



Wollensack Michael 18.09.2018

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# METAS UncLib V2.1

## User Reference

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This document is a quick reference sheet. For more details refer to the *Metas.UncLib* help with the installation of the software.

The *Metas.UncLib* C# library supports creation of uncertainty objects and subsequent calculation with them as well as storage of the results. It has been developed with Microsoft Visual Studio 2013 and it requires the .NET Framework V4.5. There are three namespaces for uncertainty propagation: 'LinProp', 'DistProp' and 'MCProp'.

- 'LinProp' supports linear uncertainty propagation. This class is fully functional.
- 'DistProp' supports higher order uncertainty propagation, i.e. higher order terms of the Taylor expansion of the measurement equation are taken into account. This class currently only supports Gaussian input distributions and assumes Gaussian result distributions. In the future it will be possible to specify non-Gaussian inputs and to use higher moments of the results to calculate more realistic coverage intervals.
- 'MCProp' supports Monte Carlo propagation but its implementation is still preliminary and its use is not recommended yet.

## 1. Global uncertainty settings

### 1.1 Using Metas.UncLib

<pre>using Metas.UncLib.Core; using Metas.UncLib.LinProp;</pre>	Use the linear uncertainty propagation.
<pre>using Metas.UncLib.Core; using Metas.UncLib.DistProp;</pre>	Use the higher order uncertainty propagation.
<pre>using Metas.UncLib.Core; using Metas.UncLib.MCProp;</pre>	Use the Monte Carlo uncertainty propagation.

### 1.2 Additional global settings

<code>DistProp.Misc.Global.MaxLevel</code>	Set the higher order uncertainty propagation maximum level. Default value: 1 (1 corresponds to LinProp)
<code>MCProp.Misc.Global.n</code>	Set the Monte Carlo uncertainty propagation sample size. Default value: 100'000

## 2. Create an uncertainty object

Square brackets indicate vector or matrix.

<pre>UncNumber x =   new UncNumber(value);</pre>	Create uncertain number without uncertainty.
<pre>UncNumber x =   new UncNumber     (value, standard_unc, (idof)); or UncNumber x =   Unc.RealUncNumber     (value, standard_unc, (idof));</pre>	Creates a new real uncertain number with value, standard uncertainty and inverse degrees of freedom (optional).
<pre>Complex&lt;UncNumber&gt; x =   Unc.ComplexUncNumber     (value, [covariance], (idof));</pre>	Creates a new complex uncertain number. Covariance size: 2x2
<pre>UncNumber[] x =   Unc.RealUncArray     ([value], [covariance], (idof));</pre>	Creates a new real uncertain array. N: value.Length Covariance size: NxN
<pre>Complex&lt;UncNumber&gt;[] x =   Unc.ComplexUncArray     ([value], [covariance], (idof));</pre>	Creates a new complex uncertain array. N: value.Length Covariance size: 2Nx2N
<pre>UncNumber x = new UncNumber(); x.Init(value, [sys_inputs],   [sys_sensitivities]);</pre>	Create uncertain number by setting sensitivities with respect to uncertain inputs. 1

### 3. Calculations with uncertainty objects

#### 3.1 Math functions

$x + y$	$x * y$		
$x - y$	$x / y$	$-x$	Math.Sign(x)
Math.Sqrt(x)	Math.Sin(x)	Math.Sinh(x)	Math.Real(x)
Math.Exp(x)	Math.Cos(x)	Math.Cosh(x)	Math.Imag(x)
Math.Log(x)	Math.Tan(x)	Math.Tanh(x)	Math.Abs(x)
Math.Log10(x)	Math.Asin(x)	Math.Asinh(x)	Math.Angle(x)
Math.Log(x, y)	Math.Acos(x)	Math.Acosh(x)	Math.Conj(x)
Math.Pow(x, y)	Math.Atan(x)	Math.Atanh(x)	Math.Atan2(x, y)

