From a TELEMAC 2D model

Preamble

The objective of this tutorial is to model the habitat of the adult barbel from several TELEMAC 2D hydraulic simulations. The results will be visualised in interactive figures, in GIS output and in 3D. The main steps are as follows:

- 1. TELEMAC data will be read by the software to create a hydraulic .hyd file.
- 2. The substrate data will be read by the software to create a .sub substrate file.
- 3. The .hyd and .sub files will be merged into a .hab file from which HABBY can perform habitat calculations.
- 4. The biological model of the adult barbel will be selected.
- 5. The habitat calculation will be performed.
- 6. The results will then be visualised and exported.



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Prerequisites

- Install HABBY.
- Download and extract the hydraulic and substrate example files:
 tuto telemac example data.zip
- GIS software, such as QGIS or ArcGIS (for viewing map exports).
- The open-source software Paraview (to visualise the 3-dimensional exports) https://www.paraview.org/.
- A spreadsheet program, such as LibreOffice Calc or Excel (for viewing TXT exports).

Description of input files

Hydraulics



These files are EDF data and can only be used for HABBY tutorials.

File(s) used	Description
d1.slf, d2.slf, d3.slf, d4.slf, d5.slf, d6.slf d7.slf, d8.slf, d9.slf	2D TELEMAC modelling of a multi-flow braided river. These files are permanent discharge simulation result files. Each file represents a simulated constant discharge . Each file contains a single time step .
indexHYDRAU.txt	To use multiple hydraulic input files at the same time in HABBY, it is necessary to have previously created a indexHYDRAU.txt file to assign a discharge value to each input file.
discharge_chronicle.txt	This file is used with the HABBY interpolation tool (optional for habitat calculation).

Here are the contents of the indexHYDRAU.txt file:

EPSG=unknown filename Q[m3/s] d1.slf 9.2 d2.slf 21.2 d3.slf 35 d4.slf 48.4 d5.slf 74.7 d6.slf 110 d7.slf 150 d8.slf 175 d9.slf 259

*User guide: Creating a .hyd file.

Substrate

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These files are fictitious data and are used only for the tutorial.

File(s) used	Description
sub_PolygonSandreCoarser-dom.shp (and associated files .shx, dbf,)	This GIS data is of type Shapefile and represents polygons of homogeneous substrate. Mapping method : Polygon (Polygon). Classification code : Sandre (Malavoi and Souchon 1989). Classification method: coarser-dominant (PlusGros- Dominant).
sub_PolygonSandreCoarser-dom.txt	It is necessary to have previously created a file with the same name as the Shapefile, i.e. 'sub_PolygonSandreCoarser-dom.txt' in order to indicate to HABBY the classification code and the classification method of the substrate as well as the default substrate values (in case of not complete superposition of the substrate on the hydraulic). The latter is provided with the example data set.

Here are the contents of the file 'sub_PolygonSandreCoarser-dom.txt':

```
substrate_classification_code=Sandre
substrate_classification_method=coarser-dominant
default_values=12, 12
```

*User guide: Detailed description of substrate files

Step by step

Create a new project

- Start the software.
- Go to menu <hi #47B5E6>**Project New**</hi>.

This opens the <hi #9BFFFF>**HABBY - New Project**</hi> window.

Project	BBY 0.26 Beta Settings Vi	ew Help			-	×
			HABitat suitaBilitY			
	Current project Name: Path:	Projects folder:	v Project C:\Users\UserName\Documents\HABBY_projects Tuto_TELEMAC	? ×		
	Description:	Project type	physical	Create project		
	HABBY dit : Créez ou ouvrez	un projet.				

- If necessary, change the <hi #9BFFF>**Projects folder:**</hi>, by clicking on
- Enter in <hi #9BFFFF>**Project name:**</hi>: 'Tuto_TELEMAC'.
- Choose in <hi #9BFFFF>**Project type:**</hi>: '*physique*'.
- Click on <hi #47B5E6>[Create Project]</hi>.

