Rotor Imbalance Measurement

with the DYBAL add-on sub-product for
PLATO – objective NVH measurement & analysis system

GET IN TOUCH
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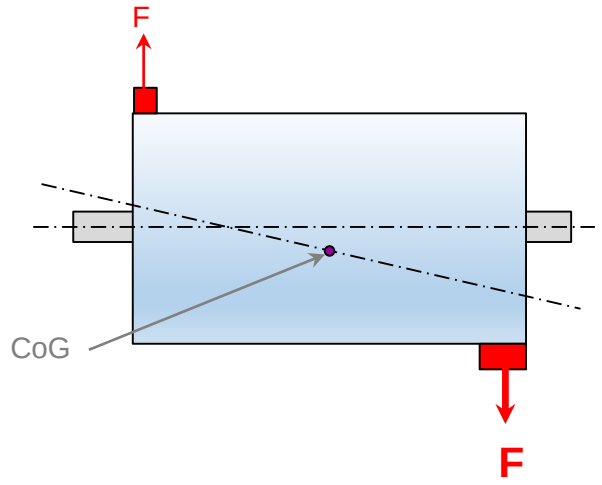
The **Dybal** add-on product for **Plato** provides a static and dynamic imbalance measurement and analysis sub-system for use with rotor imbalance measurement / correction machines (“balancing machines”)*

The following configurations are currently supported:

- 1-plane measurement / 1-plane correction
- 2-plane measurement / 1-plane correction
- 2-plane measurement / 2-plane correction



Four running modes are provided:

- **S-mode (Scale Factor Calculation)** for automatic calibration of the system sensitivities and angular offsets.
- **T-mode (Tooling Offset Measurement)** for automatic computation of tooling offset vectors.
- **P-mode (Production)** for normal testing including calculation of imbalance(s) and issue of recommended correction(s) via OPC-tags
- **V-mode (Tooling Verification)** for quick verification that the current tooling is still acceptable in terms of its inherent imbalance with results available via OPC-tags

* *Contact AB Dynamics for details of balancing machine providers*

Standalone Balance or Combined Balance/NVH Analysis

Imbalance measurement & analysis can be implemented as a:

- standalone system (with a balancing test machine)

OR

- an integrated balance & NVH (“combo machine”)

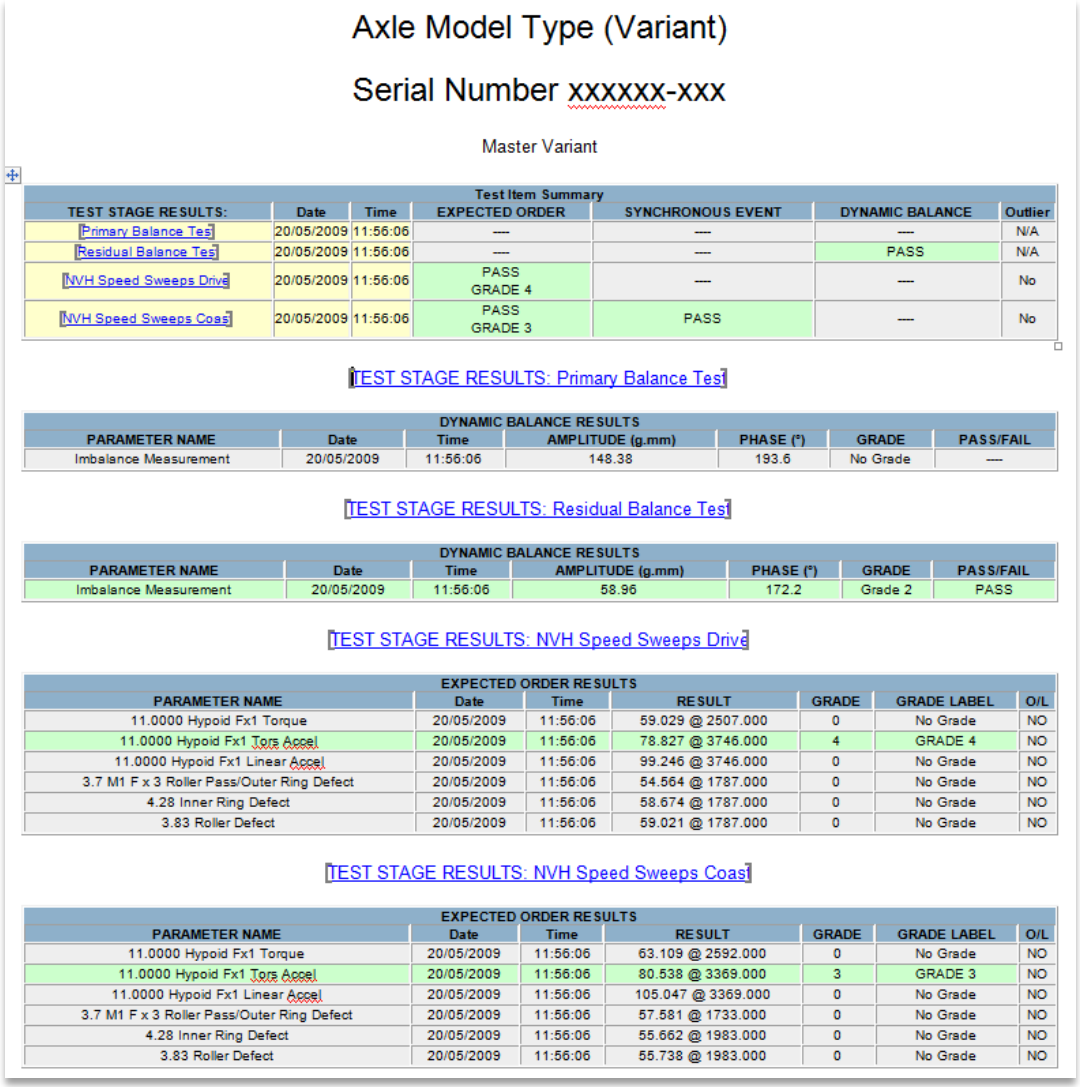
Results (imbalance and/or NVH) are stored in the same database and reported in the same test report

Balance & NVH Result Summary

Balance Results Primary:

Residual:

NVH Results



Axle Model Type (Variant)

Serial Number xxxxxx-xxx

Master Variant

Test Item Summary

TEST STAGE RESULTS:	Date	Time	EXPECTED ORDER	SYNCHRONOUS EVENT	DYNAMIC BALANCE	Outlier
Primary Balance Tes	20/05/2009	11:56:06	---	---	---	N/A
Residual Balance Tes	20/05/2009	11:56:06	---	---	PASS	N/A
NVH Speed Sweeps Drive	20/05/2009	11:56:06	PASS GRADE 4	---	---	No
NVH Speed Sweeps Coas	20/05/2009	11:56:06	PASS GRADE 3	PASS	---	No

TEST STAGE RESULTS: Primary Balance Tes

DYNAMIC BALANCE RESULTS

PARAMETER NAME	Date	Time	AMPLITUDE (g.mm)	PHASE (°)	GRADE	PASS/FAIL
Imbalance Measurement	20/05/2009	11:56:06	148.38	193.6	No Grade	---

TEST STAGE RESULTS: Residual Balance Tes

DYNAMIC BALANCE RESULTS

PARAMETER NAME	Date	Time	AMPLITUDE (g.mm)	PHASE (°)	GRADE	PASS/FAIL
Imbalance Measurement	20/05/2009	11:56:06	58.96	172.2	Grade 2	PASS

TEST STAGE RESULTS: NVH Speed Sweeps Drive

EXPECTED ORDER RESULTS

PARAMETER NAME	Date	Time	RESULT	GRADE	GRADE LABEL	O/L
11.0000 Hypoid Fx1 Torque	20/05/2009	11:56:06	59.029 @ 2507.000	0	No Grade	NO
11.0000 Hypoid Fx1 Tors Accel	20/05/2009	11:56:06	78.827 @ 3746.000	4	GRADE 4	NO
11.0000 Hypoid Fx1 Linear Accel	20/05/2009	11:56:06	99.246 @ 3746.000	0	No Grade	NO
3.7 M1 F x 3 Roller Pass/Outer Ring Defect	20/05/2009	11:56:06	54.564 @ 1787.000	0	No Grade	NO
4.28 Inner Ring Defect	20/05/2009	11:56:06	58.674 @ 1787.000	0	No Grade	NO
3.83 Roller Defect	20/05/2009	11:56:06	59.021 @ 1787.000	0	No Grade	NO

