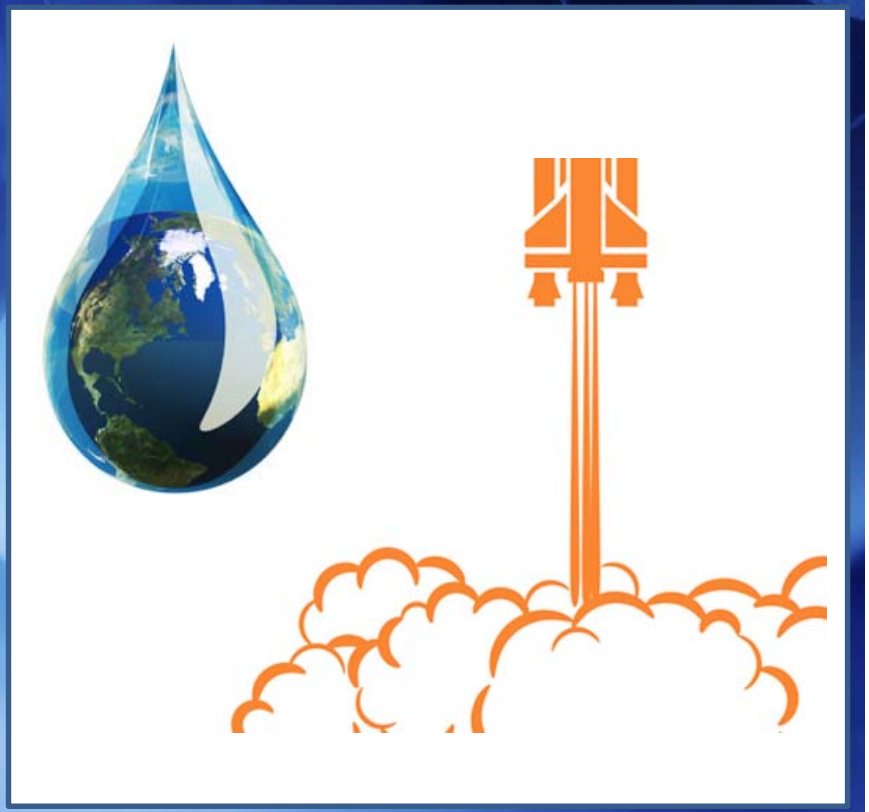

# Functional Ecology to Reduce Launchers Impact on Deep Sea



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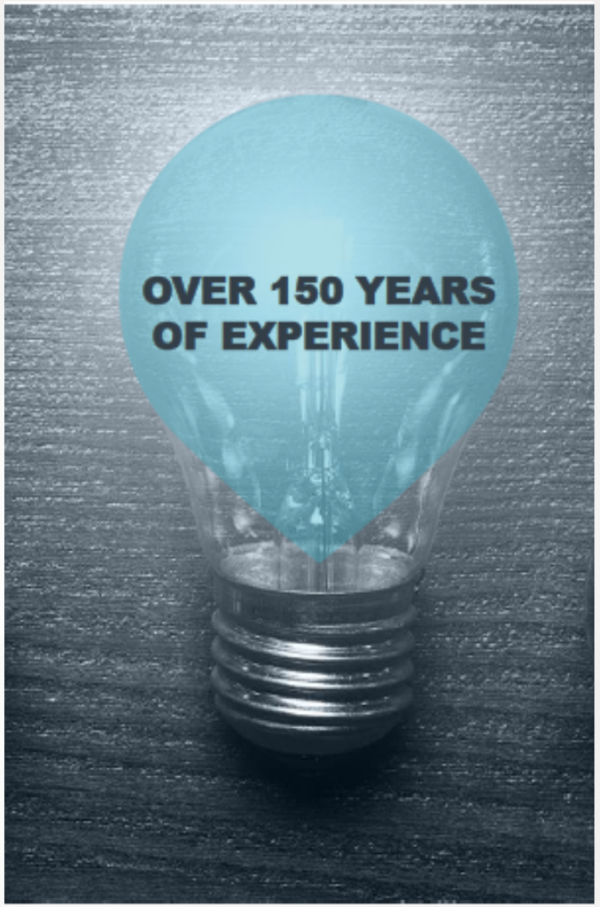
# RINA – Company Presentation

