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The ARGO Project: assessing NA-TECH risks on offshore oil platforms

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Abstract

Analysis of natural and anthRopoGenic risks on Offshore platforms (ARGO) is a 3-years project, funded by the Italian Ministry of Economic Development. The project, coordinated by AMRA , a permanent Research Centre for the development of innovative technologies applied to environmental problems, aims at providing technical-support for the analysis of natural and anthropogenic risks on offshore oil-platforms. ARGO has developed methodologies for the probabilistic analysis of industrial accidents triggered by natural events (NA-TECH) on offshore platforms. The final analysis of the ARGO Project suggest a constant monitoring of exploitation activity, fluids re-injection and storage using high technology networks.

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Keywords: Na-Tech; multi-risk; offshore oil platforms; seismicity; meteo-marine extreme events.

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1. Introduction

Within the framework of scientific collaborations on the offshore safety promoted by the "Italian Ministry of Economic Development-Directorate-General for safety of mining and energy activities" (DGS-UNMIG), AMRA has made available its expertise regarding the possibility of developing a quantitative approach for multi-risk assessments. This was achieved by the analysis of a wide range of risk sources (Fig. 1).

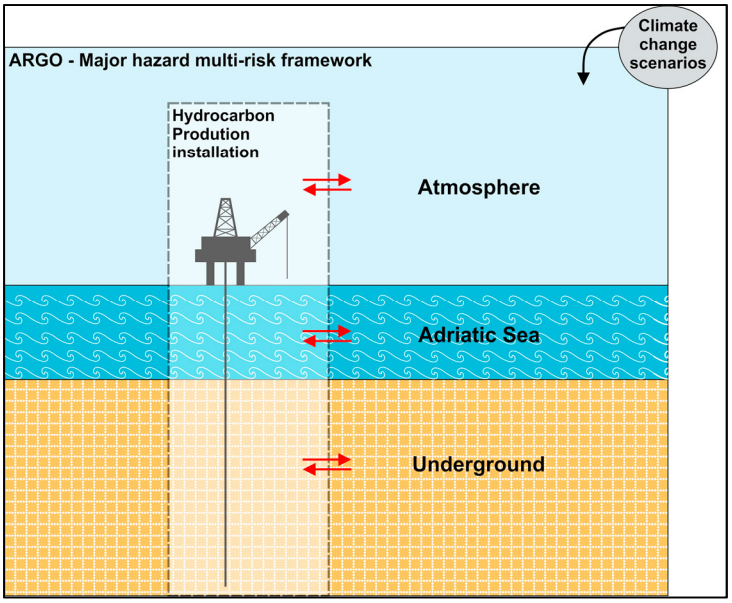

Fig. 1. Identification of possible environment where triggering sequences of events that can lead to accidents on offshore platforms can occur.

This method, taking into account possible scenarios of interaction and the cascading effects of accidents, ensure the possibility to define in terms of probabilities, the expected hazard. The multi-risk approach developed within the ARGO project (Analysis of natural and anthRopoGenic risks on Offshore platforms) is based on a case study in the offshore of the Adriatic Sea, as well as essential data provided by Edison S.p.A (Italian energy company). Project findings, described in the following sections, led to the formulation of a set of recommendations to ensure an appropriate monitoring useful to the definition of risks analysis for the offshore platforms.

2. Activities and results

The ARGO Project had two main objectives: 1) Development of methodologies to analyze natural and anthropogenic risks for protection and safety of oil and gas offshore platforms; 2) Provide technical support for the elaboration of recommendations resulting from project findings.

The selected case studies have been focused on three areas of the Adriatic Sea (Fig. 2): two gas extraction sites (San Giorgio Mare and Santo Stefano Mare) and one oil extraction site (Rospo Mare). Within the ARGO Project was also carried out an assessment of the environmental effects of the water reinjection at the site of the Santa Maria Mare.

