

Hexcore meshing is a hybrid meshing scheme that generates Cartesian cells inside the core of the domain and tetrahedral cells close to the boundaries. Hanging-node (or *H*-) refinements on the Cartesian cells allow efficient cell size transition from boundary to interior of the domain. This results in fewer cells with full automation and can handle complex geometries, internal walls and gaps.

The hexcore meshing scheme is applicable to all volumes but is useful mainly for volumes with large internal regions and few internal boundaries such as intrusions or holes. The Hexcore submenu contains options to control the hexcore mesh generation. The starting point is a valid surface mesh.

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### 12.1 Automatic Hexcore Meshing Procedure

The automatic hexcore mesh generation process comprises the following steps:

1. Generating initial Cartesian cells inside a bounding box (or the region specified) around the volume to be meshed.
2. Marking the Cartesian cells that intersect the boundary mesh and those cells having sizes larger than the average size of the faces they intersect.
3. Marking additional buffer-layer cells adjacent to the cells marked in Step 2 (if specified).
4. Marking additional cells to enforce one-level refinement difference between adjacent cells.
5. Subdividing all marked (in steps 2–4) cells and repeating steps 2–5 until the local face size criteria is met.

6. Deleting cells that intersect or are within some distance to the closest face on the surface mesh.
7. Triangulating the the external surface of the hexcore by converting quads into tri interface faces. The quad faces become parents (with type `parent-face`) of the interface faces.

*TGrid does not use pyramids to transition from the hexcore to the tet cell regions.*

8. Smoothing the interface faces (if interface smoothing is enabled).
9. Initializing and refining the tet cells between the interface faces and the boundary mesh.

*The maximum skewness reported at the end of the refinement process is not necessarily the final maximum skewness. Sliver cells on the interfaces can be removed at a later stage.*

10. Removing sliver cells on the interface faces.
11. Merging Cartesian cells with tet (and wedge, if present) cells to form contiguous cell zones.



If prism parameters have been attached to boundary zones, TGrid will first generate the prism layers. The hexcore meshing procedure will then be applied to the resulting prism caps, along with the other boundary zones that were not involved in the prism mesh generation.

You can control the general shape, size, and density of the core, as well as the size of elements created at the outer boundary of the core using the parameters in the **Hexcore** panel (see Section 12.4: [The Hexcore Panel](#)) and the TUI commands in the `/mesh/hexcore/` menu.

## 12.2 Manual Hexcore Meshing Procedure

To create a hexcore mesh manually, do the following:

1. Read in a boundary mesh and check and improve its quality, if necessary.
2. (optional) Split any quad faces in the boundary mesh into triangular faces using the `/boundary/remesh/triangulate` command.

By default, TGrid does not allow quad faces while initializing the hexcore mesh.

Alternatively, use the TUI command `/mesh/non-conformals/controls/enable?` to enable the creation of a non-conformal interface.

If this option is enabled, all the surfaces having quad elements will be copied and remeshed with triangular cells. The free nodes of the triangular mesh will be merged

with the original surface mesh. The method to be used for retriangulation can be specified using the command `/mesh/non-conformals/controls/retri-method`.

The `quad-split` method is the default method used for retriangulation. You can select `prism`, `quad-split`, or `remesh` as appropriate.

3. Specify the hexcore parameters in the Hexcore panel. See Section [12.3: Controlling Hexcore Parameters](#) for details.

TGrid automatically calculates the parameters (e.g., maximum cell length) required during the hexcore meshing. These parameters can be changed using the Hexcore panel or using the commands in the `/mesh/hexcore` text menu.

4. Click Create in the Hexcore panel to generate the hexcore mesh.

## 12.3 Controlling Hexcore Parameters


The parameters that control the hexcore mesh generation can be changed using the Hexcore panel. The following options are available to control the hexcore mesh generation in the domain:

- Keep outer domain (Section [12.3.1: Keep Outer Domain](#))
- Hexcore upto boundaries (Section [12.3.2: Hexcore Upto Boundaries](#))
- Only hexcore (Section [12.3.3: Only Hexcore](#))
- Maximum cell length (Section [12.3.4: Maximum Cell Length](#))
- Buffer layer (Section [12.3.5: Buffer Layers](#))
- Peel layers (Section [12.3.6: Peel Layers](#))
- Local refinement regions (Section [12.3.7: Local Refinement Regions](#))

### 12.3.1 Keep Outer Domain

TGrid allows you to create hexcore mesh until the boundary of the domain, instead of creating a tetrahedral mesh at the boundary. This feature is useful for the hexcore grid generation for external flow domains, e.g., external aerodynamics cases where the boundary conformity is not needed for far-field boundaries.

