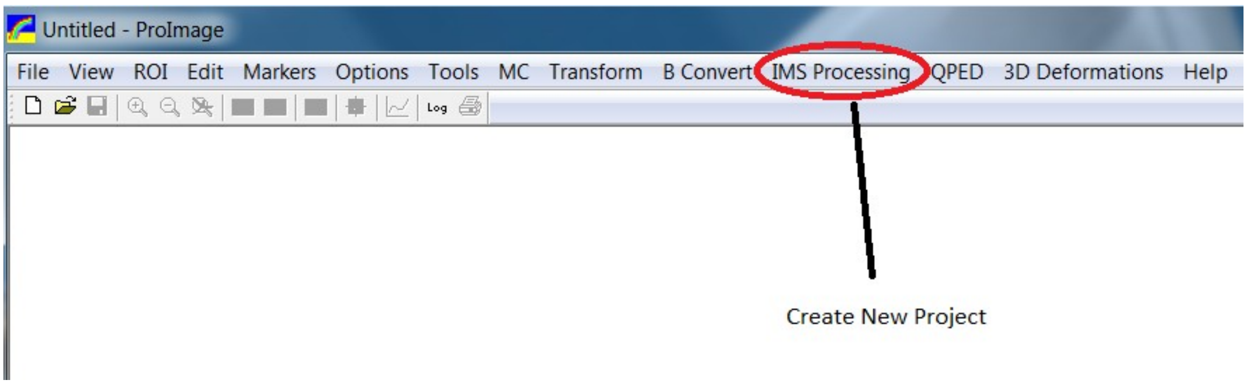
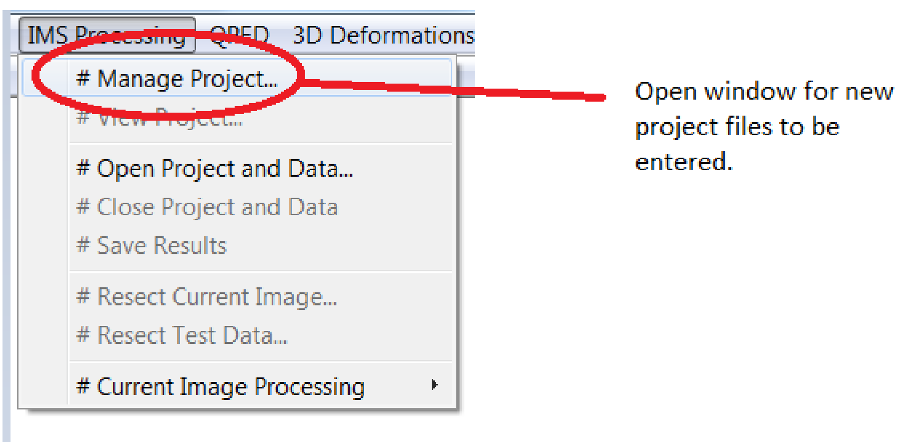
ProImage Tutorial

OMS-30i

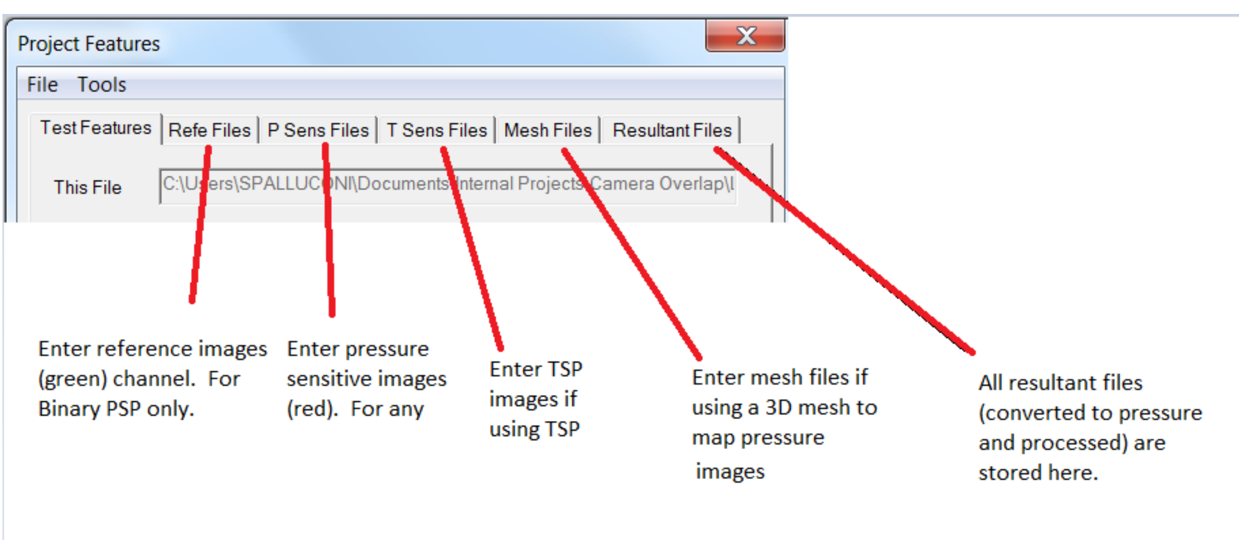
Creating a New Project File

Begin by opening ProImage and creating a new project. Go to ***IMS Processing*** and select ***Manage Project*** to create a new project file.

