutes speed vector is our safety margin. We should not allow it to be crossed by other vessel's speed vectors. **If two vessels' 3-minute speed vector is crossed it will create another close-quarters situation.** We cannot wait target close enough to our 3 minutes speed vectors to create an **unsolvable close-quarters situation.** We need earlier warning of collision risk (or **close-quarters situation) at least three minutes more** to take care as the collision situation is not as simple as one target only. **6 minutes speed vector setting is minimum requirement to access collision risk.** When targets are few, our watch will relax automatically. We need use longer speed vector settings in searching mode as a prudent navigator to find earlier collision warning and our vigilance.

4-03 資深船副階段的避碰行動考量

4-26 追越，如何有耐心的採取行動？

我們現在熟悉碰撞點，跟它在海上的位移。我們也知道改變航向的有效性，跟目標的距離有關，避碰時採取行動的時間點，是一個重要因素，避碰規則裡面規定的時間點，又是如何？

- ⇒ 在規則 13 追越，追越船隻應該避讓被追越的船隻，不要擋到他的去路。
- ⇒ 追越的船隻，應該要在任何時候，都不能擋到別人的航路。
- ⇒ 在一般的實務，追越船當值船副會等到最後的 2 和 1 海浬，才會採取大角度的動作，來避開被追越的船隻。
- ⇒ 追越船隻這樣做的理由，是避免本船，因為被追越船隻的動作，而改變自己的航線。如果被追越船一再轉向，或是在對抗流水，風力，或對第三條船隻讓路。
- ⇒ 在本船追越的過程中，被追越船可能會離開本船的航線，碰撞危機消失，因為他也許不再擋在我們的航線之前。
- ⇒ 無論如何，本船劇烈的航向改變，來讓路給被追越船 ，在大海中是合適的，當船隻不多時，而且本船的航向改變，不會引起其他的碰撞危機。
- ⇒ 在狹窄水道，或是分道航行制，如果本船必須追越，或是經常追越，因為本船的船速比較高。正確的做法，是小心規劃航行計畫，把本船的航線遠離其他船隻的航線，就是遠離近岸船隻的區域，或遠離深水航道。
- ⇒ 這樣做的理由，只是單純的避免本船的航向線，橫越其他船隻的航線。
- ⇒ 橫越的航線：就像兩條船的速度向量橫越，就會產生一個碰撞點。
- ⇒ 如果在狹窄水道，或是分道航行制，追越其他船隻，需要很多的經驗來執行，在追越的時候，跟被追越的船隻，要保持安全的正橫距離。
- ⇒ 改變本船的航向，是往側邊移動本船的船位，來創造被追越船的正橫距離。

多少度的航向改變，才足夠追越它船，與上一節的橫越是同樣的情形。

1. 目標在四海浬距離遠，5 度的航向改變，可以產生 645 米的正橫距離（1852 m x 4 nm SIN(5)= 645 m ）
2. 任何目標在兩海裡的距離，改變航向 10 度，可以有 640 米的正橫距離 1852 m x 2 nm SIN(10)= 643 m

3. 任何目標在一海浬的航向改變，就會創造 633 米的正橫距離 1852 m x 1 nm SIN(20)= 633 m。

作為一個資深船副，我們必須考慮 20 度的航向改變，在目標船最後一海浬後面，在狹窄水道或是分道航行制內，那是否是一個恰當的行為？

我們同樣必須考慮到，不得已的航向改變，在狹窄水道會有不同的底質，水深，岸線不同等等，都可能影響到本船的操作性能， 這些我們要交給船長去煩惱。

4 – 03 Avoidance actions consideration in Senior OOW

4-26 Overtaking, how to take actions patiently?

We now familiar with collision point and its movement at sea. we also know the effectiveness of course altering related with target distance. **The timing to take actions is an important factor in collision avoidance.** What's the ample timing defined by COLREG is as follow:

⇒ In Rule 13 overtaking, *overtaking vessel shall keep out of the way of the vessel being overtaken.*

- *Overtaking vessel shall keep out of the way* **all the time and any time.**
- In normal practice, OOW will **wait till last 2 or 1 nm behind the overtaken vessel then take substantial action** of big course alteration to keep out of *vessel being overtaken.*
- The reason to doing so is to avoid ownship's course line been changed by overtaken vessel if later had changed course frequently or drastically against current, wind or give way to third vessels. Two vessels may have different drifting direction and speed during the overtaking period. Waiting longer can avoid wasting ownship's efforts while she is setting to ownship after we take avoidance actions.
- There have chances that overtaken vessel will leave ownship's course line and collision risk dismissed during ownship's overtaking process.
- However, ownship drastic course altering to give way to overtaken vessel is feasible at open sea only while traffic is low and ownship's course change won't cause another risk of collision.
- In narrow channel or TSS if ownship has to conduct overtaking frequently due to our sea speed is higher than other vessels. The correct way is careful voyage plan to laid down ownship's course as far away from other vessel's course line as possible (away from inshore traffic zone or away from deep water route).
- The reason to do so is simply avoid ownship's course lines crossed with other vessels.
- Course line crossed is like two ship's speed vectors crossed which may create a collision point.
- If in narrow channel or TSS ownship has to overtake another vessel will need a lot of experiences to do so. The key point in overtaking is keep safe beam distance with overtaken vessel always.
- We should change course to move ownship's position sideward to create more abeam distance with overtaken vessel.
- **How many course changes is enough for overtaking is same as crossing in last paragraph?**
  - Any target at 4 nm distance ahead 5 degrees course change will create 1852 m x 4 nm SIN(5)= 645 m abeam distance.
  - Any target at 2 nm distance ahead 10 degrees course change will create 1852 m x 2 nm SIN(10)= 643 m abeam distance.
  - Any target at 1 nm distance ahead 20 degrees course change will create 1852 m x 1 nm SIN(20)= 633 m abeam distance (3.4 cables).
- Been a senior OOW we have to consider "20 degrees course change in last nautical mile behind overtaken vessel in narrow channel or TSS" is appropriate of not?
- Ownship also have to consider 20 degrees course change in narrow channel may have many new factors to consider including bottom nature, water depth, bank suction or cushion…. etc. which might affect ownship steerage and safety.

- Safety precaution of ownship should avoid unfavorable rush into shoal water or sail into opposite traffic lane.
    - Well let's leave to Master to worry about.

4-27 迎艏正遇 如何快速的回應

在規則 14，迎艏正遇的情況，當兩條動力船隻在相對的，或接近相對的航向航行，而有碰撞危機，這兩條船應該向右轉向，互相在對方的左舷通過。

- 本船跟目標船應該向右轉向，使他船從本船的左舷通過。
- 迎艏正遇應該採取行動的距離是 4 到 6 海浬遠，離碰撞時間最短。
- 碰撞距離只有 2 – 4 海浬，如果目標船的距離是在 4 到 6 海浬遠，我們可以反應的時間更短，目標雖然看起來遠，但是可以反應的時間並不多。
- 如果兩條 20 節的快速船隻，在 4 – 6 海浬遠迎艏正遇，離碰撞的時間只有 6 到 9 分鐘。
- 我們的避碰行動，照規則要求，只有 6 到 9 分鐘，來運轉本船的船體，以得到一些正橫距離。
- 就我們前面研究所得資料。本船回轉的第三個階段，才會有正橫距離出現，這樣就浪費了兩分鐘的碰撞時間。

圖形 4-11 正橫距離，在改變航向之後

4-27 Head-on, how to take actions quickly?

⇒ In Rule 14 head-on situation, *When two power-driven vessels are meeting on reciprocal or nearly reciprocal courses so as to involve risk of collision each shall alter her course to starboard so that each shall pass on the port side of the other.*

- Ownship and target vessels shall alter her course to starboard. So, other vessel shall pass ownship's port side: pass port to port.
- Relative speed in head-on situation is highest than other meeting situation.
- Ownship shall take action distance 4-6 miles away from another vessel because TTC time to collision is short.
- The distance to Collision is only 2 – 3 nm if target distance is between 4 – 6 nm.
- By two 20 knots speed vessels the time to collision is only 6 to 9 minutes from 4 – 6 nm distance away.
- Our avoidance action (alter course by the rule) only have 6 to 9 minutes in 4 – 6 nm distance away to walk ownship's body to get some abeam distance (cross track distance).

圖形 4-11 正橫距離，在改變航向之後

4-28 橫越，如何採取清爽的行動

在 2020 年的 5 月 20 號的碰撞案件中，“*根據所提供的資料。中國籍船隻應該讓路給在他的右舷的船隻，但是出了些差錯，CASTA DIVA 的船頭撞到明良輪的右邊，造成嚴重的船體損傷，船殼破裂。CASTA DIVA 是大約 6 倍明良輪的大小，對於這麼大的船隻，經常是不可能在交通繁忙的區域裡，安全地運轉。他可能避的了與明良輪的碰撞，但是避不了其他船隻。這經常是人為的不可能，去做任何事情來避免意外。在繁忙的交通航道，東西向進出上海港的船隻，在這個區域卻被南北向的航路橫越。有些船要進出渤海跟黃海。這惡名昭彰的大量船隻狀況，經常招致意外跟災難的發生。*“

好啦！這就是我們用來訓練資深船副知識基礎的區域。橫越來自四面八方，是最複雜的情況。橫越可以避免跟明良輪撞到，卻會碰撞其他船隻。我們對海上的交通狀況，要有全面性的瞭解，而不是一條接一條的避讓，就像桑吉輪的三副所做的事。

4-28 Crossing, how to take actions clearly?

One report of collision case in May 20, 2020. *According to information provided, Chinese ship should have given way to the tanker on its starboard side, but something went wrong. The bow of the Casta Diva struck the right side of the Ming Lian, causing serious damage to the hull, including hull breaches. CASTA DIVA is about 6 times bigger than MING LIAN, for vessels of such size it’s often impossible to safely maneuver in heavily trafficked areas. She* *could avoid collision with MING LIAN and collide with some other ship. It’s often humanly impossible to do anything, to avoid accident. Heavily trafficked lanes to and from Shanghai in this area are crossed by North-South lanes, to and from Bohai sea and northern Yellow sea. Notorious mess of ships traffic off Shanghai is ripe for accidents and disasters.*

Well, this is the area we used for Senior OOW knowledge base. Crossing, *could avoid collision with MING LIAN and collide with some other ship,* need to have full picture of the traffic at sea than avoid the collision just one by one as Sanchi 3/O doing.

4-29 橫越航線距離，正橫距離

- 在橫越的情況中，我們並不擔心正橫距離，只要我們能夠對著目標船的船尾轉向，繞過目標。
- 迎艏正遇的情況下，我們要根據目標在船頭的距離多遠，才能取得必要的正橫距離。
- 航向改變的公式，迎艏正遇的情況下，只有一半的遠離碰撞的效果，距離碰撞點的距離，在迎艏正遇時，只剩下一半。
- 一個正船頭目標在四海浬距離時，本船轉向 5 度（1852 m x 2 nm SIN(5)= 322 m），只能創造 322 公尺的正橫距離。
- 這些正橫距離，就是我們對迎艏正遇船隻的 CPA。

利用本船的速度向量線長度，我們可以立刻決定碰撞的位置在哪裡？

- 對迎艏正遇船隻的 CPA，可以借由轉動本船出發的電子方位線，到我們想要回轉的航向上後，估計橫越航線距離。以原船的速度向量線長度與本船的原始航線，來估計轉向後的正橫距離。請參考圖形 4-04 與 4-11，
    - 我們知道碰撞位置是在紅點上，
    - 碰撞的距離與時間在使用 6 分鐘速度向量時，是 1.54 海浬與 6 分鐘。
    - 繞過他船船尾的航向是 127 度，（這是紅線）從我們原始的航向 090。
- 最大的橫越航線距離，發生在使用 127 度的航向繞過他船船尾，經過他船的正橫，大約是 1 海浬。這是從目標回跡量到 90 度速度向量的端點，這是對橫越的情況。
- 在真實的海上，本船會回到原航向，在通過了目標船的船尾，此時正橫的距離，會比 1 海浬少，就像圖形 2-10 單目標避碰的標準操作。

橫越航線距離是由本船的航向改變來決定，對迎艏正遇的情況，如果碰撞位置是在紅點，橫越距離是使用相同的方法來決定，旋轉我們的電子方位線後，量取新的電子方位線到原始碰撞點的正橫距離。

這樣子的航線橫越距離，對當值船副看是太瑣碎了，但是我們必須記得，大副是必須在狹窄水道，或是限制水域裡面操船的人員，這樣的知識，也是我們情境察覺的一部分，培養這些感覺，來讓複雜的事情簡單，你就不會不知道從哪裡開始。

- 本船向右舷轉向早一點，跟大一點，可以避免在最後的 1 分鐘，劇烈的航向改變。
- 一般來說，航向改變來避碰，應該大到足夠讓目標船，看的出來，然後再緩慢小心地，回到原始航向，就像 2-10 避碰的標準操作
- **隨時穩住本船的航向**，這不是口號，卻應該深植在我們的血液之中，一次性的穩定住本船在新航向上，是一件好事。

當碰撞危機受到良好的控制，本船可以緩慢地回到原航向，這是一個操船的優良船藝的好證明。

4-29 Cross Track Distance or Abeam distance to our course line:

- in crossing situations, we do not need to worry as long as ownship can alter course to target stern, go around the target.
- In head on situations, abeam distance gained by altering course depends on target’s distance ahead.
- Course change to create abeam distance has half effect in head-on vessels.

- Course change to create abeam distance depends on DTC distance to collision point not two ship's distance to each other.
- "A head-on target at 4 nm distance ahead 5 degrees course change will create 1852 m x 2 nm SIN(5)= 322 m abeam distance only".
- These abeam distance is our CPA to head on vessels.
- By using ownship speed vector length we can determine where is Collision Position immediately.
- CPA to head on vessel can be known by swinging ownship originated EBL to the course we want to go and estimate cross track distance comparing length ownship's speed vector.
- Please refer to figure 4-04 and 4-11,
    - we know collision position is at red spot.
    - The distance and time to collision (6 minutes speed vector) are 1.54 nm and 6 minutes.
    - Go around course is 127 degrees (red line) from original heading 090 degrees.
    - Maximum Cross track distance to go around 127 degrees after passing target abeam is about 1.0 nm by measure from target echo to our 090 degrees speed vector's end or range ring. This is for crossing situation.
    - In real sea, ownship will course again after target vessel's stern. Cross track distance will be less as figure 2-10: SOP for collision avoidance in single target.
    - Cross Track distance is decided by ownship's course change. For head on situation, if collision position is in red spot Cross Track distance (abeam distance) is decided in same way. Rotate our speed vector and measure form our new course speed vector to original course line.

This Cross Track distance knowledge seems too tedious to OOW. We have to remember that we are the one to handle the vessel in narrow or confined space in some days later. This knowledge is part of our situational awareness. Cultivate the sense to make complicated things easier otherwise you will not know where to begin with. Ownship alter course to starboard side earlier and substantial can avoid drastic course change in last minute. General speaking, course altering to avoid collision should be large enough to be readily visible to Target vessel first then slow and careful turning back to original course again as figure 2-10: SOP for collision avoidance. "Steady ownship whenever you can" is not a slogan. It should embed in our blood. Steady ownship on new course once for all is a good thing. When collision risk is under well control then ownship slowly steer course back again is a well demonstrated seamanship in ship handling.

4-30 避讓的時候，應該要控制好橫越的距離

在規則 15 橫越，*當一條動力船隻有碰撞危機時，見他船在其右舷者，應該讓路，如果環境許可，避免橫越他船船頭。*

- 在起始階段，沒有任何的限制，本船與所有目標船的距離都非常遠。這是三階段避碰的第一階段，目標船在 8 到 12 海浬遠，在這個距離，兩條船沒有可能發生碰撞。兩條船都可以自由運轉，隨意轉向跟改變航速。在這起始會遇的階段，不需要考慮碰撞的這個階段，對於資淺船副來說是 8 到 12 海浬，對資深船副是 6 到 9 海浬，對船長來講，是 3 到 4 海浬。
- 船隻會遇的第二階段，橫越航線距離可能累積到無法接受的程度，意為本船因為種種因素，偏離原始航線，造成本船跟目標船的距離太接近的時候，雖然兩條船可能沒有碰撞危機，如果本船沒有採取行動，兩條船可能會變成太接近（種種因素），難以避免碰撞（近接的情況，CPA 小於 0.4 海浬），或是這兩條船之一，也許太接近航行的險阻，附近有礁石或是淺灘，容易造成擱淺，需要轉向調整。
- 近接的情況，也許會引起其他船隻驚恐惶恐，而採取本船並沒有預期到的行動。

規則 7（a）*決定碰撞危機是否存在？如果有任何懷疑，這樣的危機應該認為存在。*

這就是其中一條船應該，或可以採取行動來避免碰撞，就像規則 16……*必須讓路的時候，其他船應該維持原航向航速*……或是規則 17……*船隻可能，無論如何，採取行動來避免碰撞，使用他自己單獨的操縱，只要是該讓路的船隻，沒有採取讓路行動。*

- 讓路船，本來可能是讓路船或者是直航船，（依照規則 16 或 17）。
- 直航還是有保留先讓路的權力，只要他能確認其他船隻還沒有採取避讓的行動。
- 原來的直航船可能有些問題，無法保持原航向航速，因為它船隻的位置，已經偏開了他自己的原始航線，因為潮流，或是其他船隻的交通狀況，也就是其他船隻經過，所引起本船缺乏保持航向的能力，好像下面我們要研究的重複擱淺的案例。
- 直航船也許需要使用一些流水修正來操作，回到他的原始航線。
- 小角度的航向連續改變，去做流水修正，會引起讓路船的混淆，對於直航船的意圖，感到疑惑。

所以規則 17 (a)(ii)的運用，*船隻可以採取單獨行動來避免碰撞，只要對方很明顯的，應該讓路而沒有採取適當的行動，來符合這些規則的要求。*

這個情形包括直航船有採取行動，但不是很適當，意思就是說，他採取了行動，但是碰撞還是無法避免，直航船就必須採取行動。

- 這時直航船才取得主動避讓行動的權利，而不是被動的等待，因為讓路船的操作不當，沒辦法清爽碰撞危機。

“直航船可以採取行動，在第一時間，利用他自己的行動去避免碰撞，只要必須去行動的船隻，還沒有採取適當的行動。一旦直航船採取避碰行動，直航船必須負責去完成整個的避讓動作，使用他自己單獨的行動。”這一段是從第二章複製過來的，我們在這邊看看，還是蠻有道理的。

- 直航船可能需要去做一些流水修正，來補償橫越航線的距離，在他的航行班中，要保持本船在航線上，船長所劃定的航線上，除了要回到原始的航線。
- 直航船現在必須考慮到與讓路船發生的近接情況，在會遇的第二階段。
- 當直航船有碰撞危機，而且必須加流水修正，來回到他的原航線，應該不要妨礙到讓路船的行動。

這個聽起來是蠻複雜的，沒關係，如果我們研究的案例夠多，他就會變成我們的第二天性，也就是我們的直覺。

圖形 4-12 雙重擱淺案例探討

4-30 Take care of Cross Track Distance while give-way

In Rule 15 crossing situation, ***When two power-driven vessels are crossing so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way and shall, if the circumstances of the case admit, avoid crossing ahead of the other vessel.***

⇒ In initial stage no restrictions on cross track situation, ownship and all targets distance are very far away. There are no possibility two vessels will collide to each other. Every vessel is free to move, free to alter course or change speed in this initial stage. This is a free stage with no collision consideration needed. This stage is 8-12 nm for junior OOW, 6-9 nm for senior OOW and 3-4 nm for master.

⇒ In second stage cross track distance may reduce to unacceptable level while ownship and targets distance are close. There may not have possibility of immediate collision to each other. But if one vessel did not take action (free to alter course or change speed) these two vessels will become too close to avoid collision by one vessel only (close quarter situation, CPA=0.4 nm etc.…) or these two vessels may too close to navigational hazards (grounding). Close quarter situation may cause other vessel panic action to take action ownship had not expected as COLREG rule 7 (a) …*determine if risk of collision exists. If there is any doubt such risk shall be deemed to exist.*

- This is the time one vessel should or may take action to avoid collision as rule 16 …*vessel which is directed to keep out of the way of another vessel shall…, or* rule 17 …*vessel may, however, take* *action to avoid collision by her manoeuvre alone, as soon as it becomes apparent to her that the vessel required to keep out of the way is not taking appropriate action…*

- In this stage, no matter you are give-way or stand-on vessel. You can take action as long as other vessel had not take action.
- The one keeps out of the way of another vessel could originally be a give-way or stand on vessel (Rule 16 or 17 case).
- Original stand-on vessel may have some problem to maintain her course and speed due to her ship's position already deviated from her original course line by current, seas or another vessel's traffic or lack of proper course keeping ability.
- Stand-on vessel may need to go back to her original course line by applying avoid the collision at the same time.
- Small course change continuously to adjust Stand-on vessel leeway may cause give-way vessel's confuse of stand-on vessel's intention.
- So, rule 17 (a)(ii) applied. *The latter vessel may however take action to avoid collision by her manoeuvre alone, as soon as it becomes apparent to her that the vessel required to keep out of the way is not taking appropriate action in compliance with these Rules.* This situation includes the stand-on vessel had taken action but *not appropriate. (is not taking appropriate action)*
- "Stand-on vessel may take actions in first instance by her manoeuvre alone to avoid collision as the vessel required to keep out of the way is not taking appropriate action yet. Once stand on vessel take avoidance actions, she shall responsible to complete the avoidance by her efforts along." This paragraph is copied from chapter 2 still look good here. (*to avoid collision by her manoeuvre alone)*
- Stand-on vessel may need to take some leeway to compensate for her off-track distance in his watching keep efforts which include keep stand-on vessel on its course line laid down by Master.
- Instead of just going back to original course line, now stand-on vessel should consider the close quarter situation with give-way vessel in second stage.
- When stand-on vessel has collision risk and have to apply leeway to compensate off track distance she should keep out of the way of give-way vessel.
- Sure. This sounds complicated. Never mind. If we has studied cases enough it will become our second nature.

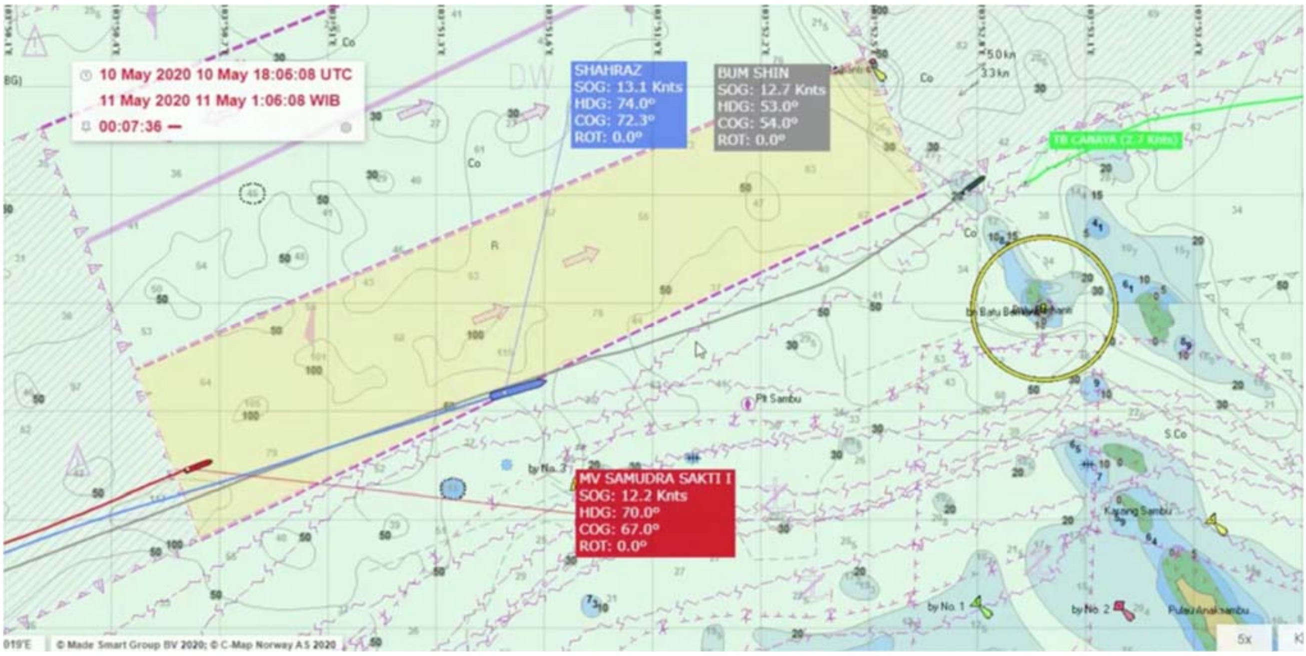


Figure 4-12 Both A/C at 0206 hours, first grounding at 0212 hours, second at 0218 hours