The project is then created and gives you access to new tabs.

*User guide : Project creation

Creating a .hyd file

- Open the tab <hi #9BFFFF>Hydraulic</hi>.
- For <hi #9BFFFF>Select a model</hi> choose 'TELEMAC 2D'.

This opens the input file manager for TELEMAC.

• In <hi #9BFFF>**Result file (.res, ..**</hi>, click on ... to then select all TELEMAC files ('*d1.slf, ..., d9.slf*') or only the '*indexHYDRAU.txt*' file.

- If the pre-reading went well, the software should display the following information:
 - o <hi #9BFFFF>Reach name:</hi>: 'Tronçon D'.
 - \circ <hi #9BFFFF>Unit name:</hi>: selection of '9.2' to '259'
 - <hi #9BFFF>**Type**</hi>: 'discharge [m³/s]'
 - o <hi #9BFFFF>Number</hi>: '9/9'
 - o <hi #9BFFFF>Mesh data</hi>: "
 - <hi #9BFFFF>Node data</hi>: 'elevation, water depth, water velocity'
 - o <hi #9BFFF>EPSG code</hi>: '2154'
 - o <hi #9BFFFF>.hyd filename</hi>: 'd1_to_d9.hyd'

😑 на	BBY 0.26 Beta - Tuto_TELEMAC		– 🗆 ×
Project	Settings View Help		
	Project Hydraulic Substr	ate Habitat Calc. Data explorer Tools	
	Select a model TELEMAC 2D	v ?	
	Result file (.res, .sif, .srf, .txt)	d1.sif, d2.sif, d3.sif, d4.sif, d5.sif, d6.sif, d7.sif, d8.sif, d9.sif	~
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	Linit name	9.2 21.2 35 48.4 74.7	Type discharge [m³/s]
		150 175 259	Number 9/9
	Mesh data Node data	elevation, water depth, water velocity	
	EPSG code	2154	
	.hyd file name	d1_to_d9.hyd	
	Last file created	no file	0/1 Create 1 file .hyd
	HABBY says : Project created.		

If this information is valid, you can start the calculation by pressing the <hi #47B5E6>[Create 1 file .hyd]</hi>
 button.

Once the process is complete, a file 'd1_to_d9.hyd' is created.

*User guide: Creating a .hyd file

Creating a .sub file

- Open the <hi #9BFFFF>**Substrate**</hi> tab.
- For <hi #9BFFF>Substrate mapping method from</hi> check that 'polygons (.shp, .gpkg)' is selected.

- In <hi #9BFFF>**File (.shp, .gpkg)**</hi>, click on ... and select the file 'sub_PolygonSandreCoarser-dom.shp'.
- If the pre-reading went well, the software should display the following information:
 - <hi #9BFFFF>File (.shp, .gpkg)</hi>: 'sub_PolygonSandreCoarser-dom.shp'
 - o <hi #9BFFF>Classification code:</hi>: 'Sandre'
 - <hi #9BFFFF>Classification method:</hi> : 'coarser-dominant'
 - <hi #9BFFF>**Default values**</hi> : '12, 12'
 - o <hi #9BFFFF>EPSG code</hi>: '2154'
 - <hi #9BFFFF>.sub file name</hi> : 'sub_PolygonSandreCoarser-dom.sub'

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S	Polygons					
	File (.shp, .gpkg)	sub_PolygonSandreCoarser-dom.shp				
	Classification code	Sandre				
	Classification metho	od coarser-dominant				
	Default values	12, 12				
	EPSG code	2154				
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	.hab file name					
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	Last file created no f	fie				
	HADDY says :					
	Project opened.					

• If the information displayed in this tab is valid, you can start the calculation by pressing the <hi #47B5E6>[Create .sub file]</hi>

Once the process is finished, a file 'sub_PolygonSandreCoarser-dom.sub' is created.

