Defence and Security Systems

Flight Testing of Eurofighter Aircraft in the Asymmetric GBU-10 Configuration

Application in the Data Analysis Tool Concept

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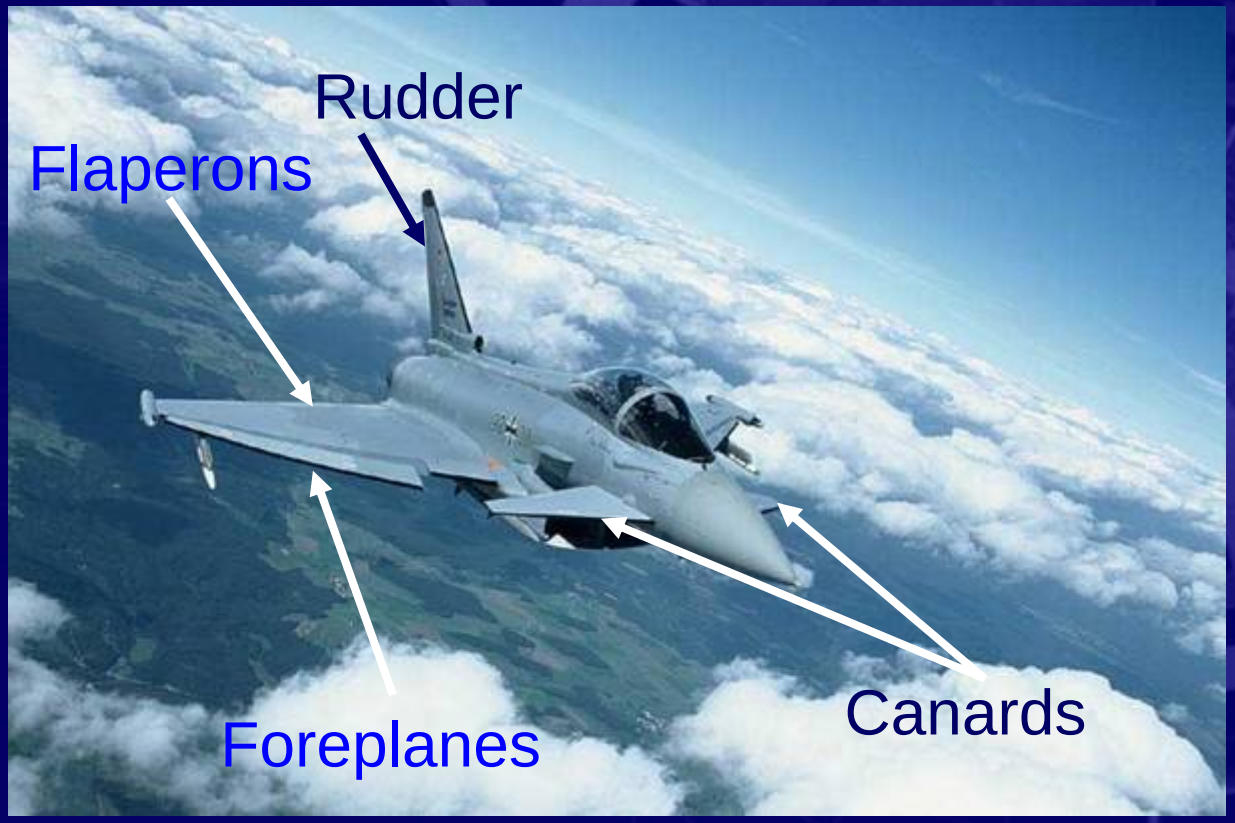
Contents

