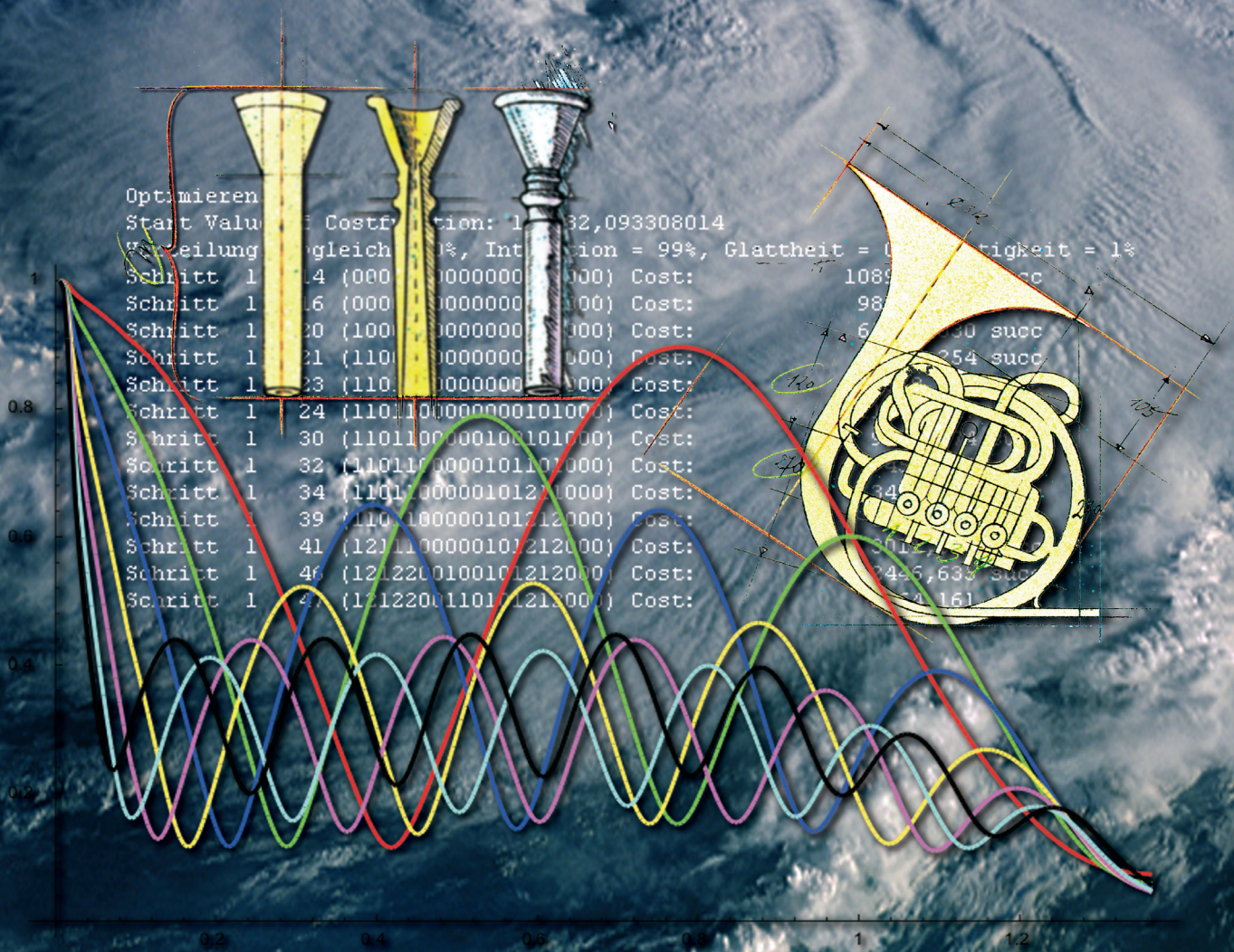


THE OPTIMISER

HANDBOOK Version 1.0



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Introduction

This computerized Optimiser for brass wind instruments offers a range of new possibilities and perspectives for instrument makers. The goal of this part of the handbook is to give the BIAS user an easily understandable introduction into the complex material at hand so that he or she can eventually use the optimiser efficiently.

To make the introduction easily understandable, a simplified perspective will be presented initially. Experience has shown that a basic knowledge of the optimiser principles helps greatly, prior to making the first real steps to optimise an specific instrument.

What can be optimised?

Intonation and response/playability can be optimised.

How do I optimise an instrument?

1. The geometry (bore construction) of the entire instrument (including the mouthpiece) is entered into the computer, or a new bore construction will be created by the optimiser.
2. The optimisation goals are defined by the user. For example, E⁵ should be 17 cents higher, the Ab⁴ should be 24 cents lower, C⁵ should speak more easily, etc.
3. The optimiser is informed which areas of the instrument may not be altered, like the valve section or in the last quarter of the bell section, for example.
4. The optimiser can be set for allowed alterations to the bore construction, which is limited by what is actually possible in practice. This is possible in absolute values, for example: maximum 0.6 mm expansion or contraction in the cylindrical section and maximum 4 mm at the bell, or even better, as relative values (maximum 10%, etc.)
5. The optimisation is started with a click on "Start". The user can observe the suggested changes to the intonation, response and to the bore construction while the process is in progress. The user may change the weighting of the parameters during the operation, which is often necessary.
6. The result is a new bore list with precise directions alterations for intonation and response.

How is it possible, and how does it work?

- Optimization is based on :
- two physical facts
 - a physical model, and
 - a powerful optimisation algorithm

Fact 1: the input impedance* contains all relevant characteristics of a wind instrument and within a linear system, there is a direct relationship** between the input impedance and the bore construction.

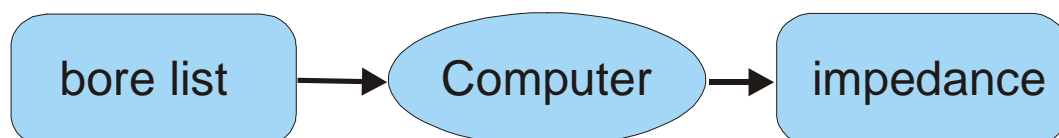
* *The input impedance over the frequency domain is a complex value and consists of the **real** and **imaginary** parts and the **phase**. With the BIAS software version 5.1, only the real part is displayed as an "impedance curve". The phase can be displayed in Version 6.0.*

** *This means that an unknown bore construction can be calculated from a known impedance and vice versa.*

Fact 2: If the diameter of the bore is reduced at the position of an air pressure antinode for a particular note, the pitch will become higher, and vice versa.

Physical Model: Because of the unequivocal relationship between the bore construction and the input impedance, the impedance (and therefore the intonation and playability) can be calculated from the bore construction***.

*** *we use the **Transmission-Line-Model** of Dan Mapes-Riordan, which is capable of accounting for viscosity and friction losses, as well as radiation losses at the bell.*



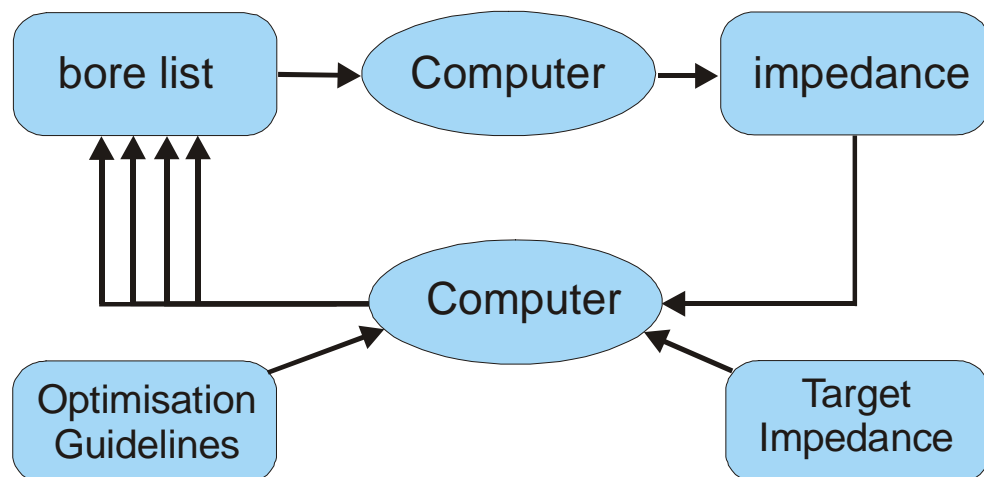
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Optimizer algorithm: The Rosebrock-Algorithm implemented by Dr Kausel functions by the following principles (the illustration is greatly simplified):

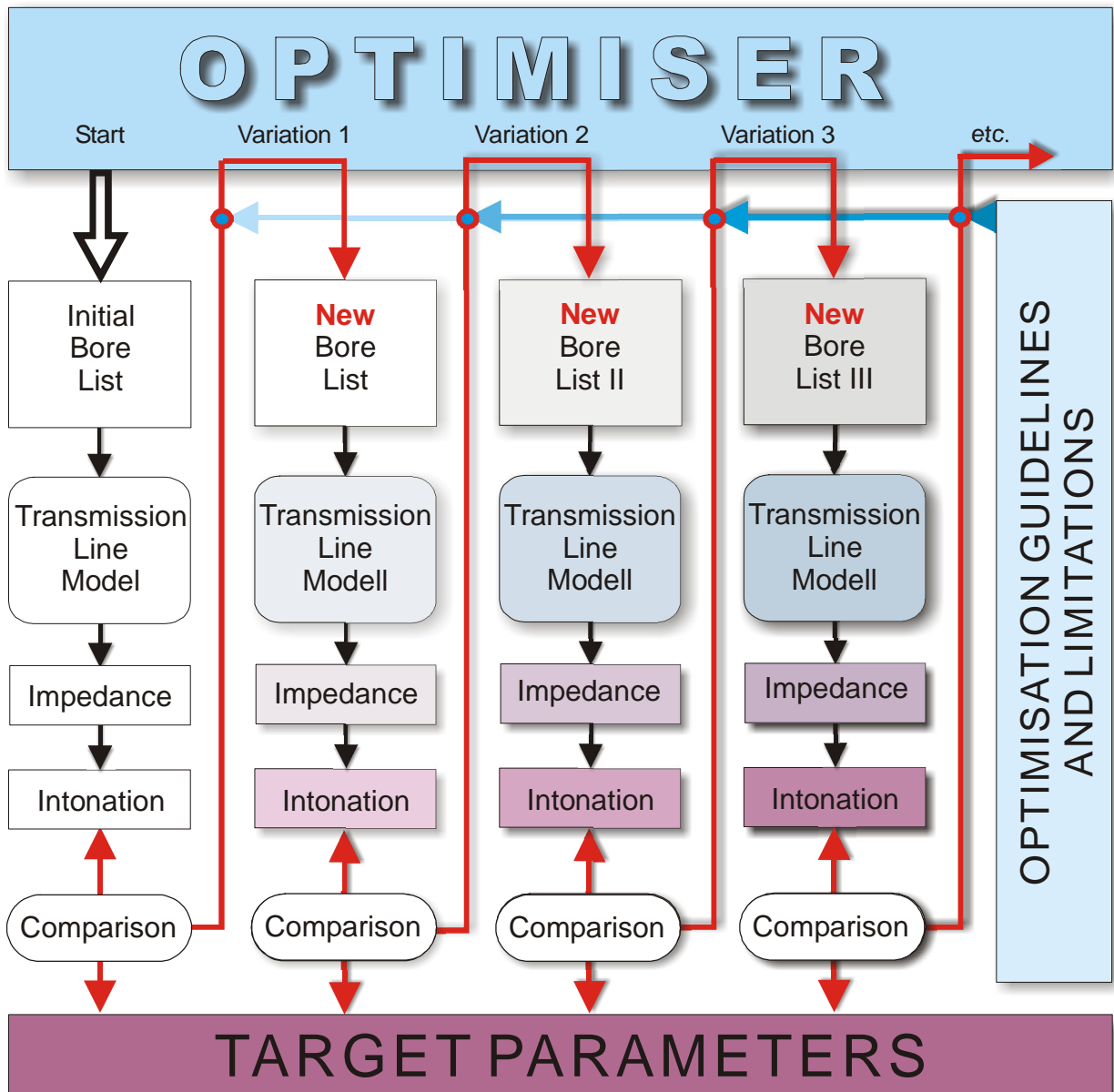
1) The impedance, and consequently the intonation, is calculated from the bore geometry and compared with the target impedance.

2) Following **fact 2** and the set of guidelines and limitations you defined, the optimiser modifies the bore construction and compares the new calculated impedance again with the target impedance.

3) If an improvement is made, the optimiser tries other modifications in the same direction. If the modification results are further from the target, the optimiser tries at another position in the bore, repeating steps 1) to 3).

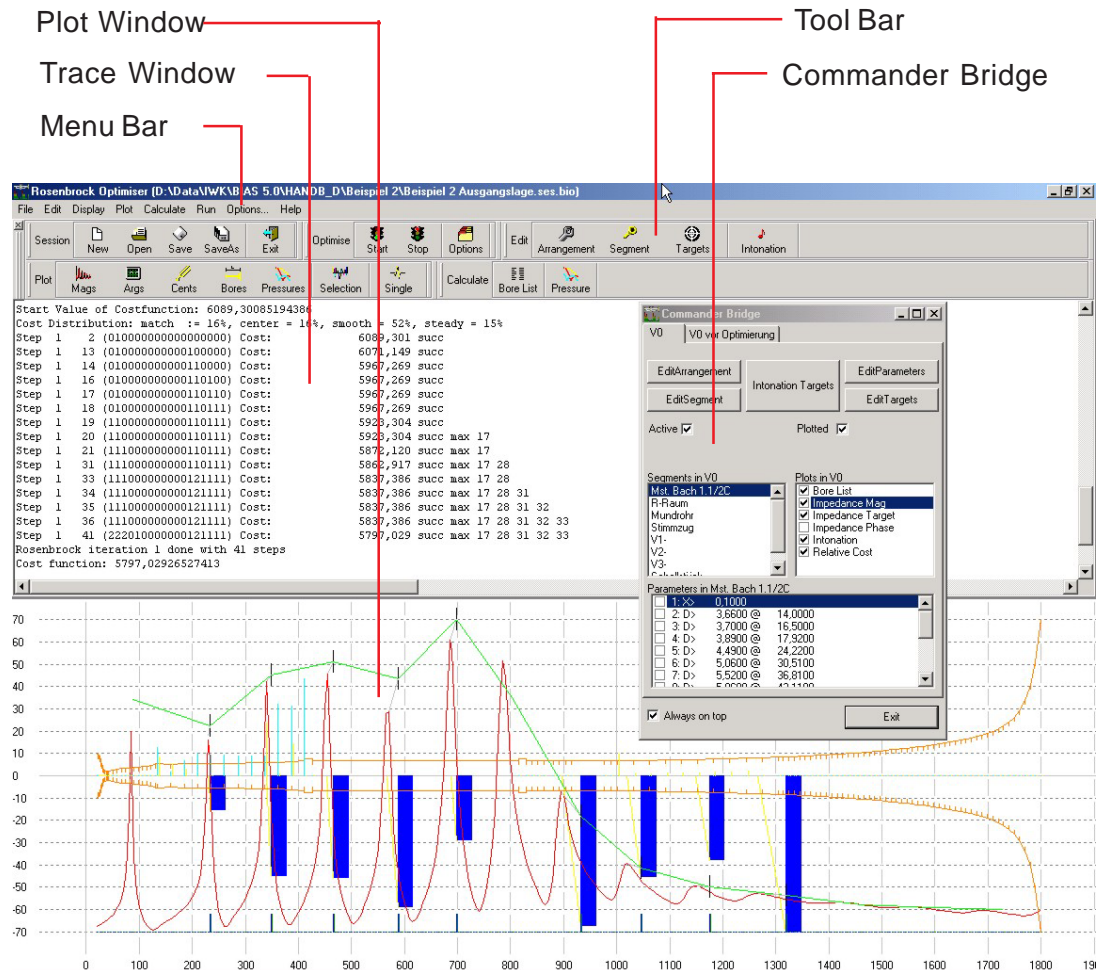


The process described in step 3) will be repeated hundreds or thousands of times. The illustration on the next page shows steps 1) to 3) in schematic form.



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How is the optimisation program constructed?



The **Menu Bar** contains the usual Windows commands.

By moving the mouse over the various command buttons, a help text will appear to identify it.

The **Tool Bar** contains five groups of commands that are most often used:

SESSION: Commands for opening, New Start, to Save and Close work sessions.

OPTIMISE: Commands to control the optimiser

EDIT: Commands for editing the segments and arrangements and targets

PLOT: Commands for controlling the data displays on the Plot Window

CALCULATE: Commands for starting specific calculations

The size of the Protocol Window relative to the Plot Window on the screen may be changed by „dragging“ the deviding line to the desired position.

The **Trace Window** lists all the activities of the optimiser in action. It shows, for example, which optimisation parameters have been reached or exceeded, the current weight distribution, the current cost function value, and lots more.

In the **Plot Window**, the display of the current data is visible. Display is constantly refreshed in order to observe the success of the optimisation in progress. Bore, Intonation, Impedance, Phase, Weight Distribution, Target Impedance, Pressure Node Distribution, etc. can be displayed.

The **Commander Bridge** contains all commands (context menu) and is the central working area of the optimiser. The standard setting is that the commander is always on top while optimising, which can be changed by checking or unchecking the appropriate box.

Saving Options- What can be stored?

Single "Segments"

For example, the bore data from a mouthpiece, leadpipe, bell, valve, etc. The suffix "**seg.bio**" (valve.seg.bio, for example) will be added to the assigned filename. The files can be read in normal text editor programs. Segments may also be saved as text (txt.) documents, which can be imported by CAD programs.

An "Arrangement"

An Arrangement consists of several Segments. the suffix "**arr.bio**" is added to the filename (MyTrumpet.arr.bio, for example). These data are also readable in a text editor.

A "Session"

All used Segments, Arrangements, optimiser settings and optimiser results will be saved. The filename receives the suffix "**ses.bio**", as in "MyTrumpet.ses.bio".

It's a good idea to save intermediate stages of the optimisation to go back to, in case the user-defined parameters start to deliver unsatisfactory results or progress.

2

The Instrument in the Computer

What is a bore list?

The bore list describes the progress of the diameter throughout the instrument by means of coordinate pairs (x_n, d_n) .

- x_n = the distance from the edge of the mouthpiece (or the beginning of the measured section) in mm, cm, or meters.
- d_n = the inner diameter in mm, cm or meters.

How is the bore list derived?

Either the bore list can be taken from a CAD program, if possible, or the instrument must be measured as accurately as possible by hand.

The values can then be:

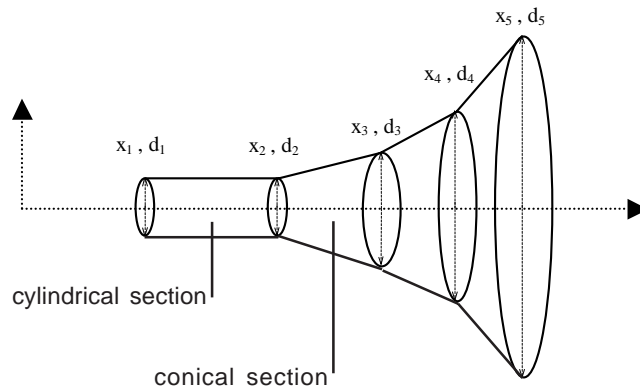
- directly entered into the optimizer
- entered into a Microsoft Excel table (x-values 1st column, diameter values in the 2nd column)
- or entered into Windows Notepad (x-values and diameter values separated by the tab key or a "space")

Measure by hand

To acquire a bore list, the instrument is theoretically divided into a series of cylinders and conical sections, whose measurements should be as close to the actual instrument's as possible. In areas where the diameter changes strongly in a non-linear way, many intermediate values are required (short sections), in order to minimize errors. Cylindrical and conical pipes can be described by just 2 coordinate pairs

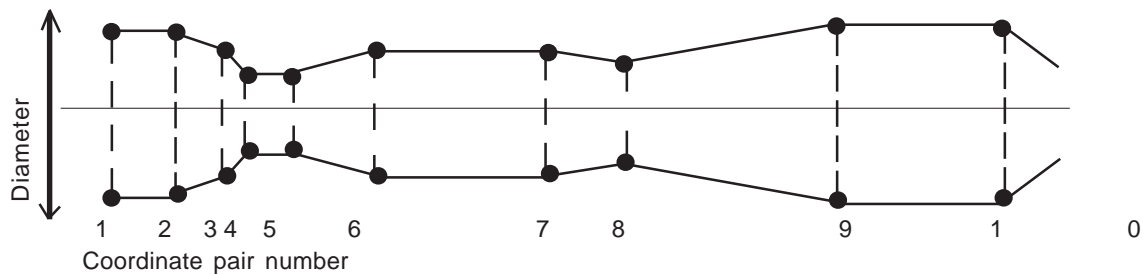
Two simplifications are applied to the description of the bore in list form:

- the geometry of a non-linear bore section (the bell or the mouthpiece cup) can be simulated by sufficiently short conical sections.
- it is assumed that the diameter is constantly circular (also at the curves near the slides). Each section is described by 2 coordinate pairs (x_1, d_1) and (x_2, d_2) .



x_1 = distance to the edge of the mouthpiece in mm
 d_1 = diameter of this section in mm

For example:



The bore list for the above simplified mouthpiece and leadpipe section may look like this:

Coordinate pair:

x_1 d_1

1	0	20
2	10	20
3	18	14
4	21	10,78
5	29	10,78
6	49,3	13,6
7	78	13,6
8	86,435	12,1
9	91,2	20,67
10	111,4	20,67

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While cylindrical and conical sections may be described as 2 coordinate pairs,

x **d (both in mm)**

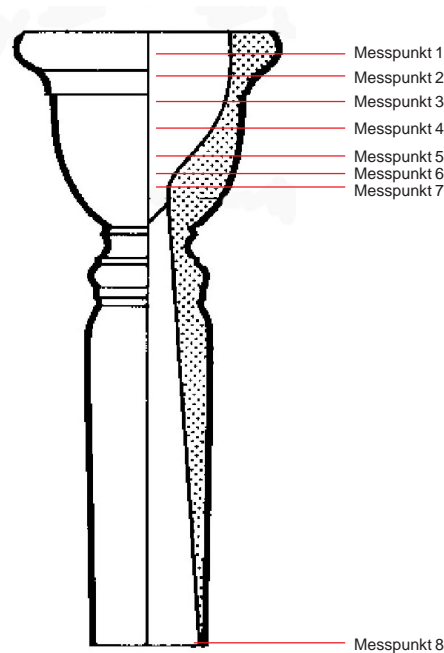
0 15
1000 15



0 15
1000 20



non-linear sections, like the bell and the mouthpiece cup, must be described in sufficiently short sections to provide sufficiently similar values. See the following example:



To measure a mouthpiece is about the most difficult task possible. Many mouthpiece manufacturers use computer-guided production. Ask if the mouthpiece supplier can provide you with a bore list for the inner diameter.

If this is not possible, the illustration at left shows that the distance between the measuring points in an area of curvature must be shorter. The backbore on the other hand (between Points 7 & 8) requires only two coordinate pairs, since it is conical.

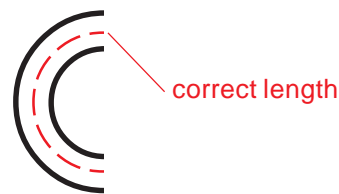
IMPORTANT: While playing, the lips of the musician protrude into the mouthpiece cup and decrease the volume. The entire intonation will be consequently several cents higher! This phenomena is accounted for by setting the beginning of the bore list for trumpets and horns approx. 2 mm further toward the bell, and trombone and tuba bore lists 4-5 mm nearer to the bell.

Practical Tips for measuring

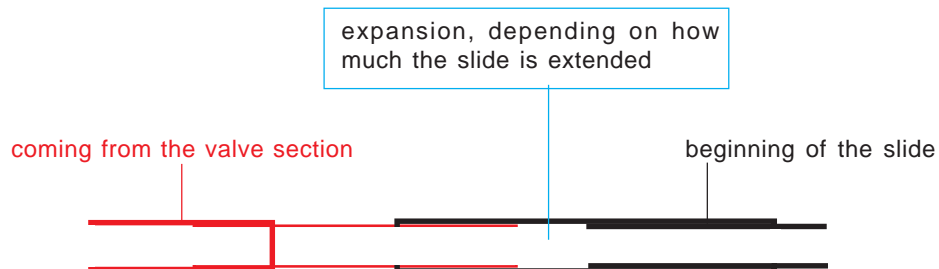
1. Only the inner diameter is relevant! Because this is difficult to acquire from a finished instrument (except for the cylindrical sections), it is recommended to measure the thickness of the pipe wall at an appropriate position, and then to measure the instrument from the outside with a sliding guage. Remember the sleeves at vulnerable positions.

2. It is advised to use the traditional instrument maker's method of measuring the pipe length with a string, to find the distances (x-values), and to mark these on the instrument.

3. Remember to measure the length of curved sections relative to the center point of the diameter.



4. Caution at the valve slides: since the playing position is most often somewhat open ("pulled out"), take the additional increased cross section into account.



It is, however, recommended to treat the slides as an independent part ("segment"). Then the problem of a varying length of an expanded diameter can be avoided by using the "**Offset**" function of the **Segment Editor** (see the chapter)

5. The applied physical model assumes that the cross section of the pipe is always circular. If at some point the pipe is not circular, on account of damage or imprecise production, the average should be calculated.

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Recommended division of the valve section into independent parts (=segments):

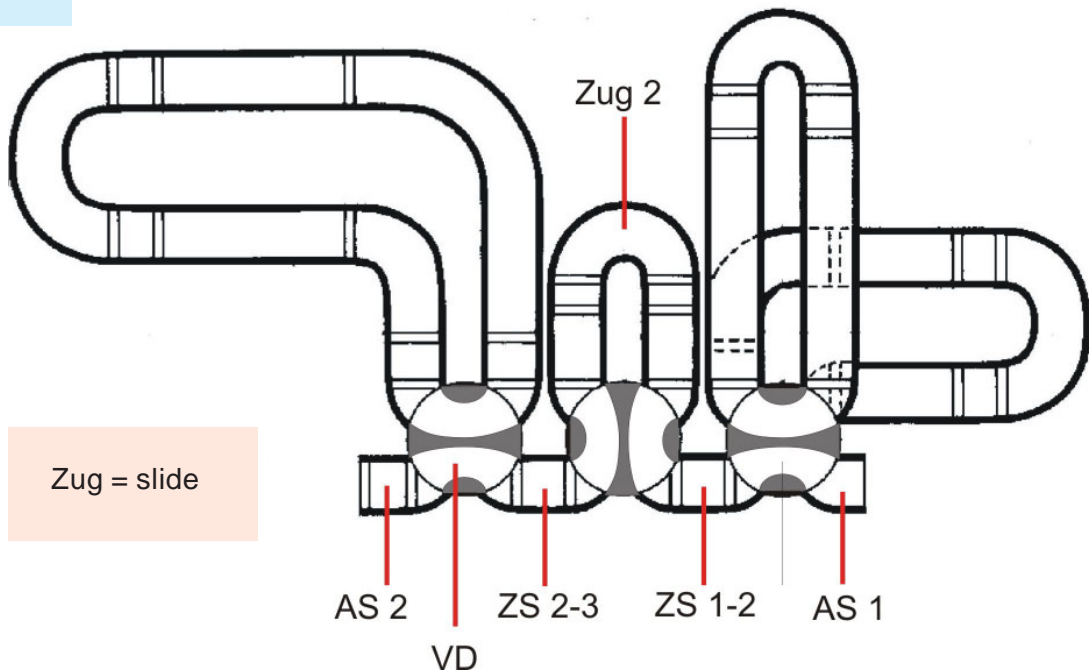
The valve section consists of many "segments".

The sound path for the various valve combinations is assembled by combining the relevant segments.

By means of dividing the valve section into separate segments, the sound path for all possible valve combinations can be simply combined with the **Arrangement Editor**.

In the example below, valve No. 2 is depressed. The complete segment list for this combination (for the valve section) would be:

... + AS2 + VD + ZS 2-3 + VD + Zug 2 + VD ZS 1-2 + VD + AS 1 + ...



AS = connecting piece
ZS = intermediate piece *
VD = valve path

* If the intermediate section pieces are identical, only one type is required, being present then between each of the valves.

How to convert an **Arrangement** consisting of many Segments into a **single Segment**.

Representation of the eight valve combinations by 8 single **Segments**.

If you are using one model of valve section for many different instruments, and you often optimise instruments, it's a good idea to take the time to combine the various parts of the valve section into one Segment, for each valve combination.

Then you will have segments numbered for example: V0, V1, V2, V23, etc., whereas the segment "**V0**" represents the entire valve section with no valves engaged, the segment "**V1**" is the same section with Valve 1 engaged, etc.

