

Lucullus PIMS Lite Windows Version



OPERATOR MANUAL

Software Version 3.7.4 Document Version 1.0



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1 GENERAL

1.1 INTRODUCTION

The Lucullus software suite is a PIMS (Process Information Management system) developed by SecureCell in association with Applikon Biotechnology. It is a rich toolbox designed to support planning, preparation, execution, and evaluation of experiments in bioprocess development and production environments.

In its core functionality, the **full** version of Lucullus manages *control* and *data acquisition* in a heterogeneous installation from a single central database. In its core functionality, Lucullus manages *control* and *data acquisition* in a heterogeneous installation from a single central database. A set of **Tools** have been built around this core functionality:

- The Graphic Tool
- The Online Tool
- The Operation Tool
- The Data Tool
- The Media Tool
- The Planning Tool
- The SysAdmin tool

Users with the most privileged license have access to all these tools. In addition to licensing privileges, SecureCell has developed a **simplified** version of Lucullus (Lucullus Lite) consisting of the following components:

- The Graphic Tool
- The Online Tool
- The Data Tool
- A simplified Operation Tool (running as a separate *Configuration Editor*)

The installation and configuration of Lucullus Windows Lite is described in the separate installation manual.

Most of the screenshots will be based on a Windows 10 system. The administrative procedures under Windows 10 differ in small details from those under Windows 7. If you have a Windows 7 system, this manual should still be applicable since most of the procedures are very similar.

For a proper understanding of the application, it helps to consult the Basic Lucullus Concepts in the Appendix (<u>BASIC CONCEPTS</u>).

Note

A common error during startup yields the following message:

application startup failed: unable to connect to database

The reason for this is fairly simple: the user is double-clicking on the LPIMS icon too quickly after switching on the system. The user should give the system some time (15-30 seconds) to establish a connection with the database.



As explained in the installation manual, one runs the **Configuration Editor** after installation in order to set up a number of reactors and controllers. Any number of reactors and accompanying controllers, up to a total of 8, can be set up. To quickly become familiar with the system, this chapter starts an experiment with a single reactor, the one called **R01**. Maybe more than 1 reactor (and accompanying controller) have been set up, but to make things easy, the first experiment uses just 1 reactor.

The setup therefore consists of: reactor R01 with a medium, an Applikon controller (*my*-Control, *in*-Control, or *ez*-Control) and a temperature and pH probe.

Start Lucullus via the Lucullus PIMS icon on the desktop, or otherwise via the Windows Start button:



Lucullus for Windows Lite provides 3 tools for viewing processes: The **GRAPHIC**, **ONLINE**, and **DATA** tools. The **Online Tool** is used to start a data viewing & logging session. The **Graphic** and **Data Tools** allow one to view the incoming data graphically or in tabular form.

Click on the **Online** tool to start a data measurement (and viewing) process. This launches the (initially blank) ONLINE Tool:



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STARTING AN EXPERIMENT

🖾 Online Tool - Lite	_	\times
File Graphic Operation Format Table Monitor/Console Window Help		
📑 🔄 🥩 🕲 🥼 🖉 💿 🖽 🖉 🔛 🕅 🥙 🗸 No Phase		2
🕐 🦛 🍑 🔹 🔨 None	•	
Information of the second seco		

Select Run a new process and click on OK.



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	Process Desc	scription X
	Attributes F	Phases More Attributes Notes Documents
	Operation	Base Operation
The following screen is	Version No	1
shown:	Variation	
	Reactor	R01
	Process Name	Test1
	Process Owner	r
	Process Start	
	Cultivation Start	art
	Process End	
	Duration [h]	
	Process Group	
	State	
		Apply Attribute Set Ok Cancel

Attributes	mases	Hore Attributes	notes	Documenta	
Operation	Base Op	peration			
Version No	1				
Variation					
Reactor	R01				
Process Name	Test1				
Process Owner	r				
Process Start					
Cultivation Sta	rt				
Process End					
Duration [h]					
Process Group					
State					



Click on **OK**.



This automatically displays the **port table** for the selected reactor:

Online Tool - Base Operation - [Po	ort Control]						_
ile Graphic Operation Form	nat Table	Monitor/Consol	e Window	Help			
' 🔄 🔊 🕲 📜 🖉	1	J 🖽 🕅	2 🛷 -	Automatic	V No Phase		
All Devices		•	All Phases	•	None		•
						All Devices	
Port	Unit	R01	Undate Time				
	onne		opulate fille				
r 🔄 fcode							
✓	tert						
m_do	[%]						
m_level1	1						
m_level2							
m_ph							
m_stirrer	[rpm]						
m_temp	[°C]						
V V 02 SETPOINT 1							
sp_do	[%]						
sp_ph							
sp_stirrer	[rpm]						
sp_temp	[°C]						
OB CONTROL STATUS 1							
cs_do							
cs_level1							
cs_level2							
cs_ph							
cs_stirrer							
cs_temp							
🗸 📹 04 DOSE MONITOR 1							
dm_air	[L]						
day col	[L]						

To start collecting and viewing data, click on the process Start button (shown circled).

After pressing on Start, the reports the progress of process startup using status bars as shown at right.

The green bar indicates that communication between the device driver and the bioreactor has been successfully established.

Starting Operation									
Starting Device Drivers									
R01	ok								
System Device	ok								
Start	More	Cancel							





After the device drivers have started, the **Trend Graph** is automatically invoked:

It will display the trends for a default set of ports. Initially the default is to record data upon changes only, so it is possible that this display will remain blank for a long while. You can restart the Configuration Editor and set the port of interest (for instance, **m_ph**) to *active logging* every so many seconds (instead of logging on *changes only*).

With the STOP button (circled) you can stop the process. The data is permanently saved, under the same name as the name of the process.



This section will present the main Lucullus Windows Lite functions that an operator can execute in addition to starting an experiment. The main additional functions are:

- 1. Attach to an existing process
- 2. Load historical data
- 3. Make calculations on the data
- 4. Smooth the data
- 5. Do a regression analysis on the data
- 6. Make graph overlays
- 7. Export data
- 8. Save graphs

A basic aspect of working in Lucullus involves dealing with *attributes* and there are various kinds of attributes in Lucullus. Generally there are **physical attributes** such as those relating to layout (color, line, line width of the axes of a graph) or those relating to behavior (state of logging, logging mode, logging interval, and dead band of a port). Then there are **informational attributes** such as process attributes (process name, duration, start time, organism, etc.) which can be used to organize processes, and to filter or search for them when selecting from the process list.