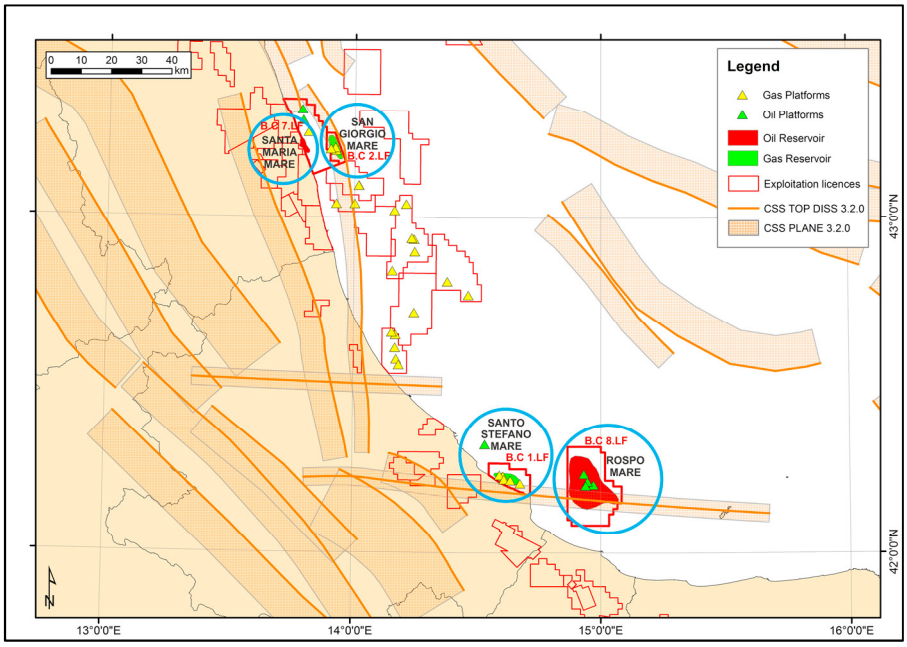

Fig. 2. The ARGO Project case studies. INGV DISS 3.2.0 of DISS Working Group [1] composite seismogenic sources are also showed.

The study initially focused the definition of the case studies and the identification of necessary data for analysis, with particular reference to: meteo-marine data, atmospheric – circulation model, operational characteristics of the platforms and production data, historical offshore accidents documentation, geological and structural data, seismic lines, reservoir characteristics, images from remote sensors. The following phase consisted in the collection of all the kind of data available for the study area at the archive of the DGS-UNMIG [2] and from scientific and technical literature. Finally, specific workflows for the defined project aims have been developed. In order to achieve these objectives, the project activities were divided into six macroactivities. Results are illustrated in the following section.

2.1. Determination of risk related to meteo-marine extreme events, considering the effects of climate change scenarios.

The aim of this activity was to characterize the study area from the meteo-marine point of view by analyzing historical and instrumental data such as sea level, atmospheric pressure, temperature of the sea and air, relative humidity and wind speed.

Subsequently, it was carried out the correlation analysis between the meteomarine instrumental data and the atmospheric model data (RCM); this analysis showed significant correlations between instrumental and model data for the parameter “air temperature” in all study areas. Further significant correlations identified refer to the maximum wind speed. Finally, it was performed an analysis for the extreme events for different scenarios [3], [4] of climate change (RCP scenarios - Representative Concentration Pathways of the IPCC RCP4.5 and RCP8.5) in order to identify possible anomalies for the local climate [5], with particular attention to “maximum wind velocity” (Fig. 3) and “daily accumulated rainfall”.

In Figure 3 appear rather evident that the hazard curves (median), obtained for projections (near and far future) show higher values than the curve obtained for the historical reference period. However, considering the uncertainties in the estimates, the values are higher for the low return periods (up to 10 years), while for the highest return periods, the uncertainties are much wider, and therefore the comparison becomes more uncertain.