Using the example of rotary valves on the previous page, the description of the "**segments**" would then look like this:

V0 = AS1 + VD + ZS 1-2 + VD + ZS 2-3 + VD + AS2

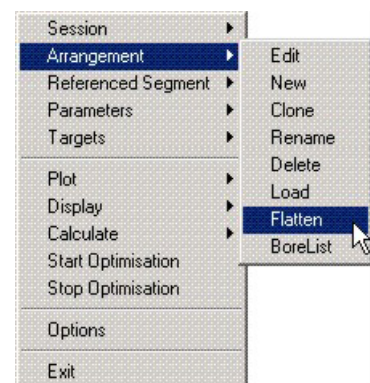
V1 = AS1 + VD + Zug1 + VD + ZS 1-2 + VD + ZS 2-3 + VD + AS2

V23 = AS1 VD + ZS 1-2 + VD + Zug2 + VD + ZS 2-3 + VD + Zug3 + VD + AS2

If the different valve combinations are correctly described as single Segment, the eight combinations then require only a simple click on the appropriate "Segment", V13, for example. This not only saves entering the order of bore sections new for each valve combination, but also eliminates potential errors in the assignment of bore sections to valve combinations. The eight possible combinations (=Arrangements) are distinguished then only through the single Segments **V**(xxx).

You may either decide while measuring the instrument between one of the two available methods, or you create the above mentioned new "**Segments**" afterwards from the separated (individual)parts named on the previous page. Do it in this way:

1. Start a new (Help) Work Session with the name "Valves", for example.
2. Load all separated parts (Segments) of the valve section.
3. Create a new arrangement with the name "**V0**", using the context menu "**New Arrangement**" and select the corresponding Segments mentioned above.
4. Create a "flat bore list" from this Arrangement by using the context menu **Arrangement -> Flatten**
5. In the left protocol window of the Commander Bridge you will find now a new segment with the name. "Flat copy(1) of . . . "
6. With a click on the "**EditSegment**" button of the Commander Bridge you can verify that you have created a new segment.
7. With a click on the "**Save to file**" button of the Segment Editor you can save it with the name "**V0**" Use the same process for the other valve combinations.



Now you have converted an "**Arrangement**" into a "**Segment**". If you start a new WorkSession, you only have to select a single Segment for the entire valve section instead of combining many Segments

1 Instrument = 8 Instruments!

Engaging a valve results in an additional, cylindrical section being added to the sound path, which makes the instrument longer and consequently deeper in frequency. Instruments with three valves must therefore be considered as **eight individual** "natural" instruments, with eight different bore lists and eight different impedance curves.

Certain parts of the instrument, like the mouthpiece, leadpipe, some slides and the bell, remain constant for every combination, while others change according to which valve combination is engaged.

This is a problem for the optimisation, since large portions of the bore cannot be altered independent on one another because they are assigned to more than one valve combination.

The mouthpiece, leadpipe, some slides and the bell **may** exist only once since they influence the impedance curves of all valve combinations. If the optimiser alters the lead pipe, then the impedance for each valve combination will also be altered. But the alteration of a valve slide will only affect the intonation and playability of notes played by engaging **this very** valve or valves.

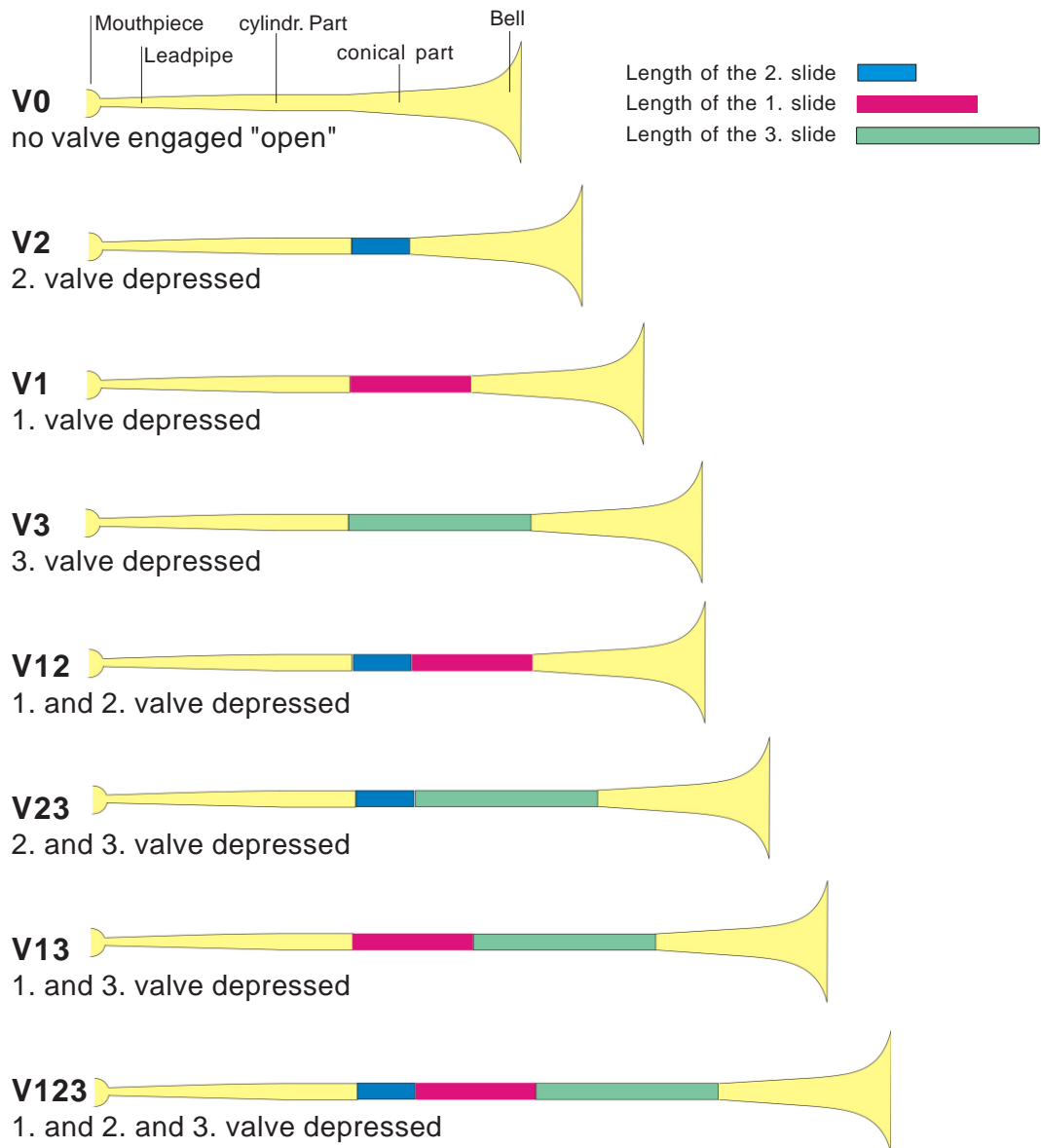
The solution to this problem is solved by a hierarchical representation:

The instrument is divided into parts, which most often the components that an instrument maker joins to complete the finished instrument. Each of these parts, the so-called **Segments**, is described by an independent coordinate list, which can be read, entered and altered in the **Segment Editor**.

A list of possible Segments which may be measured separately may look like this:

- Mouthpiece
- Leadpipe
- Valve 1
- Slide 1. . . .
- Tuning Slide
- Bell Section, etc.

The **Segment Editor** contains all of the components in a list. The user may then add the various valve combinations in desired combinations with a simple mouse click.



For the optimizer, a "real" instrument most often consists of 8 **Arrangements** (V0 bis V123) which represents the eight most often used valve combinations.

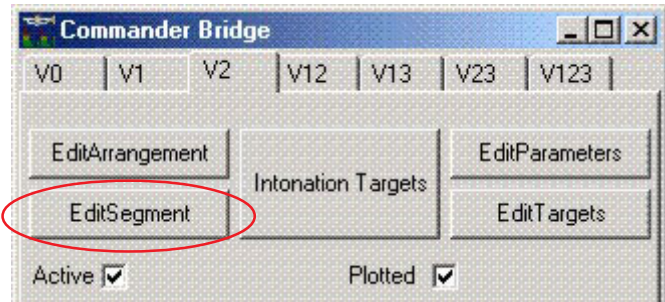
An **Arrangement** consists of several single **Segments** that may be added and configured in any desired order.

4

Create a new Segment

1a. If you start a completely new Work Session with no previous Segments:

Click on the button **EditSegment** on the **Commander Bridge**.

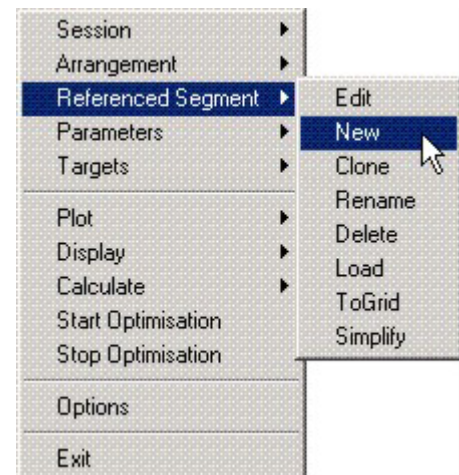


or

1b. Add new Segments (if Segments are already present in the current session):

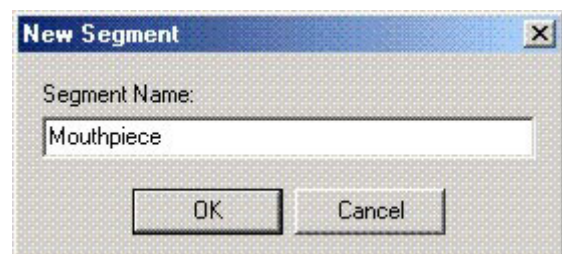
With a click of the **right mouse button** anywhere within the Command Bridge, use the context menu command:

Referenced Segment -> New



2. The name of the Segment is entered and saved with click on **"OK"**.

The **Segment Editor** appears, and values may be entered or can be imported from a file.



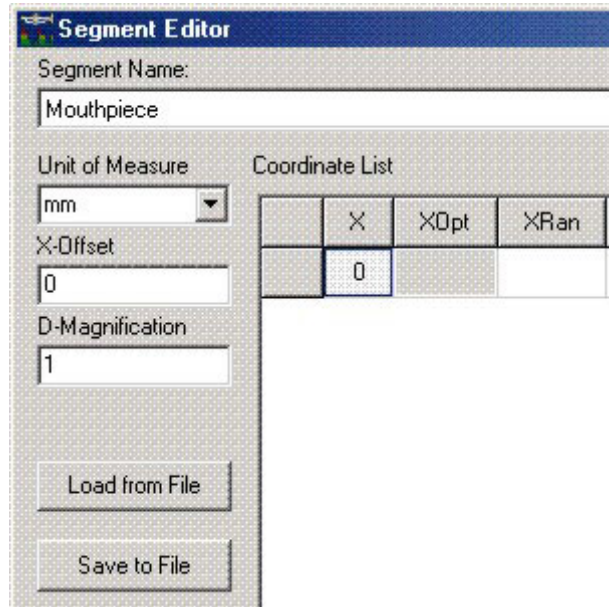
Importing Data - Option 1: Load a Segment

To import a bore list, click on the "**Load from File**" button of the Segment Editor and select a file.

Because the Microsoft Window for loading is universal, all formats are displayed. In this case, however, only text formats and borelists are possible:

(All Files)

To import data, all formats in the active folder are shown. there's no guarantee that loaded formats can be read properly by the optimiser!



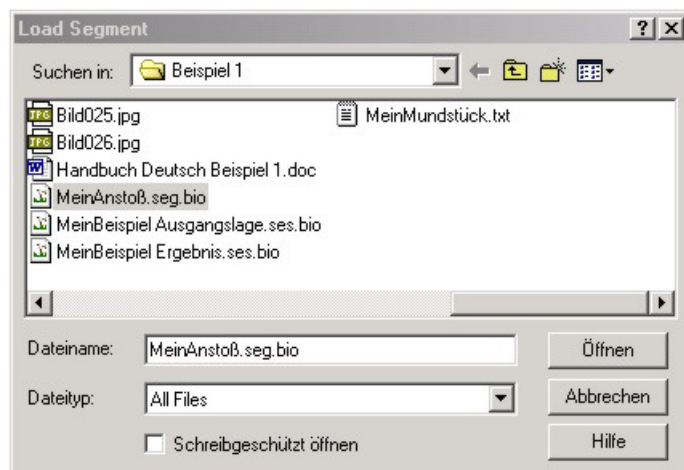
Text Files

Data with the suffix ".txt" are edited in Windows Notepad or other text editors. The X-values must be separated from the D- values by several spaces or with tab stops.

(Data Files)

BIOS Segment Files

Data files with the suffix ".seg.bio" contain the bore list as a text file, and also all optimisation parameters assigned to this Segment, such as subsegments of the Segment which are alterable or not, the allowed range of optimisation steps, the defined limits, etc.



(All BIOS Files)

Bore list data can be imported from simple **text files** with the suffix ".txt" or from **Segment files** created with the Optimiser (saved segment data) with the suffix ".seg.bio".

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Importing Data - Option 2: Copy Data from a File and Paste

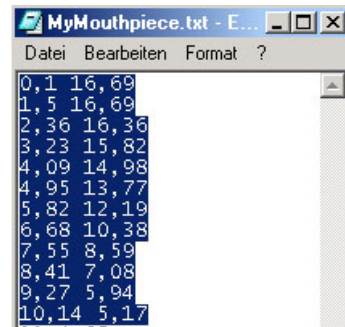
1. Open the file in which you saved the bore data (such as "MyMouthpiece.txt" for example).



Leave the optimiser Segment Editor open, while using the **Windows Start Menu** to open the text editor program.

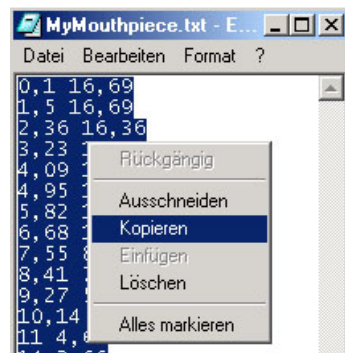
2: Mark all data

- either with **Cntr. + A**
- or by pulling the mouse



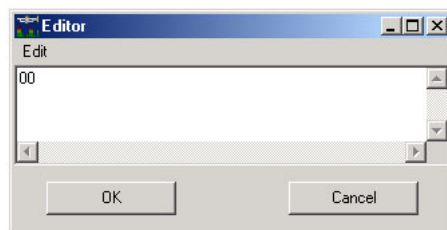
3. Copy the data

- by using **Cntr. + C**
- or by using the context menu (right mouse button) and click on **Copy**



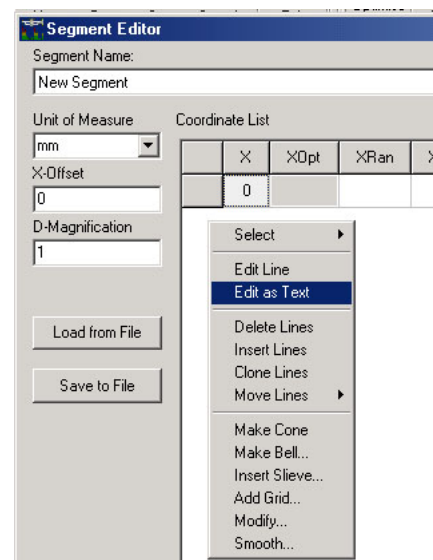
4. Change back to the optimiser with **Alt + Tab** and click somewhere within the Segment Editor and using the command "**Edit as Text**".

This window appears:



5. **Mark** both zeros and use **Cntr. + V** or "**Paste**" to add the desired data.

6. A click on "**OK**" will save the changes.



5

Example 1: A Natural Trumpet

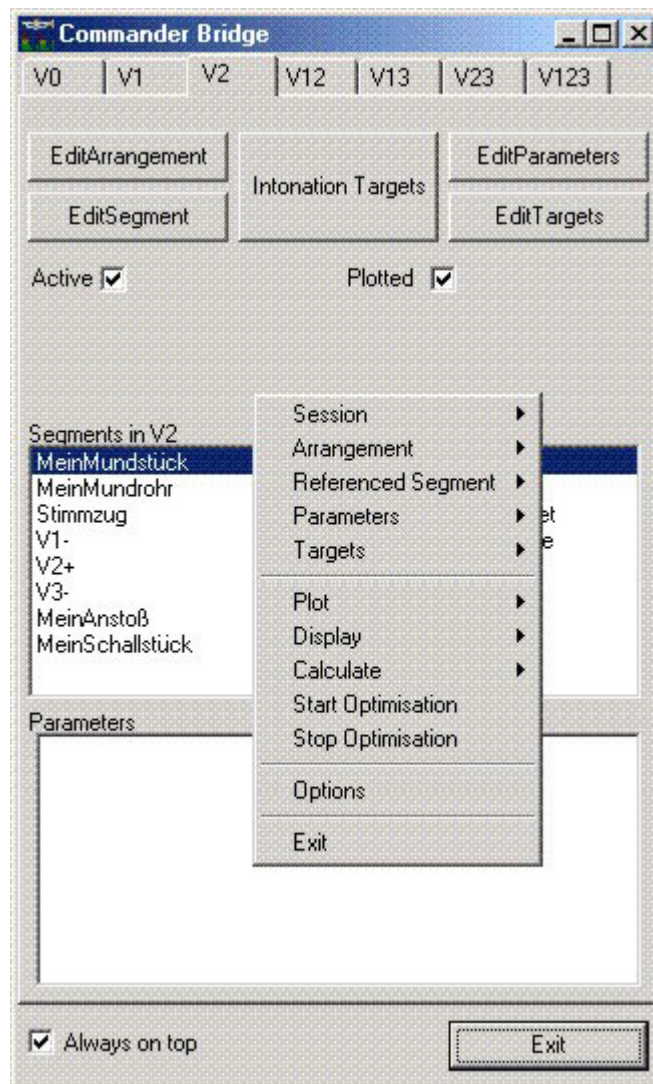
This example shows how a new natural trumpet can be designed and optimized, without measuring an existing instrument.

The **context menu** is called up with a click on the **right mouse button**, where the available commands are ordered in groups.

▶ Start the optimizer with the Windows Start Menu.

The **Commander Bridge** shows an overview of the current session, and the **Context menu** shows all of the available functions.

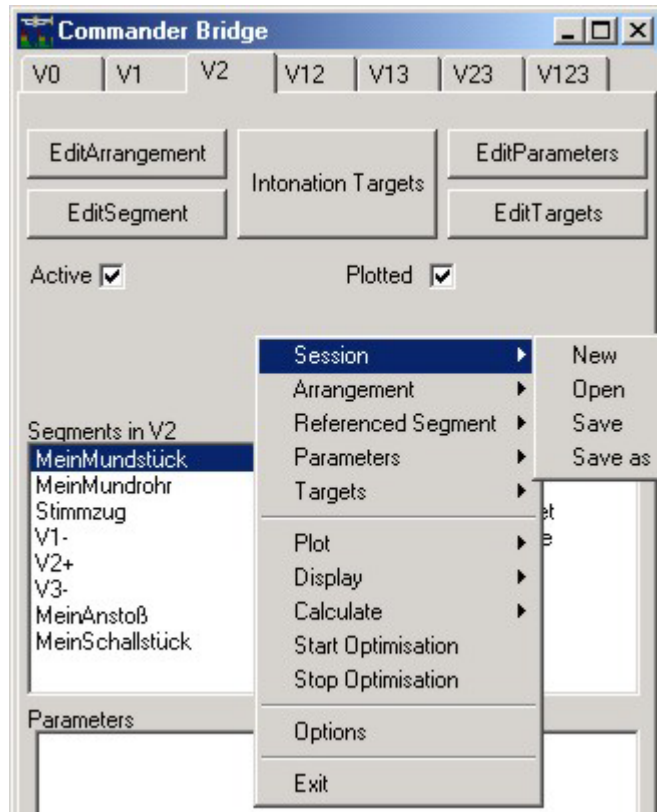
If the Commander Bridge does not appear, it can be brought to foreground with the command of the main menu bar **Edit > Commander** or with the **function key F8**.



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The first group, "**Session**", (at right) contains all commands for saving and recalling **session data**.

The data includes not only segment bore lists, arrangements and optimisation targets and **guide lines**, but also the program settings made during the session.



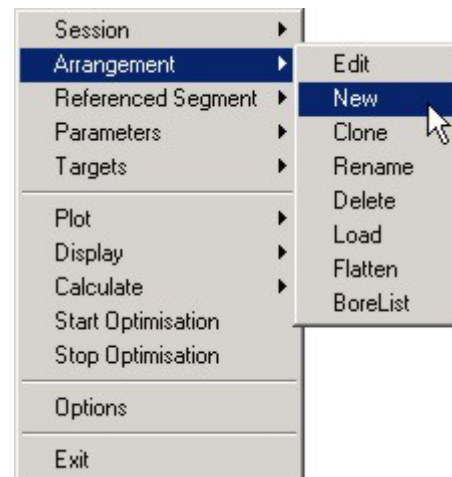
An instrument with three valves is normally defined with the valve combinations V0, V1, V2, V3, V12, V23, V13, V123, for example.

In the case of a natural trumpet, these combinations are obviously unnecessary.

The second group "**Arrangements**" contains all commands pertaining to creating, editing, deleting and manipulating segment arrangements.

An **Arrangement** determines the order of segments that are active during the engagement of valve combinations.

It is furthermore possible to optimise, edit and manipulate many different arrangements during a single session simultaneously.



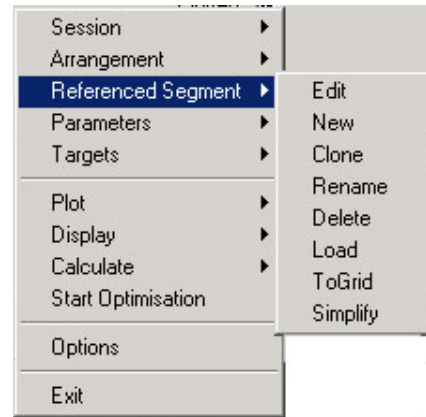
In brief, every arrangement has one impedance curve, which also has its own set of natural tones and intonation values.

Various arrangements may use exactly the same segments, which will influence more than one set of natural tones. The mouthpiece, tuning slide, bell section, etc. affect all valve combinations, but the first valve slide will only affect V1, V12, V13, V123.

The third group of commands is concerned with specification, editing and manipulation of physical **Segments** that are present in an arrangement.

These are listed in the Commander Bridge and can be marked.

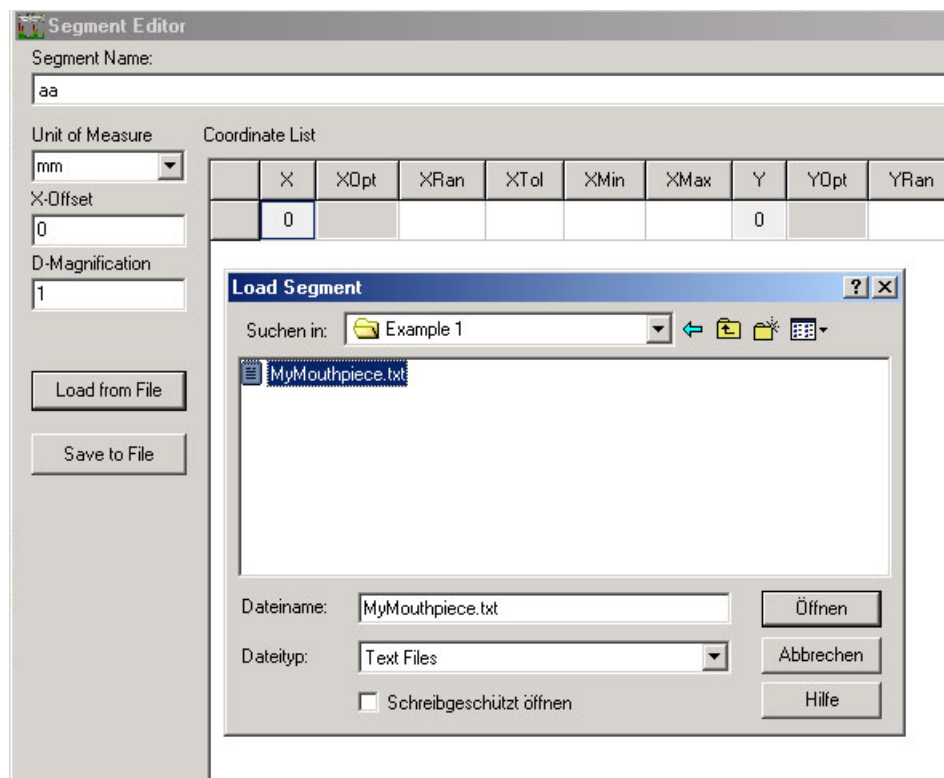
Segments which are not used in Arrangements are available in the Segment Editor and in the segment pool of the Arrangement Editor, where they may also be marked.



Create a New Segment

Option 1: Import Data from Another File

- ▶ Start the Segment Editor by clicking **EditSegment** on the top part of the Commander. Choose a name for the segment, "MyMouthpiece" for example.
- ▶ Click on the button "**Load from File**", and go to the appropriate file folder. You may read simple text files or BIOS files into the program.
- ▶ Double click the file ("MyMouthpiece.txt" or "MyMouthpiece.seg.bio" in our example), and answer "**Yes**" when prompted to overwrite the segment.



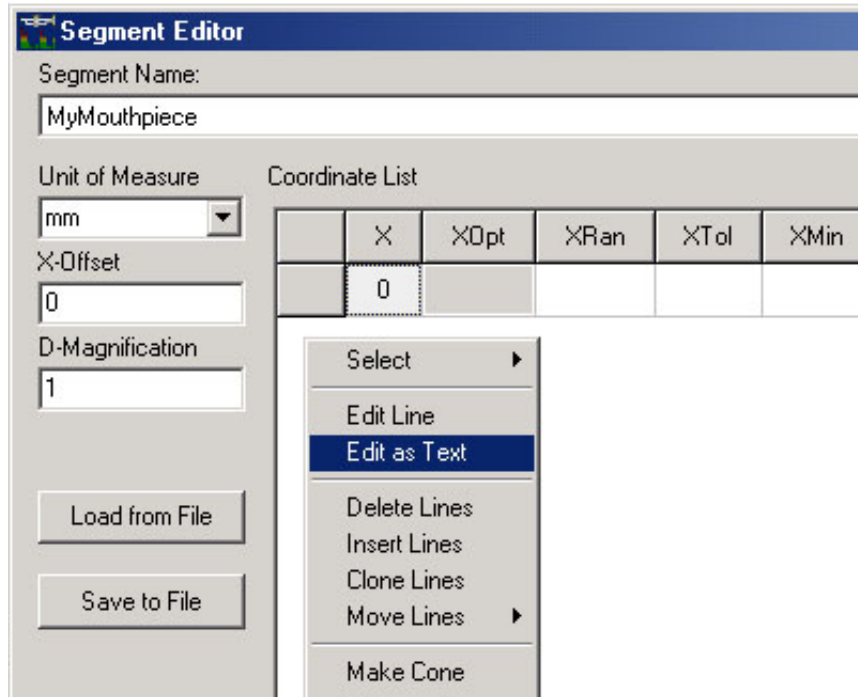
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Create a New Segment

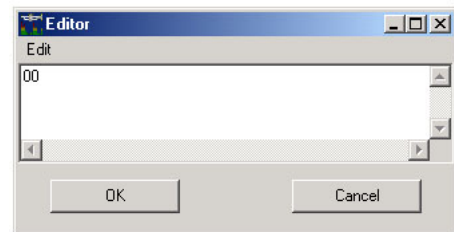
Option 2:

Copy Data from Another File and Paste

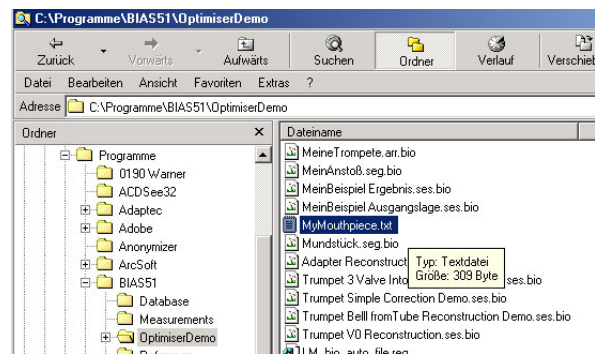
- ▶ Create a new Segment, and name it.
- ▶ Select "**Edit as Text**" by clicking the right mouse button within the coordinate list.



- ▶ This pictured window will appear: Leave it as it is and start the "**Windows Explorer**".



- ▶ Goto the file folder "OptimiserDemo" and doubleclick on the file "MyMouthpiece.txt". The file is opened in the **Windows Text Editor**.

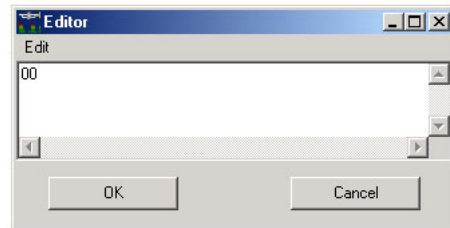


- ▶ Mark the entire text by pressing **Ctrl. + A** or with the context menu command "**mark all**", and enter "**Ctrl. + C**" to copy the data into the clipboard, or use the context command "**Copy**".

- ▶ Change to the open **Segment Editor** of the optimiser by using **"Alt+Tab"** or by activating the Segment Editor with a click into the icon in the task bar.

- ▶ Delete both zeros in the line and paste the data from the clipboard by using **Ctrl. + V** or the context menu command **"Paste"**.

Store the changes and close the window with a click on "OK".



Create a Segment without an Existing Borelist!