*User guide: Creating a .sub file

Creating a .hab file

- Stay in the <hi #9BFFF>**Substrate**</hi> tab.
- In the <hi #9BFFFF>Merging of hydraulics and substrate data</hi> group, check that the

file names are selected for:

• <hi #9BFFF>.hyd filename</hi>: 'd1_to_d9.hyd'.

• <hi #9BFFFF>.sub filename</hi>: 'sub_PolygonSandreCoarser-dom.sub'.

HABBY 0.26 Beta - Tuto, Project Settings View	,TELEMAC Help	-		×
Project Hydrauli	: Substrate Habitat Calc. Data explorer Tools			
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Classification of	ode Sandre			
Classification n	ethod coarser-dominant			
Default values	12, 12			
EPSG code	2154			
.sub file name	sub_PolygonSandreCoarser-dom.sub			
	1/1	Create .	sub file	
Last file created	no file			
 Merging of hyperbolic 	draulic and substrate data			
.hyd file name	d1_to_d9.hyd		~	
.sub file name	sub_PolygonSandreCoarser-dom.sub		~	
.hab file name	d1_to_d9_sub_PolygonSandreCoarser-dom.hab			
	0	/1 Create	hab file	
Last file created	no file		~	
HABBY says :				
Warning: 34 hydrauli	: triangle(s) detected with a null surface in unit 6. This is removed.			^
Warning: 38 hydrauli Warning: 48 hydrauli	: triangle(s) detected with a null surface in unit 7. This is removed. : triangle(s) detected with a null surface in unit 8. This is removed.			
- d1 to d9.hyd creati	in done (process time = 7 s).			
Substrate in progress				
 sub PolygonSandret Substrate finished. 	loarser-dom.sub creation done (process time = 2 s).			
				~

• Then launch the merge with the <hi #47B5E6>[Create .hab file]</hi> button.

Once the process is finished, a 'd1_to_d9_sub_PolygonSandreCoarser-dom.hab' file is created.

*User guide: Merging Hydraulics and Substrate

Habitat calculation

- Open the tab <hi #9BFFF>Calc. Habitat</hi> tab.
- Check for <hi #9BFFF>**Habitat File(s)**</hi> that the 'd1_to_d9_sub_PolygonSandreCoarserdom.hab' file is selected.
- To add biological models to be calculated, click on the <hi #9BFFFF>[Add Models]</hi>button.

This opens the biological model explorer.

In the first tab <hi #9BFFF>Model filter</hi>, refine your search by the following criteria:
 <hi #9BFFF>Country</hi>: 'France'.

- <hi #9BFFFF>**Aquatic animal type**</hi>: 'fish'.
- <hi #9BFFFF>Stage and size</hi>: 'adult'.
- <hi #9BFFFF>Code alternative filter</hi> : 'BAF'.



- In the second tab <hi #9BFFF>**Model selection**</hi>:
 - Click on the model 'Barbus barbus adult BAF01' in the left-hand list <hi #9BFFFF>Available models</hi>
 - Optional) You can click on <hi #9BFFF>[Show habitat suitability indices]</hi>
 to display the biological model in an interactive figure
 - Drag and drop from left to right the '*Barbus barbus adult BAF01*' model into the righthand list <hi #9BFFFF>**Selected models**</hi>.

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-						
Bolo						Barbus barbus - adult - BAFR1
						le la
	Habitat Suitab	iity Index inf	ormation			
	Latin Name:	Barbus b	arbus			Show habitat suitability indices
	Code alternat	ve: BAF				Show hydrosignature
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						Validate selected models Close

• Validate with the <hi #9BFFFF>[Validate selected models]</hi> button.

The model 'Barbus barbus - adult - BAF01' has been added to the list of models to be calculated.

- The hydraulics and substrate options for the biological model 'Barbus barbus adult BAF01' are left as default:
 - <hi #9BFFFF>**Hydraulic option**</hi>: '*HV*' (Height and Velocity).
 - <hi #9BFFFF>**Substrate option**</hi>: '*Dominant*' (Dominant substrate).