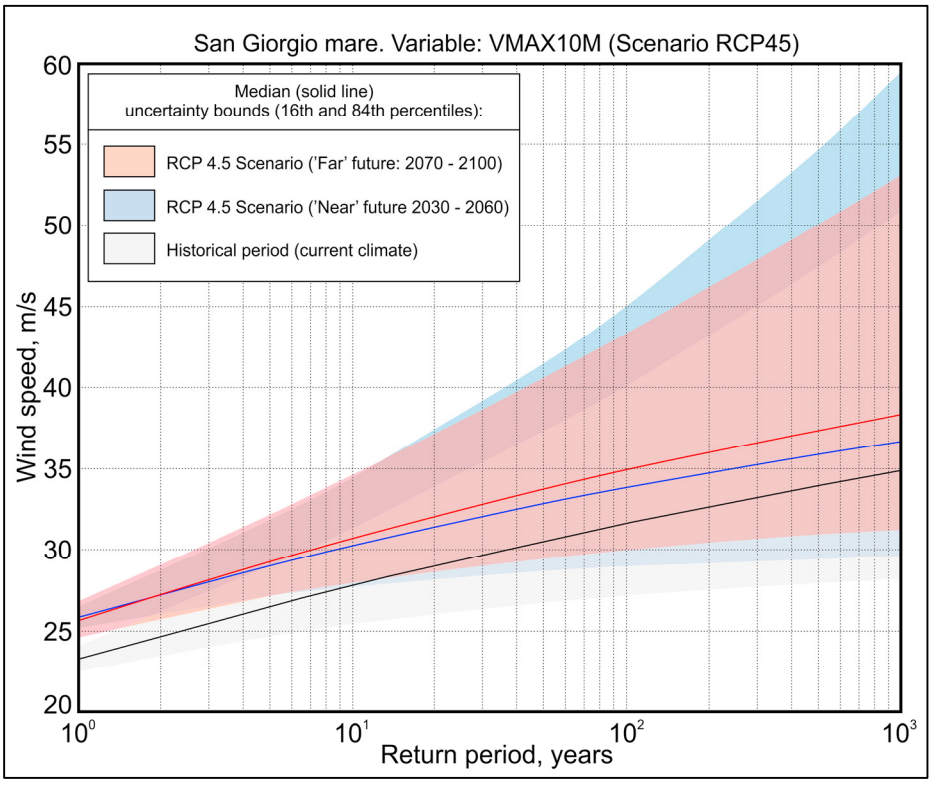

Fig. 3. Example of hazard curves for the daily maximum wind speed in the area of San Giorgio Mare. Comparison between the historical reference time and projection, considering the RCP4.5 scenario.

2.2. Assessment of systemic vulnerabilities and of the main structural elements of the offshore platforms to meteo-marine events.

The objective of this activity was to characterize the vulnerability of the offshore platforms with respect to the occurrence of meteo-marine extreme events using fragility curves (for types of platforms) that provide the probability of exceeding a certain threshold of damage.

For this purpose, the different type of offshore production platforms and the structural elements that characterize it were defined, paying particular attention to fixed platforms, the category to which belong the studied Edison platforms. The study framed the European and national regulatory environment, in particular in reference to the standards used in the design of the offshore platforms in response to extreme natural events (i.e. API RP 2A and ISO 19900 series). It was carried out an historical analysis on damages observed in past, caused by extreme meteo-marine events [6]. Furthermore, historical data adopted to assess the vulnerability of the offshore platforms, have been described. After many industrial accidents related to offshore oil platforms caused by extreme weather events in the last years, it is of uppermost importance to perform a detailed assessment on incidental dynamics in oil and gas production areas.

The study also included a data collection phase on the structural characteristics and layout of all the sensitive plants present on the studied platforms, with particular attention to the Santo Stefano Mare platform.

2.3. Coastline evolution analysis near the offshore platforms.

The study focused on the analysis of possible deformation of the coastline in front of the studied offshore platforms by using DInSAR. In particular, the activities were focused on the evaluation and analysis of deformation

using SBAS-DInSAR of images acquired by Envisat satellite in the period 2002-2010 from ascending orbit, producing velocity maps and deformation time-series (Fig. 4).