Create a New Segment

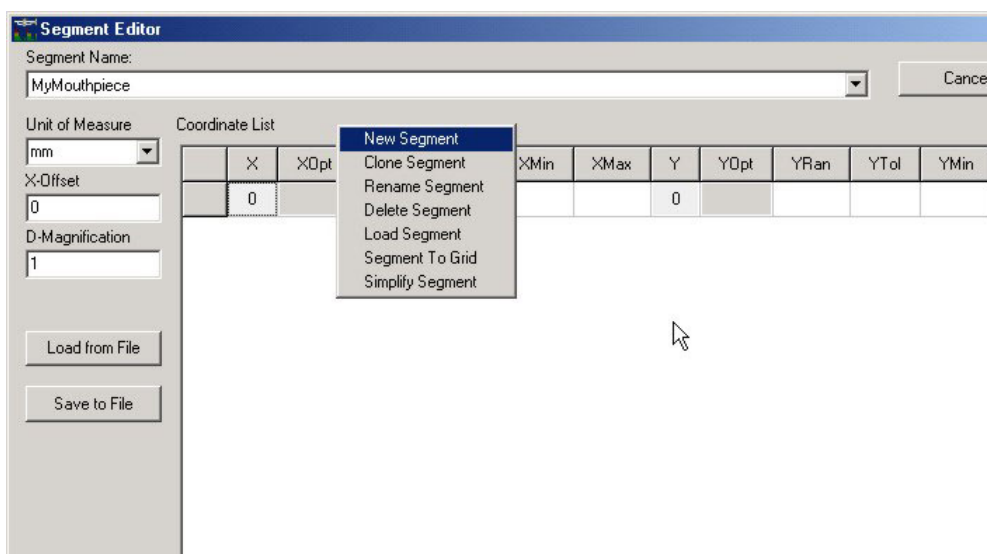
Option 3:

Create directly in the Segment Editor

- ▶ To get the context menu of the open Segment Editor click with the right mouse button and select **"New Segment"**.

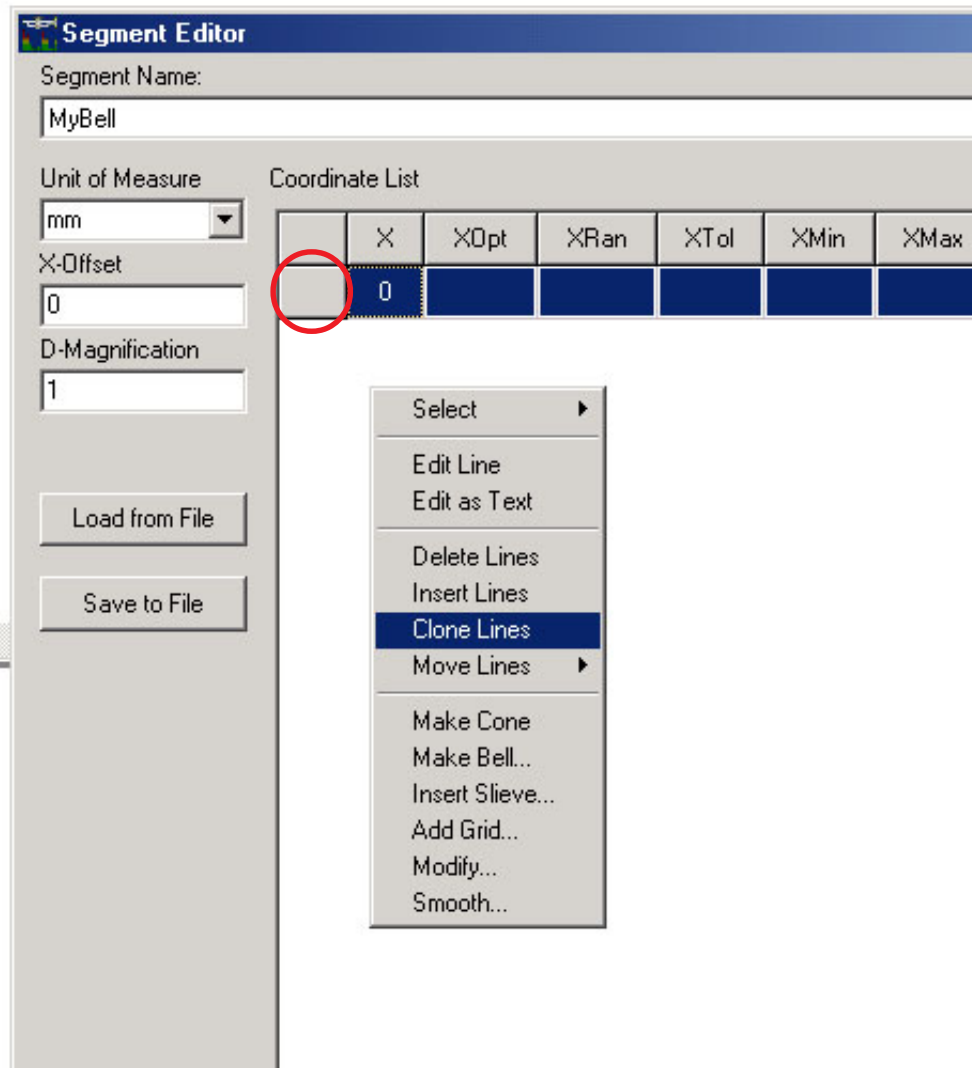
Please ensure that you are clicking on the upper part of the Editor, and not on the coordinate list, which results in the wrong context menu being shown.

- ▶ Give the segment a new name for example "Mybell".



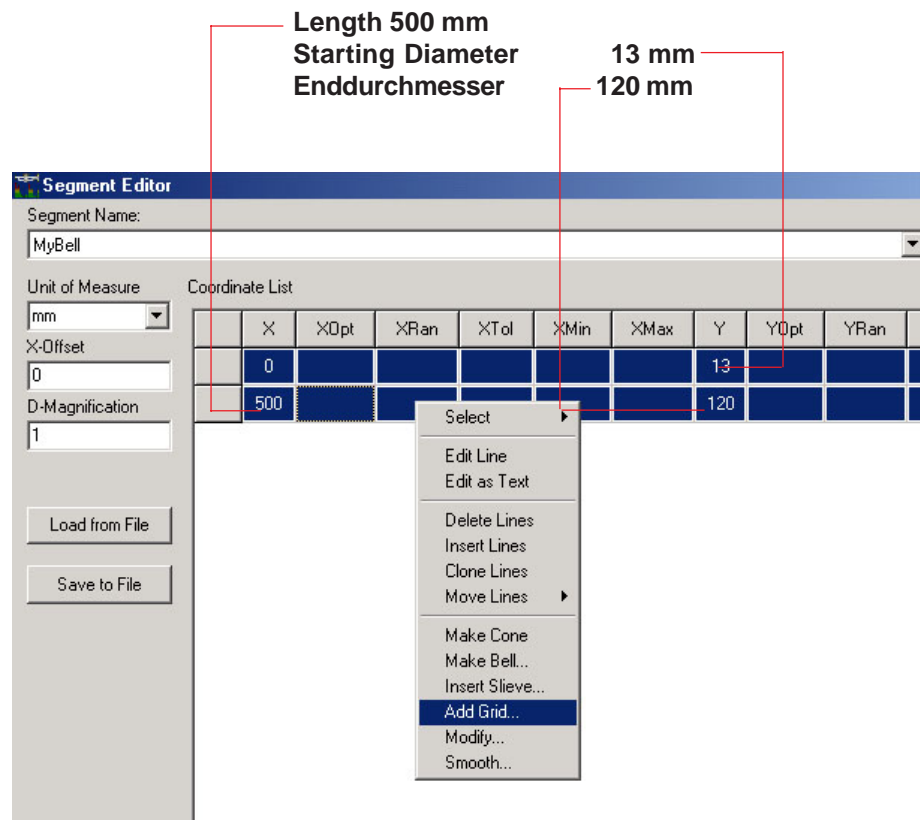
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- ▶ Mark the single coordinate line in the new segment and click on the gray field left in order to create a new line, and use the context menu "**Clone Lines**".



Create a Conical Pipe

▶ Change the coordinate values to create a segment with the following sizes:

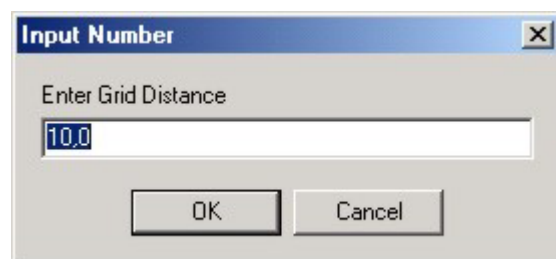


How to Add a Grid

Now mark both lines (hold the **Shift** key and click on both of the grey fields at the left of the lines), to create support positions (a grid) with a spacing of 10 mm .

▶ To create a grid, use the **Context Menu** command "**Add Grid**".

▶ Here, you may add the value for the distance between support points (in mm). For our example, we will accept the suggested value of 10 mm. Simply click "**OK**".

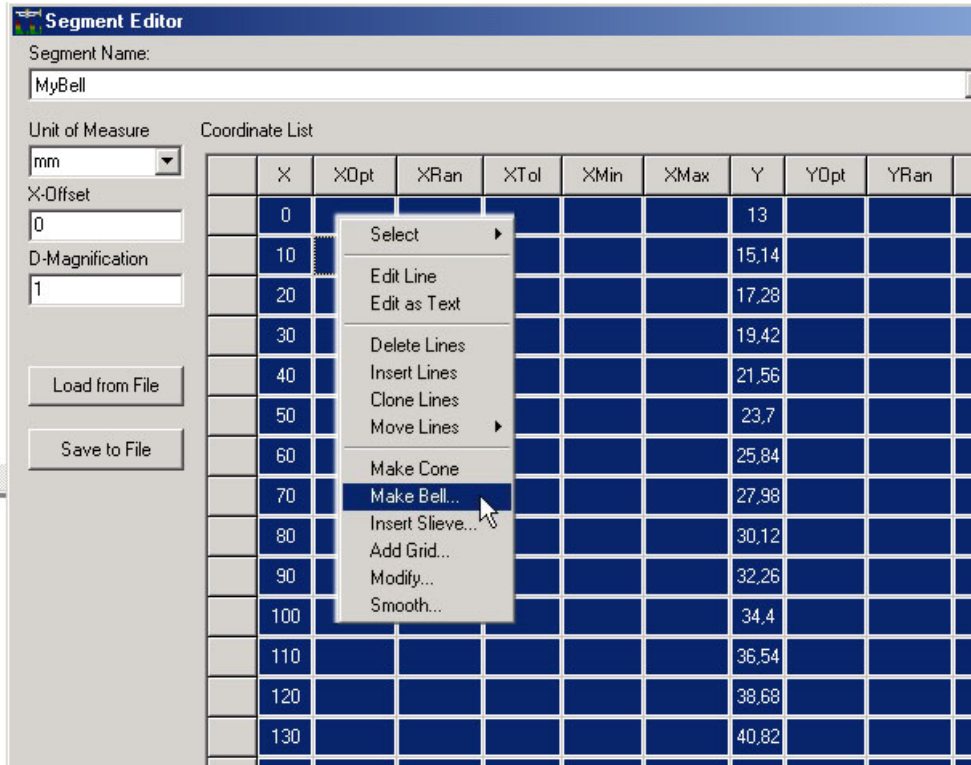


Now the segment is represented not only by its length, starting diameter and an ending diameter, but also by 48 support or reference positions (coordinate pairs).

Create a Bell from a Conical Tube

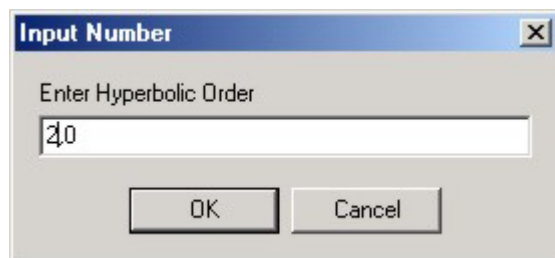
Now, the created cone may then be further edited.

- ▶ Mark the newly created lines by clicking the gray field at the left upper corner, then select the context menu command **Make Bell**.



- ▶ Select the hyperbolic order of "2".

Thus a new bell, typical of a Bb trumpet, is created.



Examples of hyperboles with other orders (0.5, 1, 1.5, 2, 2.5) are shown in the chapter "Editing and Shaping Tools" page 74/75.

Create a new segment with the name "MyLeadpipe".

- ▶ Define it as a 300 mm long cone with a starting diameter of 8.5 mm and 13 mm end diameter, as the previous example. (A reminder: clone the first empty line, then add the values in the "X" and "Y" fields).

Now mark both lines to create support positions with a grid spacing of 20 mm, and the segment is completed.

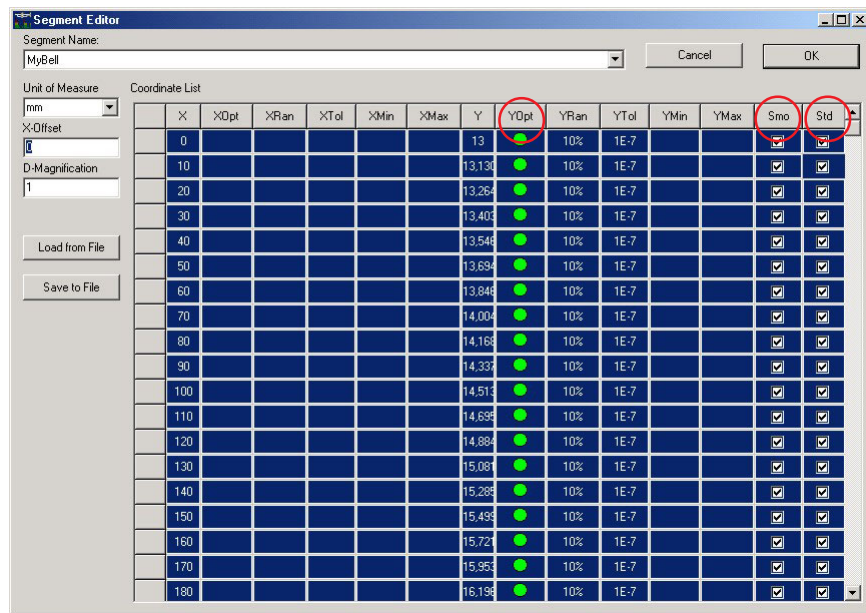
Defining optimisation parameters

Now the **Optimization parameters** will be defined.

Setting the Diameter to "Free" for Optimisation

The optimiser may change now the diameter value of each supporting point up to 10 %

- ▶ Mark all lines and click on the table column header "**YOpt**". Here, all bore values for the leadpipe will be made into optimization parameters within a dynamic variation range of "**10%**", where the smallest step will be "**1E-7mm**" and without "**hard limits**" (default values).



- ▶ Mark the entire region as "**smooth**" and "**constant**" by clicking on the appropriate table column header (see illustration).

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- ▶ Finally create a fourth segment with the name "MyPipe", and define it as a 480 mm long cylindrical pipe with a diameter of 13 mm.

Unit of Measure	Coordinate List	X	XOpt	XDyn	XTol	XMin	XMax	Y	YOpt	YDyn	YMin	YMax	Smo	Std
mm	X-Offset	0						13					<input type="checkbox"/>	<input type="checkbox"/>
	D-Magnification	480						13					<input type="checkbox"/>	<input type="checkbox"/>

We leave the length of this segment "Free" to enable the program in a relatively uncomplicated way to adjust the entire intonation.

The lengths of the segment becomes a "parameter" which can be modified by the optimiser

- ▶ To set the length to Free, click in the column "**XOpt**" directly next to the last x-coordinate (=line) with the value of 480 (the red circle in the figure below). A green spot will appear and further parameters will become visible.
- ▶ Set the value "**XDyn**" to **5** (simply enter "5" in the field, the unit is in mm) and enter a hard limit in "**XMin**" of **460**, and the upper limit "**XMax**" at **500** (figure below).

The optimiser may then choose a value between 460 mm and 500 mm for the length of the entire Segment.

With this segment we will not only give the length but also the bore free to be

Mabeinheit	Koordinatenliste	X	XOpt	XDyn	XTol	XMin	XMax	Y	YOpt	YDyn	YMin	YMax	Glatt	Stetg
mm	Versatz der X-Werte	0						13					<input type="checkbox"/>	<input type="checkbox"/>
	D-Skalierung	480		5	1E-7	460	500	13					<input type="checkbox"/>	<input type="checkbox"/>

altered. In order to keep the pipe cylindrical, the beginning diameter will be free and the end diameter will be referenced to the beginning diameter by the **relative coordinate "0"**.

In this way, the optimiser is forced to create a cylindrical bore while still being variable.

Setting "relative" Coordinates

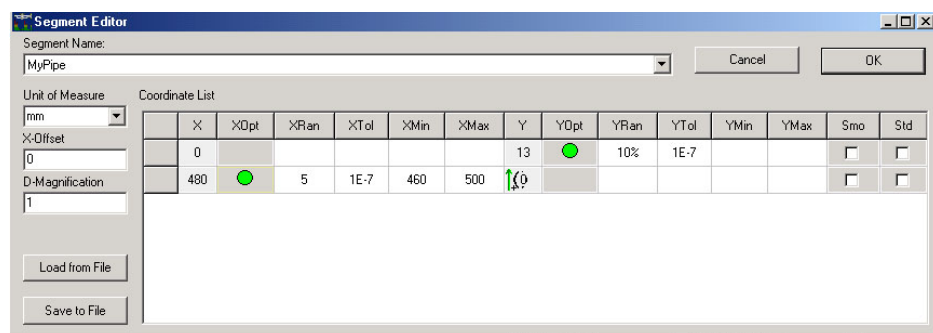
▶ A relative coordinate value of "0" is created by entering a "**^**" in front of the numeral (in this case "0") ("**^0**" is found next to the number 1 on the keyboard).

▶ Click on the field below in the "**Y**" column (next to the value 500), delete the value "13" and enter "**^0**".

Setting the diameter to Free, but ensuring a cylindrical shape

▶ Set the beginning diameter to Free by clicking in the column "**YOpt**" in the field next to the diameter value "13".

In the editor window, the optimiser shows the relative coordinates as a **green vertical arrow**.



▶ Set reasonable limits for the variation range for the bore, by setting the maximum diameter change at 5%, for example. Click the field of the column next to the green spot, delete 10% and enter "**5%**".

▶ Close the Segment Editor by clicking on "**OK**".

The creation of all the necessary parts is now complete!

The X-Offset Tool

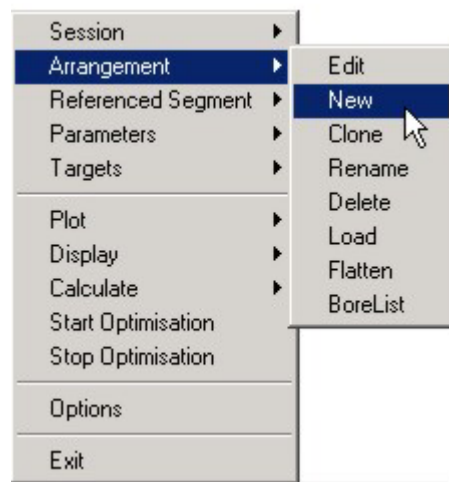
The "**X-Offset**" function is a very practical tool for segments which are joined. For example, the "MyMouthpiece" and "MyLeadpipe" segments, which in reality are joined by sliding the mouthpiece into the leadpipe. The leadpipe is shortened by the amount the mouthpiece protrudes into it.

To save the complications of altering the leadpipe, simply measure the length of the mouthpiece protruding into the pipe and enter the value in the "**X-Offset**" field. The optimiser will take care of the rest.

Assemble the parts into a complete instrument using the Arrangement Editor

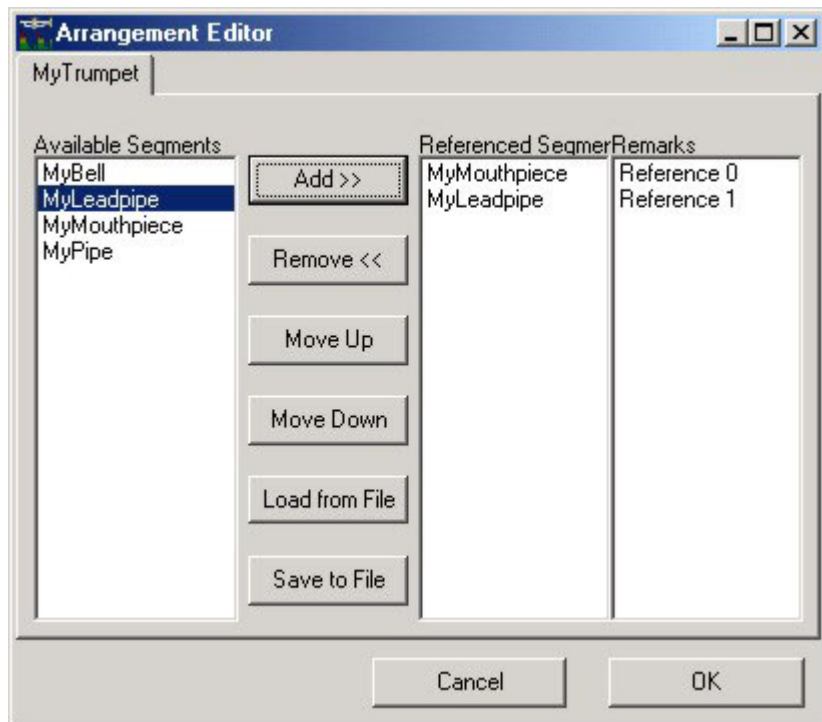
▶ Call up the **context menu** of the **Commander Bridge** (right mouse button).

Click "**Arrangement**" and "**New**" and assign the name "**Mytrumpet**".



Now we assemble the parts of the instrument into a complete trumpet using the Arrangement Editor. Use "**MyMouthpiece**", then "**MyLeadpipe**", "**MyPipe**" and finally "**MyBell**" in this order.

▶ Click on "**MyMouthpiece**" and then on **Add >>** then on "**MyLeadpipe**" etc. Thus you have created the "**Arrangement**" "**MyTrumpet**".

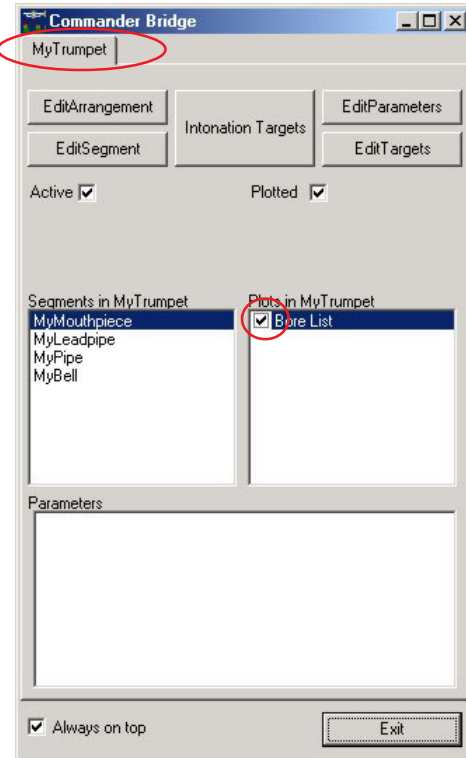


With the buttons "**Move Up**" and "**Move Down**", you may rearrange the segments within the instrument. The button "**Load**" is used to load a previously saved arrangement (The present Arrangement may be saved by using the command "**Save to file**").

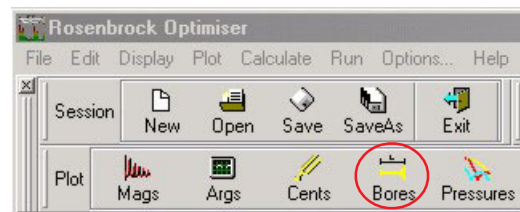
- ▶ A click on "**OK**" closes the Arrangement Editor.

Within the Commander Window, the new arrangement appears as a catalog file card with the name "MyTrumpet".

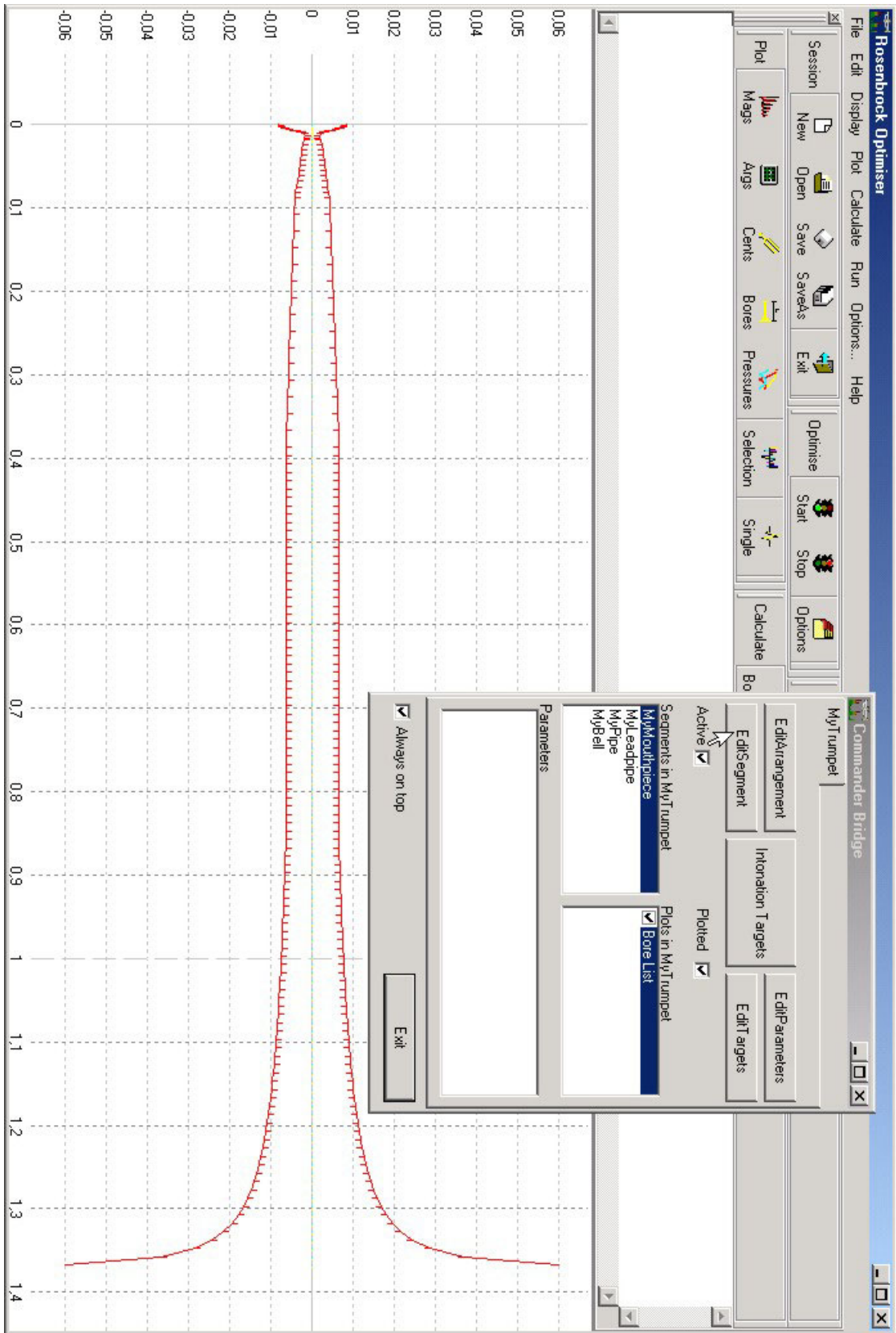
- ▶ Click on the box "Bore list" (if not automatically activated) at the right of the Commander to activate/enable the graphic representation of the bore list.



- ▶ Click on the button "**Bores**" in the tools section "Plot", and the created instrument will be plotted.



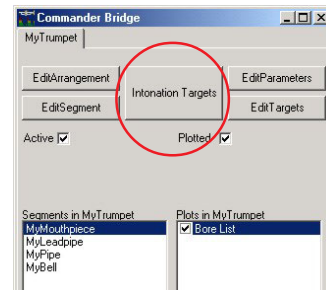
Congratulations!
You've just created your
first trumpet in Bb.



Definition of the optimisation targets

Optimise intonation using the Intonation Assistant

- ▶ To optimise intonation, start the Assistant which will assist you in defining the intonation targets. The button is found in the upper center of the Commander.



A table appears which contains a line for each resonance peak. The first line stands for the *pedal tone* or *fundamental* which is rarely played on the Bb trumpet. Because optimisation of unplayed notes is unnecessary, this and other notes (for example the 7th) can be eliminated from the optimisation procedure by simply deleting them from the table.