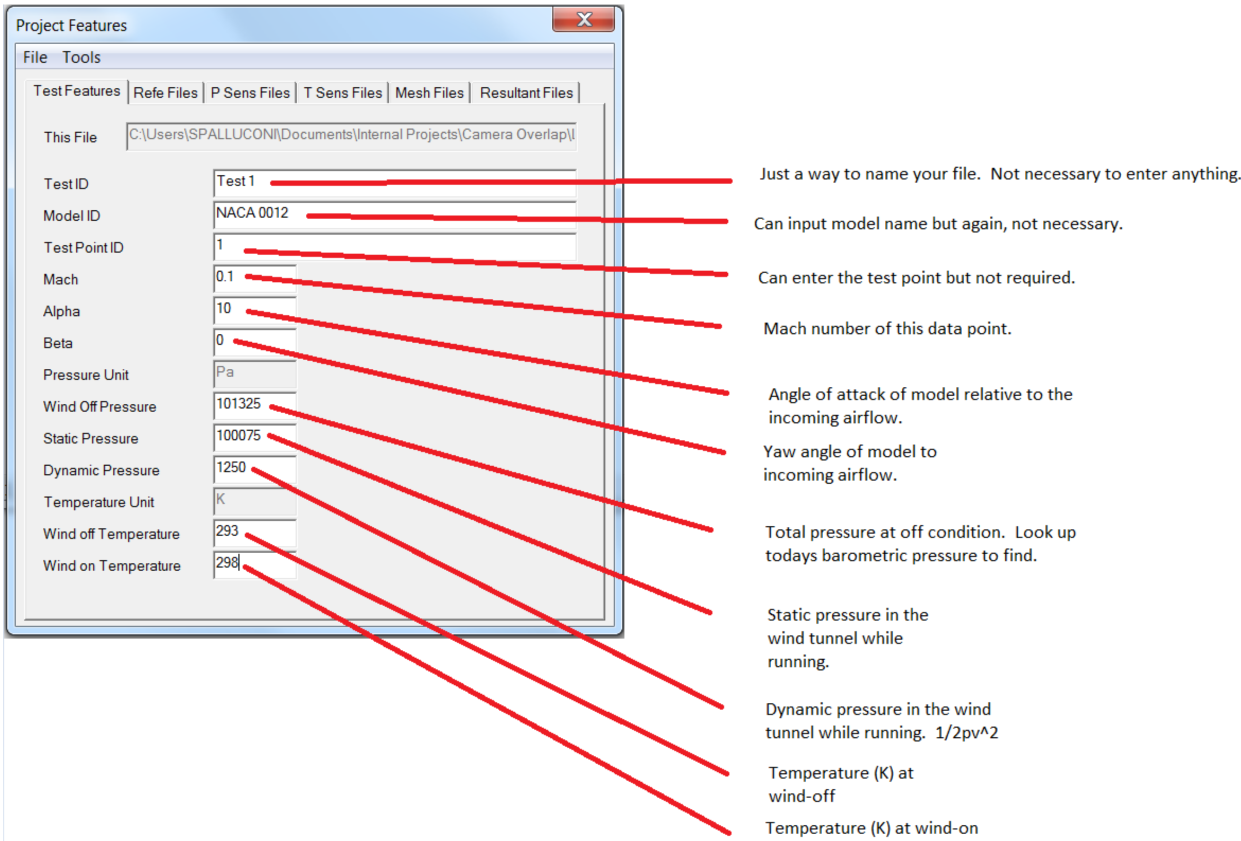




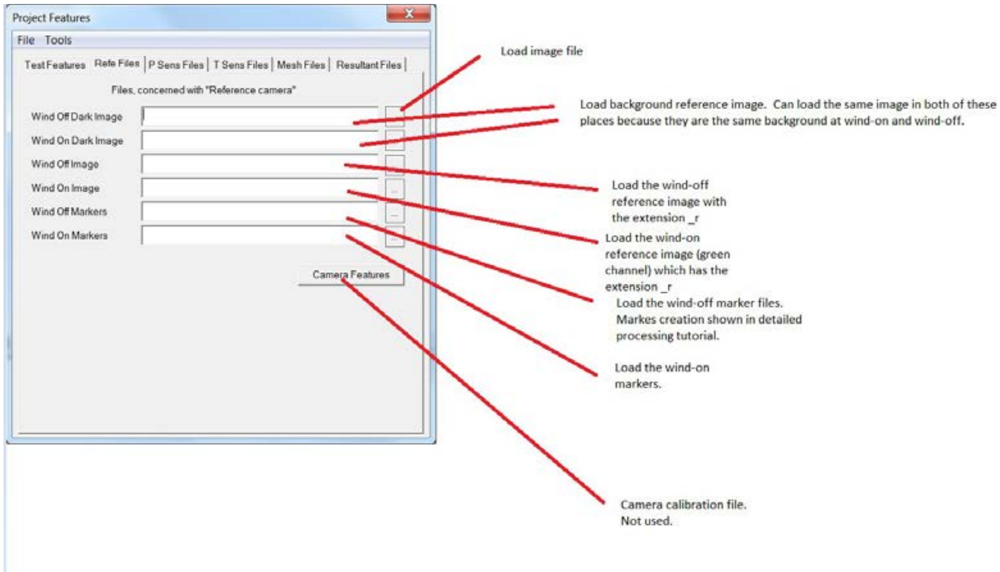
This window contains the areas where the project data and images will be stored for this test condition.



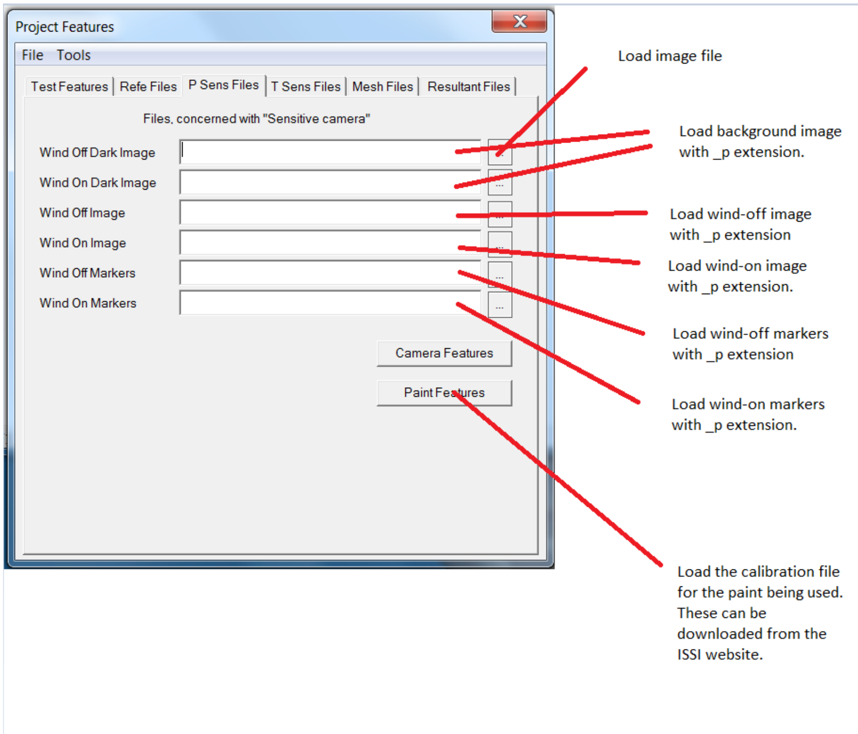
Begin by entering the test condition data for the experiment. This should be saved and recorded during the run. For demonstration, if this is not known exactly, just estimate.



Next, the images for the reference channel (green) will be used. Note that this is only used when processing Binary PSP. If not using Binary PSP, leave this blank. Load files with the extension _r.

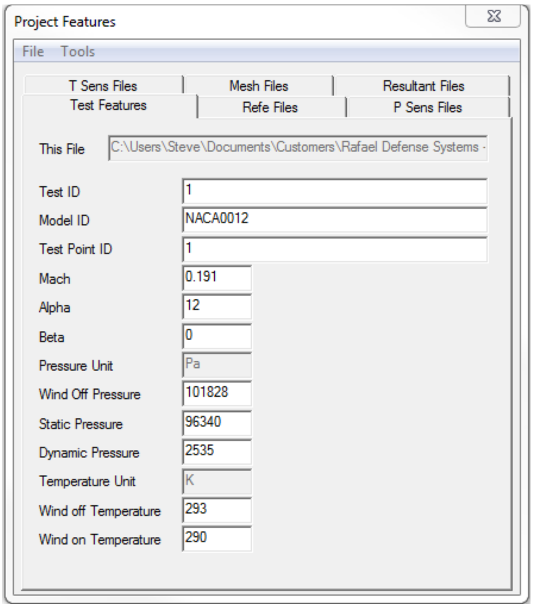


Next, load the images for the pressure sensitive channel (red). This is used whether the paint is Binary or not. Not for TSP, only PSP. There is a separate tab for TSP data if using TSP. Note that the extension on the pressure sensitive channels is _p. Markers will be created during the data processing as shown in that tutorial. Those should be loaded later.