RINA provides **Certification, Testing, Inspection and Consulting Services** across the **Energy, Marine, Certification, Transport & Infrastructure and Industry** Sectors, through a global network of 170 offices in 65 countries with a turnover of 434 million of € (2017)

RINA is a member of key organizations and an important contributor to the development of new legislative standards



# CREOCEAN - Company presentation

CREOCEAN helps public & private sectors improving their knowledge and **management efficiency of the coastal & marine environment by providing high value science-based services**, using the latest technology and available methods

CREOCEAN provides a global approach to **integrate the environmental component into the development projects** like:

- Marine habitat mapping / Sensitivity mapping and Marine biodiversity studies
- Environmental Baseline Studies (EBS) and Environmental Impact Assessment (EIA)

## Project Objectives

The project aims at acquiring the necessary knowledge and references for an objective study, which **quantifies the impacts on deep-sea ecosystems of launchers components falling into the ocean,** through a stepwise process based on:

- **List and characterize the concerned launchers materials,** and the reactions that will occur in the ocean
- **Study the deep sea ecosystem in the zones where launcher residuals fall back**
- Investigate through an initial study the **impact of these materials on the deep sea ecosystems**
- **Propose a method(s) to better understand the environmental impact of disposed launcher stages falling back into the ocean**
- Issue **recommendations for future work**

# Characterisation of Relevant Launcher Materials

**INPUT**:
Documents survey (Sources: ESA, Internet, Literature, Other…)

- Classification of materials at launch that have an impact on the ocean
- Creation of a shared template for the collection of relevant information on such materials
- Such list of materials is given to Creocean and RINA's LCA experts for a preliminary LCA approach

**OUTPUT**:
Characterisation of relevant Launchers Materials

# Characterization of Relevant Launchers Materials

**VEGA**

According to available data and correspondent uncertainty, involved masses, from VEGA side, the study has been focused on the **three stages: P80, Z23 and Z9**

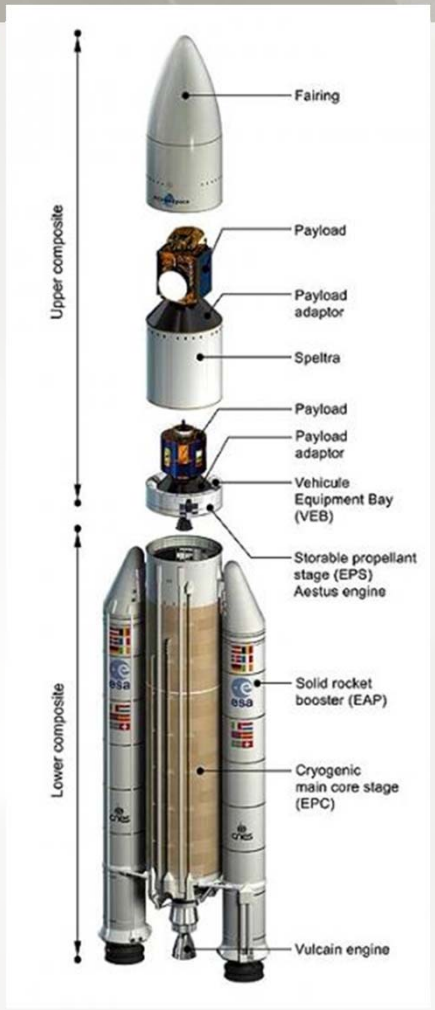
# Characterization of Relevant Launchers Materials

**Ariane 5 EC & ECA**

Instead for Ariane 5, the first **two stages EPC and EAP** have been analyzed in details for the following reasons:

- Dimension and weight;
- Zone of Splashdown ecosystem;
- Recurrent geographical statistics for first two stages compared of the remaining stages.