You can generate the hexcore mesh till the far-field boundary of the domain by enabling **Keep Outer Domain** in the Hexcore panel. The minimum and maximum domain extents will be automatically updated with values slightly greater than the bounding box of the surface mesh in the domain. In Figure [12.3.1](#), the hexcore mesh has been extended until the domain boundary and does not have a tetrahedral mesh at the far-field boundary.

-  Hexcore mesh extends upto user defined domain extents. If the gap between user defined domain extents and geometric boundaries is less than 20 % of size of the bounding box which contains the given geometry, TGrid gives warning.

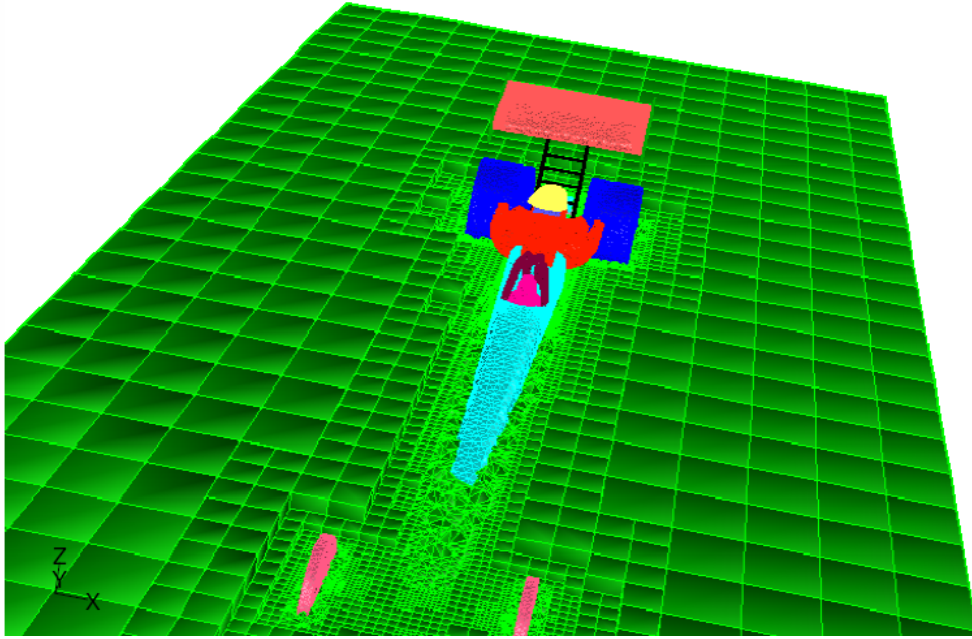



Figure 12.3.1: Hexcore Until the Far-Field Boundary

### 12.3.2 Hexcore Upto Boundaries

The Hexcore Upto Boundaries option can be used when the boundary of a domain touches the geometry. In such cases, you can also create the hexcore mesh extending exactly until the boundaries of the domain. When you enable **Grow Upto Boundaries**, the minimum and maximum domain extents will be automatically updated with values exactly equal to the bounding box of the surface mesh in the domain. The hexcore mesh will extend upto the boundary, aligned with the *X*, *Y*, and *Z* axes. An example is shown in Figure 12.3.2, where the hexcore mesh has been generated upto the bounding box for the geometry.

-  TGrid will report an error if you attempt to use this option when the geometry is completely within the domain.

Enable **Grow Upto Boundaries** and specify the domain extents for the bounding box. You can either enter the values manually or select the zones comprising the bounding box in the **Outer Box Zones** panel (see Section 12.4.1: [The Outer Box Zones Panel](#)). You can also specify the outer box zones using the command `/mesh/hexcore/controls/outer-box-zones`.