When having to select stored data sets, Lucullus will automatically display the relevant screens within which the user can select the attributes to search on. The addition of attributes is an advanced capability available in the Full version of Lucullus.



3.1 ATTACH TO AN EXISTING PROCESS

In this situation, you have started a process by following the steps described in the chapter <u>RUNNING A</u> <u>SIMPLE EXPERIMENT</u>. After following all the steps, you will have a running process collecting the desired data.

Now suppose that instead of clicking on the STOP button, you simply close Lucullus. You will get the following screen:

🕮 Online Tool	×
After quitting the Online Tool , this operation will continue to run in the background.	⊠ ⇒ ⊠
You may open another Online Tool anytime, and use Attach to Process , found in the File menu, or tool bar, to regain control.	Attach to Process
Do you really want to quit ?	
Yes No Ca	ncel

Click on **Yes** and the Online Tool closes but the process will continue to run, as it should. This is the way to prevent unauthorized access to Lucullus, for instance when you leave the lab for the evening, while the experiment continues to run.

If you start Lucullus Windows Lite again, the process will still be running but will no longer be visible in the PIMS interface. You need to *reattach* the process, which can be done in two ways. The first way is to select *Attach to a running process* in the popup that is automatically displayed when you start the Online Tool again:

Online Tool							
What would you like to do?							
Run a new process							
O Attach to a running process							
Ok	Cancel						



But if you here close the popup via 'X' or clicked **Cancel**, you can still reinvoke it via the **File** menu item:

ile N N R A	Graphic Operation lew Process up Planned Process ttach to process	Format	Table	Monitor/C								^
° N ≥ R Ø A	lew Process un Planned Process ttach to process		8 CTT		onsole	Window	Help					
A P	up Planned Process				2	20	- ₂ -	Automatic	V No Phase			2
P A	ttach to process				•		-	- 	None		-	
P			\mathcal{P}	_		_	_			_		
	ort Info											
) Pi	rocess Info	Ctrl+I										
D	evice Info											
A	larms											
In	nteractions											
P	rocess Relationships											
0	verlay Process											
R	efresh Ports											
觉 Pi	rint	Ctrl+P										
Ð	xport to File	Ctrl+X										
§ Ε	xport Signals	Ctrl+E										
🌡 Q)uit	Ctrl+Q										

Click on **Attach to process** as shown above (circled) and you will now get a screen showing all running background processes:

The Attach to Process								
Owner	Name	Start Date	Start Time	Hos				
group1	Test1	30-11-2017	08:30:47	DESKTOP-				
<				>				
			7	-				
		Load	J					
Remark:								



In this case, there is only one process 'Test1'. We can select it and click on **Load**. This loads the data gathered so far and displays it, initially using the default set of axes (which you can then change):



Since this is a running process, the display will continually update with new data.



3.2 LOADING HISTORICAL DATA

A valuable feature is the ability to recall the full data from previous experiments. You will follow this procedure very frequently. Start up the **Graphic Tool**, then navigate to **File** \rightarrow **Open**:

2	Graphic Too	ol - Lite									_		×
File	Graphic	Evaluations	Report	Format	Table	Consolidation	Window	Help					
1	Open)	Ctrl+0			•							?
	New Proce	ss Group		-	-	_				Nana	_		
	Process Fir	nder			_	•	_		• •	None	·	_	_
-	Export Sigr	nals	Ctrl+E										
3	Import Sig	nals											
1	Save Signa	l											
0	Info		Ctrl+I										
	Attributes.												
8	Alarms												
	Events	_											
	Drocess Re	S											
	Phase Edite	nr.											
	Show Vect	ors											
	Show Imag	jes											
5	Print		Ctrl+P										
	Export to F	ile	Ctrl+X										
	Quit		Ctrl+Q										
_													
Load	processes											4	¢ .
2000													



This invokes the **Data Selection** dialog:

	×
🔶 🗾 Data Selection	
Process Data Selection	
Please select your filter(s)	
	Quick Search
	Filter By
	Name, Remark,
	Date
	Reactor
	Process State
	Select By
	Process Process Group
	Next Cancel

You can use the dialog to do a preselection (i.e. to filter the data sets). Otherwise, leave the fields blank and all data sets will be shown. Click on **Next**.

											×
← P	Data Sel rocess Da	lection ata Selection	n interested in								
	Additional Filt	ers									
	None			O Signal					rt		
	Owner group1	Process Test1	Date 30-11-2017	Time 08:30:47	> >> <	Owner	Process	Date	Time		
					Remark:						
										Finish	Cancel



Select one of the entries in the list at left, press on ">" to transfer it to the right pane:

← ⊇ (Proce Please : Addit	Data Sele ess Dat select the	ction a Selection data you are i	ר nterested in						×
() N	lone			🔿 Signal			O Port		
0	vner	Process	Date	Time	> * *	Owner Proces group1 Test1	s Date 30-11-2017	Time 08:30:47	
					Remark:				
								Finish	Cancel

Here, process **Test1** has been selected. To complete the load, click on **Finish**:



The data has been loaded, and now one can perform analyses on it, as explained in the following sections.



3.3 USING THE CALCULATION TOOL

Once data has been loaded, one can perform operations on it. In the **Graphic Tool** one can invoke the **Evaluate** menu option (which holds all the Tools for Data Analysis) and from there, the **Calculate** menu option. **Calculate** allows one to perform mathematical operations on the loaded data, in general by composing expressions combining algebraic operations and mathematical functions.

Operations	Functions
+	@abs(x)
-	@acos(x)
*	@asin(x)
/	@atan2(x,y)
%	@ceil(x)
^	@cos(x)
and	@exp(x)
or	@floor(x)
xor	@hypot(x,y)
not	@ln(x)
<	@log(x)
>	@pow(x,y)
=	@sin(x)
==	@sqrt(x)
!=	@tan(x)
	@rnd(x)
	@round(x,y)
	@integ(x)
	@deriv(x)
	@derivb(x)
	@positiv(x,y)
	@sum(x)
	@prod(x)
	@avg(x)
	@stddev(x)
	@count(x)
	@max(x)
	@min(x)
	@first(x)
	@last(x)
	@const(x)
	@ref(x)
	@if(A;B;C)
	@exists(x)
	@numberof(x)
	@numberof(x,h)

Examples of valid formulas are:

oxid := @sin(P0 * P1(0:10)) * @sqrt(P2(10:20)) actuation := @exp(T)

 $\begin{array}{ll} K := 32 \\ TEMP_F & := 9/5*temp_c + K \end{array}$

Proceed as follows. Launch the Graphic Tool and if no data has been loaded yet, you can load it now via File



→ Open:

اسے	Graphic Tool -	Lite									-		×
File	Graphic E	valuations	Report	Format	Table	Consolidation	Window	Help					
	Open		Ctrl+0		- 🔎 -	-							?
	New Process	Group			-				-				-
	Process Finde	er			_	•			÷	None	•		
4	Export Signals	5	Ctrl+E										
*	Import Signal	s											
	Save Signal												
0	Info		Ctrl+I										
	Attributes												
	Alarms												
	Process Relati	ionsshins											
	Phase Editor	ionssinpsin											
	Show Vectors	;											
	Show Images												
3	Print		Ctrl+P										
	Export to File.		Ctrl+X										
	Quit		Ctrl+Q										
Load	l processes										Δ.	-+: 🔄	B 1,+;

This will invoke a data set selection dialog:

	×
← 🗾 Data Selection	
Process Data Selection	
Please select your filter(s)	
	Quick Search
	Filter By
	Name, Remark,
	Date
	Reactor
	Process State
	Select By
	Process Process Group
	Next Cancel

Use the above criteria to filter the collection, otherwise just leave everything blank – and this will display all data sets ever created on the system:



← F	Data Sel Process Da	lection ata Selectio ne data you are i	n interested in										×
	Additional Filt	ters											
	None			🔘 Signal				O Por	t				
	Owner group1 group1	Process Test1 Test2	Date 30-11-2017 30-11-2017	Time 08:30:47 08:50:40	Remark:	Owner	Process	Date	Time				
										F	inish	(Cancel

The above shows "Test2" being selected. Click on '>' to transfer it to the right pane:

Data Process Please selec	Selection Data Selectio t the data you are Filters	n interested in								;
None			🔿 Signal				○ Port			
Owner group1	Process Test1	Date 30-11-2017	Time 08:30:47	> >> <	Owner group1	Process Test2	Date 30-11-2017	Time 08:50:40		
				Remark:						
								Finis	h	Cancel





Then click on finish and a trend graph of the selected data is shown:

Now we define a calculation. Navigate to **Evaluations** \rightarrow **Calculate**.





Select Calculate and this displays the following screen:

Calculation				×
Apply To Processes Properties O All O Current Unit Phase Choice None Formula: Contract of the second seco	•	Show Inputs	Entries	Va
	Functions			
Execute Online Calc	Inputs	٢	Close	>

Enter the Celsius to Fahrenheit conversion formula in the left *formula* input field as follows:

Calculation							×
Apply To Processes	Properties Unit -	Phase	Choice None	•	Show Inputs		
🥥 📊 Formula:					Result Name	Entries	Va
TEMP_F:=9.0/5.0*m_te	emp+32.0			Functions			
				Inputs			
Online Calc	l	Execute			<		> Close

In writing the above formula, we needed to determine the name of the measured temperature variable. Clicking on the **Inputs** ... button displays all known variables. In the 01 SENSOR INPUT 1 "folder" for sensor inputs, we see **m_temp** which must be the temperature process variable.

Temperature is measured by default in Celsius and we wish to display the temperatures trend in Fahrenheit. So we enter the formula as shown above, which is the basic conversion from Celsius to Fahrenheit (note: you can transfer m_temp to the formula by doueble-clicking on it in the Inputs window).

Then click on Execute.





This will create the variable **TEMP_F**, calculate its values and will automatically display by default the values of the new variable (or variables) in graphical and tabular form:

Graphic	Tool - Lite	Concolidation Windo	Hal			_		×
	A CONTRACTOR CONTRACT POINTAL TABLE) -	w ne	P				0
< 🛃	Test2	✓ All Phases		▼ ▼ N	one	•		
🗾 Calcula	tion		Z Te	est2				×
Group: group1	Test2	Reactor: R01	Date	and Time 🔻 🔖 🔹	+ 🗙 🗸 🔊 🗉	9 😵		
Start: 30-11-20	17 08:50:40 Duration: 00:06			Timestamp	TEMP_F			^
			1	30/11/2017 08:50:43	28.940			
45 -			2	30/11/2017 08:50:45	28.940			
40			3	30/11/2017 08:50:50	28.940			
40		Λ	4	30/11/2017 08:50:55	28.940			
35 -			6	30/11/2017 08:51:05	28.940			
30 -			7	30/11/2017 08:51:10	28.940			
			8	30/11/2017 08:51:15	28.940			
25-			9	30/11/2017 08:51:20	28.940			
20 -			10	30/11/2017 08:51:25	28.940			
			11	30/11/2017 08:51:30	28.940			
15-			12	30/11/2017 08:51:35	45.140			
10-			13	30/11/2017 08:51:40	45.140			
			14	30/11/2017 08:51:45	45.140			
5-			15	30/11/2017 08:51:50	45.140			
0		<u></u>	16	30/11/2017 08:51:56	45.140			
0	0.02 0.04 0.06 Time [b]	0.08 0.1	17	30/11/201/08:52:00	30.740			*
anonymous			_				4	B
unonymous							4	

You can now choose to include the original measured values. Navigate to Graphic \rightarrow data/axes:





🗾 Data/Axis Relationsship										×	
Phase Plot											
		Ava	ilable Sign	als:							
Signal	Entries	^			Axis	Owner	Process	Reactor	Device	Su	
 group1 ✓ Test2 ✓ R01 ✓ R01 ✓ 01 SENSOR INPUT 1 m_do m_level1 	77 77		>	 	x-axis y-axis 1 TEMP_F y-axis 2 y-axis 3 y-axis 4 y-axis 5	group1	Test2	R01	R01	01 SEN	
m_level2 m_ph m_stirrer m_temp TEMP_F ✓ ு 02 SETPOINT 1 sp_do sp_ph	7 77 77 77 77 7 7	<	<		· y-axis 6 · y-axis 7 · gy-axis 8 · gy-axis 8						
<	>			<						>	
Remark:											
L		Ok		Cano	cel						

The calculated variable **TEMP_F** is shown. Select **m_temp** in the left pane:





🗾 Data/Axis Relationsship										×
Phase Plot										
Available Signals:										
Signal	Entries	^			Axis	Owner	Process	Reactor	Device	S
^(m) group1 ^(m) Test2 ^(m) R01 ^(m) 01 SENSOR INPUT 1 ^(m) 100 ^(m) 100 ^(m) 100 ^(m) 100 ^(m) 100 ^(m) 100 ^(m) 200 (m) 200	77 77 77 77 77 77 77 77		> <	 * * 	x-axis y-axis 1 TEMP_F y-axis 2 m_temp y-axis 3 y-axis 4 y-axis 5 y-axis 5 y-axis 7 y-axis 8	group1 group1	Test2 Test2	R01 R01	R01 R01	01 SEP
sp_do sp_ph	7 7									
<u>د</u>	>	Ť		<						>
			Remark:							
		Ok		Cano	el					

Click on '>' to transfer **m_temp** to y-axis 2:

Click on **OK**, and now both variables are displayed:







Here we wish to change the colors of the data plots. So Navigate to **Graphic** \rightarrow **Attributes** \rightarrow **Data** as shown above.

