# Usages of the degradation analysis platform in automotive semiconductor test

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## Abstract

A product is qualified with 2016 hour High Temperature Operating Life (HTOL) reliability accelerated stress test
A new mission profile would need a qualification on 4000 hour HTOL test

➔ *How to avoid the extra 2000 hour HTOL test ? (cost avoidance)*

## Objective

- ***Objective 1:*** Need to estimate the HTOL drift at 4000 hours from drift at 2016 hours (and from drift at 168, 512 and 1008 hour read points) (estimation needed for the 1169 tests implemented for this product)

- ***Objective 2:*** Test of several jmp platforms and analysis type in order to use the best one: Fit Y by X, Fit Model or Degradation analysis ?

➔ *Here, focus only on the 'degradation' platform*

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## JMP example

**Typical usage:** several samples are tested in the same test conditions. A measure that monitors degradation/evolution of the parts is performed regularly in time

**Goal:** to find the best model of the degradation/evolution

**File:** 'GaAs Laser.jmp': current measures are performed on several test units, regularly during the test

**File structure:** for one unit (ex: Unit 101), a line per current measure

## Analysis launch

**Command:** 'Degradation' in the menu 'Reliability and Survival/Analyze'

**Parameters:**
Repeated Measure Degradation
Time = Hours
Y, Response = Current
Label, System ID = Unit

## Research of the best fitting model

- In the **Overlay box**, Model Specification allow to search the best model:
  o linear model with an intercept equal or different per label/system ID and with a slope equal or different per label/system ID
  o or using transformation of the Time or of the response
  o or using any custom model