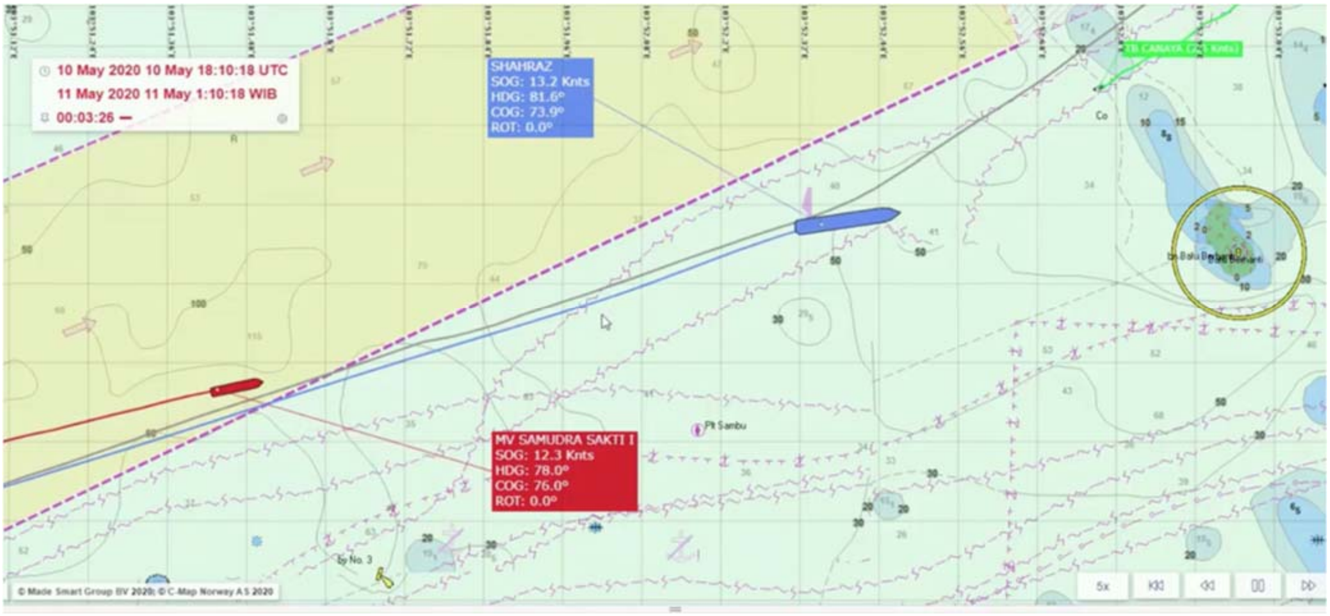


Figure 4-13 avoidance action before and after double grounding

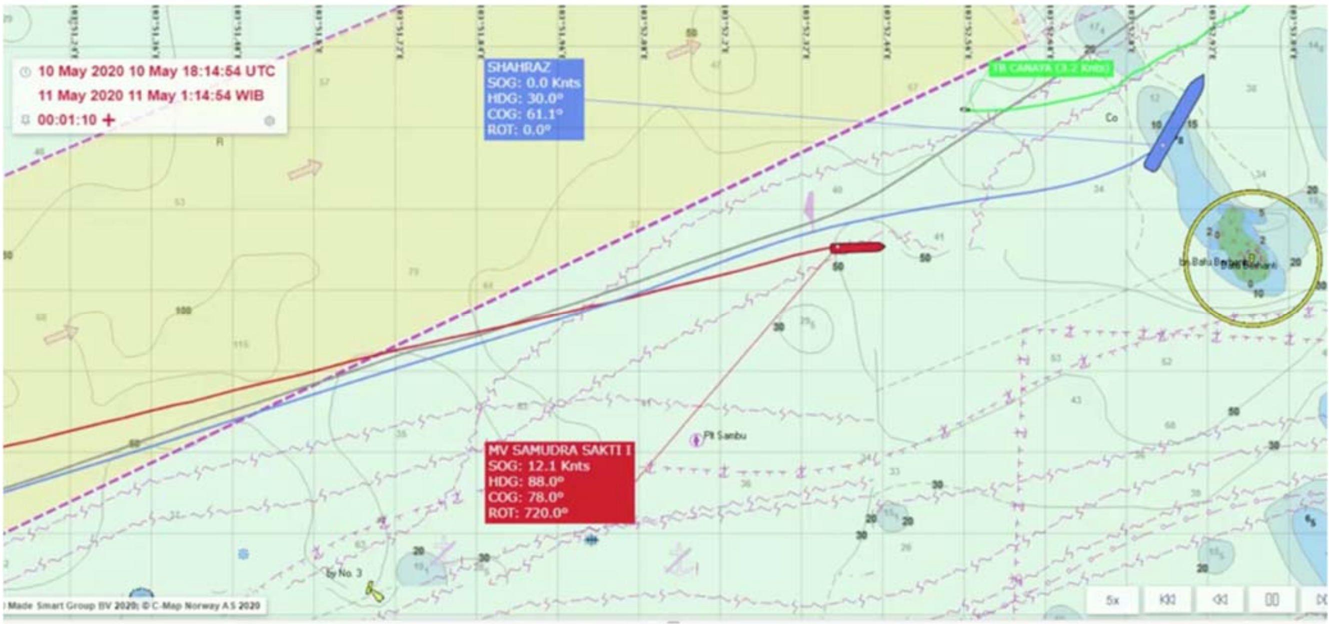


Figure **4-14** 0215 hours，second vessel A/C at 0215 , and grounded at 0218 hours

4-31 連續擱淺案例（改寫）

連續擱淺案例的起始情況，見圖形 4-12-1,1206 時，一條南下的綠色拖船，位於航行巷道外側，意欲小角度進入東向航道，與 02：01 時開出去航道外之黑色船隻（該船有 4 分鐘的時間，沒有好好瞭望），在 02：04 時迎艏正遇南下的綠色拖船，黑色船隻依照避碰規則 2 的要求，顧慮到向右轉會有擱淺的風險。所以不顧規則第 14 條迎艏正遇的規定，直接向左轉，避讓正船頭對方的來船，綠色拖船已於一分鐘前，轉向航向 246 度（T）向西南方航行，他是在分道航行制外側航行，他的左邊是淺水區，只有 8 米 3 的深度。

⇒ 這條拖船的位置，位於分道航行制的外面，在 02：04 開始的時候。

⇒ 拖船的航線是沿著分道航行制的外側航行，如果黑色船隻跟這條拖船有碰撞危機，碰撞位置就是在分道航行制的外側。這是因為我們知道，碰撞位置都是在本船的原始航線上。所

以作為資深船副，我們要知道第一重要的事，就是如何利用雷達瞭望的技巧，判斷碰撞的位置？

⇒ 確認在碰撞位置的附近，是否有航行險阻，或與附近其他船隻碰撞的可能性，橫越航線的距離是多少？在採取適當行動的決策之前，先檢查碰撞位置附近的船隻狀況，水深是否足夠，是否有其他的航行危險。

⇒ **任何碰撞位置，在分道航行制外側，都是不合理的，而且也不可以，無法接受**。因為這是違反了避碰規則第二條適當的注意，應該對所有航行的危險，碰撞或是擱淺，任何特殊的情況，都必須加以注意。

⇒ 在 02：06 時，黑色船隻採取避免與拖船碰撞的左轉，將要回到航行巷道裡時，第二條藍色船隻正循著前面黑船的錯誤，沒有好好瞭望與定位，將船隻開到航道之外。

⇒ 請見圖形 4-12-2 0210 時（同樣是 4 分鐘的時間，沒有回到航行巷道），第二條藍色船隻開始向右轉向，這是重大錯誤，也許船副沒有時間去檢查船位，也許船副被碰撞危機所分心。

⇒ 0210 時，第二條藍色船隻與拖船發生迎艏正遇，第二條藍色船隻不顧擱淺的危險，選擇向右舷轉向，就像是迎艏正遇在規則 14 的要求，此時第三條紅色船隻正循著前面藍船的錯誤，將船隻開到航道之外。

⇒ 兩分鐘後，在 0212 時，第二條藍色船隻發生擱淺。

⇒ 又 3 分鐘後，在 0215 時，第三條紅色船隻與拖船發生迎艏正遇，第二條藍色船隻不顧擱淺的危險，選擇向右舷轉向，3 分鐘後擱淺。

⇒ 這兩條船都選擇向右舷轉向，就像是迎艏正遇在規則 14 的要求，兩條船在 2 分鐘與 3 分鐘後，都發生擱淺事件。

⇒ 根本原因是，後面的船隻隨著船頭前面的船隻，一條接著一條，而沒有仔細核對本船的船位，是否偏離航線？對本船的船位，沒有保持適當的觀測與維持。這種事我也做過一兩次，一次做船長在關門海峽下領港後，沒時間定船位，跟其他船右轉，原因是對雷達目標不熟系。另一次是做三副時，在蘇彝士海峽中航行，追越前船，一個鐘頭沒有定位。原因都是準備不足，或是人手不夠。

⇒ 適當的避碰程式，應該考慮到規則 2 的需求，不可對注意事項的疏忽，避免疏忽海員常規的需求，或是對該案件特殊情況，產生疏忽。

本船應該重回到分道航行制的方法，就像第一條黑船，在 02：06 時轉向左舷，見圖形 4-12-1，也許它是幸運的，綠色拖船是在 1 分鐘前，02：05 時左轉，來到他的左側，黑船隻是順勢左轉。而另外一條船也是同樣大角度的左轉，是在第二條船擱淺之後的 2 分鐘，請見圖形 4-13 02：20：04 時，拖船先右轉，又再度左轉到分道航行制的外側。

這三條東航的船隻，原來都在分道行精製的航行巷道之內航行，卻接二連三的駛出航行巷道外，與航行巷道外的拖船，產生迎艏正遇的情況，進而因為避碰的行動，直接開上淺灘上。最主要的原因，就是沒有及時回到原始的一般流動方向，066 度的航向。所以，無論何時，發現有碰撞危機的時候，第一件事情就是要檢查碰撞的位置在哪裡？航道外的碰撞位置都是不合理，而且不可以接受的情況。如果對這些碰撞位置採取避碰措施，那就是跟這兩條擱淺的船隻一樣，只會造成自身更重大的損失。

圖形 4-13 在連續擱淺之後的避碰行動

4-31 Double grounding case study.

The initial situation of double grounding case. The tug boat top right side is green vessel in south west bound course 246^0 (T) which is sailing along outside limit of Traffic Separation Scheme TSS. Her portside is shallow water of 8.3 meters in depth.

⇒ The tug boat's position is outside the traffic lane in the beginning (10 minutes before double grounding) In figure 4-12 02:06:13.

⇒ If one ship has collision risk with this course 246⁰ (T) tug boat now, the collision point is outside TSS because tug boat's course line is along the outer limit of TSS traffic separation scheme.

⇒ This is first important thing Senior OOW should know how to judge the collision position by radar lookout.

⇒ Verify navigational hazards around collision position, does there have other collision possibilities with small vessels or adjacent to shallow water before take his decision to avoidance actions.

⇒ Any collision position outside TSS is unreasonable and unacceptable. It is against COLREG rule 2 …*due regard shall be had to all dangers of navigation and collision and to any special circumstances….*

⇒ Ownship (blue vessel in figure 4-12 02:06:13 should find the way back to TSS as one vessel turn to portside 6 minutes before ownship's grounding (starboard to starboard with green SW bound tug boat) and another one also turn left substantially 9 minutes after second vessel grounding (figure 4-15 brown vessel turn to portside)

⇒ The yellow circle is the position both vessels begin to take avoidance action to tugboat in figure 4-15.

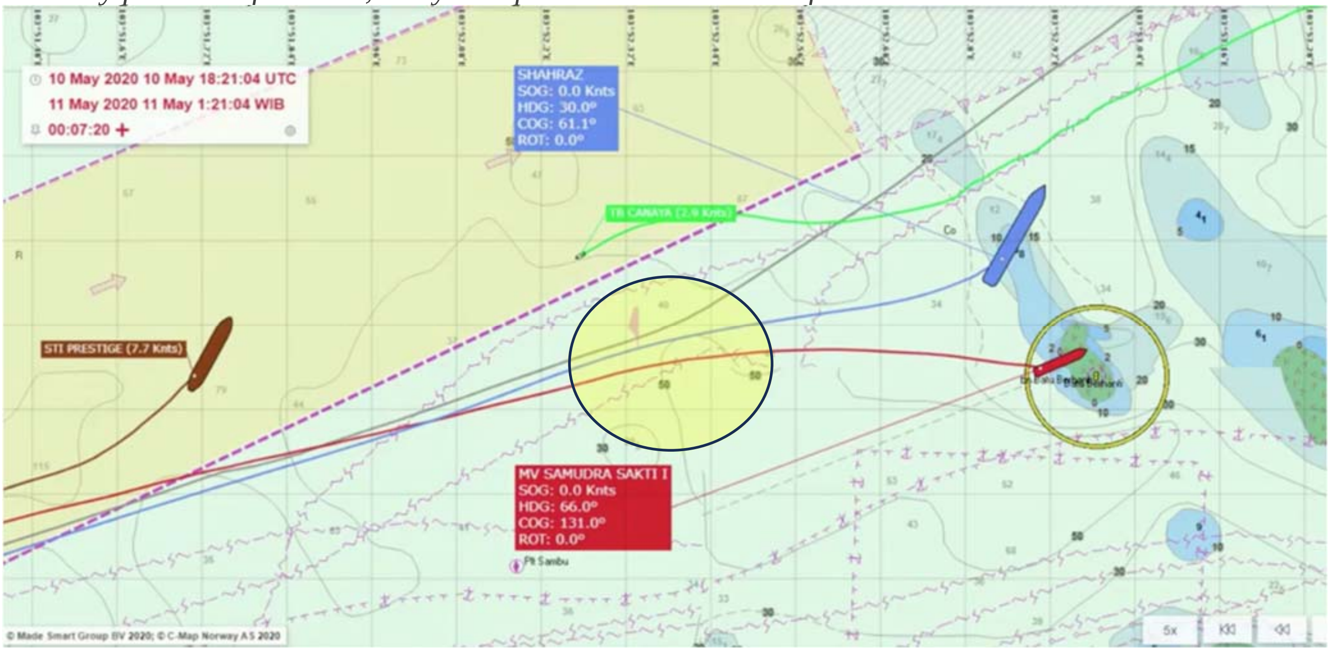
⇒ Bothe vessels choose to alter course to starboard side as head-on situation required in rule 14 and both vessels go aground after 6 and 12 minutes.

⇒ The root cause of grounding is vessel follows overtaken vessel ahead one by one without double check on ownship's position with parallel index. No proper watch keeping in ship's position.

NO proper collision avoidance procedure in this case is

⇒ Verify navigational hazards around collision position, does there have other collision possibilities with small vessels or adjacent to shallow water before take his decision to avoidance actions.

As of COLREG rule 2 requirement: …*the neglect of any precautions which may be required by the ordinary practice of seamen, or by the special circumstances of the case.*



圖形 4-15 在連續擱淺之後的避碰行動

4-32 避碰規則的三個階段

在避碰的第三階段，本船跟目標船的距離非常接近，也就是在近接的狀況中，如果只有一條船採取行動，有可能這兩條船會碰撞。兩船距離已經太接近，以至於一條船的行動無法避免碰撞，這就是兩條船都應該採取行動，來避免碰撞的時候。

⇒ 這第三階段的避碰，是由兩條船相互間的距離來劃分的，這些階段在避碰規則，並沒有做詳細的劃分，必須由他的內文邏輯來做推斷。

⇒ 避碰第一階段是自由運轉，沒有線索，也沒有內文記載在避碰規則內，當每一個目標船距離都很遠，航行當值時，只需要遵循規則 5，全時瞭望，規則 6，全時使用安全速度。

⇒ 在避碰的第一階段，本船不需要照規則 7，決定目標跟本船是否有碰撞危機？因為它隨時能改變航向航速。

避碰的第二階段，避碰規則開始全部適用：

⇒ 如果碰撞危機存在，本船必須決定本船或是目標船，是否位於規則 9 狹窄水道？或是在規則 10 分道航行制的航行巷道中？

⇒ 當兩條船在不同的風險區域，且具有碰撞危機時，（風險區域：公海，狹窄水道，航道，分道航行制內或是港區），當值船副必須決定在這樣的船位，本船是否應該像在公海上，遠離其他目標，或是本船需要"不得妨礙他船隻在狹窄水道，或是分道航行制內的安全通航。"

⇒ 換句話說，決定是否本船是一條讓路船，或是直航船在不同的風險區域，是不一樣的。這個在避碰第二階段的決定，是很重要的，就像規則 16 讓路船的行動。*"凡依規定應避讓他船之船舶，應盡可能及早採取明確措施，遠離他船。"*。

⇒ 非常的清爽通過，讓路船必須採取行動的距離，在大海上，必須讓路的距離，在近岸區域，可能還是屬於自由運轉的階段。

⇒ 這意思是說，在大海上避碰的距離比較遠，在近岸區域採取避碰行動的距離比較近。規則 17 直航船的措施，（a）*當兩船中之一船應讓路時，他船應保持其航向及航速。*

⇒ 在這第二階段，一條船必須採取行動，另外一條就變成直航船，必須保持航向航速，他並沒有說是直航船採取行動？或是讓路船採取行動？只有說有一條船要採取行動，另外一條就必須維持原航向航速。

⇒ 所以這有點豬羊變色的味道，只看誰是先下手為強，先讓路後，另外一條船就必須直航。

（ii）*直航船舶，當發現應讓路船舶顯然未依本規則採取適當措施時，亦可單獨採取措施，運轉本船以避免碰撞。*

⇒ 後面這一條船可以採取行動去避免碰撞，使用他自己的運轉，只要對他來說，船隻需要讓路的，現在很明顯沒有採取適當的行動，以符合本規則的要求。

⇒ 這一條規則是，只要讓路船沒有採取行動，直航船就可以採取單獨的行動來避免碰撞。應該直航的船隻，可以先下手為強。<u>直航船讓路之前提有兩個：一個是讓路船還沒有採取行動。一個是本船負責完全的避讓行動，本船需確保對方只要直航，維持原航向航速，就已經足夠避免碰撞</u>。

所以在第二階段，在兩船距離是一樣時，在同樣的風險區域內，直航船有兩種情況。

在第二階段，如果他想要這麼做，直航船也可以採取單獨運轉來避免碰撞。這是直航船的一個選項，他要能看得出來讓路船並沒有採取適當的行動，沒有採取適當的行動，包括有採取的行動，但是不足以避碰。

直航船希望有這樣子的選項，是因為"直航船也許需要採取大角度的轉向，來補償本船離開原航線的正橫距離"，就像我們看到船隻在圖形 4-13 02：21 時（ 大角度的從 064 的航向，轉到 015 的航向，這就是因為他已經快要開出航道外側）

避碰的第三階段，規則 17（b） *不論任何原因，應保持航向及航速之船舶，發現本船已逼近至僅賴讓路船之單獨措施，不能避免碰撞時，應採取最有助於避免碰撞之措施*。當無論任何理由，船隻必須保持航向航速，發現本船太接近碰撞，無法由讓路船的單獨行動，加以避免，應該採取會最佳的避免碰撞的行動。

在避碰第三階段，直航船應該採取這樣的行動，來最好的幫助避碰，這是直航船的一個義務。
換句話說，**在避碰第三階段，沒有直航船，兩條船都是讓路船**。

4-32 Give-way vessel or stand-on vessel in different risky area?

In third stage, ownship and targets vessel distance are so close (close quarter situation now). There is a possibility these two vessels will collide each other. If only one vessel take action only these two vessels will become too close to avoid collision. This is the time both vessels should take action to avoid collision.

⇒ There are three stages of collision avoidance divided by two vessel's distance to each other. These stages are not specified in the COLREG but judging by its context.

⇒ First stage has no clue, no rule and no text in COLREG. When all targets are far away, OOW just follow rule 5 keep lookout all the time, rule 6 use safe speed to navigate all the time, rule 7 to determine does risk of collision exists with any target. This is the stage ownship don't need to decide whether any vessels might have collision risk with ownship.

⇒ Second stage,

- if risk of collision exists ownship have to determine whether ownship or other ship is in location of Rule 9 Narrow channel or rule 10 Traffic Separation Scheme.
- When two vessels have collision risk in different risky area (open sea, narrow channel, TSS or harbour area) OOW has to decide "Is this distance ownship should keep out of the way in open sea or is required not to impede the passage / safe passage of another vessel in narrow channel or TSS?".

- In another words, to decide does ownship is a give-way vessel or stand-on vessel is different in different risky area?
- This decision is important in second stage as Rule 16 *Action by give-way vessel: Every vessel which is directed to keep out of the way of another vessel shall, so far as possible, take early and substantial action to keep well clear.* What is the distance a give-way vessel has to take action in open sea may be a free to move stage in coastal area. Different obligation required in different risk area.
- Rule 17 *Action by stand-on vessel (a).*
- (i). *Where one of two vessels is to keep out of the way the other shall keep her course and speed.* In this second stage, one vessel has to take action, stand-on vessel should stand-on. (doing nothing)
- (*ii*). *The latter vessel may however take action to avoid collision by her manoeuvre alone, as soon as it becomes apparent to her that the vessel required to keep out of the way is not taking appropriate action in compliance with these Rules*. In this second stage one vessel may take action when another had not give-way yet.
- These are two different situations although the distance is the same within second stage in that risky area.
- In <u>second stage</u>, stand on vessel *may however take action to avoid collision by her manoeuvre alone* if she wants to do so. <u>It's an option of stand on vessel</u> *as soon as it becomes apparent to her that the vessel required to keep out of the way is not taking appropriate action. Stand on vessel may take action first as long as give-way vessel is not taking appropriate action in compliance with these Rules*
- Stand on vessel may want to have this option because "Stand-on vessel need to take some drastic leeway to compensate for her cross-track distance." as the Brown vessel did in figure 4-15 (alter course from 064^0 (T) to 015^0 (T).

⇒ <u>Third stage,</u> Rule 17(b). *When, from any cause, the vessel required to keep her course and speed finds herself so close that collision cannot be avoided by the action of the give-way vessel alone, she shall take such action as will best aid to avoid collision.*

- In third stage, stand on vessel *shall take such action as will best aid to avoid collision and grounding (as required by rule 2) .*

<u>It's an obligation of prudent seamanship for stand on vessel to avoid the collision and grounding at the same time.</u>

4-33 是否要讓路或是直航，當橫越分道航行制的兩邊

在最重要的規則 17，直航船的行動裡面有☹a)(i) *當兩船中之一船應讓路時，他船應保持其航向及航速*。

作為在船上的大副，我們希望他能夠處理多目標船的情況，當我們來到長江口燈船的交叉路口，本船是向東航行，遇到左舷南下船（在避碰的第二階段時），本船應該直航，而且右舷北上的船隻，（也是在避碰的第二階段）本船應該讓路。

直航與讓路同時發生的情況，如何處理？

⇒ 因為南下北上的船隻，基本上是在不同的航行巷道航行，都是圍繞著燈船，並且任何的碰撞危機，都一定會有一個碰撞的位置，在本船的船頭。

⇒ 本船跟南下的船隻的碰撞點，一定是在南下的航道內，而且與北上船隻的碰撞點，一定是在北上的航行巷道內，兩個航行巷道有 1.5 海浬的距離遠。

⇒ 如果碰撞點不在航行巷道內，本船隻要回到自己的航線，應該就不會有碰撞發生。

⇒ 有了這樣的瞭解，我們就知道碰撞危機其實是一前一後，相差 1.5 海浬，對於二十節的船隻來講，這兩個碰撞危機的時間點，就相差了 4.5 分鐘，這是與他船的船速無關。

⇒ 如果我們是東航的船隻，需要採取行動，第一個南下的船隻在我們的左舷，我們應該要保持航向航速。等到我們經過了南下船的碰撞點，與下一個北上船隻發生碰撞危機的時間，其實我們只有 4.5 分鐘的時間，去採取的行動。

⇒ 碰撞的距離只有 1.5 海浬，如果北上船隻是連續出現，也就是兩條目標船之間的間隔不夠 1 海浬，我們就要在兩條北上船隻之間危險的穿越，如果兩條間隔 0.5 海浬的北上船隻出現，就要在 1.5 海浬的前進距離，一次避讓出 0.5 海浬的正横距離。

⇒ 那這個在我們正横距離的計算裡面，需要轉向多少度？1.5 海浬的前進距離，需要轉向 15 度來創造 600 公尺，所以 900 公尺的正横距離，應該是需要轉向大約 22 度左右。

與南下船有碰撞危機，我們必須直航，直到通過南下的碰撞點，然後與右舷北上船隻的碰撞危機，我們又必須讓路，這會讓我們的船副，感到相當的困惑，或是困難。我們用上一章資淺船副對碰撞位置的研究，知道一旦本船的航向改變，碰撞點就會轉移到本船轉向的哪一側。

⇒ 如果本船的行動是向右舷轉向，新的碰撞位置就會移到右邊，左邊的來船到達新碰撞位置的時間，就會增加。

⇒ 因為本船與它的碰撞距離增加，與左舷船隻的碰撞危機就會變少。

⇒ 除非左舷南下船增加他的船速，追上本船轉向後增加的正横距離，否則本船對左舷的船隻右轉，很可能它都追不上。

⇒ 這也是為什麼我提倡新的避碰規則要求，所有船隻在有避碰危機時，都應該向右轉向。這些情況，我們都會在船長的那一章裡面，仔細討論。

圖形 4-14 本船碰撞點在分道航行制內

就像本船在圖形 4-06 接近長江口燈船，如果本船與左舷的船隻有碰撞危機，同時又與右舷的船隻有碰撞危機，那這兩個碰撞的時間一定不一樣，左舷的碰撞危機，一定是早於右舷船隻的碰撞時間（4.5 分鐘，如果本船速度是 20 節）。碰撞距離：左舷船隻與右舷船隻相隔了 1.5 海浬。問題是如果左舷的讓路船讓路給本船，本船須保持航向航速，而且本船與北上船隻有碰撞危機，本船應該提早讓路的措施。其實這個問題呢，我們在後面的章節呢，已經驗算過了。就

是可以把這些十字路口看成是一個圓環，所有船隻在經過的時候，如果有碰撞危機，都要向右轉，就可以把碰撞點推開，不會集中在同一時間。真的不行的時候，就跟路上的圓環一樣，內環車先行，外環車讓路，以減速代替轉向，更能有避碰的效果。這個會在以後討論。

4-33 Whether to give-way or stand-on while crossing two opposite directions traffic?

The most important of rule 17 Action by stand-on vessel is:" "**a**)*(i). Where one of two vessels is to keep out of the way the other shall keep her course and speed."* As a chief mate on board, we are expected to handle multiple target situations. When we come to a cross road like Chang Jiang Mouth L/V (figure 4-03), ownship sailed eastbound. The chance to meet port side south bound vessel in second stage (ownship should stand-on) and starboard side north bound vessel in second stage (ownship should give way) at the same time are plenty.

⇒ Because south bound vessel and north bound vessel basically are in different traffic lane around the light vessel, any collision risk must have a collision point at ownship's bow. Ownship collision point with south bound vessel is in south bound lane and collision point with north bound vessel is at north bound lane. These two traffic lanes have 1.5 nm distance apart. If every vessel sticks to their original route the collision risk can be handled one by one. Ownship will have portside vessel in crossing situation first then after one mile or so comes the starboard side vessel have collision risk.

⇒ If ownship course 090^0 (T) has one collision position with port side south bound vessel in southbound lane and one collision position with starboard side north bound vessel in northbound lane at the same time, these two collision positions will have 1.5 nm distance apart.

⇒ The collision risk with port side vessel where ownship have to stand-on until ownship crossed south bound lane and the chance ownship have to give way to starboard side vessel will be many but too close already because these two traffic lanes have 1.5 nm distance apart only.

⇒ By the study of collision position with junior OOW in last chapter we know "**once ownship's course is changed the collision point will shift to the side ownship had turned.**"

⇒ If ownship's action is to alter course to starboard side, collision position will shift to starboard side. Port side vessels will arrive new collision position later because her distance to collision is increased. Port side vessels' collision risk will decrease unless she increases her speed to catch up the abeam distance ownship had made by altering course to opposite side of her.

⇒ This situation will fully discuss later in Master's chapter.

