Annex 1 – Navigation, meteorological and oceanographic features of the navigational area

1. Waterway situation and sea traffic of the area.

The main waterway to the LNG Terminal on the Island of Krk is the sea passage through Kvarner, i.e. between the eastern coast of the Istrian peninsula and islands of Lošinj and Cres and through the passage of Vela Vrata. The main entry-exit waterway running through Kvarner can further be divided into two parts: wider sea area at the entry into Kvarner and narrower area of Vela Vrata and Rijeka Bay. On the open sea above Kvarner, maritime traffic takes place along the coast from and to northern Adriatic ports (Trieste, Kopar and Venice), as well as to and from Bay of Rijeka. There is no significant navigational danger at the unrestricted area of entrance into Kvarner. However, at the entrance into Kvarner, the Galijola Isle is located as the only place in that area that represents a certain navigational danger due to possible stranding. The Isle is well marked using harbour lights and radar beacon and as such can be detected on time using a shipboard radar.

The depths over Kvarner are around 50 m. The density of waterways traffic is shown in Figure 13.1. below, which is shown through Automatic Identification System (hereinafter: AIS)

![Figure 13.1. Waterways and the related traffic density (AIS images – January and July 2014)](image)

At the passage of Vela Vrata (width of 2.3 to 2.8 M) a traffic separation scheme is established, specifying the general course in a way that all vessels longer than 20 m sailing northeast and entering Rijeka Bay, must navigate close to the coast of Cres, i.e. must use the east track of the traffic separation scheme, whilst vessels sailing southwest, i.e. leaving Rijeka Bay must use the west track.

At the entrance into Rijeka Bay north (hereinafter: N) of the traffic separation scheme is a junction of navigation routes of ships sailing in and out of Rijeka Bay from various directions, i.e. terminals. The second junction is located in the middle part of Rijeka Bay at the intersection of routes of ships sailing from Vela Vrata for Bakar Bay or Omišalj oil terminal and ships from Srednja Vrata sailing for the ports of Rijeka and Opatija.
2. **Orientation points and landmarks on the waterway**

Rijeka Bay is a marine area located between the northeastern coast of the Istrian peninsula and Croatian coast up to Bakar Bay on one side and western coast of the island of Krk and northern coast of the island of Cres on the other.

![Image](image_url)

*Figure 13. 2. Lighthouse coverage (range > 5m) – waterways towards the ports of the Rijeka bay*

3. **Navigation and communication coverage of the area**

In accordance with the available equipment (mandatory and/or common), to determine the position of the vessel, terrestrial/coastal navigation, radar navigation and satellite navigation are used. Measures and control of navigation management are prescribed by Ordinance on the safety of maritime navigation in the internal waters and territorial sea of the Republic of Croatia and the manner and conditions of performing supervision and management of maritime traffic (Official Gazette No. 79/13, 140/14, 57/15).

**Radar navigation:** Across the entire navigation area, the coast is predominately high and steep, and the position of vessels can be determined visually or by using radar devices with certainty and on time in all weather conditions. Due to the very good reflection with regard to the configuration of the coastline, radar navigation can be used to determine position with great accuracy even at distances exceeding 30 NM (with a radar antenna high enough).

**Satellite navigation:** Satellite navigation (mostly the Global Positioning System (GPS) i.e. GLONASS) can be used in the entire area of the Adriatic as well as Kvarner i.e. Rijeka Bay. Accuracy, availability, reliability, time interval between two successive positions of the vessel and system capacity are in order and meet the international standards in full. In the observed area, as well as the rest of the Adriatic, there is no system that enhances the accuracy of the GPS signal, i.e. DGPS.
Annex 1 – Navigation, meteorological and oceanographic features of the navigational area

**Surveillance of maritime traffic and Communication coverage:** Determined by international rules of radio traffic and services all vessels are obliged to communicate with the VTS service available 24 hours a day, the competent Harbor Master's Office and the Port Authority on the VHF radio channel of the VTS sector in which they are located.

**The national Search and Rescue (SAR) coordination center:** In coordination with other sub centers deals with the search and rescue and performs control of safety of maritime traffic in the observed navigational areas. The office is reachable at VHF channel 16 and telephone number 195.

**Weather reports:** Taped-voice weather information in Croatian, English, Italian and German for the coastal waters of Croatia is broadcast continuously from the VTS CROATIA shown in the table below. Broadcasts are made and repeated approximately every 15 minutes, the tape is updated at 0800 and 1300 Local Time (LT). Information broadcast includes a brief situation report, 24-hour short forecast and a barometric pressure report.

