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# METAS UncLib MATLAB - User Reference V2.4.3

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### 1 Introduction

This document is a quick reference sheet. For practical demonstrations and more details refer to the tutorial and the examples that are provided with the installation of the software.

The [METAS UncLib MATLAB](#) library is an extension to MATLAB, which supports creation of uncertainty objects and subsequent calculation with them as well as storage of the results. It's able to handle complex-valued and multivariate quantities. It has been developed with MATLAB V8.3 (R2014a) and it requires the C# library [METAS UncLib](#) in the background. The classes [LinProp](#), [DistProp](#) and [MCProp](#) wrap [METAS UncLib](#) to MATLAB over the .NET interface.

**LinProp** supports linear uncertainty propagation  $V_{out} = J V_{in} J'$ .

**DistProp** supports higher order uncertainty propagation, i.e. higher order terms of the Taylor expansion of the measurement equation are taken into account.<sup>1</sup>

**MCProp** supports Monte Carlo propagation.<sup>1</sup>

### 2 Global uncertainty settings

#### 2.1 Set function handle

`unc = @LinProp` Set function handle `unc` to linear uncertainty propagation.

`unc = @DistProp` Set function handle `unc` to higher order uncertainty propagation.

`unc = @MCProp` Set function handle `unc` to Monte Carlo uncertainty propagation.

#### 2.2 Additional global settings

`DistPropGlobalMaxLevel(1)` Set the higher order uncertainty propagation maximum level. Default value: 1 (1 corresponds to [LinProp](#))

`MCPropGlobalN(n)` Set the Monte Carlo uncertainty propagation sample size. Default value: 100000

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<sup>1</sup>preliminary implementation



### 3 Create an uncertainty object

Square brackets indicate vector or matrix.

`unc(value)` Creates a new uncertain number or array without uncertainties.

`unc(value, stdunc, (idof))` Creates a new real uncertain number with value, standard uncertainty and inverse degrees of freedom (optional).

`unc(value, stdunc, (description))` Creates a new real uncertain number with value, standard uncertainty and a description (optional).

`unc(value, [covariance], (description))` Creates a new complex uncertain number.  
Covariance size:  $2 \times 2$

`unc([value], [covariance], (description))` Creates a new real uncertain array. Co-  
variance size:  $N \times N$

`unc([value], [covariance], (description))` Creates a new complex uncertain array.  
Covariance size:  $2N \times 2N$

`unc(value, standard_unc, idof, id, description)` Creates a new real uncertain number with value, standard uncertainty, inverse degrees of freedom, input id and description.<sup>2</sup>

`unc(value, [sys_inputs], [sys_sensitivities], 'system')` Create uncertain number by setting sensitivities with respect to uncertain inputs.<sup>2</sup>

### 4 Calculations with uncertainty objects

Use MATLAB call `methods(y)` on uncertainty object `y` to obtain a full list of supported methods.

#### 4.1 Math functions

- |                      |                          |                        |                         |                            |
|----------------------|--------------------------|------------------------|-------------------------|----------------------------|
| • <code>x + y</code> | • <code>sqrt(x)</code>   | • <code>sin(x)</code>  | • <code>sinh(x)</code>  | • <code>real(x)</code>     |
| • <code>x - y</code> | • <code>exp(x)</code>    | • <code>cos(x)</code>  | • <code>cosh(x)</code>  | • <code>imag(x)</code>     |
| • <code>x.*y</code>  | • <code>log(x)</code>    | • <code>tan(x)</code>  | • <code>tanh(x)</code>  | • <code>abs(x)</code>      |
| • <code>x./y</code>  | • <code>log10(x)</code>  | • <code>asin(x)</code> | • <code>asinh(x)</code> | • <code>angle(x)</code>    |
| • <code>x.^y</code>  | • <code>log(x, y)</code> | • <code>acos(x)</code> | • <code>acosh(x)</code> | • <code>conj(x)</code>     |
|                      | • <code>sign(x)</code>   | • <code>atan(x)</code> | • <code>atanh(x)</code> | • <code>atan2(x, y)</code> |

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<sup>2</sup>`LinProp` uncertainty objects only



### 4.2 Linear algebra

`M1*M2` Matrix multiplication of matrix  $M_1$  and  $M_2$

`lu(M)` LU decomposition of matrix  $M$

`det(M)` Determinate of matrix  $M$

`inv(M)` Matrix inverse of  $M$

`A\y` Solve linear equation system:  $Ax = y$

`A\y` Least square solve over determined equation system

`lscov(A, y, W)` Weighted least square solve over determined equation system

`[V, D] = eig(A0)` Eigenvalue problem<sup>2</sup>:  $A_0V = VD$

`[V, D] = eig(A0, A1, A2, ..., An)` Non-linear eigenvalue problem<sup>2</sup>:  $A_0V + A_1VD + A_2VD^2 + \dots + A_nVD^n = 0$

### 4.3 Numerical routines

`polyfit(x, y, n)` Fit polynom to data

`polyval(p, x)` Evaluate polynom

`roots(p)` Roots of the polynom

`interpolation(x, y, n, xx)` Interpolation

`interpolation2(x, y, n, xx)` Interpolation with linear uncertainty propagation

`spline(x, y, xx, boundaries)` Spline interpolation

`spline2(x, y, xx, boundaries)` Spline interpolation with linear uncertainty propagation

`integrate(x, y, n)` Integrate

`splineintegrate(x, y, boundaries)` Spline integrate

`fft(v)` Fast Fourier transformation

`ifft(v)` Inverse Fast Fourier transformation

`numerical_step(@func, x, dx)` Numerical step<sup>2</sup>

`optimizer(@func, xStart, p)` Optimizer<sup>2</sup>

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<sup>2</sup>`LinProp` uncertainty objects only



### 5 Get properties of an uncertainty object

`get_value(y)` Returns the expected value.

`get_fcn_value(y)` Returns the function value.

`get_stdunc(y)` Computes the standard uncertainty.

`get_coverage_interval(y, p)` Computes the coverage interval.

`get_moment(y, n)` Computes the n-th central moment.

`get_correlation([y1 y2 ...])` Computes the correlation matrix.

`get_covariance([y1 y2 ...])` Computes the covariance matrix.

`get_idof(y)` Computes the inverse degrees of freedom.<sup>2</sup>

`1./get_idof(y)` Computes the degrees of freedom.<sup>2</sup>

`get_jacobi(y)` Returns the sensitivities to the virtual base inputs (with value 0 and uncertainty 1).<sup>2</sup>

`get_jacobi2(y, x)` Computes the sensitivities of y to the intermediate results x.<sup>2</sup>

`get_unc_component(y, x)` Computes the uncertainty components of y with respect to x.<sup>2</sup>

`unc_budget(y)` Shows the uncertainty budget.<sup>2</sup>

### 6 Storage functions

#### 6.1 Store a computed uncertainty object

`binary_file(y, filepath)` Binary serializes uncertainty object y to file.

`xml_file(y, filepath)` XML serializes uncertainty object y to file.

`xml_string(y)` XML serializes uncertainty object y to string.

#### 6.2 Reload a stored uncertainty object

`unc(filepath, 'binary_file')` Reloads uncertainty object from binary file.

`unc(filepath, 'xml_file')` Reloads uncertainty object from XML file.

`unc(xml_string)` Reloads uncertainty object from XML string.

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<sup>2</sup>`LinProp` uncertainty objects only