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MARITIME

Denmark LNG Shipping Seminar

Risk management for LNG terminal development

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- Risk management in a project
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- Quantitative Risk Assessment
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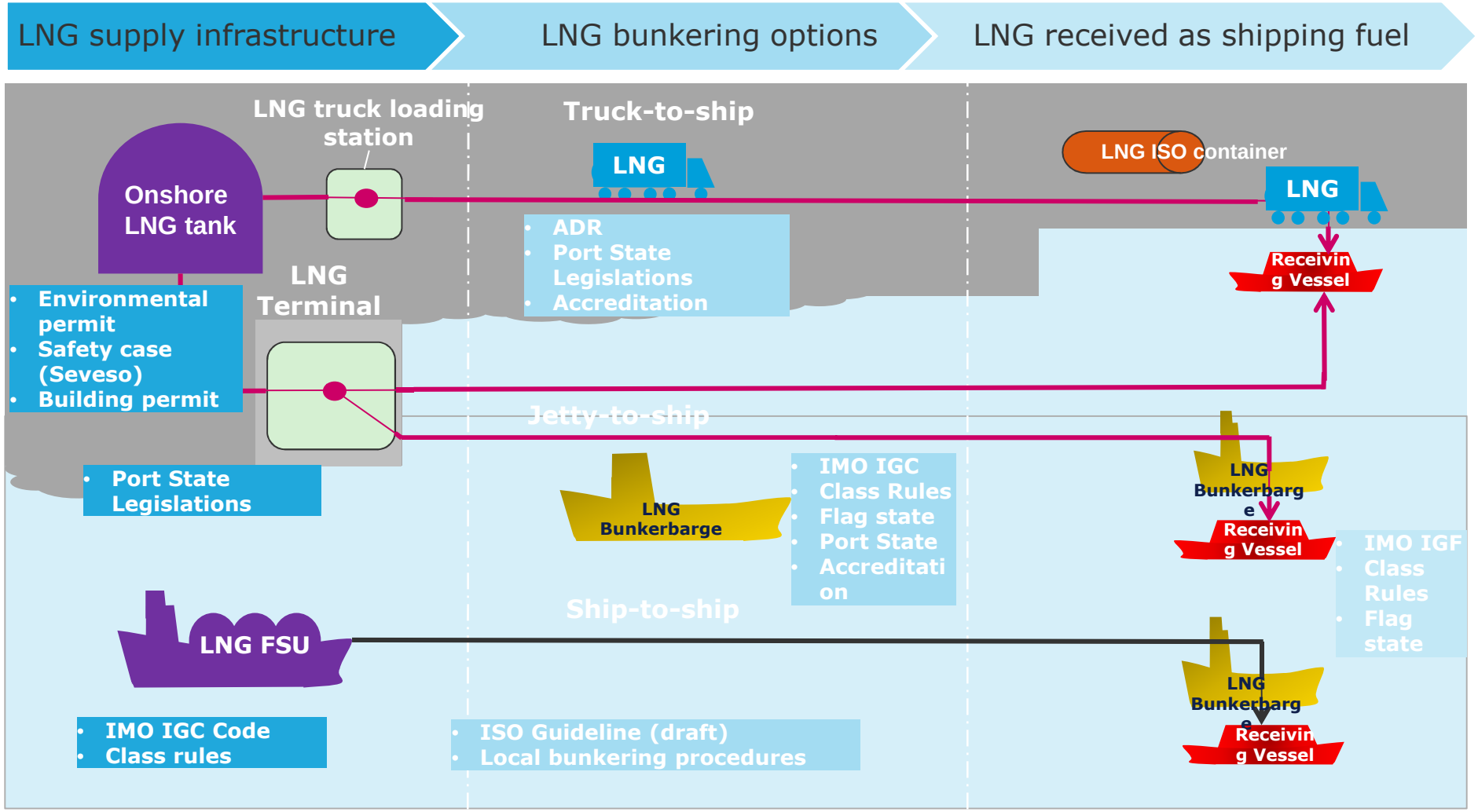
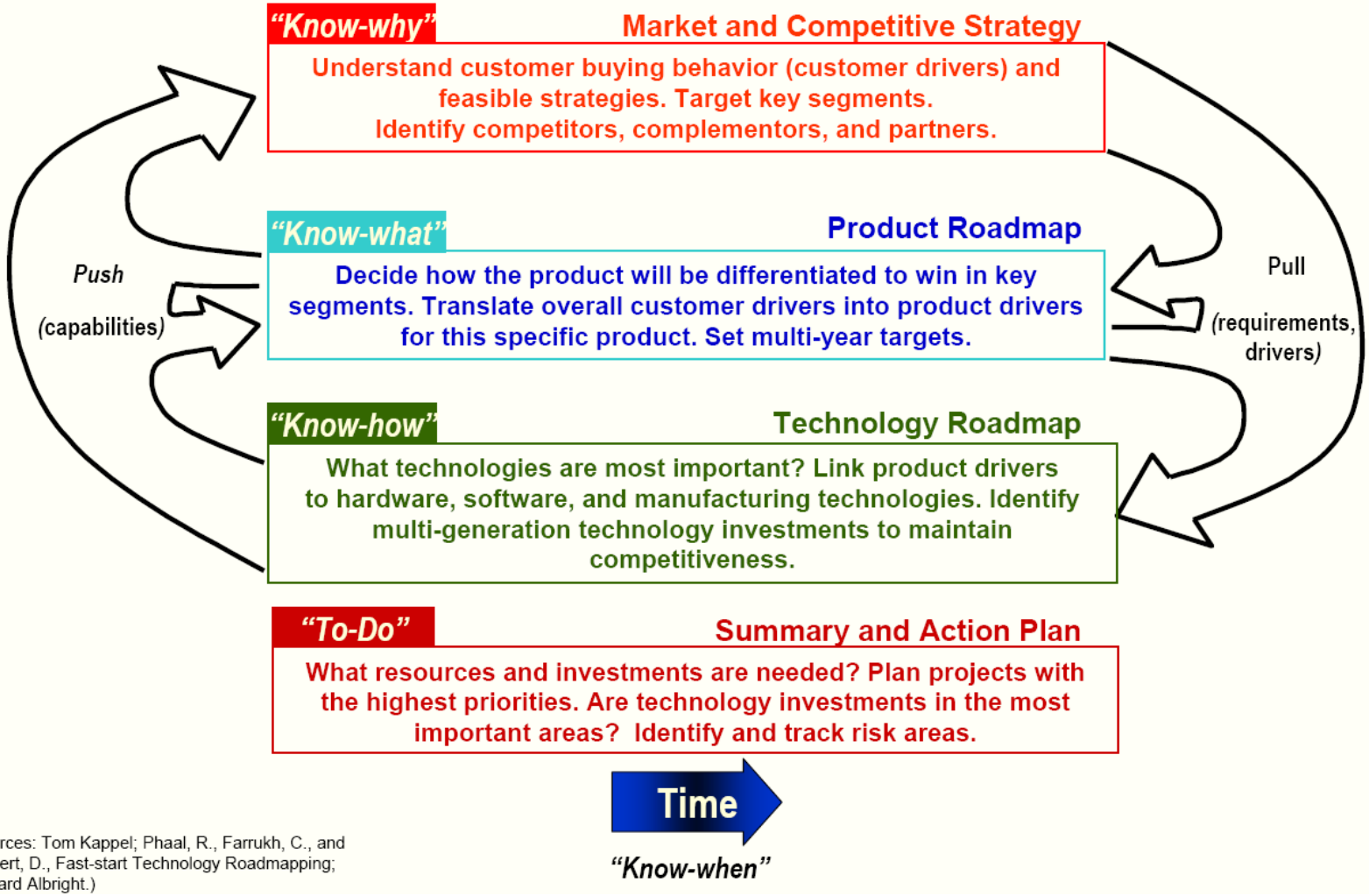
Supply of LNG as a bunker fuel – Options available



