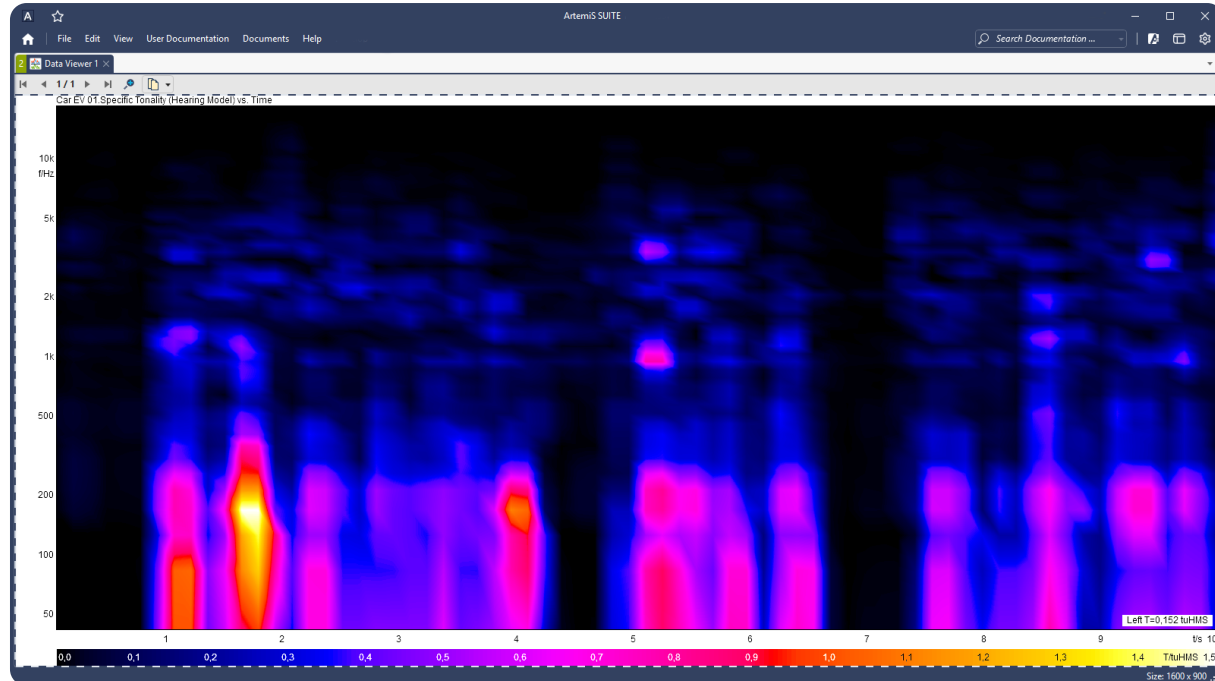




ArtemiS SUITE
Signal Processing

Code 51103

ASP 103 Psychoacoustics - Advanced Analysis

Psychoacoustics - Advanced Analysis of ArtemiS SUITE provides advanced psychoacoustic analyses, such as Loudness, Roughness, and Tonality, based on the Sottek Hearing Model.

OVERVIEW

ASP 103 Psychoacoustics - Advanced Analysis

Code 51103

Psychoacoustics - Advanced Analysis includes analyses that simulate the signal processing of human hearing and describe fundamental auditory perceptions.

ArtemiS SUITE provides further options (ASPs) including psychoacoustic analyses:

- › ASP 101 (Psychoacoustics - Basic Analysis)
- › ASP 102 (Psychoacoustics - Basic Analysis vs. Control Channel)
- › ASP 104 (Psychoacoustics - Advanced Analysis vs. Control Channel)

ASP 101 and ASP 102 provide the following standards and methods:

- › DIN 45631, DIN 45631/A1, DIN 45681, DIN 45692
- › ISO 532-1, ISO 532-3, ISO/TS 20065, ANSI S3.4-2007
- › ECMA-418-1, ECMA-74 (Annex D)
- › Aures, von Bismarck

ASP 103 and ASP 104 provide the following standards and methods:

- › DIN 38455
- › ECMA-418-2, ECMA-74 (Annex F)