圖形 4-16 本船碰撞點在分道航行制內

Like ownship at figure 4-06 approaching Chang Jiang Mouth L/V (Racon O), if ownship has collision risk with port side and starboard side vessel the time to collision TTC must be different. Port side collision risk must be earlier than starboard side vessel. Distance to collision DTC with port side vessel is 1.5 nm sperate from starboard side vessel. The question is if we have port side give way vessel (ownship should keep course and speed) and ownship has collision risk with starboard side vessel (ownship should give way in earlier action)

4-34 直航船在他船讓路前後，都可以自由運轉

規則 15,橫越船讓路的義務，是由兩條船的相關位置來定義的，*船隻見他船在其右舷，應該讓路*。

⇒ 如果左舷船隻讓路給本船，而在此同時，本船必須讓路給右舷的船隻，這樣子會延誤左舷船隻通過本船船尾的時間，換句話說，本船讓路給右舷的船隻，右舷北上的船隻，會使得避碰行動，拖的比一條目標船的情況，需要的時間更長。

⇒ 雖然本船違反了規則 17：*當兩條船之一在讓路，另外一條船應該保持它的航向航速*。本船仍然在讓路船的右邊，左舷的船隻在本船的左邊，當本船轉向或停車去讓路的時候，左舷船隻的義務，要讓路給本船，並沒有被解除掉，因為我們還是在他的右舷。

⇒ 要依照規則 17，去執行直航的選項，或是依照規則 15 的要求去讓路的選項，本船應該遵守規則 15 去讓路，因為船隻在我們的右舷，會希望我們這樣子做，也就是讓路給右舷的船隻。

⇒ 因右舷的船隻並不知道（他是無辜的第三者，直航的權利不該受到影響），本船跟我們左舷的船隻，可能會有問題。

⇒ 同樣的情況，也適用於本船讓路給在我們右邊的直航船只，當直航船在本船的右邊，已經改變航向或是減速，本船仍然應該對他讓路，不計任何代價，避免碰撞。這是說右舷的船隻，在避讓他船的時候，而不是對本船避讓，此時本船仍然應該避開他的航向航路。

避碰規則是用來避免碰撞，如果本船可以運轉來避免碰撞，本船可以這麼做，沒有問題，只要這些運轉，不會與讓路船的動作，產生衝突。這是說即使左舷的船隻是讓路船，並且讓路船已經採取某些行動，本船仍然可以採取行動，只要不會跟讓陸船的行動，發生衝突。

就像桑吉輪的三副，並沒有讓路給漁船，只要沒有碰撞的發生，桑吉輪的三副，對於他自己的行為違反避碰規則的要求，還有一套理論。一旦碰撞發生，當值船副沒有遵守避碰規則，在法庭的判決中，就會產生過失，三副必須在法庭裡面，證明他的行動是正當並且合理的。

這是當值船副必須付出的代價（舉證他的行動是正當的），如果沒有符合避碰規則，或是他有避碰規則下，其他的義務要做。

在避碰規則 17 (a)(ii) *直航船可以採取行動來避免碰撞，用他自己單獨的操作，只要讓路船沒有取適當的行動，或是沒有採取符合這些規則的行動。*

⇒ 直航船可以自由運轉，在讓路船採取避碰行動之前。

⇒ 直航船在讓路船採取符合避碰規則的行動之後，仍然可以自由運轉，但是必須滿足下列其中一個條件：

- 他的碰撞危機，並沒有因為讓路船的行動而解決，（可能在避碰的第三階段，已經產生了近接的情況），
- 或是本船必須讓路給其他船隻，（在避碰的第二階段，左邊的船隻的義務），也就是本船在他船的左舷。

規則 17（b）無論任何理由，需要保持航向航速的船隻，發現本船太接近，以致於碰撞無法由讓路船的單獨行動而避免，應採取最有助於避免碰撞的行動。

⇒ 直航船應該採取這樣的行動，最佳的避碰措施，當讓路船發現，無論任何理由，碰撞沒辦法避免，讓路船已經採取避碰行動，或是沒有採取行動。

⇒ 本船應該避碰，當兩船的距離已經太接近 3 分鐘的速度向量線內，或是一海裡的距離內，也就是兩船的太空船狀態，已經碰撞。

圖形 4-15 資淺船副避碰的例子

4-34 Stand on vessel is free to move before or after another vessel give way

The crossing rule 15 defined obligations by the position of two vessel: ***the vessel which has the other on her own starboard side shall keep out of the way.*** If port side vessel give way to ownship and ownship have to give way to starboard side vessel at the same time this practice will delay port side vessel passing ownship's stern time. In another words, ownship give way to starboard side north bound vessel will make port side give way vessel avoidance actions longer than just one target's situation. Although ownship violent rule 17: "***Where one of two vessels is to keep out of the way the other shall keep her course and speed.***" Ownship is still at starboard side of give way vessel. Port side vessel still at ownship's port side whether ownship alter course or stop engine to give way. **The obligation of port side vessel to give way to ownship is not released.** In the option whether *to stand on as rule 17* or to *give way as required by rule 15*, ownship should follow Rule 15 to give way <u>because the vessel on our starboard side is expecting us to do so.</u> Ownship's starboard side vessel did not know ownship have problem with our port side vessel.

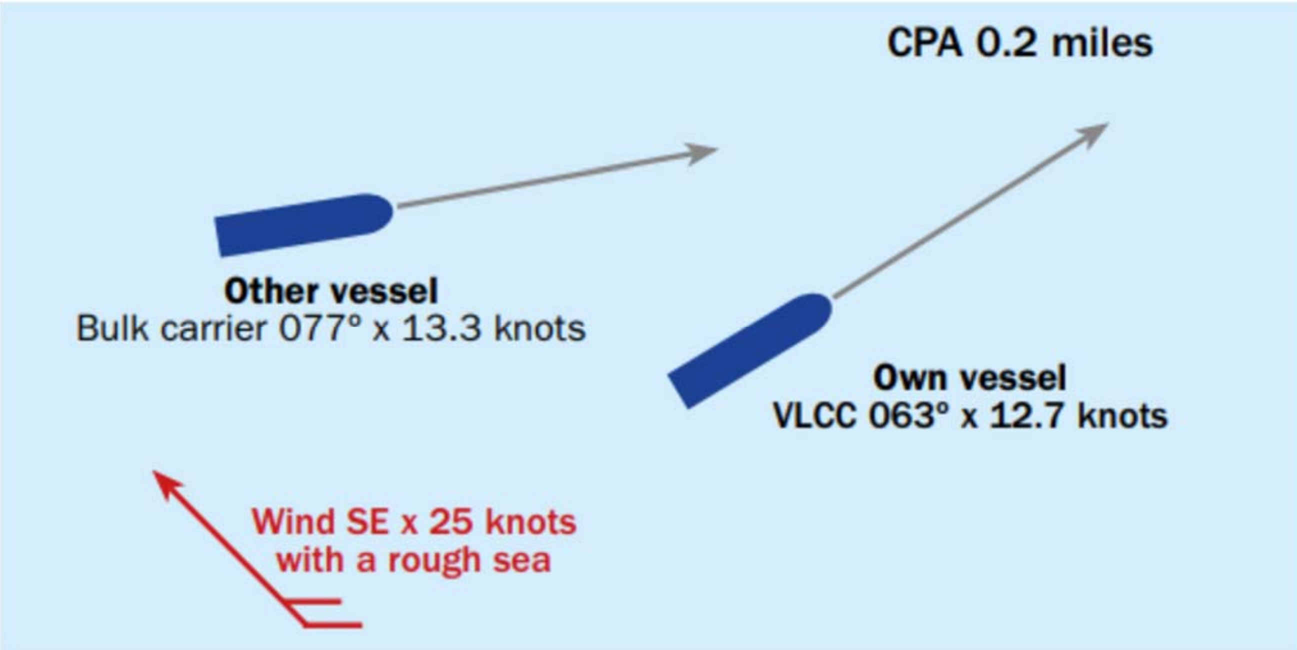
The same situation also applied to ownship. When stand on vessel at ownship's starboard side have changed course or reduced speed ownship still have to give way to her at any cost to avoid the collision. The COLREG is use to avoid collision. If ownship can maneuvering alone to avoid the collision ownship can do so without any problem as long as these maneuvering will not contradict to give way vessel on our port side. Like SANCHI 3/O did not give way to fishing boat is OK as long as no collision occurred. Sanchi 3/O had a theory for his action against COLREG requirement. Once a collision happened the OOW did not follow COLREG will be at fault in the verdict who will have to justify his action in the court. This is the cost OOW have to pay when he did not comply with COLREG even he has another obligation under COLREG.

In COLREG **rule 17** *a.(ii) stand on vessel can take action to avoid collision by her manoeuvre alone as long as give way vessel is not taking appropriate action or not taken appropriate action in compliance with these Rules.*

- Stand on vessel have the freedom to move before give way vessel take avoidance action.
- Stand on vessel have the freedom to move after give way vessel take action complied with COLREG under these two conditions: Collision risk is unsolved by give way vessel (in third stage, close quarter situation) or ownship have to give way to another vessels (in second stage, port side vessel's obligation).

In COLREG **rule 17 (b**). *When, from any cause, the vessel required to keep her course and speed finds herself so close that collision cannot be avoided by the action of the give-way vessel alone, she shall take such action as will best aid to avoid collision.*

- Stand on vessel *shall take such action as will best aid to avoid collision* with give way vessel when, from any cause, collision cannot be avoided whether give way vessel has taken avoidance actions or not.
- Ownship should give way when two vessel's distance is too close within 3 minutes speed vector or one nautical mile (space ship status).



圖形 4-17 資淺船副避碰的例子

4-35 案例探討：資淺船副避碰的例子

左舷的散裝船沒有任何可見的避碰行動，在 CPA 0.2 海浬，離碰撞時間 30 分鐘的情況下，我們決定聯絡他，在 VHF 上問他的意圖？他回答他想要保持航向航速。我們決定採取自行避碰的行動，然後向右舷轉向 30 度，維持 1.5 海浬的安全距離，利用向右轉的動作，我們讓他超越本輪，在一個安全的距離外，因為微小的航速差異，我們"被推開"預定的航線大約 3 海浬的正橫距離。因為我們當時是在公海上，我們認為這是最安全的行動，考慮到散裝船完全無視於避碰的必要。

⇒ 在判斷這情形的時候，我剛好在網路上，看到這樣一個案例，讓我們討論一下這個例子，有什麼地方不對勁？

- ⇒ 本船跟他船的速度相差 0.6 節，他船快 5%，與本船有碰撞危機，而且幾乎是與本船相同的航向。他在我們的左邊，所以這一條船，無論他的速度與航向是多少？只要本船不是從他的正橫之後 22.5 度接近（從圖上看，本船是從他右船頭接近），他可能有兩種情況：第一種是規則 15 的橫越，因為他的相對位置，在我們的左邊，他必須讓路，或是是規則 13 的追越，他也必須讓路給本船。
- ⇒ 如果他船從大約左邊正橫接近本輪，他就是讓路船，沒有權利維持他的航向航速。
- ⇒ 如果本輪對於他的意圖有所懷疑，我們應該使用日間信號燈，顯示我們的問號。VHF 的通訊在大海上，是不被推薦的。因為沒辦法立刻確認目標船的問題，雖然如此，我們也可以試著與散裝船聯繫如下。
- ⇒ 如果我們能夠確認來船的姓名以後，用他的船名在 VHF 裡面聯絡，**只要說出來：其他船隻需要做什麼？而不是你希望他們去做什麼。當然更不是他希望自己要做什麼**？
- ⇒ 我們不是領港，不需要照港裡面那一套，相互協調如何通過。
- ⇒ 一切都是按照規則來走，只要知道該做什麼就好。
- ⇒ 這是在規則裡面很清楚的，應該要求他去遵守，不管他的答案是什麼。
- ⇒ 這一段 VHF 的錄音，會記錄在我們的航行資料記錄器裡面，在法庭上，他就站不住腳。

下面就是人為因素裡面所提到的“主張”，要求目標船去遵守避碰規則，只要告訴他，去做正確的事情。這在第 3 章有講過，那時候是，當我們用來提醒我們的上級。現在我們的主張是，提醒應該具有同樣知識水準的他船船副。說出我們所知到的事實，就可以了，我們的呼叫，可以試著如下：

- ⇒ 散裝船，這是超大型油輪呼叫，你正在追越，你要保持遠離我的航線，這是規則 13 條的追越，我的船長要求 1.5 海浬的 CPA，完畢”
- ⇒ 即使目標船說他想要保持航向航速，我們可以告訴他，他是錯的，依照規則，我們可以這樣說，“我恐怕，你並沒有遵守避碰規則 13 條，CPA 已經太近，你需要讓路，否則我要叫船長”。
- ⇒ 如果通訊無法建立，或是在他的駕駛台沒人當值（有可能的），怎麼做？最安全的方法是轉動本船的航向與目標船的航向相同，077 度。兩條平行線不會有交點，也不會有碰撞點，等到兩船已經接近到 1-2 海浬的時候，可以鳴放霧號，他的當值船副就會被霧號叫醒。
- ⇒ 距離碰撞時間是 30 分鐘，本船的速度是 12.7 節，距離碰撞點是 6.3 海浬。
- ⇒ CPA 船長需要的是 1.5 海浬，等於距離 6.3 海浬的人，需要改變的航向是 13.66 度（1.5 nm= 6.3 sin(Ø)，Ø= 13.66）。
- ⇒ 當值船副向右轉了 30 度，如果我們使用這樣的航向改變，來計算新的 CPA，經過半小時的的航行，以速度 12.7 節來計算 ，新 CPA = 6.3 nm sin (300) = 6.3 x ½ = 3.15 (nm)海浬，這個 3.15 海浬，看起來很熟悉，為什麼？
- ⇒ 我們被從預定的航線上，“推開”大約 3 海浬，這不是因為兩條船之間微小的速度差距。
- ⇒ 這是單純因為當值船副的行動，向右轉了 30 度，創造出來的正橫距離，就是 3 海浬。
- ⇒ 當值船副應該主張避碰規則上面的要求，而不是他船想要怎麼做？這個簡單的計算，對資淺船副，或是部份海上的或是岸上的船長，可能還是沒辦法瞭解。當 CPA 已經增加到 1.5 海浬，當值船副就可以回到原航向。
- ⇒ 轉向後，經過三海浬的前進距離，或者是 15 分鐘的時間，當值船副可以知道 CPA 已經有 1.5 海浬後，本船可以回到原航向上。
- ⇒ 這個可以使用平行游標線與本船的原始的航線來比較，或是從電子海圖上讀取橫越航線的距離。

避碰的措施與效果，完全取決於本船所採取的行動，如果對方船隻沒有任何動作，我們要對碰撞點，有所瞭解，才會知道本船什麼樣的避碰措施，是否有足夠的 CPA。

圖形 4-16 目標方位改變 5 度，在四海浬的距離

4-35 Case Study: Example of a Junior collision avoidance time

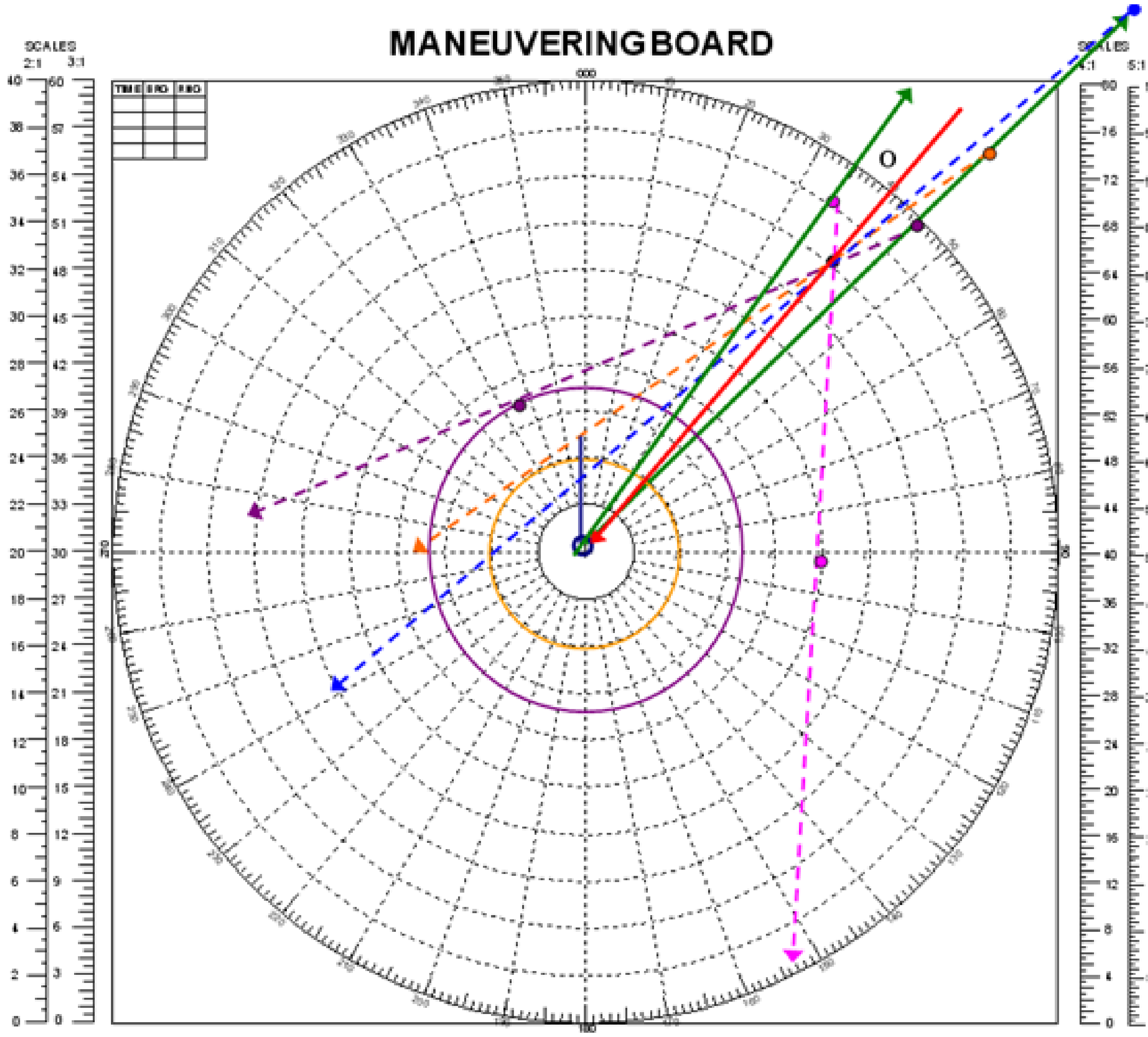
No avoiding action was observed from port side Bulk Carrier and with a CPA of 0.2 miles and TCPA of 30 minutes, we decided to contact her on VHF to ask her intentions. She replied that she intended to maintain course and speed.

We therefore decided to take our own actions and altered course 30° to starboard in order to maintain a safe distance of at least 1.5 miles. By altering to starboard, we let her overtake us at a safe distance. Due to the relatively small difference in speed between these two vessels, *we were 'pushed' off our intended track by about 3 nautical miles*. As we were in the open ocean, we considered this is safest action given the complete ignorance of Bulk Carrier in judging the situation.

We happen to come across this case in web-site. Let's see what wrong in this case.

- This vessel with almost same speed (0.6 knots more, 5% faster) with ownship (when these two vessels have collision risk) and almost same course who is on ownship's port side. Bulk Carrier is either a crossing in rule 15 to give way or an overtaking vessel in rule 13 to give way to ownship.
- If another vessel approaching from about port beam, he is give-way vessel. Give way vessel has no right to maintain her course and speed.
- If ownship has doubt with her intention we should use ALDIS Lamp signals to show our question mark. VHF communication is not recommended in open sea due to problem with positive identification of target, but we can try to verify it by AIS if he had tranmitted.
- If we can identify approaching vessel's name and contact in VHF. Say what others should do, not what you want others to do. There are clear rules in COLREG we can ask others to obey. The way to ask target vessel to observe COLREG is called assertiveness: Claim the right thing to do. We have seen it in chapter three. That's when we should use to remind our superior. Now, this assertiveness is used to remind outside OOW in same knowledge level.
- Once again, speak out the truths as we know. "Bulk Carrier, this is VLCC calling. You are overtaking now. Please keep well clear of my course by COLREG rule 13 Overtaking. My Captain asked for 1.5 nm CPA."
- Even target vessel say he want to maintain course and speed, we can tell him he is wrong in COLREG. "I afraid you are not complying with COLREG rule 13. I am calling my Master.".
- What if the communication cannot establish or there is no one at watch in their bridge what should I do? The safest way is to alter ownship course to target vessel's course 077^0 degrees(t). Two parallel line won't cross each other and create a collision point. Wait until this Bulk Carrier is close enough to sound the whistle to remind his OOW.
- TCPA of 30 minutes, by ownship speed of 12.7 knots, Distance to Collision DTC is 6.3 nm
- CPA requirement is 1.5 nm= 6.3 sin(Ø), required course change of ownship is Ø= 13.66 degrees.
- OOW had alter course 30° to starboard. If we use this course change to calculate New CPA after half hours run in speed 12.7 knots. New CPA = 6.3 nm sin (30^0) = 6.3 x ½ = 3.15 nm. This 3.15 nm looks familiar. Why?
- *We were 'pushed' off our intended track by about 3 nautical miles* is not due to the relatively small difference in speed between the two vessels.
- It is OOW's action (alter course 30 degrees to starboard) push ownship away.
- OOW should assert in what the COLREG's requirement not asking what they want.

This simple mathematic for junior OOW cannot be understanded by some captain at sea or at office. After CPA had increased to 1.5 nm OOW can course again after three nm run or 15 minutes with 30 degrees to starboard side. How can OOW know CPA is already 1.5 nm and ownship can course again now? Use parallel index (or ship’s position) to compare with original course line or read it from ECDIS.



觀測目標的方位變化有 5 度以上，且目標距離上在四海浬以外。

圖形 4-18 目標方位改變 5 度，在四海浬的距離

4-36 246 或 369 海浬橫越義務的改變

在圖形 2-22，在避碰的義務是隨著兩船間距離而改變，我們使用了三個階段，來確認橫越船在避碰規則裡面的義務。如果我們使用 3 海浬的間隔，第一階段是 6 到 9 海浬，兩條船都可以自由運轉，第二階段是在 3 到 6 海浬，讓路船或是直航船必須採取行動來避免碰撞，第三個階段是 0 到 3 海浬，兩條船都必須採取最佳的避碰行動。這 369 的三階段，是對資淺船副在大海上而言，就像是船長對上一個案例的三副要求，CPA 要 1 到 1.5 海浬，我們現在已經是大副了，使用 2 海浬來區分這 3 個階段，246 海浬是比較合適，當目標船在沿岸區域，數目眾多的時候，246 海浬的區分，比較合理。

4-36 246 or 369 nm in crossing obligations change

In figure 2-22 VESSELS OBLIGATIONS IN COLLISION AVOIDANCE VARIED BY DISTANCE: we use 3 stages to verify crossing vessel’s obligations in COLREG with 3 nm interval, 3 6 9 nm. First stage is 6-9 nm where both vessels are free to move. Second stage is 3-6 nm where give-way vessel or stand-on vessel have to take action to avoid the collision. Third stage is 0-3 nm where both vessels have to take best aid to avoid collision. This 3 - 6 - 9 nm stages are for Junior OOW in open sea like CPA requirement is 1.5

nm above. We are the chief now. Use 2 nm to divide 3 stages into 2 - 4 - 6 nm in coastal water are more suitable for avoid collision when target vessels are many.

4-04 目視的技巧：知道方位變化與估計 CPA 多少

4-37 航向的改變對 CPA 會有什麼樣的效果

在上一個例子，我們看到資淺船副在 6 海浬的碰撞距離前轉向，在被追越時，當值船副向右轉向了 30 度。

- ⇒ CPA 的改變在 6 海浬的時候，轉向 30 度是 6.0 海浬乘 2 分之 1 等於 3 海浬（CPA change = 6 nm sin (300) = 6.0 x ½ = 3.0 nm.），如果碰撞距離是 4 海浬，可以產生的 CPA 變化，等於 4 海浬的 30 度，四海裡乘 2 分之 1 等於 2 海浬。
- ⇒ 通常船長會要求 CPA 最少要有一海浬，對於碰撞距離四海浬的時候，需要轉向多少度？
- ⇒ 很可能 CPA 會改變一海浬，是當我們在 4 海浬的時候，航向改變 15 度。這個 4 海浬呢，是距離碰撞點 4 海浬，而不是距離目標 4 海浬，CPA 等於 sin(15０)乘上 4 海浬=1.03 海浬。

4 – 04 Two visual skill: Knowing bearing change and estimate CPA

4-37 What effect of alter course has on CPA adjustment?

In last example we see junior OOW altered course in 6 nm before DTC (distance to collision) for overtaking vessel. If OOW had alter course 30° to starboard at 6 nm DTC away.

- CPA change = 6 nm sin (30^0) = 6.0 x ½ = 3.0 nm. If DTC is 4 nm away it is likely that CPA change = 4 nm sin (30^0) = 4.0 x ½ = 2.0 nm.
- Usually captain would ask for minimum CPA= 1 nm. For DTC is 4 nm away how many degrees course have to change to create 1 nm?
- It is likely that CPA will change one nm with 15 degrees course change if DTC is 4 nm. CPA = 4 nm sin (15^0) = 1.03 nm.

4-38 利用目標方位的變化，來估計新的 CPA 是多少

在我們每天的航行當值，遇到跟碰撞有關的目標，比我們必須要讓路的機會要多。所以讓我們看看，當我們看到目標的方位變化，我們應該對目標的 CPA 如何做出正確的估計。

在下面圖形 4-16，是一個雷達測繪圖紙，本船位於距離圈的中心點，目標回跡移動是相對運動，目標回跡是在相對方位 040 度上面，本船的航向假設為 0 0 0 正北，距離圈的設定，每圈為 0.5 海浬，一個目標他的相對速度向量線，經過第二點。第二點在這裡的討論是，一個固定的藍色的圓點，距離本船四海浬，方位是在 040，目標的原始位置在他的速度向量線上，我們要分開來討論：

- ⇒ 在紫紅色的點：第一點位於 4.5 海浬，方位 035，他的相對運動線是紫紅色的，相對運動的方向是 184 度，他的 CPA 是在另外一個紫紅色點上面，該點距離本船 2.5 海浬，方位 094。
- ⇒ CPA 的定義，是從本船與目標船，兩船之間最短的距離。雷達目標現在是在相對運動線上，也就是從第一點紫色點的位置到第二點藍色點的相對運動線，與距離圈的中心點做垂線，取得的正橫距離，這就是 CPA 的距離，紫色點就是它的 CPA。
- ⇒ 在圖形 4-16，我們可以看到 CPA 的距離是 2.5 海浬，因為他等於 5 圈的距離圈寬度，這是目標方位改變 5 度的來船（以紫紅色點代表）。
- ⇒ 如果目標的原始點是在紫色的圓點上，該點距離是 5 海浬，方位是 45 度，他的相對運動線同樣使用的紫色，相對運動的航向是 247 度，他的 CPA 就是在另外一個紫色點上，距離本船 1.8 海浬，方位是 335 度，所以這一紫色點呢的原始位置。較上一個紫紅色點遠 0.5 海浬，那他 5 度的方位變化出來的 CPA，就是 1.8 海浬。

⇒ 第三個橘色距離 6.0 海浬，方位 045，相對運動線是橘色，相對運動航向是 235。他的 CPA 是在另外一個橘色點上，與本船距離 1.0 海浬，方位 320 度，所以如果她的起始位置是 6 海浬，在距離本船四海浬的時候。方位變化 5 度時，CPA 是一海浬。

⇒ 那這個可以呢作為一個公式，在以後我們估計他船的 CPA 的時候，能夠有一個快速的心算。

⇒ 再遠啊，我們以藍色點距離 8 海浬，方位 045 度來做例子，他的相對運動線是藍色，相對的航向是 230 度，CPA 是在 0.6 海浬。

現在你應該能夠看得出來它的 CPA 是在哪裡，所以由這裡的討論呢，我們也可以知道：
推論：對目標回跡在四海浬的時候，他的原始相對方位改變了 5 度，或是比 5 度更多，他的原來距離如果少於 6 海浬，他的 CPA 就會大於一海浬。
比較的標準呢，當目標距離是 6 到 4 海浬間，方位變化 5 度以上時，CPA 就大於 1 海浬。
這個呢各位可以從圖上得到證明，或者自行做圖測試。不試呢不成主顧，試過以後，你就會有很清楚的概念，下次要讓船時，需要讓幾度？就很清楚了。
如果原始方位改變比 5 度還多，相對方位改變越多，你的 CPA 距離就會越遠，所以方位改變越多越好嗎？這個是事實。
因為方位不變，就是碰撞危機，剩下的當然就是，方位改變越多越好，那我們標準的需求是什麼？目標在 6 海浬到 4 海浬的期間，方位至少要改變 5 度以上，如果船長要求的是一海浬的 CPA。
如果他的原始距離與本船是少於 6 海浬，原始距離越短，同樣的 5 度方位變化，就會產生更大的 CPA 數值。
總結的來說，一個目標起始位置在 6-4 海浬的距離，接近至 4 海浬時，方位變化是 5 度以上，CPA 就大於 1 海浬。這也是我們在目視瞭望的時候，一直在強調的。看到對方船隻的船頭浪，小心啊，要開始評估碰撞危機了。
好，現在呢看起來，要會使用還蠻複雜的，其實那原因只有一個，還不熟悉。但是如果我們願意記得，來船的原始方位跟距離，在雷達螢幕上使用黃色的蠟筆做記號，然後要知道目標的 CPA 時候。再回去檢查他的第 2 個回跡在哪裡，就會非常的簡單。
所以重要的就是，沒時間測繪的時候，先用蠟筆把目標船的回跡在雷達螢幕上，做一個記號，等一下看到他的第 2 個回跡的時候，我們就可以很快的估計出來，它與本船之間的 CPA。
這是很有趣的，如果我們必須等待目標船沿著他的相對運動線，到剛好是 4 海浬的距離，是太累了。我們必須等到目標四海浬再來確定，本船跟他之間的 CPA 有多少？那個時候呢當值船副已經忘了他的原始方位跟距離，對一個熟練的當值船副

- 使用黃色的臘筆來標注目標的回跡，在目標的原始位置被發現時，
- 然後再使用電子方位線的出發點，來對著目標船的第一個回跡，也就是蠟筆畫的位置，
- 旋轉電子方位線通過目標船現在回跡的位置，來建立相對運動線。

這個呢就是簡單版的雷達測繪技巧。只是我們不必去記憶任何數字。立刻可以核對出我們心中的安全範圍，CPA 是否足夠。

4-38 Estimate CPA by target bearing change?