Exception of single notes in the optimisation

- ▶ Mark the first line by a **click in the gray field** at the left edge of the line. While holding the Ctrl key, mark the lines 7, 11, 12, 13, and 14, which are also notes rarely played on the Bb trumpet. Their intonation will not be taken into account during the optimisation.

index	key	act [Hz]	act [Cent]	act [Ohm]	tar [Hz]	tar [Cent]	tar [Ohm]
1	E2	84,7434	48,4	86630,5	84,7434	48,4	86630,5
2	Bb3	232,5777	-3,7	90122	232,5777	-3,7	90122
3	F4	344,4167	-24	115125,2	344,4167	-24	115125,2
4	Bb4	457,6747	-31,8	123682,3	457,6747	-31,8	123682,3
5	D5	578,3651	-26,6	128561	578,3651	-26,6	128561
6	F5	685,2889	-32,9	125587,7	685,2889	-32,9	125587,7
7	G5	793,9382	21,8	86601,4	793,9382	21,8	86601,4
8	Bb5	912,6962	-36,8	48281,7	912,6962	-36,8	48281,7
9	C6	1029,8204	-27,8	29428,3	1029,8204	-27,8	29428,3
10	D6	1154,1964	-30,4	19182,1	1154,1964	-30,4	19182,1
11	E6	1289,5937	-38,4	13482,4	1289,5937	-38,4	13482,4
12	F#6	1441,2621	-45,9	11678,3	1441,2621	-45,9	11678,3
13	G6	1567,8326	-0,2	10844,8	1567,8326	-0,2	10844,8
14	G#6	1693,6802	33,5	9787,8	1693,6802	33,5	9787,8

- ▶ Press the **"Del Key"** or choose **"delete selected lines"** from the context menu to remove resonances which should not be taken into account.

The table contains, besides the **Index** of resonance peaks, the musical note in question (**key**), to which the intonation variances are referenced.

Note: The Assistant calculates notes based on equally tempered tuning at 440 Hz.

index	key	act [Hz]	act [Cent]	act [Ohm]	tar [Hz]	tar [Cent]	tar [Ohm]
2	Bb3	232,5777	-3,7	90122	232,5777	-3,7	90122
3	F4	344,4167	-24	115125,2	344,4167	-24	115125,2
4	Bb4	457,6747	-31,8	123682,3	457,6747	-31,8	123682,3
5	D5	578,3651	-26,6	128561	578,3651	-26,6	128561
6	F5	685,2889	-32,9	125587,7	685,2889	-32,9	125587,7
8	Bb5	912,6962	-36,8	48281,7	912,6962	-36,8	48281,7
9	C6	1029,8204	-27,8	29428,3	1029,8204	-27,8	29428,3
10	D6	1154,1964	-30,4	19182,1	1154,1964	-30,4	19182,1

Master Tuning: 440
Frequencies Up/Down

The next three columns contain the **present frequency** of the resonance peak in Hertz "**act [Hz]**", the **current intonation variance "act [Cent]"** in cents, as well as the **absolute value** of the impedance "**act [Ohm]**" in acoustical Ohms.

The same numerical values are found in the last three columns, but here the user may enter **any desired target values**.

The **direct entry** of the numerical values is not possible in these table fields. As in the Segment Editor, you may mark one or more lines (=resonance peaks, i.e. natural tones) and then assign the marked resonance peaks with another intonation or envelope value with the help of the context menu.

Set Intonation target

▶ Now mark all lines and select the command "**Zero Cent Target**" from the context menu.

In the column "**tar [Cent]**", there should be "0" values only. The tenth peak is shown as D6, with 30.4 cents deviation downwards. (tar means "target").

- ▶ Now you may calculate the mean intonation of the instrument by clicking the context menu point "Mean Tuning".



***Note:** due to setting the fundamental tuning to 443 Hz resetting the target deviation to "0", we could create an instrument with a fundamental tuning of 443 Hz and an optimal intonation.*

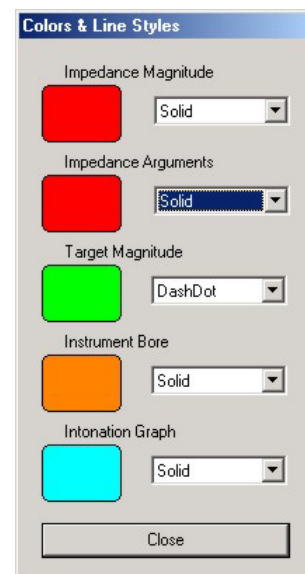
But for the moment, we shall close the assistant by selecting the current settings by clicking "OK".

- ▶ Assure that in the list of available plots in the Commander Bridge (right window titled "Plots in MyTrumpet") the boxes **Bore list**, **Impedance** and **Intonation** are checked.

A **double click** on any of these descriptions on this field opens a dialog to adjust the line color and width of the curves.

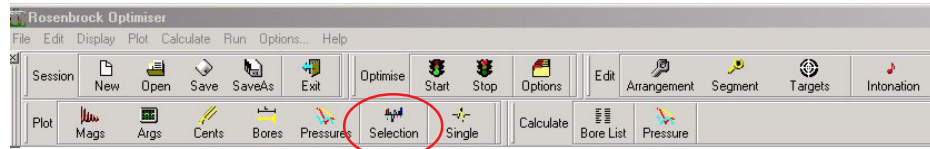
With a click on the color field, you may change the colors. Assign gold to the bore, green to the impedance, and blue to the intonation.

In the scroll box at right, the style of the lines can be set.



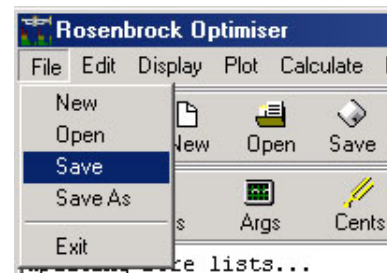
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- ▶ Now refresh the view with a click on "**Selection**" on the main optimiser toolbar.



The bar graph of the intonation deviations for the current instrument bore and impedance is now visible in the Plot window.

- ▶ Save the session data now with the name "MyExampleOriginal" by using the command "**File -> Save**" of the main menu bar. Choose an appropriate folder, for example the older Optimiser Demo.



Start the Optimisation

- ▶ Now start the optimisation with a click on "**Start**".

In the **Trace Window**, the beginning function will appear as a value of "**418**". This value should become increasingly smaller during the optimisation.

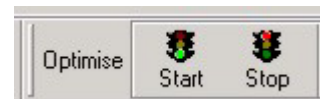
The number represents the sum of all deviations from the ideal target.

This number is derived from contributions from envelope differences, intonation deviations and deviations in the bore from "Smooth" and "Constant".

The standard values for weighting and progression lead in this case to a start combination of the target function of:

36% Envelope adjustment,
64% Intonation optimisation and
0% for Smoothness and Constancy.

Observe the optimisation for a while. Although small improvements are made, the overall speed of the optimisation is **unsatisfactory**. The contributions for intonation and envelope are apparently conflicting which leads to incompatible demands for the optimiser.



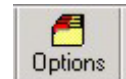
A keen observer will soon see that while large changes to the intonation is being tried, the envelope of the resonance peaks is forced to be identical! Remember: we have the values for the envelope neither altered nor deleted.

This means, the **target** for the envelope is still the best possible conservation of the values originally departed from. And this target delivers more than one third of the contributions. This in turn leads to a very conservative behaviour, or even paralysis of the process.

It is therefor necessary to think about the configuration of the optimiser to enable good results.

Optimiser Settings

- ▶ Click on the button "**Options**" in the tool bar "Optimise". A new window appears with several file cards. Select the "**Rosenbrock**" card.



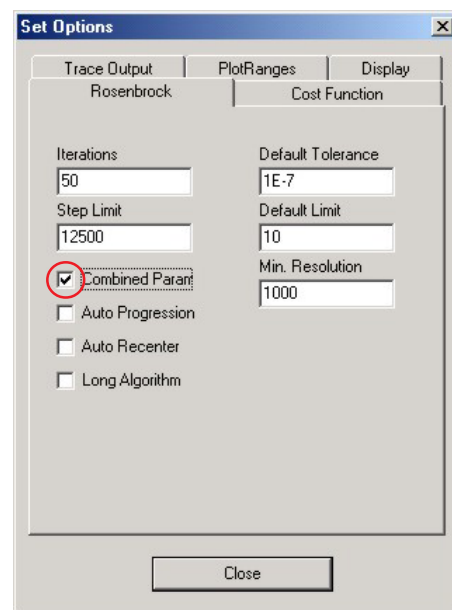
- ▶ Raise the **Step Limit** to 5000. For the amount of parameters for this optimisation, the default value of 500 is probably too few work steps allowed.

- ▶ The (number of) **Iterations** should be raised to 200. Because the optimisation can be interrupted manually at any time, it is not advisable for interactive sessions to enter settings for an automatic optimisation interruption.

The "**Combined Parameter**" checkbox allows the optimiser to alter parameters simultaneously without trying them separately. It leads mostly to an efficient processing, but may also lead the optimiser on an unsovable path.

The first run after the start is a so-called "**sounding run**", where parameters are always adjusted singly.

Only a successfully finished sounding run provides the optimiser with the essential information to combine parameters and alter them simultaneously in a successful way.



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Ideas and Strategies

After three to five such **runs**, it's advisable to interrupt the optimisation and start again to identify possibly altered conditions in a new trial run.

Especially when parameters come near their limits / boundaries, which is shown on the right of the **Trace Window**, it's good to interrupt the run.

Not only will a new trial run be started, but the dynamic variation ranges will be adjusted that they appear centered again (=recenter), as long as there were no hard limits set to prohibit centering.

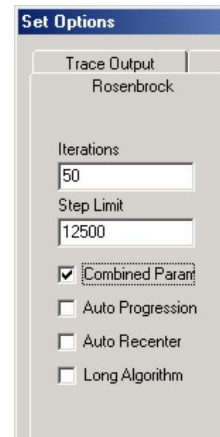
Function and Effects of the Individual Optimisation Parameters

The setting "**Autocenter**" executes this centering operation before each run, which occasionally leads to falsified results if "**Combined Par.**" is activated. The simultaneous activation of both is therefore not recommended.

"**Auto Progression**" is conceived to use random changes to bring the optimiser out of "dead ends". These changes lead to a new combination of the target function which are heavily influenced by the priorities of the optimisation.

Applied with the necessary caution, this setting can be quite useful in producing good results during long lasting and unsupervised optimisation sessions.

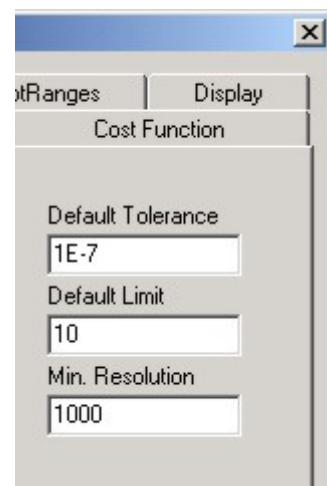
The setting "**Long Algorithm**" is somewhat slower but in certain cases more exact.



The values at the right of this file card are standard settings used by the program.

The "**Minimum Resolution**" is the minimum number of "Default Tolerance" steps (iterations) in the **dynamic ranges** of the optimiser parameters. In case they are too small, the program expands the appropriate dynamic ranges.

The default value for dynamic ranges is 10%, which can be set in the "**Default Limit**" field.



- ▶ Now select the file card "**Cost Function**". These important settings **can and must** be altered / modified during an optimisation.

The "**DisplayScale**" of the displayed Cost Function value is rather cosmetic and may be used for scaling if the displayed value is inconveniently large or small.

"**Weight**" and "**Progression**" are especially important.

- ▶ Set the weights for "**Smooth**" and "**Steady**" at "**1**". The proportional combination of the Target function is guided with the weights.

With the **Weights** and the **Progression** you draw the attention of the optimiser to particular optimisation targets.

These targets are then optimised at the expense of others (not so important) targets.

Effect of Weighting on the Optimisation

- ▶ Initially, enter **higher** weight values for the **Intonation**. Each alteration during an optimising run produces a line in the Trace Window, in which the new proportional combination of the cost function is displayed.
- ▶ If you notice that the **envelope** of the impedance curve distorts during the optimisation process too much, then **reduce** the weight of the "**combined par**" and **increase** the weight of the "**maxmatch**".
- ▶ If you want a surface which is as smooth (zylindrical) and steady (conical) as possible, raise the appropriate weights, assuming there are particular sections of the bore marked and given free as "smooth" and "steady".
- ▶ Observe the results of altering the weights in the resulting lines of the protocol window.

With the **Weights** you draw the attention of the optimiser either more on the Intonation or on the Response!

Also the alteration of the "Progression" has an influence on the combination of the Cost function:

Progressions of larger than 1 (up to nine) occupy the contributions with largely proportioned weights that make **large errors** disproportionately **more important**.

Progression **between 0 and 1** occupy the contributions inversely proportional to the size of the error, so that all error contributions are of the **similar importance**, regardless of how large the deviation is.

Effect of "Progression" on the Optimisation

- + If you prefer the reduction of single large errors instead of many small errors, then set the weights to greater than 1.
- If you prefer to reduce all errors, single large ones and many small ones, then set the weights to less than 1.

The current relative error contributions are graphically represented as **green** (intonation) and **blue** (envelope and magnitude adjustment) lines at the lower edge of the Trace Window.

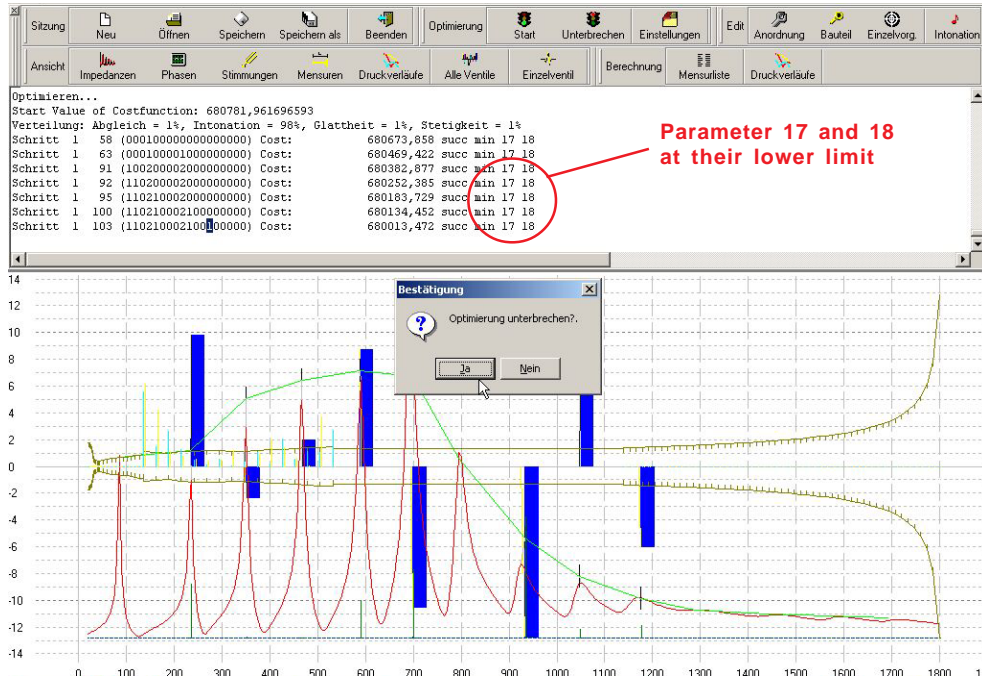
The smooth (**blue**) and steady (**yellow**) contributions are also represented, as thin streaks in the middle of the bore. But to see the relative contributions, this option must be selected in the plot window of the Commander Bridge.

With the Progression you draw the attention of the optimiser either more on large errors or on all or small errors!

New Start with Altered Parameters

- ▶ Start the optimiser once again.
- Set the value of "Weight (Intonation)" to 1000 and the "Progression (Intonation)" and "Progression (match)" at 3.
- Check in the **Trace Window** if the intonation contributions dominate (>80%). You may now observe how the intonation steadily improves, even if the geometry of the bore appears irregular.
- Interrupt the optimisation when the parameters exceed the limits of the variations for a longer period. By starting once again, the variation region will be automatically centered, as long as no hard limits disallow this.
- + You will see in the right of the Trace Window the order of numbers, for example "**min 17 18**" (as in the following figure), this means that parameter 17 and 18 have currently exceeded their allowed variation limits and won't be moved further.

- interrupt the optimiser when a manual adjustment to the geometry appears necessary (see figure).



"Smoothing" to Help the Optimiser "Come Along"

- ▶ Open the segment "MyLeadpipe" in the Commander Bridge in order to smooth the bore.

Mark all the lines and select "Smooth" in the context menu. Enter the smoothing value "10".

- ▶ Refresh the display by click in "Selection" in the main toolbar.



Segment Editor

Segment Name: MyLeadpipe

Unit of Measure: mm

X-Offset: 0

D-Magnification: 1

Coordinate List

X	XOpt	XRan	XTol	XMin	XMax
0					
20					8,745
40					9,043
60					9,516
80					
100					9,937
120					10,42
140					10,73
160					
180					
200					
220					11,94
240					11,80
260					12,55
280					

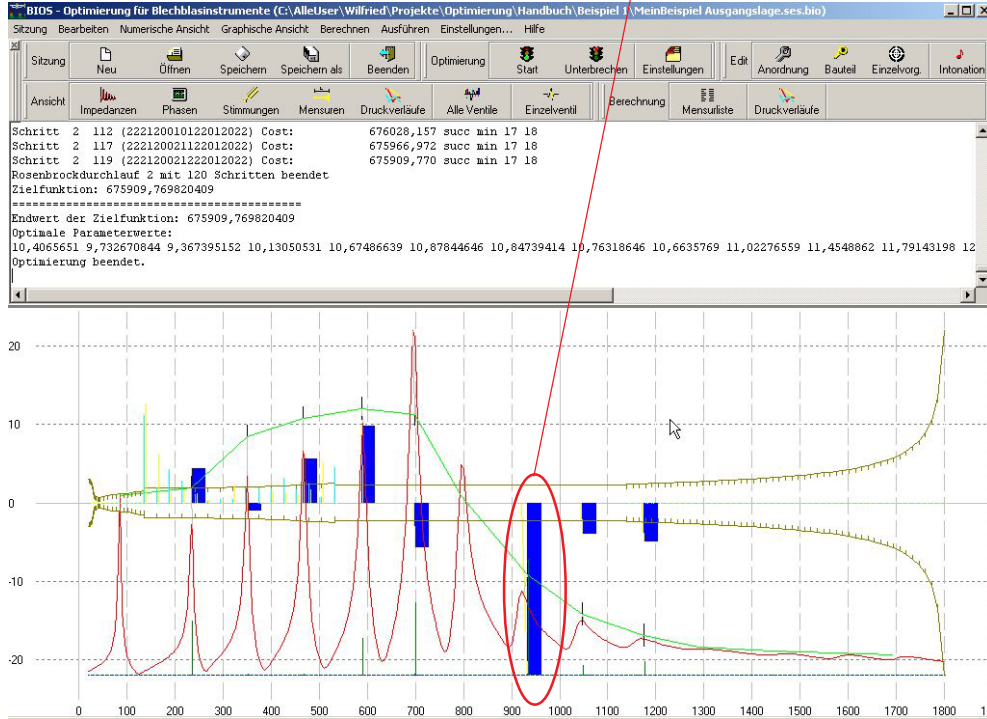
Load from File

Save to File

Select

- Edit Line
- Edit as Text
- Delete Lines
- Insert Lines
- Clone Lines
- Move Lines
- Make Cone
- Make Bell...
- Insert Sleeve...
- Add Grid...
- Modify...
- Smooth...

The bore is now nearly smooth, but the intonation is also unfortunately a lot worse.



▶ Start the optimiser once again.

After several runs, make another manual adjustment. The intonation should be nearly in the 10 cent range, which is sufficient for playing. It would appear that more accuracy is not possible with the present settings. But, with the natural trumpet, we may still make other allowances for freedom.

▶ Open the Segment Editor with a double click on "Mypipe" in the Commander Bridge. Click on the bore parameter in the second line and replace the relative value "**^0**" with the absolute value **13**, and set it to Free by clicking on the neighboring field ("**YOpt**"). A green spot will appear and indicates that the diameter may be changed by the optimiser.

With this, the end diameter is now a parameter that may also be optimised, and the forced dependence on the beginning diameter is eliminated. This also allows a conical form.

Earlier
Limitations
in the Segment
MyPipe
now
Set to Free

The Segment Editor dialog box shows the following table:

Unit of Measure	Coordinate List													
mm	X	XOpt	XRan	XTol	XMin	XMax	Y	YOpt	YRan	YTol	YMin	YMax	Smo	Std
%-Offset	0						12,500048904	●	10%	1E-7			<input type="checkbox"/>	<input type="checkbox"/>
D-Magnification	460,00111466	●	5	1E-7			13	●	10%	1E-7			<input type="checkbox"/>	<input type="checkbox"/>

- ▶ Delete all hard limits by simply marking them and pressing the **Del key**.

Remember the first bore value (beginning diameter) in order to enter it as the **last value** in the Segment "**MyLeadpipe**" because there should be no sudden leaps in the diameter! Press then "OK".

Alterations to the Segment "MyLeadpipe"

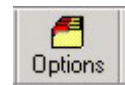
- ▶ Open the segment "MyLeadpipe" and correct the leap by overwriting the last bore value. Click in the appropriate field and enter the first value of "MyPipe".
- ▶ Smooth the leadpipe again with a smoothing factor of **"5"**. This will avoid an unnecessary leap in the bore.

- ▶ Restart the optimiser.

Now we shall set the weights to enable a good intonation and a good envelope.

Interactive Optimisation

- ▶ Click the button "**Options**" on the main toolbar, and **reduce** the values of the weights for smoothness and steadiness.



The **Progression** values for **Intonation** and **Match** leave with **"3"**. These values will become proportionally smaller, depending on how good the previous intonation improved.

- ▶ In order to this, raise the **Intonation** weight as soon as the magnitude of the intonation deviations become significantly smaller.
- ▶ Interrupt the optimiser if parameters get stuck on limits. Restart the optimiser.
- ▶ Raise the values for smoothness and steadiness as soon as you feel that the bore is **unreasonably irregular**. The result of smoothing factors from 2 - 40 are illustrated at page 86 / 87.
- ▶ As soon as the intonation and envelope come near to your concept, helped by manual adjustments, and assuming that the conceived instrument is producible by the manufacturing means available, you may reduce the areas of dynamic changes for parameters, or deactivate the optimiser in critical areas.

How to reduce the variation possibilities for a parameter:

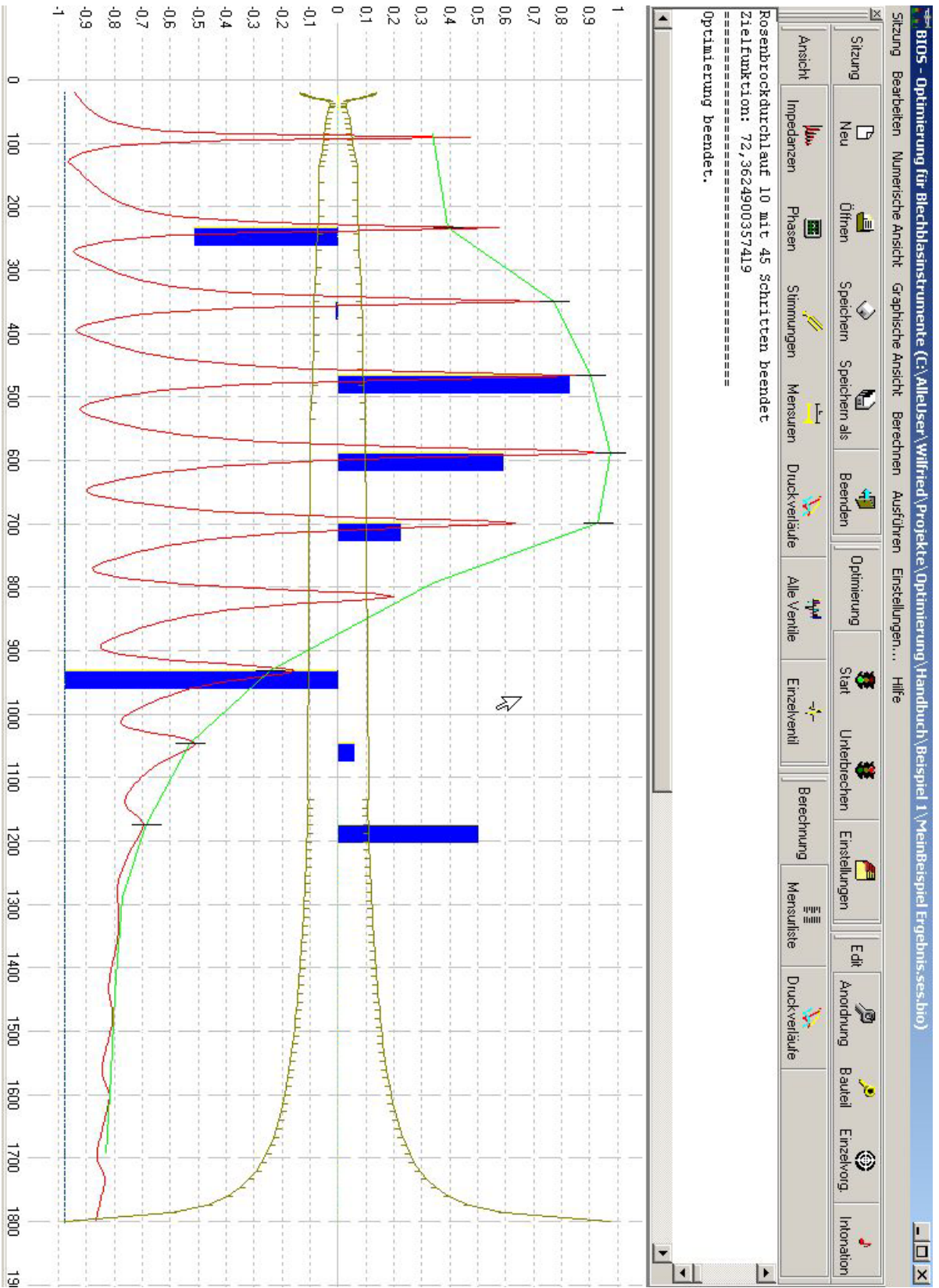
- ▶ Interrupt the optimisation
- ▶ Open the segment in question
- ▶ Mark the appropriate lines
- ▶ By clicking on the column header **XRan** or **YRan**, new values (in this case narrower, smaller) can be entered, either in % or absolute values. If the line does not show a green spot, click on the column header **XOpt** or **YOpt** to free the lines for optimisation.

How to deactivate optimisation parameters:

- ▶ Interrupt the optimisation
- ▶ Open the segment in question
- ▶ Mark the appropriate lines
- ▶ By clicking on the column header **XOpt** or **YOpt**, the green spots will become red, which means that these coordinates are deactivated and off limits for further optimisation runs.

An optimal result named "**MyExampleResults**" derived from the optimiser is included with the software (see the illustration next page).

Open this file and compare your results with this file.



6

EXAMPLE 2: VALVED TRUMPET

In this example, we will add a valve section to the Natural trumpet we created in the previous chapter and optimise all 8 valve combinations (**Arrangements**) simultaneously. We will use the same **Segments**, with the exception of "MyPipe", which will be shortened accordingly to accommodate the length of the valve section.

▶ Start the Optimiser and open the session file with the result of Example 1. You will find the file in question with the name "Example2.ses.bio" in the Folder Demo of your BIAS Installation data.

In this example, we will add a valve section and tuning slide to the optimised natural trumpet. In order to this we have to shorten the tube length (Segment MyPipe) because of the additional length of the valve section and to create and define the new Segments.

Each valve switches between two possible sound paths. When not engaged, the path is shorter between the entry position and the exit position. When engaged, the valve slide with a longer tube length is engaged. Thus, the sound channel is changed in a more or less complex way, depending on the valve type (rotary or Perinét).

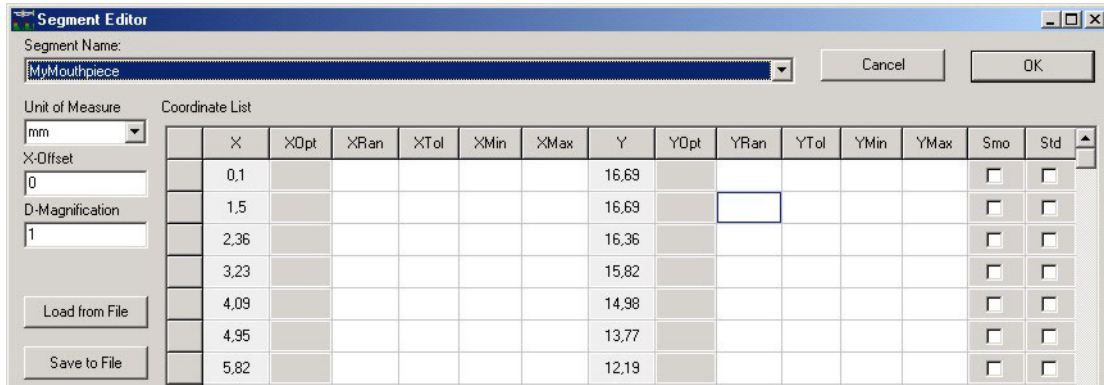
There are several methods available to add the 8 combinations in the form of segments to the instrument.

1. The valve section can be divided, for example, into the connector, valve path, valve slide 1, intermediate connector, etc. and these Segments will be combined with the Arrangement Editor to a Arrangement representing the appropriate soundpath (see page 12 and 13).
2. The soundpath is treated functionally and the involved Segments are converted into a single Arrangement, that is, as a valve combination acts as a whole. The segment V2 would represent the entire valve section when the second valve is engaged (see page 13).
3. For each valve, there will be two possible substitute geometries described. "V1-" is a segment where the first valve is not engaged, "V1+" is the same segment with the valve engaged. The connection between the valves is cut at the appropriate place, so that the simple order of V1-, V2- and V3- represents all the valves not engaged.