This invokes the dialog shown at right where one can change attributes of the plot for the listed data sets.

Drocess	Device	S.,	bdev	Ctata			
Teet2	Device						
Test2	RUI PO1	01 SEINS		TEIVIP_F			
rest2	RUI	UT SEINS	UNINPUT	m_temp			
	24	•		Line Stude	Calid Line		
Mode	Polyl	ine	•	Line Style	Solid Line	2	 •
Mode	Polyl	ine	•	Line Style Line Width	Solid Line	2	•
Mode	Polyl	ine	•	Line Style Line Width	Solid Line	e Channe Co	 •



Select the TEMP_F data set:

Data	Axis	Gener	al						
Process	Devic	2	Subde	v	State				
Test2	R01	01 S	ENSOR I	NPUT 1	TEMP_F				
Test2	R01	01 S	ENSORI	NPUT 1	m_temp				
M		. i				Solid Lina			
Mode	Po	yline		•	Line Style	Solid Line			
Mode Symbol	Po	yline		•	Line Style Line Width	Solid Line			
Mode Symbol Unmarked	Po J	yline		¥ ¥	Line Style Line Width Color	Solid Line	Choose C	olor	•

And the color button takes on the current color of the **TEMP_F** plot. Click on **Choose Color ...** :

🖉 Select Color	×
Basic colors	
Custom colors	Hue: 300 - Red: 255 - Sat: 255 - Green: 0 - Val: 255 - Blue: 255 - OK Cancel



We select pink in the **Select Color** dialog. The selection is confirmed by the colored rectangle (indicated by the red arrow). Click on **OK** and this makes our TEMP_F curve pink.

Then we perform the same action for **m_temp** and change its color to orange. Click on **OK** to display the result:



Finally, close the tabular display and maximize the trend:





The above now shows the temperature measurement in Centigrade (orange) and the corresponding Fahrenheit value (pink). This is admittedly a simple example but the calculation capability allows you to make far more complex computations.



3.4 SMOOTHING GRAPHS

Smoothing is useful function for showing a general trend by smoothing out fluctuations in data. Proceed as follows. Launch the **Graphic Tool**. If no data has been loaded yet, you can load it now via **File** \rightarrow **Open**, as was done in the previous section.





Navigate to **Evaluations** \rightarrow **Smooth**.



Clicking on Smooth will display the following dialog:

🛃 Smooth		×
Interpolation Spline O Fourier	Degree (%)	: 5
Signal	Entries	State Ni ^
	NDUT 1	
m do	77	Measurement DO
m_level1	77	Measurement Leve
m_level2	7	Measurement Leve
m_ph	77	Measurement pH s
m_stirrer	77	Measurement stirre
m_temp	77	Measurement tem
✓ ➡ 02 SETPOINT	Г 1	× *
Smooth Derivative	Integral Clea	ar Clear All

We can select between Spline or Fourier methods for smoothing. Here we select **Spine** and set the **Degree** of smoothing to 5%. Select **m_temp** and click on **Smooth**. The result of this is the following:





The original curve in black has been overlaid by the smoothed curve in red. As one can see here, 5% does not do very much smoothing.

Invoke again the Smooth dialog.	🛃 Smooth			×
Note that the smoothing operation created the 3 extra	Interpolation Spline Fourier 		Degree (%): 5	
variables:	Signal	Entries	State Name	^
m_tempSmo m_tempSmoDer m_tempSmoInt	m_level1 m_level2 m_ph m_stirrer m_temp	77 7 77 77 77 77	Measurement Level 1 sensor Measurement Level 2 sensor Measurement pH sensor Measurement stirrer speed Measurement temperature sensor	
In the Smooth dialog. m_tempSmo holds the smoothing data. The other two variables hold the derivative and integral of the smoothed data.	m_tempSmo m_tempSmoDer m_tempSmoInt	77 77 77 7 7 7 7 7	m_temp Smooth Spline 5% Derivative m_temp Smooth Spline 5% Derivative m_temp Smooth Spline 5% Integral Setpoint for DO Setpoint for pH Setpoint for stirrer Setpoint for temperature	
To start over, click on Clear All in the dialog at right and	cs_do Smooth Derivative	7 Integral	Control status for DO Clear Clear All	~



close the plot in the Graphic window via the 💌 button. This clears all generated variables and restores the original plot:



	∠ Smooth		×
	Interpolation Spline Fourier 	Degree (%)	: 80 🜩
alue	Signal	Entries	State Ni ^
	m_level1	77	Measurement Leve
	m_level2	7	Measurement Leve
	m_ph	77	Measurement pH s
	m_stirrer	77	Measurement stirre
	m_temp	77	Measurement tem
	V 🏐 02 SETPOINT 1		
	sp_do	7	Setpoint for DO
	sp_ph	7	Setpoint for pH
	sp stirrer	7	Setpoint for stirrer 🗡
	<		>
	Smooth Derivative I	integral Clea	ar Clear All

With the **Smooth** dialog still open, now raise the **Degree** value to 80%.



This produces the following result:



This shows somewhat better smoothing. If you now choose **Fourier** smoothing with **Degree** 25, in order to approximate the data with sinusoidal components, the result would be:



which clearly shows the sinusoidal nature of Fourier smoothing.



3.5 PERFORMING REGRESSION ANALYSIS

While the previous section illustrated data *smoothing*, this one illustrates data *fitting*. Recall the distinction: *smoothing* abandons an exact data match in order to produce a smooth curve that approximately follows the data; *fitting* tries to find the mathematical expression that most closely matches the data.

To fit data using regression analysis, one tries to determine a mathematical expression that best matches the data. The mathematical expressions used here are:

- Linear expressions
- Polynomial expressions
- Exponential expressions
- Logarithmic expressions
- Sigmoidal expressions

We will illustrate the first two, but the general approach applies to the others as well. By following the same procedure as in the previous section once again, start the Graphic Tool and open a data set selected from the collection of all data sets:



This is a fairly simple data set but is useful in illustrating how the regression analysis performs.