In our daily watch the chance we met collision related target are more than the chance ownship have to give way. Let's see what situation awareness we can get by target bearing change? In figure 4-16 below is a radar plotting sheet. Ownship is at center of range rings. Echo movement is in relative mode. Target echo is in relative bearing. Ownship course 000^0 degrees(T), 10 range rings each is 0.5 nm. For a relative bearing line can be defined by two points on radar screen: first echo and second echo. In figure 4-38
If one target has his relative speed vector passed second echo (blue spot, distance 4.0 nm/bearing 040^0(T)) and original echo in his relative speed vector is varied as below:

- At pink spot = 4.5 nm/bearing 035^0(T). Her relative motion line is colored pink, relative course 184^0 (T). Her CPA is at another pink spot 2.5 nm/bearing 094^0(T). CPA is the shortest distance from ownship to target vessel's relative motion line (perpendicular distance to relative speed vector). We can get CPA by measuring vertical distance to relative motion line. (in figure 4-16, we can see the CPA is 2.5 nm = 5 rings of range rings)

- At purple spot = 5.0 nm/bearing 045^0(T). Her relative motion line is colored purple, relative course is 247^0 (T). Her CPA is at another purple spot near ownship 1.8 nm/bearing 335^0(T).
- At orange spot 6.0 nm/bearing 045^0(T). Her relative motion line is colored orange, relative course 235^0 (T). Her CPA is at another orange spot 1.0 nm/bearing 320^0(T). CPA's bearing is irrelevant to ours discussion.
- At blue spot 8.0 nm/bearing 045^0(T). Her relative motion line is colored blue, relative course 230^0 (T). Her CPA is at 0.6 nm. You should be able to identify where is CPA now.

We can see 5 degrees bearing change will cause CPA change because different CPA distance from radar plotting as above. In these plotting on maneuvering board (radar plotting sheet) we are demonstrating the CPA change due to target bearing changed 5 degrees from different distance (first observed location) to 4 nm distance (second observed location) away. **Now, we try to use these plotting to solve the question of how much CPA target vessel will be if we had observed her relative bearing change in visual lookout.** For target echo at 4 nm (second location in visual), if her relative bearing had changed more than 5 degrees and her first location to ownship is lesser than 6 nm, her CPA to ownship is more than one nautical mile. (please refer to orange color relative motion target)

⇒ **For target locate at 4 nm:** this is **her** second position when ownship observed her relative bearing is 040^0(T)

⇒ **if her original relative bearing had changed 5 degrees more:** more relative bearing change, means more CPA distance will be.

⇒ **her original distance to ownship is lesser than 6 nm:** lesser distance to second location (4 nm) with same 5 degrees bearing change will have more CPA distance created.

⇒ **her CPA to ownship is more than one nautical mile.** In summary, one target at about 4 nm distance away now and her original distance is about 6 nm if her bearing had changed more than 5 degrees then her CPA will be more than 1 nm away.

In radar lookout application, we can save the trouble to remember her original bearing and distance by put a simple crayon pencil mark on her first radar echo (those point of pink, purple and orange) and use this mark as first location of her relative bearing line. After some time when we observed target's ECHO is at 4 nm range ring (her second location is 4 nm) we can use EBL electric bearing line off-center to align these two location (first crayon pencil mark, second radar echo at 4 nm) to know target's CPA will become a simple job for Senior OOW in any time.

OK. This is quite interesting both in radar and visual lookout. If we have to wait for target to moving along the relative motion mode radar to exactly 4 nm range it would be too tire to do so. We have to wait for target arrived 4 nm to make sure what CPA Ownship can have. By that time OOW had forget what are her original bearing and distance? For a prudent OOW, **use yellow crayon pencil to mark target vessel first position** (or echo, distance and bearing) **then offset the Electric Bearing Line EBL to align with Target vessel first echo and Target vessel's current echo position to establish the relative motion line.** This is also the simple version of radar plotting skill.

⇒ mark target echo with crayon pencil when we first saw it at radar screen.

⇒ Using EBL original point off-center to first crayon pencil mark and

⇒ Rotate EBL to overlap target echo now

⇒ Read CPA from this EBL originated from first echo and overlapped on second echo.

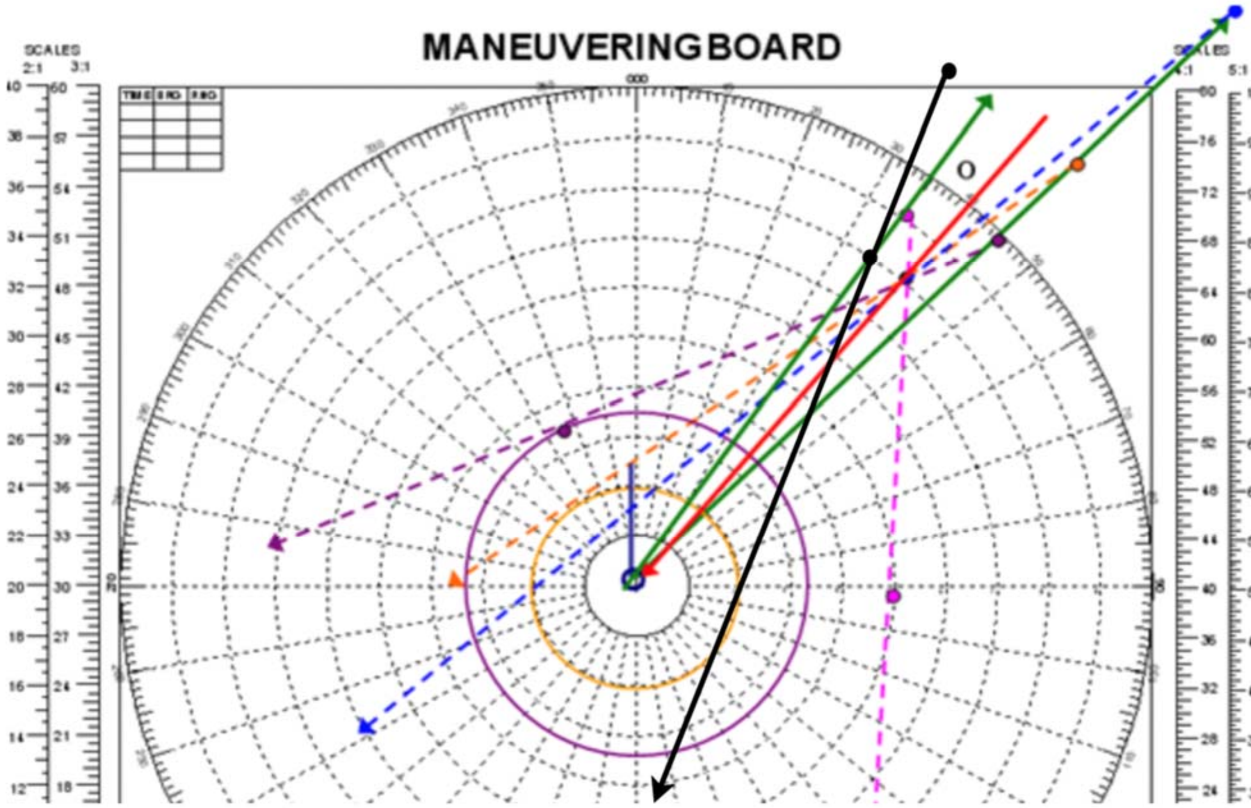


Figure 4-18 Black Target bearing change 5 degrees at 4 nm distance away
圖形 4-18 黑色目標在 4 海浬，方位改變 5 度

例如我們標記在 6 海浬遠的橘色目標回跡，方位為 045 度，使用黃色的蠟筆，離心顯示一條電子方位線，端點呢放在這個臘筆的標記上，一段時間以後，我們旋轉這條電子方位線通過橘色目標現在的回跡上。他的端點仍然在黃色的蠟筆標記上，也就是使用橘色目標的兩個回跡來決定他的相對運動線，就可以從電子方位線讀出它的 CPA 是多少？

如果目標船沒有改變航向航速，就能知道它的 CPA 是多少？現代的阿帕能夠提供相對運動的速度向量線，如果目標呢已經被擷取，圖形化的相對運動線，可以使兩條船會遇的情勢，比阿帕的數字顯示更加清晰。如果我們習慣使用圖形檢查 CPA，阿帕的數位的資料，就不會讓我們更迷惑。

For example, if we mark 6 nm away orange target echo (6.0 nm/bearing 045^0(T)) with yellow crayon pencil and offset one EBL end rested on this pencil mark. After some time later, we rotate the EBL to cross orange target current echo (the end of EBL is still rested on yellow crayon mark), we can read the CPA from EBL is how many? If target vessel maintains her current course and speed, we can read her future CPA from EBL now.

In this day ARPA can provide relative speed vector if the target had been acquired. Graphical relative motion line can make the situation more clear than digital data along. If we used to check CPA in this way ARPA will less confuse to us.

4-39 資淺與資深船副的避碰標準

如果一個目標，他的相對方位是 030 度，並且他的距離是 6 海浬，它的相對運動線，在圖形 4-17 上，是以黑線表示，通過 4 海浬的距離圈時，他的方位是 035 度。那它的 CPA，對本船來說是多少？我想這也是一海浬。這就有點奇怪了，

1. 如果本船希望保持與目標一海浬的 CPA，必須在 6 海裡遠的時候，轉向 10 度，(6 nm x sin (10) = 1.04 nm)
2. 本船希望與目標保持一海浬的 CPA，目標的方位從 6 海浬到 4 海裡的時候，必須改變 5 度，這是圖形 4-16 所看到的。

如果在 6 海浬的距離遠，本船已經轉向 10 度，我們可以檢查目標的方位變化，到 4 海浬的距離時候，是否他的方位改變少於 5 度，他的 CPA 就會少於一海浬。**這個準則可以被資淺船副用來在 6 海浬距離，採取行動時候的標準**。也就是目標 6 海浬時轉向 10 度（他可以檢查目標的方位變化），到 4 海浬的時候，方位變化是否有 5 度？這樣就或多或少知道 CPA 是多少？方位變化比 5 度多，我們就知道 CPA 大於 1 海浬。方位變化比 5 度少，我們就知道 CPA 是小於一海浬。

記得我們在 4-36 資淺船副的三階段避碰義務的時候，已經討論過，資淺船副的避碰階段，應該是以 3 海浬距離來區隔，也就是 369 海浬。

如果本船希望與目標保持一海浬的 CPA，就必須在 4 海浬的距離轉向 15 度，如果希望目標有 1 海浬的 CPA，目標的方位變化，從 4 海浬到 2 海浬必須改變 15 度。讀者呢，對這個觀點，可以從測繪圖紙上面作圖來證明。(4 nm x sin (15) = 1.035 nm，請看黑線方位由 35 度變成 50 度。)

橘色目標的相對運動，現在方位是 040 度的時候，是 4 海浬遠。在 2 海裡距離遠的時候，他的方位是 025 度，所以這個方位的變化，就有 15 度的差別。請參考圖形 4-17，如果本船已經轉向 15 度，在 4 海浬的距離，我們可以檢查目標的方位變化，當他的距離只有 2 海浬的時候，如果目標船的方位沒有改變 15 度，那它的 CPA 或多或少，就是大於或小於一海浬，也就是方位的改變大於 15 度，CPA 就是大於 1 海浬，少於 15 度 CPA 就是小於一海浬。這可以讓資深船副來使用，**當他在 4 海浬的距離去轉向 15 度的時候**，作為自己的一個參考，如果他不需要 1 海浬的 CPA，他就不必轉到 15 度這麼多。資深船副他的避碰規則三個階段的義務不同，應該是以兩海浬的距離來區隔，也就是 246 海浬。

4-39 Criteria of collision avoidance for Junior and Senior OOW

If a target at relative bearing 030^0 degrees and distance is 6 nm, her relative motion line (as black line in figure 4-19) passing 4 nm rang ring at 035^0 degrees, what is her CPA to ownship? I think CPA is 1 nm too. By simple calculation of abeam distance of our avoidance action, one nm CPA need 10 degrees course at 6 nm away :

- Ownship want 1 nm CPA from target have to alter course 10 degrees at 6 nm distance away. (6 nm x sin (10) = 1.04 nm) ------------ First Rule
- Ownship want have 1 nm CPA from target, target bearing has to change 5 degrees from 6 nm to 4 nm distance away. (as figure 4-19) ---------------- Second Rule

If ownship had alter course 10 degrees at 6 nm distance away we will have 1.04 nm beam distance by First Rule. The effectiveness of this course change can be checked by Second Rule: her relative bearing had changed 5 degrees when her distance is 4 nm away. If target's bearing had not changed 5 degrees her CPA will less than 1 nm by second rule. Something must have gone wrong when our OOW had altered 10 degrees course. Maybe target vessel had changed course or her speed after ownship's action. This criterion could be used by Junior OOW **when he takes action at 6 nm distance to alter course 10 degrees by first rule. He can check the bearing change of target at 4 nm distance is 5 degree or not by second rule** to get a rough CPA estimation for reference. Remember we had discussed in 4-36 Junior OOW's three stages of COLREG obligation are divided by 3 nm distance apart, 3-6-9 nm.

- Ownship want 1 nm CPA from target have to alter course 15 degrees at 4 nm distance away.
- Ownship want have 1 nm CPA from target, target bearing has to change 15 degrees from 4 nm to 2 nm distance away. (reader may prove this from the plotting sheet above, observed black line carefully)
- The orange relative motion line at bearing 040 degrees is 4 nm away and bearing 025 degrees at 2 nm distance away, the bearings have 15 degrees difference, please refer to figure 4-19.

If ownship had alter course 15 degrees at 4 nm distance away we can check target's bearing change at 2 nm distance away. If target's bearing had not changed 15 degrees more, her CPA will less than 1 nm. This criterion could be used by Senior OOW **when he takes action at 4 nm distance to alter course 15 degrees. He can check the bearing change of target at 2 nm distance is 15 degree or not** to get a rough CPA estimation for reference. Senior OOW's three stages of COLREG obligation are divided by 2 nm distance apart, 2-4-6 nm.

4-40 在 4 海浬的距離，想要一海浬的 CPA

同樣 CPA 的位移，我們可以這樣子總結：

在 4 海浬遠，要有 1 海浬的 CPA，我們可以改變本船的航向，或是等待目標船的方位變化，要大於 15 度。

利用觀測相對運動線方位的變化，從 6 海浬到 4 海浬的距離圈上的方位讀數變化，我們現在可以預測 CPA。使用下面的規則：6 到 4 海浬的目標，方位變化有 5 度，CPA 就有一海浬。
這是對資淺船副來說，如果我們的觀測時間比較晚，是從 4 海浬到 2 海浬的目標方位，變化需要大於 15 度，才能夠得到 1 海浬的 CPA，對資深船副 CPA 的需求，可以放鬆到 0.7 海浬，那這樣 4 海浬到 2 海浬間，如果目標方位的變化，如果有 10 度，它的 CPA 就有 0.7 海浬。（請參考藍色的相對運動線，因為從 040 變到 030 度，就是從 4 海浬到 2 海浬的方位變化）
實際上，我們並不需要觀測方位變化，我們只需要拉長相對運動線來通過本船附近，（本船就是在固定距離圈的中心點），然後使用固定距離圈，判斷目標的 CPA。如果在資淺船副的班。目標船不多，或是大副已經減少了目標的數目（借由降低本船雷達的增益），就像我們前面在圖形 4-03 裡面所看到的，如果目標數目眾多，大副可能需要，把特定的大型目標，使用黃色的蠟筆標注出來。在長距離是比較容易識別大型目標，如同桑吉輪的案子。大型目標在雷達螢幕上的回跡，在遠距離的時候，比較容易跟漁船區分出來。然後我們可以使用 6 到 4 海浬的目標方位變化規則：也就是 5 度的方位變化，可以得到一海浬的 CPA。
所以我們應該使用搜尋的相對運動線模式，也就是改變相對速度向量線的時間設定，來檢查目標的 CPA，這就是我們在雷達瞭望上的情勢感知。作者並不推薦去記憶方位變化的度數，或是多遠距離的方位變化的度數，需要多少？這些討論，只是讓我們瞭解目標的方位變化，與有多少的安全距離的一個基本概念。

只要我們用蠟筆把目標的回跡，在陸海浬的固定距離圈上做一個標記，碰撞的情勢，就會很清楚，也就是 6 到 4，方位有 5 度，這個船應該是沒有問題的。前提是什麼？還沒有忘吧！它船保持原航向航速。

4-40 At 4 NM to achieve CPA = 1 nm by ownship or target vessel's action

For same CPA displacement we summarized as follow:

our course change 15 degrees at 4 nm will have 1.035 nm abeam distance ($\sin(15^0) \times 4 = 1.035$ nm)

Target bearing change from 4 nm to 2 nm distance away will be 15 degrees if CPA is 1 nm.

At 4 NM to achieve CPA = 1 nm by ownship or target vessel's action,
either the heading of ownship
or the bearing change of target vessel (before 2 nm)
has to more than 15 degrees.

By observing relative motion line bearing change from 6 and 4 nm range ring, we are now in a position to predict the CPA by the rule of:

for junior OOW: 6 to 4 nm target bearing change 5 degrees, CPA = 1 nm.

If our observation is delayed (from 4 nm to 2 nm) target bearing change have to more than 15 degrees to achieve 1 nm.

For Senior OOW: CPA requirement may relax to 0.7 nm then **4 to 2 nm target bearing change 10 degrees, CPA = 0.7 nm.**

(Please refer to blue relative motion line bearing changed 10 degrees from 040 to 030 degrees (from 4 nm to 2 nm)).

Actually, we don't need to observe bearing change we only need to prolong the relative motion line to pass around ownship (at center of radar in relative motion) and judging CPA distance by fixed range ring if the vessels are few for junior OOW or Chief officer had reduced target number by reducing the GAIN of target as we said before in figure 4-03. If the targets are many, chief mate may need to locate specific large target with crayon pencil mark (large target is easy to identify in long range than close range as Sanchi's case) and use the rule of 6 to 4 nm target bearing change 5 degrees to get CPA = 1 nm. So, we should use relative motion line in manual searching mode (varied the range ring setting by her relative speed vector) to check CPA of target. This is our situational awareness in radar lookout. I don't recommend to remember how many degrees change before how many distances away but to use crayon pencil mark.

As long as we can mark target echo with crayon pencil at 6 nm range collision situation will be much more clearer to ownship.

4-41 相對方位變化的直覺

現在我們要回到目視瞭望的基本概念，然後做進一步的運用。目標的方位變化，是在本船航向航速不變時，所觀測到目標的方位變化 。不論他是真方位或是相對方位的變化，差別只是方位度數的差距，而不是測量方位的基準是真北？還是船艏向？真方位的變化量必須由羅經複數器，或是雷達的螢幕上讀取，像之前所討論的。相對方位的變化，我們可以使用目視的技巧來做估計，

- True bearing 1 ± heading = relative bearing 1 --- ①
- True bearing 2 ± heading = relative bearing 2 --- ②

真方位加減船首向就等於相對方位，如果這是第一點的方位。第二點的真方位加減船首向就等於第二點的相對方位。方位的變化呢等於第二點的方位減掉第 1 點的方位，真方位的變化等於相對方位的變化。

圖形 4-18 一個貨櫃的寬度是 4 度的方位變化

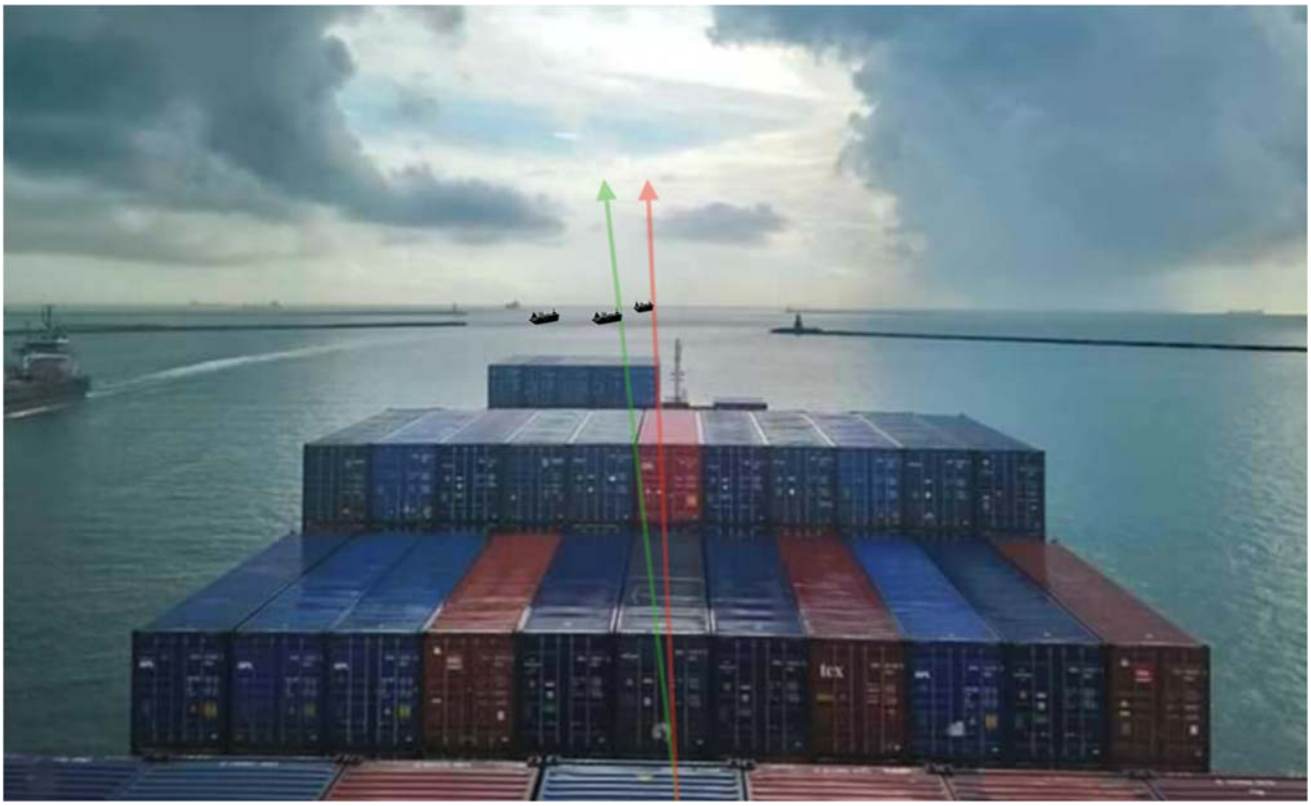
4-41 Relative bearing change we can get it from our visual instinct

Now let's look back to basic visual lookout skill with advanced application. If ownship maintained current course and speed, how many bearing had changed can be observed from True bearing or relative bearing. True bearing change have to get from compass repeater or Radar Screen as we discussed before. Relative bearing change we can get it from our visual skill.