- A **Model List** compares the different models:
  o comparison test deals with the explanation level of all the measures for all the label/system ID per model
  o model choice: minimum BIC for a better prediction accuracy/ minimum AICc for a better explanation
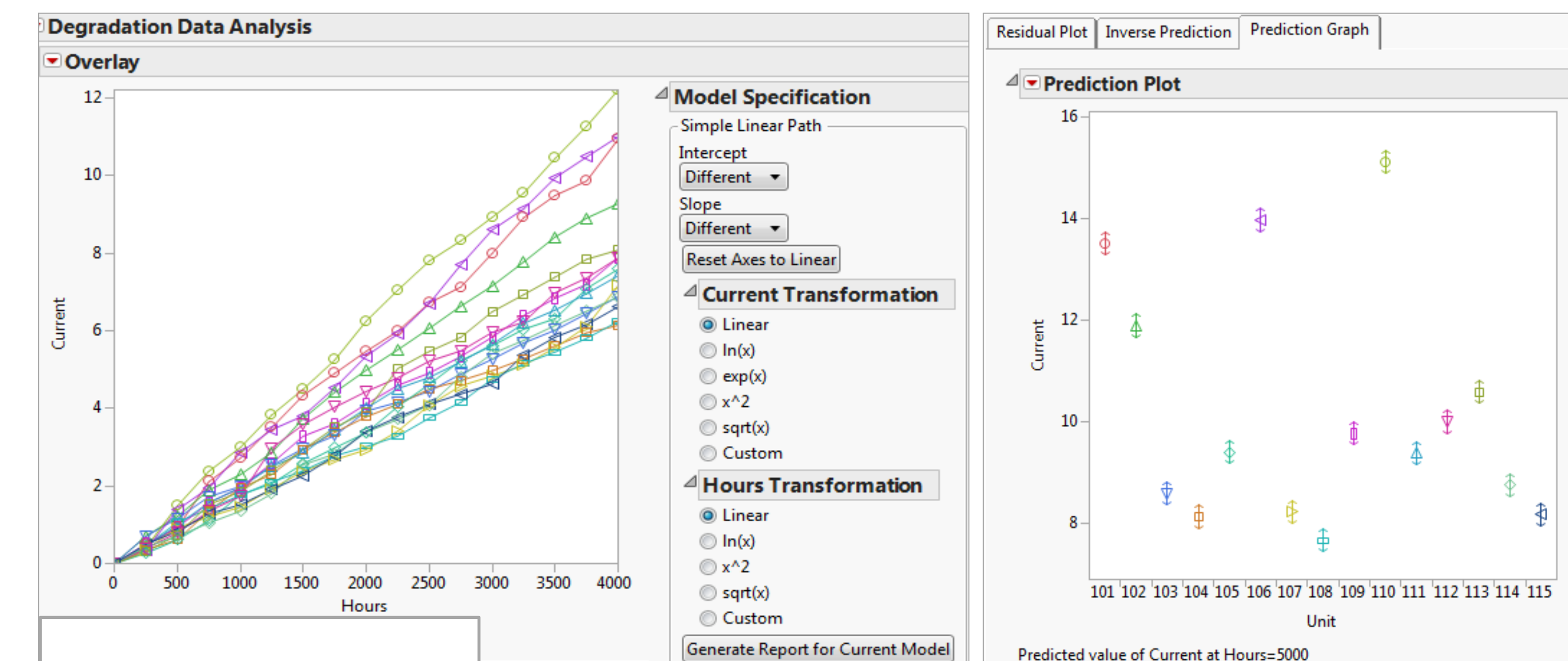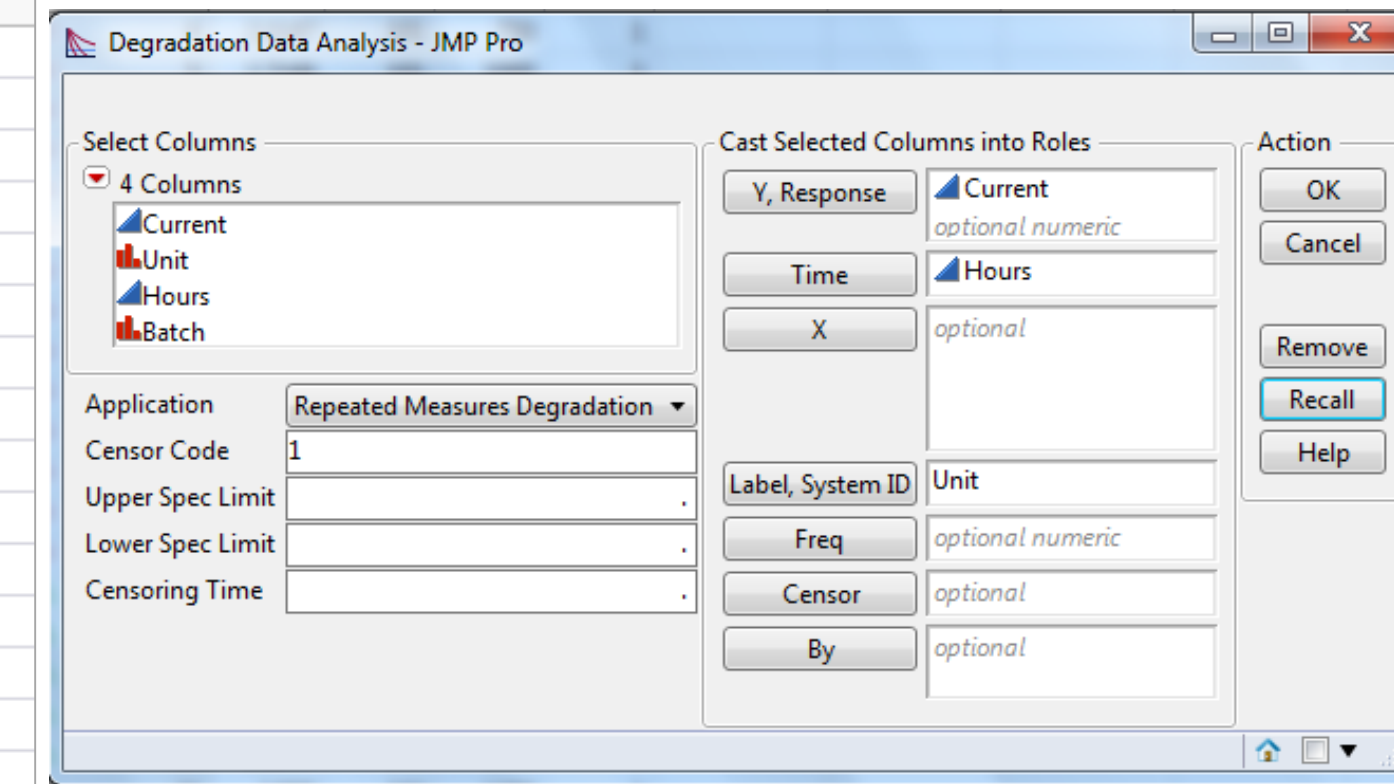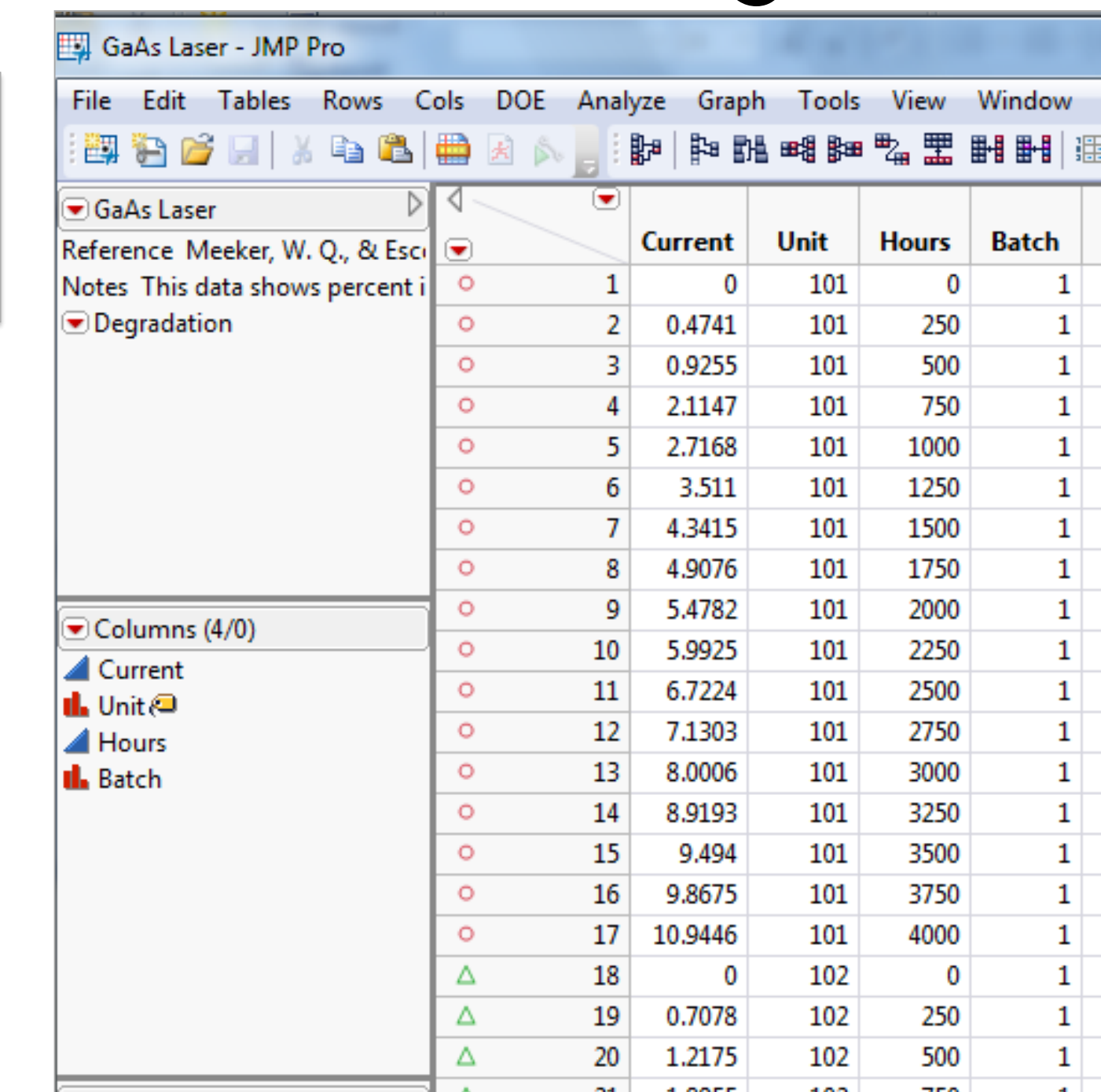