1. The Eurofighter/ Typhoon Aircraft

- General Description

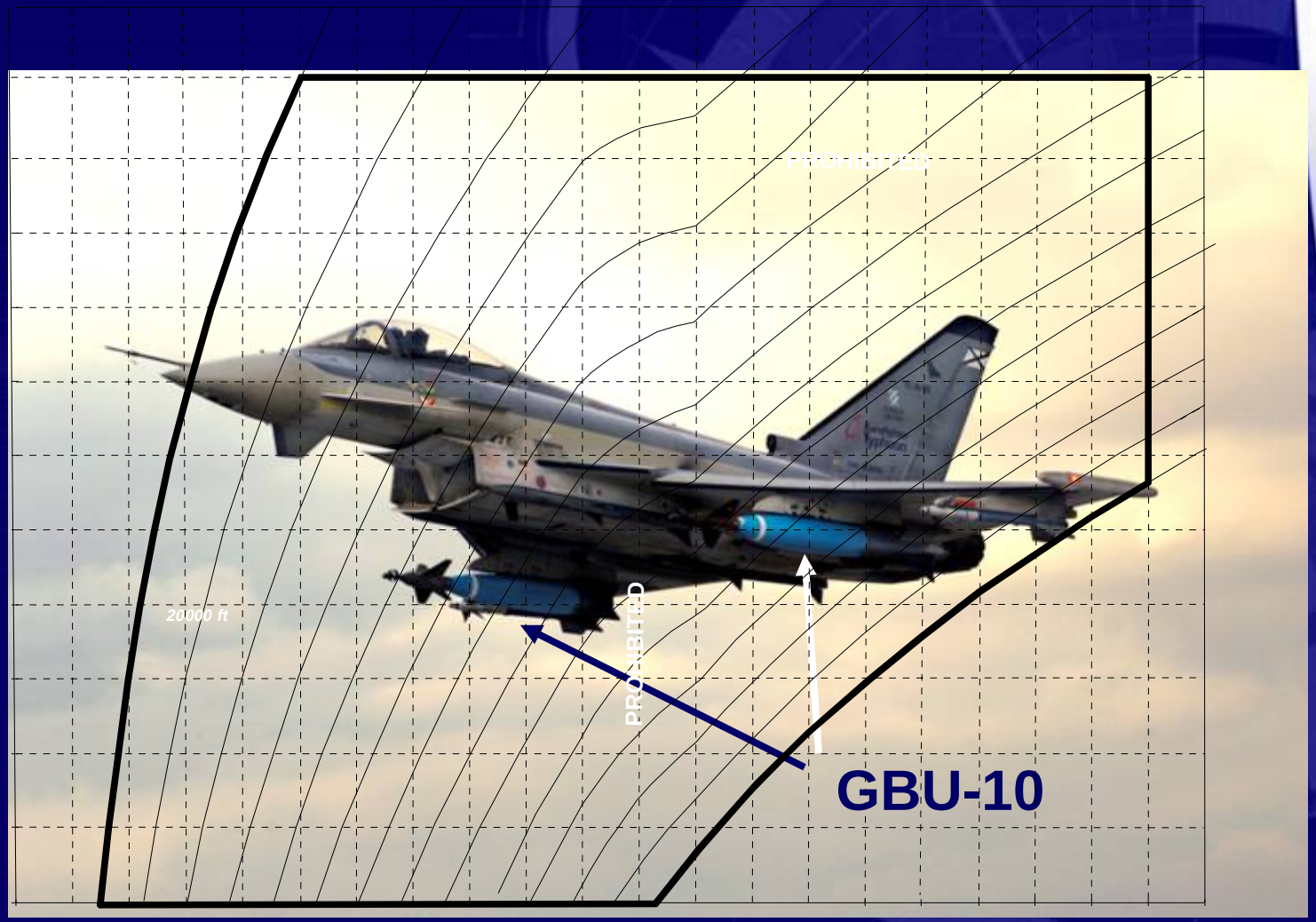


- Concept Multi-Role

2. Eurofighter Role: Air-to-Ground

Flight Testing of Eurofighter Aircraft in the Asymmetric GBU-10 Configuration