- True bearing 1 ± heading = relative bearing 1 --- ①
- True bearing 2 ± heading = relative bearing 2 --- ②

Bearing change = ②-① =True bearing 2 - True bearing 1 = relative bearing 2 - relative bearing 1

Bearing change = ②-① =True bearing change = Relative bearing change



圖形 4-20 一個貨櫃的寬度是 4 度的方位變化

我們討論很多在 4 海浬的距離，目標的方位如果有變化的話，它對 CPA 會有什麼影響？例如在 4 海浬的距離，本船轉向 15 度，或是目標船的方位已經改變了 5 度，CPA 應該是多少？作為一個大副，我們應該要有的第一個直覺：首先是要知道目標相對於本船的距離，是在 4 海浬左右，這是他看到目標船的時候，就應該做出的直覺性判斷。利用他的目視技巧，他又怎麼能夠知道目標船的方位變化多少度？

現在讓我們看看相對方位變化，在圖形 4-18 時，一個貨櫃寬度的方位變化是多少？用貨櫃的櫃腳作參考點

當一個目標的方位參考點，紅線是在右邊的櫃腳，利用同一個貨櫃的左邊櫃腳，用綠線代表，方位變化是 4 度。圖形 4-18 一個貨櫃的寬度代表 4 度的方位變化。如果對更左邊沒有標注方位線的同型目標船，他的原始方位是在紅線，我們怎麼估計他現在的方位變化有多少？

（答案就是大約 12.5 度的方位變化）

We had discussed a lot what change will happen to CPA at 4 nm range when ownship had 15 degrees course changed or target bearing had changed 5 degrees. Chief mate should have first instinct in knowing target distance to ownship is at 4 nm immediately by his visual skill. What about his instinct to know how many bearings had changed in visual? No knowledge comes no skill. No skill nourishes no instinct. Now let's look at Relative bearing change in Figure 4-20. The bearing will change as visual reference point changed from this container corner post to another: When a target relative bearing reference point is at right corner (red line) then move to left corner of same container (green line), how many degrees' relative bearing had changed? We don't need to do wild guess. We can read its relative bearing from bridge centered gyro repeater. Target vessel's bearing change is 4 degrees as figure 4-20 shown. **One container (width of 8 and half feet) in first bay has 4 degrees bearing change.** By this knowledge, we can practice our skill in relative bearing changed estimation. Now check the third vessel to our port bow we had not marked with bearing line what is her bearing changed if her original bearing line is red one? (Answer is about 12..5 degrees)

4-42 多兩個目視瞭望的知覺：目標的方位變化跟 CPA

當我們做資淺船副的時候，練習的目視技巧是分兩部分：目標的距離多少與方位變化。如果目標的相對方位增加，它就會通過本船的船尾。如果目標的相對方位減少，它就會通過本船的船頭。只有這樣，我們並不知道目標通過的最近距離，也就是 CPA 是多少？當我們做了大副的時候，我們的目視能力，多了另外一項技術，知道目標的方位改變了幾度？利用目視的技巧來判斷。使用判斷方位變化度數的技巧，再確認目標的最近距離，可以估計目標通過的 CPA 是多少。

一個貨櫃的標準寬度是 8 尺半，國際標準的櫃腳寬度。但是這八尺半的寬度，代表幾度的水準夾角，在每條船上面是不一樣的，因為貨櫃跟觀測者的距離不一樣，也就是有的貨櫃離駕駛台比較近，他的水準夾角呢就比較大，同樣的貨櫃離駕駕台比較遠，他的水準夾角呢就會比較小（花開效應）。

我們可以使用貨櫃的水準夾角，在不同的櫃池(Bay)的位置（在本船駕駛台前面的距離），來估計目標的水準方位的變化。我們使用來校對目標方位變化的貨櫃，離駕駛台有多遠，並不重要。我們可以使用羅經複述器來測量，不同的櫃池貨櫃櫃角之間的方位變化，在我們以後做方位變化估計的時候，就有一個標準。並希望能由經常的比較呢，產生對目標方位變化度數的一個直覺。

在圖形 4-18，一個貨櫃寬度是 4 度的方位變化，這有一條紅色的方位線是在左舷 2.7 度的櫃角上，也就是最接近前桅杆的那一個櫃子，綠色的方位線，是在這個貨櫃的另外一個櫃角上，方位是左舷的 6.7 度，貨櫃的寬度在第一 Bay 就是 6.7 度減掉 2.7 度等於 4 度。

如果我們跟著這兩條方位線去觀測，我們可以看到紅色的貨櫃在本船正中間這一列，有大約 10 度的水準夾角，在他後面的兩個櫃角上。

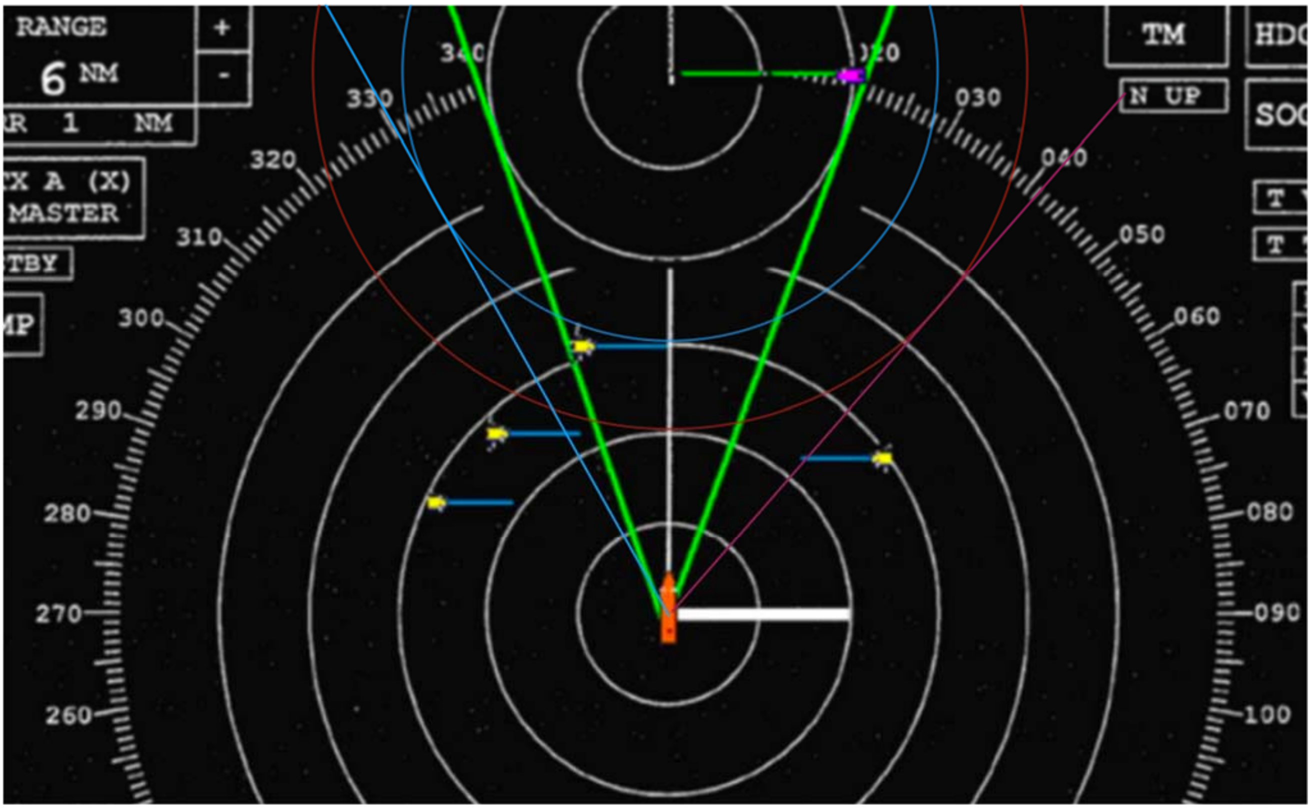
這些貨櫃櫃角的水準方位差距，可以被當值船副所利用，找出最適合的甲板貨櫃，做每日方位變化的比較參考之用。如果本船不是貨櫃船，船副可以使用前桅杆上面瞭望台的左右兩側，作為水準夾角的參考，也就是前桅裝設雷達跟霧號的平臺，作為標準的水準夾角參考。他的水準角度是多少？可以事先測量過，如果前桅杆平臺的水準夾角太小了，我們可以使用其他的裝備，或是甲板艑裝，作為比較水準夾角的參考。借由這些練習，資深船副能夠記得第一個視覺參考點的人，那他就能夠估計目標的方位變化，當他由駕駛台的原來位置，去重新觀測目標的方位變化，他就能夠估計出目標的 CPA。當然對這兩個視覺參考點所採用的目標距離，也是我們關切的事項之一。目標的 CPA 不是最重要的東西，最重要的東西是：**記得方位變化的度數，在多遠有多少？**是否足夠安全的避碰。最後的 CPA 數值，只是讓我們對安全的範圍，有一個概念。

圖形 4-21 安全相對方位，對 1/3 半速與 2/3 速度的目標

4-42 Two more awareness we can get from visual lookout: Target's bearing change and CPA

When we are junior OOW we practice visual lookout skill in two parts, verified bearing and distance change of targets. If target's relative bearing increased, she will pass ownship's stern. If target's relative bearing decreased, she will pass ownship's bow. Only by then we don't know closest passing distance of target (CPA). When we become chief mate, our visual ability has one more skill: **Knowing how many degrees Target Bearing had Changed by visual.** Together with our skill to verify target's distance to ownship we can estimate the CPA of passing target. One container width is an international standard= 8½ feet. The horizontal angle of this 8½ feet width is different according to his distance to observer (or ship's type and length). Those containers close to observer look like bigger and occupy more horizontal angle than those containers far ahead. **We can use the container width at different bay (longitudinal location to load container) to estimate the horizontal bearing change of target.** We can use compass repeater to measure the bearing difference of container on deck at different bay for later bearing change estimation.

In Figure 4-20 One container space is 4 degrees bearing change, we have red bearing line 2.7 degrees to port side at aft end in first bay container and green bearing line of this containers another end at 6.7 degrees to port side. This container's width at first bay is $6^0.7 - 2^0.7 = 4^0$ degrees. If we use these two bearing lines to observe, we can see the red container at center row aft of first bay has about 10 degrees horizontal angle between her two aft corner fitting. OOW can decide most suitable horizontal bearing reference point on deck can be used for daily usage which should be decided before voyage begin. Beside the container vessel, OOW can use the horizontal bearing of fore mast platform (for radar and fog horn) as a standard horizontal angle reference if its horizontal angle had measured beforehand. If horizontal angle of fore mast platform is too small to use we can use other deck cargo or deck fittings. By remember location of first reference points on deck Senior OOW will be able to estimate target's bearing change when he come back to observe target's bearing again and estimate the CPA of this target (part of his visual awareness in CPA).



圖形 4-21 安全相對方位，對 1/3 半速與 2/3 速度的目標

4-05 安全的相對方位：橫越船

4-43 SRB 對 3 分之 1 速度目標是 20 度

如果我們有能力在看到目標的第一眼，就能夠判斷出他的碰撞危機，那我們的目視瞭望就會比以前更有效率。在圖形 4-19 雷達畫面的設定是像這樣子的：

- 速度向量線是真運動
- 本船的速度是 6 圈，目標船的速度是 2 圈，也就是本船與目標船的速度比例是 3 比 1。
- 我們是 6 節他就是 2 節，我們是 12 節，他就是 4 節，如果我們是 18 節，他就是 6 節的速度。
- 本船的航向是 000 正北，本船的位置現在是在雷達的中心點，雷達畫面現在是 6 海浬的距離。
- 假如本船發現紫色目標的速度是本船的三分之一，在 6 海浬遠的時候，他的方位是 020，他的速度是本船的三分之一，（在這邊是以兩個距離圈的長度來代替）他的船首向是正西 270 度。

本船跟紫色的目標具有碰撞危機，兩條船就會同時到達同一個碰撞點。碰撞點就是在本船現在位置的 6 海浬之前。方位呢就是在本船的船首向上 000 度。在這一個碰撞點，我們把他再加了兩個距離圈來代表目標的速度，也是方便讀者比較目標船跟本船的速度比例是多少？目標船的

可能位置，一定是在距離碰撞點兩海浬的這一個距離圈上面，因為本船可以前進的距離是 6 圈，假如我們不是以每小時來計算，可能是以同樣 30 分鐘的碰撞時間，可能是 20 分鐘，或是 15 分鐘，所以本船的前進距離是 6 圈的話，依照比例紫色目標的前進距離就是兩個距離圈，三分之一本船的速度。它的最後位置也就是碰撞的位置，跟本船的碰撞位置是相同的，因為我們跟他有碰撞危機，那這個碰撞點是在本船船首向前面的 6 海浬的位置。

好！現在呢！還是有點亂，不過我們再試試看，重新再理順一下。

1. 如果目標跟本船都會同時到達碰撞點的位置，目標船現在位置，一定是在碰撞點週邊，兩海浬的距離圈上面，這個距離圈的中心點就是碰撞點，目標船要跑的距離是 2 海浬，或者是兩圈的距離，所需要的時間，跟本船要跑 6 海浬或是 6 個距離圈的長度，時間是一樣的。當本船可以前進 6 圈的時候，目標船隻能前進兩圈的距離，如果目標與本船，在本船六圈的距離之外會碰撞，他的位置一定是在碰撞點週邊第二圈的距離圈上面。
2. 如果具有本船三分之一速度的目標，位於第二圈的距離圈更外面，目標船就不會跟本船同時到達碰撞點，他一定是比本船慢到，三分之一船速的目標在第二圈的外面，會比本船慢到，那就不會發生碰撞，因為本船已經通過了碰撞點，目標船才到達。（但這個並不包括追越／被追越船在安全相對方位，本船左右舷相對方位 20 度之內，因為這個方位之內的追越／被追越船，會被本船先撞到。）
3. 如果具有本船三分之一速度的目標，位置位於第二圈距離圈之內，那這條三分之一速度的目標，會先到達碰撞點。當本船到達碰撞點的時候，目標已經通過碰撞點。

如果我們的理論是正確的，紫色的目標只有三分之一本船的速度，就應該位於碰撞點週邊第二圈距離圈上，才會有碰撞危機。假設目標的相對方位，是從他為在第二個白色的距離圈上面的可能位置上面量取，則它的最大的相對方位（對這第二圈的距離圈），是用兩條綠線來代表，這兩條綠色的相對方位線，代表他最大的可能方位，具有本船 3 分之 1 速度的目標，他的安全相對方位 SRB。

4 – 05 Safe Relative Bearing SRB in crossing vessels

4-43 SRB for 1/3 speed target is 20 degrees.

If we have **the ability to know collision risk at first sight** then our visual lookout will be much more effective than ever before. In Figure 4-21. The setting of this radar screen is as below:

- The speed vector of target is in True Motion and Radar screen is set at 6 nm range.
- Ownship at center of radar our speed is 6 knots (6 rings run) and heading is north 000^0(T)
- Target vessel (pink echo at 020 degrees and 6 nm away) her speed is 2 knots (2 rings run), her heading is 270^0(T).
- The collision point according to speed vector intersection point will be at 000^0 x 6’ away from now.

OOW find this pink target vessel speed is 1/3 of ownship who has collision risk with ownship after one hour run. Her speed is 2 knots comparted with ownship 6 knots(one third of ownship represent by green speed vector). Ownship has collision risk with purple target now. Both vessels will arrive same collision position 6 nm ahead/ bearing 000 degrees from ownship after one hour. If the collision is due to happen with ownship maintain current course and speed (0000(T) x 6 Knots), the target’ s possible position with 2 knots speed must be located on concentric circle’ s second white ring. With her final position (collision point) same as ownship (in the center of concentric circles 6 nm ahead of ownship), her original position have to locate on white circle drawing with 2 nm semidiameter for the collision to happen. It is hard to understand now. But, we will try

1. If target will have collision with ownship at the same time, the target with 1/3 speed position must on the white circle of 2 nm semidiameter concentered at ownship 6 nm distance ahead. The time for 1/3 speed target to finish 2 nm or 2 rings run is the same as ownship to finish 6 nm or 6 rings run (one

hour). When ownship advance 6 rings, target vessel can advance only 2 rings. If target collides with 6 rings away ownship, his position must be on the white second concentric circle.

2. If target with 1/3 speed locate outside second concentric circle, target vessel will not arrive collision point at the same time as ownship. 1/3 speed target outside second rings will arrive collision point later than ownship. No collision will happen when ownship had passed collision point.
3. **But it does not include overtaking vessel within relative bearing 20 degrees from both side of ownship.** The reason is simple because within these bearing range is dangerous bearing.
4. If target with 1/3 speed of ownship locate inside second concentric circle, 1/3 speed target will arrive collision point earlier than ownship. When ownship arrived collision point, target already passed.
5. **But it does not include overtaking vessel within relative bearing 20 degrees from both side of ownship.** The reason is simple because within these bearing range is dangerous bearing.
6. In summary, target with 1/3 speed outside **relative bearing 20 degrees from both side of ownship will be safe.**

If our theory is correct pink target with 1/3 of ownship speed should located at second white concentric circle. Pink target relative bearing measured from her possible position on second white concentric circle will be within **relative bearing 20 degrees to both side of ownship.** The maximum relative bearing of 2 nm white concentric circle is represented by two green lines. These two green relative bearing lines is maximum bearing of 1/3 speed target possible position on second white concentric circle which is Safe Relative Bearing SRB for all 1/3 speed target vessels. These rules can be applied to all target vessel with one third of own ship’s speed. For example:

- if ownship is 18 knots, target speed is one third of 18 knots = 6 knots can be applied.
- If ownship is 12 knots, target speed is one third of 12 knots = 4 knots can be applied.

4-44 如何第一眼就看出碰撞危機？

對三分之一速度的目標，如果他的相對方位是大於 20 度，也就是目標位於碰撞點距離圈的週邊，這個三分之一速度的目標到達碰撞點的時間，就會晚於本船。換句話說，本船與這條 3 分之 1 速度的目標，不會有碰撞危機。我們可以測試這個安全相對方位 SRB：safety relative bearing 的正確性。

使用螢幕上黃色的目標，當本船到達第三圈時，3 分之 1 速度的目標只能前進一圈的距離，只有本船左舷 20 度的黃色目標，跟本船有碰撞危機。其他的三個黃色目標（速度向量線時間長度是紫色目標的一半），不管它是往什麼樣方向開，他的船首向是多少？都只會通過本船的船尾，也就是被本船拋在後面。

好了，在前面我們開始說的是，**如何第一眼就看出碰撞危機？這個能力呢是包括了三種的知識**，當我們的眼睛放在目標上面，我們要有能力，知道他的相對方位，目標速度的知識與安全相對方位 SRB 的角度大小。

1. *知道他的相對方位*，那這個要參考圖形 4-18，或者是更早的第一章圖形 1-07 這些甲板的舾裝，可以事先測量決定方位參考點的相對方位是多少？然後謹記在心，無論何時，目標在這個參考點附近出現，我們就會立刻知道他的相對方位是多少？
2. *目標速度的知識*，這個呢就沒有那麼簡單，它的速度只能由他的 AIS 資料，或是他的速度向量來得知。但是一旦我們有了目標的速度，與本船速度的比例是多少，我們必須記得它的輪廓是什麼，下一次當我們看到這一類型的船隻，再度出現，我們就能夠立刻知道他的速度大概是多少？感覺這個過程呢是不太合理。其實呢這樣子也沒什麼不合理，因為呢同型船大部分都是成群出現，就像漁船一樣，單拖一堆，雙拖一堆，就像在中國海，印度洋，日本海，在同一個國家，經常都是同型船，使用國產相同的主機型式跟速率，如果其中一條船的最大速度是 7 節，那我們可以估計其他長得差不多的漁船呢，具有相同的輪廓，最大的航速也會是是 7 節。

3. *安全相對方位 SRB 的角度大小*，跟目標的船速，跟本船的船速是成比例。目標的距離呢，跟他的安全相對方位角度大小是無關的，只要知道他的安全相對方位是多少？那不論目標跟我們的距離遠近是多少，都不成問題，只要目標的方位大於安全的相對方位，本船就會晚到達碰撞點，本船就安全了。

但是這樣的想法，會忽視目標的水準夾角的變化，尤其是當他在近距離的時候，所以呢我們還必須考慮，也就是目標的水準夾角放大的效應，在近距離發生。當我們使用安全的相對方位，在近距離的時候，目標的水準方位增大值，要加到安全的相對方位這裡面去考慮，有的目標船，特別是在近距離的大船，他的水準方位可能達到 10 度，20 度的水準夾角。
如同圖形 2-38 所討論的，經過這 3 點的考量，**當值船副應該瞭解安全的相對方位 SRB，對小型的近洋船隻相當管用**，因為他們的數目眾多，速度緩慢。

4-44 Judging collision risk at one look

For 1/3 speed target, if her Relative Bearing is over 20 degrees (outside second white ring), she will arrive collision point later than ownship. In another words, **no collision risk with 1/3 speed target if her relative bearing is over 20 degrees.** Reader can test this SRB (Safe Relative Bearing) correctness with yellow targets on our port bow. If ownship speed is 3 knots when ownship arrived 3 rings location ahead, this 1/3 speed yellow target (speed one knot: 1/3) can reach 1 ring distance only. Only the one within ownship port side 20 degrees will have collision with ownship. **Other three yellow targets no matter what direction she is sailing will pass ownship's stern (ownship will pass collision point first).**
Well, what we said in the beginning is judging collision risk at one sight. This subject to three kinds of knowledges when we laid our eyes on targets:

1. the ability to know her relative bearing by one sight: please refer to figure 4-20 or earlier at chapter 1 figure 1-07. Those deck fittings' bearing can be determined beforehand and memorized at heart. **Whenever target appears around these deck fitting, we will know its relative bearing immediately.**
2. The knowledge of target's speed: Well, this is not that easy by visual. Her speed can only be known from her AIS or her speed vector comparison on radar. For coastal vessels, when we have the target speed (in ratio to ownship's speed) in mind, we have to remember what their silhouette (look like) is. Next time when we saw this kind vessel again, we can estimate her speed immediately. This process may seem not reasonable. No, **this kind of slow speed vessel usually come out in group like fishing boat.** In different part of world like China Sea, India sea or Japan sea, they all have similar shape in their coast in identical engine type and speed. If one of this fishing has 7 knots speed we can estimate other fishing boat look like the same will have same maximum speed of 7 knots as others.
3. As the speed is in ratio to ownship's speed, target's distance is irrelevant to her safety relative Bearing SRB. As long as this kind target bearing is outside the limit of SRB, it will be left behind ownship. Ownship is safe then. But, this thought may overlook the danger of horizontal angle augment of target when she is in close range. We need to consider blossom effect of target in close range. **When we apply SRB in close range, horizontal bearing augmentation of target need to add into SRB rules.** Some target vessel especially big vessel in close range her horizontal bearing may up to 10, 20 degrees more as Chapter 2-38 had discussed.

After these three points discussed **OOW should understand SRB only useful in small coaster vessels** when their number are many and speed are slow.

4-45 6 分之 1 速度目標的安全相對方位是 10 度

利用另外一個黃色的目標船為例子，它具有本船六分之一的速度，如果這條 6 分之 1 速度的目標船，跟本船有碰撞危機。那他的船位應該是位於碰撞點週邊的第一圈，當本船前進了六圈的距離，目標船才能前進到碰撞點的位置。這黃色目標的安全相對方位大約是 10 度，這個跟我

們在圖形 2-23 的結論一樣，向右舷轉向超過 10 度，對具有本船 6 分之 1 速度的船隻，當它有碰撞危機時，就可以避免與他的碰撞，如果他保持原來的航向航速。如果一條 6 分之 1 速度的目標，位於本船 3 海裡的距離圈，就像在圖上顯示目標在本船的左船頭，本船會經過這個碰撞點，早於這個黃色的目標。總共有四條黃色的目標，具有本船六分之一的速度，其中三條位於 10 度的安全相對方位之外，都不會跟本船發生碰撞危機，如果本船不改變航向航速。如果目標是小型船隻，他們的水準夾角是 4，5 度左右，即使是在近距離的時候，就像我們在圖形 2-05 觀測到的目標的方位變化。

4-45 1/6 speed target vessel's SRB is about 10 degrees

Let's take another yellow target vessel with 1/6 speed of ownship for study. If this 1/6 speed target have collision risk with ownship she has to locate at first white circle around concentric collision point (when ownship sailed 6 rings ahead). Yellow target's SRB is about 10 degrees. It coincided with our conclusion in figure 2-23. **Altering course more than 10 degrees to starboard side for vessel with one sixth (1/6) speed and have collision risk with ownship, ownship can avoid her if she keeps her heading at that time.** If one 1/6 speed target bearing 300 degrees located at ownship's 3 mile range rings as the one on ownship's port side, ownship will pass collision point before yellow target. These three yellow targets with 1/6 speed outside 10 degrees SRB has no collision risk with ownship in any way. If the target is small vessel their horizontal angle will be about 5 or 6 degrees in very close range as we observed in Figure 2-05.

4-46 資深船副的經驗要用在哪裡

安全的相對方位，他們的水準方位參考點可以從圖形 1-07 取出，使用油輪上固定的甲板舾裝作為參考的標記，做相對方位的核對之用。

當大副看到一條三分之一速度的目標，SRB 等於 20 度，似乎呢在相對方位 30 度的方向出現，大副呢並沒有很注意他的動態，這個就是實習生感到最奇怪的地方，當他看到這些資深的船副，並沒有在阿帕上面擷取目標，仔細對這些目標做方位的測定，也從來沒有認真的瞭望，好像也沒有碰撞危機的麻煩。看起來就是，只有膽子大的人，才能夠在海上生存。我的膽子太小，在這一個行業無法存活，其實不是這樣的，這不是事實。安全的相對方位就解釋了，為什麼有經驗的資深船副的做法，因為他知道漁船的速度，與相對方位的參考點在哪裡？以及目標現在的距離，離本船有多遠？但是現在目標的最神秘的部分，還沒有解決，那就是目標的速度是多少？這可以由雷達或是 AIS，對當地漁船的知識，或是當地工作船與補給船的瞭解來得知。

4-46 What Senior OOW are doing with their experience

The SRB horizontal angle reference can be taken out as figure 1-07: use tanker fixed deck fittings as reference mark for relative bearing checking. When chief mate saw a 1/3 speed target (SRB= 20 degrees) appear at relative bearing 30 degrees direction chief mate did not pay too much attention to it. This is the mystery an apprentice saw at bridge those Senior OOW did not acquire target at ARPA and did not take bearing of it. They had not lookout carefully and always have no problem of collision risk. It seems like only those who has guts can survive at sea. I am too nerves for this career. No, this is not truth. SRB explained what Senior OOW are doing with their experience (knowing no threat from local target's current speed and relative bearing reference mark and target's distance away from ownship now). **Now the unsolved part is the speed of the target.** Target speed have to get from radar or AIS or local speed knowledge of fishing boat or working boat.

4-47 在這種情況下，大副的心裡在想什麼？

在下面圖形 1-07，大副看到在左舷有一條帆船，距離很接近，要見習船副告訴他，這一條帆船的速度是多少？這個見習船副正呢忙著在阿帕上面，檢查目標的 CPA，與方位是否有變化，回答道“6 節”，這就是本船速度的一半，大副又看了看帆船，就不講話了。在這個狀況下，到底大副的心理是在想什麼？看著窗外的帆船，大約是在本船的 45 度方位，利用甲板吊杆位

置，也就是這條綠線來判斷，對於速度是本船二分之一的目標，安全相對方位是 60 度的一半，（以後會再做探討）知道是 30 度。基本上來說，這一條帆船是沒問題的，但是帆船的距離已經非常近，就像我們已經看到他水線上白色的水花，為了安全起見，我們應該繼續觀測它的相對方位，是否有增加？如果方位增加的非常慢，本船應該向右舷避讓，這是有兩個理由，在避讓的第三階段，也就是近接的階段，本船必須採取最有助於避免碰撞的行動。第二是動力船隻應該讓路給帆船。

圖形 4-20 相對方位的運用與他的限制

4-47 What chief mate has in mind of this situation?

In figure 1-07 below, Chief mate saw a sailing boat at port side. The distance is close. Chief mate asked cadet officer what speed this sail boat has? The cadet officer who is busy on ARPA to check target CPA and bearing change replied “6 knot” which is 1/2 of ownship’s speed. Chief mate looks at sail boat once again and say nothing. What chief mate has in mind of this situation? Looking out the window, the sailing boat is about 45 degrees to our port side judging by the crane on deck (green lien). The speed is ½ of own speed which SRB is ½ of 60 degrees = 30 degrees(?). Basically, this sailing boat is OK. But the distance of sailing boat is very close because we can see his white splash at water line. For safety reason, we should observe his relative bearing increase or not. If the bearing increased very slowly ownship should alter course to starboard to avoid the collision for two reasons. In third stage (close quarter stage) ownship have to take actions as best aid to avoid collision. Second reason is power driven vessel should give-way to sailing boat.