🗾 Graphic Tool -	Lite		– 🗆 X
🗾 File Graphic	Evaluations Report Format	Table Consolidation Window Help	_ <i>8</i> ×
i 🎒 🌛 🔊	Calculate	P •	0
i 🔥 👍 📥	🔌 Smooth	▼ All Phases ▼	X None V
	Pattern	, and the second s	
Group: group1	Regression	test3	Reactor: R01
Start: 30-11-2017 09:14	Productivity		
	Generic Evaluation		
6 -	Evaluation Sequences		
5-			
4-			
-			
J, 3-			
۲. ۲.			
Ε 1-			
-			
0-			
-1 -			
-2	0.005 0.01	0.015 0.02	0.025 0.03
		Time [h]	
Calculate regressio	ns on signals		

Navigate to **Evaluations** → **Regression**:

This invokes the following dialog shown at right.

Select the signal **m_temp** and for the **Regression Type**, select:

• Linear

Whether the data is meant to go through the origin is a judgment you have to make based on your knowledge of what the data should be at time zero; here we choose not to, so we leave **Through Origin** unchecked.

🛃 Reg	pression				×
F	Regressio Linea Logar	n Type r 💿 Exponentia rithmic 💿 Sigmoidal	l 🔘 Polynomial	Through Origin	
X-Axis	Process 1	Time		Change	
Chi Squar	re:	242.3	Correlat	tion: -0.05094	
Result:					
		Signal	Entries	State Name	^
	~	a 01 SENSOR INPUT	[1		
		m_do	24	Measurement DO sensor	
		m_level1	24	Measurement Level 1 sensor	
		m_level2	2	Measurement Level 2 sensor	
		m_ph	24	Measurement pH sensor	
		m_stirrer	24	Measurement stirrer speed	
		m_temp	24	Measurement temperature sen	SI
	~	a 02 SETPOINT 1			
		sn do	2	Setpoint for DO	×
<				>	
		Regression Der	ivative Cle	ear Clear All	



The result is as shown below.



The data has been approximated by the red line shown above.

To start again, click on **Clear All** and close the regression plot using the statuton

Let us now choose the following **Regression Type**:

- Polynomial
- Polynomial Order 2

Select **m_temp** and click on **Regression**.

<u></u> R	egression					×
	Regression O Linear O Logari	n Type O Expone thmic O Sigmoid	ential 🖲 Polynomial Ial		Polynomial Order	
X-Axis	Process T	ime			Chan	ge
Chi Squ	Jare:	242.3	Correla	ation:	-0.05094	
Result:						
		Signal	Entries	5	State Name	^
	~ 📢	🔰 01 SENSOR IN	IPUT 1			
		m_do	24	Measur	ement DO sensor	
		m_level1	24	Measur	ement Level 1 sensor	
		m_level2	2	Measur	ement Level 2 sensor	
		m_ph	24	Measur	ement pH sensor	
		m_stirrer	24	Measur	ement stirrer speed	
		m_temp	24	Measur	ement temperature s	ensi
	~ (🗃 02 SETPOINT	1			
		sn do	2	Setnoin	t for DO	· *
<						>
		Regression	Derivative C	lear	Clear All	



The result is as shown below:



The data has now been approximated by a quadratic.

To start again, click on **Clear All** and close the regression plot using the button

Let us now choose the following **Regression Type**:

- Polynomial
- Polynomial Order 6

Again, select **m_temp** and click on **Regression**.

<u>ح</u> Re	gression				×
	Regressio	on Type ar O Exponenti rithmic O Sigmoidal	al 🖲 Polynomial	Polynomial Order	
X-Axis	Process	Time		Cha	ange
Chi Squ	are:	223.7	Correla	tion:	
Result:					
		Signal	Entries	State Name	^
	~	inpu 🗐 🕲 🗐 🏐	JT 1		- 1
		m_do	24	Measurement DO sensor	
		m_level1	24	Measurement Level 1 sense	or
		m_level2	2	Measurement Level 2 sense	or
		m_ph	24	Measurement pH sensor	
		m_stirrer	24	Measurement stirrer speed	
		m_temp	24	Measurement temperature	sensi
	~	02 SETPOINT 1			
		sn do	2	Setpoint for DO	~
<					>
		Regression	erivative Cle	ear Clear All	



The result is shown below:



And one can see that for this data, a polynomial of sufficiently high degree can fit the data fairly closely.



3.6 MAKING GRAPH OVERLAYS

When running an experiment one can overlay the data from past and stored experiments over the data of the currently running experiment. This is visually extremely useful for comparing trends.

To do this in Lucullus, one first starts an experiment and then selects one or more prior experiments to overlay. So start by examining your stored experiments to select the ones to overlay. You do this by invoking the **Graphic Tool** and then navigating to **File** \rightarrow **Open**, and finally selecting an experiment. If it is not the desired one, you repeat these steps until you have found the desired experiment or experiments. For this example, we choose the following experiment:





Then you start a run. We will run through the steps of starting a process again, as a refresher. Start the **Online Tool** and you get the following:

🕲 Online Tool - Lite	_	\times
File Graphic Operation Format Table Monitor/Console Window Help		
Image: Second secon		2
	•	
IN Online Tool X What would you like to do? I Run a new process Attach to a running process Ck Cancel		

Select Run a new process.



This will invoke the following screen:

Process Des	cription	
Attributes	Phases More Attributes Notes Documents	
Operation	Base Operation	
Version No	1	
Variation		
Reactor	R01	Ø
Process Name	lambda	÷
Process Owner		
Process Start		
Process End		
Duration [h]		
Process Group		
State		
		Ok Cancel

Enter the Operation and the process name (the minimum required entries) and click **OK** for the port display:

Inline Tool - Base Operation - [Graphic Operation Fr	Port Control	Monitor/Const	ole Window Help		-
·			M Con y Dy Autom	No Phase	
				No Flase	
All Devices		•	All Phases	▼ None	•
					All Devices
	•				
ort	Unit	R01	Update Time		
🖌 📹 fcode					
O1 SENSOR INPUT 1					
m_do	[%]				
m_level1					
m_level2					
m_ph					
m_stirrer	[rpm]				
m_temp	[°C]				
1 SETPOINT 1					
sp_do	[%]				
sp_ph					
sp_stirrer	[rpm]				
sp_temp	[°C]				
V is control statu:	S 1				
cs_do					
cs_level1					
cs_level2					
cs_ph					
cs_stirrer					
cs_temp					
🛩 📹 04 DOSE MONITOR 1					
dm_air	[L]				
dm co2	[L]				



Assuming that the port configuration is ok, we proceed to start the experiment using the **Start** button:

Starting Oper	ation	×
Starting Device Dri	vers	
R01	ok	
System Device	ok	
Start	More	Cancel