## Prediction Graph

- Possibility to give predictions by the box '**Prediction Graph**'
- Possibility to have the prediction plot with **Confidence Interval** or with **Prediction Interval**

**Model List**

| Display | Model Type | Report | Nparm | -2LogLikelihood | AICc | BIC | SSE | DF | Description |
|---|---|---|---|---|---|---|---|---|---|
| ⦿ | 1 Simple Linear Path | ☑ | 30 | -179.299 | -110.995 | -13.0606 | 7.39094 | 225 | Intercept:Different; Slope:Different; Y:Linear; X:Linear |
| ○ | 2 Simple Linear Path | ☑ | 30 | 1670.577 | 1738.88 | 1836.815 | 10453.25 | 225 | Intercept:Different; Slope:Different; Y:x^2; X:Linear |

## Analysis types available for this analysis

- 'Degradation analysis' platform on jmp → looks for only one model and the best one for several curves: it's possible to compare all the parameters for each curve each other in only one table
  → **Advantage:** simultaneous work on a great number of curves
  → **Drawback:** difficult to select some curves that particularly fit with a specific model

- 'Fit Y by X' or 'Fit Model' analysis → looks for a model for one curve, and it's not very possible to work simultaneously on the curves

- An other solution would be to write a jmp script to automatize the Fit Y by X or Fit Model analysis