The low resolution spatial processing showed no deformation phenomena taking place in the period of observation, in the coastal area in front of the San Giorgio Mare platform, while the deformation time series in the vicinity of the Santo Stefano Mare offshore platform show a trend of about 4 cm subsidence in the time interval 2002-2010. In the case of Rospo Mare was not possible to detect any subsidence, due to the high signal inconsistency reflected from the site.

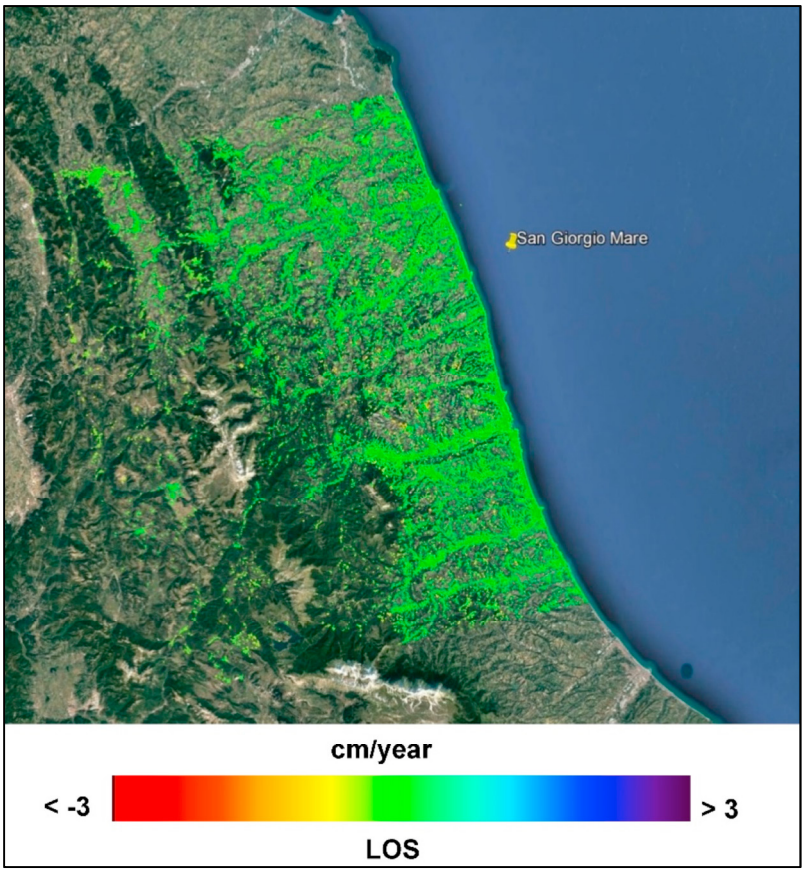

Fig. 4. Geocoded Map of average deformation velocity in LOS (cm/year), estimated at low spatial resolution and superimposed to an image of Google Earth of San Giorgio Mare area. The image refers to the elaboration of ENVISAT data acquired from ascending orbits in the period 2002-2010.

2.4. Triggered/Induced seismicity analysis.

In order to carry out the geological-structural and seismotectonic characterization of the study area [7], it was performed the analysis of confidential data, seismic reflection profiles and well data, granted by Edison S.p.A.. In parallel, was carried out a study of historical seismicity (1000-1980), and of instrumental seismicity (since 1980 to present) (Fig. 5) by using data of the INGV (CPTI Working Group [8] and ISIDe database [9]). Figure 5 shows the epicenters localizations in the study area for $M > 2$. Is evident the existence of poor, low energy, seismicity ($3 \leqslant M \leqslant 4.0$) in the northern portion of the analyzed area, where is possible to highlight the existence of a small cluster in proximity of central Adriatic Sea [10], [11]. Along Abruzzo-Molise Apennine, near the Gargano Promontory and in proximity of the Tremiti Islands were identified others low- to middle-energy clusters.