KEY FEATURES

- › Loudness (Hearing Model) vs. Time
- › Specific Loudness (Hearing Model)
- › Specific Loudness (Hearing Model) vs. Time
- › Roughness (Hearing Model) vs. Time
- › Specific Roughness (Hearing Model)
- › Specific Roughness (Hearing Model) vs. Time
- › Tonality (Hearing Model) vs. Time
- › Specific Tonality (Hearing Model)
- › Specific Tonality (Hearing Model) vs. Time
- › Tonality (Hearing Model) Frequency vs. Time
- › Impulsiveness (Hearing Model) vs. Time
- › Specific Impulsiveness (Hearing Model)
- › Specific Impulsiveness (Hearing Model) vs. Time
- › Spectrum (Hearing Model) vs. Time
- › Fluctuation Strength (Hearing Model) vs. Time
- › Specific Fluctuation Strength (Hearing Model)
- › Specific Fluctuation Strength (Hearing Model) vs. Time
- › Relative Approach 2D
- › Relative Approach 3D

The analyses can be used in Pool Projects (APR 010 is required), Automation Projects (APR 050 is required), Standardized Test Projects (APR 220 is required), and Metric Projects (APR 570 is required).

APPLICATIONS

- › Simulation of human perception using appropriate analyses
- › Improvement of product sound quality
- › Evaluation of environmental noise

OVERVIEW ASP 101 – ASP 104

PSYCHOACOUSTICS - BASIC ANALYSIS (ASP 101)

- › Loudness vs. Time
- › Specific Loudness
- › Specific Loudness vs. Time
- › Sharpness vs. Time
- › Specific Sharpness
- › Tonality
- › Tonality vs. Time
- › Tone-to-Noise Ratio
- › Tone-to-Noise Ratio vs. Time
- › Specific Prominence Ratio
- › Specific Prominence Ratio vs. Time

PSYCHOACOUSTICS - BASIC ANALYSIS VS. CONTROL CHANNEL (ASP 102)

- › Analyses from ASP 101 as a function of control channels

PSYCHOACOUSTICS - ADVANCED ANALYSIS (ASP 103)

- › Loudness (Hearing Model) vs. Time
- › Specific Loudness (Hearing Model)
- › Specific Loudness (Hearing Model) vs. Time
- › Tonality (Hearing Model) vs. Time
- › Specific Tonality (Hearing Model)
- › Specific Tonality (Hearing Model) vs. Time
- › Tonality Frequency (Hearing Model) vs. Time
- › Roughness (Hearing Model) vs. Time
- › Specific Roughness (Hearing Model)
- › Specific Roughness (Hearing Model) vs. Time
- › Impulsiveness (Hearing Model) vs. Time
- › Specific Impulsiveness (Hearing Model)
- › Specific Impulsiveness (Hearing Model) vs. Time
- › Spectrum (Hearing Model) vs. Time
- › Fluctuation Strength (Hearing Model) vs. Time

- › Specific Fluctuation Strength (Hearing Model)
- › Specific Fluctuation Strength (Hearing Model) vs. Time
- › Relative Approach 2D
- › Relative Approach 3D

PSYCHOACOUSTICS - ADVANCED ANALYSIS VS. CONTROL CHANNEL (ASP 104)

- › Analyses from ASP 103 as a function of control channels

STANDARDS AND CALCULATION METHODS

- › Loudness
 - › DIN 45631 (1991), DIN 45631/A1 (2010)
 - › ISO 532-1 (2017), ISO 532-3 (2023)
 - › ANSI S3.4-2007 (FFT) / (FFT / 3rd Octave)
- › Sharpness
 - › Aures
 - › von Bismarck
 - › DIN 45692 (2009)
 - › DIN 45631/A1 (2010)
 - › ISO 532-1 (2017), ISO 532-3 (2023)
 - › ANSI S3.4-2007 (FFT) / (FFT / 3rd Octave)
- › Tonality
 - › DIN 45681 (2006)
 - › ISO/TS 20065 (2022)
- › Specific Prominence Ratio
 - › ECMA-418-1 (3rd) (2024)
 - › ECMA-74 (8th) (2003) / (9th) (2005)
- › Tone-to-Noise Ratio
 - › ECMA-418-1 (2nd) (2022) / (3rd) (2024)
 - › ECMA-74 (9th) (2005)
- › Tonality (Hearing Model)
 - › ECMA-74 (15th) (2018) / (17th) (2019)
 - › ECMA-418-2 (1st) (2020) / (2nd) (2022) / (3rd-4th) (2025)
- › Loudness (Hearing Model)
 - › ECMA-418-2 (2nd) (2022) / (3rd-4th) (2025)
- › Roughness (Hearing Model)
 - › DIN 38455 (2024)
 - › ECMA-418-2 (1st) (2020) / (2nd) (2022) / (3rd-4th) (2025)
- › Fluctuation Strength (Hearing Model)
 - › ECMA-418-2 (4th) (2025)