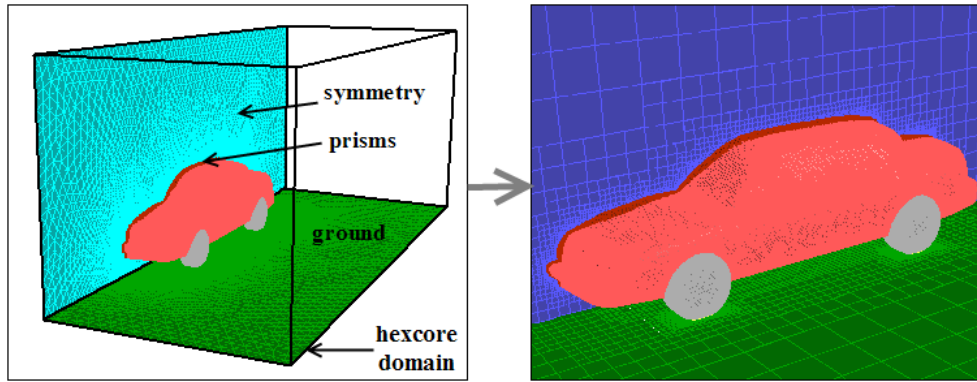


Figure 12.3.2: Hexcore Upto Boundaries



The outer box zones specified should comprise a bounding box. You cannot specify zones that are individual faces of the bounding box. The hexcore mesh generated using this option will have hex cells generated upto all the boundaries defining the bounding box.

### 12.3.3 Only Hexcore

The Only Hexcore option allows you to prevent the automatic creation of the tetrahedral mesh after hexcore generation (see Figure 12.3.3). However, the tetrahedral mesh domain is created and activated during the hexcore meshing procedure. You can manually create the tetrahedral mesh in a separate step.

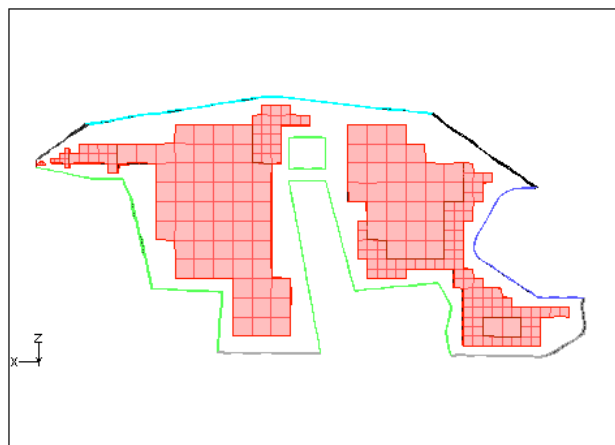


Figure 12.3.3: Only Hexcore

Hex cell islands may be created when the **Only Hexcore** option is used. You can delete small islands which may be created by setting the minimum allowable size for the hex cell islands using the command `mesh/hexcore/controls/post-relative-island-count`. This command is available only when the **Only Hexcore** option has been enabled in the Hexcore panel. You can also use the command `/mesh/hexcore/controls/only-hexcore?` to enable only hexcore meshing.

The default value for `post-relative-island-count` is 10. All hex cell islands whose size is less than the specified percentage (in the default case, 10%) of the largest hex cell zone will be automatically deleted.

*No islands will be removed if you set the value to 0.*



You may need to verify that hex cells are created only in the domain of interest since TGrid cannot identify whether the cells are within the domain without tet meshing. Also, all the non-fluid type zones are created as separate fluid zones. You need to retain the fluid zone(s) of interest and delete the others.

### 12.3.4 Maximum Cell Length

TGrid can automatically calculate an optimal maximum cell length for a particular mesh.

Click the **Compute** button next to the **Max Cell Length** field to obtain the optimal maximum cell length for the mesh. Alternatively, specify the maximum cell length as required.

TGrid generates the initial Cartesian cells based on the maximum cell length.

### 12.3.5 Buffer Layers

The Cartesian cells are marked (and subsequently subdivided) to satisfy the size requirement on the boundary mesh. When there is large disparity in size distribution between the boundary mesh and the initial Cartesian cells, there will be a rapid transition from fine to coarser cells. To avoid this, TGrid marks additional layers of cells adjacent to those marked by the size requirement (see Figure 12.3.4). You can control the number of additional layers by setting the **Buffer Layers** in the Hexcore panel. The default number of buffer layers is set to 1. Setting the number of buffer layers to zero may result in a poor quality mesh.