Which location and storage solution shall be chosen depends on the why, what, how & when for all relevant domains in the LNG bunkering value chain

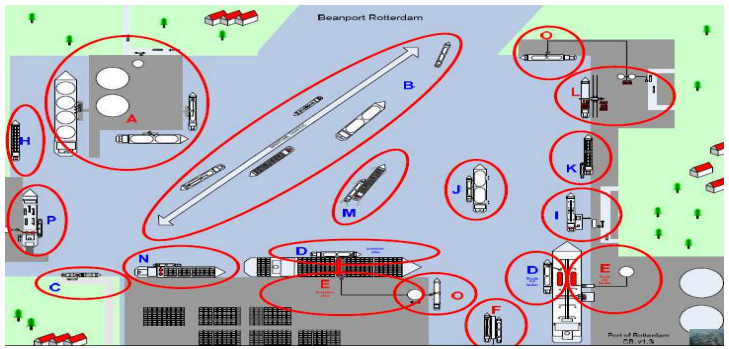


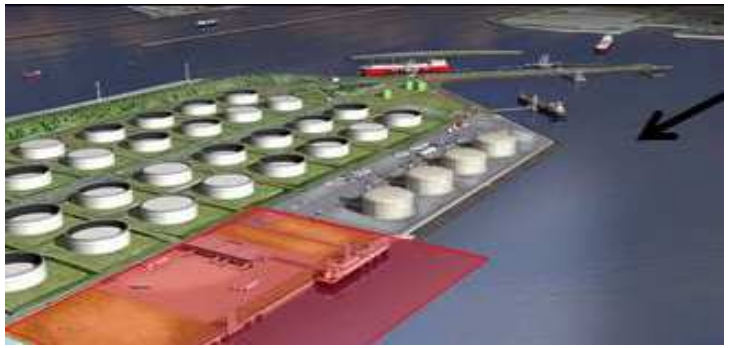
(Sources: Tom Kappel; Phaal, R., Farrukh, C., and Probert, D., Fast-start Technology Roadmapping; Richard Albright.)

1 Supply solution
Fixed storage solutions

- Seveso legislation, if the capacity exceeds 50 ton (low tier Seveso) or 200 ton (high tier Seveso) => requires a safety report (exact form / scope depending a bit on national legislation)
- Building permit
- Environmental permit

- Might be subject to local legislation issued by e.g. the municipality
- Might be subject to additional rules issued by e.g. the local fire brigade, the harbour master office





1 Supply solution
Truck supply

1. Trucks supplying LNG to land installations

- Truck transport is governed throughout Europe by the ADR legislation, contains requirements for the truck as well as for the driver
- For access to port area/terminal additional accreditation can be asked for (e.g. at the Zeebrugge LNG terminal only accredited truck & drivers are allowed access, the requirements for this accreditation are issued by the operator of the terminal, they are more stringent than what ADR prescribes)

2. Trucks supplying LNG to ships (bunkering)

- Governed by bunkering procedures & port state legislation with regard to handling of dangerous goods in the port
- Temporary storage of ISO containers at quays is considered similar