Project Hydraulic Substrate Habitat Calc. Data explorer Habitat file(s) d1_to_d9_sub_PolygonSandreCoarser-dom.hab Model to compute	Tools	
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Barbus barbus - adult - BAF01	HV Dominant	
		0/1 Compute nabitat
HABBY says : Project opened.		

• You can now start the habitat calculation for the adult barbel with the <hi #47B5E6>[Compute habitat]</hi>

Once the process is finished, the result of the model 'BAF01_adult_HV_Dominant' has been added to the file 'd1_to_d9_sub_PolygonSandreCoarser-dom.hab'. By default, at each calculation, the text habitat calculation result file is created: 'd1_to_d9_sub_PolygonSandreCoarser-dom_spu.txt' describing the habitat values and the weighted usable area of adult barbel for each simulated discharge.

You can view the results in detail, either via the figures or via exports from the explorateur de données.

The *User guide: Calculating habitat from a .hab file explains in more detail the possibilities offered by HABBY.

Visualising habitat results

Preamble

In this tutorial, for the adult barbel, we will :

- 1. Create figures to visualise:
 - 1. an interactive habitat map for a discharge of $74.7 \text{ m}^3/\text{s}$.
 - 2. an interactive habitat record for all discharges.
- 2. Create GIS, 3D and TXT file exports.
- 3. View the exported files:
 - 1. GIS representing the mesh for all discharges (.gpkg).
 - 2. 3D representing the topography of the river bottom (.stl).
 - 3. 3D representing the water level for all discharges (.pvd representing several .vtu).
 - 4. TXT describing the state of the mesh for all discharges.

To view the data in detail as a figure and as a file export:

• Open the <hi #9BFFFF>Data Explorer</hi> tab.

*User guide: Data Explorer

Figures

- In the <hi #9BFFFF>**Data Explorer**</hi> tab, for <hi #9BFFFF>**file types**</hi>, select '*habitat*'.
- In the list of <hi #9BFFF>**File name**</hi>, select the file 'd1_to_d9_sub_PolygonSandreCoarser-dom.hab'.
- Open the group <hi #9BFFF>**Figure viewer/exporter**</hi> by clicking on its name.

	w Help						
Project Hydr	aulic Substrate Habitat Calo	. Data explore	er Tools				
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Interactive map

- In this group <hi #9BFFF>**Figure viewer/explorer**</hi>, choose:
 - <hi #9BFFF>**reach(s)**</hi>: 'Tronçon D'.
 - <hi #9BFFFF>discharge [m³/s]</hi>: '74.7'.
 - <hi #9BFFFF>**mesh variables**</hi>: '*BAF01_adult_HV_Dominant*'.
 - Figure options:
 - <hi #9BFFF>map</hi>: enabled.
 - <hi #9BFFF>global habitat value</hi>: disabled.
 - <hi #9BFFF>mode</hi>: 'interactive'.
- Start the figure creation process with the <hi #47B5E6>[run]</hi> button.

An interactive habitat map is then displayed.



NB: To close all interactive figure windows, use the 🥴 button in the main window's quick menu.

Interactive Chronicle

- In this group <hi #9BFFF>**Figure viewer/exporter**</hi>, choose:
 - <hi #9BFFFF>**tronçon(s)**</hi>: '*Tronçon D*'.
 - <hi #9BFFFF>**discharge [m³/s]**</hi></hi>: all discharges (from '9.2' to '259').
 - <hi #9BFFFF>**mesh variables**</hi>: '*BAF01_adult_HV_Dominant*'.
 - Figure options:
 - <hi #9BFFFF>map</hi>: disabled.
 - <hi #9BFFFF>global habitat value</hi>: enabled.
 - <hi #9BFFF>mode</hi>: 'interactive'.
- Start the figure creation process with the <hi #47B5E6>[**run**]</hi> button.

An interactive habitat chronicle is then displayed.



NB: To close all interactive figure windows, use the $^{\textcircled{1}}$ button in the main window's quick menu.