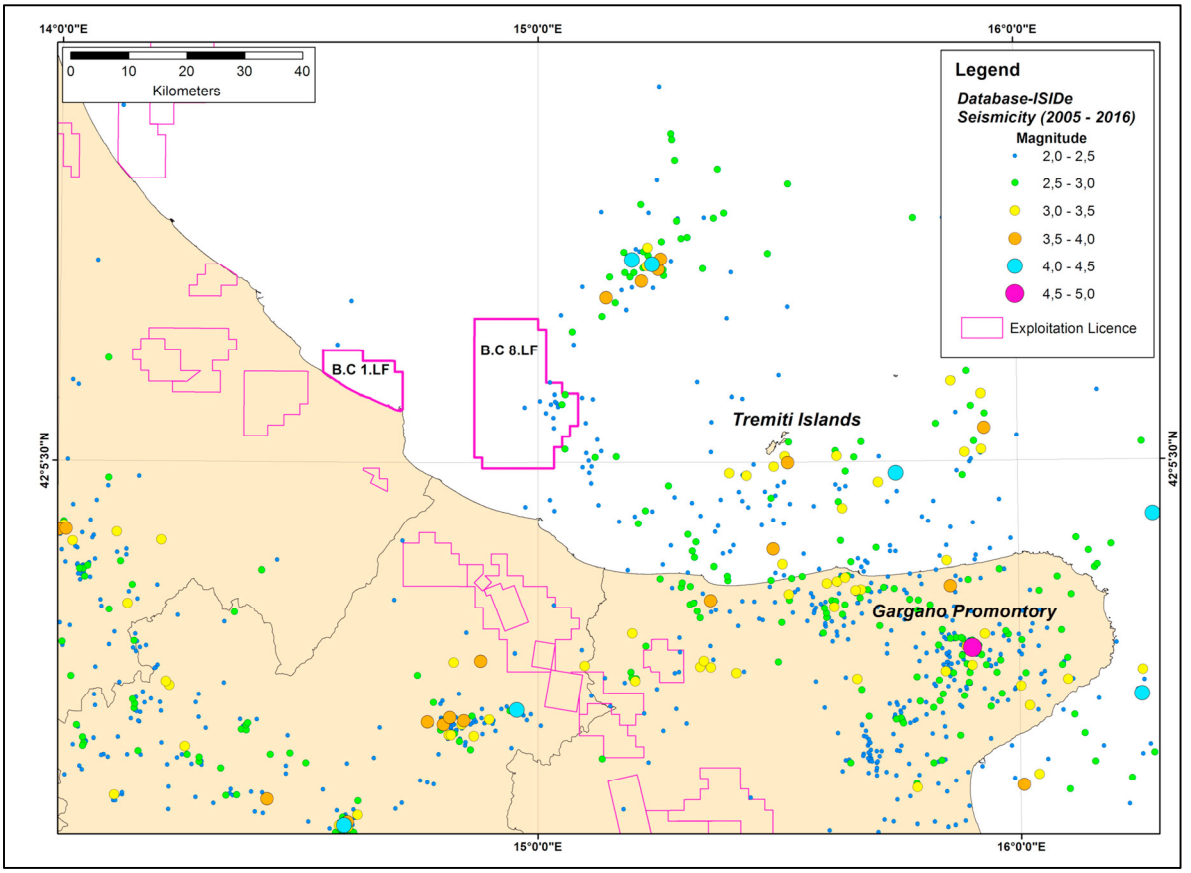

Fig. 5. Instrumental seismicity (2005-2016) of the study area.

2.5. Environmental impact studies of industrial accidents on offshore platforms.

The study focused on the collection and analysis of the main methods used by public authorities, by non-governmental organizations, and trade associations operating in the main western countries, for purposes of monitoring, analysis and assessment of accident risks arising from mining activities, with particular reference to releases of hazardous substances from offshore platforms [12].

The comparison between the different evaluation impact models is a prerequisite to built a methodology for the Italian case, starting from a database of environmental impacts and major accidents occurred on the oil & gas platforms and to the definition of studied asset danger level. We summarize the methods produced by the: International Association of Oil & Gas Producers (OGP) [13], the American Petroleum Institute (API), the Det Norske Veritas (DNV), the Health & Safety Executive (HSE) [14] and by the Norwegian Petroleum Safety Agency (PSA).