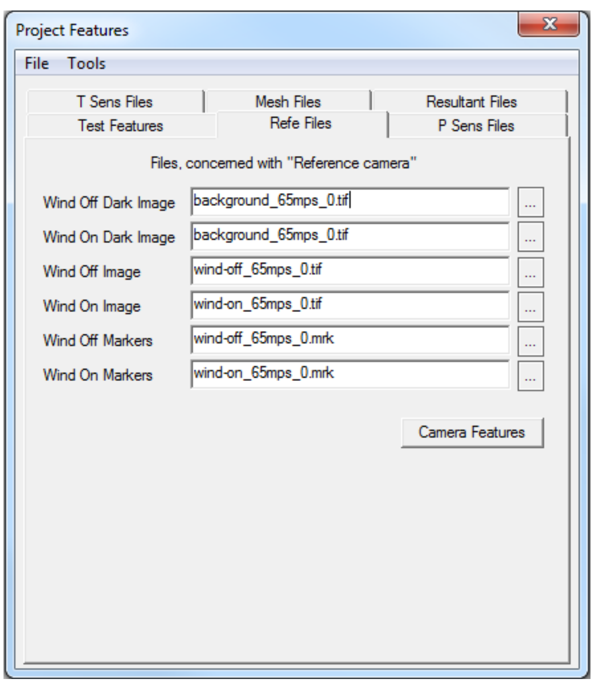

Project Features
File Tools
Test Features | Refe Files | P Sens Files | T Sens Files | Mesh Files | Resultant Files
Files, concerned with "Sensitive camera"
Wind Off Dark Image
Wind On Dark Image
Wind Off Image
Wind On Image
Wind Off Markers
Wind On Markers
Camera Features
Paint Features
Load image file
Load background image with _p extension.
Load wind-off image with _p extension
Load wind-on image with _p extension.
Load wind-off markers with _p extension
Load wind-on markers with _p extension.
Load the calibration file for the paint being used. These can be downloaded from the ISSI website.

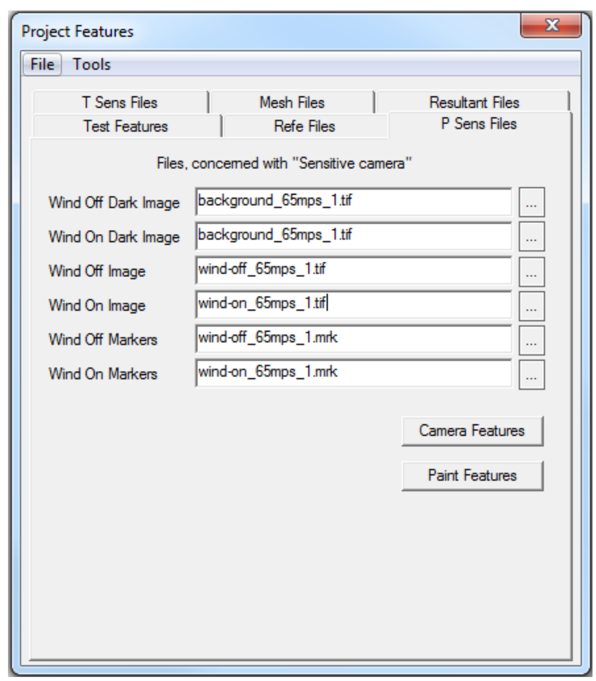
Data Processing in ProImage NACA 0012 Model with Pressure Taps

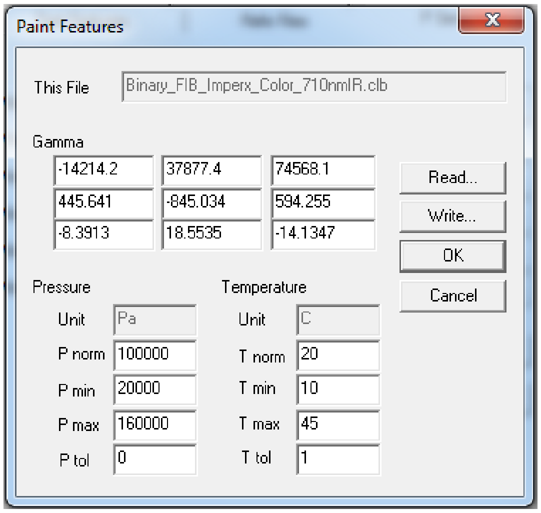
Begin by opening ProImage and creating a new project file (***IMS Processing*** > ***Manage Project***). Characteristics of the model and test should be entered here. Pressure values are in Pascals and temperature values in Kelvin.



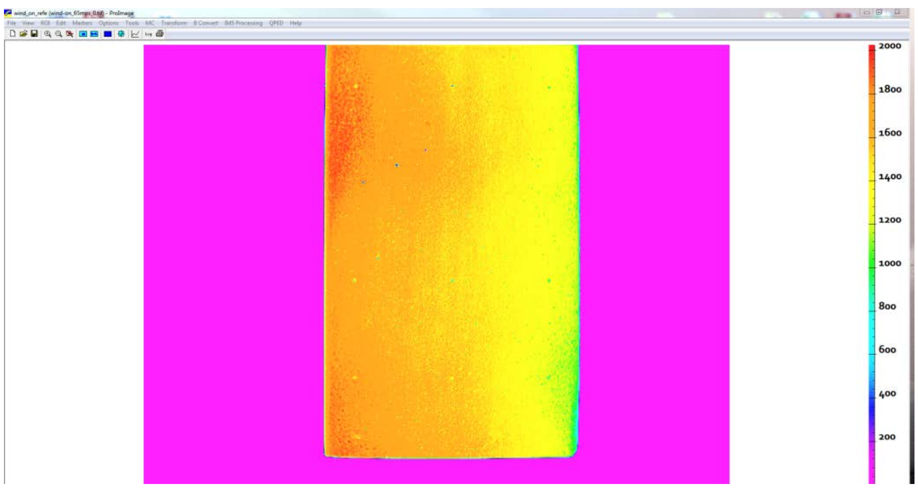
Be sure all of the saved data (images, calibration file, marker files) are in the same directory where the project file is saved.





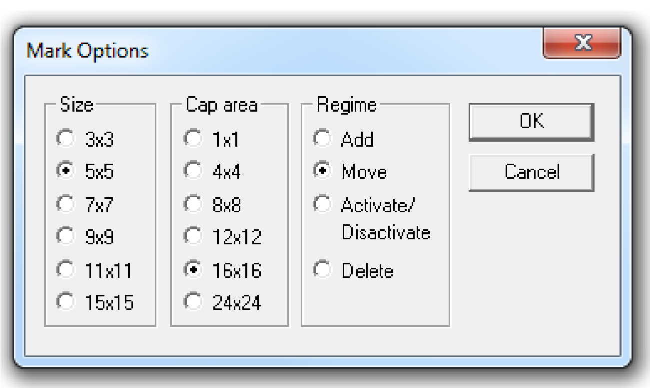


To open the new project for data processing, from the B-Convert menu, select ***Open Project*** and load the ***.ims*** project file just created.