EAP and EPC



# Characterization of Relevant Launchers Materials

## Preliminary Characterization

Once identified the critical materials, and their involvements in launchers, a **preliminary characterization of most pollutant materials** has been conducted. The info collected here, have been used for the assessment of environmental impacts. Several aspects have been retrieved:

- Main applications in space sector,
- Physical parameters,
- Chemical properties,
- Toxicity information,
- Known degradation processes in marine environment.

# Ecosystems Characterization and Preliminary Environmental Impacts

**INPUT**:
ESA information (splashdown areas)
Characterization of launcher materials
Literature review

- Identification of main deep-sea habitats potentially impacted
- Characterization of ecosystems
- Description of ecological functioning

- Characterization of the effects
- Chemical impacts : exposure assessment
- Physical impacts: damage assessment
- Hazard characterization

**OUTPUT**:
Preliminary Environmental Impact Assessment

# Ecosystems Characterization and Preliminary Environmental Impacts

**Deep-sea ecosytems potentially impacted**

- **Splashdown areas identified from:**
  - Launcher description
  - ESA information
  - Navigation warnings
  - Nominal launch
- **ARIANE 5**
  - Boosters: *confidential*
  - Cryogenic stage: *confidential*
- **VEGA**
  - P80: *confidential*
  - Z23: *confidential*
  - Z9: *confidential*





# Ecosystems Characterization and Preliminary Environmental Impacts

The **most important ecosystems** have been assessed in terms of **ecotoxicological impacts**

- The **physical impacts** have been assessed on the base of several assumptions on the behavior and the fate of launcher materials in the marine environment, considering the **impact induced by the rocket materials after their fall into the sea**
- The **chemical impacts** have been evaluated following the European methodology for risk assessment in which the **contamination levels in natural environment are compared to environmental quality standards**. Preliminarily, the chemical risk is characterized for two emission scenarios: release of the contaminants in the whole water column (pelagic organisms) or release only in a deep-sea layer (benthic organisms)

**It is a preliminary assessment based on available data and on very conservative assumptions**

# WP2 – Ecosystems Characterization and Preliminary Environmental Impacts

## Chemical impacts : substances of concern

| Compound | Launcher |
|---|---|
| Chromium | Vega and Ariane 5 |
| Aluminum | Vega and Ariane 5 |
| Copper | Vega |
| Iron | Vega and Ariane 5 |
| Molybdenum | Vega and Ariane 5 |
| Nickel | Vega and Ariane 5 |
| Silver | Vega and Ariane 5 |
| Tin | Vega |
| Titanium | Vega and Ariane 5 |
| Antimony | Ariane 5 |
| Epoxy resin (4,4'-DDS diaminodiphenylsulfone) | Vega and Ariane 5 |
| Viscose | Vega and Ariane 5 |
| Phenol formaldehyde resin | Vega and Ariane 5 |
| Polyisoprene IR | Vega and Ariane 5 |
| Phosphorus | Ariane 5 |
| Tantalum | Vega and Ariane 5 |
| Gold | Vega |

# Ecosystems Characterization and Preliminary Environmental Impacts

## Chemical impacts : methodology

European Union / European legislation on chemicals

Common procedure for **chemical risk assessment**

**Levels of contamination in the Environment = PEC**
*Predicted Environmental Concentration*
*measured/ modelled in the environment*
**Exposure assessement**

**Threshold values of effects in organisms = PNEC**
*Predicted No Effect Concentration*
*measured on organisms*
**Hazard assessment**