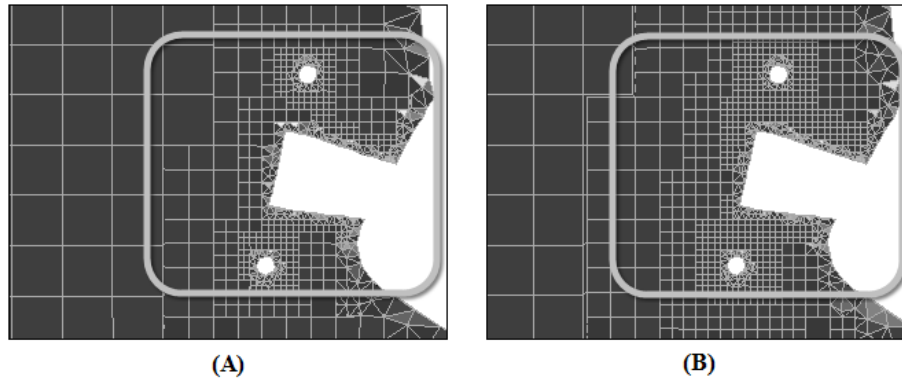


Figure 12.3.4: Hexcore Mesh Using (A) Buffer Layers = 1 (B) Buffer Layers = 2

### 12.3.6 Peel Layers

The peel layers control the gap between the hexahedra core and the geometry. After the Cartesian cells are subdivided to meet the size requirement, TGrid deletes the cells intersected by boundary mesh and those within some distance to the closest face on the boundary mesh. The default value for Peel Layers is 1, hence TGrid assumes this distance to be the height of an ideal tetrahedral cell on the boundary face. If Peel Layers is set to 0, TGrid will allow the gap size to be smaller than the ideal height. The resulting hexcore mesh will contain the maximum number of Cartesian cells possible for the chosen parameters.

Figure 12.3.5 shows the hexcore mesh generated for different values of Peel Layers.

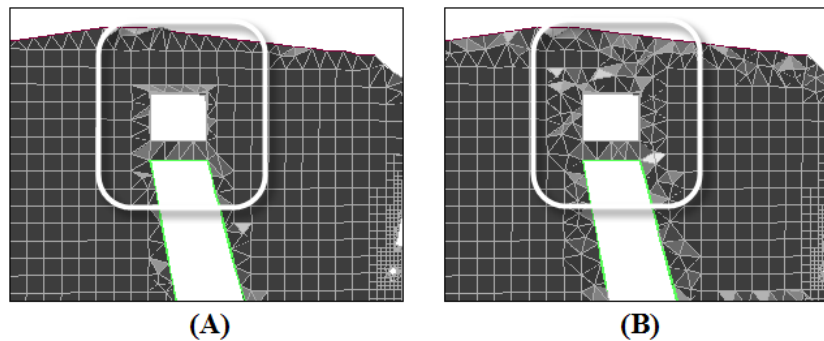


Figure 12.3.5: Hexcore Mesh Using (A) Peel Layers = 0 (B) Peel Layers = 2

### 12.3.7 Local Refinement Regions

You can use local refinement regions to refine specific cells within the domain. During the hexcore meshing procedure, TGrid will refine the cells within the activated local refinement region(s). Currently, the only possible region shape is a box, either aligned with the coordinate axes, or oriented as required.

The region extents are defined by the center and the length of the region. The cell size within the region can be manipulated by setting the level of refinement relative to the maximum cell length in the hexcore domain. You can also orient the region as required. You can create multiple regions that overlap each other and the geometry. To create additional regions, you can copy an existing region and then modify the parameters as required. The default region includes the entire geometry.

You can use the Draw button in the Hexcore Refinement Region panel to display the defined region. Figure 12.3.6 shows a refinement region defined. A sample Cartesian cell with the specified Max Length is also displayed at the center of the refinement box.