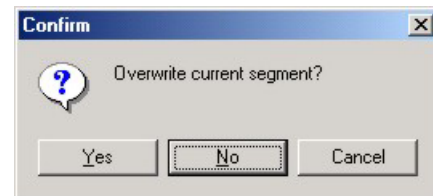
An order of V1+, V2+ and V3+ represents the fingering V123, and V1+, V2- and V3+ the fingering V13.

For our example, we will use the third possibility, since it hasn't been discussed in the manual up until now.

- ▶ Start the Segment Editor and **import** the **Segments V1- (filename: V1-.seg.bio), V1+, V2-, V2+, V3-, V3+** by using the command **"Load from File"**.



- ▶ As an answer to the prompt **"Overwrite current Segment?"**, enter **"No"**, since **"MyMouthpiece"** should not be altered with valve section data. Instead, we will create (load) new segments and save them under their names.



- ▶ After loading **V1-.seg.bio, V1+.seg.bio, V2-.seg.bio, V2+.seg.bio, V3-.seg.bio, V3+.seg.bio**, import the description of the tuning slide **"TuningSlide.seg.bio"** in the same way, and close the Editor with a click on **"OK"**.

+ *The newly imported segments do not appear in the left window of the Commander Bridge, because they are up to now not parts of the instrument. But with a click on **"EditArrangement"** you will see the new parts under **"Available Segments"**.*

Finally, the optimisation targets and guide lines entered by the optimiser at the previous optimisation runs, must be deleted (concerns only the "old" segments). We do this by a click on the button "EditTarget" of the Commander bridge.

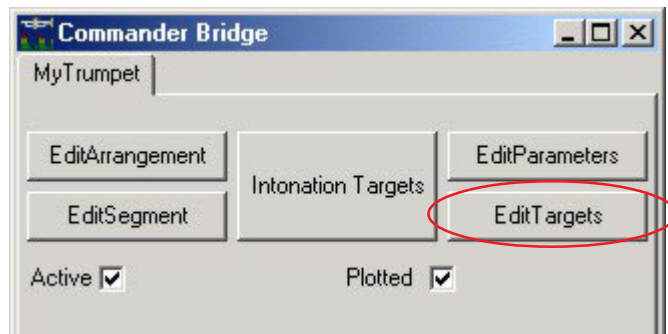
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Optimisation Targets and Optimisation guide lines:

Delete Old Entries

Click on "Edit Targets".

The following window will then appear, showing all "attributes" entered by the Assistant during the last optimisation session.



Bearbeiten von Einzelvorgaben

MeineTrompete

Untere Grenzfrequenz	Frequenz	Impedanz	Sollwert	Gewichte	Nr.	Attribute
20	20,0000	2182,6989	-1,0000	1,000	1,000	0
Obere Grenzfrequenz	25,0000	2744,7521	-1,0000	1,000	1,000	0
1800	30,0000	3339,6108	-1,0000	1,000	1,000	0
Frequenzabstand	35,0000	3979,8725	-1,0000	1,000	1,000	0
5	40,0000	4682,1080	-1,0000	1,000	1,000	0
	45,0000	5469,3259	-1,0000	1,000	1,000	0
	50,0000	6375,1160	-1,0000	1,000	1,000	0
Frequenz Raster	55,0000	7451,1846	-1,0000	1,000	1,000	0
	60,0000	8782,1587	-1,0000	1,000	1,000	0
	65,0000	10517,4740	-1,0000	1,000	1,000	0
	70,0000	12948,7262	-1,0000	1,000	1,000	0
	75,0000	16730,5580	-1,0000	1,000	1,000	0
	80,0000	23682,7061	-1,0000	1,000	1,000	0
	85,0000	41039,0902	-1,0000	1,000	1,000	0
	90,0000	95415,9932	-1,0000	1,000	1,000	0
	95,0000	40257,0651	-1,0000	1,000	1,000	0
	100,0000	18984,9419	-1,0000	1,000	1,000	0
	105,0000	11082,5982	-1,0000	1,000	1,000	0
	110,0000	6926,5463	-1,0000	1,000	1,000	0
	115,0000	4299,6689	-1,0000	1,000	1,000	0
	120,0000	2457,7382	-1,0000	1,000	1,000	0
	125,0000	1166,0250	-1,0000	1,000	1,000	0
	130,0000	886,2662	-1,0000	1,000	1,000	0
	135,0000	1642,9680	-1,0000	1,000	1,000	0
	140,0000	2518,7219	-1,0000	1,000	1,000	0
	145,0000	3372,6377	-1,0000	1,000	1,000	0
	150,0000	4203,8097	-1,0000	1,000	1,000	0
	155,0000	5026,0177	-1,0000	1,000	1,000	0
	160,0000	5854,9184	-1,0000	1,000	1,000	0

Einzelattribute: No change, Add targets, Sub targets, AbsMatch, RelMatch, MaxMatch, MinMatch, Pred, Succ, Center, Widen

Vertikalgewichtung: 1

Horizontalgewichtung: 1

Skalierung Frequenzachse: 0

Skalierung Impedanzachse: 1

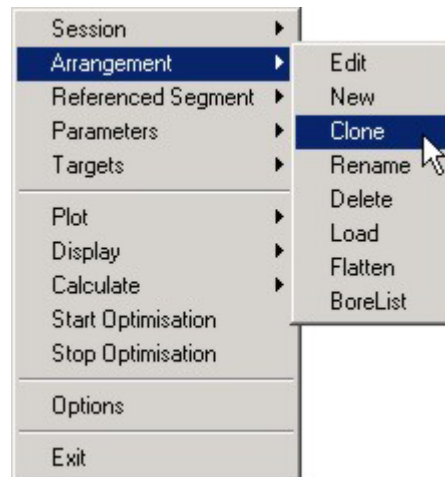
Spitzen nummerieren

Buttons: Verwerfen, Übernehmen

Click on the "Frequency Grid" button and all values will be overwritten. Close the Editor with a click on "OK".

Creating the structure of a valved Instrument through 7 Arrangements

- ▶ Clone the last arrangement "**MyTrumpet**" seven times by using the command "**Arrangement ▶ Clone**" in the Context Menu of the Commander seven times.



- ▶ Rename the seven Arrangements **V0, V1, V2, V12, V13, V23, V123** by a click on the corresponding file cards and by using the Context Menu Command "**Arrangement ▶ Rename**".

- ▶ The old Arrangement "MyTrumpet" may now be deleted. If you wish to keep the file for comparisons, follow the following instructions:
 - ▶ Click on the file card "MyTrumpet"
 - ▶ Execute "**Arrangement ▶ Flatten**".
 - ▶ Back to the Commander Bridge, deactivate the checkbox "**Active**".
The arrangement is still available for use at some time, but is not active involved into the current optimiser process.

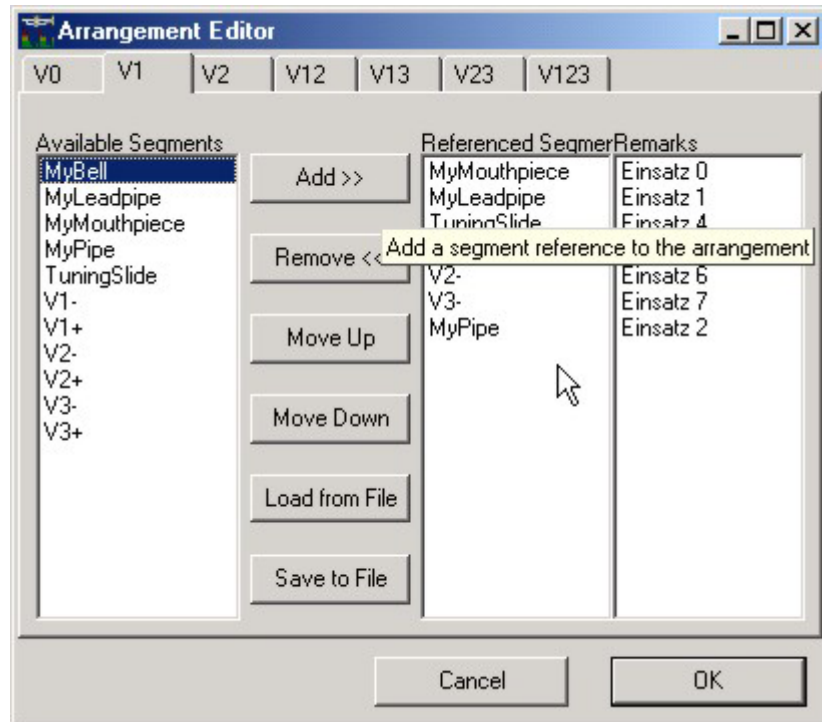
Note: the missing Arrangement **V3** can be saved, because it is most ordinarily not used in trumpet playing.

- ▶ Click on the button **EditArrangement** in order to place the Segments in the correct order along the bore.

EditArrangement

The Arrangement Editor window will open.

At the left, the available segments are shown, and at the right, the selected order of the arrangement.



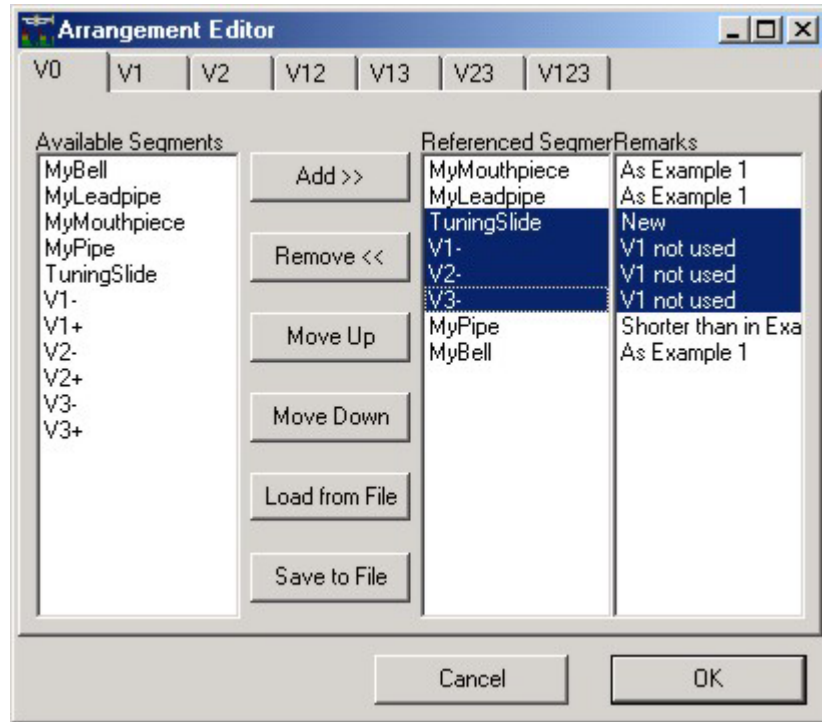
Arrange Segments in the Correct Order

- ▶ Use the commands "**Add**", "**Remove**", "**Move Up**" and "**Move Down**". You may simultaneously mark more than one Segment and move up or down, add or remove the given segment(s) from the arrangement.

*Note: if you have retained the old "flattened" Arrangement, it will appear in the window at right for all arrangements. You can remove it from the current arrangement by using "**Remove**".*

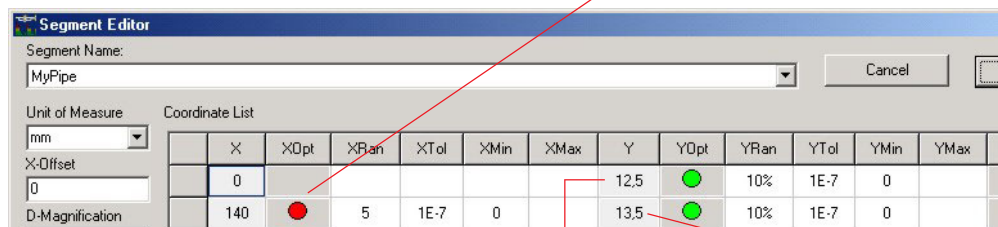
These commands function only for the current **Arrangement**. You can select from among arrangements by clicking on the name of the arrangement. In the illustration above, only changes to the current arrangement **V1**, the instrument with first valve engaged, are possible.

The correct arrangement for **V0** is shown below. For the other arrangements, **V1-**, **V2-** and **V3-** can be substituted with **V1+**, **V2+** und **V3+**, depending on which valve should be depressed.



Finally, the tube must be shortened by the length of the valve section to arrive back at the correct tube length.

- ▶ A double click on the Segment "Mypipe" in the Commander will open the Segment Editor with the coordinates of this segment.
- ▶ Reduce the length to 140mm.
- ▶ Click on the green spot to fix the tube length. A red spot will then appear, which marks a defined parameter which is deactivated.



- ▶ Define the tube as a cone form starting at 12.5mm and ending at 13.5mm. Then click "OK".

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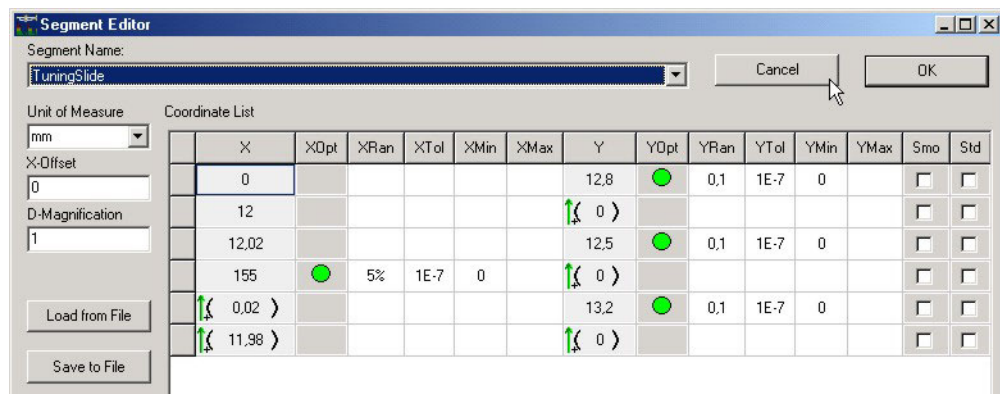
The length of the entire instrument should be defined now **exclusively** by the tuning slide. Therefore redundant parameters must be avoided!

Redundant optimisations parameters exist when a particular acoustical change (the basic tuning of the entire instrument, for example) is changeable through **more than one parameter**. Redundant optimisation parameters should be avoided as much as possible. For example, the tuning may be determined through the length of the tuning slide, the pipe length and the temperature.

▶ Let's turn now to the **TuningSlide**, and open the segment with a click.

The last defined coordinate pair of a segment always determines the **length** of the section. If these coordinates are set to Free, the length becomes an optimisation parameter.

Therefore it is possible to set the **length** and with it the **basic tuning of the entire instrument** as Free.



The description of the tuning slide in this example contains a lot of useful information for us:

- It begins with a cylindrical tube of 12mm and a constant bore of 12.8 mm.
- The second bore value for this segment is **relative** to the first entry and has the value **"0"**, which defines it as an exactly cylindrical pipe.
- This is followed by a leap to the smaller bore value of 12.5 mm of the tuning slide, which remains the same in the coordinates from 155 mm. The bore of the tuning slide may again be **optimised**. Here, it is necessary to set limits according to the building materials and the forms that are practically possible with them.

**Tips
for
Practical
Aspects
of
Optimiser
Settings**

- Also the effective length of the tuning slide may be altered within broad limits. A relative definition of this section of pipe that is inserted into the tuning slide follows.

In the current case, assuming the optimal positioning in the middle, the tuning slide could be inserted (moved) at each end 12 mm into the pipe, which results in shortening the total length of the instrument by 24 mm, and consequently 32 cents.

- The relative coordinate values (with several of the length and diameter values) will be entered on the keyboard with the symbol ^ before the number.
- The total length of the segment "TuningSlide" including both sleeve ends results in a absolute length coordinate of 155 mm plus the two following relative length entries 0.02 mm and 11.98 mm. These are necessary due to the sliding in and out the tuning slide, and represent an abrupt change (leap) in the bore caused by the wall thickness.

The **leadpipe** as well as the end of the **mouthpiece shaft** (for higher peaks) is one of the **most sensitive** areas of the instrument.

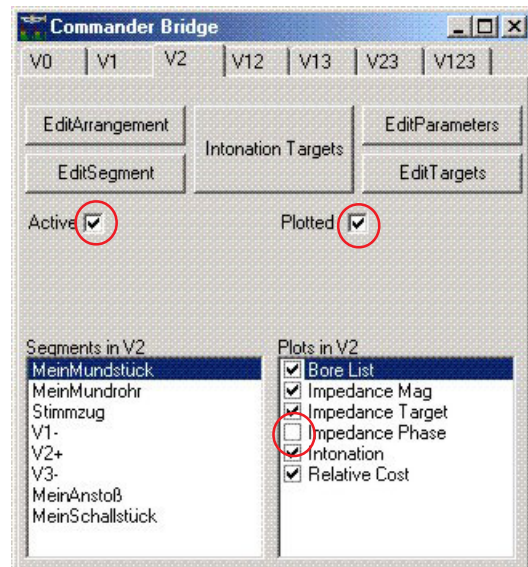
The intonation optimisation will function better if **these segments are set to Free**, because this area is uniquely capable of altering the intonation of one particular note while not adversely affecting others.

- Please ensure that there are enough defined **support points** (=coordinate pairs), since the optimiser cannot create these support points during the optimisation.

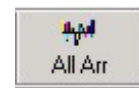
That's what the contex menu command "**Add Grid**" is for. With further commands, you may alter the marked area and "Smooth", narrow or enlarge the segment in different ways (see pages 73 to 87).

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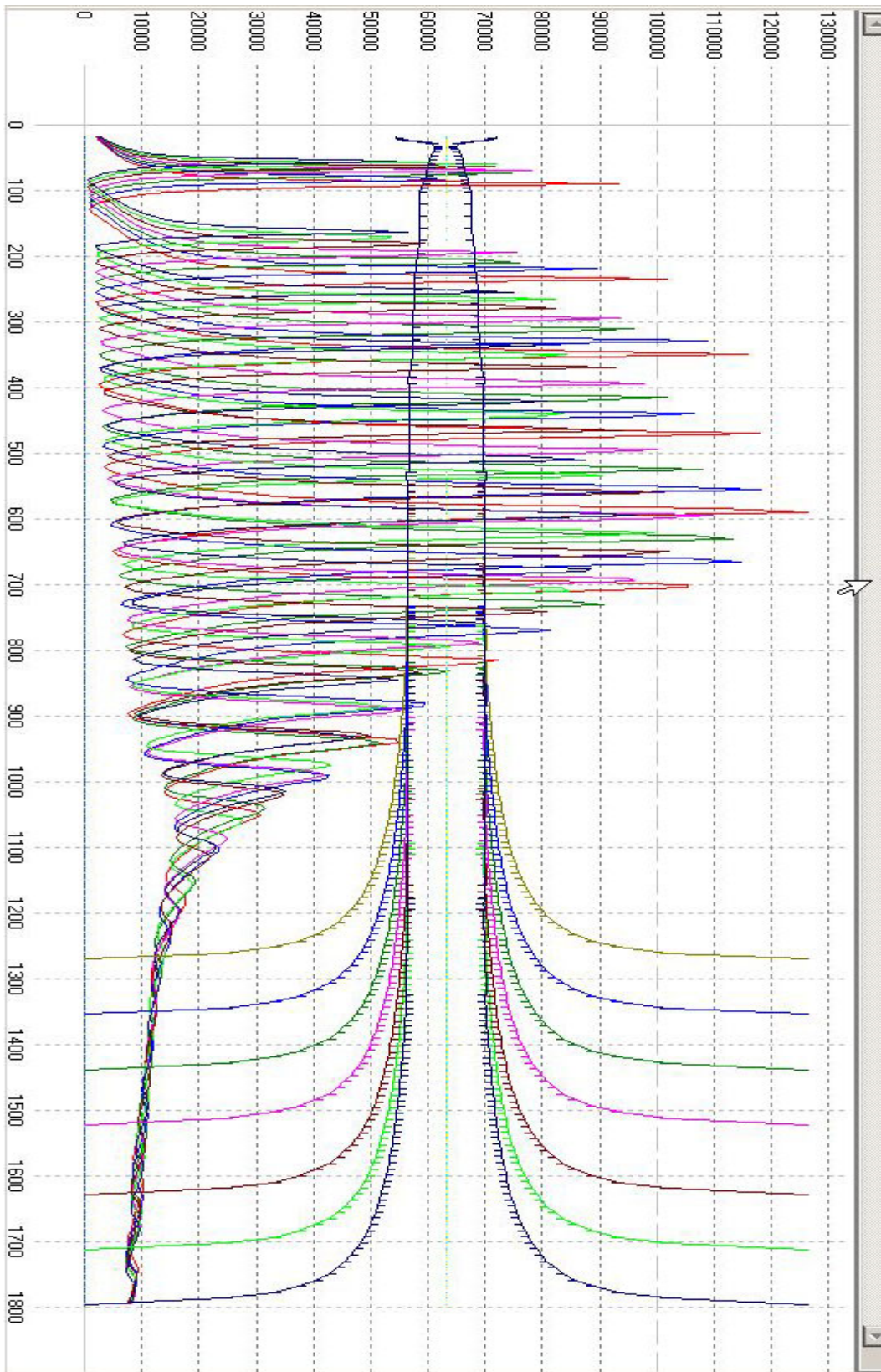
- ▶ Now mark all the valve combinations as **Active** and **Plotted**, and deactivate the checkbox for **Impedance Phase**, since the display becomes too dense to be useful.



- ▶ Activate all of the preset views by pressing the button "All Arrangements".



- + As a result, you will see the plots for all seven bores (valve combinations) and the associated impedances, as shown on the following page.

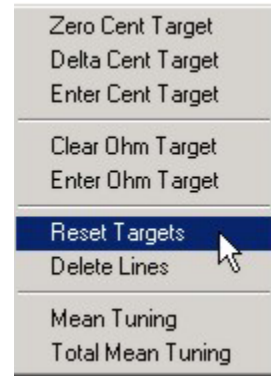


- ▶ Start the **Intonation Targets** assistant, which will help you through defining the optimisation targets. The button is found in the center of the upper part of the Commander Bridge.

An empty table will appear.

- ▶ Press the **right mouse button** while on the table area field, to open the context menu.

Use the command **"Reset Targets"**. Now each resonance peak receives its own line. The first line is for the pedal tone which is not played on the Bb trumpet.



- ▶ Mark the first line by clicking in the grey field at the left of the line. Mark lines 7, 11, 12 and 13 by depressing the **Ctrl Key** and clicking on the appropriate fields. These lines are also for resonance peaks which are seldom or never used in trumpet playing: their intonation should be disregarded in the optimisation. Press the **"Del Key"** or use the context menu command **"Delete Lines"** to delete the marked lines.

Select Notes to be Optimised, and deselect Notes that Aren't Used

- ▶ Follow this procedure for each of the seven file cards (arrangements) and initialise in this way the display of all resonance peaks. Mark and delete the first and seventh peak for each fingering, as well as all peaks above the tenth resonance.

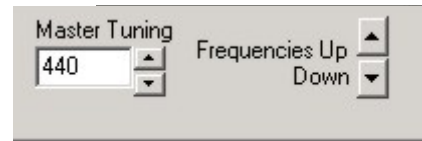
- ▶ delete additionally the ninth peak from **V1, V2 and V12**
- ▶ delete additionally the fourth and eighth peaks from **V2**
- ▶ delete additionally the sixth peak from **V12**
- ▶ delete additionally every peak except for the second and third from **V13 and V123**
- ▶ and finally, delete additionally every peak except for the second, third, fourth and eighth from **V23**.

Now, only the standard fingerings are left over for optimisation. Check the list once again.

+

Note that if a natural tone is more than a half tone **too flat or sharp**, the wrong name will be assigned to it. The name of the resonance peak is assigned automatically according to which note in the tempered scale the peak is nearest to.

- ▶ Mark the peak in this case and use the command "**Frequencies Up and Down**" as long as it takes for the necessary change in the note name to take place.



- + If you choose "**Zero Cent Target**" of the Context Menu, the initial intonation error for such a peak will be more than 50 cents.

- ▶ Mark all notes (tones) on all file cards, click on the **header** of the **tar[Cent]** column, and **confirm** the default value. You should find only "0" values (see figure below).

Specify Intonation Targets

V0	V1	V2	V12	V13	V23	V123			
index	key	act [Hz]	act [Cent]	act [Ohm]	tar [Hz]	tar [Cent]	tar [Ohm]		
2	G#3	208,4242	-2,7	86248,6	208,7549	0	86115,3		
3	Eb4	311,7963	-5,4	104163,1	312,7790	0	103129,7		
4	G#4	416,1840	-5,5	103423,6	417,5099	0	104608,1		
5	C5	524,4957	-5,1	109587,2	526,0295	0	109397,5		
6	Eb5	628,1051	7	117160,1	625,5580	0	115856,3		
8	G#5	832,0628	-6,1	64977,8	835,0198	0	64636,3		
10	C6	1039,9720	-20	31496,1	1052,0590	0	31680		

Context Menu:

- Zero Cent Target
- Delta Cent Target
- Enter Cent Target
- Clear Ohm Target
- Enter Ohm Target
- Reset Targets
- Delete Lines
- Mean Tuning**
- Total Mean Tuning

- ▶ Now get the mean tuning of the instrument with the context menu command "**Mean Tuning**". You will find that the instrument used in the example is 13.9 cents, or 3.5 Hz too flat. But this is not of importance at the moment, since the total intonation will be optimised through the tuning slide.

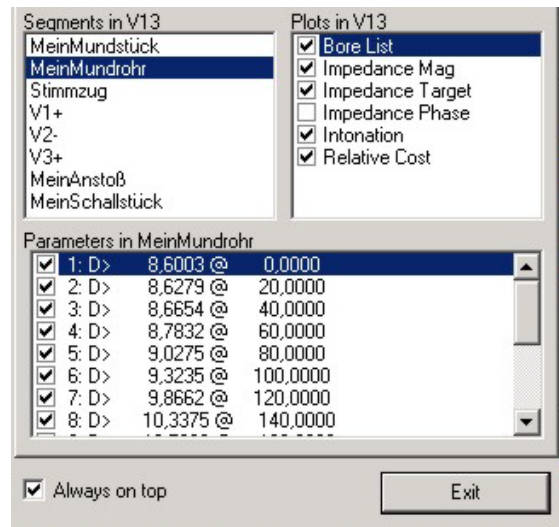
- ▶ Close the "**Specify Intonation Targets**" window by clicking "**OK**", and refresh the graphic viewer.

Tips for Using the Windows of the Commander Bridge

In the left-hand window named "**Segments in V13**" you find all used segments of the actual marked **Arrangement**, in the right-hand window of the Commander Bridge, named "**Plots in V13**", the following views are active or available:

With a check-box, you have:

- **Bore List** (geometry)
- **Impedance** Magnitude,
- **Target Impedance**,
- Impedance phase (not activated)
- **Intonation** and
- and the **Relative Cost**, which becomes relevant during the optimisation. This value stands for the entire optimisation success.



A double click on one of these elements shows its given color.

Beneath these two windows the window "**Parameters in xxx**" contains a short table of all in the actual marked Segment **activated** optimisation parameters (**coordinate values**).

- The letter **D** denotes a diameter parameter, while **X** stands for length parameters. Only for interest mark all **Segments** one after the other to see which optimisation parameters are active (marked with a green spot).