**Table 13. 1. Weather reports channels**

<table>
<thead>
<tr>
<th>VTS CROATIA location</th>
<th>VHF Ch</th>
<th>VHF coverage area</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>SV. MARTIN</td>
<td>73</td>
<td>Northern Adriatic- west coast of Istria</td>
<td>45°07'·56N 13°44'·33E</td>
</tr>
<tr>
<td>OSORŠĆICA</td>
<td>69</td>
<td>Northern Adriatic – east part</td>
<td>44°39'·99N 14°21'·88E</td>
</tr>
<tr>
<td>DUGI OTOK</td>
<td>73</td>
<td>Central Adriatic – east part</td>
<td>43°59'·38N 15°03'·43E</td>
</tr>
<tr>
<td>VIS</td>
<td>67</td>
<td>Central Adriatic – east part</td>
<td>43°01'·79N 16°06'·57E</td>
</tr>
<tr>
<td>DUBROVNIK</td>
<td>73</td>
<td>Southern Adriatic – east part</td>
<td>42°39'·60N 18°05'·23E</td>
</tr>
</tbody>
</table>

Weather reports and navigational warnings are also are broadcast on Croatian VHF Coastal Radio Stations:

- CRS Rijeka – Local Time: 05:30, 12:30, 19:30, 00:30
- CRS Split - Local Time: 05:45, 12:45, 19:45, 00:45

**Maritime Safety Information:** are also available under the NAVTEX System:

**Table 13. 2. Maritime safety channels**

<table>
<thead>
<tr>
<th>NAVTEX station</th>
<th>NAVTEX frequency</th>
<th>Broadcast schedule (Coordinated Universal Time - UTC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPLIT (Q) International NAVTEX</td>
<td>518 kHz</td>
<td>02:40 / 06:40 / 10:40 / 14:40 / 18:40 / 22:40</td>
</tr>
<tr>
<td>SPLIT (F) National NAVTEX</td>
<td>490 kHz</td>
<td>00:50 / 04:50 / 08:50 / 12:50 / 16:50 / 20:50</td>
</tr>
</tbody>
</table>
Magnetic conditions: In the area of the Adriatic Sea, magnetic anomalies have been observed in the area of Lošinj - Rijeka and in the southern part of the Adriatic in the area of Jabuka - Svetac - Vis, especially due to the geologic structure of mountains along the coast as well as eruptive rocks of the isles of Brusnik and Jabuka. In these areas, it is advised to check on a more regular basis the position of the magnetic compass; also, devices that do not depend on the Earth's magnetism should be used, as much as possible, to determine the position of vessels.

4. Maritime safety of the area

The waterway stretching from the open part of the Adriatic to the LNG Terminal on the Island of Krk is an area of various hydro meteorological and navigational conditions and diverse maritime traffic in which vessels of significantly different characteristics sail side by side. Srednja Vrata and Tihi Kanal are approaching waterways for the ports in Rijeka Bay for cargo and passenger vessels of smaller sizes sailing nationally as well as vessels used in nautical tourism. During the summer months, there is heavy traffic of vessels used in nautical tourism which leads to a higher risk of collision. Tihi Kanal poses a particular threat, for vessels that use it must significantly change their course and sail through a passage with a minimum width of 0,25 NM.

Regarding the above mentioned, safety domain around the approaching LNG Vessel is introduce by the VTS service during the navigation area Vela Vrata until berth or anchorage: 1,000 m from the bow and stern of the vessel and 500 m on each side of the vessel.

Navigation through Vela Vrata has been organized in the way as defined in Maritime study. Due to favorable navigation coverage of the passage, safety domain around the approaching LNG Vessel, sufficient depths, clear radar visibility and the right width of the navigation route with a traffic
Annex 1 – Navigation, meteorological and oceanographic features of the navigational area

separation scheme, the safety of navigation in this passage, considering the existing traffic, has been deemed satisfactory.

In the area at around 2 NM after exiting the traffic separation scheme, there is a change of course toward the final destination in the area of Rijeka Bay. The new courses range from $005^\circ$ towards the Port of Opatija to $067^\circ$ towards Special Purpose Port - Industrial port LNG Terminal, Omišalj - Njivice Krk i.e. LNG terminal on the Island of Krk.

PBS for LNG Vessels is located at the following coordinates: $44^\circ 56,2''$ N, $14^\circ 31,0''$ E

5. Anchorage information

There are a number of marked anchorages in front of the Port of Rijeka and its terminals, as well as in front of Opatija Port. Vessel anchoring in other areas is common in front of local ports. Anchorage for vessels transporting liquefied gas in a circular shape of an approximately 3 M diameter with the center at $45^\circ 11,1'$ N, $014^\circ 28,3'$ E; the position of the anchorage is located at approximately 1,5 NM from the shores of the island of Krk close to Njivice, as provided in figure 13.4 below.

East and west anchorages of Rijeka Port are used for cargo and passenger vessels that enter the terminals in the area of Rijeka Bay in Rijeka, Sušak and Bakar basins, Brajdica container terminal and shipyards Viktor Lenac, 3. Maj and Kraljevica. Anchorage for tankers is used by vessels entering the JANAF terminal and Bakar tanker port, whilst the anchorage for vessels transporting liquefied gas is intended for use only to anchor vessels transporting liquefied gas.