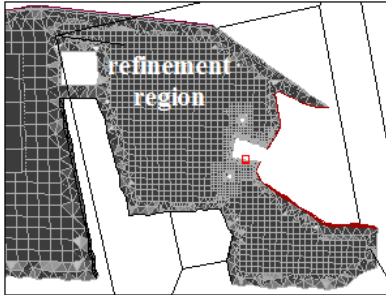


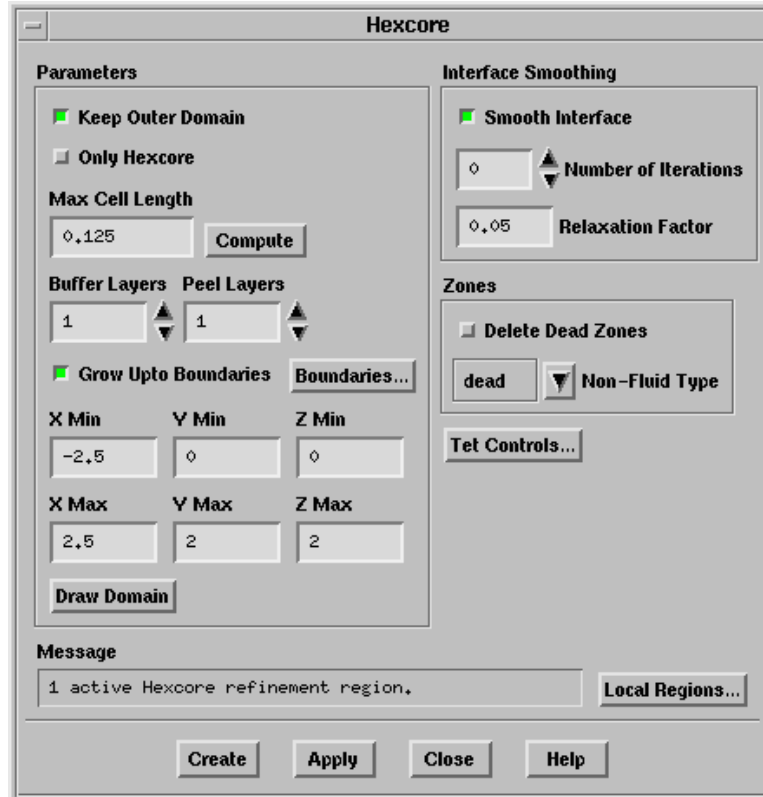
Figure 12.3.6: Local Refinement Region for the Hexcore Mesh



## 12.4 The Hexcore Panel

The Hexcore panel allows you to control the hexcore meshing procedure.

**Mesh** → Hexcore...



### Controls

Parameters contains options that control the hexcore meshing in the domain.

**Keep Outer Domain** allows you to create Cartesian cells until the boundary of the domain.

**Only Hexcore** allows you to prevent the automatic creation of the tetrahedral mesh after hexcore generation. When the **Only Hexcore** option is enabled, the hexcore is created and the tetrahedral domain is activated. You can manually create the tet mesh separately.

**Max Cell Length** sets the maximum length for the hex cells in the domain. The final length may not be the specified value as it is also limited by other parameters.

**Compute** computes the maximum cell length based on the surface mesh.

**Buffer Layers** specifies the number of additional layer of cells to subdivide. Increasing the buffer layers will significantly increase the number of cells. Refer to Section 12.3.5: [Buffer Layers](#) for details.

**Peel Layers** controls the gap between the hexahedra core and the geometry. Refer to Section 12.3.6: [Peel Layers](#) for details.

**Grow Upto Boundaries** allows you to create the hexcore mesh extending upto the boundaries of the domain. Refer to Section 12.3.2: [Hexcore Upto Boundaries](#) for details.

**Boundaries...** opens the **Outer Box Zones** panel (see Section 12.4.1: [The Outer Box Zones Panel](#)) where you can specify the boundaries comprising the bounding box.

**X Min, Y Min, Z Min, X Max, Y Max, Z Max** specify the extents of the domain.

**Draw Domain** draws the defined domain.

**Interface Smoothing** specifies the parameters controlling interface smoothing.

**Smooth Interface** toggles smoothing at the hexcore interface.

**Number of Iterations** sets the number of smoothing iterations on the parent face. Increasing the number of iterations will increase the value of maximum skewness of the hex cells near the boundary. It also helps initializing the tets and obtaining lower maximum skewness in the tet region. The default number of iterations is zero. When the number of smoothing iterations is zero, the nodes at the parent face will be perturbed.

**Relaxation Factor** sets the value of under relaxation for smoothing the parent face.

**Zones** contains parameters that related to the zones created during hexcore meshing.

**Delete Dead Zones** toggles the deleting of the dead zones.

**Non-Fluid Type** selects the default non-fluid cell zone type. After the mesh is initialized, TGrid will set any non-fluid zones to the specified type. By default, the non-fluid type is set to **dead**, as TGrid considers the grid to comprise a single fluid region and one or more dead regions. The active zone is considered to be the fluid zone and only this fluid zone will be considered for refinement during the automatic meshing process.