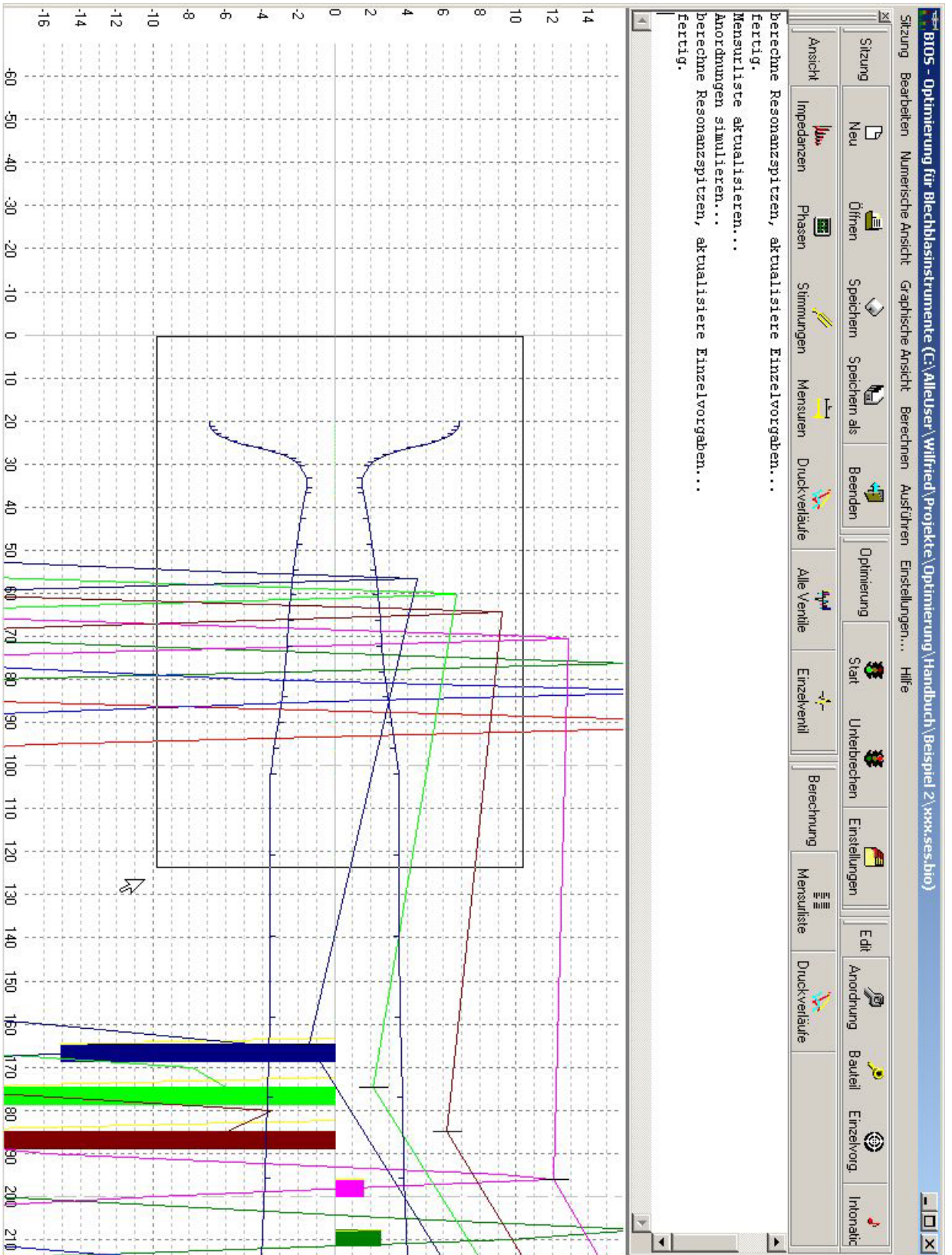
Tips for Using the Plot Window

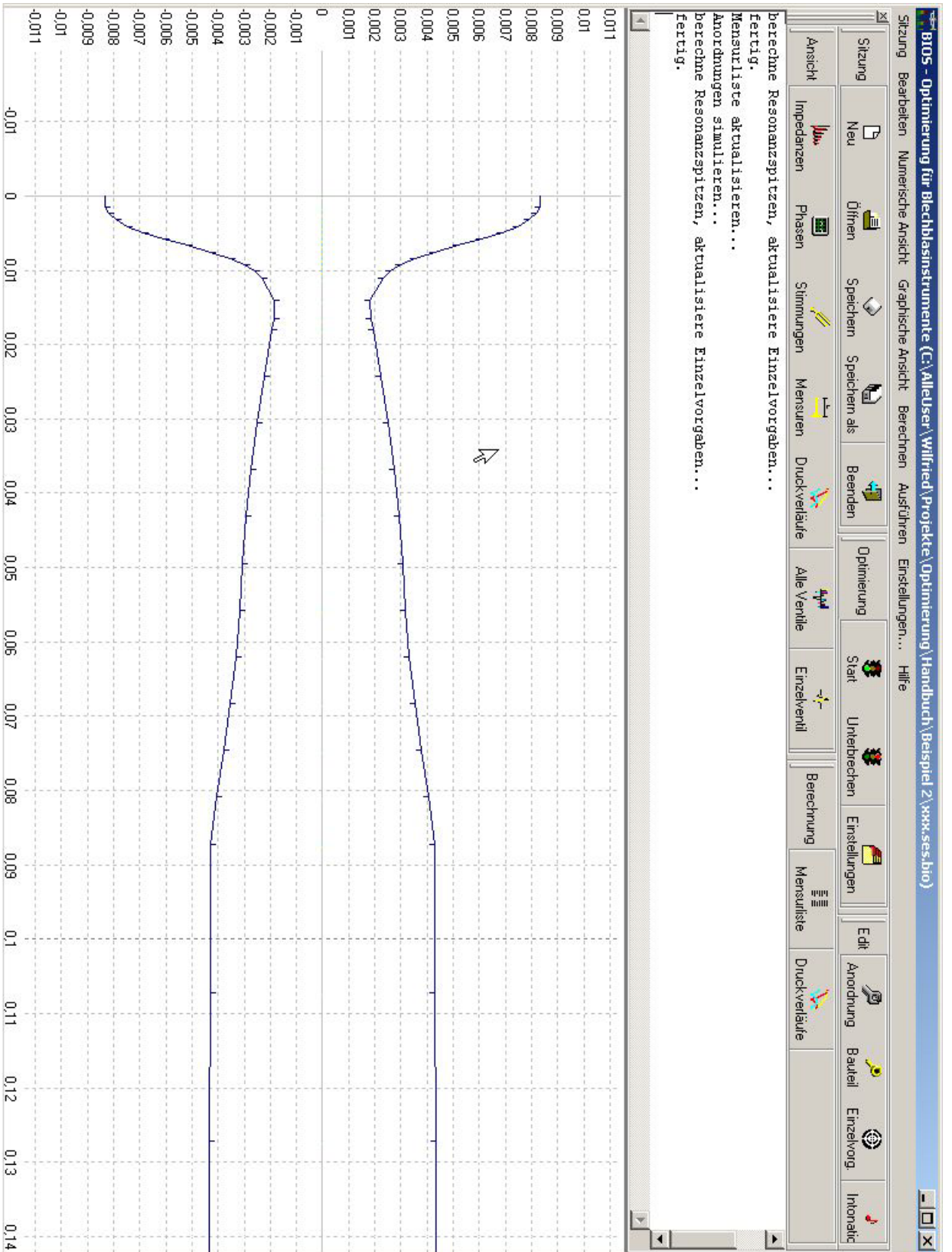
Graphic Display

- By dragging with the left mouse button, you may select smaller areas of the display in the **Plot Window** to zoom in and out. The areas of the display are then subject to the available commands (context menu).
- Enlarge the mouthpiece, for example (figure on the following page).
- If the button **Bores** is selected from the **Views** tool bar, the bore will be displayed in meters (see figure on the following pages).

► Now start the optimisation, as in the first example.

It is a good strategy to optimise at first only **V0**, **V1** and **V2** simultaneously. Therefore, deactivate "**Active**" and "**Plots**" for all the other Arrangements in the Commander Bridge.





- ▶ Interrupt the optimisation process again, if you think it is necessary to "smooth" the bore, modify the limits, recenter the parameters, and so on.
- ▶ Observe the distribution of weights and adjust them if the Intonation contribution should be increased.

PLEASE READ THE "GENERAL NOTES" SECTION ON THE NEXT PAGE.

- ▶ As soon as the optimisation of the three basic fingerings V0, V1, and V2 is satisfactory- in this example the maximum intonations error will be around 8 cents- we will fix the geometries of the **leadpipe**, **tuning slide** and **pipe** by clicking on the **green spots** in the Segment Editor. The spots become **red** which means these parameters do exist, but the Optimiser is not allowed to include them into the actual optimisation process.

The coordinate values are then no longer taken into account so that only the lengths of the valve slides will be altered to find the best compromise among all tones.

The calculation time increases with the amount of arrangements to be simultaneously optimised.

A good intermediate result for V0, V1 and V2 may be found in the session file "**Example Result V0 V1 V2ses.bio**". A usable result may be found with the file "**Example 2 Results.bio**".

The largest intonation errors of around 30 cents affect only the lowest resonances of the combined fingerings. Such deviations in the unweighted (!) intonation, when more than one valve is engaged, is difficult to avoid and quite common.

These deviations are not harmful because the harmonics of the notes are also determining factors in the intonation, and the "weighted intonation", which is much closer to the played intonation, becomes much better for the lower peaks. That is, as long as the resonances are as well in tune as in this example.

7 Appendix: Tools, Variables, Attributes...

General Notes on Optimisation Parameters

- ▶ The Variation Ranges (XRan, YRan) function not only to limit the parameter variations, but also to determine the step size of alterations at the beginning of the optimisation run.
- ▶ Sometimes, the optimiser can only function with larger steps to depart from a "local optimum" to reach a "more global optimum".

+

The optimisation is analogous to a ball which is released into a "hilly" area, and will continue to roll until it reaches the lowest point- the optimum. The ball will continue to roll as long as the floor of this area remains sloped.

The size of the ball, which is like the step size, is important because the optimiser should not get stuck in smaller indentations. If the optimiser remains stuck in one of these small valleys, it has reached a "local optimum" and gets bogged down: it gets stuck in a hole of its own size.

As long as the probe steps do not reach over the edge of the hole, the ball will remain stuck, even if the slope leading directly to the **global optimum** is right next to it.

- ▶ In this case, **increasing** the step size by increasing the **size of the dynamic variation** ranges will help.
- ▶ If, however, a satisfactory optimisation result seems imminent, smaller steps are advantageous: the surface is smoother and the optimisation will be finer. After finding the rough optimisation, the fine optimisation should follow.

Definition of Terms

Optimisation Targets

While optimising, it is always about making the differences between current values and target values as small as possible. Optimisation targets can be:

- ▶ **1. Intonation.** To be precise, the optimiser must dictate the exact frequency for each resonance peak (natural tone). You may take control over this parameter by clicking "Edit Targets" and entering a high Ohm value into the "TMag" column of the correct frequency (what is the correct frequency?).

This job is made easier by the Targets Assistant. It calculates the complete series of frequencies for all natural tones, relates them to an equal tempered scale and shows the deviation from the target. You only have to tell the Assistant if you want all or only some particular natural tones set to "ideal intonation" (Difference from the target = 0), or you enter the altered value in Cents. The Targets Assistant will then add the appropriate Ohm values in the target list.

- ▶ **2. Envelope (Response).** The envelope is the curve when all resonance peaks are connected. Because the height of the peaks influences the response (see BIAS Handbook: "Interpretation"), the response may be optimised by setting the peak targets as a certain amplitude. In general, it is desirable to have a set of relatively even peaks, with no extreme changes. As we know from measured instruments, the peaks in the region of the mouthpiece resonance should be highest and then will continually fall off to the right.

The target values for the peaks (natural tones) must be entered by the user in the **Edit Targets** window. A peak is easy to find, because it has the highest local Ohm values. Find the peak by looking in the second column Ohm values, then add the appropriate value.

- + There is a complex relationship between intonation and response. If you weight the intonation heavily, it may be, though not necessarily, that the response may become worse. Also, demanding a perfect response may hinder good intonation during the optimisation.

- ▶ 3. **SMOOTHNESS** and **STEADINESS**. The optimiser sees to it that the neighboring diameter values remain as similar as possible (smoothness), and / or change continuously to a larger or smaller value (Steadiness). This applies **not** to the impedance curve, but to the tube! Perfect smoothness would be a cylindrical tube, and perfect steadiness would be a conical tube.
- ▶ 4. **"MATCHING"** is absolute or relative. In this case, the target is to achieve two identical impedance curves. The Actual Value (act (Hz)) are the values of the current impedance curve, whereas the Target Values (tar (Hz)) are the values of a good instrument, for example. In this way, an instrument can be adjusted to the values (properties) of an other instrument (=cloning!). **Absolute matching** (remaining mismatch is calculated as difference between both impedance magnitudes) puts more emphasis on matching of impedance peaks while **Relative matching** (difference between both impedance magnitudes is normalised) results in better matching of impedance troughs. Both attributes can be used simultaneously. This way focus is equally set on both items, the peaks and the troughs. It is especially useful for the reconstruction of unknown bores.

As you may recognise with the words "**Intonation**" and "**Response**", the optimisation targets are named in musician's language. But the "Target" Intonation is in reality a complex of single targets and values. The optimiser must alter the bore in such a way as to allow specific impedance peaks for equally specific frequencies.

The main point is therefore always the **impedance curve**. Regardless of which type of optimisation target you choose, the process is always to adjust the bore construction as to match the impedances of the optimised instrument to the target. This is shown most clearly by optimisation target Nr. 4 (matching).

Take a look "behind the scenes", and you will find that "intonation" is always a matter of transforming the current impedance curve into the target curve. The progress of this process is viewable at all times with the help of the "Edit Targets" window, the Trace Window and the plot window.

A Quick Look Behind the Scenes

- ▶ Please take the time to load the session "MyValvedTrumpetStarting point.ses.bio".
 - ▶ Click on the button Edit Targets, and then on "Frequency Grid", in order to delete all targets listed.
 - ▶ Close the window with a click on "OK".
 - ▶ Start the "Intonation Targets" button of the commander, which will open an empty window.
 - ▶ Select "Reset Targets" from the context menu (right mouse button). You will now see a list of all the natural tones.

- ▶ Mark all entries, click on "tar [cent]" and select the default value of "0". You can now see that the 4th natural tone is at 470.19 Hz, but should be at 466.16 Hz.
- ▶ Close the window with a click on "OK" and click on "Edit Targets".

In this window, you will see nothing but the familiar BIAS impedance curve, but in the form of a list. The first column shows the frequency value (in 5 Hz grid), the second column shows the associated impedance value in Ohms. The third column shows the target value.

Lowest Frequency	Freq	Mag	TMag	Weights	Num	Flags
20	440,0000	22016,5467	-1,0000	1,000	1,000	0
Highest Frequency	445,0000	26851,5961	-1,0000	1,000	1,000	0
1800	450,0000	33466,4677	-1,0000	1,000	1,000	0
Frequency Increment	455,0000	43261,2986	-1,0000	1,000	1,000	0
5	460,0000	59248,5297	-1,0000	1,000	1,000	0
	460,8094	62780,7627	-1,0000	1,000	1,000	4 pred
	465,0000	87121,6293	-1,0000	1,000	1,000	0
	466,1638	95537,4478	116727,9851	1,000	1,000	4 maxmatch,center
	470,0000	116490,4736	-1,0000	1,000	1,000	0
	471,5803	114334,5774	-1,0000	1,000	1,000	4 succ
	475,0000	90604,7023	-1,0000	1,000	1,000	0
	480,0000	57318,2386	-1,0000	1,000	1,000	0
	485,0000	38394,9649	-1,0000	1,000	1,000	0
	490,0000	27159,0154	-1,0000	1,000	1,000	0
	495,0000	19738,1810	-1,0000	1,000	1,000	0
	500,0000	14393,8153	-1,0000	1,000	1,000	0
	505,0000	10296,5413	-1,0000	1,000	1,000	0

It's clear that the fourth peak (natural tone) is found at 470 Hz with 116,490.47 Ohms, and that the Intonation Target Assistant has set the target value at 466 Hz, where it should be.

See how the Targets Editor defines the target in this example:

What are "Attributes" and how are they applied?

- ▶ Because the target frequency, at which the natural tone should be found, is not present on the frequency grid, the Editor creates a new line with the target frequency 466.16 Hz.
- ▶ At the same time, the attributes "MaxMatch" and "Center" are assigned.

MaxMatch means that the greatest possible agreement between the current frequency and the target frequency is required during the optimisation.

Center affixes the center of the peak at the given frequency.

- ▶ As accompanying measures, the attributes "**pred**" and "**succ**" are assigned at a distance of about 6 Hz. Because the frequency 471.58 Hz is not present for the attribute "succ" in the current frequency grid, a new line with this frequency value will automatically be added.

The attributes "**pred**" (before) and "**succ**" (after) are internal attributes to generate peaks within the impedance curve. If as target only the impedance value is entered for a specific frequency (466 Hz, for example), this peak will be seen as a distinct line protruding from the impedance "landscape", without a continuous rise or fall before and after.

Attributes

Attributes are assigned to frequencies or frequency ranges to place the emphasis of the optimisation on certain characteristics of these frequencies or frequency ranges. They should not be confused with the **Variables** of the Segment Editor. The variables set limits for the stepwise alteration of the bore, whereas the attributes influence the way the optimiser works in adjusting to the target values (impedance curve).

- ▶ While the variables determine the way in which the optimiser alters the bore, the attributes, weights and progressions set the priorities within the targets and guide the optimiser to matching specific target values more or less.

AbsMatch If this attribute is set at a frequency, the optimiser will see to it that the desired impedance value is matched exactly to this frequency. The focus is on matching the peaks only. May lead sometimes to undesired "double peaks".

RelMatch this attribute makes the impedance dips (troughs) more important than the peaks.

MaxMatch If this absolute value is set, the optimiser will find (for example) the third peak and resolves it to the desired value.

MinMatch executes the same with the impedance dips.



Pred, Succ and **Center** were explained by the example on the previous page.

Widen If this attribute is set for a frequency range or peak, this peak will be widened (a broadened impedance peak gives more freedom to alter the pitch for that note).

Narrow This attribute narrows the peak.

- ▶ **How to assign Attributes.** Attributes are assigned for specific frequencies by marking the appropriate lines in the **Edit Targets** window. Mark then at first "**Add targets**" to add attributes or "**Sub targets**" to remove them, then mark the desired attribute by depressing the **Ctrl** key and clicking on the attribute (can be more than one attribute). Close the window with a click on "**OK**".

Weighting

In the Edit Targets window (see figure page 65), under the Header "Weights", two columns can be seen. For the present case, all values are set to "1".

The first field is for the "vertical" weights, which applies to "AbsMatch", "RelMatch" and "Maxmatch", and the second is for the horizontal weights, like "Center", "Widen" and "Narrow".

Here the weights can be entered that are valid for particular frequencies. For example, if the response (envelope) is particularly important between 300 Hz and 800 Hz, then set the vertical weight for this frequency range (in connection with MaxMatch) to a higher value.

- ▶ Simply mark the line(s), enter the numerals in the fields below the window "Attributes" and click on "**Apply Attributes**".

Optimisations Set to "Free"

What can be set to "Free" for Optimisation?

- ▶ the diameter at a particular position (a coordinate= support point) or in a range (more than one coordinate = support point)
- ▶ the length of one or more segments
- ▶ the temperature

Where do I set to Free?

- ▶ In principle all settings to Free are set for each Segment individually in the **Segment Editor**. The geometry of new segments is by default **not free**.
- ▶ Setting the temperature to "Free" is done with a click on the "Edit Parameters" button of the Commander Bridge, because unlike other segment-related parameters, the temperature is a "global" optimisation parameter.

How do I set to Free?

- ▶ Parameters are set to free by clicking the grey field next to the coordinate values.
- ▶ To set the length to Free: click the field next to the **final X-value**. If all X-values are set to Free, the optimiser is able to "move" these coordinates as necessary.
- ▶ To free the diameter: click the gray field next to the Y-value.
- ▶ A click on the XOpt or YOpt column header sets **all marked lines** to Free.

Significance of Colored Spots in the Control Fields

Coordinate List			
	X	XOpt	XI
	0,1		
	1,5		
	2,36		
	...		

Coordinate List			
	X	XOpt	XI
	0,1		
	1,5		
	2,36	●	1
	...		

Coordinate List			
	X	XOpt	XI
	0,1		
	1,5		
	2,36	●	
	...		

"No Spot" is the default setting. The value or coordinate is no optimisation parameter and not alterable by the optimiser.

"Green Spot": appears with the first click. Now, the value or coordinate is a parameter that the optimiser may change, according to the limits which appear in the neighboring columns.

"Red Spot": appears with a second click on the field. The value is an optimisation parameter but may not be altered until it is set to Free again at a later time.

With a third click, the field returns to the default value again, etc.

Active

There is another possibility to deallocate parameters on a higher level in the hierarchy, by using the Segment Editor found on the Commander.

It's valid for the **entire Arrangement**. A click on the Check Box "Active" removes the check mark and makes the segment off limits for alterations. It remains as a part of the instrument but will not be optimised.

Optimisation Variables in the Segment Editor

Besides the setting to Free of the fields XOpt and YOpt, you will find additional fields in which options can be set. That is, limitations for values will be set for the optimiser within which it may operate.

	X	XOpt	XRan	XTol	XMin	XMax	Y	YOpt	YRan	YTol	YMin	YMax
	0						8,6003395448		2%	1E-7	0	
	20		10%	1E-7	0	3	8,6279410718		2%	1E-7	0	0,5
	40		10%	1E-7	0		8,6653569531		2%	1E-7	0	0,5
	60						8,7027728345		2%	1E-7	0	

The Variation Ranges **XRan** and **YRan**

10% means that the optimiser may alter any value that is marked with a green spot by + or -10%. This is the default standard value, which quite useful to find the direction for an optimisation early on.

You may also set the variation range in absolute values, for example in mm. but the relative value in % has proven to be useful, for an alteration of 1 mm in the leadpipe is a significant change, where a difference of 1 mm at the bell is insignificant. Using percent settings you need not look if it makes sense at particular areas, absolute values are recommended only at special situations: for example length parameters.

Tolerance Limits **XTol** and **YTol**

These limits are set automatically to 1×10^{-7} , a very small number. During the optimisation process, the optimiser alters these values (=step size) continuously.

The afore mentioned minimum limits are meant to avoid that the optimiser continues in the same direction, even though the step sizes are much too small to cause significant improvements. If the variation ranges fall below this value, the optimisation process will be stopped.

Hard Minima and Maxima - XMin, XMax and YMin, YMax

If, for example, YMin is set to 4 (mm), the diameter may not fall below this value, and YMax = 13 means that the maximum diameter may not exceed 13 mm. Setting hard limits makes sense in some cases, especially where an instrument maker does not wish to exceed building limitations.

Watching the Optimiser at Work: the Trace Window

Watching the Optimiser at Work

The Trace Window is permanently visible during the progress of the optimisation. The successful, as well as the unsuccessful steps may be seen at any time, as well as the amount of **steps** and **runs** have been completed, and which limits have been reached, as well as how successful the entire operation has been up to the present, etc.

Using a single line, we will explain the significance of the individual symbols.

```

Parameter zentrieren...
Optimieren...
Start Value of Costfunction: 418,545978727485
Verteilung: Abgleich = 36%, Intonation = 64%, Glattheit = 0%, Stetigkeit = 0%
Schritt 1 31 {000000000000100000} Cost: 417,064 succ
Schritt 1 34 {000000000000100100} Cost: 413,851 succ
Schritt 1 36 {000000000000100101} Cost: 364,634 succ
Schritt 1 40 {000100000000100101} Cost: 362,239 succ
Schritt 1 43 {000100100000100101} Cost: 358,166 succ
Schritt 1 44 {000100110000100101} Cost: 356,265 succ
Schritt 1 48 {000100110001100101} Cost: 340,080 succ
Schritt 1 50 {000100110001210101} Cost: 329,482 succ
Schritt 1 56 {010100110001210202} Cost: 328,203 succ
Schritt 1 57 {011100110001210202} Cost: 318,485 succ
Schritt 1 60 {011201110001210202} Cost: 313,308 succ

```

First run in progress. One run consists of many steps.

Has achieved the 60th step (alteration) of this run.

```
Step 1 60 (011201110001210202) Cost: 313,308 succ
```

"Cost Function"
Level of success for the entire run.

this parameter is being altered at the moment.

each digit stands for an optimisation parameter. In this simple example, there are a total of only 18 parameters (for instance diameter values) to be changed. The numerals 0, 1, 2, and 3 are explained below.

- 0** =these parameters show no success
- 1** = a success: the value is at least one time better than before
- 2** = at least one failure since the previous successes
- 3** = this parameter obviously has no influence on the optimisation

How Does the Optimiser Proceed

Strategies

- ▶ The first run is always a "sounding" run. It changes the first parameter a tenth part of the given limit, calculates a new impedance curve, compares it to the target impedance, and determines if it is closer to the target than before.
 - ▶ If **YES**, then the next, another step in this direction will be attempted with an increased step size (for example, when the limit is 10%, the new value is altered 2%, if again a success then the next alteration is 4%, and so on)
 - ▶ If **NO**, an alteration in the other direction will be attempted with a step size only 1/3 as large.

- ▶ If a parameter is in danger of overstepping its limits, it won't be altered anymore in the current run.
- ▶ As soon as all parameters show a "2" (at least one failure since the previous successes), the run will be ended, and the whole coordinate system "turned around" to start the next run.
- ▶ All parameters that have reached their limits will be shown next to the cost function.
 - ▶ "Min" means that the step size has gone below the allowed limit, and
 - ▶ "Max" means the upper limit has been exceeded.

The figure below (from the Trace Window) shows how this applies to the 17th and 18th optimisation parameters.

```

680202,388 succ min 17 18
680183,729 succ min 17 18
680134,452 succ min 17 18
680013,472 succ min 17 18

```

- ▶ The "Cost Function" is a numerical value which is derived from the sum of all contributions. This value is therefore a way to judge the success of the optimiser's progress.

The cost function should decrease steadily during the process of optimisation, and the lower it is, the better the agreement between the current optimisation and the targets.

- ▶ When the "sounding" run is completed, and if the box for "Long Algorithm" is activated (Main Toolbar -> Options -> Rosenbrock -> Long Algorithm), the parameter will no longer be altered singly and one after another, but simultaneously and in combinations.

Editing and Shaping Tools in the Segment Editor

In practice, instrument makers use different tools to increase or decrease the diameter of the tube geometry. If a segment of the instrument is present in the form of a list of coordinate pairs (at position X a diameter Y), then an alteration which is quite easy to do with for example a hammer, can be rather complicated to represent the alteration in form of a bore list.

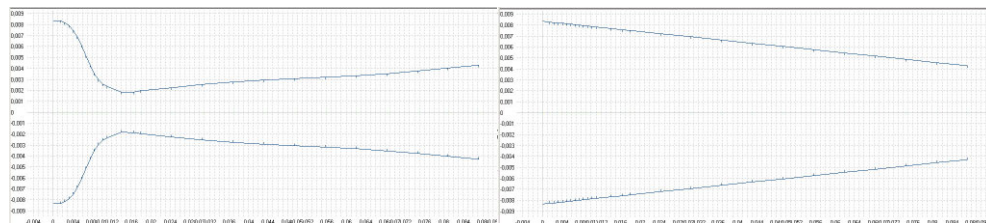
For this purpose, the Segment Editor has a few features to make this aspect simple and easy.

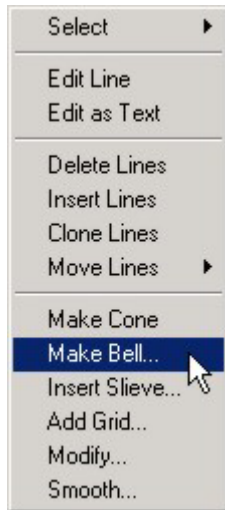
The advantage applies most of all to new designs, which can be created with just a few mouse clicks in a short amount of time. Until now, similar work took days or even weeks.

Use the following commands of the context menu:

- Make cone
- Make bell
- Insert sleeve
- Modify
- Smooth

Select	MAKE CONE
Edit Line	Mark all lines in the Segment Editor or just a part of them and use this command.
Edit as Text	
Delete Lines	The cone is determined only by the first diameter of the marked section, and by the last diameter.
Insert Lines	
Clone Lines	If you load the Segment "Mouthpiece", for example, and mark all lines, a conical segment will result, as shown.
Move Lines	
Make Cone	
Make Bell...	
Insert Sleeve...	
Add Grid...	
Modify...	
Smooth...	





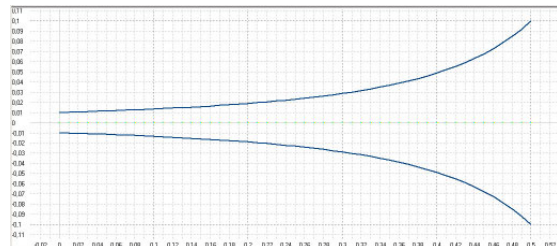
BELL DESIGN

This function allows the quick and easy design of the bell section form a tube that was simply a cone with beginning and ending coordinates (before executing "make bell" you have to add a grid!).

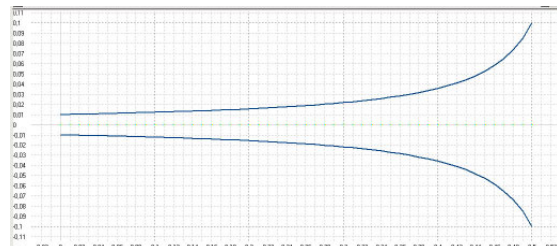
The following examples show the types of bells created by entering the values 0.5 or 1, 1.5 or 2 or 2.5.

Experiment with various values!