Opening the project file in B-Convert will load all of the raw images in the project file. Press the Tab key to scroll through the images loaded from the project file.

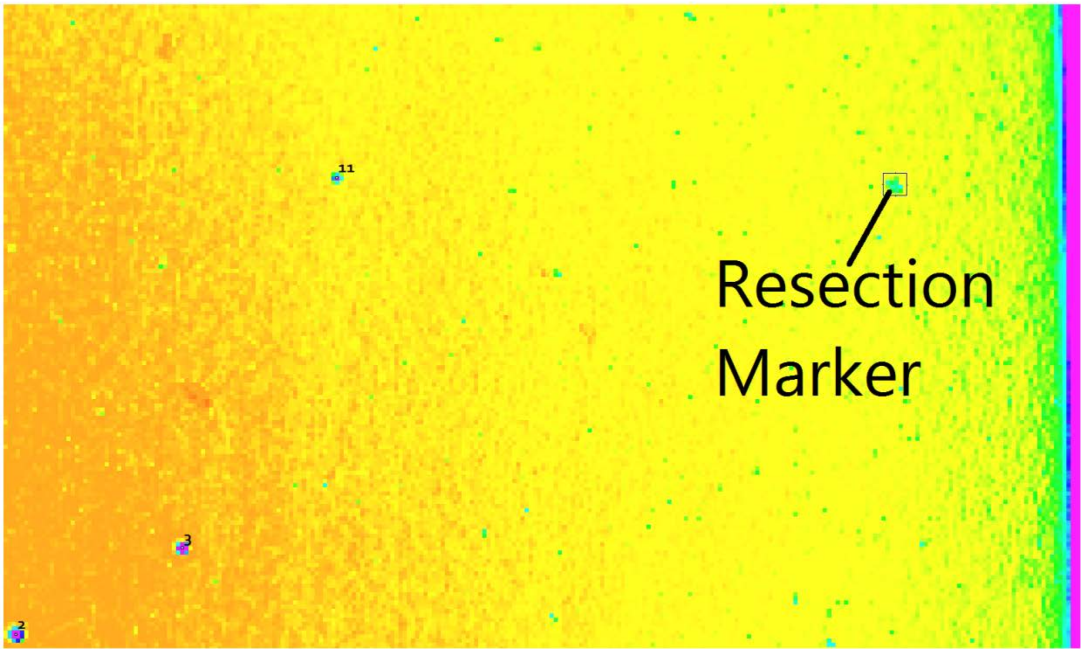
Markers are used for image alignment or pressure tap correction. Often, PSP images need to be aligned due to shift between loaded and unloaded conditions. Commonly, models have registration marks on the surface. Sometimes, pressure taps on the model are numerous enough that they can be used as registration markers. These pressure taps are also used to input pressure tap data into the PSP processing to anchor the PSP data and apply a bias correction.

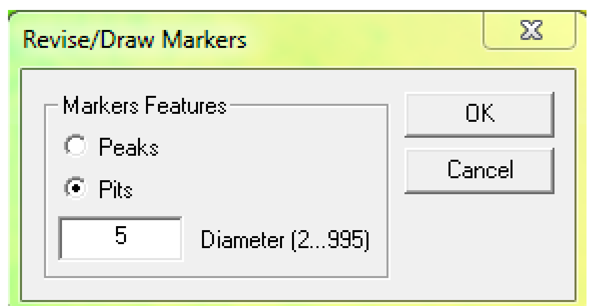


Markers can be added from the ***Markers*** tab.

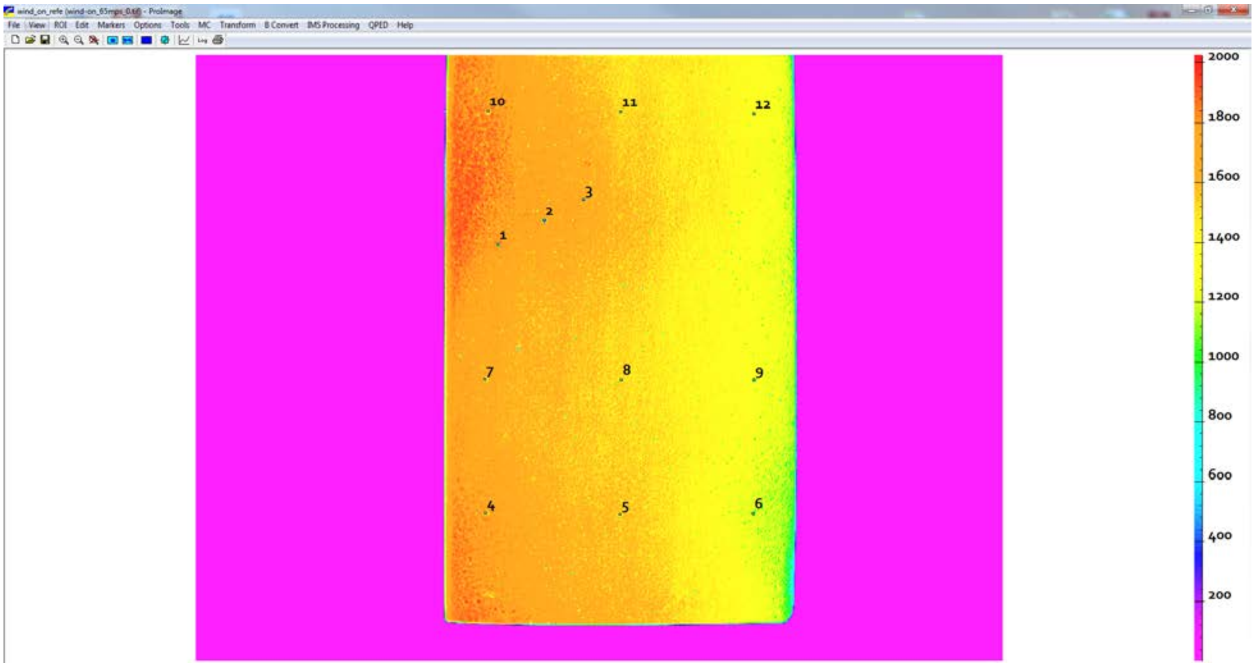
Navigate to ***Markers>Mark*** or from . This will bring up the Mark Options window. Here, markers can be added, moved, activated/deactivated or deleted. The ***Size*** option is the size of the marker tool. The ***Cap Area*** is the area of the search window over which marker will be searched for. ***Regime*** is the command to execute. ***Add*** will add a marker in the location. ***Move*** will allow the marker to be moved to another location. ***Activate/Deactivate*** will turn a marker on or off for resection, alignment or pressure tap correction. ***Delete*** will permanently remove a marker. When using the marker tool, right-click the mouse to go back to the ***Mark Options*** window.

Hold the selection tool over each resection marker or pressure tap and add a marker to each such location until complete.