If the mesh includes multiple regions (e.g., the problem for which you are creating a grid includes a fluid zone and one or more solid zones), and you intend refining all of them using the same refinement parameters, modify the **Non-Fluid Type** *before* generating the hexcore mesh. When the **Non-Fluid Type** is set to a type other than **dead** (e.g., **solid**), all the zones will be active after the initialization is complete. Hence, TGrid will refine all zones automatically during the refinement process.

**Tet Controls...** opens the Tri/Tet panel (see Section 11.5: [The Tri/Tet Panel](#)), where you can set the parameters for tetrahedral meshing.

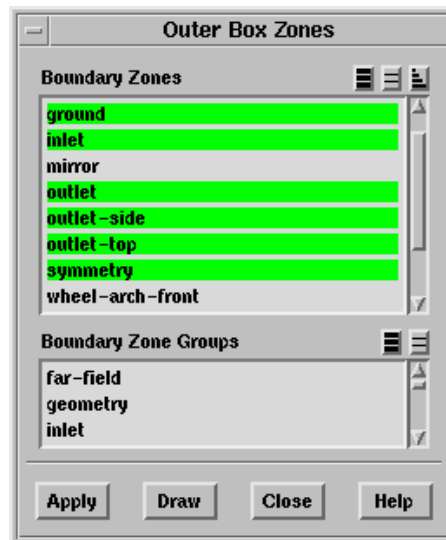
**Local Regions...** opens the Hexcore Refinement Region panel (see Section 12.4.2: [The Hexcore Refinement Region Panel](#)).

**Create** creates the hexcore according to the parameters specified in the Hexcore panel.

**Apply** applies the parameters specified in the Hexcore panel.

### 12.4.1 The Outer Box Zones Panel

The Outer Box Zones panel allows you to select the boundaries comprising the bounding box of the domain.



#### Controls

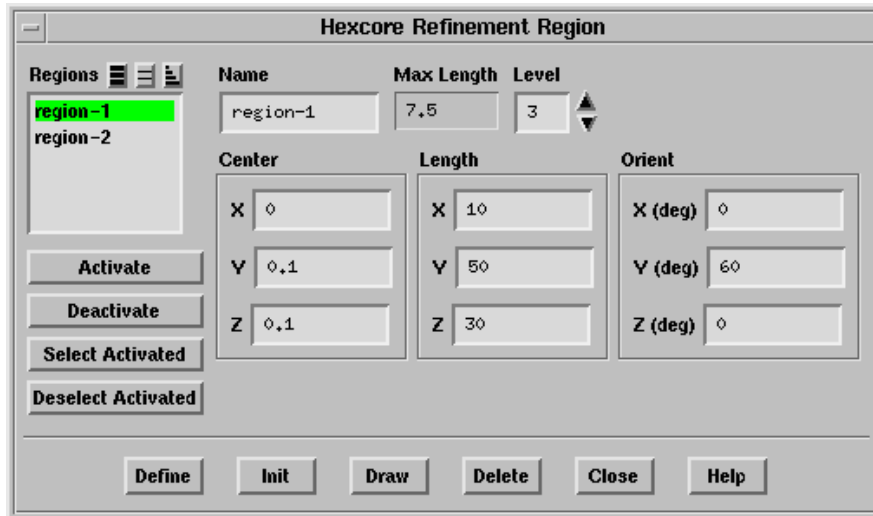
**Boundary Zones** contains a list of the boundary zone(s) available.

**Boundary Zone Groups** contains a list of the default boundary zone groups and user-defined groups available in TGrid. If you select a zone group from this list, all zones of that group will be selected in the **Boundary Zones** list. You can also select multiple types to select all the zones of different types (e.g., **inlet** and **outlet**).

**Apply** defines the bounding box based on the zones selected in the **Boundary Zones** selection list.

**Draw** draws the zones selected in the **Boundary Zones** selection list.

## 12.4.2 The Hexcore Refinement Region Panel



The Hexcore Refinement Region panel provides options for creating, modifying, and activating/deactivating a local region for hexcore mesh refinement.

### Controls

**Regions** contains a list of the defined regions.

**Name** specifies the name of the region selected in the **Regions** list, or the name of the region to be created.

**Max Length** specifies the maximum cell length in the region. The **Max Length** value is determined by the specified refinement level.