TEST STAGE RESULTS: NVH Speed Sweeps Coas

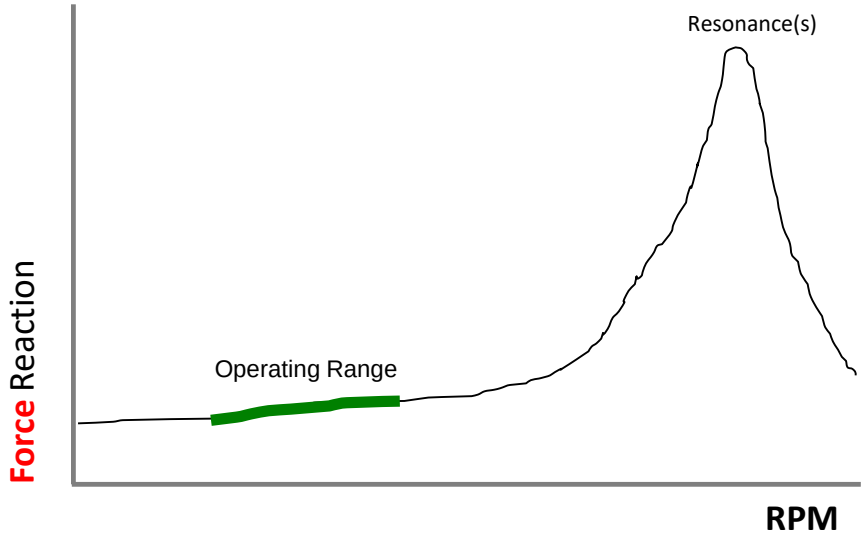
EXPECTED ORDER RESULTS

PARAMETER NAME	Date	Time	RESULT	GRADE	GRADE LABEL	O/L
11.0000 Hypoid Fx1 Torque	20/05/2009	11:56:06	63.109 @ 2592.000	0	No Grade	NO
11.0000 Hypoid Fx1 Tors Accel	20/05/2009	11:56:06	80.538 @ 3369.000	3	GRADE 3	NO
11.0000 Hypoid Fx1 Linear Accel	20/05/2009	11:56:06	105.047 @ 3369.000	0	No Grade	NO
3.7 M1 F x 3 Roller Pass/Outer Ring Defect	20/05/2009	11:56:06	57.581 @ 1733.000	0	No Grade	NO
4.28 Inner Ring Defect	20/05/2009	11:56:06	55.662 @ 1983.000	0	No Grade	NO
3.83 Roller Defect	20/05/2009	11:56:06	55.738 @ 1983.000	0	No Grade	NO

“Hard” Mount

If balance speed = **3000 RPM** (50Hz)
System must not resonate below circa < 150Hz

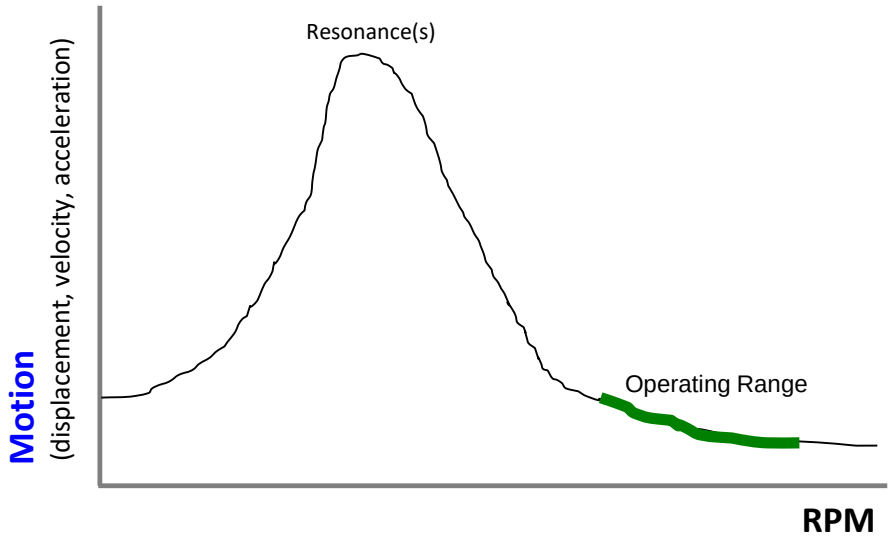
Force (reaction) is measured.



“Soft” Mount

If balance speed = **3000 RPM** (50Hz)
System must resonate at circa < 15Hz (max)

Motion (displacement, velocity, or acceleration) is measured at bearings.

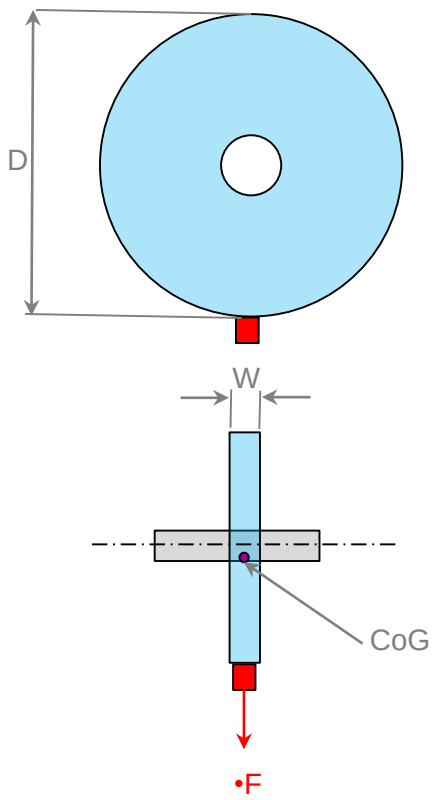


There are typically two (2) generic types of balancing machine: “hard” mount and “soft” mount. **PLATO**-**DYBAL** can operate with either.

Pure Static Imbalance

Centre-of-gravity does not lie on the axis of rotation.

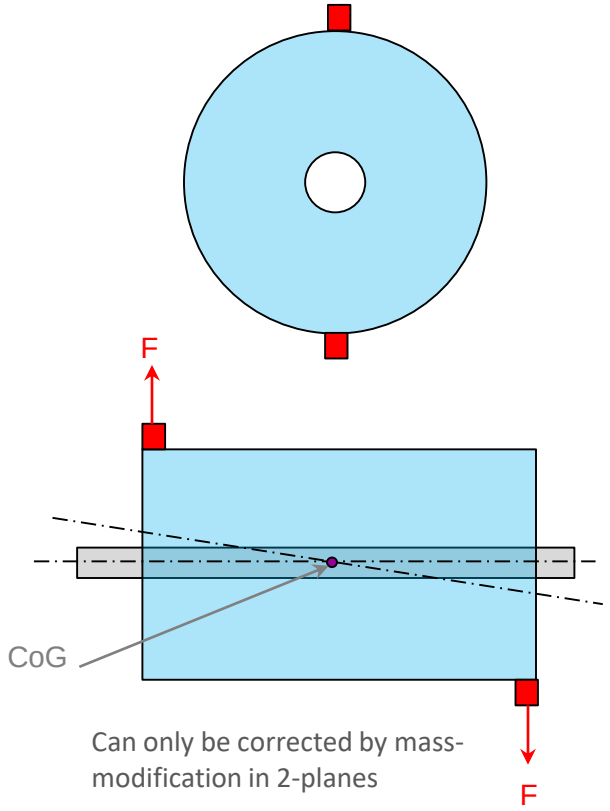
Usually applicable if: D > Wx7



Pure Couple Imbalance

Centre-of-gravity lies on the axis of rotation i.e. statically balanced, but inertial axis skewed.