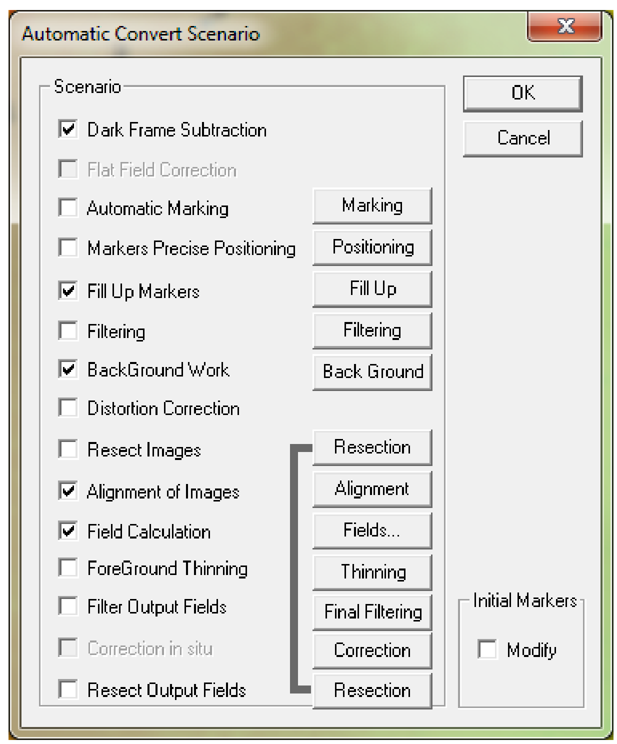




Once the markers have been placed over all registration marks and pressure taps, revise the markers using the ***Revise Markers*** tool. The markers should be located at the '*pit*' or lowest intensity value of each marker site. When they are placed on the surface manually using the 'add marker tool' they may be slightly off of the pit. To correct for this, once all markers are placed, us the 'Revise all' tool to revise all markers to the true low intensity pit of each tap location. This will assure the markers are at the central point of each registration mark. Select ***Pits*** and a pixel diameter just larger than the marker diameter. This will search an NxN window around the marker for the lowest pixel value and place the marker there. The markers can then be copied to the other images (***BConvert > Markers Copy/Markers Past***) and then revised on each image to assure they are at the same center point. This assures that image mapping is done to the correct marker position when mapping wind-on back to wind-off. The same is true with pressure tap correction in that the marker is at the true center of the pressure tap where the pressure tap value is being compared versus PSP. The marker files are saved for the individual images once marked. When the images are converted to pressure, a new marker file for the pressure image will be automatically created which is then saved with the final data. Pressure tap data is entered here. This will be shown later.



Adding markers will look like the above image. The markers are automatically enumerated. Save each image marker file by ***Markers > Mark > Save Markers As.*** The marker files will automatically reflect the name of the image they are associated with having the extension ***.mrk***. The marker files then need to be loaded into the project file in the ***IMS Processing*** window. Save the project with the marker files added.



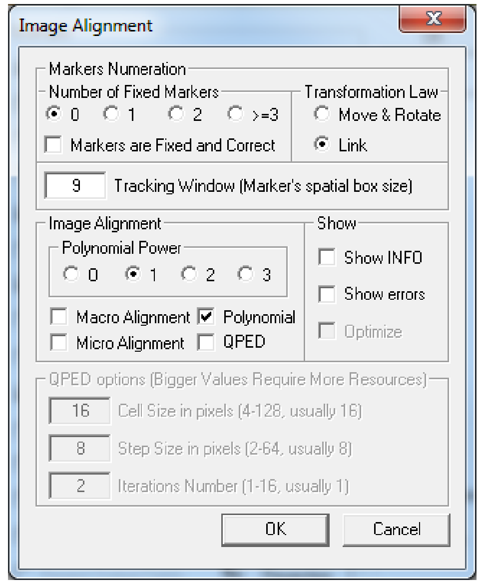
Once the project file is complete (test data, all raw images, marker files created and added and calibration file loaded), load it with ***BConvert > Open Project***.

BConvert contains most of the post processing tools used to convert the raw data into useable final data. The ***BConvert*** menu will be covered in detail.

BConvert incorporates all of the conversion tools to take raw data and produce final pressure data. The ***Automatic Convert Scenario*** window (***BConvert>Automatic Convert***) is where this is done. Check each box to activate each tool.

Dark Frame Subtraction removes the dark from (background image) from each of the wind-off and wind-on images. This removes any effect or artifact from ambient lighting that could adversely affect the final PSP results.

Automatic Marking will automatically add markers. Only use this tool for very well defined markers.



Markers Precise Positioning will then revise those markers from the automatic marking.

Fill Up Markers will fill in the markers with a spatial filter to remove them from the final processing images.

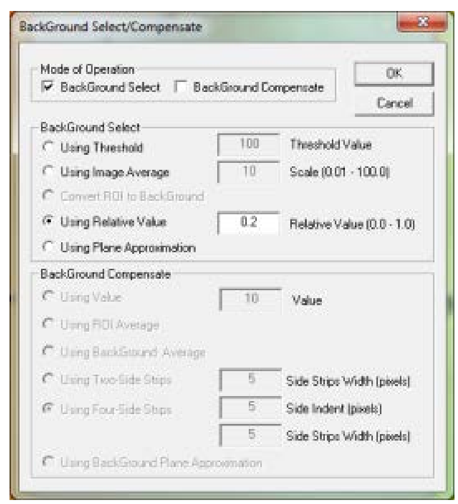
Filtering will apply a Gaussian filter to the raw images before conversion to pressure. A NxN filter will be applied to the entire image.

Background Work will remove the background of the images below a certain threshold. This effectively removes any non-painted regions from the final data. This can be done as a percentage of the maximum intensity value or a threshold below a given value.

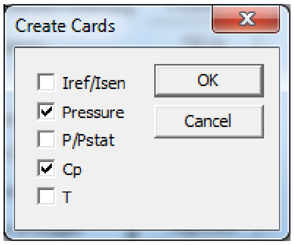
Distortion Correction compensates for objective lens distortions on the images.

Resect Images is used to resection 2D data to 3D meshes. This will be covered in more detail in the ProGraph and ProField instruction manuals.

Alignment of Images allows the user to select a polynomial alignment of images using resection markers or a cross-correlation algorithm to align. For the polynomial alignment there are several options. ***Number of Fixed*** Markers creates a basis for translation of the markers. If none are fixed, all can shift for translation.



Transformation Law has two options, ***Move and Rotate*** (rotating images) and ***Link*** (shift images 2D). ***Tracking Window*** is the NxN pixel window around each marker to search for on the deformed (on-condition) image. This should be larger than the maximum marker displacement so the algorithm can find the appropriate marker to map to. Polynomial Power refers to the order of the polynomial used in the alignment. For simple shifts in one dimension, use 0. For 2D shifts, use 1 and for twisting and bending type deflections, use 2 or 3. For ***QPED***, the Cell size in which to compute the cross-correlation algorithm, the step size for the step from the original box size to do the cross-correlation and the number of iterations are all selectable. Recommended sizes are listed.



Field Calculation gives the option to select which final images to compute. Select all desired final processed cases.

Foreground Thinning will trim the perimeter of the image (if background is removed, it will only trim the perimeter of the painted surface where intensity values are nonzero). Select the size of the thinning filter in pixels. This is used if there is an edge effect on the painted surface from a smoothing filter. This is typically done post conversion after the automatic conversion is computed.