The analysis of the WOAD database (World Offshore Accident Dataset) enabled the assessment of offshore accidents occurred at global and national levels. In order to get a useful result to classify these accidents, highlighting the causes and effects, have been extrapolated data on Italians accidents, those relating to accidents caused by global weather events that have determined containment releases or fires and those caused by earthquakes and volcanic eruptions. The WOAD database data on NA-TECH accidents on oil & gas platforms were reorganized in terms of Key Performance Indicators (KPI) according to the HSE scheme, chosen as analysis system. The result obtained refers just to the scenarios described, to define the level of release (whether gas oil), and then the corresponding value of the KPI.

2.6. Implementing multihazard and multi-risk models for the integral evaluation of NA-TECH risks on offshore platforms.

AMRA in the frame of this activity has developed a multi-hazard/risk methodology [15], [16], based on the bow-tie approach (this is a graphical tool to support the representation of accident scenarios, starting from the cause of the accident to the consequences) and Bayesian techniques for data analysis. Thanks to this method, it is possible to analyze the probability of accidents occurrence on offshore platforms and their potential impact, taking into account uncertainties, and considering a wide range of natural and anthropic events. The methodology was applied to some of the platforms of San Giorgio Mare field in order to assess the probability of gas spill considering nine different paths used events tree (Fig. 6).

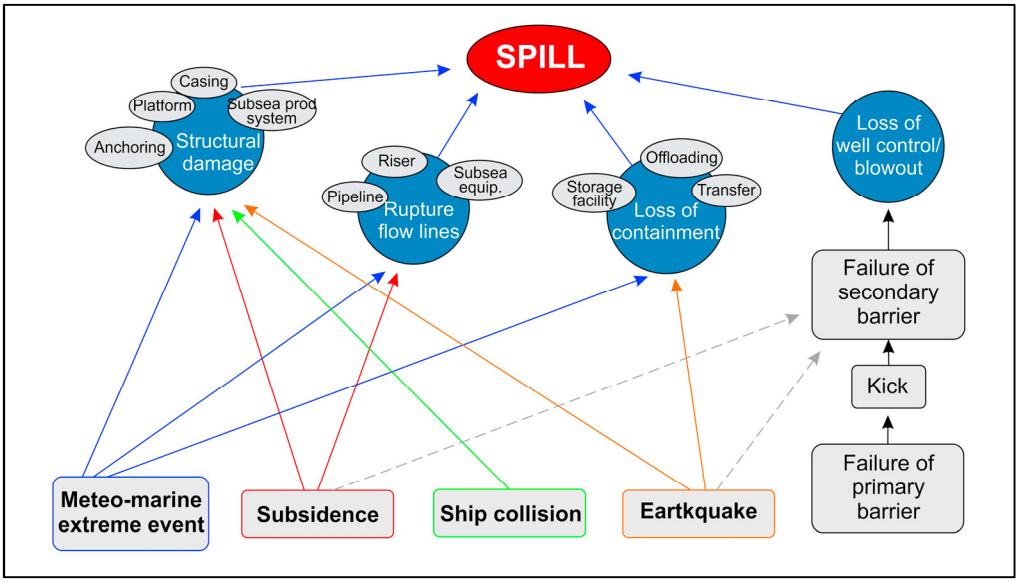

Fig. 6. Example of scenarios of events that can lead to hydrocarbon leak/spill.

3. Conclusion

The final analysis of the ARGO Project has led to the expression of a series of recommendations, among which one of the most significant involved a constant monitoring of exploitation activity, fluid re-injection and storage through the use of high technology networks. Such networks should be designed to follow the evolution in space and time of microseismic activity, of soil deformation, of the pore pressure and of major meteo-marine parameters. Such networks should be operated before launching new activities, in order to evaluate the natural seismicity conditions, of ground deformation, of meteo-marine parameters and of downhole pressures in "unperturbed" conditions.

Acknowledgements

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