Usually applicable if: D < Wx7

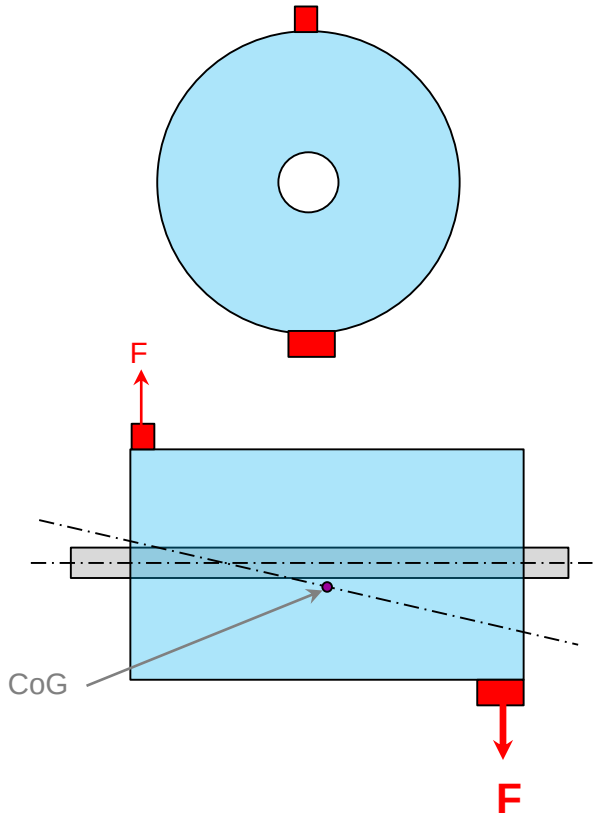


Can only be corrected by mass-modification in 2-planes

Dynamic Imbalance

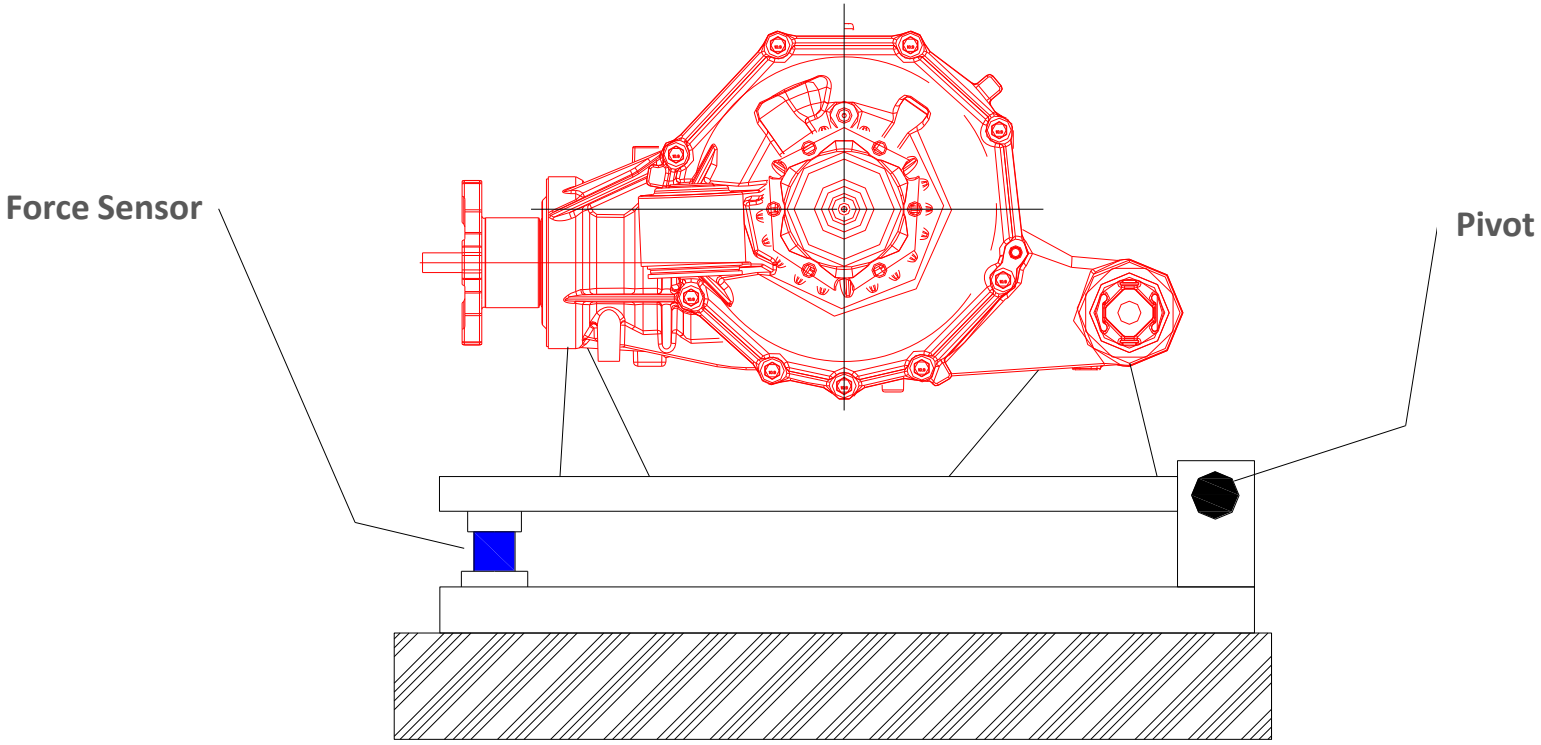
Combination of static and couple imbalance.

Usually applicable if: D < Wx7



PLATO-DYBAL performs 1-plane balancing (with 1-plane correction) or 2-plane balancing with 1-plane (compromise) or 2- plane (optimised) correction.

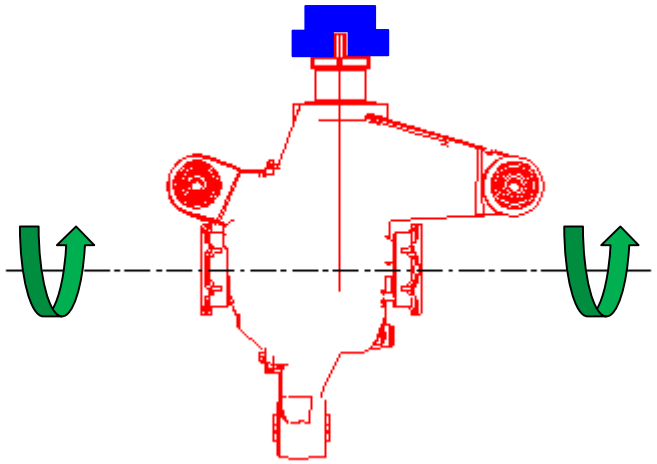
Typical RDM Single-Plane (Static) Imbalance Set-Up (Hard-Mount)



1-plane measurement / 1-plane correction

Typical RDM Imbalance Measurement Drive Configurations

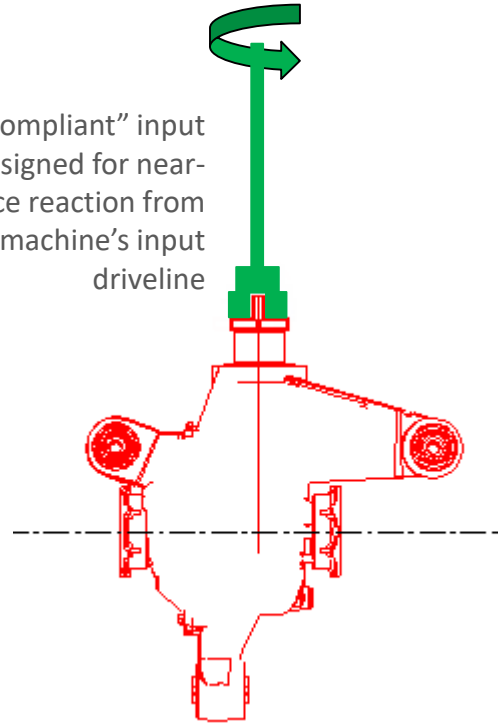
Hung Mass
or “Master Propshaft”
(zero force reaction from test machine’s input driveline)



Output Driven

Outputs driven (synchronously) to achieve balance speed for input.
Small out speed differential sometimes useful to stabilise differential gears