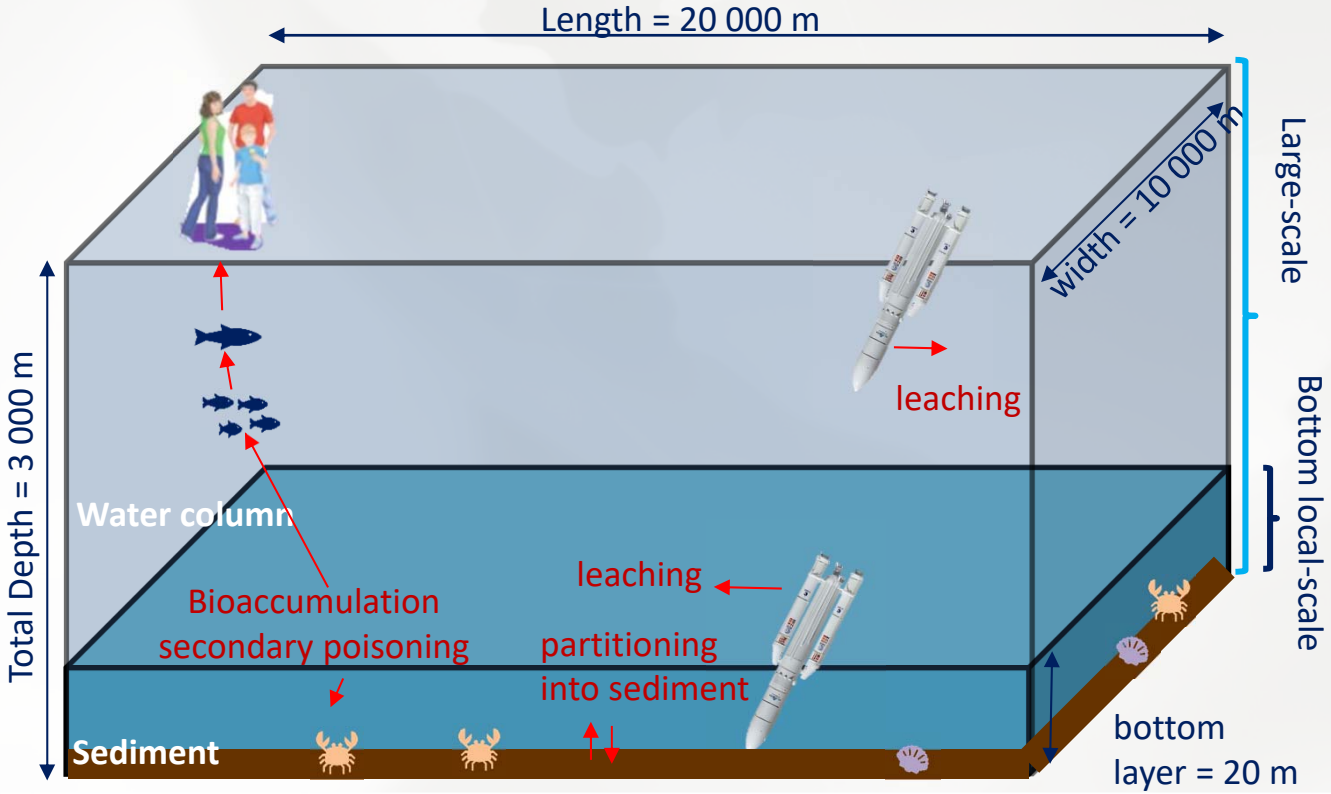
=

**Risk ratio**
*< 1 → No Risk*
*> 1 → Risk*

# Ecosystems Characterization and Preliminary Environmental Impacts

## Chemical impacts : methodology - exposure assessment

*Exposure assessment = calculation of concentration in the marine environment (PEC – Predicted Environmental Concentration)*