The **Starting Operation** popup automatically disappears and the plot after some time looks as follows:

D Online	Tool - R01 201	7 Week 50	004 - [Trend	Graphi						_		×
Jos File G	ranhic One	ration E	ormat Tabl	• Monitor/Console	Window He	ln.						
i ne o						чч Ч				7		
	50 U	I			y 🧭 🕇 🧨	Automat	ic 🔻	No Phase				Ø
🏠 🦛	All Dev	ices		✓ All	Phases		• •	None		•		
Group: group1					lambo	la				Reactor: R01		
Start: 12-12-20	17 11:26:03 Dura	tion: 00:00										
80 - 75 - 60 - 55 - 50 - 845 - 9 - 445 - 440 - 45 - 30 - 25 - 20 - 15 - 10 - 5 - 0 -	120 - 110 - 90 - 80 - 70 - 50 - 50 - 40 - 30 - 20 - 10 - 0 -	120 110 - 100 - 90 - 80 - 70 - 70 - 50 - 40 - 30 - 20 - 10 - 0 -	2.2 2- 1.8- 1.6- 1.4- 2.2 1.8- 1.6- 1.4- 0.8- 0.6- 0.6- 0.4- 0.2- 0 0	0.0001 0.0002	0.0003 0.000	4 0.0005	0.0006	- 120 - 110 - 90 - 80 - 70 - 60 - 50 - 40 - 30 - 20 - 10 - 0.0007	- 16 - 14 - 12 - 10 - 10 - 10 - 8 - 8 - 6 - 4 - 4 - 2 - 0	0.2 0.4 0.6 1.2 1.2 1.4 1.6	-8 -7 -6 -4 -3 -3 -2 -1 -0	
anonymous												a) .
anonymous												

Since only m_temp is measured, we can remove all the other y-axes via Graphic \rightarrow data/axes, or by loading a stored format.



The result is a temperature plot for the current experiment:



Now we can add an overlay via File \rightarrow Overlay Process:





This invokes the screens where w	e can select from all prior data runs:
----------------------------------	--

	>	ĸ
🔶 📴 Data Selection		
Process Data Selection		
Please select your filter(s)		
	Quick Search	
	Filter By	
	Name, Remark,	
	Date	
	Reactor	
	Process State	
	Select By	
	Process Process Group	
	Next Cancel	

Leave all entries blank to select everything and click on Next:

Additional Filt	ers									
None		🔾 Si	gnal				O Por	t		
Owner group1 group1 group1 group1 group1 <	Process epsilon lambda my4-doy quickrun1 R01 2017 Week 50 002	Date 30-11-2017 12-12-2017 12-12-2017 30-11-2017 12-12-2017	Time ^ 11:48:33 11:07:27 00:00:00 12:09:07 09:32:4€ >	> >> <	Owner	Process	Date	Time		
				Remark:						



We scroll to the desired entry and select it, then click on '>' to move it to the right window:

dditional Filt None	ers	🔾 si	ignal			C) Port		
Owner group1 group1 group1 group1 group1 <	Process epsilon lambda quickrun1 R01 2017 Week 50 002 R01 2017 Week 50 003	Date 30-11-2017 12-12-2017 30-11-2017 12-12-2017 12-12-2017	Time ▲ 11:48:33 11:07:27 12:09:07 09:32:4€ 11:04:4C >	> >> <	Owner group1	Process my4-doy	Date 12-12-2017	Time 00:00:00	
group1 <	R01 2017 Week 50 003	12-12-2017	11:04:4C ↓ >	*					

After clicking on **Finish**, we will probably not see the trend of this previous run yet; we still have to specify which of its parameters are to be plotted onto which axis. Navigate to **Graphic** \rightarrow **data/axes**. Then scroll down in the left pane until you see the entry corresponding to the process you wish to overlay (alpha1).

Signal group1 Signal group1 Signal 1 Signal 1 M_ai1 m_ai2 m_ai3 m_ai4 m_ai5 m_ai6 m_air m_biomass m_do_raw	599 529 529 598 597 598 598 598 599 49 598 598 598	<	> *	Axis x-axis - axis y-axis 1 m_temp - y-axis 2 m_do_raw y-axis 3 y-axis 3 y-axis 4 y-axis 4 y-axis 5 y-axis 6 y-axis 7 y-axis 8	Owner	Process lambda my4-doy	Reactor	Device	C
			Remark:						

- Locate the desired process in the left pane
- 2. Locate the process value to overlay
- Select the process value (m_do_raw here) and click on '>' to transfer it to the next available axis on the right pane



Press on **OK** and the overlay is displayed:



And here we recognize the trend plot for **my4-doy** in red that was shown at the start of this section, overlaid onto the trend in blue for the current run. The trend in blue is compressed as a result of horizontal rescaling in order to fit the larger number of data points in **my4-doy**.

You can rescale the axes to show the blue trend in more detail, or you could use the magnifying glass to zoom in on it. If you do this last, the result looks like the following:





3.7 EXPORTING DATA

It is very convenient to be able to export data in order to further process it outside of the Lucullus environment.

Exporting from previous runs

When exporting data from previous previous runs, the main steps consist of loading the desired data set, then selecting the signals from this data set that we wish to export. The steps in more detail are:

- 1. Start the Graphic Tool
- 2. Load the stored data set via **File** \rightarrow **Open**
- 3. Select the desired data set
- 4. Start to export via File \rightarrow **Export Signals**
- 5. Select the desired signal
- 6. Select the phases (select **all** if in doubt)
- 7. Select the mode for time intervals and interpolation options
- 8. Provide target folder and file name
- 9. Complete the export

We first start the **Graphic Tool**:



Then we follow the same steps as in previous sections to load the desired data.



Select Open:

2	Graphic Tool - Lit	e									-	\times
File	Graphic Eval	uations	Report	Format	Table	Consolidation	Window	Help				
	Open		Ctrl+0	0	- ,0	•						2
	New Process Gro	oup			-	_				Nees	_	
	Process Finder					•			•	None	•	
4	Export Signals		Ctrl+E									
3	Import Signals											
ы. С	Save Signal			- 100								
0	Info		Ctrl+I									
	Attributes											
	Alarms											
	Interactions	sching										
	Phase Editor	issnips										
	Show Vectors											
	Show Images											
5	Print		Ctrl+P									
	Export to File		Ctrl+X									
	Quit		Ctrl+Q									
Load	processes											 \$

The Process Data Selection window appears:

	×
🔶 🗾 Data Selection	
Process Data Selection	
Please select your filter(s)	
	Quick Search
	Filter By
	Name, Remark,
	Date
	Reactor
	Process State
	Select By
	Process Process Group
	Next Cancel

Adjust the filter criteria, or leave everything blank to select all data sets.