Exports

In the <hi #9BFFFF>**Data Explorer**</hi> tab, for <hi #9BFFFF>**file types**</hi>, check that '*habitat*' is selected.

- In the list of <hi #9BFFFF>**File name**</hi>, check that the file 'd1_to_d9_sub_PolygonSandreCoarser-dom.hab' is selected.
- Preferably, close the <hi #9BFFF>**Figure viewer/exporter**</hi> group.
- Open the group <hi #9BFFF>**Data exporter**</hi> by clicking on its name.
- Check the following items:
 - o <hi #9BFFFF>Geopackage (.gpkg) Mesh units</hi>
 - \circ <hi #9BFFFF>3D (.slt) Mesh whole profile</hi> (DEM)
 - o <hi #9BFFF>3D (.pvd, .vtu) Mesh units</hi>
 - o <hi #9BFFFF>TXT (.txt) Mesh detailled</hi>

Project Hydraulic Substrate Habitat Calc.	Data explorer Tools	
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O substrate		
habitat		
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Data exporter		
Geopackage (.gpkg)	Mesh units	
Geopackage (.gpkg)	Point units	
3D (.stl)	Mesh whole profile	
3D (.pvd, .vtu)	Mesh units	
Text (.txt)	Global habitat values	
Text (.txt)	Mesh detailled	
Text (.txt)	Point detailled	
Report (figure extension)	Fish informations	
		0/4 run
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HABBY says :		
- d1 to d9 sub PolygonSandreCoarser-dom.hab habitat calc Habitat finished. Figure in progress	ilation done (process time = 3 s).	
 BAPUI adult NV Dominant done (process time = 2.5). Figure finished. Edure to progress. 		
Ingore in progress in		

• Start the export process with the <hi #47B5E6>[run]</hi> button.

At the end of the process, all the requested files have been exported.

NB: All exported files are located in the project's output directory. To access them, use the \blacksquare button in the main window's quick menu.

<u>SIG</u>

First, we will look at the exports <hi #9BFFFF>**Geopackage (.gpkg) Mesh units**</hi>, which is the file 'd1_to_d9_sub_PolygonSandreCoarser-dom_Troncon D_mesh.gpkg'.

• Open this file 'd1_to_d9_sub_PolygonSandreCoarser-dom_Troncon D_mesh.gpkg' in the project directory ('...\Tuto_TELEMAC\output\GIS') in your GIS software.

This Geopackage file contains several layers (each equivalent to a Shapefile) of triangular polygons (mesh data) for each discharge.

Ø OGIS 2,18,21

Projet	Éditer	r V <u>u</u> e	Couche	Préférences	s Extens	sion <u>V</u> ecte	ur <u>R</u> a	aster Base de données Inte	ernet <u>T</u> raitemen	t <u>A</u> ide						
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			3		2		1	0.00893179302165906	0	89.217084248	0.0072498319	0.0008198699	41.71875	0.9859578803	89.224334080	
			4		3		2	0.00729698780675729	0	89.215530395	0.0059228797	0.0005979194	46.25	0.8529011268	89.221453275	8
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			6		5		4	0.00728350578993559	0	89.229021708	0.0059119365	0.0006596398	43.28125	0.5820335240	89.234933644	2
			7		6		5	0.0618314363718033	0	88.943229675	0.1256887987	0.0221304879	23.15625	1.4844376253	89.068918474	
			8		7		6	0.0631022940635681	0	88.954488118	0.1294711132	0.0076714221	23.46875	8.1613623759	89.083959231	
			9		8		7	0.0616	0	89.047375996	0.0965734533	0.0051293924	49.1875	21.602363727	89.143949450	
			10		9		8	0.0616	0	89.032892862	0.0846967523	0.0054086138	7.78125	20.459875514	89.117589615	1
			11		10		9	0.00974311092744271	0	89.169418334	0.0079083692	0.0010222232	39.5625	1.8625007064	89.177326704	
			12				10	0.0616	0	00.076212272	0.0054121227	0.0004176117	2 6075	1.0603939346	00.071725205	1

The attribute tables of these layers contain all the mesh data including the habitat data of the adult barbel.