**Level** specifies the refinement level for the local region defined.

**Center** allows you to specify the coordinates of the center of the region you want to create.

**Length** allows you to specify the absolute size of the new region in the x, y, and z directions.

**Orient** allows you to specify the orientation of the new region.

**Note:** TGrid orients the region by rotation first about the x-axis, then the y-axis, and finally the z-axis. You need to take this into account while specifying the orientation of the region as rotation in any other order will produce different results.

**Activate** activates the region(s) selected in the **Regions** list.

**Deactivate** deactivates the region(s) selected in the **Regions** list.

**Select Activated** selects the activated regions in the Regions list.

**Deselect Activated** deselects the activated regions in the Regions list.

**Define** creates a new region according to the specified parameters. It also allows you to modify the selected region according to the specified changes.

**Init** creates a default region encompassing the entire geometry.

**Draw** draws the region(s) in the graphics window. The maximum cell size for the refinement regions will also be displayed. If the boundary grid was displayed (using the **Display Grid** panel (see Section 14.1.3: [The Display Grid Panel](#))) before drawing the refinement region, the grid will also be included in the display.

**Delete** deletes the selected region.

## 12.5 Text Commands for Hexcore Meshing

Text commands with the same functionality as the **Hexcore/Auto Mesh** menu item and the controls in the **Hexcore Controls** panel along with additional text commands related to meshing are as follows:

`/mesh/hexcore/controls/boundary-merge-tolerance` specifies the tolerance for merging zones aligned to domain boundaries.

`/mesh/hexcore/controls/buffer-layers` sets the number of additional cells to mark for subdivision.

`/mesh/hexcore/controls/delete-dead-zones?` toggles the deleting of dead zones during hexcore meshing.

`/mesh/hexcore/controls/keep-outer-domain?` allows you to enable the creation of Cartesian cells until the boundary of the domain during hexcore meshing.

`/mesh/hexcore/controls/maximum-cell-length` sets the maximum cell length for the hex cells in the domain.

`/mesh/hexcore/controls/maximum-initial-cells` specifies the maximum number of cells in the initial Cartesian mesh.

`/mesh/hexcore/controls/maximum-subdivisions` number of change in size (hanging node subdivisions) allowed in the hex mesh region. The default value is 50.

`/mesh/hexcore/controls/mesh-rel-island-count` specifies the threshold cell count (relative to the total cell count) for islands to be deleted when separating cells by region during hexcore meshing. The default value is 1% of the total cell count.

`/mesh/hexcore/controls/non-fluid-type` allows you to set the cell zone type for the non-fluid cell zones.

`/mesh/controls/hexcore/only-hexcore?` allows you to create only the hexcore mesh and activates the tet-mesh domain (without tet mesh generation). This option is disabled by default.

`/mesh/hexcore/controls/peel-layers` specifies the distance for the hexcore interface to peel back from the boundary. The default value is 0. The higher the value of peel layer, the greater the distance between the hexcore interface and the boundary.

`/mesh/hexcore/controls/outer-box-zones` allows you to specify the zones comprising the bounding box when using the **Grow Upto Boundaries** option.

`/mesh/hexcore/controls/post-relative-island-count` specifies the threshold cell count (relative to the cell count of the largest zone containing hex cells) for islands to be deleted after generating the hexcore mesh using the **Only Hexcore** option. The default value is 10.

`/mesh/hexcore/controls/smooth-interface?` enables smoothing of the hexcore interface.

`/mesh/hexcore/controls/smooth-iterations` sets the number of smoothing iterations on the hexcore.

`/mesh/hexcore/controls/smooth-relaxation` sets the smoothing under relaxation on the hexcore interface.

`/mesh/hexcore/create` allows you to create the hexcore mesh according to the specified parameters.

`/mesh/hexcore/local-regions/activate` allows you to activate the specified local region(s) for refinement.

`/mesh/hexcore/local-regions/deactivate` allows you to deactivate the specified local region(s).

`/mesh/hexcore/local-regions/define` defines the local region according to the specified parameters.

`/mesh/hexcore/local-regions/delete` deletes the specified refinement region.

`/mesh/hexcore/local-regions/ideal-hex-vol` reports the ideal hex volume for the given edge length.

`/mesh/hexcore/local-regions/init` creates a default region encompassing the entire geometry.

`/mesh/hexcore/local-regions/list-all-regions` lists the defined and active regions in the TGrid console.