1 Supply solution
Bunker vessel/barge supply

- Have to comply with class rules in general + flag state
- Have to comply with IMO IGC code (The International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk)
- Bunkering operations governed by port state legislations/procedures
- Some ports allow bunkering companies only after an accreditation process

ISO guidelines
Defines philosophies of designs and operations relevant to LNG bunkering facility (May 2013)

IAPH/WPCI
Develop guidelines/checklist and/or assess the possible impact at ports (Nov 2013)

DNV GL RP
a practical guide on developing design solutions and operating procedures to undertake LNG bunkering safely and efficiently (Oct 2013)

DMCA
Provided an example of operational guidelines for LNG Bunkering (2012)

Various initiatives
Norway
Stockholm
Gothenburg
Antwerp (TTS) – Q1 2014
Singapore - ongoing

Shell guideline
(2012)

EMSA
EMSA (European Maritime Safety Agency) study on standards and rules for bunkering of gas-fuelled ships (2012)

Ship to Ship
Operating procedures for LNG bunkering from barge in Port of Gothenburg (2010)

LESAS
Started its own development of LNG bunker regulations – National approval guidelines are under development

SIGTTO / SGMF
Through the LNG Fuel Safety Advisory Group, SIGGTO will provide advise on design, operation and maintenance of LNG marine fuel system

Risk management in a project – An integral part of the engineering

Methodologies for managing risk rather than following a prescriptive rule can be selected based on the level of uncertainty and novelty in the concept to be evaluated:

LOW: Well understood changes, little new or unusual, no strong stakeholder opinions, no major economic impact

MEDIUM: More complexity, deviation from standard or best practice, uncertainty in risks, some trade-offs, some stakeholder concern, significant economic impact

HIGH: Unique challenges, novel or challenging aspects, large uncertainties, strong views and perceptions, major economic impact

Based on UKOOA

Risk management in a project – An integral part of the engineering

The three levels of uncertainty and novelty in turn can be addressed as follows:

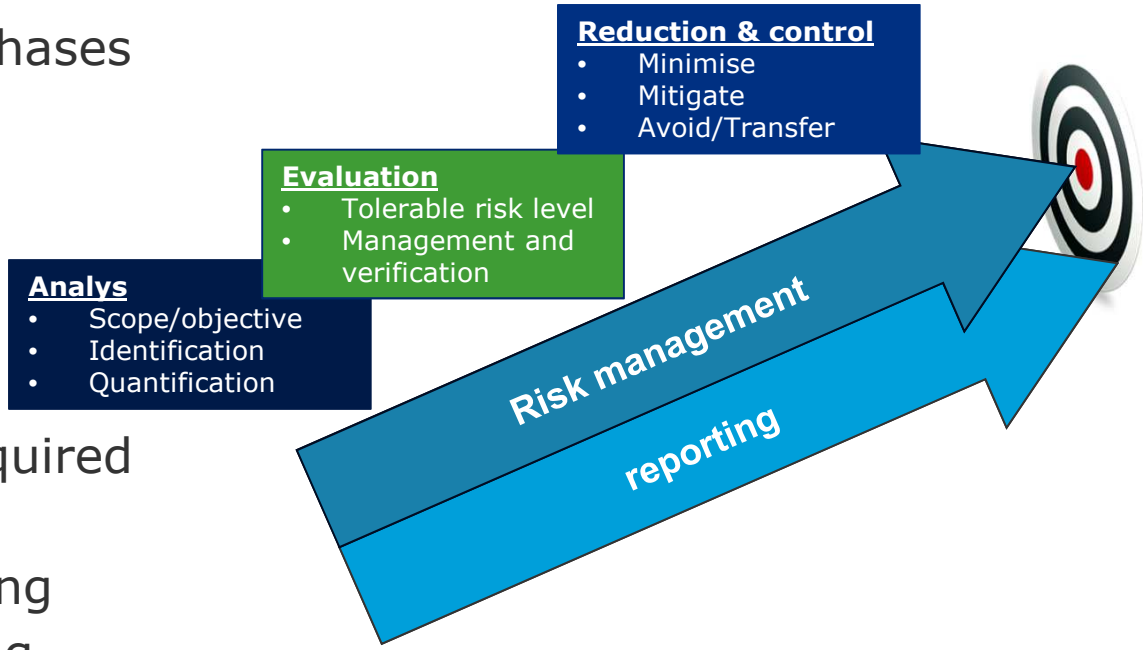
LOW: Mainly a straight forward engineering issue

MEDIUM: Thorough identification of the hazards and risk scenarios required, followed by decisions of how to manage

HIGH: As for Medium, adding a quantified analysis of the risk levels and detailed risk management, including engineering changes and other risk control actions

Risk management in a project – An integral part of the engineering

- Risk for human health and safety as well as environmental risks
- Structured risk management; identify and illustrate risk enabling improvement in engineering and operations.
- Risk management in three phases
  1. Risk **analysis**
  2. Risk **evaluation**
  3. Risk **reduction**