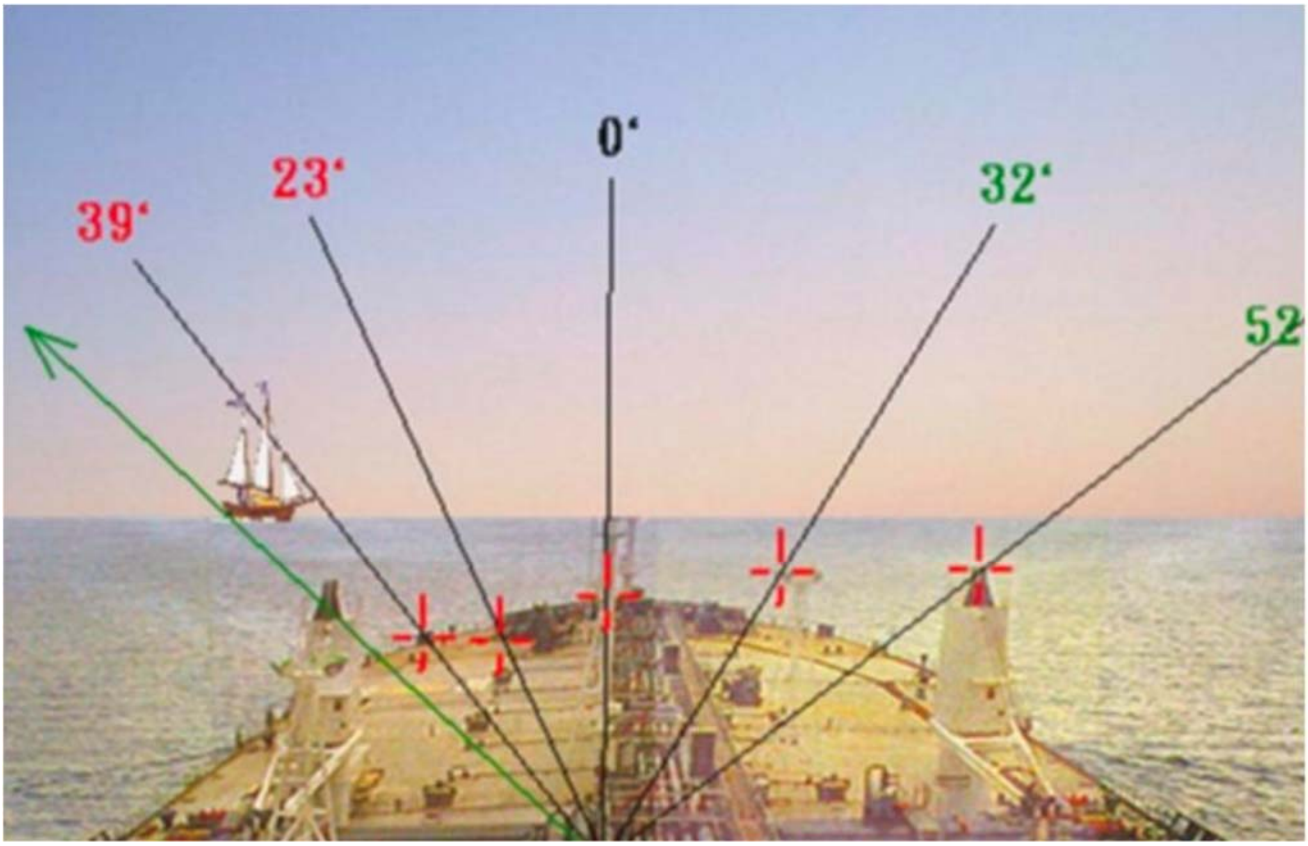
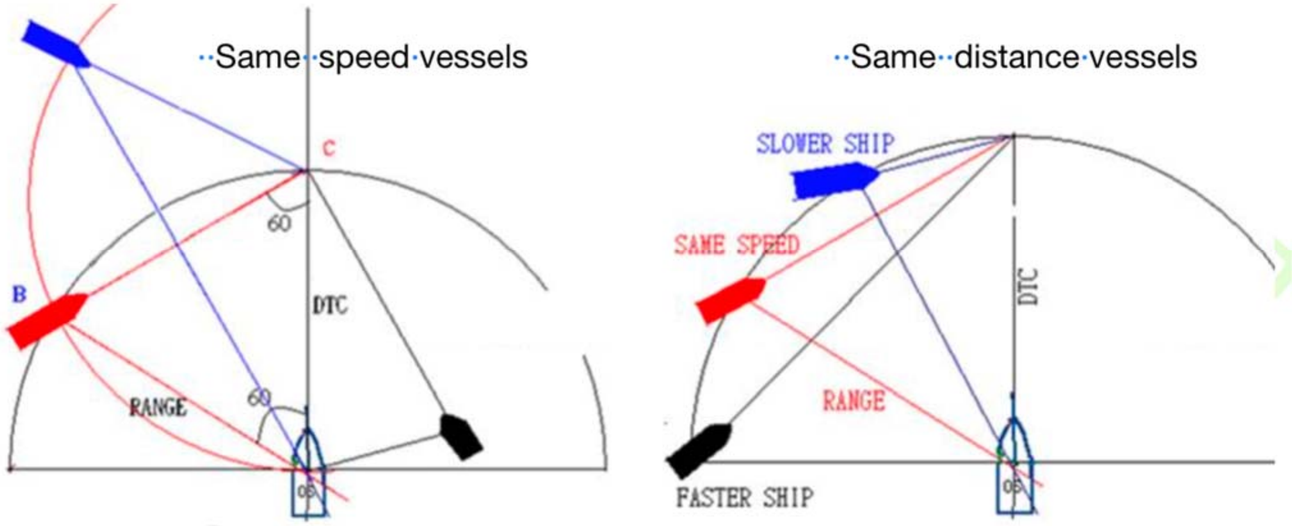


Figure 1-07: use tanker fixed deck fittings as reference mark for bearing checking



圖形 4-22 相對方位的運用與他的限制

4-48 安全相對方位運用的限制

圖形 4-22 左圖，紅船與本船具有同樣的速度，他的接近方位是位於紅色的圈上，我們看到他的相對方位的範圍，是從 0 度到 90 度，在我們的左舷。請看圖形 4-19 安全的相對方位：

- 對三分之一速度的目標船是 20 度，碰撞點的第二圈白色來代表。
- 對二分之一速度的目標，他的安全相對方位是 30 度，用藍色圓圈碰撞點外面的第三圈來代表。
- 對於 3 分之 2 速度的目標，安全相對方位是 41 度，紅色圓圈用碰撞點外面的第四圈來代表。
- 對速度 6 分之 5 的目標，安全相對方位是 55 度。

安全相對方位的規則，大致如下：目標船的速度比本船慢的，可以有個大約的公式，來求得他的安全相對方位。

- 對三分之一速度的目標 SRB 是 60 度的 3 分之 1=20 度。這是我們已知確定的。
- 二分之一速度的目標，他的安全相對方位是 60 度的二分之一等於 30 度。
- 對於 3 分之 2 速度的目標。他的 SRB 是 60 度的三分之二等於 40 度。實際上的 SRB 是 41 度。這是有 1 度的誤差。
- 6 分之 5 速度的目標，SRB 是 50 度，但是實際上的 SRB 是 55 度。

對於同樣速度的目標，我們的最好還是在雷達上面做瞭望，而不是只用目測來估計。在安全相對方位的運用上，我們的假設是目標保持它的航向航速，目標實際上的大小，跟他在船尾的水準夾角，並未列入估計。**所以大型船隻不要使用安全的相對方位，是比較老練的做法**，因為我們對這些船隻的船型，跟他的速度不熟，並且對於速度超過本船三分之二的船隻呢，也不建議使用，因為會有相當的誤差，安全的相對方位，主要使用在漁船或是當地的工作船補給船。
本船速度一半的船隻，他的安全相對方位是 60 度的一半等於 30 度

4-48 The limitation in SRB application

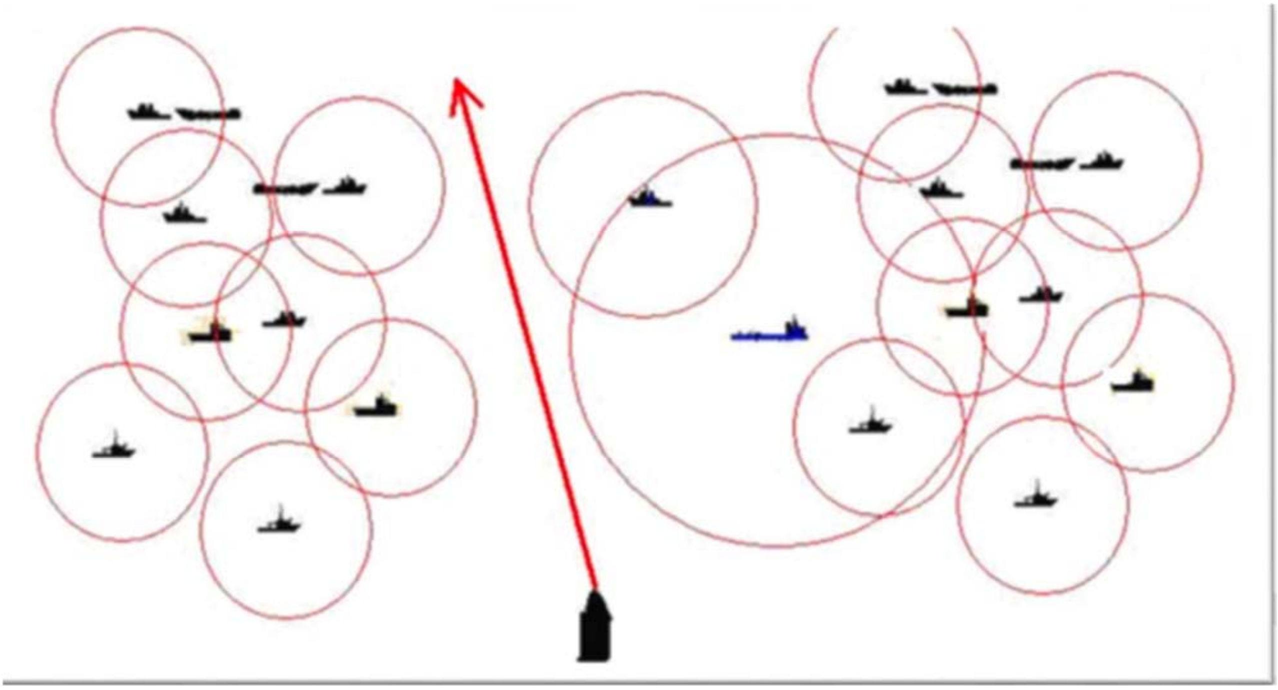
In figure 4-22: the red vessel has same speed as ownship. Her possible collision position with ownship located on red circle. We can see her relative bearing range is from 0^0 degrees to 90^0 degrees to our port side. However. in figure 4-21 Safety Relative Bearing SRB:

- for 1/3 speed target 1s 20^0 degrees (white circle: second circle around collision point)
- for 1/2 speed target 1s 30^0 degrees (blue circle: third circle around collision point)
- for 2/3 speed target 1s 41^0 degrees (red circle: fourth circle around collision point)
- for 5/6 speed target 1s 55^0 degrees (estimated)

SRB rule can be summarized as follow: For vessels speed slower than ownship, we have a rough formula to get her SRB:

- for 1/3 speed target 1s 1/3 of 60 degrees = 20^0 degrees
- for 1/2 speed target 1s 1/2 of 60 degrees = 30^0 degrees
- for 2/3 speed target 1s 2/3 of 60 degrees = 40^0 degrees, actual SRB is 41^0 degrees
- for 5/6 speed target 1s 5/6 of 60 degrees = 50^0 degrees, actual SRB is 55^0 degrees

For same speed target, it is better to lookout in radar instead of visual only. In SRB application, our assumption is target maintain her course and speed. Target's actual size and horizontal angle of her stern line had not taken into consideration. **It would be prudent not to use SRB on big vessels or speed over 2/3 of ownship for junior OOW.** SRB is used mainly on fishing boats or local working/supply slow speed ship. If target vessel speed is half of ownship, its SRB will be about ½ of 60 degrees = 30 degrees.



在圖形 4-23 高速船的安全航向

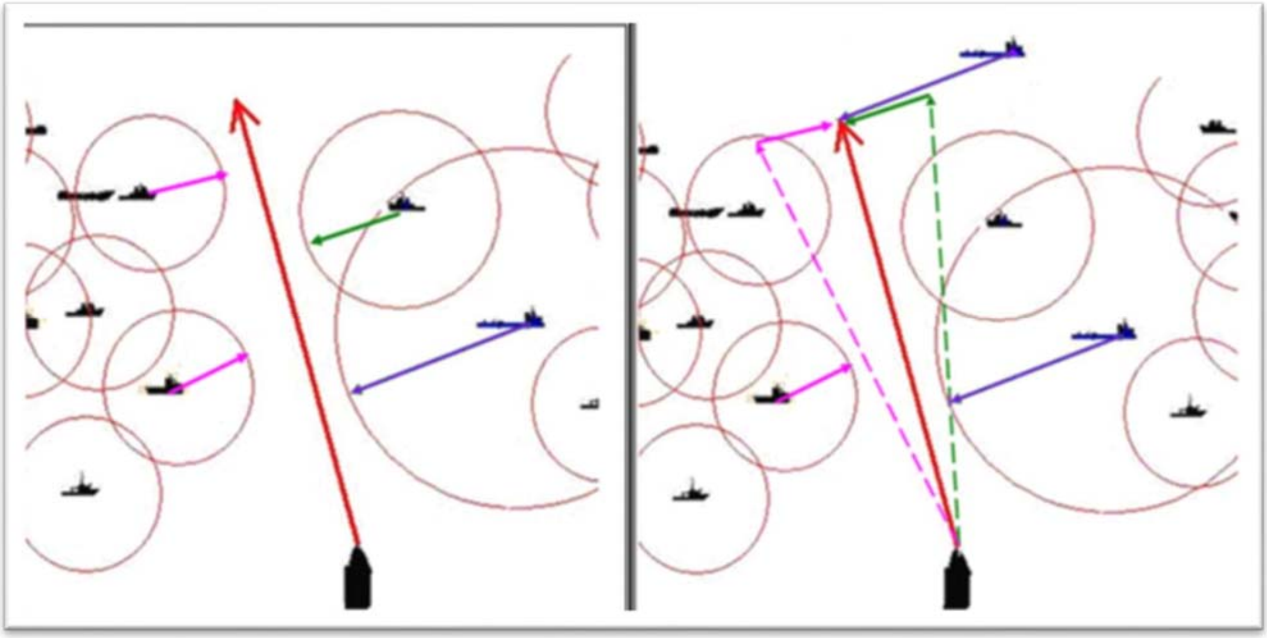
4-49 高速船使用的的安全航向

如果我們仍然對安全相對方位的使用，感到不太確定，這是很正常的。那我們可以看看下面這一個主題，高速船的安全航向，在圖形 4-23 有不同速度與大小的船隻，在海面上航行，那些大船跟本船速度可能一樣，但是只有高速船速度的二分之一，高速船隻使用 6 分鐘的速度向量，在他的雷達螢幕上所有的目標，都有一個圓圈，圍繞的他現在的位置，這些圓圈呢是由目標 6 分鐘速度向量端點的集合，所構成的圓圈。代表以目標現在的速度，跑 6 分鐘之後的可能位置，都是在這個圓圈上面，也就是不管他往東西南北跑，最後呢也只能跑到這個圓圈上，跟這個如來佛的五指山一樣。這些呢就是他們現在速度所能到達的極限，換句話說呢這些目標沒有辦法開出，身邊的這個圓圈，因為這是以他現在的速度來計算出來距離，除非他呢增加他的船速。目標打算要加速呢，在海上的人都知道，是不太可能啊。因為目標船平常都是受到主機馬力型式，跟船隻型態的限制，每個船都有他自己的位置圈，也就是他的界線，能夠航行到的界線。快速的船隻，他的圓圈就比較大，慢速船呢，它的位置圈就比較小。本船想要穿越這些地區，在高速下穿越，是沒有時間去一一確認這些船隻的碰撞危機，**像這個紅色的速度向量現在 350 度的方向，沒有碰觸到任何船隻的位置圈，在這一條船首向上，就是我們的選擇**。那這些位置圈是目標的 6 分鐘可能位置，任何的位置在這 6 分鐘的時間，都不會超出他現在的位置圈，那是不可能的事，除非他有加車。

圖形 4-24 高速船安全相對方位與目標位置圈

4-49 Safe Heading used in High Speed Craft

If we still feel uncertain of SRB usage now, it is normal. Then we can look into this topic: Safe Heading for High Speed Craft. In figure 4-24, we have many target vessels with different speed and size at sea. Those big vessels have same speed with ownship may account for half speed only compared with High speed craft. High Speed Craft is using 6 minutes speed vector in her radar screen. All targets have a circle around her current position now. This circle semidiameter is her 6 minutes speed vector. The semidiameter is her 6 minutes distance run. The circle around the target are her possible positions by using all 360 degrees heading to sail. In another words, these targets cannot sail outside her circle bounded by her current speed unless she increases her speed now. Within this 6-minutes, target vessel is limited to her circle only unless she increases her speed. Every ship has her own circle (boundaries). Faster ship has big circle and slower ship has small circle. If ownship want to cross this area in high speed and ownship have no time to access collision risk one by one, the red speed vector pointing about 350 degrees (T) without touching any circles is the course we should choose (as we knew already collision always happened in our ship's bow, right now no collision point in this direction). These circles are target's possible position within 6 minutes. Any position outside her circle within this 6 minute is impossible.



圖形 4-24 高速船安全相對方位與目標位置圈

4-50 標出附近船隻的可能航向，來檢查本船的安全相對方位

本船的船首向是 350 度，圖形 4-22 將目標船的速度向量顯示在圖面上，我們將三條目標船的速度向量移動到，本船的速度向量的端點，來決定安全相對方位。我們發現這 3 條目標船現在的位置，都是在他的相對方位的範圍之外，不論它是紫色，綠色或是藍色的船隻。

- 有著藍色速度向量線的船隻，大約是本船的五分之二的速度，所以他的安全相對方位大約是 24 度。
- 紅色速度向量船隻呢大概是本船速度的五分之一，他的安全相對方位大約是 12 度。
- 綠色的速度向量船隻大約是本船的 1/4 倍，四分之一速度船隻的相對方位，大約是 60 度的 4 分之 1，等於 15 度。

利用目標的安全相對方位，跟他們的現在的相對方位比較，我們可以確認，這個安全的相對方位的規則，在船上是確實可用的。在海上我們並不需要去計算，並且記得安全相對方位的數字，像前面的 15 度，12 度，24 度等等。我們可以使用分規來取出速度向量的長度，然後將他們放在本船速度向量的端點位置，就像圖形 4-22 的右圖，把他們的安全相對方位的另一點，用

臘筆標注在本船的雷達方位圈上面，或使用電子方位線，也就是綠色或是紅色的虛線，從本船的位置往外，取出安全相對方位的角度，作為呢以後避碰與航行的參考。對於小型的船隻，在近距離對他的水準夾角，可能需要多 5 度的容許值，如同在圖形 2-05 目標方位改變上面所量到的。對於大型船隻，他的可能需要多 20 度的水準夾角容許值，在近距離的時候，就像圖形 2-09 水準夾角的變大與方位改變，水準夾角的改變，在我們考慮安全的相對方位時，要列入我們的考慮事項。

4-50 Mark Safety relative Bearing SRB on azimuth circle for High Speed Craft

If High Speed Craft heading is 350 degrees now as in figure 4-24, we have target vessel's speed vector shown on picture. **We move those three speed vectors of target to the end of ownship's speed vector to decide the Safety Relative Bearing.** What we found all three targets are outside of his SRB whether it is purple, green or blue. This is another prove of our RSB principle is correct.

- The vessel with blue speed vector is about 2/5 speed of ownship. So, it SRB should be 2/5 x 60^0= 24^0.
- Purple speed vector vessel is about 1/5 ownship's speed, it's SRB = 1/5 x 60^0= 12^0.
- Green speed vector vessel is about ¼.₅ ownship's speed, it's SRB = 1/4 x 60^0= 15^0. (actual SRB =¼.₅ x 60^0= 13^0.3, we use more SRB ratio 1/4 x 60^0= 15^0 to easy the calculation)

By comparing target SRB and their relative bearing, we can make sure SRB rules is applicable on board. In real sea, we don't need to calculate SRB value. We can use a divider to take out speed vector length and overlapped their end position together as figure 4-24 right drawing and **mark SRB on ownship's azimuth circle on our radar by EBL** (green or red dotted line from ownship's position) for later reference.

For small vessel of 50 meters long her horizontal angle needs 5^0 degrees more as we see in Figure 2-05 "what did you see about target bearing change?". For big vessel **horizontal angle allowance** may need 20 degrees in close range as figure 2-09 "horizontal angle augment of approaching vessel and her bearing change". Horizontal angle change due to distance change should take into consideration when applied SRB. SRB is good at first sight. Everything can happen after our first observation. Continuous lookout is necessary as required by COLREG lookout rules.

4-51 多目標避碰

我們在圖形 2-10，對資淺船副講解時，已經看到多目標避碰的情況，與避碰的標準作業程式 SOP。在圖形 4-23 這裡，我們將討論這些船隻碰撞危機的本質，對於多船隻避碰的標準作業程式。在這裡呢，多佛海峽有 8 條船遭遇，每一條船的航跡，都是以 6 分鐘的間隔標注，在中間黃色的圓圈，是 F3 燈船，這也是這四個航行巷道的交會區，他的位置選擇呢，並不是在這些船航線的中間，還是要遷就當地的海底的地形，避開淺水區域，這個分道航行制的安排，在這邊就造成了很多橫越的情形，那當然船隻會互相橫越，就會有很多的碰撞點的產生，有 4 個碰撞點在 F3 燈船北邊，是由這些船的航線交叉所造成的。我們呢在圖上用四個黑色的圓圈，作為標注。

4-51 Multiple target collision avoidance

We had seen multi-ship situation in figure 2-10 when we explain avoidance SOP for Junior OOW. In figure 4-25 here we will discuss the nature of collision risks with each vessel and avoidance SOP for multi-ship vessel. There are 8 vessel encounters in Dover Strait. Every dot of each vessel track marked 6 minutes run. In the center of yellow circle is light vessel F3 which marked precautionary area of four directions traffic around it. Its position chosen is considering the water depth and shallow water around it. Unfortunately, the traffic separation scheme arrangement here created a lot of crossing situation and collision point as well. There are four collision point north of Light buoy F3 created by these vessels at sea marked with four black rings.

4-06 在多佛海峽避碰時，更多的考量

4-52 對所有目標船，做一次性的避讓

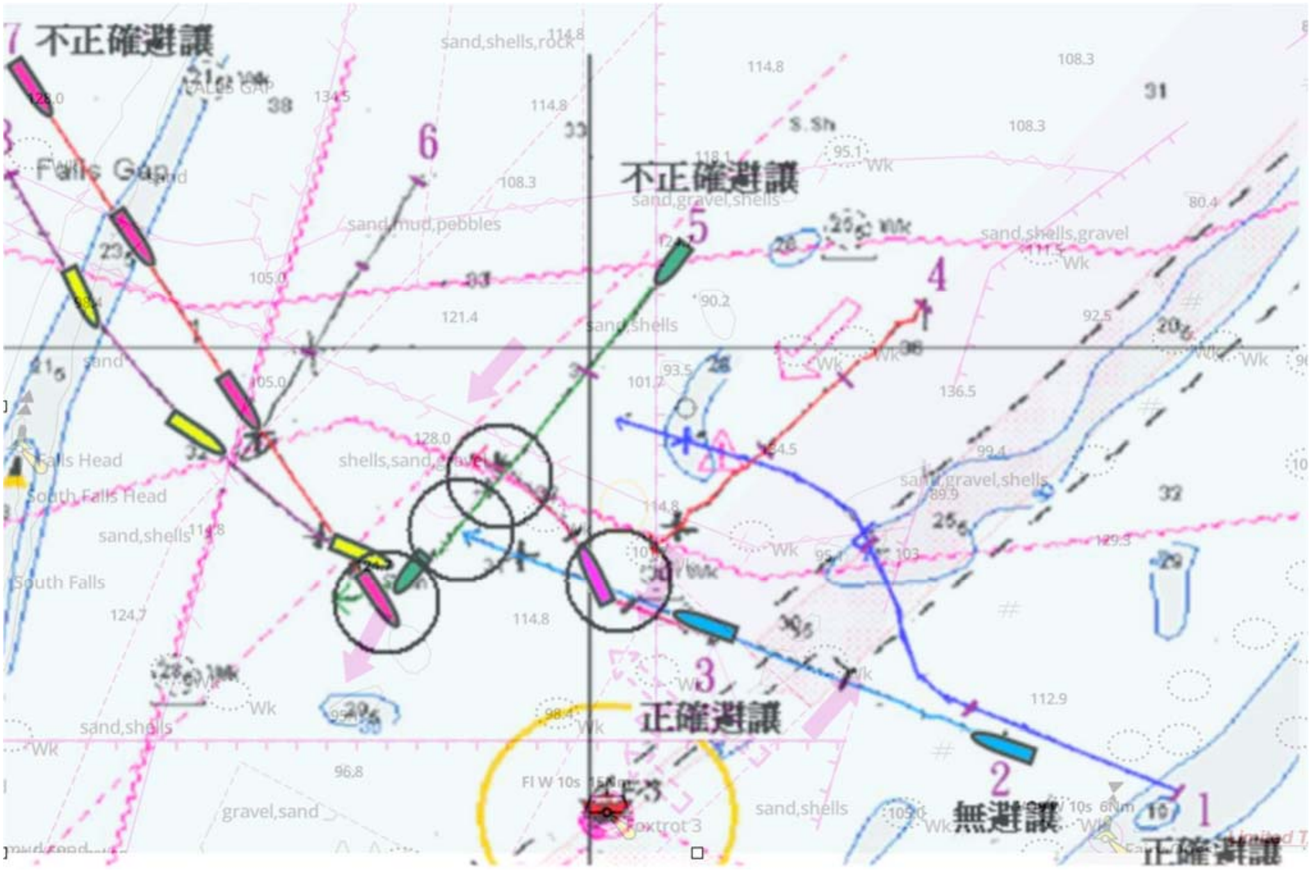
⇒ 西北方向的一號船隻，使用藍色的航跡標注，是一條快速船隻具有高速航行的特質，他必須讓路給 3 條船，2 號與 3 號是被追越船，4 號的右舷船隻是橫越船，解決的方法，就是將這三條船呢當作是一條大船，或是一座大山，本船必須繞過他們的尾部，由 4 號船隻的船尾繞過，實際上海面的航跡，我們可以看出來，一號船也是這樣子做的。他在航行開始 7 分鐘後，從 293 度轉向到 345 度，讓路給 4 號船，同時也讓路給所有的船隻，一次性避讓。

圖形 4-25 多目標避讓的標準程式

4 – 06 More thoughts of Collision case in Dover strait

4-52 One avoidance action for all targets

⇒ No. 1 vessel north west bound in blue color track is a fast vessel sailing with high speed. She has to give-way to three vessels: No.2 and No.3 overtaking vessel and No. 4 starboard side crossing vessel. The solution is to treat these three vessels as one big vessel or mountain to go around their stern which is No.4 vessel's stern. That's what No. 1 vessel had done: alter course after 7 minutes from course 293^{0} to 345^{0} degrees to give way to vessel No.4 and all vessels.