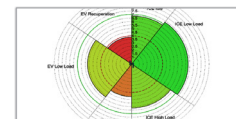
BINAURAL MEASUREMENT AND PLAYBACK



JURY TESTING SOFTWARE SQALA



SOUND QUALITY INDEX



DETAILS

Sottek Hearing Model

Human hearing is far superior to all available technical systems in terms of performance and flexibility for analyzing sounds. To capture the widest possible range of psychoacoustic phenomena, we developed the Sottek Hearing Model based on the physiology of the human ear. The model enables psychoacoustic effects and fundamental hearing impressions to be explained and described.

The Sottek Hearing Model is based primarily on an auditory time-frequency representation and exhibits a high correlation with the results of numerous psychoacoustic experiments. For example, amplitude and frequency fluctuations at the threshold of perception can be predicted, while nonlinear processing is of fundamental importance.

Analysis According to Standards

Assessing and ensuring sound quality have become important aspects of modern product design. Given that human hearing does not function like a linear measurement instrument, a simple signal level measure, such as dB(A), cannot adequately represent the loudness actually perceived. Therefore, DIN 38455 and ECMA-418-2 were developed based on the Sottek Hearing Model. These standards describe methods for the automatic quantification of spectrotemporal noise patterns, such as tonal noises or modulated signals.

To ensure compliance with these standards, ASP 103 provides the following analyses:

- › Loudness ECMA-418- 2 (2nd) (2022) / (3rd-4th) (2025)
- › Roughness DIN 38455 (2024), ECMA-418-2 (1st) (2020) / (2nd) (2022) / (3rd-4th) (2025)
- › Tonality ECMA-418-2 (1st) (2020) / (2nd) (2022) / (3rd-4th) (2025) ECMA-74 (15th) (2018) / (17th) (2019)

These analyses are performed in accordance with the standard procedures and provide an analytical assessment of subjectively perceived sound quality.

Advantages of Psychoacoustic Analyses

Given that human hearing does not function like a linear measurement instrument, a simple signal level measure such as dB(A) cannot adequately represent the auditory impression perceived by the listener. Like human hearing, psychoacoustic analyses focus on level differences, modulations, tonal components, roughness components, and other characteristics present in a sound. This reflects the cognitive signal processing that occurs during listening.

Listening tests form the foundation of psychoacoustic analyses development. As a pioneer in the development and application of psychoacoustic methods, we have been conducting extensive listening tests for several decades, with the results continuously incorporated into the ongoing development of these analyses. The results of the listening tests confirm the high validity of all our psychoacoustic analyses.



Loudness

Loudness is the perceived magnitude of sound intensity. Given that the perception of loudness by human hearing is frequency-dependent, sound events with the same level but different frequencies are not always perceived as equally loud. Consequently, the loudness scale is defined such that a sound perceived as twice as loud is assigned twice the value on the loudness scale.

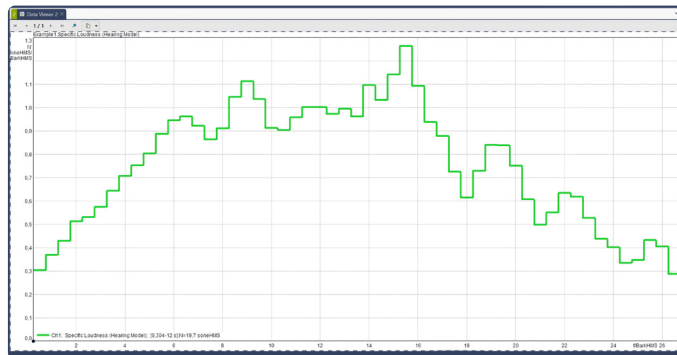
The calculation is based on the following standards:

- › ECMA-418-2 (2nd) (2022) / (3rd-4th) (2025)

The Loudness (Hearing Model) analysis accounts for the differing loudness perception of tonal and non-tonal sound components and is characterized by significantly improved prediction accuracy, for example for synthetic and technical sounds.