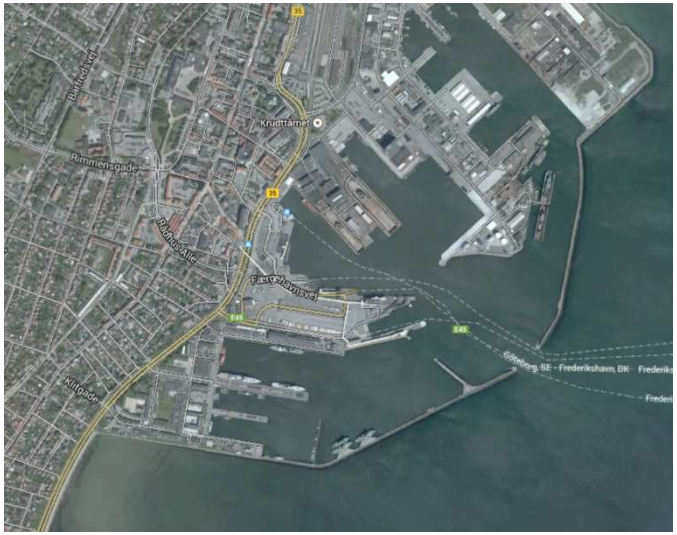
- Risk management will be required both in relation to terminal development, seaside shipping solutions as well as bunkering solutions in any development project
- Risk analysis may have to be refreshed as engineering progresses

Risk management in a project – An integral part of the engineering

- Risk analysis in two stages:
  - **HAZID** – initial identification of scenarios, hazards and barriers
  - **QRA** – Quantitative risk analysis based on HAZID scenarios
    - Evaluation of domino scenarios (cumulative risk, reinforced risk)
    - Evaluation of risk level in relation to generally accepted criteria, eg. UK Health and Safety Executive - HSE, Netherlands Purple Book and local legislation and interpretations.

HAZID (HAZard IDentification) study

- Identification of:
  - **What can go wrong?**
    → identification of hazards and risk scenarios
  - **What is the effect?**
    → Consequence to human, property and the environment
  - **How to manage?**
    → Recommendations for risk management activities
    (prevent, limit, or monitor).