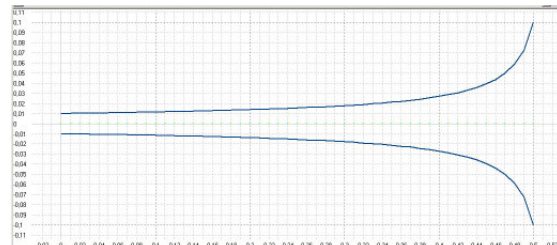
Hyperbola Order = 0.5



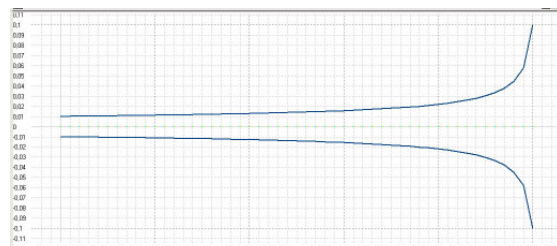
Hyperbola Order = 1,0



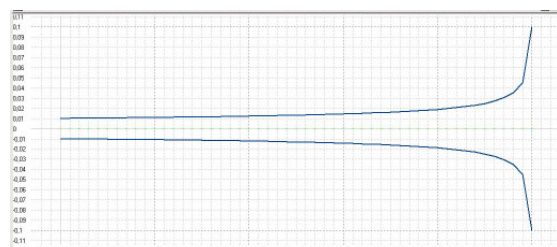
Hyperbola Order = 1,5

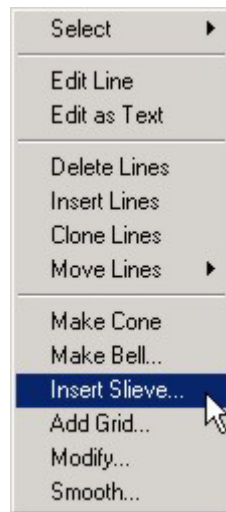


Hyperbola Order = 2,0



Hyperbola Order = 2,5





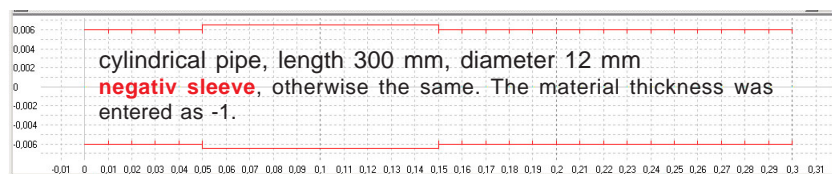
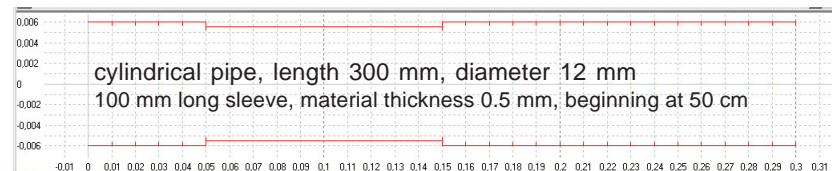
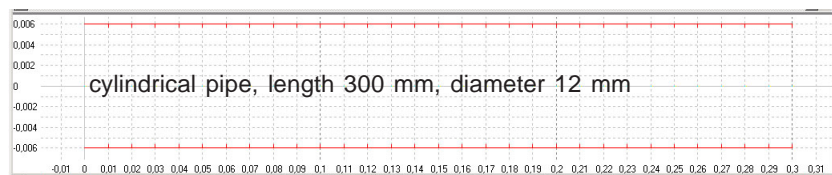
INSERT SLEEVE

In practice, sleeves are often inserted at certain positions to improve intonation. Besides, sleeves also appear at every point where one part of the instruments is inserted into another, such as at the tuning slide, etc.

In instrument making, inserting a sleeve is not difficult, but for bore lists, special knowledge and experience is required to define a Sleeve correctly. The "Insert Sleeve" Command" makes it simple. You need only enter:

- the thickness of the sleeve (2x the thickness of the wall material)
- the length of the sleeve
- the position in the tube at which the sleeve should begin (mark the appropriate lines)

The following figure shows a 10 mm sleeve beginning at centimeter 50 which has a thickness of 1 mm (that is, the material is 0.5 mm thick).



It is visible in the Segment Editor how the sleeve is defined in the coordinate list (see next page). As is shown by the green arrows, the diameter definition is given in **relative values**, as well as for the length.

Experiments have shown that the insertion of two or three sleeves with a length of four to five cm can result in a dramatic improvement of intonation.

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Definition of a sleeve of 100 mm length and a thickness of 0.5 mm (that means the combined decrease in tube diameter is 1 mm in total) beginning at centimeter 50 from the beginning of the tube.

	X	XOpt	XDyn	XTol	XMin	XMax	Y	YOpt	YDyn
	0						12		
	10						12		
	20						12		
	30						12		
	40						12		
	50						12		
	↑↓ 0)						↑↓ -1)		
	↑↓ 100)						↑↓ 0)		
	↑↓ 0)						↑↓ 1)		
	60						12		
	70						12		

Definition of a **negative** sleeve with a length of 100mm, a thickness of 0.5 mm, beginning at centimeter 50.

	X	XOpt	XDyn	XTol	XMin	XMax	Y	YOpt	YDyn
	10						12		
	20						12		
	30						12		
	40						12		
	50						12		
	↑↓ 0)						↑↓ 1)		
	↑↓ 100)						↑↓ 0)		
	↑↓ 0)						↑↓ -1)		
	60						12		
	70						12		

The sleeve tool is very flexible and offers many possibilities, like being reversible. Changes can be reversed (simply delete the 3 lines in our example).

A few of the possibilities are shown in the following example. We will again use a sleeve 100 mm long which begins at 50 cm (as on the previous page).

To allow the optimiser to adjust the position of the sleeve, put a green spot here.

To allow the optimiser to adjust the length of the sleeve, put a green spot here.

	X	XOpt	XDyn	XTot	XMin	XMax	Y	YOpt	YDyn
	0						12		
	10						12		
	20						12		
	30						12		
	40						12		
	50	●					12		
↑↓	0 >						↑↓ -1 >	●	
↑↓	100 >	●					↑↓ 0 >	●	
↑↓	0 >						↑↓ 1 >		
	60						12		
	70						12		

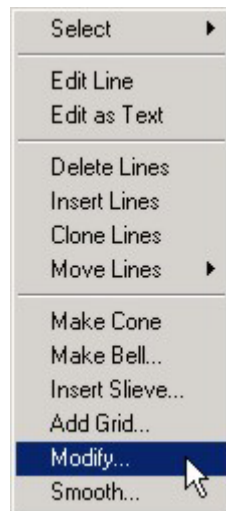
To set the thickness to Free, put a green spot here

In this case, the end diameter of the sleeve may not be entered as a relative value, as shown here. It must be an **absolute** value.

A green spot at this line allows a conical sleeve.

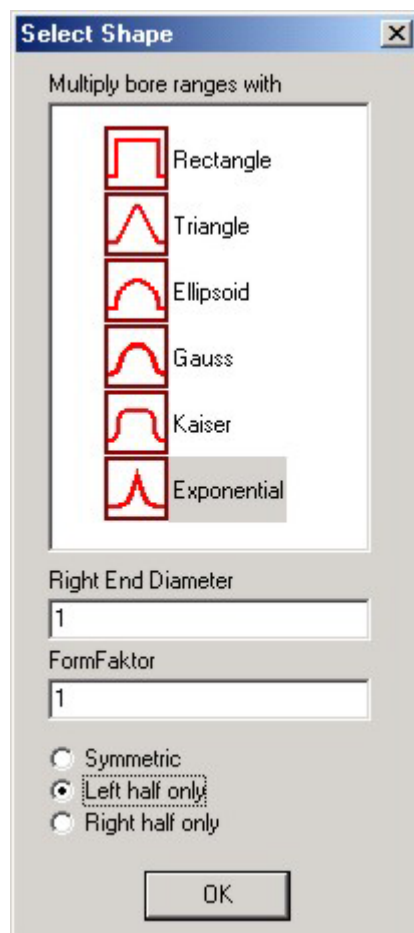
Please note that the sleeve lines will be added additionally to the list. The sleeve has a length of 10 cm and reaches in this case to cm 150, on top of the existing lines for 60 cm, 70 cm, etc.

- + This is not a problem, since the doubled lines do not have a green spot and are not active optimisation parameters. It would become a problem, however, if by accident the area between 50 cm and 150 cm is set as active. Therefore, this area may not be set to Free for optimisation at present.



MODIFY ...

The Modify function does not **replace** marked bore areas in the same way as the **Make Bell** command or **Make Cone**, but instead stretches or compresses the given bore to a selected form.



- The **symmetrical** editing functions allow the beginning and ending diameters to remain the same, while making changes to the bore in between.

- The function "**left half only**" stretches or compresses the bore at the right end of the selected areas. The function "Right half only" alters the left areas while leaving the right side unaltered.

- Some editing functions (like **Gauss**, **Kaiser** and **Exponential**) require the entering of additional form factors, which influence the shaping of the tool. The form of the tools can be seen in the figure.

The following examples show how these tools are applied to a:

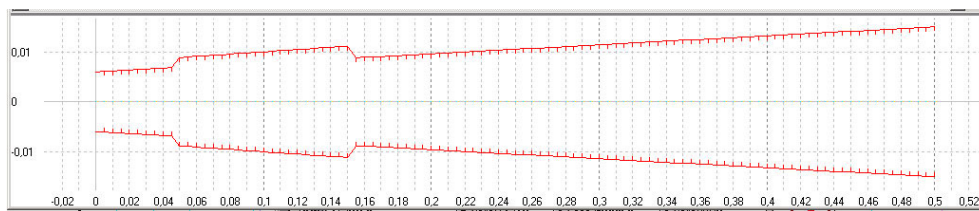
- 300 mm long cylindrical pipe (diameter 12 mm), and a
- 300 mm long conical pipe (beginning diameter 12 mm, ending diameter 30 mm).



RECTANGLE

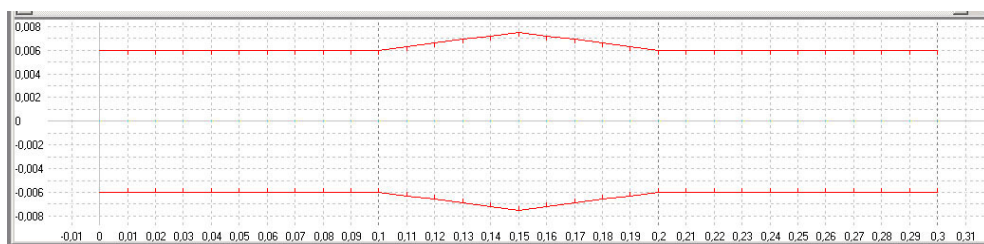
This tool functions similarly the sleeve tool in the case of a cylindrical pipe. The difference is that it is also useable for conical pipes. The example below was created in the following way:

- conical pipe $L=500$ mm, $D_B = 12$ mm, $D_E = 30$ mm.
- Lines from 50 mm to 150 mm are marked
- Value = 20 is entered

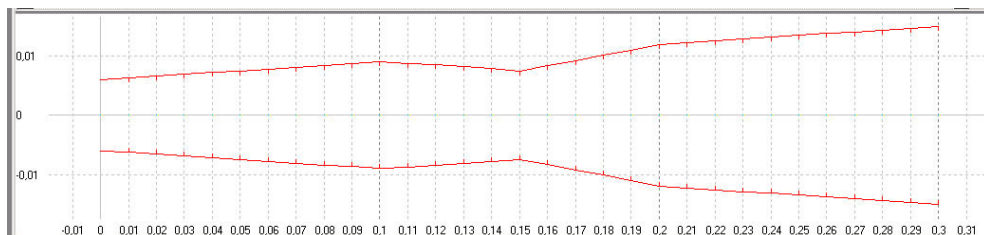


TRIANGLE

Both tubes, cylindrical and conical were marked from 100 to 200 mm and a value of 15 entered .



For the conical tube, at the middle of the marked region, the original diameter is larger than the entered diameter, therefore the 15 mm means a constriction of the actual bore section.



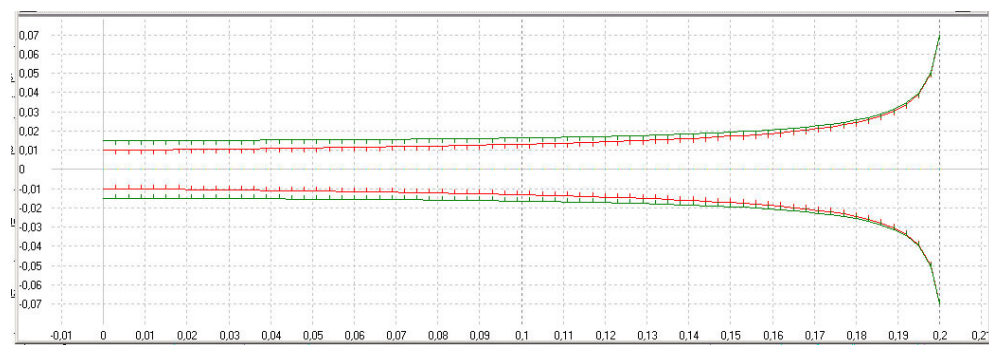
An example of practical application:

You have a bell with a beginning diameter of 20 mm and an end diameter of 14 cm. For different reasons, the beginning diameter should be 30 mm.

With the triangle function (in this case asymmetrical!), you can expand the beginning diameter of the bell without influencing its shape.

- ▶ Load the segment with the bell in question.
- ▶ Select the context menu command "**Shape**" -> "**triangle**".
- ▶ Select "**right half only**" and enter 30 mm for the "**left end diameter**".

The results look like the following picture.

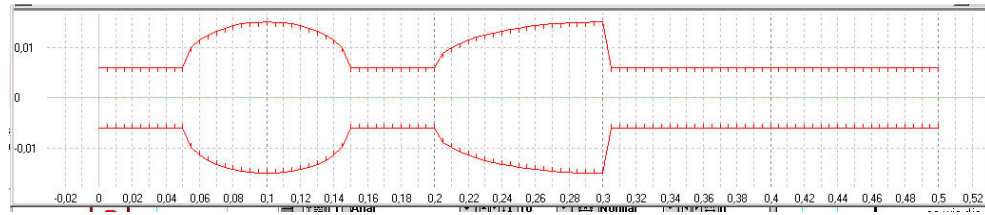


red= the original bore
green = the expanded bore

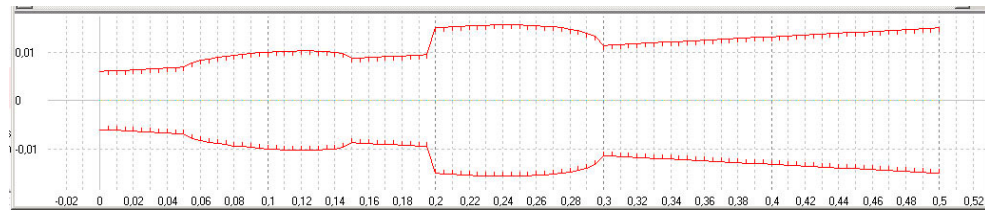


ELLIPSE

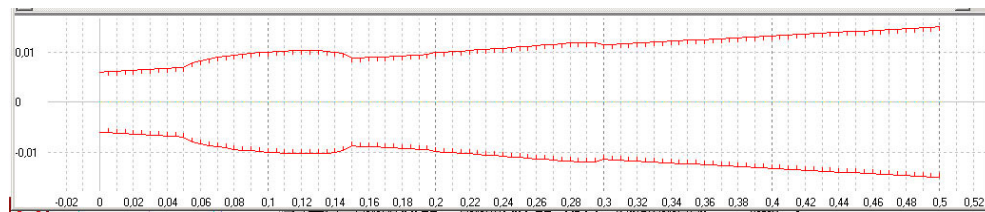
A value of 30 mm was entered for the maximum diameter (exaggerated). The function was executed as "symmetrical" at the length between 50 and 150 mm, at 200 up to 300 mm the function was entered as "left side".



With the conical tube, the same was done, but the maximum diameter was entered as 20 mm, and "right side" was entered for the length between 200 and 300 mm. In that case the left end diameter was specified as 30 mm.



In the next figure, the segment between 200 and 300 mm was modified once again by setting the left bore diameter to the same value that the tube has at 200 mm. The tube was stretched to a maximum value of 20 mm from the actual diameter, according to the entered diameter.

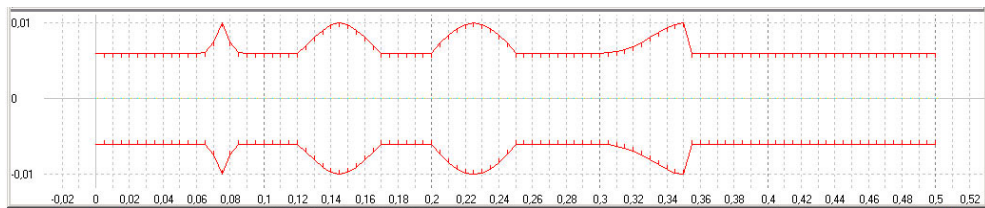




GAUSS

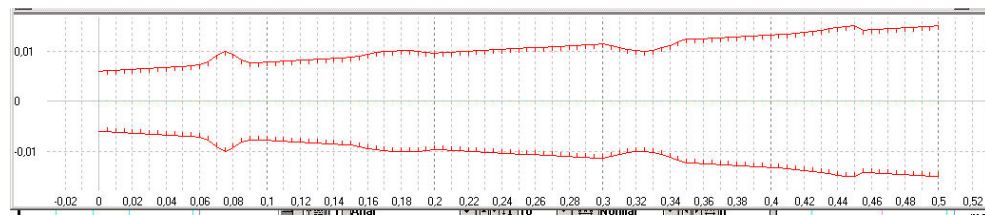
With the first three forms from left, the option "symmetrical" was selected. For these examples, the diameter value was set at 20 mm, and the applied range was set at 2 cm for the first form and 5 cm for the others.

- Form 1 (from left): Form factor 5
- Form 2: Form factor 1
- Form 3: Form factor 0.5
- Form 4: Form factor 1, "left half only", right end diameter 20 mm.



With the conical tube, the tools were applied to a length of 5 cm. The first form (from left) is exactly the same as the cylindrical pipe, with the exception of the application area.

- Form 2: Form factor 1, symmetrical
- Form 3: Form factor 0.5 symmetrical. Observe that the entered maximum diameter is smaller than the actual diameter, creating a constriction.
- Form 4: Form factor 2, "left half only", right end diameter 30 mm (which is close to the actual diameter).



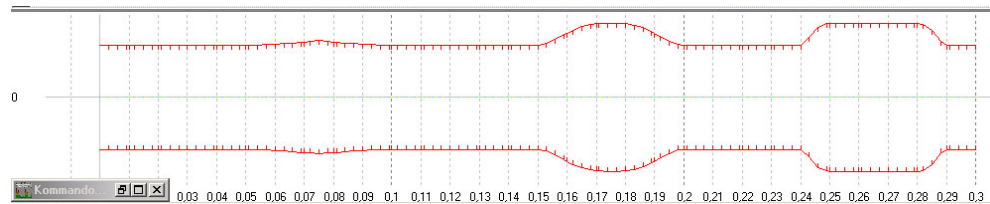


KAISER WINDOW

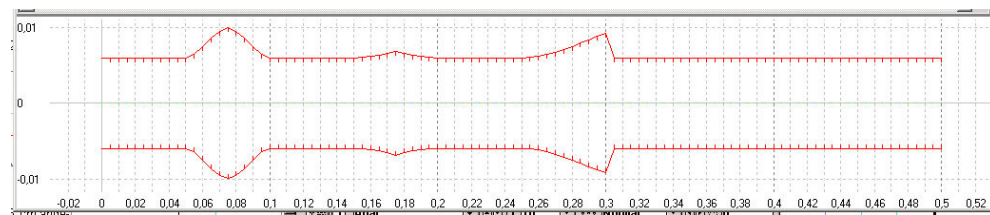
This mathematical function can be used to create "soft sleeves". In contrast to the other examples, the diameter here was expanded to 17 mm.

Form 1: Form factor 1
 Form 2: Form factor 10
 Form 3: Form factor 60

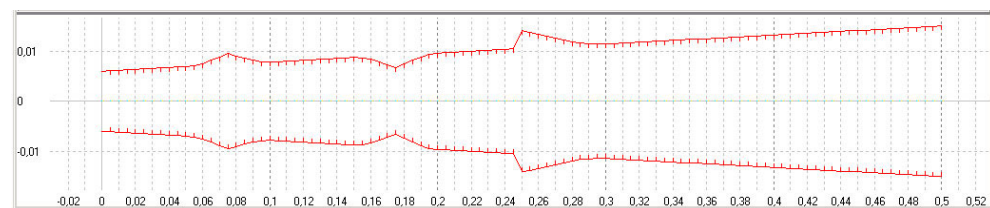
With Form Factor 1, the expanded diameter of 17 mm is not fully achieved. Only at Form factor 10 does it apply for a length of 15 mm. The higher the factor, the steeper the border. (Factors of 200 to 300 are certainly possible).



Form 1: symmetrical, diameter 20 mm, Form factor 6
 Form 2: symmetrical, diameter 20 mm, Form factor 1
 Form 3: left side, right end diameter 20 mm, Form factor 3



Form 1: symmetrical, diameter 20 mm, Form factor 3
 Form 2: symmetrical, diameter 12 mm, Form factor 3
 Form 3: right side, left end diameter 30 mm, Form factor 3

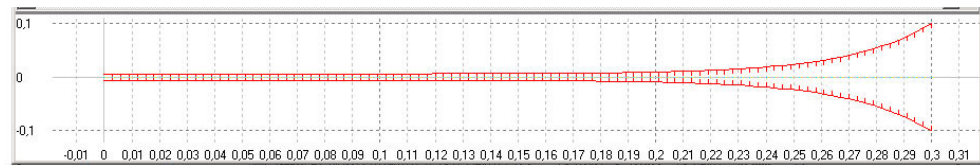




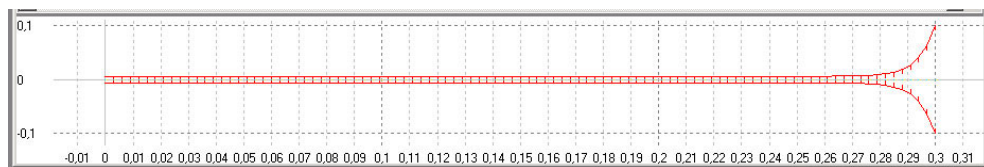
EXPONENTIAL

The exponential function kann be used for the creation of bells. Deactivate the "left side" and select the desired (right) end diameter. The larger the factor value, the steeper the slope.

Length 300 mm, 12 mm diameter, 200 mm end diameter. **Form factor 10**



Length 300 mm, 12 mm diameter, 200 mm end diameter. **Form factor 50**.

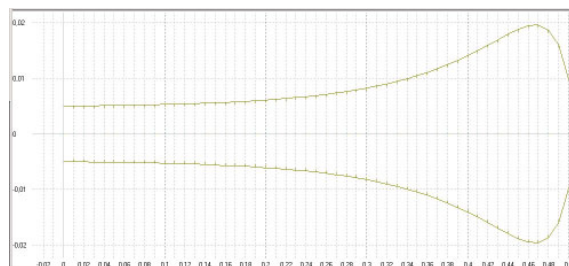


Note: The exponential factor is used world-wide in the design of loudspeakers, because it guarantees an optimal adaption to the room, giving optimal radiation characteristics. There are two important aspects to remember in instrument-making, however. On one hand, an optimum radiation is desirable, on the other, that the standing wave within the instrument will lose more energy in this case. The player must play harder (add more energy), and the synchronization effect with the player's lips for support is weaker.

As far as the form of the bell is concerned, the entire world is divided: there are avid devotees of both hyperbolic and exponential forms. A few focused experiments- which have unfortunately not yet been made (because there was no appropriate designer tool available?) could clarify this point.

To become familiar with the possibilities offered by these tools for modifying the bore, start a new session. Start the Segment Editor to define a new Segment. Name the new file as you wish, "a_trial", for example.

- ▶ Mark the coordinate line and select "**Clone lines**" from the context menu.
- ▶ Change the coordinate values to create a 500 mm long tube with a diameter of 10 mm. Mark both lines and create support points every 10 mm as a grid by using the context menu command "**Add Grid**"....
- ▶ Mark also the new lines by using the grey field in the left upper corner of the table (means "mark all") and continue to edit the tube.
- ▶ Select **Modify...** from the context menu and mark the the icon of the form "**exponential**" (for example), and "**left half only**".
- ▶ Enter a Form factor of "**5**" and an end diameter of **60** mm. Then select "OK".
- ▶ Mark the last 12 coordinate lines and repeat the process with an end diameter of **20** mm.
- ▶ Observe the results by creating a new Arrangement and using the newly created Segment. Click on the button "Bores" of the main tool bar to see the result (Make sure, that "bore list" in the right sub window of the Commander Bridge is activated). Figure below.



Select Shape
✕

Multiply bore ranges with

Rectangle

Triangle

Ellipsoid

Gauss

Kaiser

Exponential

Right End Diameter

FormFaktor

Symmetric
 Left half only
 Right half only

OK

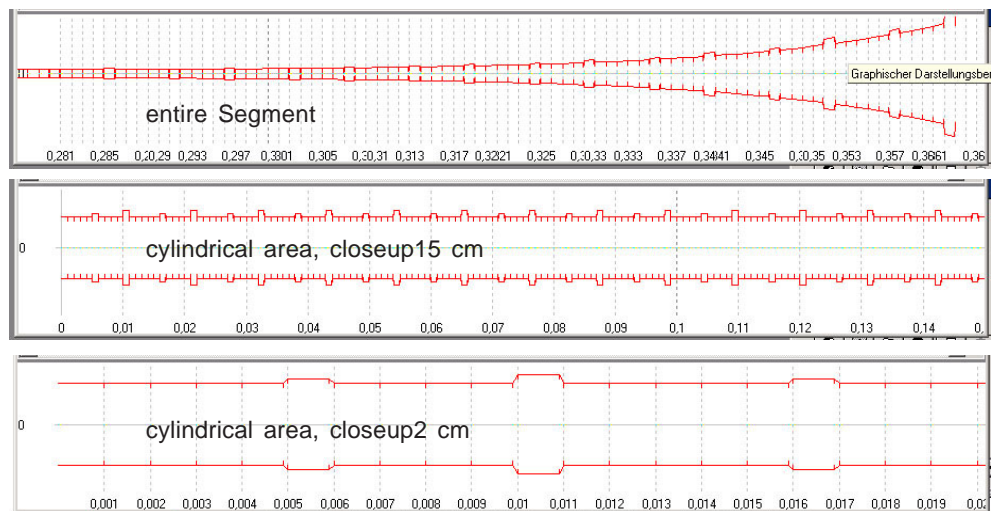
SMOOTH

The function of the **Smoothing Tool** is comparable to sand paper, where the **Smoothing Factor** is the **Grade**. The higher the factor, the rougher the grade of the sandpaper.

- + During optimisation, "ripples" will constantly appear in the bore. In this case, smoothing the bore is recommended, after which the optimisation should be resumed. This manual adjustment usually results in better intonation and response.

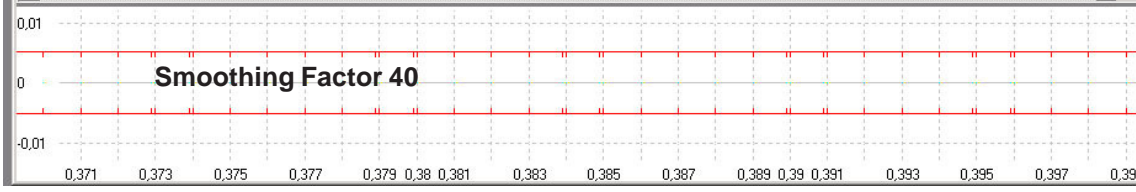
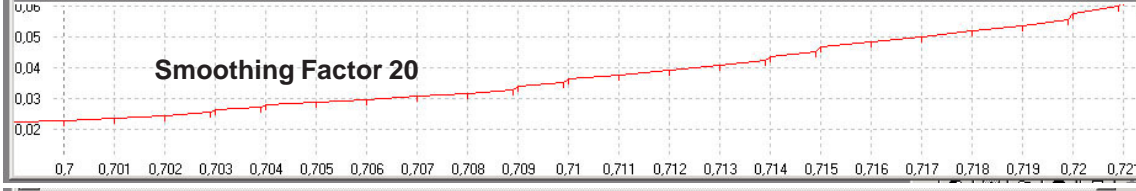
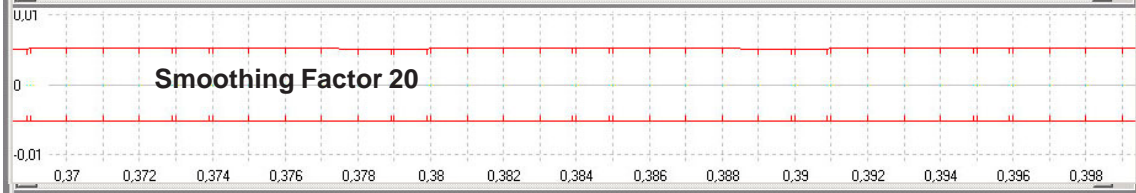
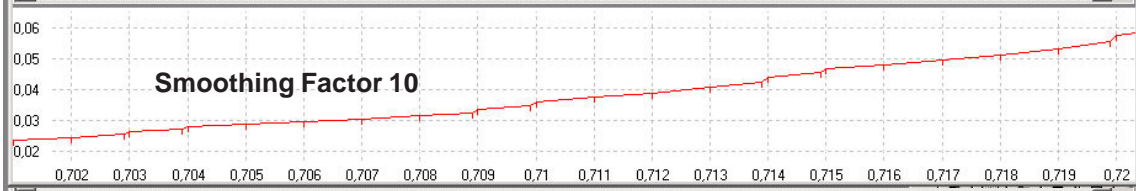
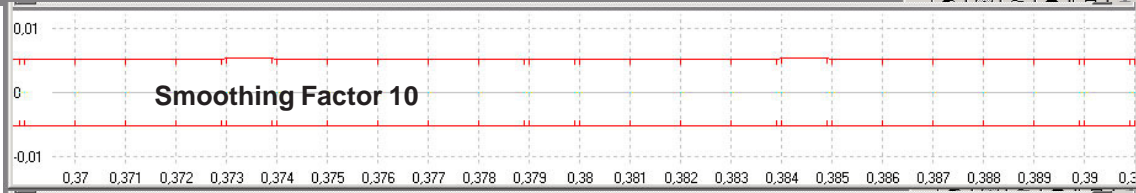
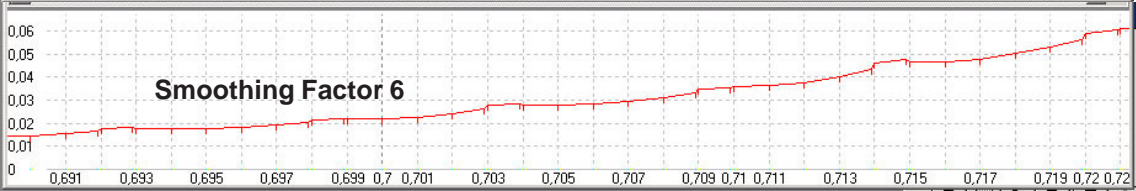
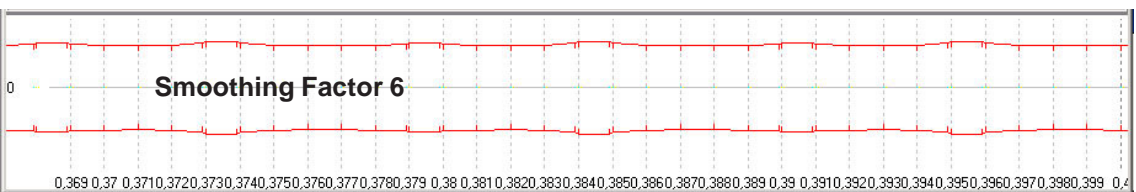
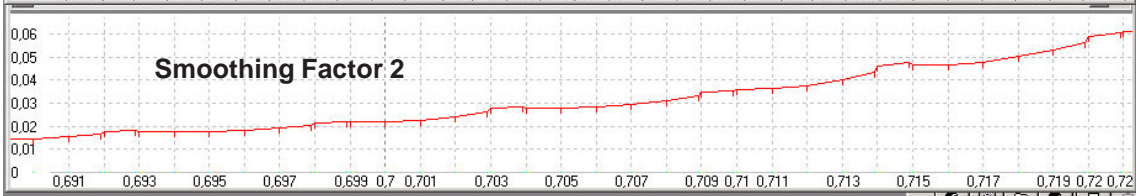
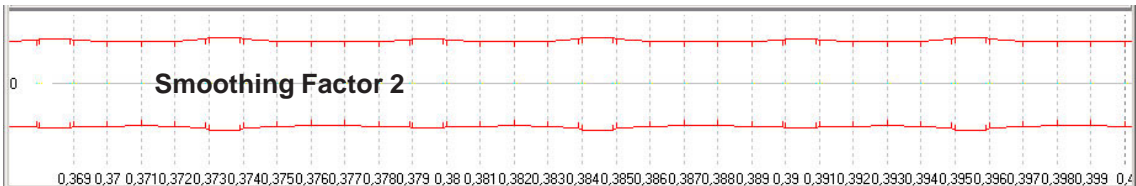
As a demonstration, we will observe a segment which is similar to a bell with a diameter of 10 mm, and that widens to 16 cm at the end. This will show the smoothing function on cylindrical and hyperbolic bores.