“Super-Compliant” input tooling designed for near-zero force reaction from test machine’s input driveline

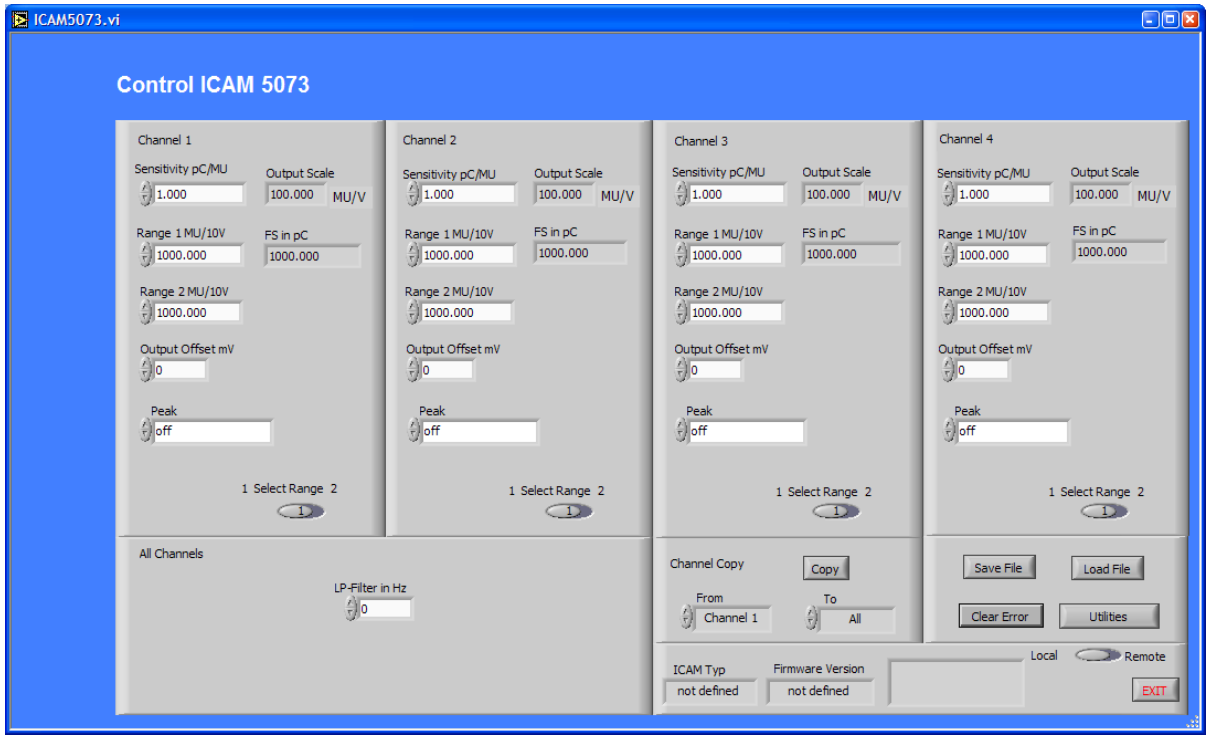


Input Driven

Imbalance Measurement – Kistler Force Gauge Conditioning/Sensitivity Set-Up

- Kistler industrial charge amplifier ("**ICAM**") converts sensor **charge to a voltage**
- 1, 2, 3 & 4-channel versions available direct from Kistler or via ABD
- Each force gauge is supplied with a Sensitivity value (pc/MU), where "MU" = Measurement Units, in this case Newtons

- ICAM parameters are inspected/set by using the Kistler-provided software
- PC-communication with ICAM via serial link
- Values (specific for each channel) can be edited and then "loaded" to the ICAM



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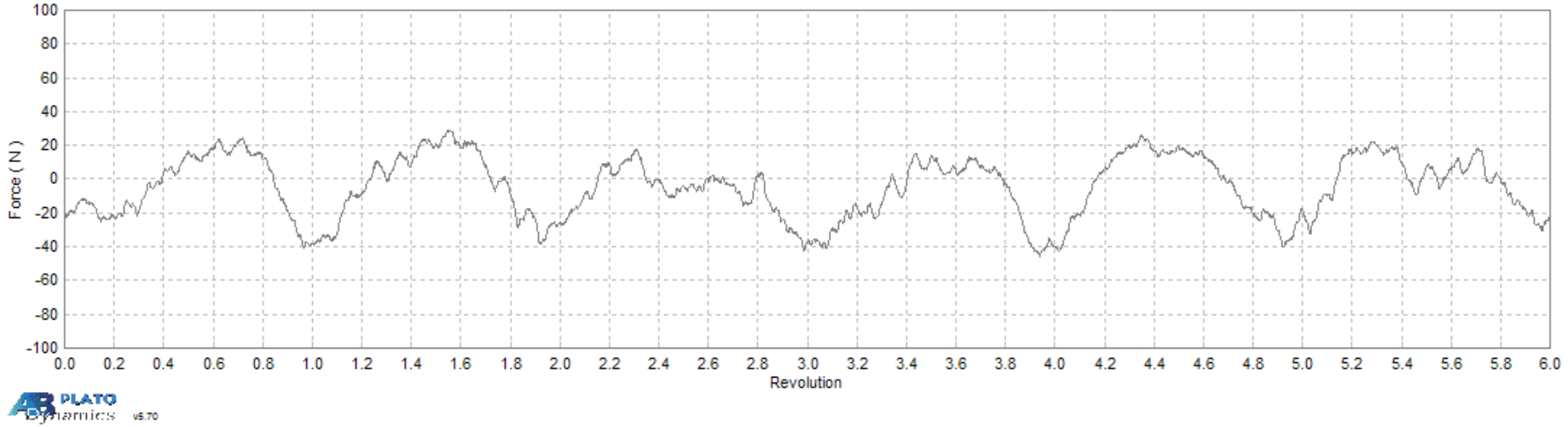
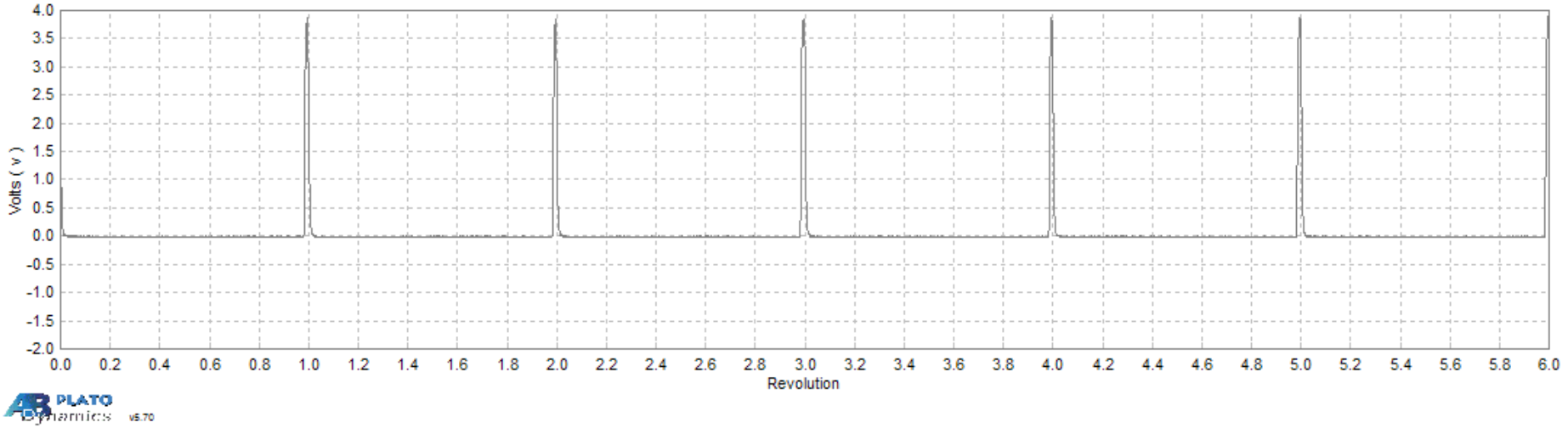
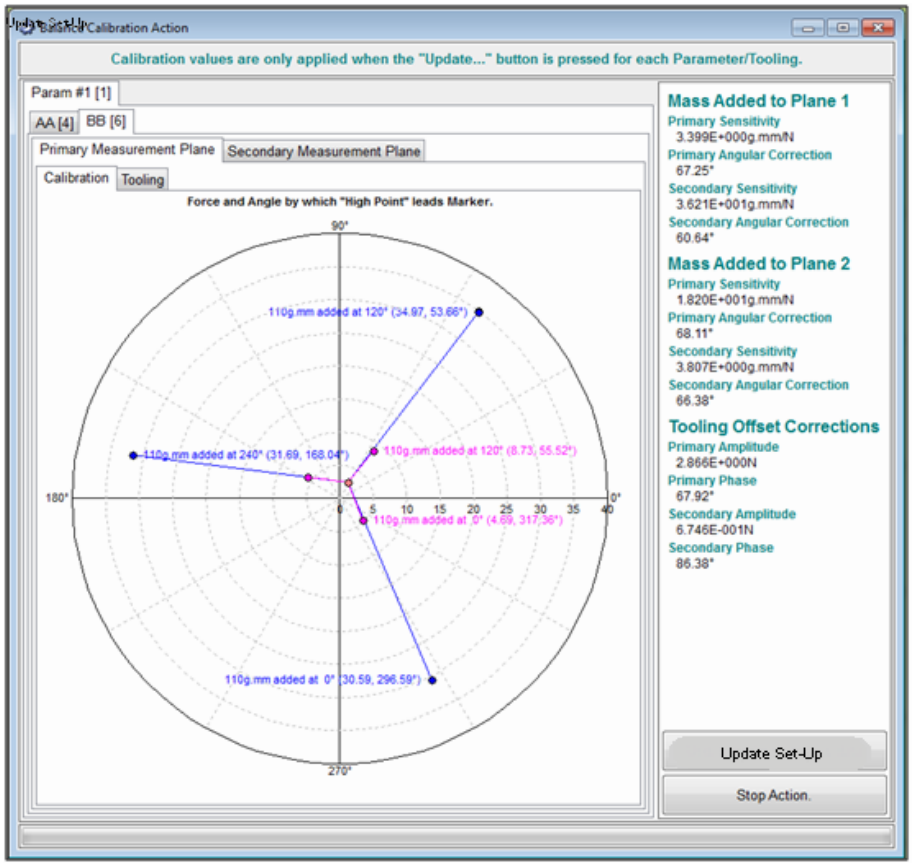
- **reaction force** – resampled to N points/revolution using once-per-revolution marker pulse