Scroll the data sets until the desired one is found. Highlight it:

Data Sel rocess Da ease select th Additional Filt	ection ata Selectio e data you are i ers	n interested in								
None			🔾 Signal				O Por	t		
Owner group1 group1 group1 group1	Process epsilon Test1 Test2 test3	Date 30-11-2017 30-11-2017 30-11-2017 30-11-2017	Time 11:48:33 08:30:47 08:50:40 09:14:46	> >> <	Owner	Process	Date	Time		
				Remark:						
										 -

Select the desired data set, click on '>' to transfer it to the right pane and click on **Finish**:

None			🔵 Signal				○ Port		
Dwner jroup1 jroup1 jroup1	Process epsilon Test1 test3	Date 30-11-2017 30-11-2017 30-11-2017	Time 11:48:33 08:30:47 09:14:46	> >> <	Owner group1	Process Test2	Date 30-11-2017	Time 08:50:40	



The desired data set (test2 here) is displayed:



Now navigate to File \rightarrow Export Signals ...





The signals available for export are displayed.



Select, for this example, **m_temp** to export.



Click on '>' to transfer it to the right pane. Then click on Next.



				?	×
4	Export Sid	anals			
	Process Pha	ase(s)			
	You might want t	o restrict the selection to specific process phases			
0	All Phases				
	Abbr	Name			
	В	Batch			
	C	Cleaning			
	CD	Cool Down			
	F	Fermentation			
	FD	Feed			
	FL	FIII			
		Harvest			
	P	Preparation			
	SD	Split			
	ST	Sterilization			
	т	Terminated			
	w	Waiting			
		г	Next	Cre	
		L	Next	Can	.ei

In this window you select for which phases of the process signal data is to be exported. In this case we select **All Phases** (circled).



										?	×
←	Exp	ort Signals									
1	Signal I	nterpolati	ion								
Γ	Select the Column He Time Form	type of interp aders	olation and	d alignment		Process T	ime [h]				•
	Time Sta	mp Selection -				Interpola	tion/Alignm	ent			
	Type:			Fixed Interval	•	Type:			Default / Per Sig	nal	-
	Interpol.	Interval: [see	c]	5		S	et per Sign	al			
	State	Alignment	Interval	SubDevice	Device	Reactor	Process	Owner			
	m_temp			01 SENSOR INPUT 1	R01	R01	Test2	group1			
									Next	Ca	ncel

In this next window, we can take the data with the time stamps as they are, or we can force to have equispaced data, in which case the system supplies the intermediate values between two existing consecutive timestamps by linear interpolation. Here we select fixed interval time stamps with an interval of 5 seconds.



Select the signal to export from the list of signals and press Next:

		? ×
← 🗾 Export Signals		
Target File		
Select the target file(s)		
		Save Format As
Process Selection		
Single Process	All Processes	
Destination		
Single File Multiple Files		
File		
Browse		
		Finish Cancel

Here one can save a single process which is automatically saved as a single file. If you save all processes you can choose to have the data for all processes in a single file or one file per process.

For the current example, we choose **Single Process**. Then click **Browse** to specify the target location **and** the file name:

🗾 Save As	>	<
$\leftarrow \rightarrow \checkmark \uparrow$ _ 	✓ ♂ Search export	
Organize 👻 New folder	≣≡ ▾ (?)	
🛫 vmshare_folder 🔥 Name	Date modified Type	
🝊 OneDrive	No items match your search.	
💻 This PC		
🛄 Desktop		
📋 Documents		
🖶 Downloads		
👌 Music		
E Pictures		
📕 Videos		
🛀 Local Disk (C:) 🗸 🧹		>
File name: export1		Л
Save as type: Microsoft Excel-Workbook (*.xlsx)	Л
	·	
∧ Hide Folders	Save Cancel	



You can select the format of the output:

Z Save As				×
$\leftarrow \rightarrow \land \uparrow$	« Lucullus » export	√ Ō	Search export	Ą
Organize 🔻 Ne	w folder			∷ .
🛖 vmshare_fold	er i ^ Name ^		Date modified	Туре
ineDrive 🍊		No items match y	our search.	
💻 This PC				
📃 Desktop				
🔮 Documents				
👆 Downloads				
👌 Music				
Pictures				
🚆 Videos				
🏪 Local Disk (C:) 🗸 <			>
Ele energy	avport1			
File name:				
Save as type:	Microsoft Excel-Workbook (*.xlsx)			~
∧ Hide Folders	Microsoft Excel-Workbook (*.xlsx) Microsoft Excel 97-2003-Workboo Text CSV (*.csv) Text Files (*.txt)	k (*.xls)		
	All files (*)			

The file will be saved in C:\lucullus\export, under file name export1 and you can choose the format as XLS, CSV, or TXT:

Save As	×
$\leftarrow \rightarrow$ \checkmark \uparrow \frown « Lucullus \rightarrow export	✓ ♂ Search export
Organize 🔻 New folder	III 🔻 (?)
🛫 vmshare_folder ^ Name	Date modified Type
🕋 OneDrive	No items match your search.
💻 This PC	
Desktop	
Documents	
🖶 Downloads	
👌 Music	
Pictures	
Videos	
🟪 Local Disk (C:) 🗸 🧹	>
File name: export1	
Save as type: Text Files (*.txt)	~
∧ Hide Folders	Save Cancel



Click on **Save**. The next window is shown:

				Ĩ	? X
🗧 🗾 Export Sig	gnals				
Target File					
Select the target	file(s)				
			Save Fo	rmat Save F	ormat As
Process Selecti	on				
Single Processing	ess	All Prov	cesses		
Destination Single File File Browse 	O Multiple Files C:/Users/Public/Documents/	.ucullus/export/export1.txt			
				Finish	Cancel

Click on **Finish** and the export is created. The file extension you type determines the output format.