Defence and Security Systems

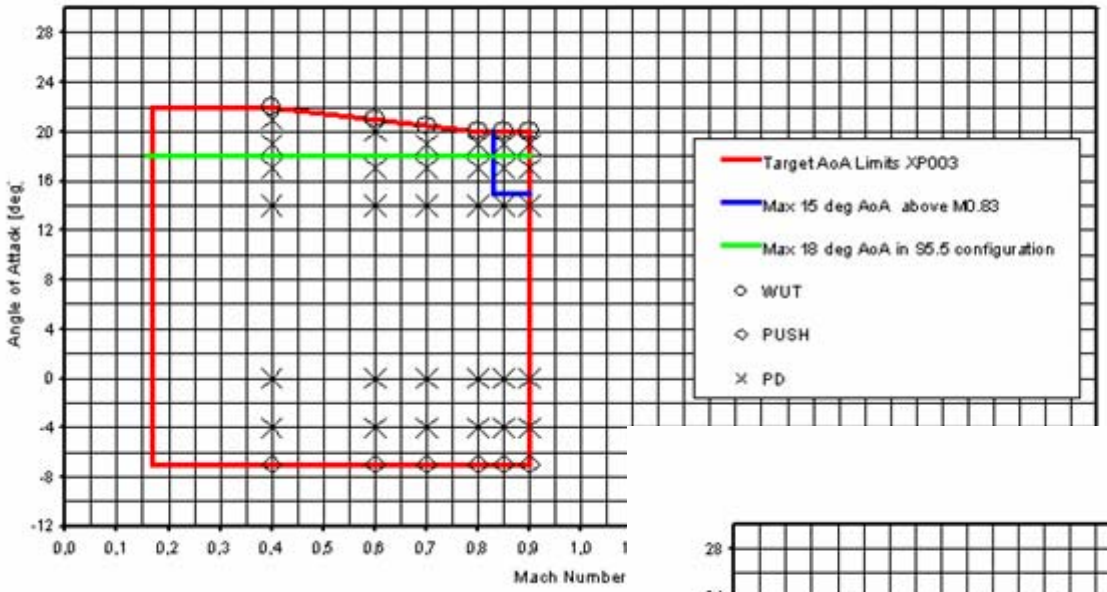


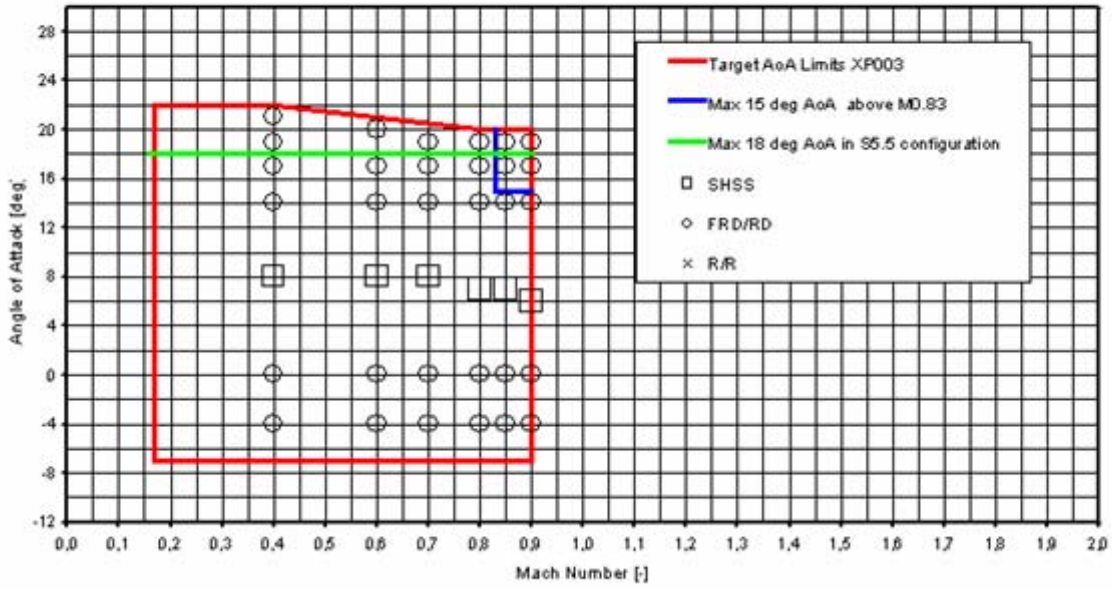
Flight Testing of Eurofighter Aircraft in the Asymmetric GBU-10 Configuration

