ART User Guide

Introduction
ART is a free web-based tool for the estimation of inhalation exposure at the workplace. ART combines a mechanistic model and a facility to update the estimates with the user's own data. This integration of information is done using Bayesian statistics. The use of the mechanistic model as well as the Bayesian facility to update with exposure measurements will be described below.

For detailed information on the underlying science we refer to the report on the mechanistic model (this website). In addition, a report on the Bayesian module is in preparation and will be available on this website soon. In addition, papers on ART have and will be published in the peer-reviewed literature; an up-to-date list of publications is provided on the website.

Exposure that can be modelled
There exists a multitude of different activities and types of products at the workplace that give rise to different types of inhalation exposure. ART is currently calibrated and can be used for estimation of the following exposure types:

Dust: Solid particles that are formed by aerosolization of already existing powders or by abrasion of solid objects.

Mist: Any airborne liquid particles. A water mist in the form of fog or a fine spray is a common example.

Vapour: This is the airborne state of a chemical which, if a sufficiently large amount of liquid were released into a closed room at normal temperature, would not completely evaporate but rather would reach equilibrium with its liquid. Exposure during the application of various organic solvents is a common example.

Fume: Solid particles that are formed by condensation from high temperature vapour, such as from molten metal or smoke.

ART is currently not calibrated for the following exposure types:

Gas: This is the airborne state of a chemical whose liquid is so volatile that its vapours cannot reach equilibrium with its liquid.

Fibres: Elongated particles whose length-to-diameter ratio is at least 3:1 (e.g., asbestos, MMMF).

Use of the mechanistic model
The mechanistic model follows several consecutive steps with general questions on the scenario (scenario overview) and the configuration of activities that are relevant in the particular scenario.

Scenario overview
The software tool starts with a general description of the scenario, the chemical name of the substance of interest, CAS No., and an overview of the activities and their respective duration. A scenario within ART can consist of up to four activities. The activities together represent one working day with a total duration that should be around 480 minutes. A warning message appears if the duration deviates from 480 minutes. ART assessments are still possible but should be treated with some caution as variability estimates are based on shift measurements. If applicable, a non-exposed period can also be assigned a duration in minutes.

Configuration of activities
For each activity in the scenario questions are asked on exposure determinants covering the following items:

Product type:	Various product types can be used at the workplace. In ART version 1.0 the following types can be selected: - Powders, granules, or pelletized material - Solid objects - Liquids - Powder dissolved in a liquid or incorporated in a liquid matrix - Paste, slurry or clearly (soaked) wet powder - Hot or molten metal
Substance emission:	Based on the above selected product type, the user has to indicate the intrinsic emission potential of a substance, e.g. dustiness for powders and volatility for liquids.
Activity Class (AC):	Subsequently, the user has to select an AC. An AC is a generic group of activities with similar underlying determinants for the emission potential of an activity (e.g., spray applications; handling of contaminated objects, etc.). The list of possible AC depends on the product type. One to four questions then follow that determine the exposure emission potential of the activity. Each AC has a unique set of questions.
Localized controls:	The user can choose from a generic list of types of localized controls (e.g., suppression techniques, containment, type of local exhaust ventilation).

Surface contamination:	Questions relating to the level of general housekeeping give an indication of the contribution to exposure from re-suspension of deposited contaminants on surrounding surfaces.
Dispersion:	ART will estimate the effect of dispersion for indoor, outdoor, spray room or downward laminar flow booth environments. For example, for indoor environments the level of dispersion is based on the room size and number of air changes per hour.
Segregation:	The user can select from a list of types of isolation of the source from the work environment.
Separation:	The user can select from a list of types of personal enclosure within a work environment.

Near Field and Far Field sources

The source during an activity can either be in the Near Field (NF) of the worker, the Far Field (FF), or multiple sources can be present in both NF and FF. The location of the source relative to the worker is taken into account in the model by the following questions:

- Is the source located in the breathing zone of the worker (i.e. within one meter of the worker's head)?
- Are there also secondary sources present, for example due to activities of other workers?

All exposure determinants have to be considered for both NF and FF sources, except for segregation and separation which only apply for FF sources. There is a facility to carry over already given NF inputs to the FF questions.

Running the mechanistic model

After all the activities of the exposure scenario have been configured successfully, the user can run the mechanistic model by clicking on the 'finish' button. The mechanistic model results are displayed in a separate output page.

From the results page a 'quick revision' function allows the user to go back and revise one or more input parameters and run the model again.

Use of Bayesian module

After running the mechanistic model, the user may update their exposure estimates using measured exposure data. The ART version 1.0 has a facility for the update with fully analogous exposure data; i.e., representative exposure data from the particular scenario of interest. In addition, partially analogous exposure data may also be provided. These are data from comparable but not fully analogous scenarios. In version 1.0 the user must make their own assessment of the degree of analogy using the following classifications 'Fully analogous', 'Highly analogous', 'Moderately analogous' and 'Weakly analogous'.

The user is asked to upload new analogous data. The file must be in Comma Separated Values (CSV) format with specific order of the fields. An example file can

be downloaded from the data upload help page on the website. Once the data have been uploaded the Bayesian model can be run. The original mechanistic model estimates and the updated estimates are displayed together in the Bayesian output page.

The influence of the data in the overall Bayesian exposure assessment increases with i) increasing numbers of measurements, ii) for a given number of measurements, when more workers and companies are covered, and iii) increasing strength of analogy.

Output of ART

Types of predictions

Different exposure predictions are required in the risk assessment depending on the relevant health effects (i.e., chronic vs. acute). ART currently produces two types of exposure predictions:

Full-Shift: ART calculates an overall distribution for full-shift exposures. In this case, the 90th percentile provides the exposure level, which has a 10% probability of being exceeded by the exposure from a randomly selected worker on a randomly selected day.

                        This measure can also be used for short-term estimates, but it should be recognized that short-term exposures (less than 60 minutes) may have a different pattern of variability. The ART full-shift measure is based on variability estimates derived from measurements collected over periods of 4 hour or longer.

Long-Term Average: ART calculates the distribution of workers' long-term average (mean) exposure (e.g. over a period of months). In this case, the 90th percentile provides the long-term mean exposure level, which has a 10% probability of being exceeded by the long-term exposure from a randomly selected worker.

                        From a scientific perspective, the distribution of long-term average exposure is the most appropriate one when considering chronic health end points, or when comparing exposure levels with chronic toxicity data.

Percentiles and uncertainties

Exposure variability and uncertainty are clearly distinct entities with different implications. Uncertainty arises from lack of information about the exposure, whereas variability arises from true heterogeneity of situations in the scenario. Variability and uncertainty are often treated implicitly together in the risk assessment; e.g. using a higher percentile of the exposure distribution in case of more uncertain data.

The ART provides separate estimates for variability and uncertainty. The user can select a percentile of the exposure distribution (i.e., 50th, 75th, 90th, 95th, or 99th). The difference between the 50th and a higher percentile level is a reflection of the variability in the scenario. In addition, a level of uncertainty around the estimated percentile is given (i.e., 80 %, 90 %, 95 %, or 99% confidence interval).

A Bayesian update with measurements will generally reduce the level of uncertainty as more information is available for estimating the exposure. However, the point estimate of the particular percentile of the exposure distribution may either shift to higher or lower values after a Bayesian update, depending on the particular scenario and the distribution of the measurement data.

What is an acceptable percentile of the exposure distribution and level of uncertainty of the exposure estimate to be used in a risk assessment? The answer to this question is not straightforward. Currently, additional guidance is developed on this topic. As soon as a proposal for guidance is available this will be published on the website.