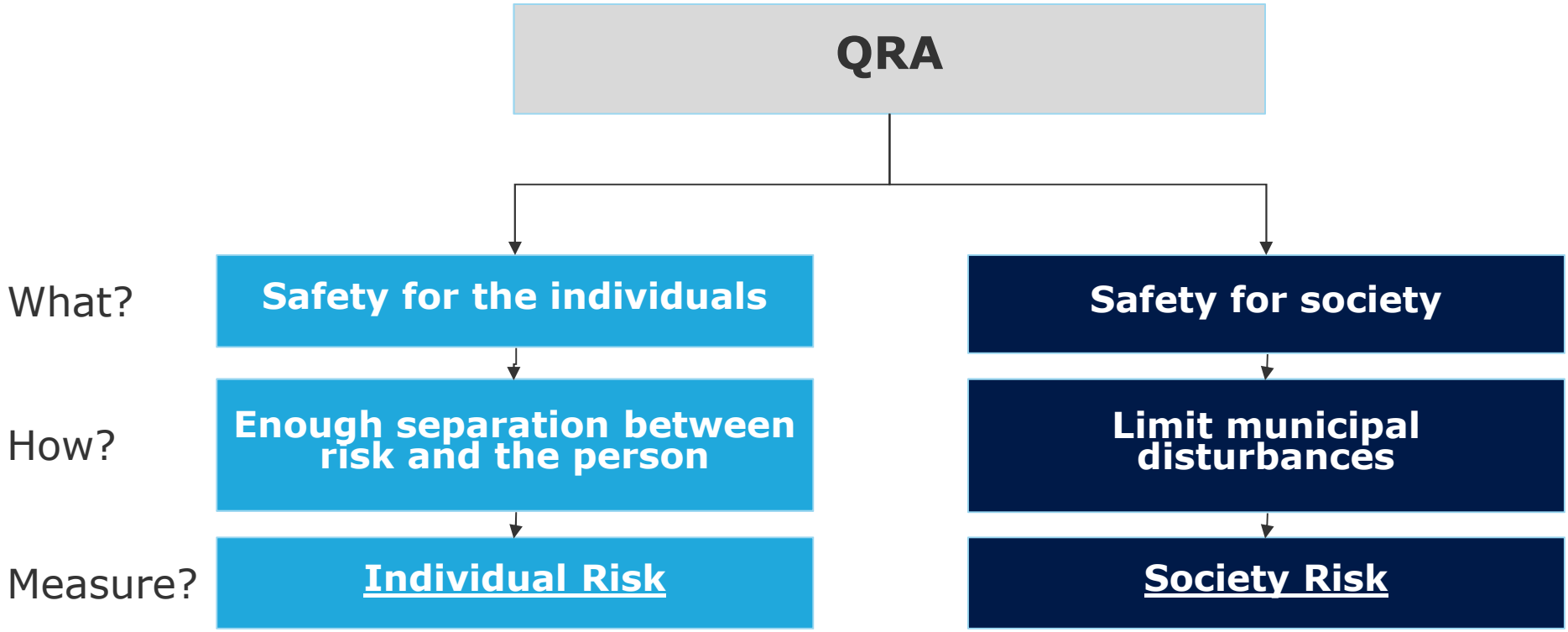


A HAZID for a terminal typically produces around 90 risk scenarios

QRA – Quantitative risk analysis

Risk = Probability x Effect

Why QRA?
→Visualise and illustrate risk levels based on quantification of



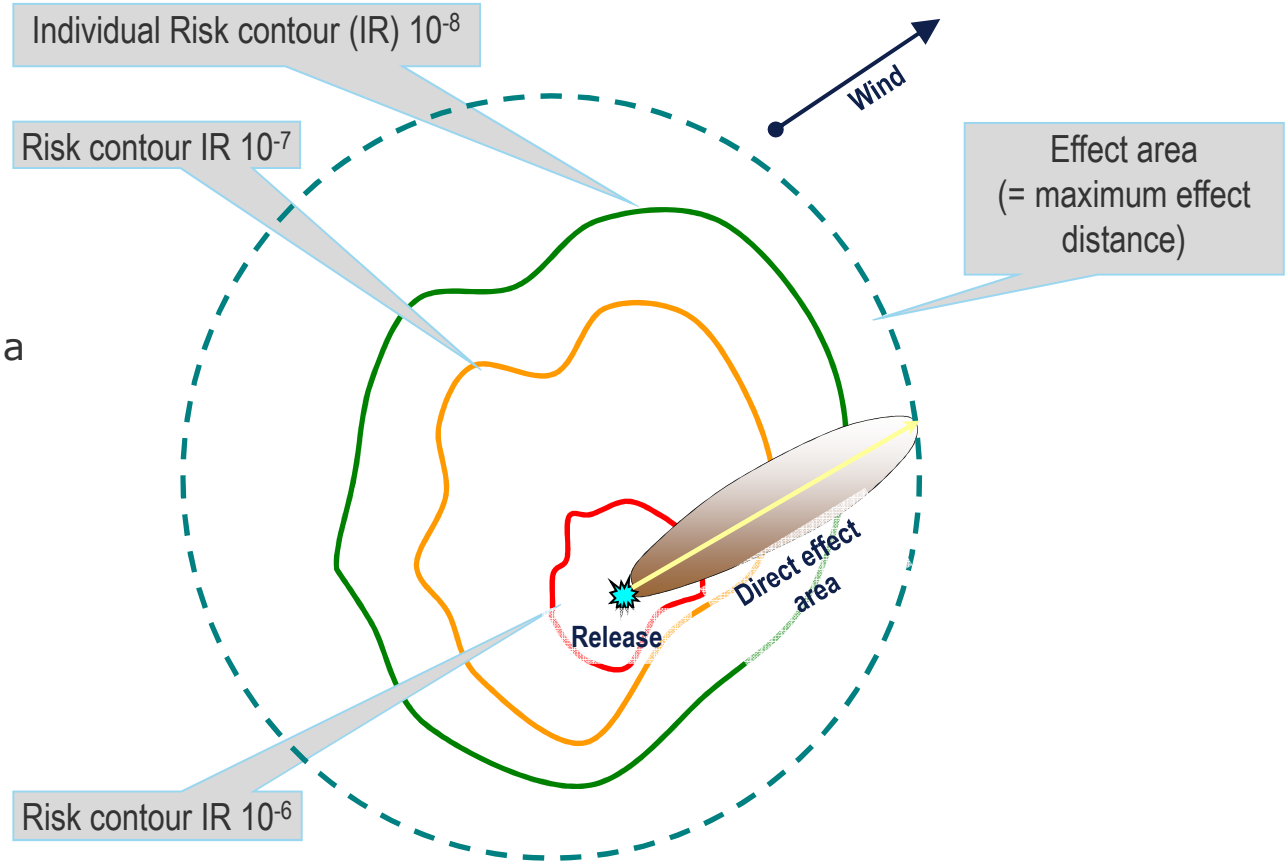
Example for terminal development, but will be similar for all areas

- Safety aspects related to **maritime operation** and loading/unloading and quay
- Safety aspects **within terminal**
- Safety aspects in relation to **train and truck traffic**
- Safety aspects of **pipelines and flare**
- Effect on **surrounding society**
- Potential domino effect and escalation scenarios to **other adjacent industry**.

Risk is quantified based on probability of a scenario and effect on human life

- **Probability classes**:
  - 1 in a million years= 10^{-6}/y
  - 1 in a billion years= 10^{-9}/y
  - Etc.
- **'Effect area'**
  - Maximum area where humans will be affected by a scenario.
- Shall be established using validated and acknowledged dispersion models.

Individual risk illustration



How to assess the results form a QRA, what is acceptable risk

Risk in everyday life?

- Different day to day risks
  - Bee sting $1x10^{-7}$ 1 in 10 million years
  - Lightning $2x10^{-7}$ 1 in 5 million years
  - Airplane crash $1.2x10^{-6}$ 1 in 814.000 years
  - Driving $1.75x10^{-4}$ 1 in 5.700 years
  - Smoking (1 pack/day) $5x10^{-3}$ 1 in 200 years
- Acceptable risk is not a universal axiom, differs between persons, companies, municipalities, regulators and countries.

Are there readily defined acceptance criteria?

- **No** – but there are acceptance criteria in Europe that can be used as benchmarks, in combination with any local industry standards.
- **Great Britain (HSE):**
  - Maximum tolerable risk for workers 10^{-4} per year
  - Maximum tolerable risk for society 10^{-5} per year
  - Negligible 10^{-7} per year
- **Netherlands:**
  - Maximum tolerable risk → 10^{-6} per year

Risk Controls

Key words for options:

- **Tolerate** – the risk is deemed acceptable to all stake holders
- **Treat** – the risk can be reduced or mitigated to an acceptable level in a cost effective manner
- **Transfer** – the risk can be made acceptable by transferring the effects (e.g. insurance)
- **Terminate** – the risk can never be acceptable and the activity must cease

How does it look in Frederikshavn

Modelling assumptions

- Worst case scenario: catastrophic rupture of LNG storage tank
- Maximum effect zone is represented by 100% Lower Flammability Level.
- Storage conditions:
  - 1000 m3 storage tank
  - Saturated liquid at 5 barg storage pressure
- Weather type: D5 (most conservative for all considered scenarios)

Location

- Modelled at randomly selected locations in the port purely for illustrative purposes.
- To show the effect distance and what needs to be included in the analysis, if a terminal is to be located in the port
- Does not say anything about the risk and risk analysis will require more work, but illustrates the impact area,.

