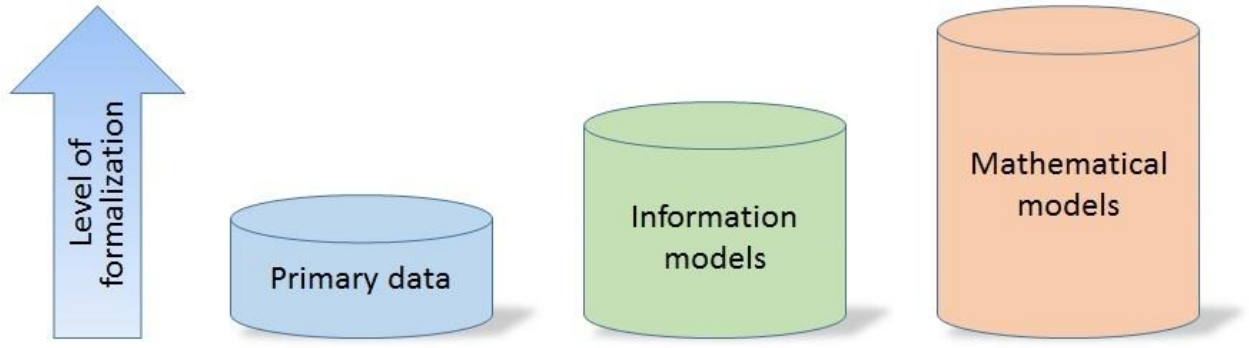
Dataware-aided life cycle management

This engineering method is part of a complex methodology known as nuclear power **Plant Life Management** (PLiM), which aims to ensure the long-term, safe and efficient operation of NPPs. The approach to PLiM, developed in Russian nuclear power industry, covers technologies, resources and processes related to all stages of the life cycle, based on **the advanced concept of information support**. This concept provides for:

- creation of a single source of data on the initial and current state of NPP components (equipment, pipelines etc.) for planning and implementing their maintenance, repair, replacement and other management measures based on the actual information concerning their integrity, structural health and performance;
- access to this data for all participants in the life cycle (designers, component manufacturers, builders, installers, operating organizations, etc.) who need it and are allowed to do it;
- minimizing errors when transferring data between different participants and stages of the life cycle.

Traditionally, information support includes **documentation** (design, production and operational), **software** and **hardware**, as well as **methodological tools** and **organizational measures** that ensure the processing of information in order to justify management decisions. The advanced concept introduces **an additional element**: the so-called **dataware**. This element consists of three categories:

1) **primary data**: the results of observations and registration (manually or by sensors), which can be presented in a form directly accessible to humans (for example, records, drawings, diagrams);
2) **information models**: idealized objects that describe real objects and situations, processes and cause-effect relationships in a mostly qualitative way (filtered and generalized data, for example, verbal/verbal-numeric tables or matrices, flowcharts and similar items) – they are understandable to humans and accessible for computer processing;
3) **mathematical models**: ideal objects describing the properties of objects and phenomena of the real world in the form of mathematical equations that allow us to quantitatively predict their development based on data on the current state.



Categories of dataware and level of formalization (suitability for use in quantitative assessments)

All these categories are interrelated, and a higher level of formalization is based on the use of lower-level items.

The key principle underlying the method of dataware-aided life cycle management is the use of mathematical models covering all stages of the lifecycle of the NPP components important for safety. Initially, such models are created at the design stage (for the component state ‘as

designed'). After the components are manufactured and installed, the models are corrected (identified) based on the test results (for the state 'as built'). Their properties obtained by parametric identification take into account initial imperfections. Then the models are periodically identified in accordance with monitoring data during operation in order to account for the evolution of initial imperfections, the nucleation and development of operational defects, as well as other effects of aging (for the current state). The identified models are used in analyses aimed at assessing the exhausted life, evaluating the integrity, structural health and performance of components, and predicting their residual life. Based on the results of these analyses, PLiM measures are planned and implemented.

The method of dataware-aided life cycle management, proposed by the author in 2007, is described in the following publications:

Spirochkin YK, Evropin SV (2008) Podkhody k informatsionnomu soprovozhdeniyu prochnosti YaU v techenie zhiznennogo tsikla (Approaches to information support of the strength of nuclear facilities during the life cycle). Godovoi otchyot FGUP NIKIET - 2008: Sb. statei/ Pod red. E. O. Adamova (In Adamov EO (ed) Annual report of NIKIET - 2008: Collection of articles), p 120-121. NIKIET, Moscow

SPiR-O-2008 (2009) Svod Pravil i Rukovodstv po Opornym konstruktsiyam elementov AES s WWER (Code of rules and guides on suppors for nuclear power plants with WWER). Standard of organization. ENES, Moscow (Contributors: Evropin SV, Filatov VM, Golovlev YN, Obushev AE, Rodchenkov BS, Spirochkin YK et al.)

Evropin SV, Obushev AE, Spirochkin YK, Petrenko AV (2009) Guidelines and dataware for life cycle management for NPP pipeline supports. Proceedings of the 20th International Conference on Structural Mechanics in Reactor Technology (SMiRT 20), Division 6. Design and Construction Issues, Paper 1774. http://www.lib.ncsu.edu/resolver/1840.20/23809

Spirochkin YK, Atroshenkov RS (2009) Primenenie IPI (CALS-tekhnologii) v sovremennoi yadernoi energetike (Application of IPI (CALS technologies) in modern nuclear power). Komp'yuternye tekhnologii analiza inzhenernykh zadach mekhaniki: Lektsii I Mezhdunarodnoi nauchnoi shkoly dlya molodezhi (Computer technologies for analysis of engineering problems in mechanics: Ist International Scientific School for Youth), IMASh RAN, 9-13 November 2009. Sbornik lektsii (Collection of lectures), p 36-42. A. A. Blagonravov Institute of Machine Science of the Russian Academy of Sciences (IMASh RAN), Moscow

VERLIFE (2013) Guidelines for integrity and lifetime assessment of components and piping in WWER nuclear power plants. IAEA, Vienna. Appendix F – Component and piping supports (Contributors: Obushev A, Spirochkin Y)

OTT 1.5.2.01.999.0157-2013 (2013) Opornye konstruktsii elementov atomnykh stantsii s vodo-vodyanymi energeticheskini reaktorami. Obschie tekhnicheskie trebovaniya (Support structures for elements of nuclear power plants with water-water power reactors. General technical requirements). JSC Concern Rosenergoatom, Moscow (Contributors: Spirochkin YK, Obushev AE, Filimonov SV, Sorokin AN, Tarakanov PV et al.). https://meganorm.ru/Index2/1/4293736/4293736524.htm

Spirochkin YK (2019) Bezopasnost' rossiiskikh AES s tochki zreniya inzhenera-mekhanika (Safety of Russian nuclear power plants from the viewpoint of mechanical engineer). SUPER Publishing House, Saint Petersburg. https://www.super-izdatelstvo.ru/product/bezopasnost-rossiyskih-aes-s-tochki-zreniya-inzhenera-mehanika

Spirochkin YK (2020) Chelovecheskii faktor i proektirovanie (Human factors and design). Right Print, Saint Petersburg.