圖形 4-25 多目標避讓的標準程式

4-53 對所有目標直航，"煙消雲散"

⇒ 而 2 號船天藍色航跡，西北向，並無任何畏懼，即使沒有雷達的幫助，大副也能夠看出他跟其他目標的碰撞危機，從圖形上來看，我們看到有兩條天藍色船隻的形狀，在他的天藍色的軌跡上，第一個是他的原始位置，第二個就是他經過 12 分鐘之後的船位，也就是兩個六分鐘線段之後。2 號目標必須對下面三條船隻讓路，3 號，4 號，5 號。

⇒ 3 號目標是在正船頭，顏色是紫色，3 號目標已經向右舷轉向，大概在 9 分鐘的時間轉向的，位置是在圖上紫色船隻所畫的位置上，他的航向從 293 度轉到 324 度，這個是接近 30 度的轉向，讓路給呢五號的目標船，在他的右舷。

⇒ 那在第 12 分鐘的時候，他又慢慢走回原航向 293 度。

⇒ 3 號船轉向到 2 號船的右邊，當 2 號船維持在，他原來的 293 度的航向。

⇒ 如果 2 號船太早採取行動去讓路給三號船，那在第 9 分鐘的時候，當三號船採取避讓行動，轉向到 329 度的時候呢，就會剛好擋到 2 號船的航路，所以一般呢追越船是在比較近，或是非常近時，確認呢被追越船，沒有其他的航行障礙，或是採取其他可能避碰行動的時候，才大角度的避讓追越船，太早的避讓，會呢越避越亂。

⇒ 因為 2 號船沒有太早的採取行動，所以就避免了 3 號船在 9 分鐘時候的轉向，可能引起新的混亂。

在這一章稍早，我們討論過

如果本船能夠確認被追越船與其他船隻，是否有碰撞危機？那本船對被追越船是否會採取讓路行動，被追越船隻跟其他目標船的碰撞危機，可以使用真運動向量線來確定。當然啊，這個是需要當值船副，已經學到了我們前面所講解的雷達瞭望，使用速度向量線來做避碰瞭望的種種技巧，才能看出來被追越船與其他目標船，是否也有碰撞危機。單由本船的相對運動線，或是本船的阿帕計算的能力，都無法判斷出目標船隻相互之間的碰撞危機，那不在阿帕的運算範圍之內，就算有更多的 CPA 數位，也只會造成更多的混亂，所以雷達的瞭望，我們一定要養成圖畫式的瞭望，圖形式的瞭望，而不是 CPA 數值的瞭望，借由檢查被追越目標的真速度向量線與其他目標船的真速度向量線，是否有交點？則我們對他的碰撞危機，也會有一個瞭解。

⇒ 對西南向的 4 號目標，它的相對方位是在我們右舷的 50 度，在航跡開始的時候，經過 12 分鐘以後，相對方位呢大約是在二號目標的正橫，他的相對方位增加了 40 度，在這 12 分鐘的時間，本船已經將 2 號目標，甩在後面。

⇒ 5 號的目標同樣是西南向，他的相對方位開始的時候，大約是在右舷 35 度，經過 12 分鐘以後，他的相對方位是右舷的 20 度。在這 12 分鐘內，他的方位減少了 15 度，這樣的方位變化，是否足夠？那我們要再看 2 號船的碰撞位置，由他天然色的航跡來判斷，目標的碰撞時間從開始測繪的起點到碰撞，大約要 20 分鐘。綠色的目標是西南向的目標，碰撞點的時間大約 15 分鐘，所以通過的時間呢，有 5 分鐘的差距。經常呢我們要求避免碰撞，需要有 3 分鐘通過時間的差距，對大副操船的要求，所以現在呢兩條船通過碰撞點的時間，有 5 分鐘。如果 5 號船沒有其他的避碰行動，2 號船就可以安全通過。

除非 5 號船對其他目標，採取了避碰行動，也就是向右轉，對於 2 號船講，可能就要再重新考慮。不過呢，依照目前的估計呢，是可以過的。

4-53 Stand-on action for all targets' smoke are clear

⇒ No. 2 vessel (colored light blue) north west bound in light blue color track fears of nothing. Without any radar help chief mate should be able to read his collision risk with other target vessels from this drawing. We saw two light blue vessel shape on her light blue track. The first one is her original position. The second one is her position after 12 minutes (two dotted segment). For all these tracks are at same time interval No. 2 vessel has passed Vessels No. 4's bow and No. 5 vessel passed her bow. No. 3 vessel alter course to starboardside after 9 minutes same time as No.1 target's moving time.

- No. 3 target (colored purple) dead ahead No. 2 vessel who had altered course to starboard side at about 9 minutes time (at the position of purple ship on drawing) from course 293^0 to 324^0 degrees to give way to No. 5 vessel on her starboard side.
- No. 3 target vessel course again slowly from 12 minutes to course 293^0 again.

- No.3 vessel alter course to No. 2 vessel's starboard side when NO.2 vessel steady on her original course 329^0 degrees.
- If No.2 vessel take too early action alter course to starboard side to No. 3 vessel it would be a trouble at 9 minutes when No.3 also alter course to 329^0 degrees.
- If we verify the relative bearing of No. 4 and No.5 target to No. 2 vessel's by their 6 minutes position dot one by one, it will be very clear that No.4 vessel's relative bearing is getting bigger each time (pass astern to No. 2 target) and No.5 target's relative bearing is getting smaller each time (pass No. 2 target bow).

⇒ As we discussed earlier in this chapter, for overtaking case give way too earlier could be a trouble when overtaken vessel also takes action to avoid another target.

- For safety reason if ownship can make sure overtaken vessel ahead has no collision risk with other vessels then ownship's give-way action to overtaken vessel will be safe too. Overtaken vessel collision risk with other target vessel can be verified by true speed vectors of all target vessels applying same principal: **Check overtaken vessel's speed vector has collision point with other target vessels' speed vector or not?** No.2 and No.3 vessels' course line are almost the same in the beginning.
- No. 4 target southwest bound who's relative bearing is about 50 degrees to No.2 vessel starboard in the beginning. After 12 minutes her relative bearing is about abeam of No.2 vessel. Her relative bearing increase 40 degrees in 12 minutes. She is left behind by No. 2 target.
- No. 5 target southwest bound who's relative bearing is about 35 degrees to No.2 vessel starboard in the beginning. After 12 minutes her relative bearing is about 20 degrees to No.2 vessel starboard. In 12 minutes, her bearing decreased 15 degrees, is this enough? Let's see collision position (black ring) ahead of No. 2 vessel's light blue track. No. 2 vessel's Time to collision point from the beginning point is about 20 minutes. No. 5 target (in green color) southwest bound whose Time to collision point from the beginning point is about 15 minutes. The passing time has 5 minutes difference. **Usually we will ask for 3 minutes difference to clear same collision point as a standard for chief mate.** During these 5 minutes time, if No.5 target had taken other action to avoid collision, No.2 target still have the option to alter course to starboard side to avoid collision.

4-54 慢速船對所有目標一次性的避碰

⇒ 這邊說的應該是，慢速船對所有目標的避碰。3 號的目標船是西北向，在紫色的航跡上。她是一條慢速船，他也同樣呢對駕駛台右舷的 5 號目標避讓，因為這是優良傳藝，避免快速船的當值船副憂慮。如果我們檢查他現在的航跡，跟他的速度，我們可以發現他到碰撞點的時間是 18 分鐘，同樣的碰撞點，對於 5 號的目標船會在 15 分鐘到達，從起始點的位置算起。所以呢這兩條船到達碰撞點的時間，是有 3 分鐘的差距，對於小型的慢速船至來講，這應該是足夠。那對於被追越船的船尾，又怎麼樣呢？他們可能只有使用目視航行，對一個熟練的航海者，若對任何目標船是否能通過本船船頭的疑慮，那這時候的碰撞危機，應該認為是成立的。這似乎是說 3 號船，對 5 號船的避讓行動，同時呢也解除了船尾追越船的疑慮，因為本船擋到他的前進方向，所以 3 號船的行動，也是什麼?一次解決兩條船的避碰危機，他並沒有絕對的必要去採取行動，他這個是優良船藝。大家都方便，也不必去煩惱後面船，是不是會開上來追撞。

4-54 Slow speed vessel avoidance action for all targets

⇒ No. 3 vessel north west bound in purple track is a slow speed vessel who give-way to No. 5 vessel in her starboard side as a good seamanship to relieve the worry of those OOW on bridge. If we check on her original track with her speed, we found her Time to collision is 18 minutes. For the same collision point No. 5 vessel will arrive at 15 minutes from the beginning position. So there three minutes time difference for a small slow vessel (No. 3 vessel) should be enough. Actually. No.3 vessel doesn't need to give way and No.5 target will pass her bow if No.3 target's visual lookout is qualified. For a prudent navigator if there is any doubt, (crossing vessel can pass own ship's bow or not?) such risk shall be deemed to exist. What about the overtaking vessel No. 2 target astern? She may have some confused time of No.3 target's action at 7 minutes times.

4-55 慢速船是否應該沿著航行巷道的中線航行

⇒ 4 號的目標船是西南向，紅色的航跡，是一條慢速船，並沒有避讓的義務，只需要對左舷的一號船直航，保持它的航向航速。

⇒ 避碰規則 9（a）船舶循狹窄水道或適航水道行駛，于安全且實際可行時，應儘量靠近本船右舷水道或適航水道之外側行駛

⇒ 我們看到，他並沒有沿著分道航行制巷道的外側航行，如同分道行情制規則 10 船隻應該在實際可行的時候，盡實際可能,離開分道線或分道區。

⇒ 4 號目標船的航線，也許跟南向航道的船隻，產生碰撞危機，例如船隻從歐洲開往直布羅陀海峽的方向。

4-55 Slow speed vessel sailed along center of traffic lane

⇒ No. 4 target southwest bound in red track is a slow vessel who has no obligation to give way but to stand on for port side vessel. No.1.

⇒ COLREG rule 9 (a) *A vessel proceeding along the course of a narrow channel or fairway shall keep as near to the outer limit or the channel or fairway which lies on her starboard side as is safe and practicable.* Her course line is not along the outer limit of TSS, but still complied with COLREG rule 10 *(b) (ii) A vessel shall so far as practicable keep clear of a traffic separation line or separation zone.*

⇒ No. 4 target sailed along the center line of fairway which is not advisable in voyage planning stage. However, today her choice seems right because all collision points (black ring) concentrated on out limit of fairway and one collision actually happened there. However, if No.1, No.2 or No.3 vessel are going to SW bound (for ex. vessel outbound from Europe to Gibraltar strait)they will need to conduct sharp or mild portside turn somewhere around Buoy F3. There will be have trouble with No.4 target sailed in center line when she just goes straight to SW bound.

4-56 直航船與正橫快速船的碰撞

⇒ 5 號的目標船是西南向，用的綠色航跡，是一條郵輪，跟 7 號的橫越船，紫色的航跡，發生了碰撞。碰撞的時間是 0055 時，在下面圖形 4 之 24，是碰撞前 6 分鐘的畫面，

- 左舷正橫的 2 條目標船，根本船呢沒有碰撞點，所以本船跟左舷正橫目標，並沒有碰撞危機。他們會通過本船的左船尾，如果他們的航向航速不變
- 對於二號的快速船隻跟三號的慢速船隻，都是接近本船的左舷正橫，那在這個圖形，真運動的速度向量線不相交，沒有碰撞點，沒有碰撞危機。相對運動線是沒有直指本船，也沒有碰撞危機。
- 在五號目標右舷的正橫，有兩條目標船，8 號的目標船是沒問題的，會通過本船的船尾。七號的目標船，在五分鐘之後，有碰撞危機，這是由圖上的碰撞點，本船速度向量線上的碰撞點判讀出來的，這一個碰撞危機在右圖的相對運動速度向量線，也是很明顯。因為呢相對速度向量線呢指向本船，從右邊正橫的相對方位，大約是在本船右舷的 85 度，那這個就是一個什麼？很清楚碰撞危機的顯示。

7 號目標船速度呢比本船要快，這個呢我們可以參考圖形 4-20 的右圖，快速船隻呢他接近本船的相對方位，比慢速船來得寬，又來得遠。簡單的說就是，速度比本船高的船，可能從四面八方來撞本船，跟本船發生碰撞危機。速度低的船隻有在本船船頭有限的角度之內（安全相對方

位角），才可能跟本船發生碰撞，我們在海上瞭望的時候，要特別注意任何速度比本船高的船隻，因為都是可能會撞到本船的危險目標。

⇒ 本船必須對 7 號目標船讓路，他正從右舷正橫橫越，這對資淺船副是困難的操作，如果我們要對右邊正橫的目標轉向，或是避讓。

⇒ 如果 5 號目標要向右舷轉向，在這麼近的距離，對右舷正橫的目標做航向的改變，必須大於 90 度，從 212 度轉到 302 度，在 3 分鐘的時間內，對一條客輪來講，不是不可能，只是會造成船上老弱婦孺的傷亡。

⇒ 這樣需要的回轉速率，就是每分鐘 30 度，而且要持續 3 分鐘這麼久，來遠離碰撞點。

⇒ 向左舷轉向就必須由 212 度轉到 120 度，也是接近 90 度的轉向，因為 7 號的目標船速度比本船快，向左舷轉向，可能比向右舷轉向還要糟糕，因為本船船尾部位可能被橫越船所撞擊。

⇒ 當碰撞很可能發生時，向左舷轉向，會暴露本船的船尾，是最愚蠢的方法，特別是在對快速船隻的避讓。

我們的結論是停車，或是儘快減速，對在正橫方向來的快速船隻。就像我們在圖形 4-20 的右圖，同樣距離的船，當本船停車或減速來避碰時，當速度一慢下來，碰撞點會往本船的船頭方向移動。這不是一句口號，這是我們在減速的時候，應該具有的情勢感知，讓我們對我們的避碰行動，更有信心行動。避碰時減速的效果，我們還沒有仔細討論過。想像本船按下“緊急倒車”的按鈕，在 6 分鐘後，本船終於停止在水面上。

⇒ 在這 6 分鐘的時間，平均速度是原始航速的二分之一。在開始的 3 分鐘，平均速率也許是原始速率的 4 分之 3。減速其實並不能減掉多少的速度，使用緊急倒車，尤其是對一條慢速的船隻，減速並不是有效的方法，因為速度的差距太小，創造出來的距離，前進距離的差別也會太小。

⇒ 本船可以如何預期減速時，這些目標船相對運動的速度向量線的改變，當本船開始減速，這些相對運動的速度向量線，都會向本船的船頭方向移動，在圖形 4-24 的右邊，7 號目標船的相對運動速度線，指向本船，將會向前移動，解除與本船的碰撞危機。

⇒ 8 號目標跟 3 號目標，原來並沒有碰撞危機的目標船，它們的相對運動線，將會向本船的船尾接近，在我們減速之後，這就是我們的常識。但是我們必須視覺化這些變化，讓它成為我們的直覺的一部分，**在決定要減速的時候，雷達螢幕上的所有相對運動線，都應該先行變化，來預期碰撞危機的變化**。

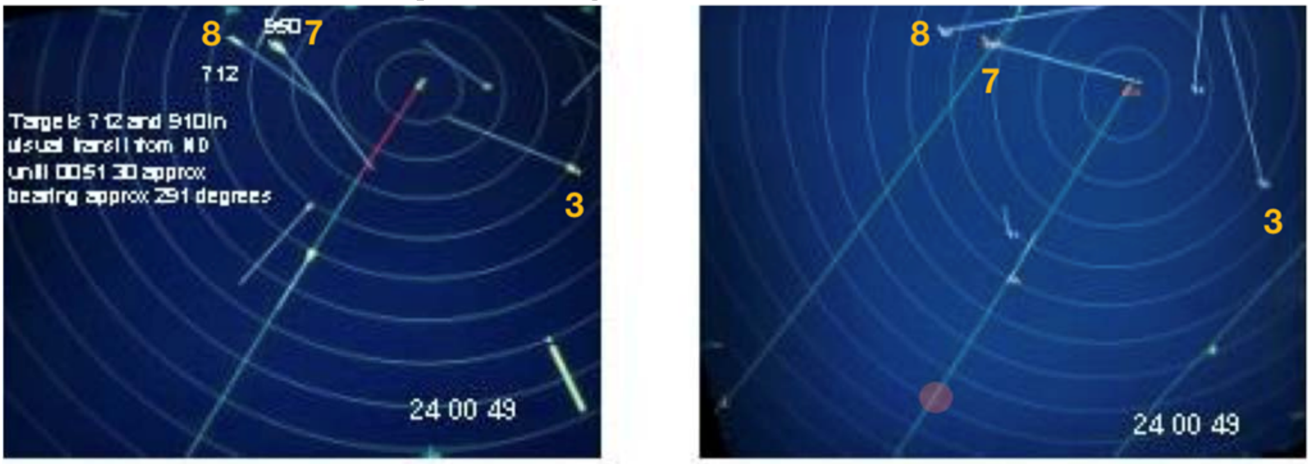
另外一個方法，就是迴圈舵，在緊急時候，用來減速之用。當船長的階段，我們會學習更多的迴圈舵的技巧來減速與避免碰撞，與用滿舵來操縱船隻的動態。

4-56 Stand-on vessel has collision with fast vessel abeam. Figure 4-2 6 minutes before collision.

⇒ No. 5 target southwest bound in green track is a cruiser who has collision with no.7 crossing target (color purple). The collision time is 0055 hours.

- No. 5 target has No. 2 port side abeam targets whose speed vectors has no collision point with ownship. No collision risk between these two targets. No. 2 target will pass No. 5 target port quarter by they keep their course and speed now.
- No. 5 target has to stand on for No. 2 fast targets and No.3 slow target as well who is about her port beam. (No. 3 vessel is the purple slow one about to pass No. 5 target stern.)
- No. 5 target has 2 starboard side abeam targets. No. 8 target is OK. <u>No.7 target has collision risk with ownship about 5 minutes later</u>: read TTC from collision point at left picture ownship's speed vector (color red). This collision risk is also evident from right picture relative motion speed vector which point to ownship from starboard beam. Her relative bearing is almost 85 degrees to ownship's starboard side. This is a clear indication of her fast speed as we can see from figure 4-20 right

drawing. **Faster vessel has no RSB: Collision Risk will come from all 360 degrees.** Right now, collision risk comes from portside 85 degrees.



Relative motion - 3 mile range - 0.5 mile rings
True vectors with manual 14.5 kt speed input

Relative motion - 3 mile range - 0.5 mile rings
Relative 6 minute vectors

圖形 4-26，是碰撞前 6 分鐘的畫面

- Ownship have to give way to No. 7 vessel who is crossing from starboard beam now. It is a difficult maneuvering to alter course to crossing No. 7 vessel's stern as Junior OOW's SOP which have to alter course to 85 degrees to starboard side because this is No.7 target's relative bearing.
- If No. 5 target is about to alter course to starboard side in this closing range for starboard beam targets the course change must be more than 90 degrees (from 212^0 degrees (T) to 302^0 degrees in 3 minutes time).
  - Starboard side turning needs turning rate of 30 degrees per minutes and last for 3 minutes to swing ownship out of collision position. This drastic turning 3 minutes to 90 degrees is possible but not allowable to a cruiser vessel due to excess swing always cause somebody fall off to ground whether he is on bed or floor like heating by a big wave in heavy weather.
  - Another option: Alter course to portside will need to alter to 120^0 (T) from 212^0 degrees (T) about 090^0 degrees turn. Because no.7 target is faster than ownship A/C to port side is even worse than A/C to starboard side.
  - Alter course to port side will expose ownship's stern to target vessel while collision is likely to happen. This is most foolish way to do especially with a faster target.
  - Alter course to both sides is not a good option to avoid faster vessel coming from abeam direction.
- **Our conclusion is to stop engine or reduce engine as quickly as possible for faster vessel at our beam as COLREG rule 19 also regulated.** As we can see at Figure 4-22 right drawing: same distance vessels. When ownship stop or reduce engine to avoid the collision, **the collision point will move ahead of ownship's bow whenever our speed had slowed down.** This is not a slogan. This is situation awareness in reduce speed which make us more confident in our avoidance actions.
- If OOW is prudent enough OOW should check target vessel's relative bearing change (reduced quickly) to judge stop engine is enough or not. Seeing how many minutes are left before collision from radar speed vectors and how many relative bearings had reduced from visual lookout since ownship stopped the engine.
- If stopped main engine is not enough then alter course to starboard side is recommended due to slower speed comes with less rudder effect.
- We have not discussed what the effect of reduce speed in collision avoidance can do. We will leave to Master lever to study.

- Imaging ownship activated crush astern button after 6 minutes ownship finally stops in water.
- In these 6 minutes the average speed is ½ of original speed. Average speed = (0+original speed)/2
- In initial 3 minutes the average speed might be ¾ of original speed.

The speed reduction actually cannot take too much speed out even with crash astern especially for a slow vessel.

- Another way is rudder cycling to reduce speed in emergency.

- What ownship can expect those **relative motion speed vectors change when ownship reduced speed.** There all move ahead of ownship including those vessels have no collision risk before we reduce the speed. New collision risk may arise.
  - In the right side of figure 4-26, No. 7 target relative speed vector pointed to ownship will moving ahead to release the collision risk with ownship.
  - No. 8 and No. 3 original no collision risk target. Their relative speed vectors will move more closer to ownship's stern after our speed reduction.
  - Yes. This is common sense but **we need to materialize it in radar screen as part of our instinct when we decide to reduce speed.**
  - In Master level, we will learn another skill "rudder cycling" to reduce speed and avoid collision with hard over rudder cycling to both sides.

4-57 直航船與正橫的慢速船碰撞

7 號船是西南向船隻，在圖形 4 之 23 的紫色航跡上。快速船必須讓路給被追越的 8 號船隻，

⇒ 在雷達測繪圖形 4-23，我們可以看到 8 號目標，在本船追越的過程中，並沒有保持他的航向。在碰撞發生的時候，本船在 2，3 分鐘前，剛好通過 8 號船的船頭。

⇒ 當 8 號目標在本船的船尾，7 號目標船要怎麼做？才能避免跟跟橫越 5 號目標船的碰撞。

⇒ 向右舷轉向，然後橫過 8 號目標船的船頭，也許可以。因為本船速度比較快，本船的右舷沒有其他船隻，但是我們的右轉行動，會將本船的左舷，向左舷的來船開展，也就是暴露本船的左舷船舯。

⇒ 停車，讓五號目標船通過本船的船頭，是一個好主意。但是這樣會什麼？擋住 8 號目標船，然後將本船的船尾，暴露給 8 號的目標船。

⇒ 向左舷轉向是危險的，因為在 5 號的目標船後面，還有其他的目標船。

如何同時降低碰撞的風險，跟 8 號的目標船與 5 號的目標船。

⇒ 當橫越船還有 1.8 海浬的距離，我們仍然有兩個選項，向左舷轉向，然後與 8 號目標船的航向平行，或是向右舷轉向，然後與 5 號目標的航向平行。現在的情況是，在避碰的第三階段，兩條船都必須採取最佳的避碰行動，1.8 海浬並不是一個短距離，但是本船是 20 節速度，使得本船距離碰撞的時間，只有 5.5 分鐘。

⇒ 要與 8 號目標平行，需要從 145 度的航向，轉向到 110 度，在這麼近的距離是比較容易做到。這樣避碰可能會遇到更多的迎艏正遇的情況，也就是與西北向的 2 號跟 3 號目標船，發生迎艏正遇，如果本輪不能夠將航向穩定在，新的 145 度的方向。

⇒ 對 5 號的目標船船尾轉向，繞過船尾需要從 145 度轉到 105 度的方向，這個對於避碰最有效果，因為轉向的度數，只要 40 度就夠了，並且也符合避碰規則的要求，具有足夠，及時的性質。

⇒ 但是這樣的行動，並不符合避碰規則 17 條（c），動力船隻在橫越的情況下，採取符合本條規則的行動，當避讓其他的動力船隻，如果這環境許可的話，不要向左舷轉向。因為在他的左舷又有其他的船隻，這個規則就像他的描述，提供在橫越情況下，採取行動的船隻遵守。在避碰的第二階段，應該避免對左舷的目標做左轉，這是常識，像在圖形 4-24 的右圖，我們可以看到 5 號目標到達碰撞點時間，是早於本船，轉向的行動，對他

船尾轉向，看起來應該是合理的。實際的案例，5 號的目標船停車，並且在最後一分鐘向右轉向，如果本船向左舷轉向，會把他撞沈，造成數千人的生命損失。

⇒ 仔細看著雷達的畫面，我們看到有一個未確認的目標，在五號跟 3 號目標的後面，正在向 5 號目標的船尾航行。

⇒ 對 5 號目標船的船尾轉向，使用滿舵時，如果本船不能穩定在 105 度的航向，就會產生新的碰撞危機，跟 2 號目標或 3 號目標船。

太多目標的情況下，航向的選擇必須非常的精確，因為碰撞危機，會隨著本船的速度向量線掃過而增加，所以本船的航向，如果不能穩定在新的航向上，就容易造成新的碰撞危機。那這個是每一個船長必備的技術與認知。

⇒ 向右舷轉向並與 5 號的目標船航向平行，這個行動可以執行，但是需要更多的努力，才能回到本船的原始航向，考慮到客輪上的人命安全，這是一個值得的選項，只要 5 號目標能及早通過本船的船頭。

也許我們沒有時間去完全評估所有目標，如果任何目標突然出現在海上，都會讓我們淬不及防。

最好的選項，就是停留在現在的位置，現在本船是安全的。用盡全力減速，如果我能夠停止在現在的位置，我們就有更多的時間來評估現場的狀況。這也是避碰規則所推薦的，但是本船的速度，沒有辦法馬上停止。

8 號的目標船是西南向，是黃色航跡的慢速船，正在被 7 號目標船追越，他向左舷轉向，讓路給客輪 5 號目標船，同時避讓追越的 7 號目標船。

圖形 4-25 多目標碰撞前 3 分鐘，本船能做什麼？

在 0051 時碰撞前 3 分鐘，5 號的目標跟 7 號的目標，還有什麼選項？ 現在碰撞的情勢是：

⇒ 3 號的目標向著 5 號目標的船尾前進，在圖形 4-25 的左圖，

⇒ 5 號目標的碰撞點，位於速度向量線的一半位置，他的碰撞距離是 0.75 海浬，碰撞時間是 3 分鐘之後。

⇒ 7 號目標的碰撞點，在它速度向量線上，一半位置還要多一點，他的距離大約是 1 海浬，他的碰撞時間，由碰撞點來判斷，大約是 3 分半鐘。

總結來說，7 號目標船有比較多的空間與時間去改變航向來避碰。這種趨勢，不但是在碰撞前 3 分鐘如此，就是在圖形 4-24 的左圖，碰撞前 6 分鐘，如果 7 號目標船仔細的判讀碰撞的位置，在本船的速度向量線上，都看出來。所以資深的船副，應該具有本船發生碰撞時，會造成什麼樣損害的預期。這個在以後的章節裡面，我們會更詳細的討論，**也就是船副應該可以預見在碰撞時，本船是船頭，船舯，或船尾會被撞到**。

⇒ 7 號目標船減速，並向左舷轉向，方向 105 度，轉向五號船的船尾。
  - o 如果要轉向，最好是使用左滿舵，快速的啟動回轉，使用霧號跟日間信號燈，發出兩短聲來表示本船的意圖（向左舷轉向），這是避碰規則 34 條船隻運轉的信號。
  - o 然後使用右滿舵減速，當航向開始從 145 度轉向 125 度的時候，就是左轉了 20 度以後，要趕快打右邊的滿舵，以避免本船回轉速率增加的太快。。
    20 度的航向改變，對 300 公尺長的船隻，避開他船的水準夾角，就已經足夠，如同圖形 2-09 水準夾角的增大，也就是花開效應。
  - o 先用左滿舵啟動左轉，然後使用右滿舵，來把本船的航向穩定在 105 度，這樣的兩個滿舵，就是迴圈舵的技巧，這是我們在做船長所需要的技術。

⇒ 5 號目標不應該只用減速，作為最佳的避碰措施，而且要會用左滿舵轉向 145 度，去平行 7 號目標船的船首向，比較有避碰的效果。

在實際的海上，5 號的目標船有停車，並向右舷轉向避碰。主機的停止，或是緊急地停車，在目視或是雷達測繪都不是立即可見的，反之，轉向只需要 1-2 分鐘就能夠目視察覺，雖然實際

避碰的效果，還是要 3 分鐘的時間，才會產生。這是第四章 16 節船隻回轉避碰的三階段概念。

碰撞需要兩條船才會發生，避碰同時需要兩條船的相互合作，才能成功。當我們有了足夠的知覺，其他船隻可能沒有。5 號的目標船，一旦停車並向右舷轉向，7 號的目標船可能仍然繼續向左舷轉向，如果 7 號目標船的船頭，指向 5 號目標船的右舷（5 號目標船先到達碰撞點），想要造成一個右對右的通航。或是 7 號目標船可能穩定在他的現在的船首向不動，如果 5 號的目標船的船頭指向 7 號目標船的左舷，那也許可以左對左地通航（7 號目標船先到達碰撞點）。

在實際的海上，本船必須注意目標船的船頭，是指向本船的哪一個部位？如果他的船頭指向本船的船頭，或是本船迴旋支點的後面，會在碰撞後，產生不同的後果。這些討論比較複雜，我們呢往後會再討論。

4-57 Stand-on vessel has collision with slow vessel abeam

⇒ No. 7 vessel (colored purple) southwest bound in orange track in figure 4-25 is a fast speed vessel who have to give way to overtaken vessel No. 8. (colored yellow)

⇒ In the radar plot of figure 4-25, we can see No. 8 target did not maintain her course while No. 7 vessel in overtaking process.