## Strategy for the 1169 tests

In order to lighten the analysis, some tests are excluded from the degradation analysis (in particular, non parametric tests and the tests for which HTOL drift is very low at 2016 hours). Degradation analysis on the remaining 118 tests allow to highlight 3 different models followed by the tests:
- Linear model on the whole curve of the HTOL drift values (0, 168, 512, 1008 and 2016 hours)
- Non linear model with possible transformation
- Non linear model without any possible transformation on the whole curve: linear model on a part of the curve
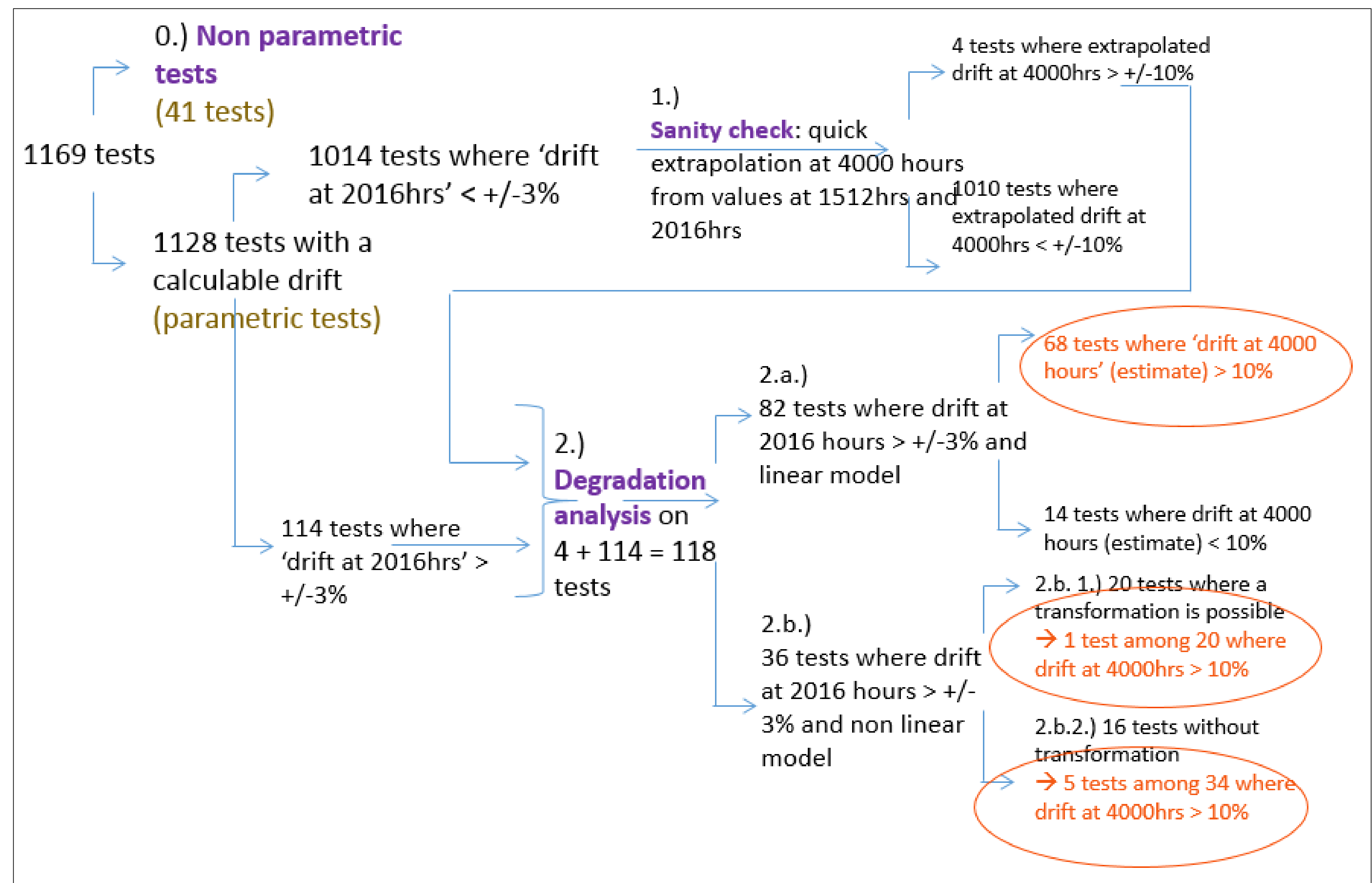
## Linear model