The following analyses are available:

- › Loudness (Hearing Model) vs. Time
- › Specific Loudness (Hearing Model)
- › Specific Loudness (Hearing Model) vs. Time



Specific Loudness (Hearing Model) vs. Time

Roughness

The perception of roughness arises whenever a time-varying envelope is present within a critical band, for example when tones exhibit temporal structure as a result of changes in their amplitude or frequency. Roughness depends on the center frequency, modulation frequency, and modulation depth. Perceived roughness increases with increasing modulation depth. Signal level has only a minor effect on the perceived roughness.

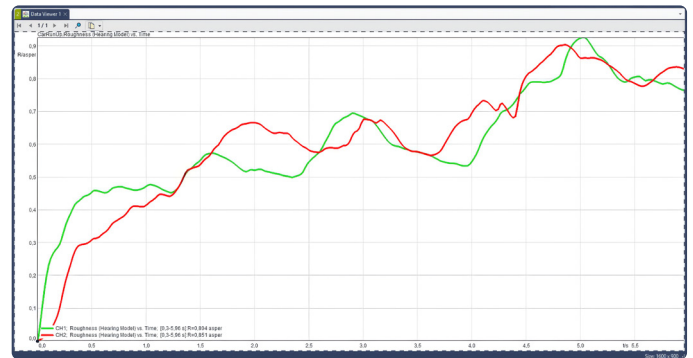
The Roughness (Hearing Model) vs. Time analysis calculates the roughness of the input signal over time. The analysis is ideally suited for evaluating technical products, such as electric or internal combustion engines as well as information technology and telecommunications (ITT) products.

The calculation is based on the following standards:

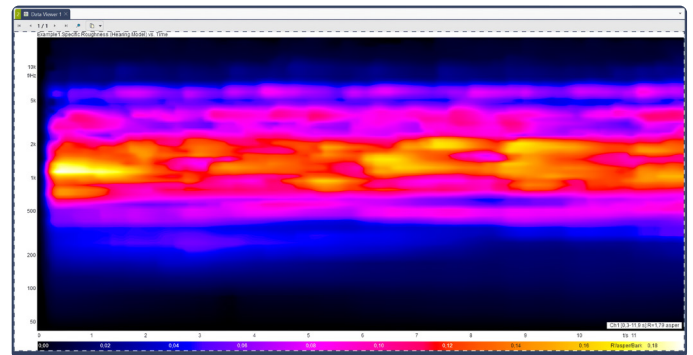
- › DIN 38455 (2024)
- › ECMA-418-2 (1st) (2020) / (2nd) (2022) / (3rd-4th) (2025)

The following analyses are available:

- › Roughness (Hearing Model) vs. Time
- › Specific Roughness (Hearing Model)
- › Specific Roughness (Hearing Model) vs. Time



Roughness (Hearing Model) vs. Time



Specific Roughness (Hearing Model) vs. Time

Tonality

Sounds are perceived as tonal when they contain distinct tones or narrowband noise. Unwanted tonal noises are perceived as more annoying than comparable noises without tonal components. Tonal noise components generated by a product or machine adversely affect perceived overall quality.

The Tonality (Hearing Model) vs. Time analysis, based on the Sottek Hearing Model, is characterized by a linear representation of the human tonality perception, exhibits high correlation with listening-test results, and accurate detection of noises with rapidly changing tonality.

The analyses detect annoying components even in noises with rapidly changing tonality, such as those generated by electric engines or information technology equipment. In addition, the analyses are ideally suited for identifying tonal noise components using a metric. For this purpose, the Metric Project (APR 570 is required) can be used.

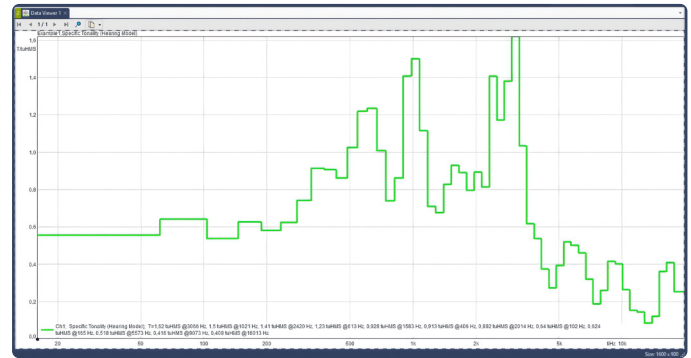
The following calculation methods are available:

- › ECMA-418-2 (1st) (2020) / (2nd) (2022) / (3rd-4th) (2025)
- › ECMA-74 (15th) (2018) / (17th) (2019)

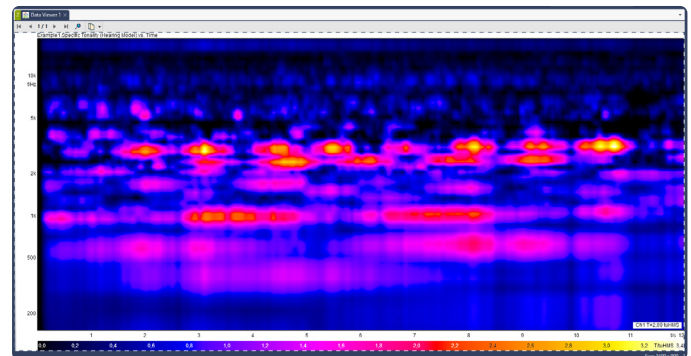
The Specific Tonality (Hearing Model) vs. Time analysis calculates the frequency of the tonal component with the highest tonality in the input signal over time. This analysis provides meaningful results only for airborne sound signals that provide a linear representation of human perception. The standards correspond to those of the Tonality (Hearing Model) vs. Time analysis.

The following analyses are available:

- › Tonality (Hearing Model) vs. Time
- › Specific Tonality (Hearing Model)
- › Specific Tonality (Hearing Model) vs. Time



Specific Tonality (Hearing Model)



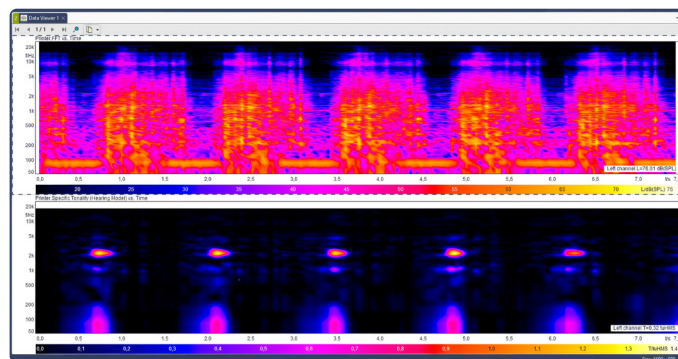
Specific Tonality (Hearing Model) vs. Time

Impulsiveness

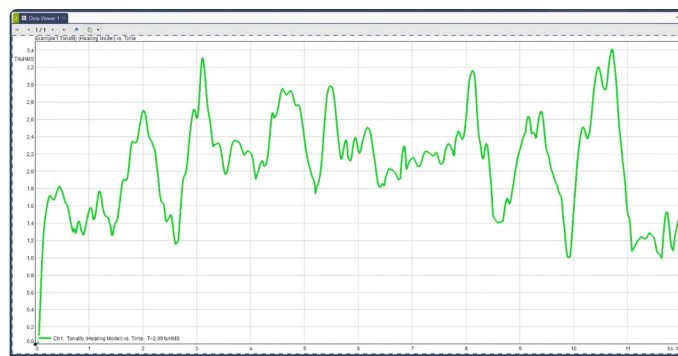
The perception of impulsiveness arises from rapid, large signal-level fluctuations. The impulsiveness analyses take this into account by mapping the human perception of rapid and simultaneously large changes in noise level on a linear scale.

The following analyses are available:

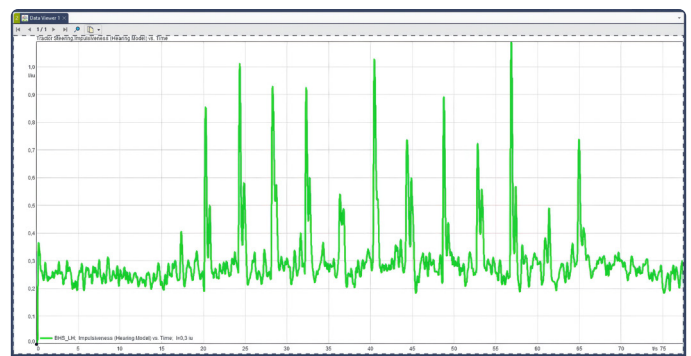
- › Impulsiveness (Hearing Model) vs. Time
- › Specific Impulsiveness (Hearing Model)
- › Specific Impulsiveness (Hearing Model) vs. Time