#### 3.2 Linear Algebra

LinAlg.Dot(M1, M2)	Matrix multiplication of matrix M1 and M2
LinAlg.Lu(M)	LU decomposition of matrix M
LinAlg.Det(M)	Determinate of matrix M
LinAlg.Inv(M)	Matrix inverse of M
LinAlg.Solve(A, Y)	Solve linear equation system: $A * X = Y$
LinAlg.LstSqrSolve(A, Y)	Least square solve over determined equation system.
LinAlg. WeightedLstSqrSolve(A, Y, W)	Weighted least square solve over determined equation system.
UncLinAlg.NonLinearEig(A)	Non-linear Eigenvalue problem <sup>1</sup> : $A[0] * V + A[1] * V * D + A[2] * V * D^2 + \dots + A[n-1] * V * D^{(n-1)} = 0$

#### 3.3 Numerical Routines

NumLib.PolyFit(x, y, n)	Fit polynom to data
NumLib.PolyVal(p, x)	Evaluate polynom
NumLib.Interpolation(x, y, n, xx)	Interpolation
NumLib.Interpolation2(x, y, n, xx)	Interpolation with linear unc interpolation
NumLib.SplineInterpolation(x, y, xx, boundaries)	Spline interpolation
NumLib.SplineInterpolation2(x, y, xx, boundaries)	Spline interpolation with linear unc interpolation
NumLib.Integrate(x, y, n)	Integrate
NumLib.SplineIntegrate(x, y, n)	Spline integrate
NumLib.Fft(v)	Fast Fourier transformation
NumLib.Ifft(v)	Inverse Fast Fourier transformation

## 4. Get properties of an uncertainty object

<code>Unc.GetValue(y)</code>	Returns the expected value.
<code>Unc.GetFcnValue(y)</code>	Returns the function value.
<code>Unc.GetStdUnc(y)</code>	Computes the standard uncertainty.
<code>Unc.GetIDof(y)</code>	Computes the inverse degrees of freedom. <sup>1</sup>
<code>1.0/Unc.GetIDof(y)</code>	Computes the degrees of freedom. <sup>1</sup>
<code>Unc.GetCoverageInterval(y, p)</code>	Computes the coverage interval.
<code>Unc.GetMoment(y, n)</code>	Computes the n <sup>th</sup> central moment.
<code>Unc.GetJacobi(y)</code>	Returns the sensitivities to the virtual base inputs (with value 0 and uncertainty 1). <sup>1</sup>
<code>Unc.GetJacobi2(y, x)</code>	Computes the sensitivities of y to the intermediate results x. <sup>1</sup>
<code>Unc.GetUncComponent(y, x)</code>	Computes the uncertainty components of y with respect to x. <sup>1</sup>
<code>Unc.GetCorrelation([y1 y2 ...])</code>	Computes the correlation matrix
<code>Unc.GetCovariance([y1 y2 ...])</code>	Computes the covariance matrix

## 5. Storage functions

### 5.1 Store a computed uncertainty object

<code>y.BinarySerialize(filepath)</code> or <code>Misc.Storage.BinarySerialize(y, filepath)</code>	Binary serializes uncertainty object y to file.
<code>y.BinarySerializeToByteArray()</code> or <code>Misc.Storage.BinarySerializeToByteArray(y)</code>	Binary serializes uncertainty object y to byte array.
<code>y.XmlSerialize(filepath)</code> or <code>Misc.Storage.XmlSerialize(y, filepath)</code>	Xml serializes uncertainty object y to file.
<code>y.XmlSerializeToString()</code> or <code>Misc.Storage.XmlSerializeToString(y)</code>	Xml serializes uncertainty object y to string.

### 5.2 Reload a stored uncertainty object

<code>y.BinaryDeserialize(filepath)</code> or <code>Misc.Storage.BinaryDeserialize&lt;T&gt;(filepath)</code>	Reloads uncertainty object from binary file.
<code>y.BinaryDeserializeFromByteArray(d)</code>	Reloads uncertainty object from binary byte array.

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<sup>1</sup> 'LinProp' uncertainty objects only

or Misc.Storage. BinaryDeserialize FromArray<T>(d)	
y.XmlDeserialize(filepath) or Misc.Storage. XmlDeserialize<T>(filepath)	<b>Reloads uncertainty object from xml file.</b>
y.XmlDeSerializeFromString(s) or Misc.Storage. XmlDeserializeFromString<T>(s)	<b>Reloads uncertainty object from xml string.</b>