![Figure 13.4. Anchorages areas in Rijeka bay](image)

6. Wind influence in the area.

The prevailing wind in Kvarner is the bura (bora). It blows from a wide range of directions: along the island of Cres from a direction close to north and along the Istrian coast from a direction close
to east. It generally occurs in autumn and winter, from November to March. Warning signs of bura are crown like whitish clouds over Velebit. It usually blows for 3-4 days but can also last a whole week. In this area, bura is also the strongest wind. It is strongest in winter and early spring and generally in the colder months of the year. It blows intermittently and can reach a high hourly value of up to 30 m/s. The maximum speed of the gusts can significantly exceed the mean hourly values and reach up to 60 m/s. Inherent to local terrain, thunderstorm from west – southwest (W-SW) and wind from northeast (hereinafter: NE) i.e. bora could appear suddenly with considerably less time for preparedness, unlike from winds appearing from the south. Therefore, if bora or gale thunderstorms are in weather forecast it is reasonable to follow weather forecasts more frequently, at least every 6 hours, and monitor natural glimpses for wind gusts that might appear.

**Figure 13.5.** Seasonal wind roses, the number of days with the intensity of the wind higher than 8 Beaufort (N) and the frequency of silence (C), for certain places in the northern Adriatic

In the observed area, immediately after bura, in significance (considering the top speeds and frequencies), is jugo which mostly blows in the direction from E (hereinafter: E) SE to S and in most part in the winter months from October to March. In the observed area, during jugo, the biggest waves occur due to the fact that Kvarner is open to the winds from the southeast. They usually blow for 2-3 days but can last an entire week. A warning sign of jugo is a dark cloud cap over Mt. Učka and fog over Osoršćica and Velebit.

During the summer months there can be a sudden appearance of local storms (nevera). These result from local atmospheric disturbance and are difficult to predict. They are mostly short-lived sudden gusts of south-westerly winds sometimes of a storm intensity, with speeds over 40 knots and are accompanied by heavy rain.
7. **Waves influence in the area.**

The length of waves in Kvarner ranges from 20 to 30 m, depending on the direction and intensity of the wind. The longest waves come from the SW direction. After the wind stops, the waves in Kvarner and Rijeka Bay slowly calm down due to the spacious fetch length and the steep and high coastline, and for a long time the waves of the swell are felt. The biggest waves in the Adriatic sea can be expected in the area of Kvarner, due to the long term stormy jugo or oštro winds. Partially limited fetch length affects the waves in Kvarner, especially waves coming from the east. Bura and levant can develop waves up to 2,9 m. Waves of lebić are not expected at heights above 3,2 m. The highest waves in Rijeka Bay are the waves coming from the SE. The fetch length toward S and SW (Mala and Vela Vrata) is open. The waves coming from the south in Rijeka Bay change direction from SE to SW and can be expected at heights up to 3,5 m.

Due to the position of the LNG terminal Krk on the western side of the island of Krk, i.e. due to a short fetch length, the waves caused by bura and jugo are not significant. Those types of waves are not expected to have a negative impact on LNG Vessels during their stay at the LNG terminal on the Island of Krk. **Waves in general should not influence the possibility of stay of an FSRU vessel and/or LNG vessel at the terminal.**

![Figure 13. 6. Fetch lengths for main directions](image)

8. **Currents influence in the area.**

Currents, alongside wind and waves, significantly affect the movement of a vessel without power and the movement of oil after an oil spill. Currents in Kvarner and Rijeka Bay follow the flows of general circulation and do not exceed 0,5 knots. In most part, they flow in a counter clockwise direction. **It should be noted that the speed of the current at berth during nice weather will not exceed 0,5 knots and even during the strongest winds it should not exceed 1,5 knots. In depths over 2 m currents will already not exceed 0,5 knots.**
Annex 1 – Navigation, meteorological and oceanographic features of the navigational area

9. Tides influence in the area.

Tides in Kvarner are very similar to those in the open sea of the Adriatic. Only during intensive and long-lasting jugo, the water levels rise somewhat more than in the open sea. Also, during intensive and long-lasting bura, the water levels fall somewhat more than in the open sea of the Adriatic. Tides will in no way affect the maritime traffic in Kvarner or Rijeka Bay. At the location of the Special Purpose Port - Industrial port LNG Terminal, Omišalj - Njivice (LNG terminal Krk), water levels in the winter months in relation to the hydrographic zero can change (average level of lower low waters of spring tides) ranging from approximately 1.7 m above to 0.6 m below the level of the map.

1. Visibility in the area.

Fog in the Kvarner region can reduce visibility on an average of 8 days per year. In general, rainfall in the area of the terminal, i.e. its berth, is of a small intensity and will hinder the arrival and departure maneuvers only in rare cases. The occurrence of fog can be somewhat predicted based on the relative air humidity. In the area of the Special Purpose Port - Industrial port LNG Terminal, Omišalj - Njivice, fog occurs 5 days a year on average, mostly in autumn and winter.