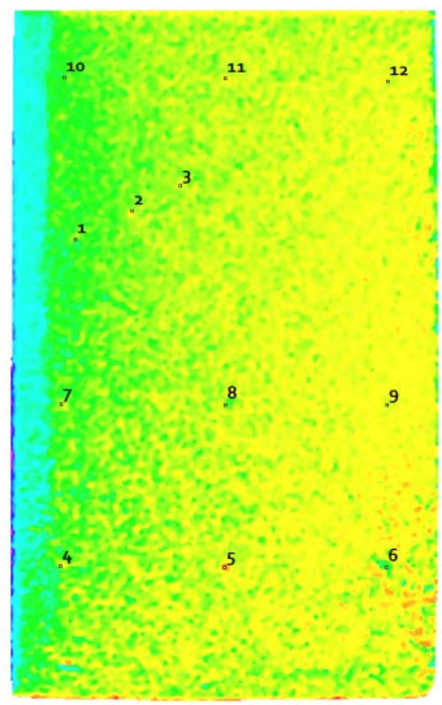
Filter Output Fields will apply a NxN smoothing (Gaussian) filter to the final fields computed.

Correction in-Situ will apply and in-situ pressure tap correction to the data. Typically this is done after the automatic conversion once all images have been cleaned up and filtered manually.

Resect Output Fields is used to resection final, converted 2D data to 3D me shes. This will be covered in more detail in the ProGraph and ProField instruction manuals.

Converted Pressure Image (No Filtering)

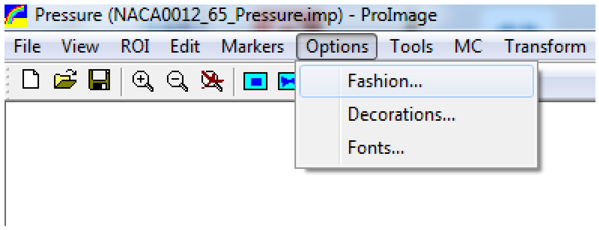
Without filtering applied, the converted pressure image does not look like much. This data was taken at 60 m/s (dynamic pressure = 2,160 Pa) and thus will have a lower signal to noise ratio than higher speed (larger dynamic pressures). Therefore, some spatial filtering should be applied.
Applying a 5x5 pixel medial filter (2 iterations) cleans up pixel to pixel variations from camera shot noise so the pressure distribution can be more clearly shown. To apply this and all filtering after automatic conversion, the filtering options are available in the ***Edit*** tab.

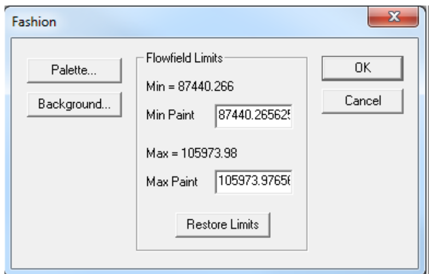


5x5 Median Filter

The median filter may not smooth the data enough so a 15x15 Gaussian filter was chosen to better show the pressure gradient over the wing.

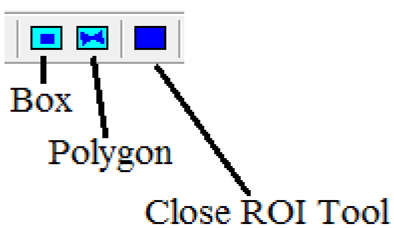
Each time a smoothing filter is applied, the pixel to pixel variation is being reduced to produce a smoother image. Each time one is applied, the minimum and maximum (look-up table) values change. To adjust the look-up table (LUT) to reflect this change, the image fashion menu will allow adjustment of the LUT.



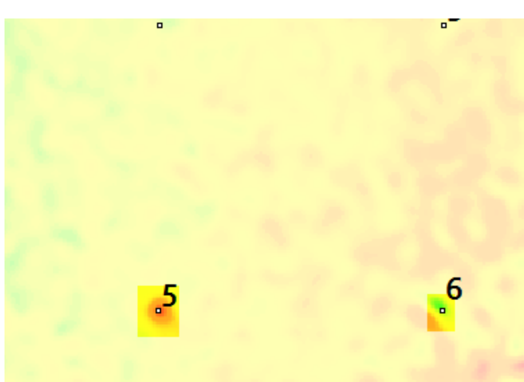


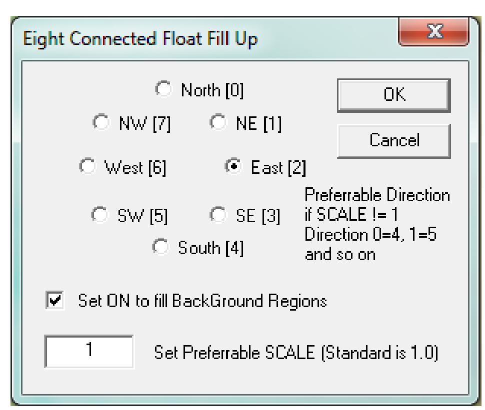
Press Restore Limits to automatically scale the LUT to the minimum and maximum on the image scale.

If the fill up markers tool does not remove all makers effectively or if a region of interest such as a screw or seam (for models assembled from several pieces) needs to be filtered out (removed), the region of interest (ROI) tool can do just that.

