NANORIGO

	Executive Summary D 2.3
DELIVERABLE TITLE	Integrative prospective early risk screening tool prototype (PERST)
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Executive Summary

PERST is a prototype of a prospective early risk screening tool developed in the EU-based project NANORIGO. It integrates predictive computations for humans and environments based on various questions concerning exposed organisms' risk and vulnerability by combining the load contamination of potential pollutants with toxicity and ecotoxicity considerations and data. The source of such potential risks (contamination) is identified as the manufacturing and use of any products and in the emission (exposure) of their materials to humans and nature, particularly product ingredients that should not be emitted.

Thus, PERST aims to predict target and specific product ingredients, including but not exclusively new engineered nanomaterials, as well as their life cycle-long location in and migration through environmental (human) and technical systems (Fig. 1). Such product material monitoring also considers its degradation or deposition and accumulation in any of the receiving media mentioned above. Material load (exposure) concentrations are computed for various target environments and bioaccumulation bodies (listed below), and they are then compared to toxicological or ecotoxicological concentration data for the target material. From such comparisons, risk is predicted for humans and the environment. The following compartments and organisms (creatures) potentially at risk are considered: air, freshwaters, marine waters, groundwater, saline groundwater, freshwater sediments, marine water sediments, soil, soil treated with sewage treatment sludge, freshwater flora, marine water flora, freshwater fauna, marine water fauna, adult humans and children humans.

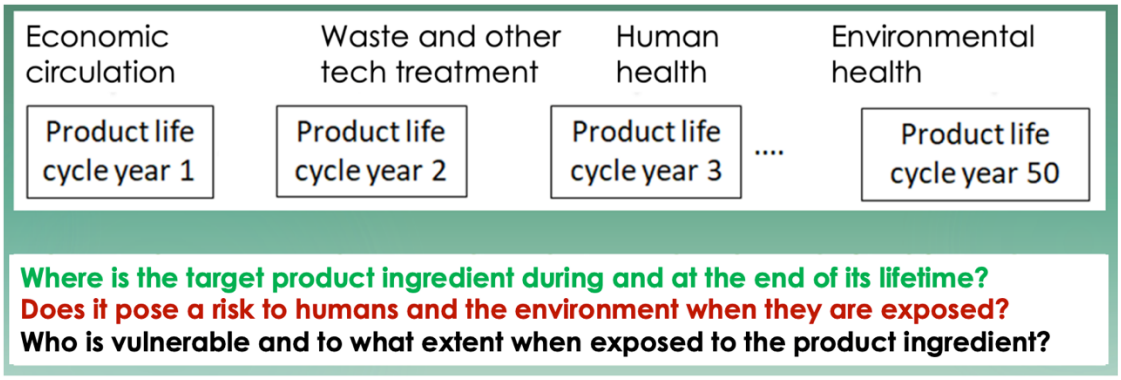

Figure 1: Stochastic-probabilistic long-term product material (ingredient) interaction between life phases and different media and environments.

PERST's services may be utilized in different target geographic regions covering all EU member states, as well as in Switzerland and the UK. For its routine use the status quo of available information on a material's use, emission patterns, and—to some extent—fate (residence time) in potentially exposed compartments (bioaccumulation bodies) will be needed in a form that can be linked to the tool computations. In doing so, PERST's services would remain easy to use, as

there is no need for the user to deal with any probabilistic data and prediction routines, meaning no specific programming skills are required. Users (producers or stakeholders) must provide, among others, some data on the(ir) target product ingredient(s), production or use volumes and some product (material) life cycle properties, the geographic region (EU country) of interest, and other information not specified here. The collaboration can be protected by a confidential agreement between the user and service provider.

One key property of this prototype predictive software for risk (vulnerability and other) is that it is designed to do its best when encountering scanty and uncertain data (as is often the case in environmental and health contexts). This however only works when the above-mentioned background database can be established such that it provides a large spectrum of data for optimistic to worst case-value ranges of model input information. The main outputs (see examples in Fig. 2) distinguish risk, vulnerability (fraction of organisms and creatures potentially negatively affected), and concentrations (potential contamination load concentrations).