<u>3D</u>

In a second step, we will look at the exports <hi #9BFFFF>**3D** (.stl) Mesh whole profile</hi>, i.e. the file 'd1_to_d9_sub_PolygonSandreCoarser-dom_Troncon D_unit_all_wholeprofile_mesh.stl'. This 3D .stl (stereolithography) file represents the digital terrain model of the watercourse in 3 dimensions.

• Open this file in the project directory ('...\Tuto_TELEMAC\output3D') in the Paraview software, using drag and drop.

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- Display the layer by clicking on the \cong icon to the left of the file name.



In a third step, we will look at the exports <hi #9BFFFF>**3D** (.pvd, .vtu) Mesh units</hi>, namely:

- the file 'd1_to_d9_sub_PolygonSandreCoarser-dom_Troncon D_water level.pvd'.
- the 'd1_to_d9_sub_PolygonSandreCoarser-dom_Troncon D_XXXX_water level.vtu' files.

Together, these 3D .pvd and .vtu files represent the water level in 3 dimensions for each unit.

- Add the file 'd1_to_d9_sub_PolygonSandreCoarser-dom_Troncon D_water level.pvd' to the Paraview software, using drag and drop.
- Display it with $^{\frown}$.
- In the 'Properties' tab and then the 'Display' sub-tab of the .pvd file layer, choose for 'Coloring': 'BAF01_adult_HV_Dominant' to display the coloration of the Barbel habitat.

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- You can change the angle of view using the mouse or mouse + CTRL
- You can also scroll through the units using the $\mathbb{M} \ll \mathbb{M} \otimes \mathbb{M} \otimes$ buttons.



<u>TXT</u>

Finally, we will look at the TXT exports in the '...\Tuto_TELEMAC\outputtext' project directory, i.e. :

- 'd1_to_d9_sub_PolygonSandreCoarser-dom_spu.txt': habitat chronicle exported at each calculation.
- 'd1_to_d9_sub_PolygonSandreCoarser-dom_Troncon D_XXXX_detailled_mesh.txt': mesh data per unit, exported manually.

These can be directly used in a spreadsheet by drag and drop.

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Using the interpolation tool

Preamble

The objective of this last part of the tutorial is to find out the habitat values for a discharge time series using the Interpolation tool.

- Open the <hi #9BFFFF>**Tools**</hi> tab.
- Open the <hi #9BFFF>Interpolation</hi> sub-tab.

*User guide: Interpolation

Available data

- If necessary, click on the <hi #9BFFFF>Available data</hi> group to open it.
- Select the habitat file 'd1_to_d9_sub_PolygonSandreCoarser-dom.hab'.
- Check that the '*Tronçon D*' is selected.
- Check that the 'BAF01_adult_HV_Dominant' is selected.

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unit max :				259.0					
unit type :				discharge [m³/s]					
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The <hi #9BFFFF>**Desired data**</hi> group is then ready to choose the data to be interpolated.

Desired data

- If necessary, close the <hi #9BFFFF>**Data available**</hi> group.
- If necessary, click on the <hi #9BFFFF>**Desired data**</hi> group to open it.
- Select the discharge chronicle file '*discharge_chronicle.txt*' with the <hi #47B5E6>**[load and run]**</hi> button of the group <hi #9BFFFF>**from .txt file**</hi>.

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The interpolated results are then displayed in the <hi #9BFFFF>Interpolated results</hi>

Interpolated results

- If necessary, close the <hi #9BFFFF>**Desired data**</hi> group.
- If necessary, click on the <hi #9BFFFF>Interpolated results</hi> group to open it.

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• Click the <hi #47B5E6>[run]</hi> button of <hi #9BFFFF>View interpolated chronicle:</hi> to display the interpolated chronicle.



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