In this Segment, at 5 mm intervals, lengths of 1 mm were alternating widened at 10% or 20%. The length of the flank of the enlargement is always 0.1 mm and relatively steep (see closeups).



In this Segment, various smoothing factors were applied, namely : 2, 6, 10, 20 and 40. The next page shows a closeup of a section of the Segment from the cylindrical and hyperbolic areas. The vertical grid lines are always 1 mm.

It can be seen that the cylindrical part of the tube is nearly flat with a factor of 20.



8

Internal Distribution of Air Pressure

A further function of the optimiser is the calculation and display of the positions of pressure nodes and antinodes for each note within the instrument. This function is related to the Intonation Targets assistant.

- ▶ As a precondition there must be an arrangement active.
- ▶ Click on the button "**Intonation Targets**". This assistant then calculates the natural tones and displays them.



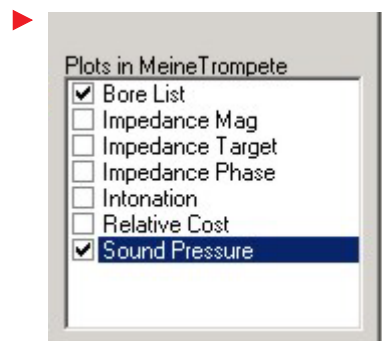
In the Intonation Targets window, you may choose for which notes you would like to see the pressure distribution inside the instrument. If not all natural tones are displayed (depends on the selected settings before), with a right mouse click on "**Reset Targets**", will display the entire amount of tones again.

If you want to see the pressure distribution for only specific notes, delete all unnecessary lines (mark the lines and use **Del**). Close the Intonation Targets window with a click on "OK".



Click on the button "**Pressures**", from the section "**Calculate**" of the tool bar. In the following window, you may select the resolution of exactness during the calculation. The default value is for a resolution of 1 mm, and should be sufficient.

- ▶ In order to see the pressure distribution in the plot window, click on the button "Pressures" - but now in the "**Plot**" section of the tool bar.



It makes sense to plot the bore also, with which you can locate the areas of pressure nodes and antinodes of the standing wave inside the instrument. In principle, the impedance curve and intonation bar graph may also be activated. But the more plots that appear, the less clear the plot window will become.

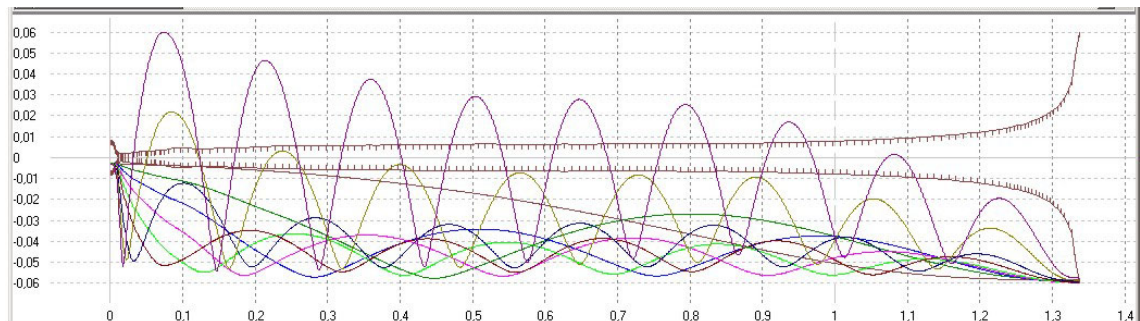
To get what you want, activate the appropriate option in the right window of the Commander Bridge (see figure).



With a click on "**Single Arrangement**" in the main toolbar ("**Plots**"), the marked data in the Commander Bridge window will then be plotted. In this case, the sound pressures and the bore are plotted.

With the "zoom" function, it is easy to see the relatively complicated series of pressure nodes and antinodes that occur in the leadpipe. The significance of these distributions for the correction of intonation is discussed in "Physical Modeling" chapter of the BIAS Handbook.

The next figure shows the sound pressure distribution for the natural tones 1, 2, 3, 4, 5, 6, 8, and 10, plotted over the bore.



9

Example 3: Bore-Reconstruction

Reconstructing the Bore of an Instrument using a BIAS Measurement

In this example, we will reconstruct the bore of a natural trumpet, whose input impedance is known by a previous BIAS measurement. This process saves complicated mechanical measurements, and can enable the creation of good basis geometry for subsequent optimisation, even if the bore is only imprecisely known.

In other words, the instrument is measured and you want to derive the exact bore geometry from the data. To do this, load the BIAS measurement in question as the "Target" and enter the bore list of a similar instrument (in the form of a 'flat' bore list, or in the form of an Arrangement).

Load a similar Bore as a Point of Departure for the Reconstruction

▶ Start the optimiser and open the session with the results of Example 1. You will find the appropriate file in the file folder *OptimiserDemo* of your installation data.

As a point of departure, an instrument (=bore list) very similar should be used. The better the similarity, the faster the optimiser can find a useful agreement between the theoretical impedance of the reconstruction and the measured impedance of the original instrument.

▶ Because the bore is altered during the optimisation, first create a flat copy of the departure bore list (arrangement). In this way you can compare (if you want) the original dimensions with the new reconstructed (=optimised) dimensions.

Create a Copy of the Departure Bore List to Compare the Results Later

▶ For this purpose, use the Commander context menu commands "**Arrangement -> Clone**" and "**Arrangement->Flatten**".

▶ With the command "**Arrangement-> Rename**" you can save the copy of "Copy (1) of Mytrumpet" as "DepartureVersion" Deactivate the box "**active**" to disallow changes to this arrangement.

▶ The new arrangement consists now of a single Segment. Use the command "**Referenced Segment-> Rename**", you may rename the segment "Mytrumpet (flat)".

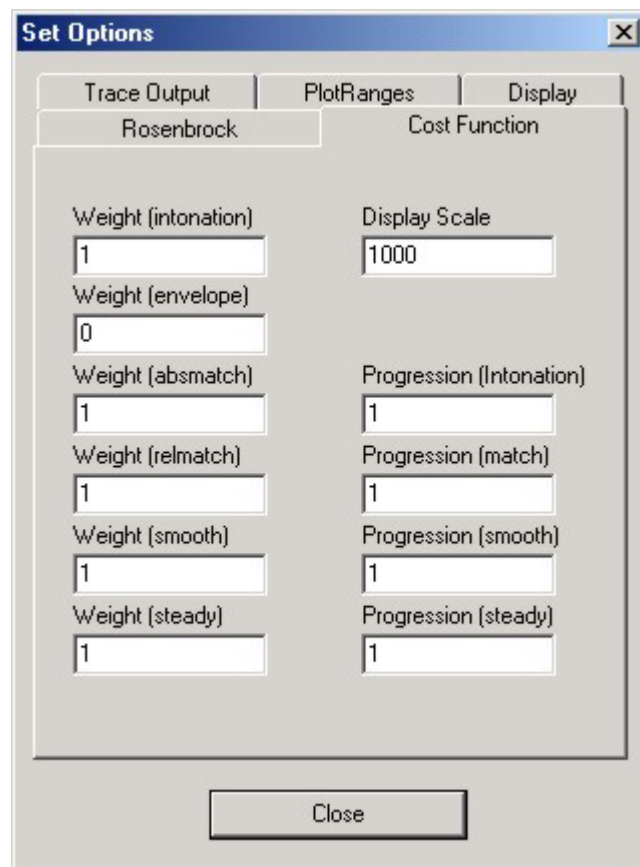
▶ Activate the **display box** of the bore list so that you can continually compare.


Load Impedance Curve of the Instrument to Reconstruct its Bore

- ▶ Change now to the **active arrangement** (the previously loaded bore list of a similar instrument which should become the reconstructed bore list). Start the **Edit Targets** window by selecting the appropriate button on the Commander Bridge.
- ▶ Load the **Target** with the help of the command button "**Matching Target**". Select the BIAS measurement "B-Trumpet-V0.bia" from the installation folder. The data-type "Bias-Files" must be selected in order to see the files from this window.
- ▶ Click on "**OK**" and start the Intonation Targets assistant. Set the target values for the natural tones 2,3,4,5,6,8,10 to +6,+11,+15,-7,+7,-18 and -9 Cents. Those are the unweighted intonation values for this trumpet, based on the BIAS data (mark the appropriate line, use the context command "**Enter Cent Target**" and enter the Cent value. If the 9th natural tone also appears, delete it by marking the appropriate line and entering "**Del**").

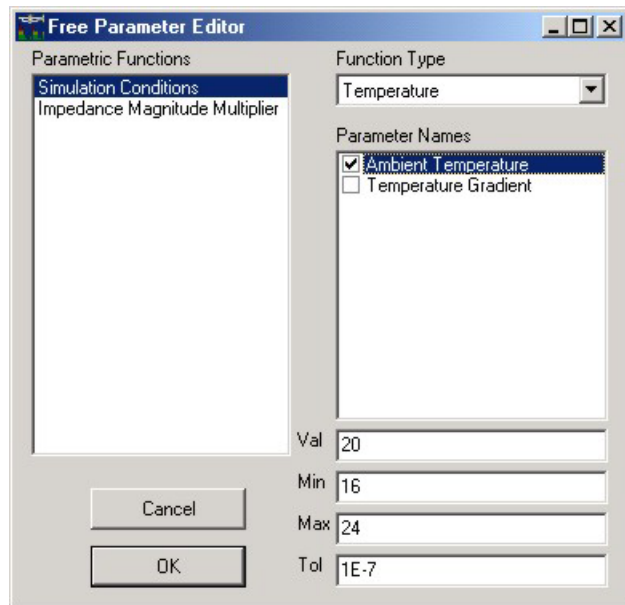
Set Optimiser Options and Prepare Segments for Optimisation

- ▶ Select **Options** from the main toolbar of the optimiser and there "**Rosenbrock**". Set the step limit to 5000 and the iterations to 200. This means that the optimiser will make a maximum of 5000 steps during a run, and its work will be limited to 200 runs.
- ▶ Now change to "**Cost function**" and set the weight of "**MaxMatch**" to **0**. Instead of this, we have a target impedance, which should be matched. That is, the weights for "**absmatch**" and "**relmatch**" should be set to "**1**". Set all other weights to "**1**" also as well as all "**Progressions**", at least for the moment, and close the window.
- ▶ Add a 10 mm grid of support points in the Segment Editor for the Segment "**Mypipe**" (mark all, right mouse, Add Grid).
- ▶ The leadpipe should also have a 10 mm grid added.

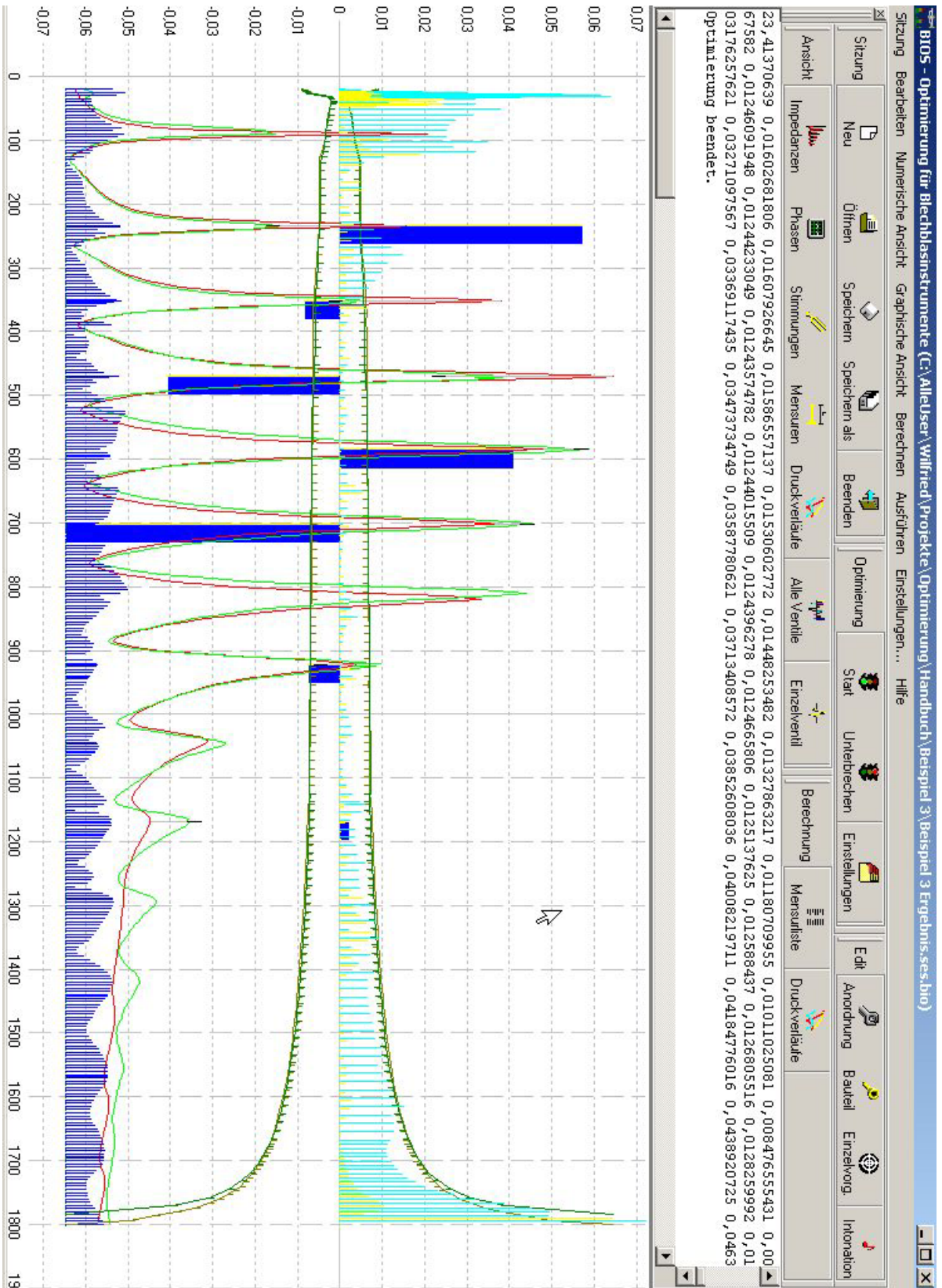


- ▶ The last 10 cm of the Segment **bell** should have a 5mm grid. The many support points slow the optimisation down, but will prove necessary.
- ▶ Mark all the lines in all segments and make the diameter to an optimisation parameter (click on the header of the column **YOpt** -> green spot) with a dynamic range of **1%** (click on the header of the column **YRan**, -> enter value). The small range is sufficient, since no large changes to the geometry are to be expected.
- ▶ Activate for all lines "**smooth**" and "**steady**".
- ▶ Start the optimisation.
- ▶  Open the Option window. Set the weights higher, especially for the intonation, until the intonation contribution to the cost function (see protocol window) is more than 50%. Interrupt the optimisation repeatedly to manually **smooth** the bore and to **recenter** the parameters.
- ▶ You will make the "final touches" by using the Commander context command **Arrangement -> Flatten**. A flattened Arrangement allows the filtering of the entire instrument and removes unnatural leaps in the bore of the segments. Because it is now impossible to set the length of the tuning slide to Free (because it's no more an independent segment), it is advisable to include the temperature as a parameter into the optimisation.

- ▶ Start the Parameter Editor with a click on the Commander button **EditParameters**. Check the box activating the absolute value of the temperature "**Ambient Temperature**" and allow a few degrees variation range up and down (simply accept the default values). This allows the program to find an optimal total intonation, without altering the length of the instrument.



With some experience and skill you will achieve a perfect agreement with the intonation of the reconstructed instrument. Therefore the resulting bore list is the reconstructed bore list of the measured instrument (see figure, which can be loaded as the file "Example3results.bio").



Some annotations to the figure (reconstructed bore list) on the previous page:

- ▶ The absolute values in the middle range of the impedance curves fit quite well. The higher frequencies show a weaker radiation from the measurement data than from the theoretically derived data, which leads to the conclusion that the bell model is not the ideal interface between the end of the tube and the air. The low frequencies show a deviation in the other direction.
- ▶ Careful calibration of your BIAS measurements helps to ensure that deviations between measured data and data derived from the optimiser are kept to a minimum. It is important for the calibration that the mouthpiece and the calibration volumes are centered exactly onto the measuring head, and that the seal is completely airtight. Even the smallest air leak is visible in data for low frequencies.
- ▶ Treat the rubber parts of the measuring head with rubber care products from time to time to keep them flexible, smooth and airtight. Note that the acoustics of the room also play a role in the high-frequency range.
- ▶ Measure in a quiet environment and avoid pointing the bell at walls and other reflecting surfaces. A sound-absorbing curtain at a distance of about three meters would be an ideal place to point the bell during a measurement, and will help create reproducible data.

A "Nice" Demonstration

Start the optimiser and load "Trumpet Bell from Tube Reconstruction Demo.ses.bio".

In this example, the optimiser is given a cylindrical pipe as the point of departure, from which a particular bell shape should result, based on a measured impedance curve.

It's the optimiser's task to match the impedance of the cylindrical tube to that of the target impedance of a measured trumpet bell.

That is, the optimiser attempts to alter the bore of the tube until the impedance is matched. If the process is successful, the cylindrical tube will naturally take the shape of the original bell.

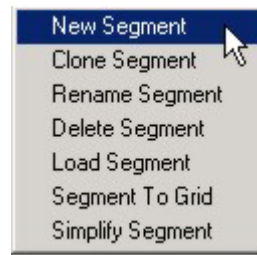
10

APPENDIX

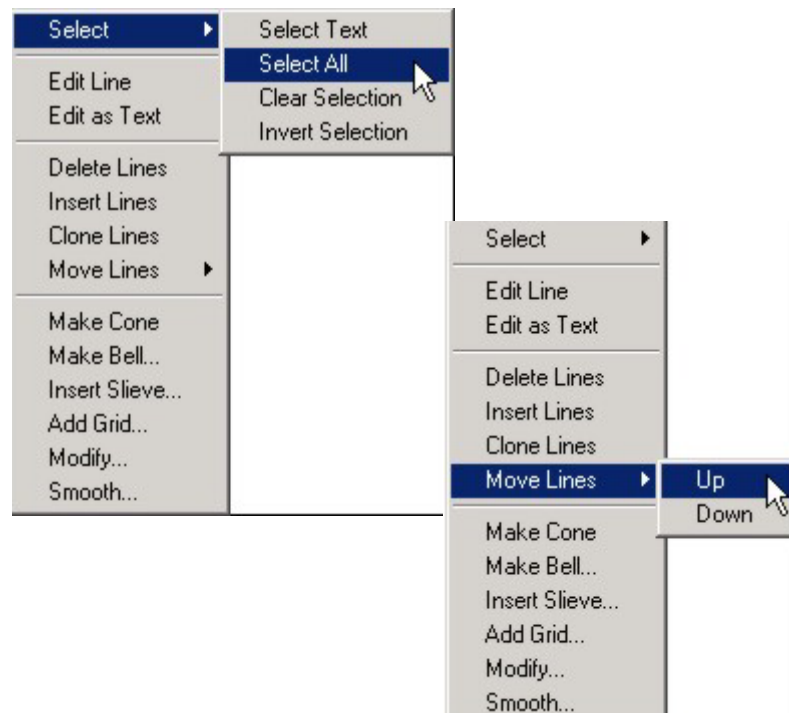
Context Menu

Commands available with a right mouse click

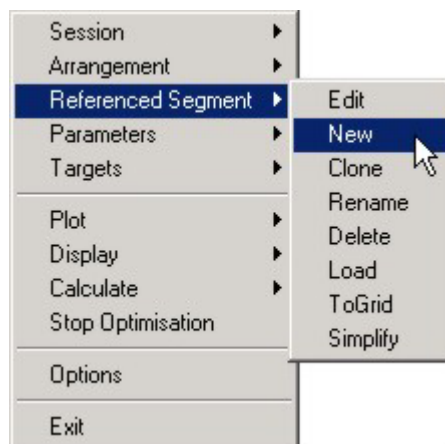
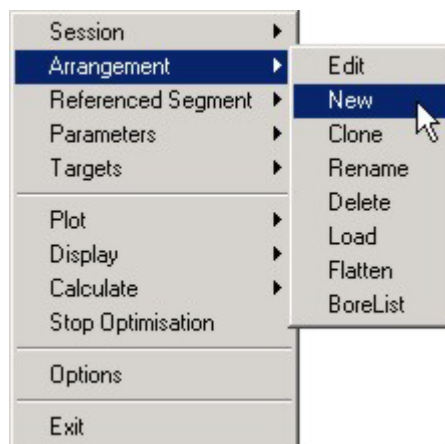
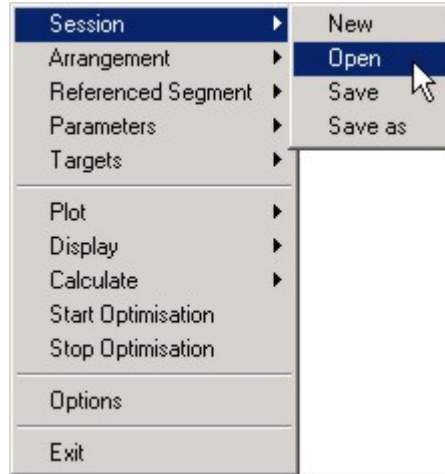
Segment Editor in the upper area:

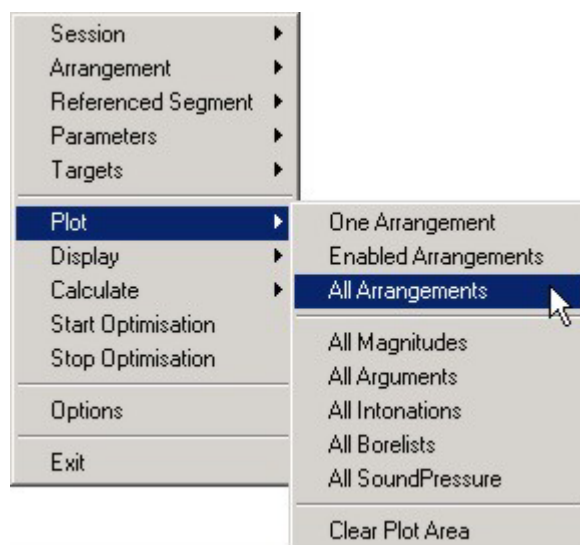
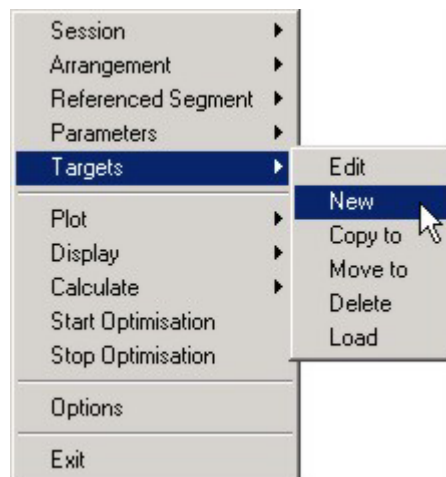
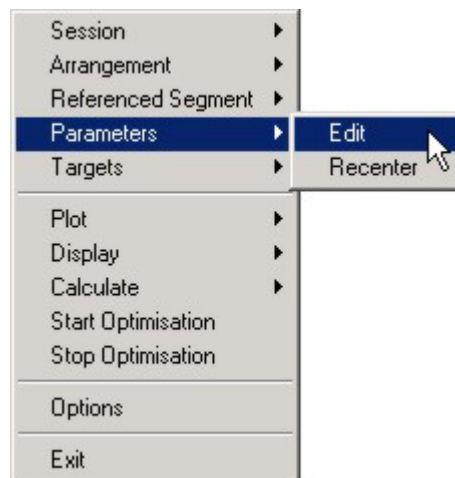


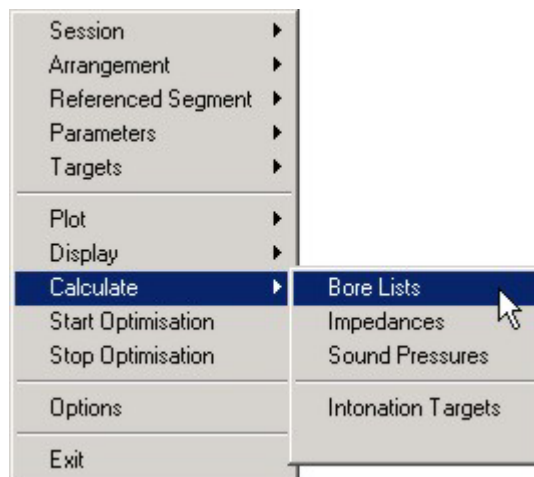
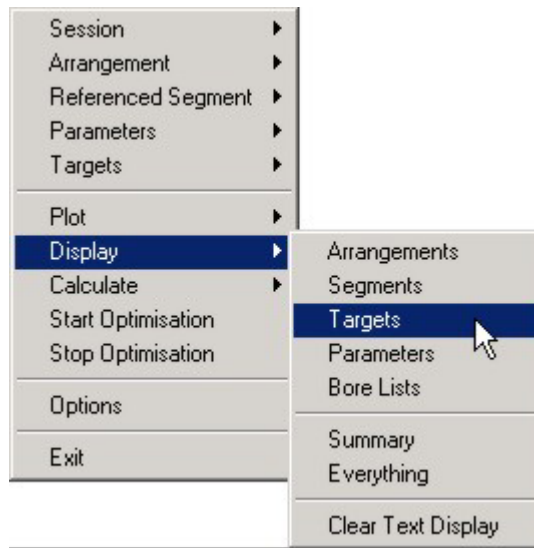
Segment Editor in the region of the data window:



Commander Bridge:



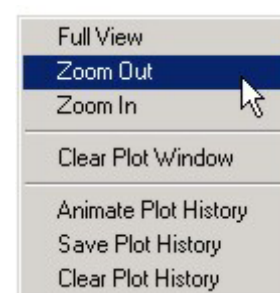


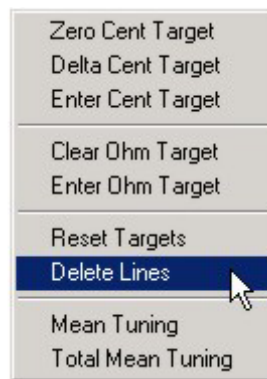


Trace Window:



Plot Window:



Intonation Assistant:**Segment Editor: Modify**