An exported .7	TXT file <i>can</i> look as follows:	An exported .csv file can look as follows:
Time [h]	m_temp	Time [h],m_temp
0.000805556	19.6	0.000805556,19.6
0.00302778	19.6	0.00302778,19.6
0.00608333	19.6	0.00608333,19.6
0.00858333	19.6	0.00858333,19.6
0.0113611	19.6	0.0113611,19.6
0.0141389	19.6	0.0141389,19.6
0.0169167	19.6	0.0169167,19.6
0.0196944	19.6	0.0196944,19.6
0.0224722	19.6	0.0224722,19.6
0.02525	19.6	0.02525,19.6
0.0280278	19.6	0.0280278,19.6
0.0308056	19.6	0.0308056,19.6
0.0335833	19.6	0.0335833,19.6
0.0366389	19.6	0.0366389,19.6
0.0391389	19.6	0.0391389,19.6
0.0416389	29.5	0.0416389,29.5
0.0444167	29.5	0.0444167,29.5
0.0471944	29.5	0.0471944,29.5
0.0499722	29.5	0.0499722,29.5
0.05275	19.5	0.05275,19.5
0.0555278	9.5	0.0555278,9.5
0.0583056	1.6	0.0583056,1.6
0.0610833	1.6	0.0610833,1.6
0.0641389	1.6	0.0641389,1.6
0.0669167	49.5	0.0669167,49.5
0.0694167	49.5	0.0694167,49.5



Excel format is also possible. If one wishes to include additional information, this will be part of the header – but the precise layout may differ depending on the version of Lucullus.

Exporting from the current run

Exporting data from the current run is almost identical to exporting data from a prior run. The only difference is that the data is already "loaded", so you can immediately proceed to export the desired signals. The procedure is as follows:

- 1. Navigate to File \rightarrow Export signals
- 2. Select the desired signal
- 3. Select the phases (select **all** if in doubt)
- 4. Select the mode for time intervals and interpolation options
- 5. Provide target folder and file name
- 6. Complete the export

Steps 2-6 here are identical to the steps 3-7 of the previous section.



3.8 SAVING GRAPHS

You can save an image of the trend of the currently running process or of a loaded data set; the procedure is the same in either case. For a running process, you can save a screen dump via the following menu selection:



Or the following menu selection:

୍ଦ୍ଧ <mark>Onl</mark> i	🐵 Online Tool - R01 2017 Week 50 005 - [Trend Graph]						
ැන- File	Grap	ohic (Operation	Form	at Table	Monitor/Console	Window Help
<u> </u>	8	New T Data/A Attribu	rend Graph Axes utes	•	€ ⊞		Image: Phases Image: Automatic
Group:	-	Defaul	t Data Set			R01	2017 Week 50 005
Start: 12-1	9	Comn	nents				
		Save G	y iraph				
	L	120-	120-	1	2.2 J		



🐵 Save Image As		×
$\leftarrow \rightarrow \cdot \cdot \uparrow$	≪ Lucullus → export v Č Search export	م
Organize 🔻 Ne	w folder	⊾ - ?
🛖 vmshare_fold	er i ^	
a OneDrive	R	
💻 This PC		
📃 Desktop		
🚆 Documents	test2img test2img-online	
👆 Downloads		
👌 Music		
Pictures		
📑 Videos		
🏪 Local Disk (C:) v	
File name:		~
Save as type:	Portable Network Graphics (*.png)	~
- see as type.		
∧ Hide Folders	Save	Cancel

Either of these will popup the same file save dialog:

Whereby the default is to save the image in PNG format. Here is the saved image is displayed using the IRFAN image viewer:





4 APPENDIX: BASIC CONCEPTS

Not only does Lucullus support an extensive set of functionalities, but it can also control broad installations with many different cell culturing systems and auxiliary systems, all running in tandem. These components can be clustered and linked in many different ways and this flexibility has given rise to clustering or grouping abstractions that allow Lucullus to accommodate many different configurations.

The following diagram gives an abstract representation of a system from the point of view of how it is configured during the initial configuration process. The terms to be defined are given in blue.



The above diagram shows data objects representing actual hardware in the real world, such as a *bioreactor*. Other data objects such as *subdevices* do not correspond to an actual piece of hardware but represent a cluster of other logically related data objects.



With the aid of the above diagram, the main concepts are summarized as follows:

Component	Description
Bioreactor	A data object representing a bioreactor. Does not embody any functionality, just the
	attributes (e.g. volume, name, etc.) of an actual bioreactor or similar device. Some
	real world examples are:
	Reactor L01 - Glass reactor L01
	Reactor M01 - Steel reactor M01
	Reactor MB01 - Microbiological reactor MB01
	Shaker A01 - Shaker A01
Device Type	Refers to the <i>category</i> of a device, not any instance of a device. It holds the general
	characteristics of attributes of a particular kind of device. Examples:
	Applikon EZ
	Applikon MyControl
	Braun GA
Device	Feed Control system
Device	ne designation for a particular device instance as a data object. The instance need
	system device implemented in software, such as an exponential ramp. Examples:
	Applikon EZ01
	Applikon EZ02
	Applikon EZ03
	Applikon MY01
	Applikon MY02
Hardware device	The designation for a particular device instance as a bardware device. This refers to
	the actual <i>thing</i> - a physical instrument with nuts and bolts and electronics. The driver
	used to control and read from that instrument is also defined here.
	A hardware device will be coupled to its device (instance). So if one wishes to couple
	a particular <i>ez</i> -Control physical device to instance <i>Applikon EZ02</i> , then one has to
	also name the new hardware device Applikon EZU2. The equality of the names is
	Hardware Device
Channel	A data object that defines the communication link between a hardware device and a
	higher level system, such as a SCADA system. One can consider this from the
	standpoint of defining a <i>channel</i> that opens a path to a source (and recipient) of data;
	it opens a path for input and/or output.
	During configuration, one defines a device and gives it a name and one then chooses
	a nardware device and gives it the same name. Using the same name creates a
	by defining a channel
	One can define the communication manually using the various Lucullus configuration
	screens, but it is more convenient to enter them into an Excel spreadsheet in a
	specific column format and then import the spreadsheet. An import is often done
	because there may be hundreds of channels and ports. Ports are defined next.
Port	A data object representing a single data entity (input or output). For instance, pH,
Subdevice	An abstract data object representing a cluster of ports. It is a useful organizing or
	grouping construct, as the following examples illustrate:



BASIC CONCEPTS

	Take for instance a reactor REACTOR01 which will be controlled by Device EZ_001. The subdevices of EZ_001 are:
	ACTUATOR LIMITS HL_acid HL_alkali HL_air LL_acid LL_alkali
	ACTUATOR OUTPUTS Output_acid Output_alkali Output_air Output_CO2
	BALANCES Balance_01 Balance_02
	CONTROL PARAMETERS ph_cycletime ph_deadzone ph_l ph_P
	and many more.
	As one can see, there is justification to clustering ports in the way shown above. ACTUATOR_LIMITS, for example, clusters the ports corresponding to the minimum and maximum values of the system actuator outputs in use.
F_code_device	The device driver software component for controlling and receiving input from Applikon controllers. This component will drive:
	<i>in</i> -Control <i>my</i> -Control <i>ez</i> -Control