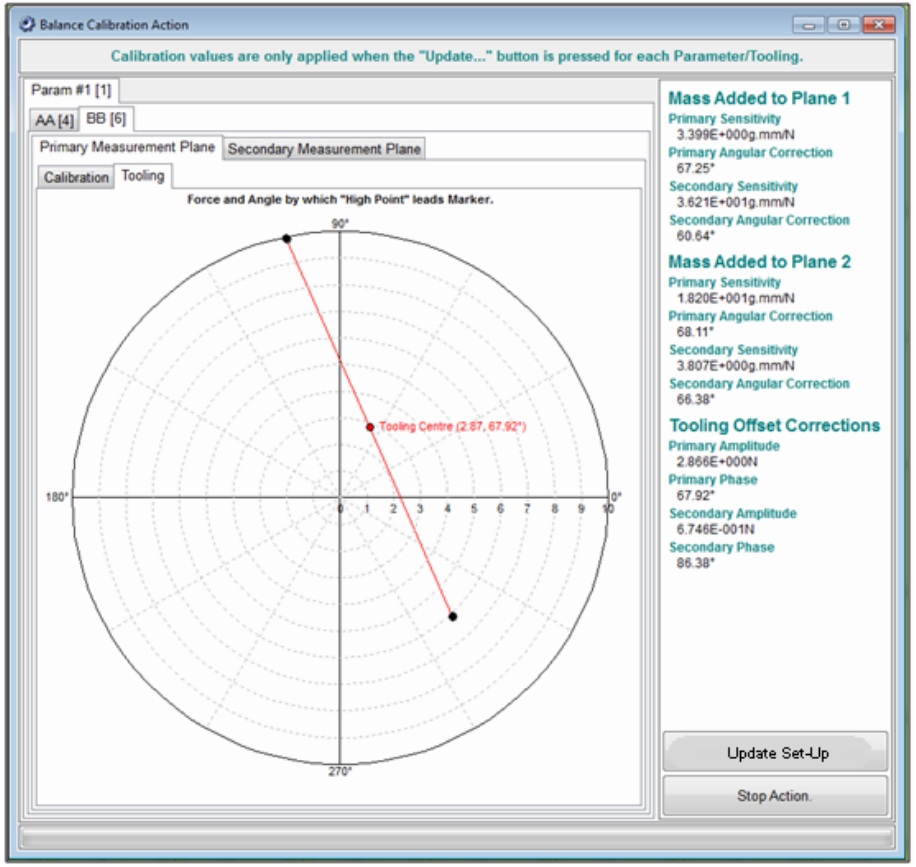
- **once-per-rev marker**



Sensitivity Calibration & Tooling Imbalance Measurement

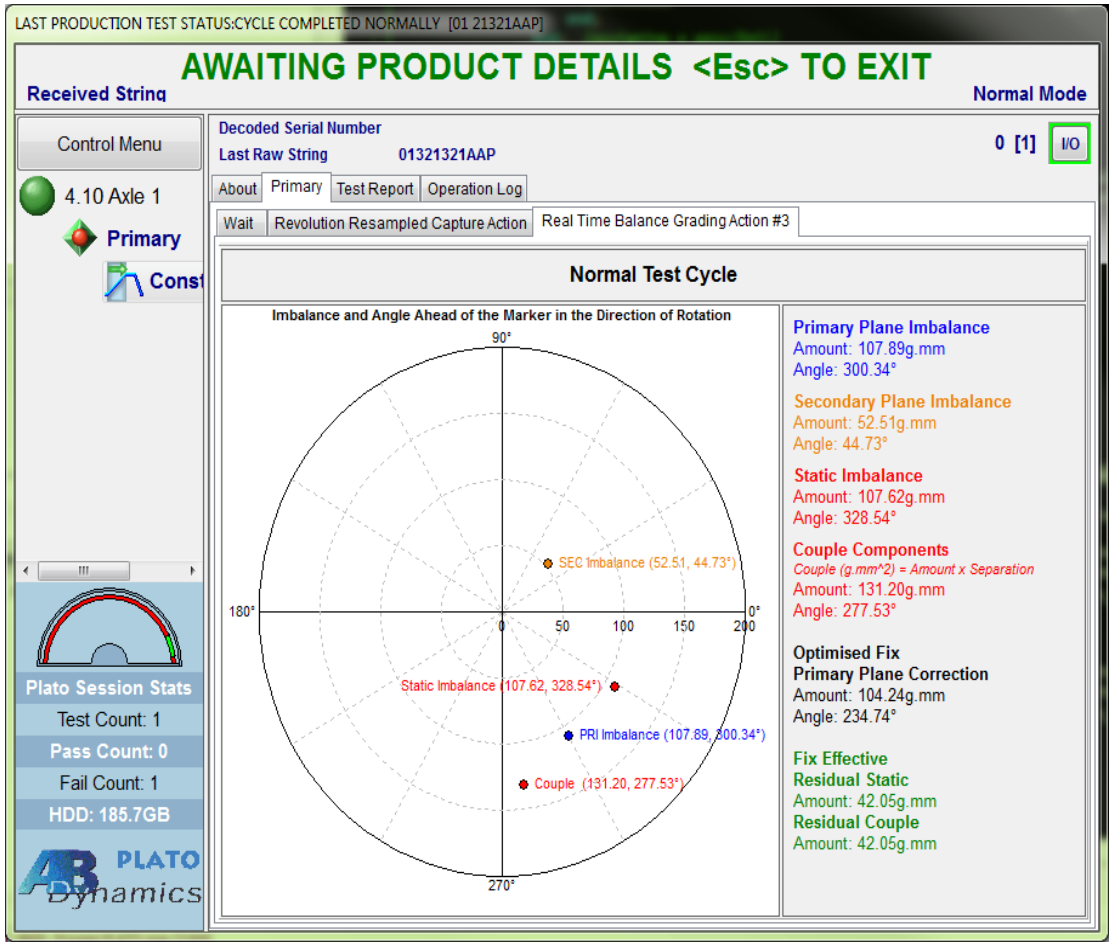


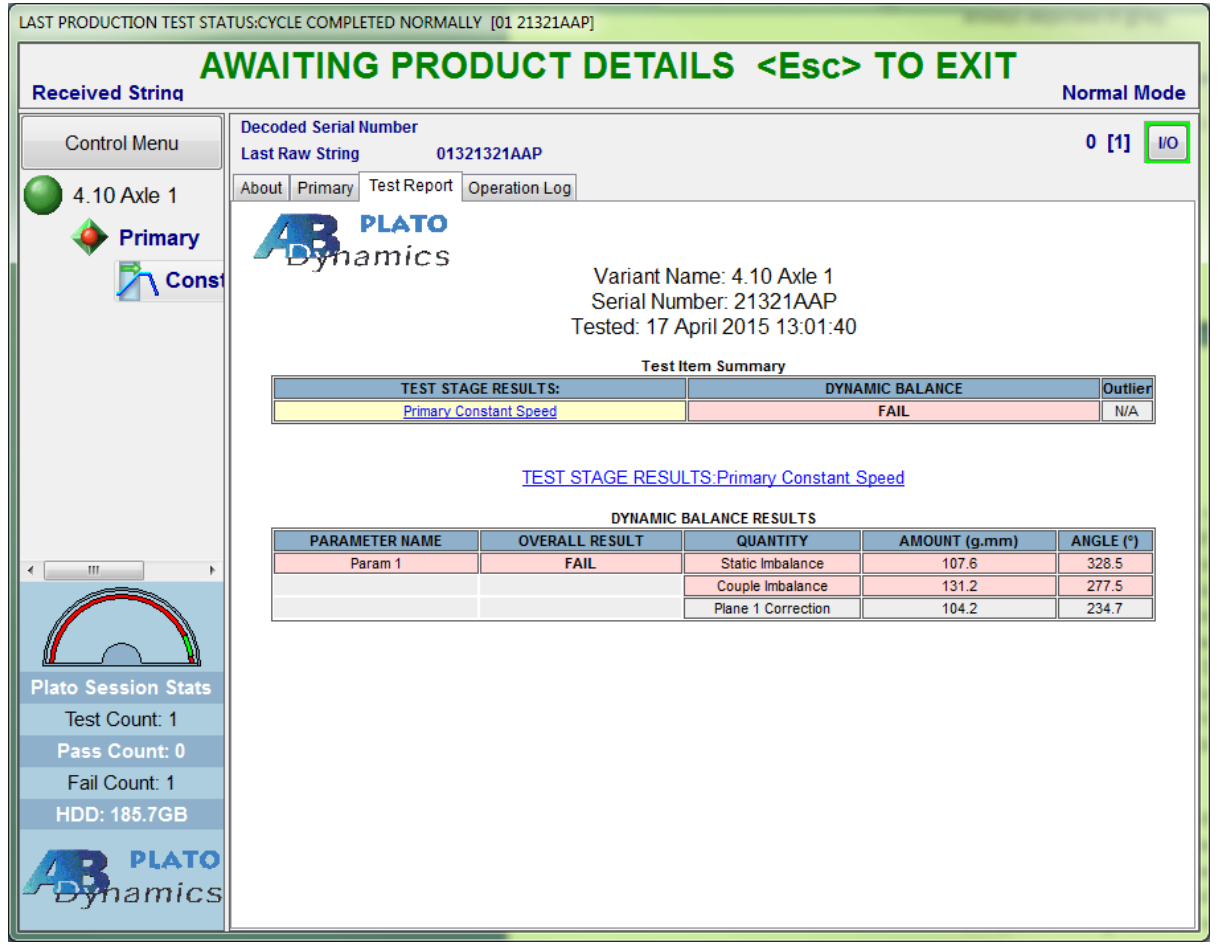
In **S-mode** (scale factor calculation), raw measurement data is used to compute the system's sensitivity to out-of-balance forces at each measurement plane, as well as cross sensitivities if more than one plane is available.