⇒ No. 7 vessel just clear of No. 8 target’s bow 2 or 3 minutes before collision in figure 4-25.

⇒ While No. 8 target at No. 7 vessel stern, what No.7 vessel can do to avoid the collision with crossing vessel No.5?

⇒ Alter course slowly to starboard side and crossing no. 8 vessel’s bow may be OK because ownship is faster. Ownship’s starboard side has no ship but will open up ownship’s stern to port side No. 5 crossing vessel.

⇒ Stop engine and let No. 5 target pass ahead ownship is a good idea but will block the way of No. 8 target and open up ownship’s stern to No. 8 target vessel.

⇒ Alter course to port side is risky with other vessels head-on coming from SE direction No. 1,2 3 vessel.

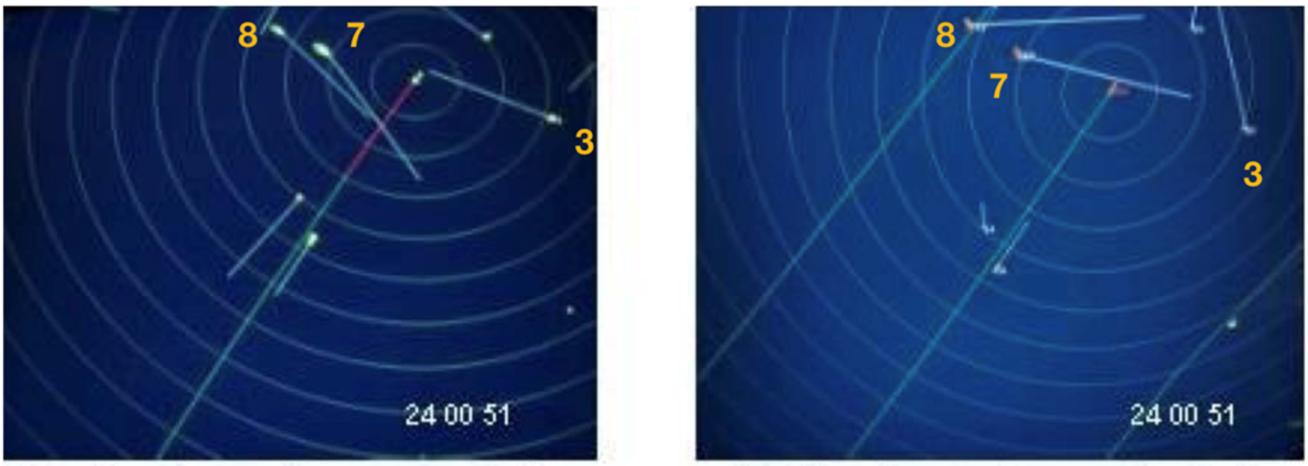
⇒ How to mitigate the collision chance with no. 5 and No. 8 at the same time? Target No. 5 is 1.8 nm distance abeam. We still have two options: A/C to port side and parallel with No. 8 target’s course or A/C to starboard side and parallel with No. 5 target’s course.

- It is third stage of COLREG: Both vessels should take best aide to avoid the collision. 1.8 nm is not a short distance but ownship speed is 20 knots which make the time to collision is only 5.5 minutes.
- To parallel with No. 8 astern target and A/C to 110^0 degrees (T) from 145^0 degrees (T) seems easier in this close distance.
- If we look at figure 4-26 left radar screen, we can see No.8 target alter course to 1100 degrees is to parallel with NW bound targets No.2 and No.3 vessel in head-on situation. So. No. 7 vessel can have same option to do the same “alter course to 110^0 degrees”.
- This avoidance action will meet two more head-on situation (with NW bound targets No.2 and No.3) if ownship cannot steady on new course 110^0 degrees (T).
- To alter course to No. 5 target’s stern to go around from 145^0 degrees (T) to 105^0 degrees. This will have best effect on avoidance of target No. 5 and obey the COLREG *if the circumstances of the case admit, be positive, made in ample time.*
- But this action is not complied with COLREG rule 17 (c). *A power-driven vessel which takes action in a crossing situation in accordance with subparagraph (a)(ii) of this Rule to avoid collision with another power-driven vessel shall, if the circumstances of the case admit, not alter*

course to port for a vessel on her own port side. This rule as it stated is for vessel *takes action in a crossing situation in accordance with subparagraph (a)(ii).* That is to say: In second stage of collision avoidance, ownship should avoid alter course to port side while target is 4 nm away.

- In the right side of figure 4-26, we can see NO. 5 target arrive collision point earlier than ownship. Our action to A/C to portside to her astern seems reasonable. In real case, No.5 target had stop engine and alter course to starboard side in last minute. Ownship alter course to port side may sink her with thousands life by his last minutes action.
- Look at the radar picture carefully, we could see one target unidentified was behind target No.5 and No.3 target is sailing to No.5 target's stern.
- Alter course to portside target no. 5 stern with hard over rudder. If ownship cannot steady to 105^0 degrees new course there may create new collision risk with target No.2 or No.3.
- In multiple targets situation, every course chosen must be very specific because collision risk is increased as our speed vector sweep around and must be steady on new course as quick as possible (this is master skill).
- To choose new course in multiple vessels situation by instinct is not a very complicated job if we can master the collision theory throughout.
- The best choice now is to alter course to portside from 145 to 110 degrees.
- A/C to 80 degrees to starboard side and parallel with No. 5 target's course. This action could be done and need more efforts (3 to 4 minutes at least) to maneuver to go back to ownship's original course line afterward. Considering the human life on that Christmas tree vessel (cruiser ship) this is a worthwhile choice as No.5 target should pass ahead of ownship earlier.
- We have no time to make full evaluation if any target come out of nowhere and caught us unguarded.
- The choice to stay where you are: Take all way out and gain more time in evaluating the situation as COLREG recommended. No.7 vessel is not safe when No.8 vessel continued her new course of 110^0 degrees after two minutes.

⇒ No. 8 vessel southwest bound in yellow track is a slow speed vessel who had overtaken by No. 7 target. She altered course to port side to give way to Cruiser vessel No. 5 and No. 7 target at the same time.



Relative motion - 3 mile range - 0.5 mile rings
True vectors with manual 14.5 kt speed input

Relative motion - 3 mile range - 0.5 mile rings
Relative 6 minute vectors

圖形 4-27 多目標碰撞前 3 分鐘，本船能做什麼？

At 0051 hours three minutes before collision, what option no. 5 and no. 7 target have to avoid the collision?

The situation now:

- No.3 target is heading into no.5 target's stern in figure 4-27 left picture.
- No.5 target's collision point is in halfway of her speed vector. Her DTC is 0.75 nm and TTC is 3 minutes.
- No.7 target's collision point is a little more than halfway of her speed vector. Her DTC is about one nm and her TTC read from collision point in her speed vector's position is about 3.5 minutes.

In summary, No. 7 vessel have more space (1 nm) and time (3.5 minutes) to A/C to avoid the collision. This tendency is not only available in 3 minutes before collision. It can also be read from figure 4-26 left picture, 6 minutes before collision if **OOW know how to pay more attention to read the collision position on each vessel's speed vector**. So, Senior OOW should have this ability to **predict what the damage ownship will be** if collision happen afterward. We will discuss more in later chapter.

⇒ No.7 target reduce speed and A/C to port side 105^0 degrees(T) (to No.5 target's stern).
  - Better use Hard Port to start the turn quickly in first stage. Use whistle and ALDIS lamp with 2 short blasts to indicate ownship's attention by COLREG rule 34 maneuvering signals.
  - Then applied Hard Starboard rudder after course changed to 125^0 degrees(T) from 145^0 degrees(T) to prevent the turning rate increased too quickly.
  - 20 degrees course change is enough to cover the horizontal angle of a 300 meters length vessel as (one NM x Sin(20) = 633 meters).
  - Hard port rudder then hard starboard rudder to steady ownship in 105^0 degrees(T). these are rudder cycling skill we will need in Master level.

⇒ No.5 target should not reduce speed as best aid to avoid the collision as No. vessel will pass collision point first. Reduce speed will increase chance to collision.

⇒ Hard port rudder to A/C to port side from 225^0 degrees to 145^0 degrees(T) (to parallel with No.7 target's heading) may be too late for a slow speed vessel.

⇒ In real sea, No.5 target had stopped engine and A/C to starboard side. Engine stop or crash astern is not visible in in visual or radar immediately. Alter course need one or 2 minutes to be effective as we learnt from 4-16 Ship Turning consist of three stages.

⇒ Collision needs two ships to happen. Collision avoidance also need two vessels to cooperate. While we have our awareness, other vessel may not.

⇒ Once No.5 target had stopped engine and A/C to starboard side, No.7 may continue A/C to port side if target vessel's bow is pointing at ownship starboard side which will make a starboard to starboard passage. Or No.7 may steady on her heading now and No.5 target vessel's bow is pointing at No.7 portside which will make a port to port passage.

⇒ In real sea, **No.5 vessel have to beware of target vessel's bow where she is pointing at now.**

⇒ Is No.7 vessel bow point ahead or aft of No. 5 vessel's pivot point will make a big difference to consequence of collision? It is a complicate situation. We will discuss later.

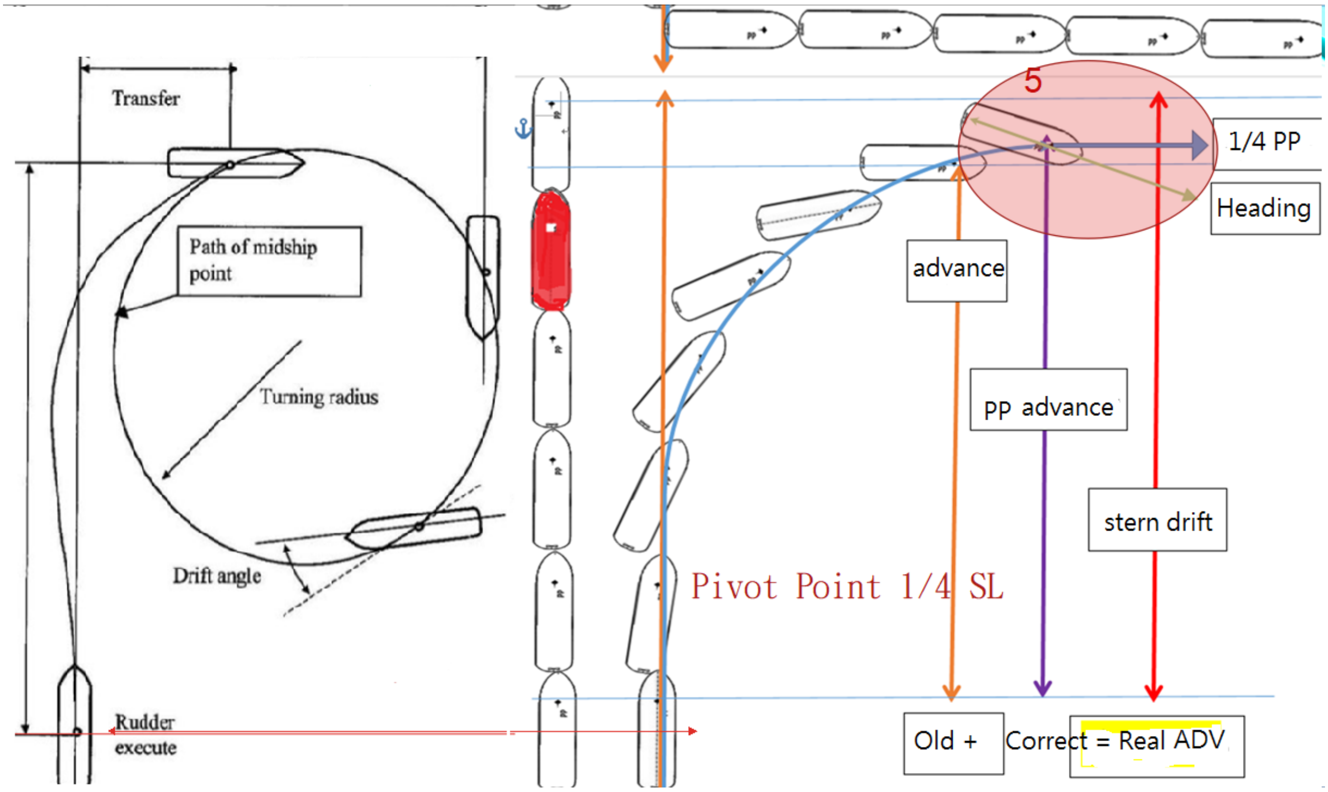


Figure 4-28 Turning Characteristics Correction Chart

4-58 Turning Characteristics Correction Chart

Thousands ship build every day around the world and thousands OOW sailed at sea. No objection of the materials provided by ship yard about the turning characteristics is very interesting to notice. Traditional tactics diameters are provided by pivot point in the center of the ship as the left drawing in figure 4-28. When vessel had turn 90 degrees the distance reached ahead her original course line is her advance distance. From the drawing provided by ship yard we can see 90 degrees turn is not at top of the chart. If vessel is at top of the chart (maximum advance) the drift angle (the angle between our heading and the COG course over ground) must take into consideration. COG course over ground is vessel's pivot point moving direction. In old time this direction is the tangent point to her turning curve. Now we have GPS position which can easily define ownship's turning curve and ground speed and course in any moment of this curve. Even the left drawing had corrected curve figure, the advance (orange color distance) still marked at 90 degrees turn only which had not corrected with drift angle. If we applied drift angle to reach her maximum advance distance (purple color distance), we can see her stern still swing out of the turning curve by the drift angle.

For a vessel of 300 meters length and 60 meters width plus 30 degrees drift angler and PP pivot point located at one fourth ship's length from her bow, we have this (if I am right)

300 x 3/4 sin 30^0 (longitudinal deviation) + 60 x 1/2 cos 30^0 (transverse deviation)

= 112.5 + 25.98 = 138.5 meter

Same rule applied to 170 meter x 30 meter vessel will be

= 63.75 + 13.0 = 76.75

1. Considering a 250 meter width break water B/W entrance its half width is only 125 meter. For a big vessel (300 x 620 meter) with 30 degrees drift her stern will swing 138.5 which means grounded there.

2. The importance of this study is vessel will not stop where she is heading as traditional thinking. Vessel will steady at her course over ground, heading plus drift angle. When ownship alter course to starboard side vessel will have some part still move to port side cause collision in close range.

4-07 總結大副的知識層面

大副班，就像我們開始所講的，這一班從來就不容易，雖然呢大副已經具有相當的經驗，在這一章，我們探討過更多的雷達瞭望的細節，主要是集中在，雷達設定如何調整？碰撞點的性質，跟安全的相對方位，這是我們瞭望直覺的中心。

我們已經瞭解 15 度的轉向與 30 度的轉向，對 CPA 會有什麼樣的效果，也就是我們避碰行動的有效性。如果我們**設定電子方位線，由本船的船位出發，來代替我們的速度向量線**，我們就可以旋轉電子方位線到本船想要航行的方向，然後檢查本船的速度向量線，來知道我們能夠獲得多少的橫越航線的距離，以及轉向後，獲得多少避碰的時間，就像在第四章 30 節所討論的，避讓的時候，同時也要能照顧到橫越航線的距離。

能夠在雷達的畫面上，找出可能的碰撞位置，必須知道如何將本船的雷達設定在搜尋的模式，在最後桑吉輪的調查報告，官方調查機構強調有兩個雷達的碰撞警告信號，以及一些 VHF 的無線電通訊，使得當值船副的工作超載，也就是船副無法一個人處理。如果是在一條客輪上，有數千條平民老百姓在船上，要解決這樣的問題，就是 DOUBLE WATCH 多派一組人馬當值，尤其是在夜間的航行當值，駕駛台是黑暗的，而窗戶外面又有太多的背景燈光，油兩個當值船副來同時執行航行當值的任務。實際上在客論上也是這麼做的，一條客輪有執照的船副管輪就超過 60 幾位，可是在一般商船上面，我們邁向榮耀的旅程是孤獨的，兩部雷達同時使用，不應該是我們的障礙，反而應該是非常有用的。

這種障礙來自于兩台雷達的信號，經常互相混淆，一台雷達打到小型船隻的回跡，可是在另外一條船上，又看不到這條船，這是因為在雷達畫面上，回跡的大小尺寸不同，我們還需要再重新確認雷達目標是否是同一條船，這樣子反而因為多開了一台雷達，浪費了更多瞭望的時間，更別說是當班的心理壓力。這樣的雷達設定就是一種浪費，如果我們知道如何設定兩台雷達，在自動搜尋的模式搜尋特定的目標，依照我們的需求，在船隻繁忙的區域，就像是在多佛海峽裡面 F3 浮標的附近。

要判斷碰撞危機，使用相對運動的速度向量線是簡單，但是要找出適當避碰行動的選項，使用相對運動線，在雷達上卻是不太可能。這是因為相對運動線，只用一條速度向量線混合了本船與目標船的綜合行動，讓我們搞不清楚本船到底應該轉向多少？應該要維持多少的船速？我們要知道自己有些什麼避碰行動的選項，雷達的設定，一定要設在真運動速度向量線上，所以是不是雷達瞭望的高手，看他在雷達上的設定，就可以加以判斷。相對運動的速度向量線要判斷碰撞危機，簡單，要判斷避碰行動的選項，困難。**真運動速度向量線要判斷避碰行動的選項，簡單，要判斷碰撞危機也不難，要訓練。**

我們呢也探討過真運動速度向量線的特性，清除了我們對本船可以採取任何避碰行動的疑慮，包括安全的相對方位，而且最佳的避碰措施是什麼？在後面的章節會有更多的例子，在圖形 4-16 當目標在四海浬時方位改變 5 度，他的 CPA 變化。

我們可以使用相對運動雷達的畫面，來示範目標的方位改變，對於目視瞭望者，代表的是什麼意義，反過來說，我們瞭解目視的相對方位改變與 CPA 的改變之間的關係。如果目標是在四海浬遠的距離，目視瞭望需要利用很多的甲板參考點，來估計目標的相對方位，與相對方位變化是多少？我們每天駕駛台當班的時侯，都看到甲板上的參考點，如果你不能記得這些甲板標誌的相對方位，你永遠都可以使用船艸羅經複數器來重新確認一遍，天天當班，如果你還不能記得甲板標誌的相對方位，你就太笨了，不適合跑船。也許你可以考慮用一張圖畫紙把它畫下來，並標注度數在上面，之後用來做目視方位的參考。要讓他成為你的潛意識，或是目視瞭望的直覺，記得它的相對方位，然後再核對方位變化。

如果只是記得目標的相對方位標誌，當本船在轉向，或是已經轉向了以後，可能會引起方位計算上的一些錯誤，這也許是對的。事實上，經過後來的研究，相對方位不變就是碰撞，不管本船是否有在轉向？**所以本船轉向之後，相對方位還是不變，那就是表示碰撞是無可避免**。目視瞭望包括安全的相對方位，在目標眾多的情勢下，是非常有用，特別是接近漁船群或是船隻在近距離。知道如何使用真運動的速度向量是最重要的，**大副對碰撞危機的處理能力，是由 3 分鐘的速度向量線或是我們的太空船狀態來決定的**。我們現在討論資深船副處理碰撞前 3 分鐘的情勢，就像圖形 4-25 在碰撞前 3 分鐘，本船還能做些什麼？考量離碰撞時間少於 3 分鐘時的行動，是船長的挑戰。

總結呢要解決多目標的情況，有兩個方法，繞過所有船隻的尾部，然後一次性的避讓，不然就是要找尋空隙，然後從中穿越，就像是高速船每天在做的事，只是呢以前沒有理論基礎，我們討論的非常多。如果你是大副一次讓過所有船隻，是你船長希望你能做到的事情，如果不幸，你發現自己已經身處在混亂之中，沉著的使用你的技巧，去確認目標方位的改變，然後集中在會碰撞目標的真運動速度向量線，尋找可能的航向改變或是減速的行動，即使本船亮的像一棵聖誕樹，就像是一艘客輪的燈光，並不能說明你的避碰情況，打開甲板的走道燈，在警急之下，可能可以幫助其他船隻確認本船的視角。

本船的減速，永遠都可以減輕碰撞的嚴重程度，如果你能注意到你的船尾，是否有船隻正在通過？對做船長來說，還有更多的挑戰，所以大副們，加油吧。

4 – 07 Conclusions of knowledge base for Chief Officer

Dog watch as we said in the beginning: this watch has never been easy to handle although Chief is well experienced. In this chapter we go through a lot more on Radar Lookout mainly concentrate on radar setting, collision point properties and safety relative bearing SRB which is the center of our instinct. We understood what effect of 15 degrees turn and 30 degrees turn can do to CPA: the effectiveness of our avoidance action. If we use electric bearing line EBL center at ownship's as our speed vector we can rotate EBL to the heading ownship want to sail and check it with target vessel's speed vector to know how many Cross Track Distance and time we can gain by our course alteration. To read possible collision position PCP on radar picture we need to know how to set the Radar in searching mode properly. In last Sanchi investigation report the authority had emphasized, two ARPA warning signals and one VHF communication overloaded the working ability of OOW. In cruiser ship has thousands civilian lives on board how to protect them the solution seems easy: Double Watch especially at night watch while bridge is dark, outside the window have too many background lights. This is what they did on Costa Concordia. Total licensed OOW are over 60 persons on board one ship. However, if traditional lookout skill needs one OOW dedicated to ARPA lookout. Double watch is still not enough.

We are merchant mariner on cargo ship. Our career journey to glory is solo. Two radars should not be our hinderance if we cannot know how to use it in automatic searching mode. Search for the specified target we need in dense traffic area like around F3 buoy in Dover Strait. To read collision risk by relative motion speed vector is easy. But to read out the options of avoidance actions we had in relative motion radar is impossible, it is also hard to know any course and speed change of target vessels in her RM speed vector. **We go through True Motion speed vector properties to clear out all the smoke of what we can do and should do to best aid to collision avoidance.**

In figure 4-16 Target bearing change 5 degrees at 4 nm distance away, we used relative motion radar picture to illustrate what Target's bearing change means by visual lookout. In return, we understand the relations of visual relative bearing and CPA change at 4 nm distance away. **Visual lookout needs lots reference mark on deck to provide target's relative bearing and to know her bearing change.** These reference marks on deck are our daily bread on bridge. If you cannot remember its relative bearing when we joined bridge watch, you can always use center gyro repeater to make sure again. Make it your subconscious or instinct in visual lookout. Remember its relative bearing by heart for later use. Reliance of relative bearing reference mark on deck when ownship's course is changed may cause some mistake in bearing change calculation. It is correct. We should beware of target's relative bearing change is closely related to ownship's heading. Visual lookout in safety relative bearing SRB are useful for multiple targets situations especially same type of vessels in group. In close range how to use true motion speed vector is most important. Chief Mate's ability to handle collision risk is defined by 3 minutes speed vector or our space ship status. All these discussions so far are to prepare Senior OOW for 3 minutes before collision (challenge of Master) as figure 4-27 what ownship can do 3 minutes before collision.

There are two ways to solve multi-target situation: One is to go around it all and pass last vessel's stern. The other is looking for the gap and go through it like High Speed Craft did. If you are Chief Mate option one is expected by your Master. If you find yourself in middle of the chaos you need to calm down and use your visual techniques to verify target bearing change and concentrate on collision target's true motion speed vector looking for possible course change and speed reduction. In open sea, to find safe route by speed vector won't touch another vessel is possible. In confined waters to find safe route to ownship in chief mate level is to have the ability to judging collision point change properties by ownship's avoidance action. Even you are lighted like a Christmas Tree like a cruise ship these lights cannot help improving your collision situation. Turn on deck alleyway lights under containers may help other vessel to identify ownship's aspect and turning tendency. Slow down can always mitigate the severe situation if you can beware vessel passing your stern at the same time. More challenges are ahead for a Master. Be it, Chief.