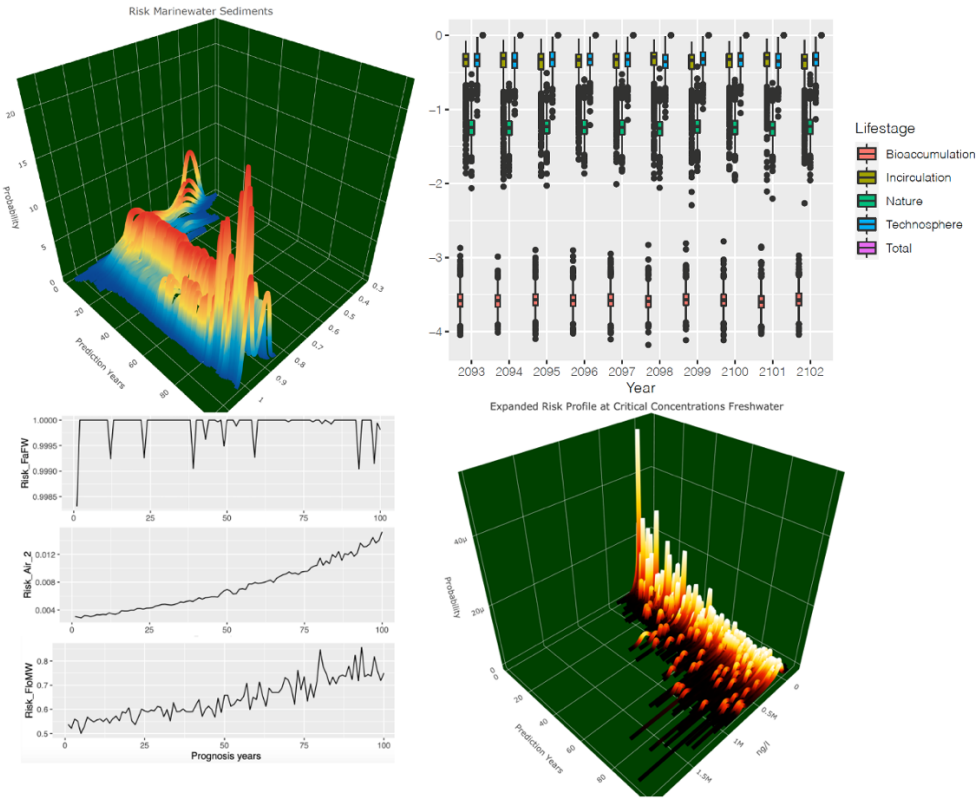

Figure 2: Some fundamental PERST output types, such as 3D graphics (probability is used synonymously with density [z-axis]), boxplots summarizing these output distributions over time, and line charts visualizing the evolution of a particular target variable. The PERST risk etiquette is under construction and not shown here.

PERST runs in two modes: a) a pure target product database mode and b) a so-called PERST expanded mode, where such target product data are partly virtually created by the tool itself when embedded in broader, beyond normal product use and material emission dynamics.

Although more idealistic in terms of its objectives, the prototype tool methodology freely originates from stochastic-probabilistic material release flow (Gottschalk et al. 2009) and species sensitivity distribution (and risk; Gottschalk et al. 2013) approaches widely used and developed, as, e.g., extensively shown in Giese et al. (2018). As far as it can already be said at the present prototype stage, however, PERST is newly developed and no longer mass flow-oriented, but purely builds on probabilistic predictions of the target material's (product ingredient's) location and transformation over its life cycle and beyond. This works well for long periods as well, (100 and more years), as confirmed by the first tests partially run with synthetic data and assuming necessary data for running such calculations will be available in the future. Further, and in fundamental contrast to compared references, PERST performs without the use of predefined (theoretical and other) probability distributions, but generates these distributions itself, what also works for the (eco)toxicity parts of predictive modeling. In doing so the developed programming in R (R Development Core Team 2021) follows fundamental arithmetic operations embedded to different extents into own Monte Carlo, Bayes, and other (combinations thereof) computational learning concepts.

The software is designed to take as much information as possible from the data available, especially if such data is highly sparse or not embedded in a too-robust consistency concerning its scientific knowledge background. This largely protects the predictive tool output from being biased by potentially uncertain or crude expert or product producers' opinions, e.g., on fixed probability distribution forms for data input parameters and others. Furthermore, this considerably reduces the amount of data that must be delivered from the user side and thus may augment the approached practicability of the tool service. One PERST computer simulation round takes a little more than an hour, and it produces a 242-page PDF output document. Such an output distinguishes i) 3D graphics of probability results in their time dynamics and revealed as density plots that give the distribution of all numeric predictions; ii) boxplots that reveal a summary (range, median, and some percentiles) of these output distributions; iii) line charts visualizing a time series that shows the evolution of the target variable and possibly in the future; and iv) PERST risk etiquette for the evaluated product (material). The latter is not yet incorporated into the automatized tool output and has not been defined in its graphical or labeling appearance, nor in its composition of risk scores to take from PERST. The tool's performance has successfully and initially been tested in some tool-use attempts, partially based on synthetic data and covering a few products: i) automotive products (carbon nanofibers [CNF]) assumed used in Spain, ii) chemical-mechanical polishing assumed used in Germany (CeO_2-ENM), iii) automotive catalytic converters (CeO_2-ENM) assumed used in Germany, and iv) rubber tires (carbon black [CB])

assumed used in Denmark. These results are only used for prototype software demonstration and testing purposes.

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