Modelled scenarios

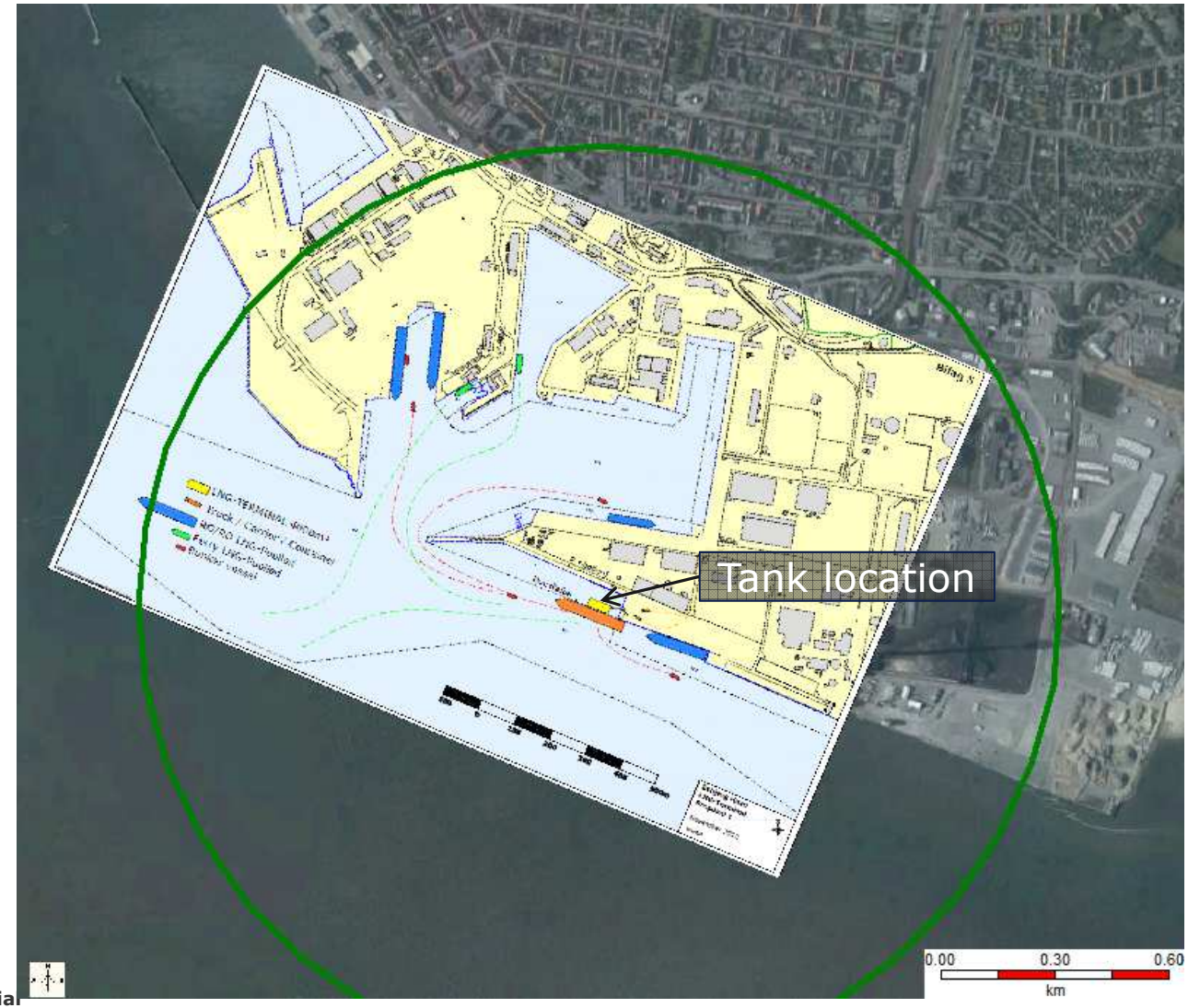
Single tank capacity	Esbjerg	Frederikshavn
1000 m^3	X	X
2000 m^3	X	
4000 m^3	X	

The 2000 m^3 and 4000 m^3 scenarios were modelled at the location of a proposed LNG terminal in Esbjerg

The 1000 m^3 scenarios in Esbjerg and Frederikshavn were modelled at randomly selected locations in the port purely for illustrative purposes

