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## Statics Convergence Guide

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Spending time to get a robust, accurate statics convergence solution will result in faster runs that remain stable and don't have un-necessary transients.

This document is to assist in achieving a high quality solution.

### 1. Monitor what is happening

Watch the animation of the static search. This will indicate what you need to do for a more robust solution.

Remember that you can get the convergence status from the top left hand bar. This will say which objects are being calculated, when Whole System Statics calculation is underway and how the solution tolerance is converging.

If you find the status bar hard to read then open the Statics Progress window. Find it by right clicking on the status bar. This window will give you the history as well as the current calculation. It will let you know which line is giving you problems too.

### 2. Get a good starting point

Set up the initial positions roughly where you expect them to be. If it is meant to be in the North Sea then don't put it on Mars. Yes Orcaflex does a load balance but the more out of balance at the start, the more risk of overshooting and finding a statically unstable position.

Also, try to avoid slack systems. These have an infinite number of static solutions. In addition a slight deflection in the static search will make no difference to static load so the search algorithm will not know where to move to.

### 3. Concentrate on the problem area

If an individual line is giving you problems then turn the others off for statics (easily done via the All Objects Data page) and concentrate on that one line. Remember you can also hide the other objects via right clicking them on the model browser.

### 4. Stop the Search Leaping Around

If you see objects flying around then the search is overshooting. This increases the chance of locking onto an unstable static solution or divergence. You need to stop the search and change something. The most likely solutions are listed below. These can be used individually or combined.

#### 4.1. Damping the Search

For an individual line do this on the Full Statics Convergence tab. For the whole system (the final static step) the damping is set on the Statics tab of the General page. Increase min damping from 1.0 to 1.5. You can try a higher damping, say 5.0, but usually if 1.5 is not working then it is something else in the model that is causing the problem. Increase max

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damping from 10 to 50 or 100. Again it can go higher, say 500, but usually the problem is elsewhere.

Note that increasing damping slows down the final stages of the calculation. If damping is helping the convergence then the algorithm will find the solution sooner and the result is a much faster overall convergence time. If it is not helping then the overall time will be longer. Therefore don't just apply a large damping value as default.

Also too much damping can cause as many problems as too little. If you make a change to the model and statics struggles then set the damping back to default before going through the checks again.

### 4.2. Change Line Starting Shape

Try a different line starting shape in Line Statics Step 1, find this on the Line data page. For example a Spline is often more successful than a Catenary for flexible riser Wave and S systems.

### 4.3. Change Line Static Search Algorithm

If you know you are not far from the static solution then change the line full static convergence method from "Line Search" to "Mag. Of Std. Error / Change". This option is found on the Full Statics Convergence tab.

You can then set the "Mag. Of Std. Change" to a small value so it will only take small steps in the search. But note if you are far from the static solution then this method can slow down the time to convergence.

### 4.4. Change System Statics Algorithm

On rare occasions changing from "Whole Systems Statics" to "Separate Buoy and Line statics" can resolve the issue. However if lots of buoys, vessels and lines are interconnected this is unlikely to help.

## 5. Static Tolerance Sticks at a value

Changing the tolerance is a last resort because it changes the accuracy of your solution. If you set a large tolerance then (a) your static results will be less accurate and (b) you will start dynamics with an initial out of balance so you can get transients, a slower implicit run as it copes with the step change and transients or even an unstable run that crashes.

If you see the tolerance stick at a value, it may be that the solution is jumping either side of the target position and not reaching it. Increase the allowable tolerance to just above this sticking point.

If you do change the tolerance then, in static state, right click on the data page of an object of interest. Go to the properties option and it will tell you the force and/or moment accuracy achieved with that tolerance.

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### 6. Problems with Shapes

First make sure you have turned the stiffness on or off, as required. Then make sure you haven't hidden any shapes by mistake. Right click on the model browser lets you show all objects.

Finally have you any line nodes for the shape to react with? Too coarse a segmentation and the shape will pass between the nodes. If the model passes these tests then try the methods below.

If you require a line to stay on one side of a shape, or inside a hollow shape, then you want to make sure the static search does not go looking on the other side. The Step 1 Spline will allow you to tell OrcaFlex where you want it to be. Damping the search or changing the line search algorithm (see above) will also reduce the amount it flies around so it is more likely to find the solution you want.

Try increasing the thickness of the shape so the "wrong face" is further away. Consider a line lying on a shape representing a deck. If the shape is 1m thick then the line static search only needs to move down slightly over 0.5m for the line to be pushed to the bottom face. If the shape was 10m thick then the search would have to move down over 5m to end up pushed to the wrong side. You can always hide the shape when presenting to clients.