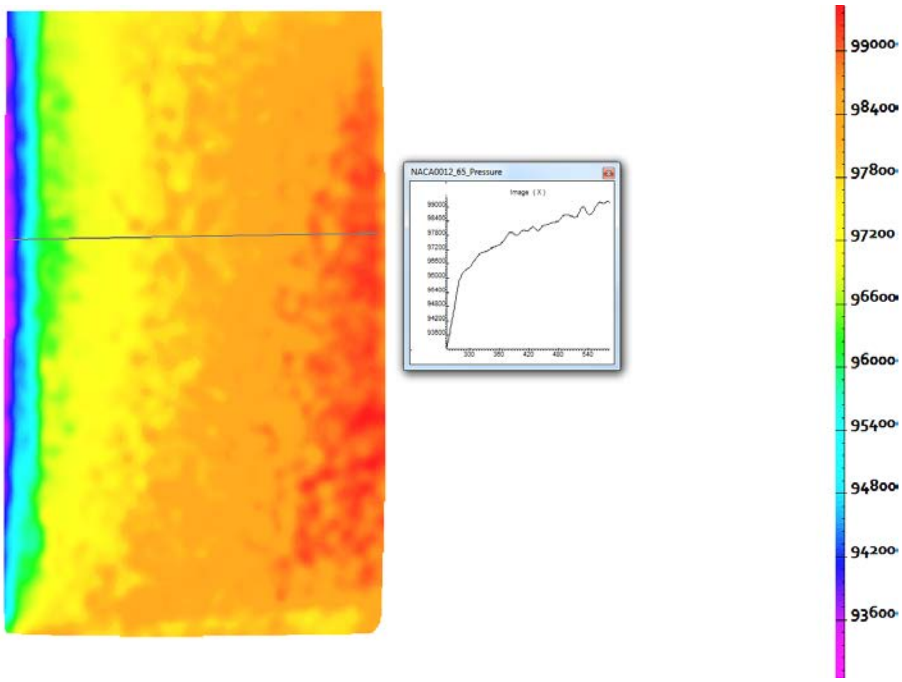


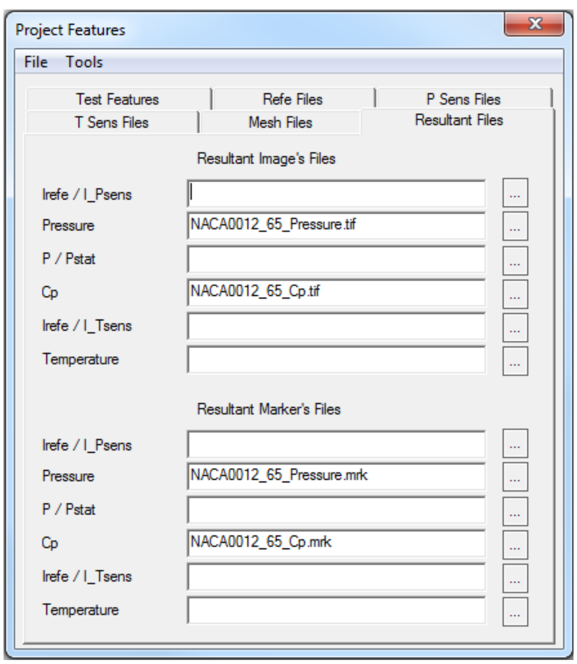
The ROI tool is on the main window (pictured above) and allows selection of a specific region of interest to filter or remove. An ROI can be filtered, biased, removed or flooded with a given value. A box or a polygon can be selected.





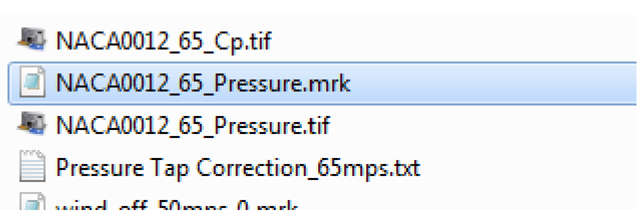
Select the ROI to remove or filter and then smoothing can be applied from the ***Edit*** tab. ***Edit>Fill Up*** will load the ***Eight Connect Float Fill Up*** window which will bias the data by the closest neighbor in a chosen direction to remove the undesirable features. The final smoothed data will look like the image below. This data has had the aforementioned smoothing filters and corrections applied.





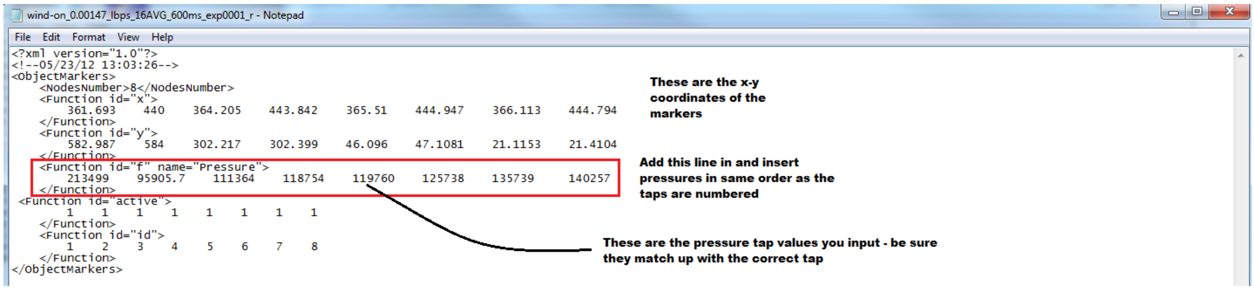
The next step is to create a pressure tap correction file to correct the final filtered and corrected data using pressure taps. When the final corrections have been made, save the project and all results (***IMS Processing>Save Results***). This will save all resultant files and marker files for those resultant files in the project file automatically.

Find the maker file associated with the final pressure image in the directory where the project file and all raw and processed data is stored.



Open this file to add the pressure tap data from the data acquisition system (pressure scanner or whichever experimental measurement is being used for comparison).

The marker files are all text files and can be opened in any text editor. The marker file contains the x- and y-coordinate of each marker, whether it is active (1=active, 0=inactive) and what number marker



it is listed as.

To add the pressure tap data (in Pa or psi), another line needs to be added to this text file. After the </Function> statement for the y-coordinates, add the following:

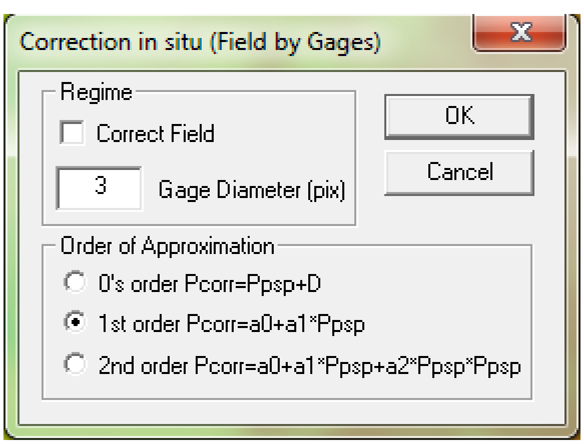
<Function id="f" name="Pressure">

Pressure tap values (in Pa) separated by a tab

</Function>

The marker file may contain a mix of pressure taps and registration markers only for resection as is the case in this example. There are only 3 pressure taps and the rest are registration markers. The pressure taps are numbers 1, 2 and 3. Make all non-pressure taps inactive so they are not used in the correction. In the line where pressure tap values are entered, the non-pressure taps still need to have a value so simply make them all zero. Rather than adding in zeros for each registration marker, they could also be deleted and not included in the marker file whatsoever.

To make the correction with the pressure tap data, go to ***Tools>Pressure Ports*** which will bring up the ***Correction in Situ*** window. There are a few options to choose from to do the correction. Checking the box for ***Correct Field*** will apply the correction to the data. Before doing this, leave it unchecked to see how well the correction has done. If unchecked, the correction can be previewed before applying. ***Gage Diameter*** is the NxN area around the pressure tap on which to compute the comparison between taps and PSP. ***Order of Approximation*** allows selection of the order of polynomial for in situ correction.



Clicking OK will bring up a window to select the pressure tap correct file (the marker file edited previously). Select the pressure tap correction marker file. This will bring up a popup window stating the conversion and then the corrected values, shown below.