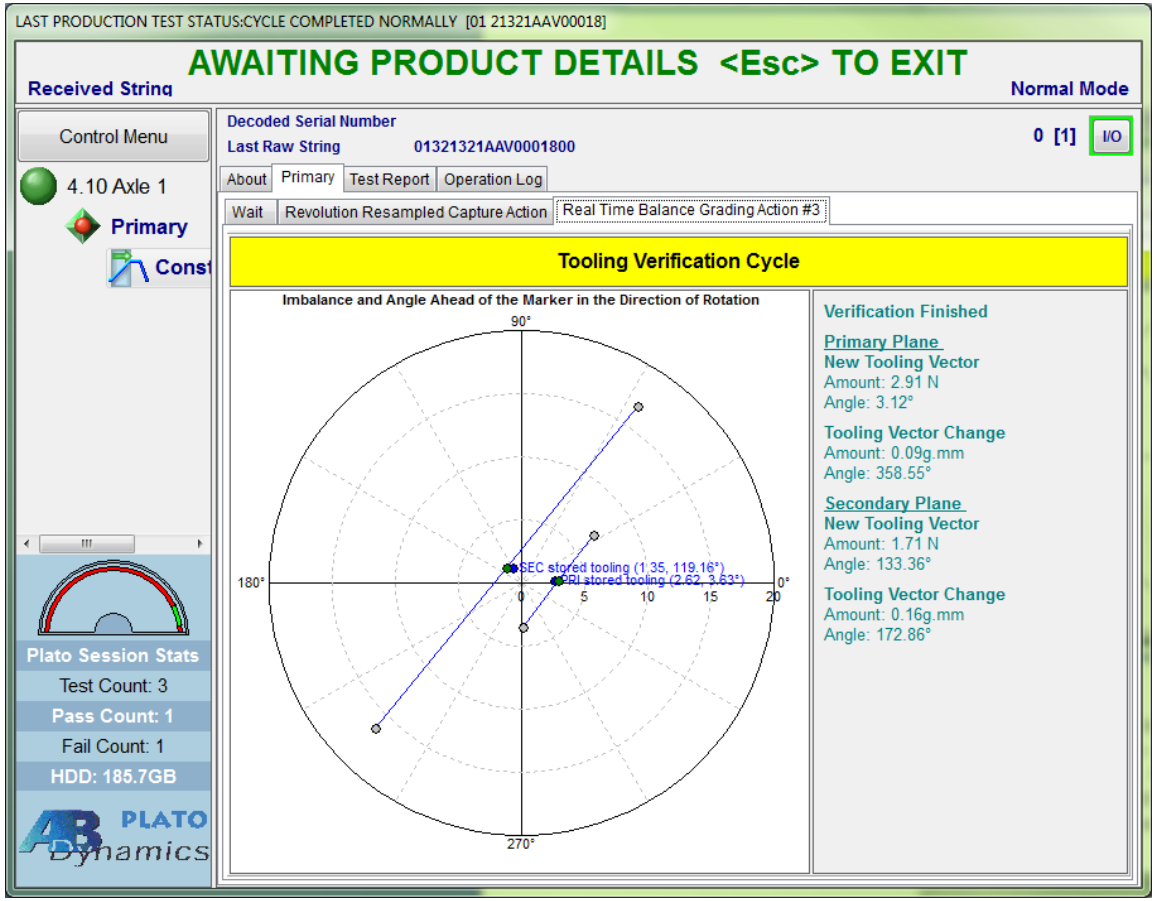
In **T-mode** (tooling offset calculation), the tooling offset is computed as the centroid of all tooling measurement groups, where each measurement group comes from a single tooling to test item angle. This example analysis screen shows the results of a 180-degree rotation test (two tests with 180-degrees angular rotation difference between tooling and part under test).