Curves of drift values at 0, 168, 512, 1008 and 2016 hours are modeled. For 82 tests, from the parameters of each linear model by curve, drift at 4000 hours is predicted, with confidence intervals or prediction intervals at 95%
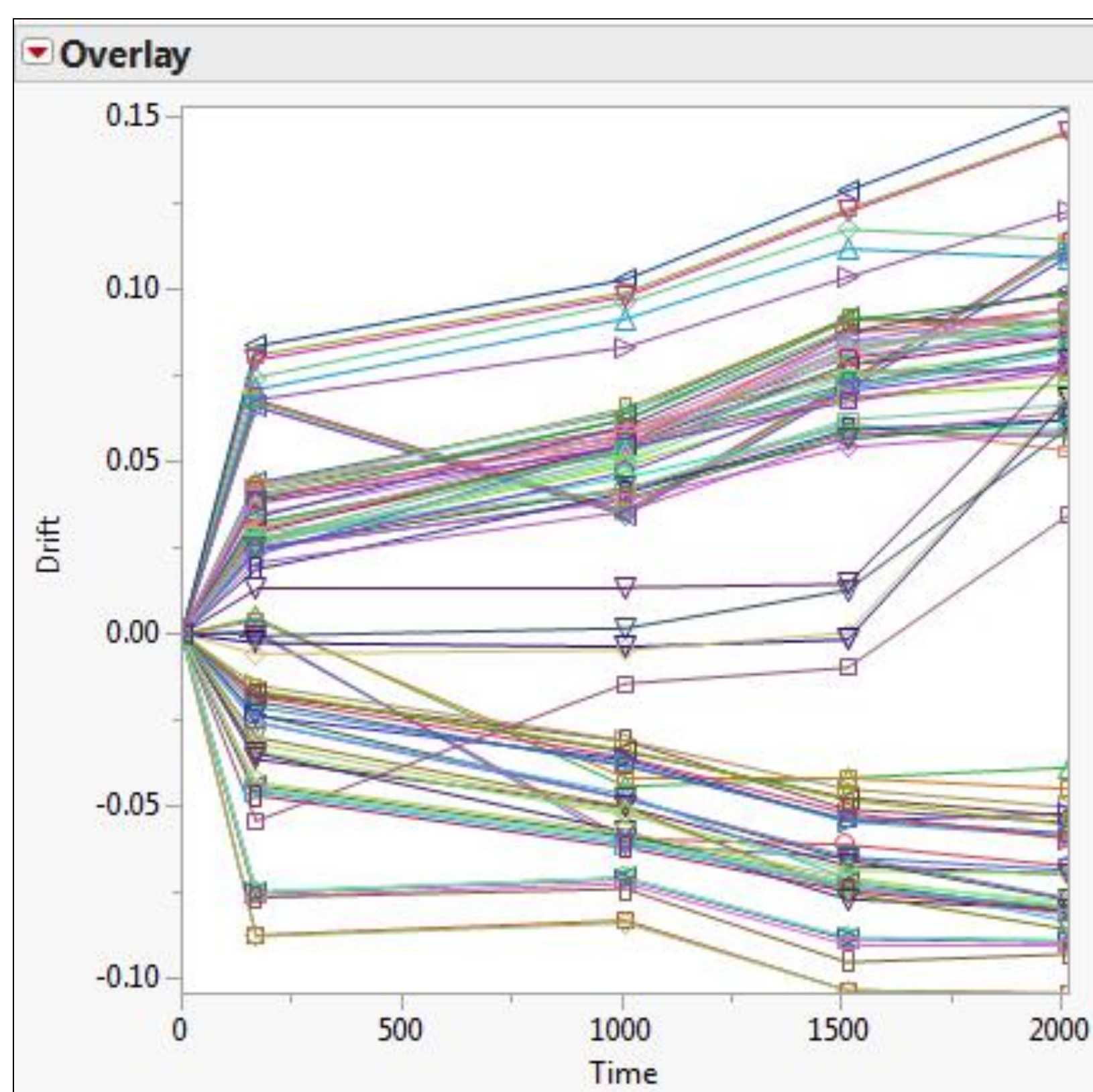