# WP2 – Ecosystems Characterization and Preliminary Environmental Impacts

## Results for chemical risk impacts

- Low for all substances and all targets : pelagic and benthic organisms, fish predators and top predators and human health via ingestion of fish
- Excepted for the **aluminum** in the 5 splashing down areas → there is a potential impact on **marine organisms of the water and of the sediment**

| | | PROTECTION TARGET | | | | |
|---|---|---|---|---|---|---|
| | | Marine ecosystem | | | | Human via environment |
| | | Marine water organisms | Marine sediment organisms | Fish eating predators and top predators | | Exposure by ingestion |
| Compound | Launcher | $PEC_{local\ seawater}$/ $PNEC_{saltwater}$ | $PEC_{local\ marine\ sediment}$/ $PNEC_{marine\ sediment}$ | $PEC_{oral,predator}$/ $PNEC_{oral,predator}$ | $PEC_{oral,\ top\ predator}$/ $PNEC_{oral\ predator}$ | Qualitative assessment based on potential bioaccumulation and secondary poisoning data |
| Chromium | Vega and Ariane 5 | No risk | No risk | No risk | No risk | Unlikely risk |
| Aluminum | Vega and Ariane 5 | Water column Bottom layer | Water column Bottom layer | No risk | No risk | Unlikely risk |
| Copper | Vega | No risk | No risk | No risk | No risk | Unlikely risk |
| Iron | Vega and Ariane 5 | Nor or insufficient data available at present | | | | |
| Molybdenum | Vega and Ariane 5 | No risk | No risk | Nor or insufficient data available at present | | |
| Nickel | Vega and Ariane 5 | No risk | No risk | No risk | No risk | Unlikely risk |
| Silver | Vega and Ariane 5 | No risk | No risk | Unlikely risk | Unlikely risk | Unlikely risk |
| Tin | Vega | No risk | No risk | Nor or insufficient data available at present | | |
| Titanium | Vega and Ariane 5 | No risk | No risk | Unlikely risk | Unlikely risk | Unlikely risk |
| Antimony | Ariane 5 | No risk | No risk | No risk | No risk | No risk |
| Epoxy resin (4,4'-DDS diaminodiphenylsulfone) | Vega and Ariane 5 | No risk | No risk | Nor or insufficient data available at present | | |
| Viscose | Vega and Ariane 5 | Nor or insufficient data available at present | | | | |
| Phenol formaldehyde resin | Vega and Ariane 5 | Nor or insufficient data available at present | | | | |
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| Phosphorus | Ariane 5 | Nor or insufficient data available at present | | | | |
| Tantalum | Vega and Ariane 5 | Nor or insufficient data available at present | | | | |
| Gold | Vega | Nor or insufficient data available at present | | | | |

# Ecosystems Characterization and Preliminary Environmental Impacts

## Physical impacts

- **Behavior at sea**: the different stages of Ariane 5 and Vega sink after falling down in the oceans and they reach the sea bottom
- **Fate on the seabed** : the deterioration and the conservation of the launcher stages in the deep-sea domain is extrapolated from data available about the fate of modern shipwrecks
- **Launchers materials should generate minor impacts on fauna and habitats of the deep-sea domain and limited disturbance of the marine food webs** (no risk were highlighted for marine food webs and human health via ingestion of fish even for aluminium)

**It is a preliminary assessment based on available data and on very conservative assumptions**

# Further Study to deepen understading of environmental impact of disposed launcher stages

**INPUT**:
Characterization of launcher materials
Preliminary environmental impact assessment

Marine habitats potentially impacted
- List of biotopes/species requiring further investigations to describe their ecological functioning

Characterization of the effects
- List of missing data/reference values to characterize chemical and physical impacts

**OUTPUT**:
- Critical analysis of EIA method
- Recommendations for future works

## Conclusions

- Models and tools to understand ecologies and ecosystems in deep-sea ecosystems could be used, tuned (if needed) and replied in **Closed Life Support System for evaluating the interactions between space components and living beings in enclosed environments**

- The main focus of this project has been the deep-sea ecosystems impact assessment, and only as a consequence the human beings. Nevertheless, the developed assessment methods could **support scientific community in terms of health assessment of spacecraft and consequently improving efficiency, safety, and reliability**

# Thanks for your attention

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