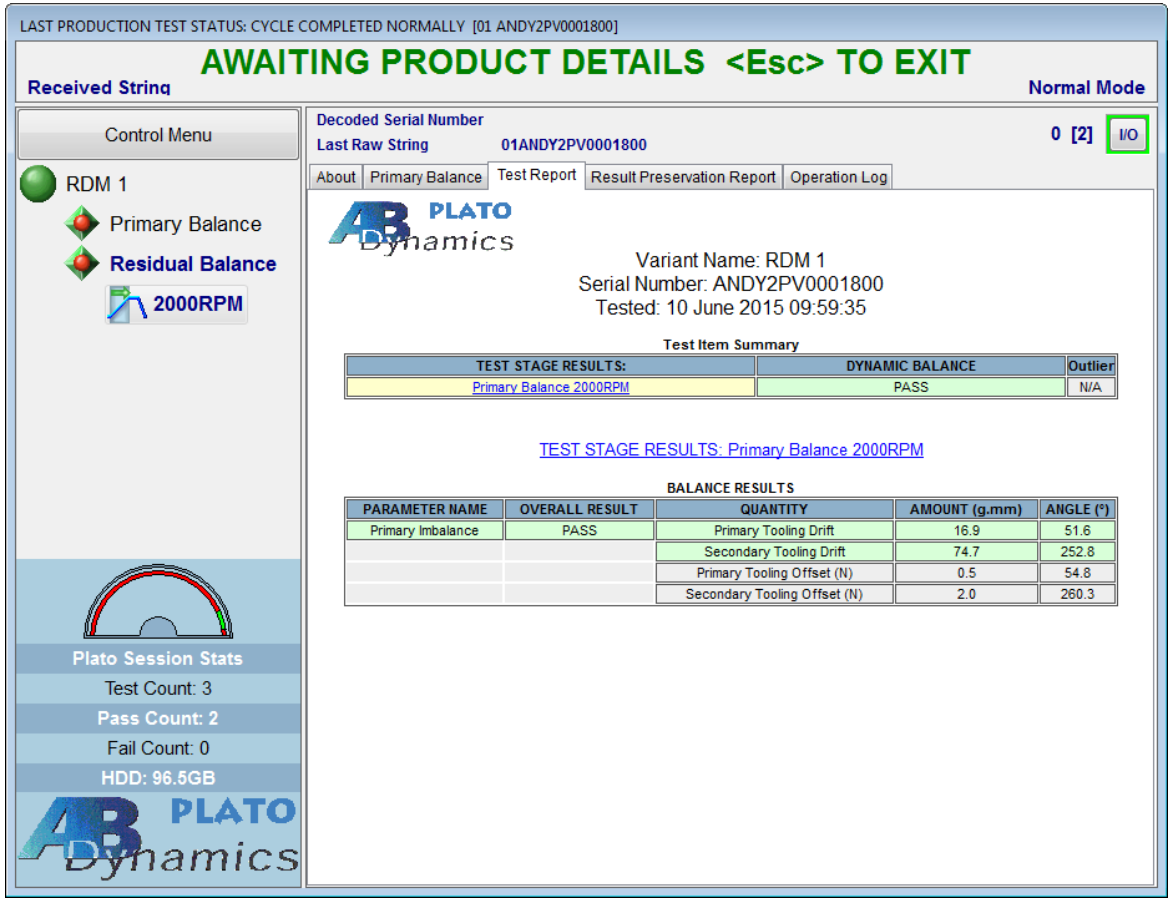
2-plane (Dynamic) Imbalance Result & Recommended Correction





In **P mode** (Production Test) the static imbalance is reported on a polar plot in **green** to indicate a pass or **red** to show a fail (**grey** for no result) and, if a second measurement plane is in use, the couple component of the imbalance is similarly plotted as well as the calculated isolated local imbalances for each plane. The tabular data summarizes the measurements, the recommended fix and the computed residual imbalance remaining after the fix is applied.