## Non linear model with a possible transformation

Several transformations are tested by SSE estimation (SSE: sum of the error squares): the best model is the one for which SSE is minimum.
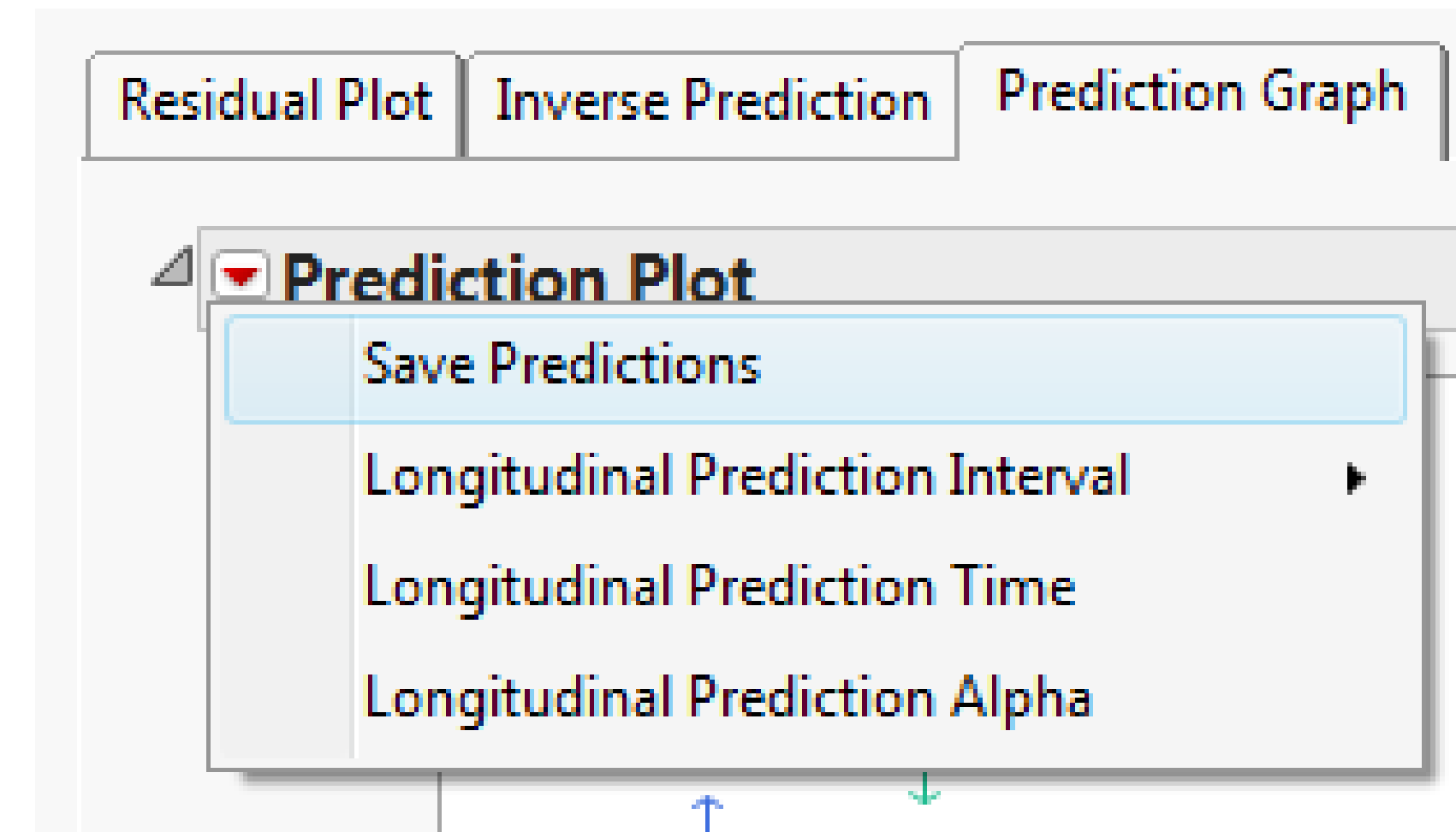
For 20 tests, a transformation in X is found possible with one of the three following models:

-Y: Linear; X: $-1/x$ (17 tests)

-Y: Linear; X: $\ln(x)$ (2 tests)

-Y: Linear; X: $x^2$ (1 test)

In this case, a numerical estimation is prefered rather than a graphical plot, using the jmp possibility to save the predictions into a table.



Examples of prediction for 3 tests:

| Prediction | Lower Bound | Upper Bound | Val Abs (Prediction) |
|---|---|---|---|
| 0.037969 | 0.001569562 | 0.074368461 | 0.037969 |
| 0.038422 | 0.002022387 | 0.074821286 | 0.038422 |
| -0.03889 | -0.077209423 | -0.000566782 | 0.03889 |

For the other 16 tests, no transformation is possible.