The result is shown as LFL or Maximum effect contours

LFL contour - Esbjerg 4000 m^3 storage tank



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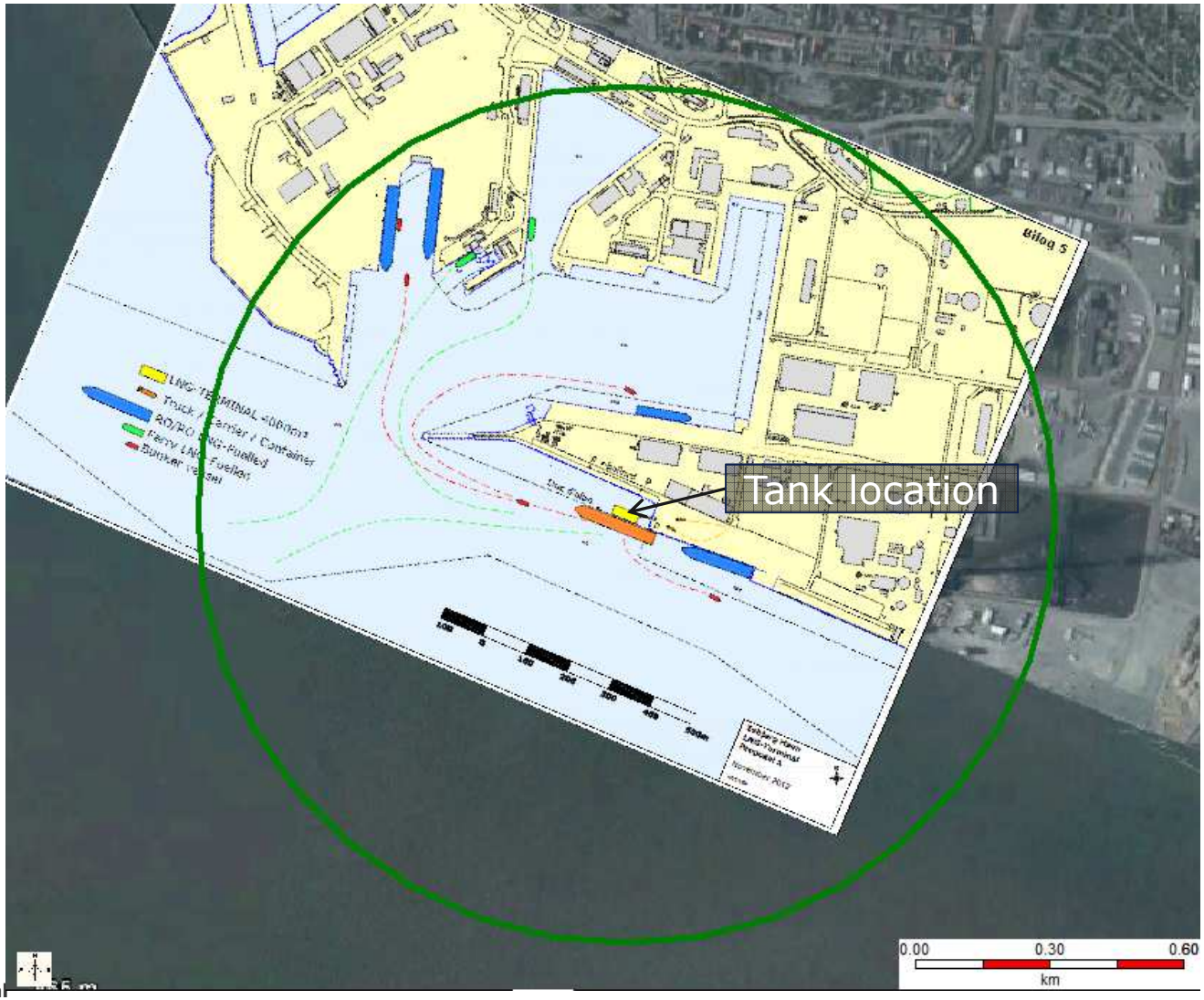
LFL contour - Esbjerg 2000 m^3 storage tank



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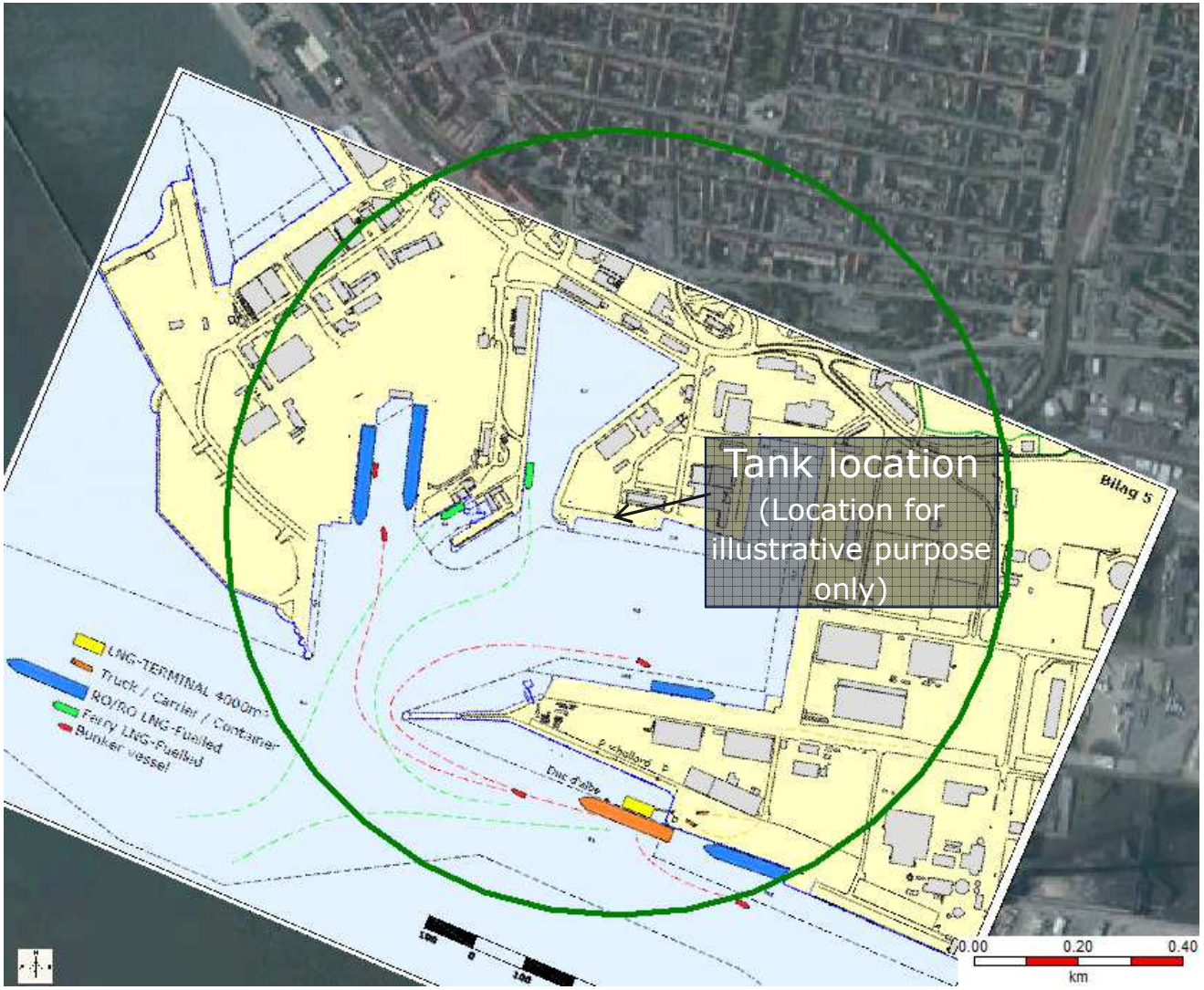
Maximum effect zone - Esbjerg 1000 m³ storage tank (Location for illustrative purpose only)