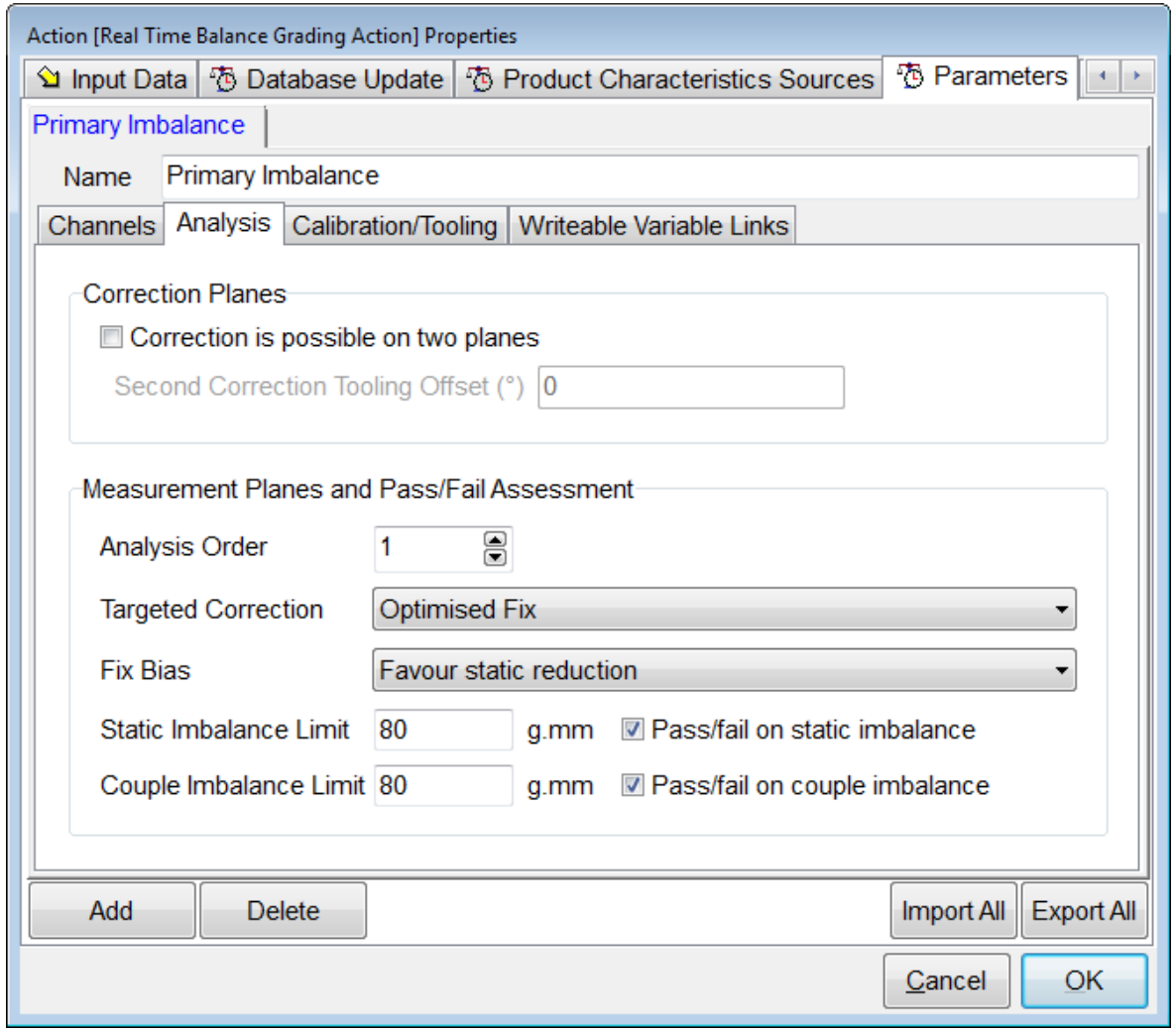




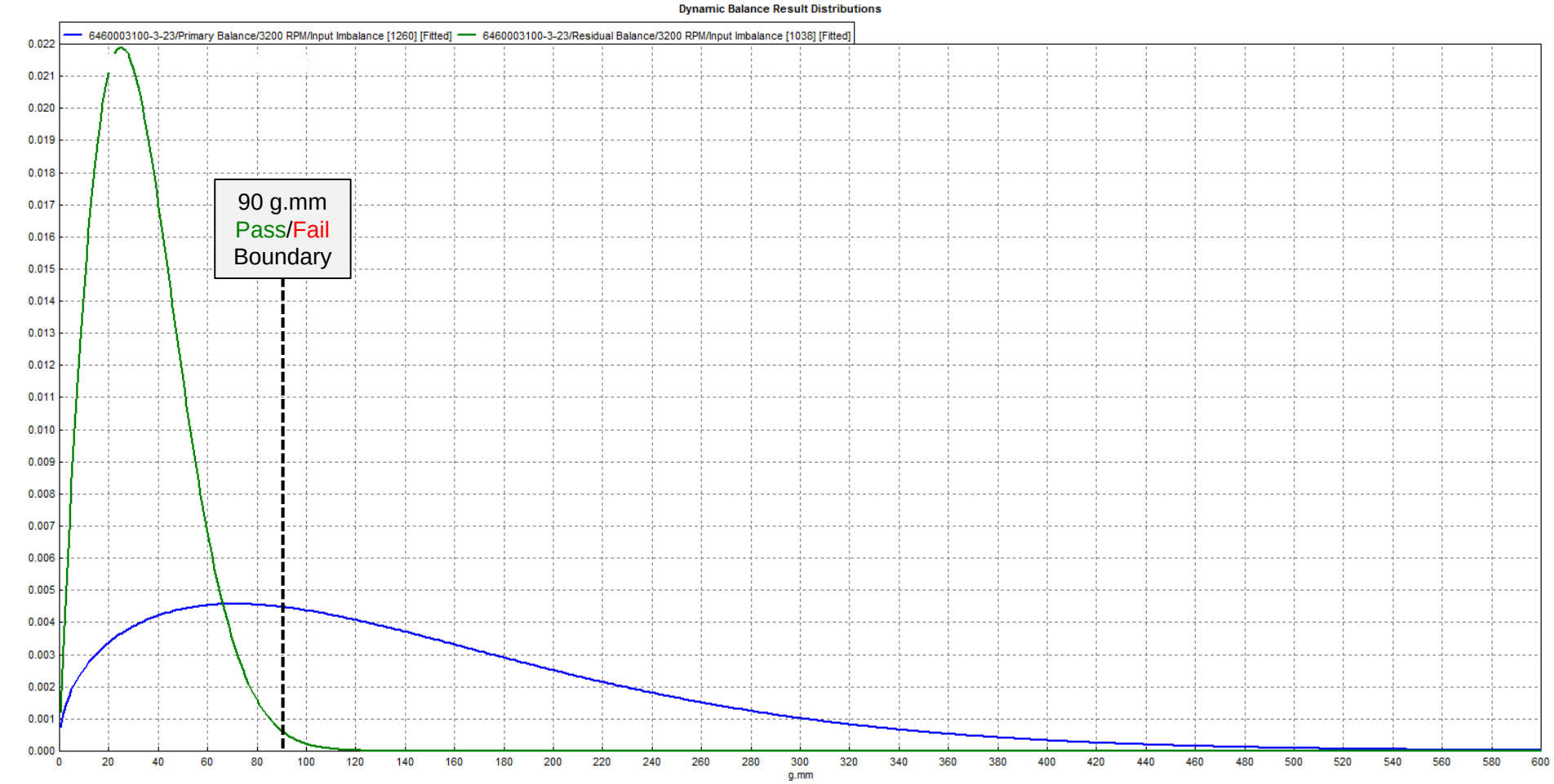
V mode (Tooling Offset verification) is used to ensure that the current Tooling Combination has not changed unacceptably with time e.g. as a result of damage. V-mode requires a pre-defined number of test cycles to be conducted, after which the newly computed tooling vector(s) will be presented along with how much it (they) has (have) changed from the stored value(s).

Intuitive Imbalance Analysis Set-Up

- Real-Time Balance Grading process:
  - reads data file (containing one (1) or two (2) force channels and once-per-rev marker records)
  - **resolves 1st order** amplitude(s) & phase(s) relative to marker
  - calculates static imbalance
  - calculate couple imbalance (2-plane only)
  - displays results on **polar plot**
  - makes results (including recommended correction) available to test machine (via **OPC-tags)**
  - allows test machine to **correct imbalance** (if required), then request a **residual balance** measurement



Summary View – Primary & Residual Imbalance Distributions



Typical **incoming**/**residual** imbalance distributions

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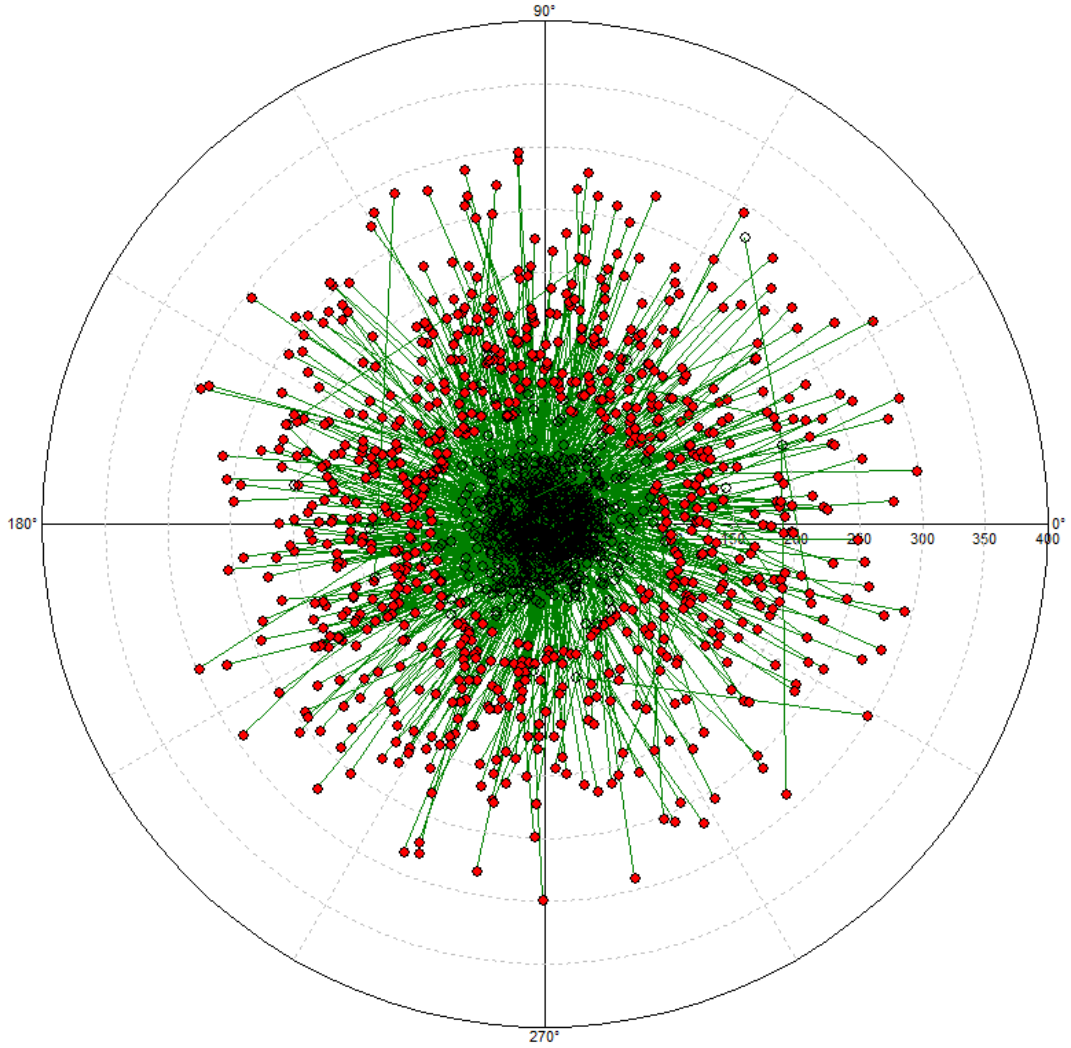
Summary Polar View – Primary & Residual Imbalance Locations



Primary (incoming) imbalance

Correction path

Residual (outgoing) imbalance

Typical **incoming**/**residual** imbalance locations (sample size: 1038)