## Non linear model without any possible transformation

Finally, for the 16 tests for which no transformation is possible on the whole curve (0, 168, 512, 1008 and 2016 hours), a linear model on two points (1008 and 2016 hours) or on three points (168, 1008, 1512 hours) is designed : then, drift is extrapolated to 4000 hours: the final value is the greatest one (worst case) between the two models (2 or 3 points)
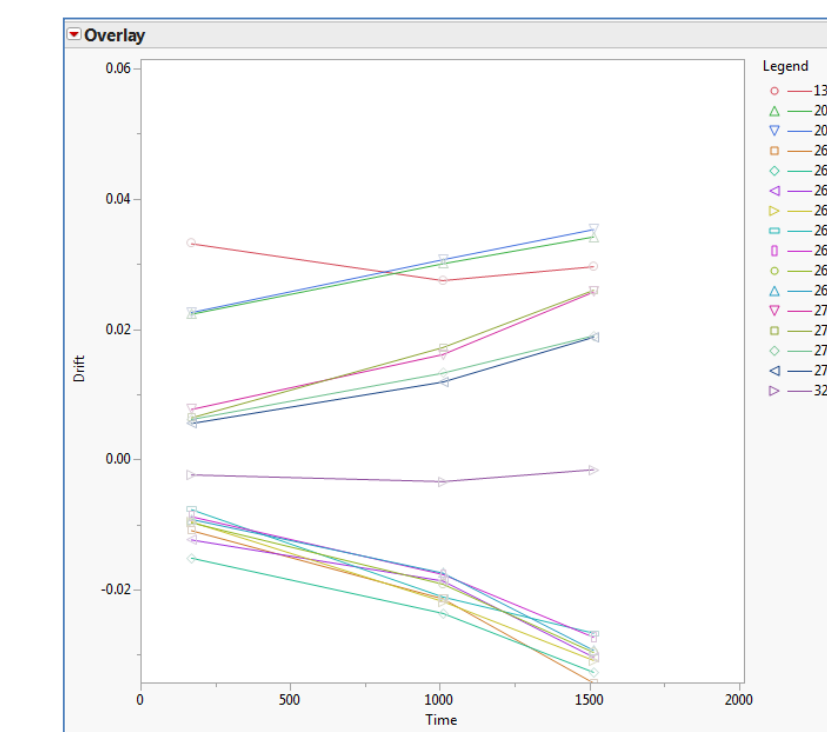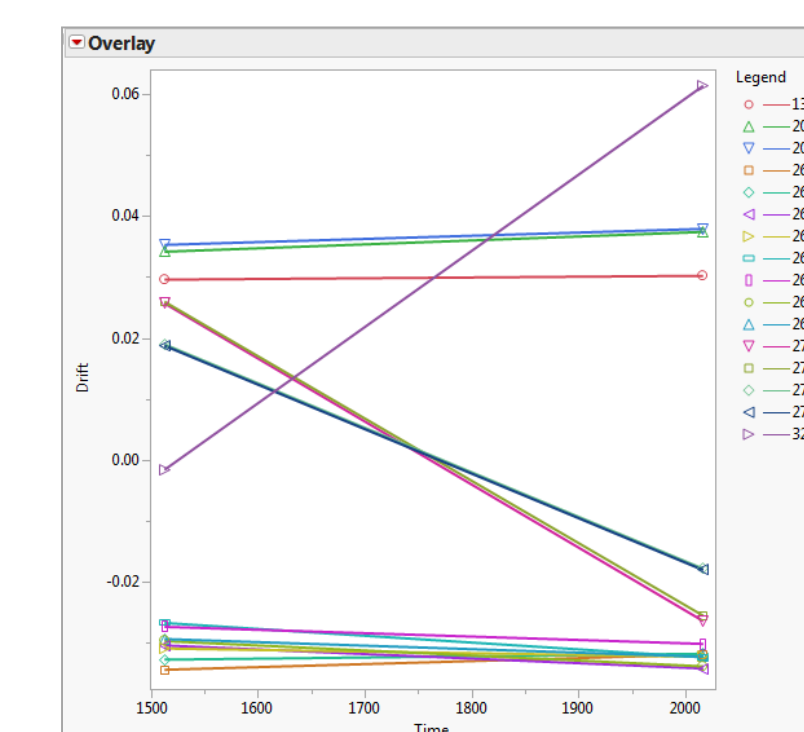


## Conclusions

Note that sample size is very low (5 points = 5 times) and that 4000 hour point is very far from the 2000 hour point
→ Cautiously, we should only keep the linear tests, and not predict anything for the other ones