- In the example a location has been chosen for illustrative purpose.
- In siting studies simplified QRAs are used for assessing suitability of location from a risk/safety perspective.

Maximum effect zone – Frederikshavn 1000 m³ storage tank (Location for illustrative purpose only)

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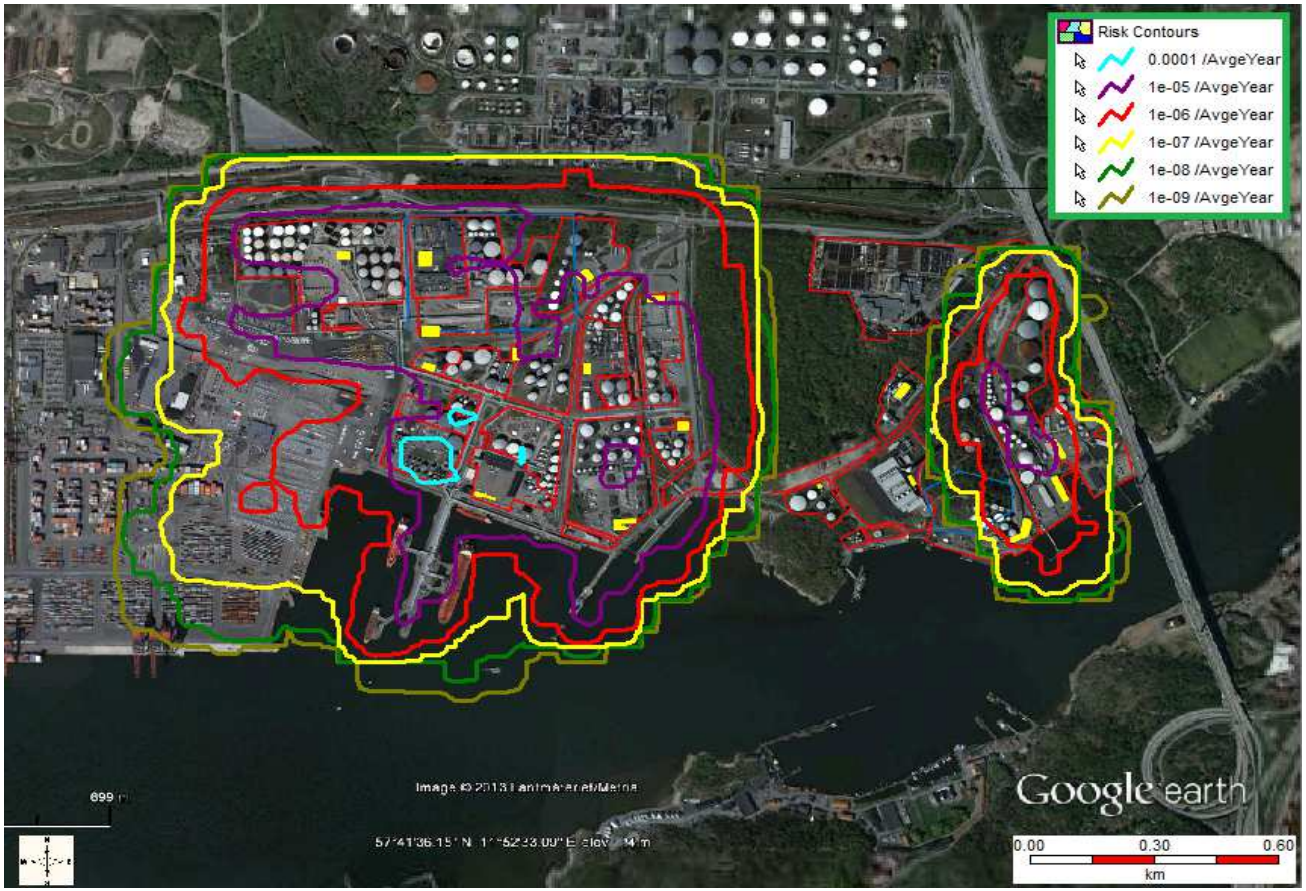
QRA usage for modelling an entire energy port risk profile – current situation in relation to suggested development



QRA is a powerful tool for illustrating the entire risk picture and facilitate communication with society, industry, regulating bodies and other stake holder organisations

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