FFT vs. Time (top) and Specific Tonality (Hearing Model) vs. Time (bottom)



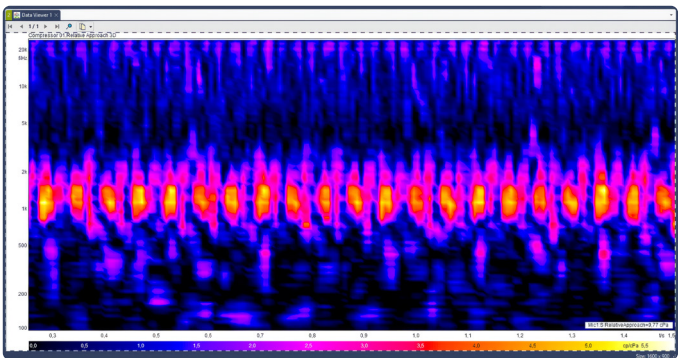
Tonality (Hearing Model) vs. Time



Impulsiveness (Hearing Model) vs. Time

Relative Approach 2D, Relative Approach 3D

The Relative Approach analyses developed by us emulate the adaptive behavior of human perception and are therefore ideally suited for evaluating patterns. The analyses perform a time-frequency analysis of signal-level curves, detect rapidly changing temporal and spectral structures in signals, and correlate strongly with human auditory pattern recognition.



Relative Approach 3D

Spectrum (Hearing Model) vs. Time

This analysis calculates the spectrum of an input signal over time.

Fluctuation Strength vs. Time, Specific Fluctuation Strength, Specific Fluctuation Strength vs. Time

The Fluctuation Strength analyses map the human perception of amplitude modulations up to frequencies of approx. 25 Hz on a linear scale. The calculation of the fluctuation strength is derived from the Roughness (Hearing Model) analysis.

LICENSES AND OPTIONAL FEATURES

General Requirements

Code	Product Name	Description
50000	APR 000 APR Framework	Basis of ArtemiS SUITE
51103	ASP 103 Psychoacoustics - Advanced Analysis	Advanced psychoacoustic analyses, standards, and methods based on the Sottek Hearing Model for the characterization of psychoacoustic effects and fundamental auditory perceptions of the human auditory system
At least one of the central projects of ArtemiS SUITE—Pool Project, Automation Project, Standardized Test Project—or a Metric Project is required and must be licensed.		

Optional Features

Code	Product Name	Description
50010	APR 010 Pool Project	Central project of ArtemiS SUITE: interactive workflow, ease of use, and data processing based on the cross-product logic
50050	APR 050 Automation Project	Central project of ArtemiS SUITE: one-time definition of the processing steps, followed by automated and repeated execution for all subsequent data
50220	APR 220 Standardized Test Project	Central project of ArtemiS SUITE: recording multiple operating conditions of objects with the Recorder and analyzing the data using different evaluation methods
50570	APR 570 Metric Project	Creation of quality metrics by correlating listening test results with acoustic signal analyses

LICENSES AND OPTIONAL FEATURES

Optional Features

Code	Product Name	Description
51101	ASP 101 Psychoacoustics - Basic Analysis	Psychoacoustic analyses, standards, and methods for the analytical characterization of perceived sound quality
51102	ASP 102 Psychoacoustics - Basic Analysis vs. Control Channel	Analyses from ASP 101 as a function of control channels
51104	ASP 104 Psychoacoustics - Advanced Analysis vs. Control Channel	Analyses from ASP 103 as a function of control channels
51107	ASP 107 Spectral Audio Feature Analysis	Analyses for the detailed characterization of spectral features and the quantitative description of sound characteristics
51108	ASP 108 Spectral Audio Feature Analysis vs. Control Channel	Analyses from ASP 107 as a function of control channels
5097	ASX 07 Local Processing Service (API)	ASX programming interface: execution of Automation Projects, for example, in End-of-Line processes, based on automation specifications (calculation jobs); ArtemiS SUITE does not need to be installed
5092	ASX 02 Data Processing and Representation API	ASX programming interface: automated or interactive control of Pool Projects and Automation Projects, including the execution of Reports, exports, and other tasks from within your software; ArtemiS SUITE must be installed

Further modules of ArtemiS SUITE (see ArtemiS SUITE Overview data sheet)



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