N	X	Y	Ptaps	Ppsp	Delta	Ppsp,corr	Delta,corr
1	299.17	414.92	96683.5	96909.719	-226.21875	96655.273	-28.226563
2	345.66	438.71	97456.297	97728.297	-272	97473.852	17.554688
3	385.07	459.28	97886.398	98151.523	-265.125	97897.078	10.679688

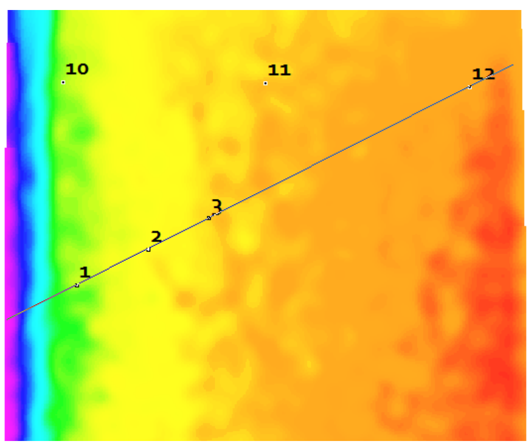
Initial Dispersion=255.245, Final Dispersion=20.1574

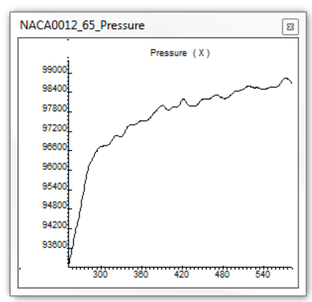
Approximation Ppsp,corr = Ppsp + A0(+-D0)

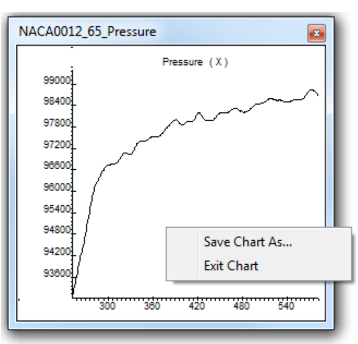
Where A0=-254.447922, D0=312.610138

Maximum Deflection=-28.2266, at N=1 with Ppsp,corr=96655.3, at X=299.172 & Y=414.915

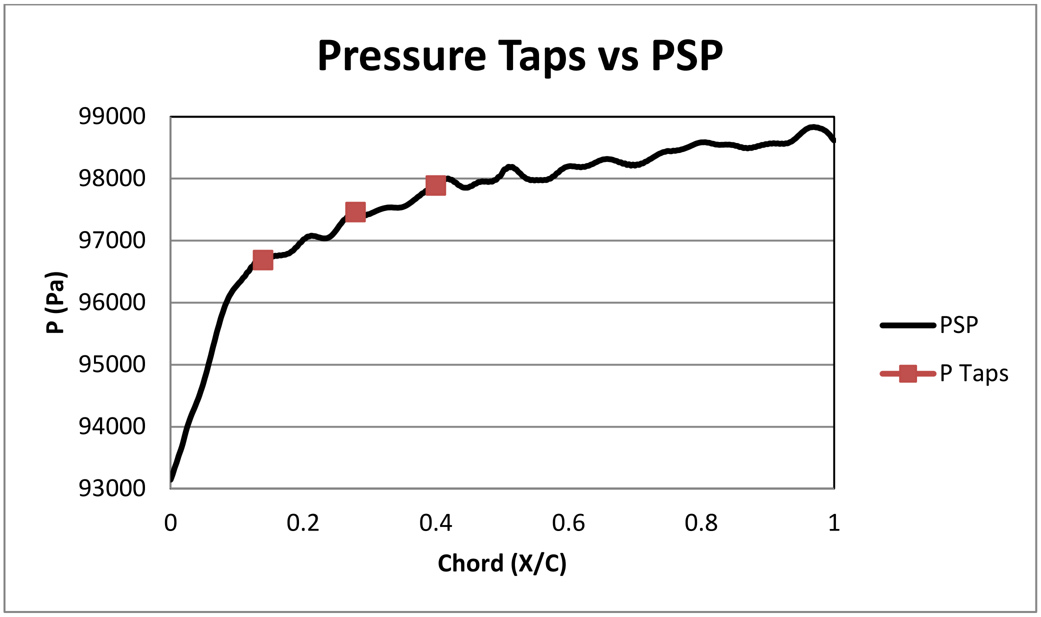
This will show the pressure taps locations, their values, the associated PSP value at that location (over the chosen gage diameter), the initial dispersion (Delta), the corrected PSP value and the final dispersion (Delta,corr) for each tap location. The average initial dispersion and average final dispersion will also be shown. The average final dispersion is used to compute the accuracy over the dynamic range.







Pressure data can be extracted along a line using the graphing tool () on the main toolbar in ProImage. This can be saved as a text file for comparison and plotting against pressure tap values.

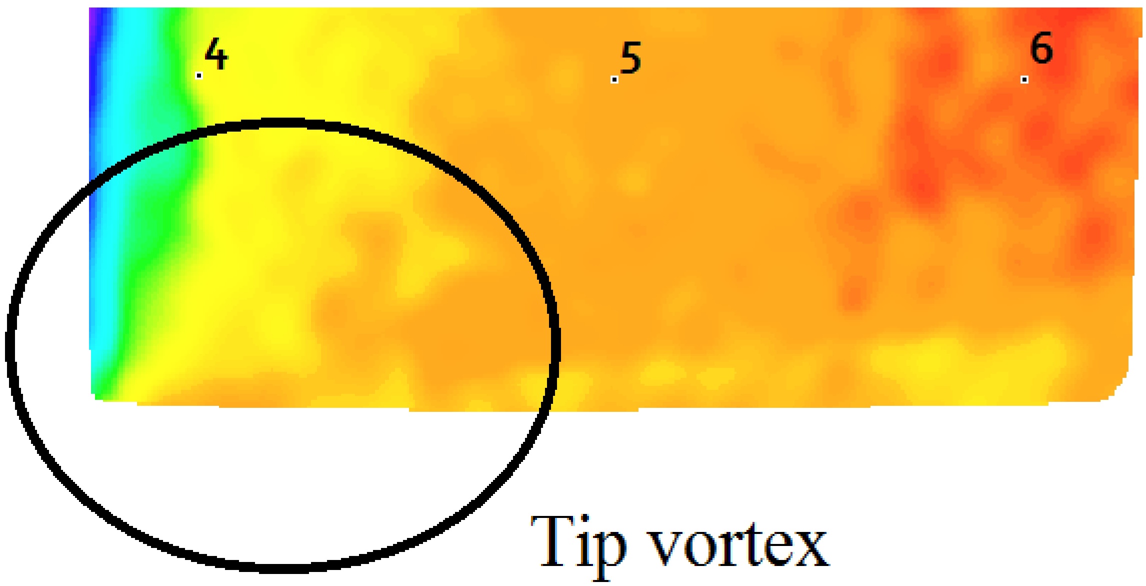


Density (kg/m^3)	Velocity (m/s)	Dynamic Pressure (Pa)
1.2	10	60
1.2	15	135
1.2	20	240
1.2	25	375
1.2	30	540
1.2	35	735
1.2	40	960
1.2	45	1215
1.2	50	1500
1.2	55	1815
1.2	60	2160
1.2	65	2535
1.2	70	2940

$$P + \frac{1}{2}\rho v^2 = P_o$$

Standard Deviation between Taps and PSP: 20.16 Pa
Dynamic Range: 2160 Pa
Accuracy with taps over dynamic range: 0.9333%

Even at lower velocities, small flow characteristics can be seen in the final data and in this case, the tip vortex is evident.



At low speeds or high speeds, pressure sensitive paint provides very high spatial resolution measurements with excellent comparison to convention pressure measurements like pressure measurements, showing its viability as an experimental technique.