Sometime a Spline alone is not enough. If gravity will pull the line down, past the shape (for example an S-lay model), then a single static convergence step could miss the shapes completely.

In these cases consider adding links to hold the line on the correct shape. Set the link length so it is short enough that it prevents the line passing beyond the shape midway point but long enough that it is slack when the line is sitting on the shape surface.

The aim is to have zero tension in the link at the end of statics so there is no change in load when it is released at the start of dynamics.

### 7. Helping Line-on-Line Contact

Line-on-line contact is not active in statics. To keep one line on the correct side of the other you may need to turn current off in statics. This is the "Ramp during build-up" option on the Current data page.

However beware. In some systems the time to settle in response to the ramped current can be significant. So an alternative is to use links to hold one line on the correct side of the other. These links can be released at the start of Stage 0.

If the static tension in the link is high it can cause a step change in force when released. This can cause problems as indicated in Section 2. Replace the line with a winch and pay out over the Stage 0 until slack, then release.

Remember to keep the lines clear of each other in statics or there will be an instant load change in dynamics when the contact force is activated. This can cause the dynamic iterations to diverge.

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### 8. Don't make things too Stiff

A big out of balance force can cause an overshoot problem, usually seen by objects flying around. One cause is a bad initial guess of position. Another is very high stiffness so a small positional change can mean a big force change.

In some cases this cannot be avoided because the stiffness is critical to the response. However with shapes, links and winches you only need enough stiffness to give the global response.

If links or winches cause the statics to struggle (lines leaping about in the search) then consider the stiffness. If the total extension with a lesser stiffness is acceptable use that.

A shape needs sufficient normal stiffness that the line does not sink in too far or pass through. Don't worry about matching the actual stiffness of say a steel structure.

Similarly with the shear stiffness of a shape. It may be the lateral motion coupled with the shape friction is causing convergence problems so a lesser shear stiffness may help.

### 9. Don't make sudden Load Changes

A sudden step change in stiffness can cause difficulties in locking onto a solution. If non-linear bend stiffness for a line or non-linear stiffness for a link causes problems (jumping either side of the tolerance) then consider making the step change gentler.

If a static solution requires balancing of two opposing lines or links (hinge pins) then it is better to have them balanced at an actual tension rather than at 0kN.

If the balance point is 0kN then the search algorithm will oscillate between one being in tension and the other not, so tension is going on-off. Convergence is faster with oscillation of more tension-less tension instead.

### 10. Don't use Field coordinates

If you use Field coordinates then you are using up significant number slots with dead numbers. If a line has one end at 1234567m and the other at 1234569m then the important information is the difference between the two, 2m. So if you have 3 slots with numbers that will not change then your model accuracy is reduced by 3 decimal places. This may be too low an accuracy for static convergence to be achieved.

You can still build the model in field coordinates if that is easier for you but then move it to the model origin before you do any calculation. To do this make the objects all one Group (model browser group view). Right click on the Group and select "Move selected objects...". Choose New position and for one of the objects in the group and move it to the model origin (X=0,Y=0). The rest of the model will move with it.



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### 11. Keeping Lines on Track – Prescribed Shapes

Prescribed shapes have their own requirements.

Statics initially ignores bend stiffness and shape stiffness. It tries its best to then fit the line length to the starting shape. For prescribed shapes this means it lays the line along the “track” you have specified. Statics then turns the stiffnesses back on.

With bend stiffness added the static search now looks at options where the line is straighter. This is not what you want so you may need to increase the static damping to overcome this and keep the line search on the track.

Sometime damping is not enough so an alternative is to change the line full static convergence method from “Line Search” to “Mag. Of Std. Error / Change” on the Full Statics Convergence tab. This is an alternative search routine and allows you to set “Mag. Of Std. Change” to a small value (so it will only take small steps in the search).

However if the bend stiffness really would overcome the friction and straighten out but you still want to force it to stay in the track for statics then use either static method with a large tolerance. This will keep the line on the track but will give errors in the line loads. It will stay put in statics but be aware dynamics will start with a sudden release of the line, giving transients, etc.

### 12. If all else fails

Skill in sorting out these problems comes with experience. If your license includes maintenance then send the model to us. We will sort it out, tell you what we did and why so you will know next time you see it.

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We hope that the information in this Orcina Knowledge Base Article is useful. Please do not hesitate to contact us if you have any comments or questions.

The Orcina Team