3. Aircraft Test Preparations

- Aircraft
  - Configuration
  - Weight and balance
  - Flight Control Software

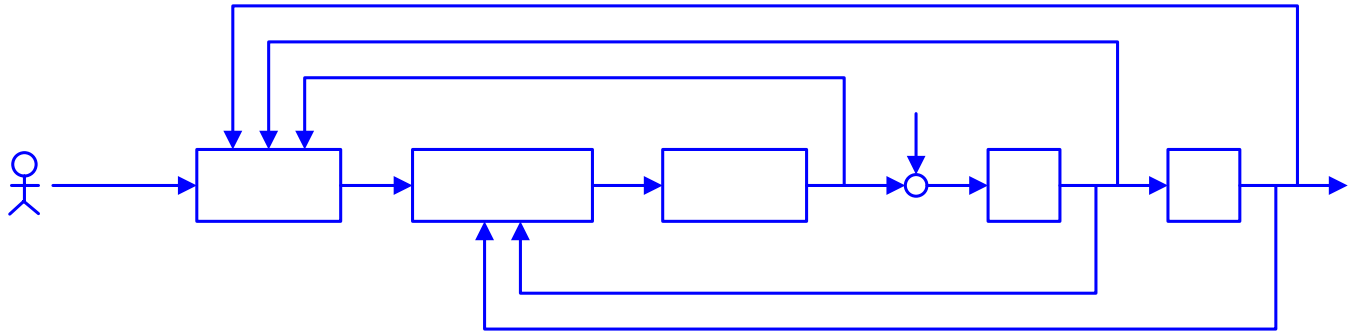
4. Development of Flight Test Matrix





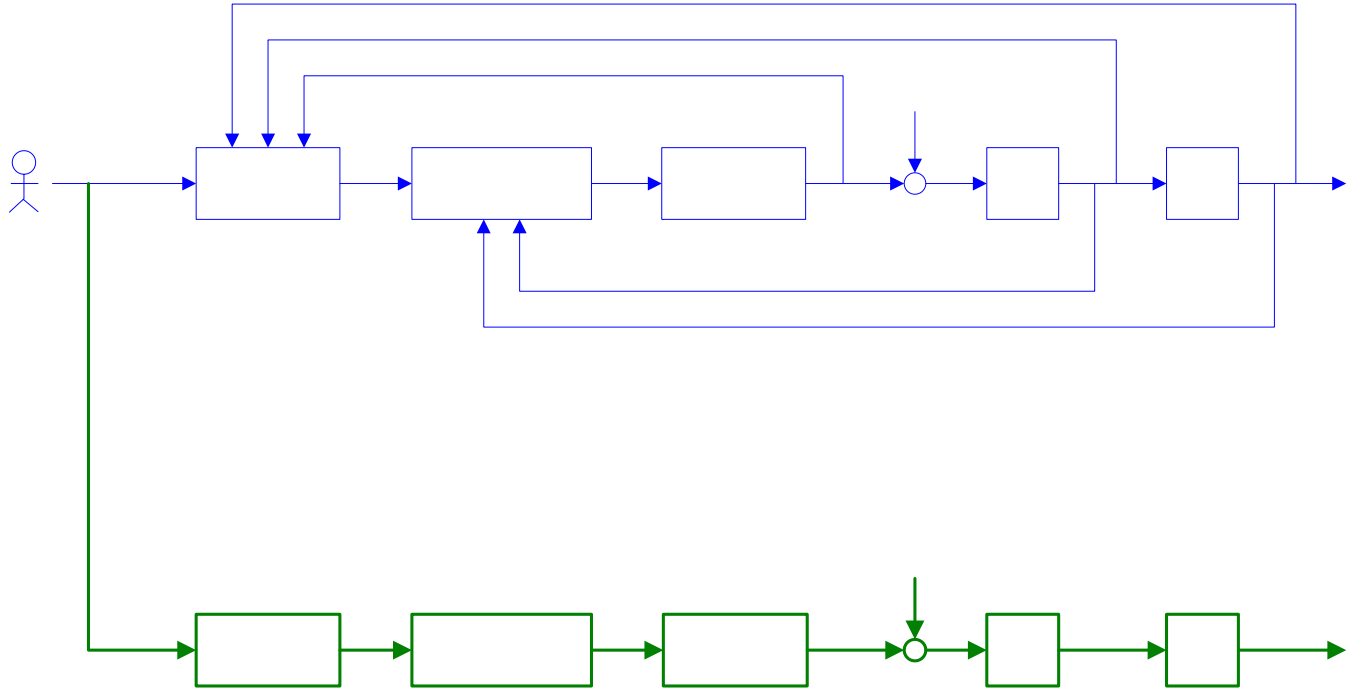
Principles of Model Validation
Concept

The real world



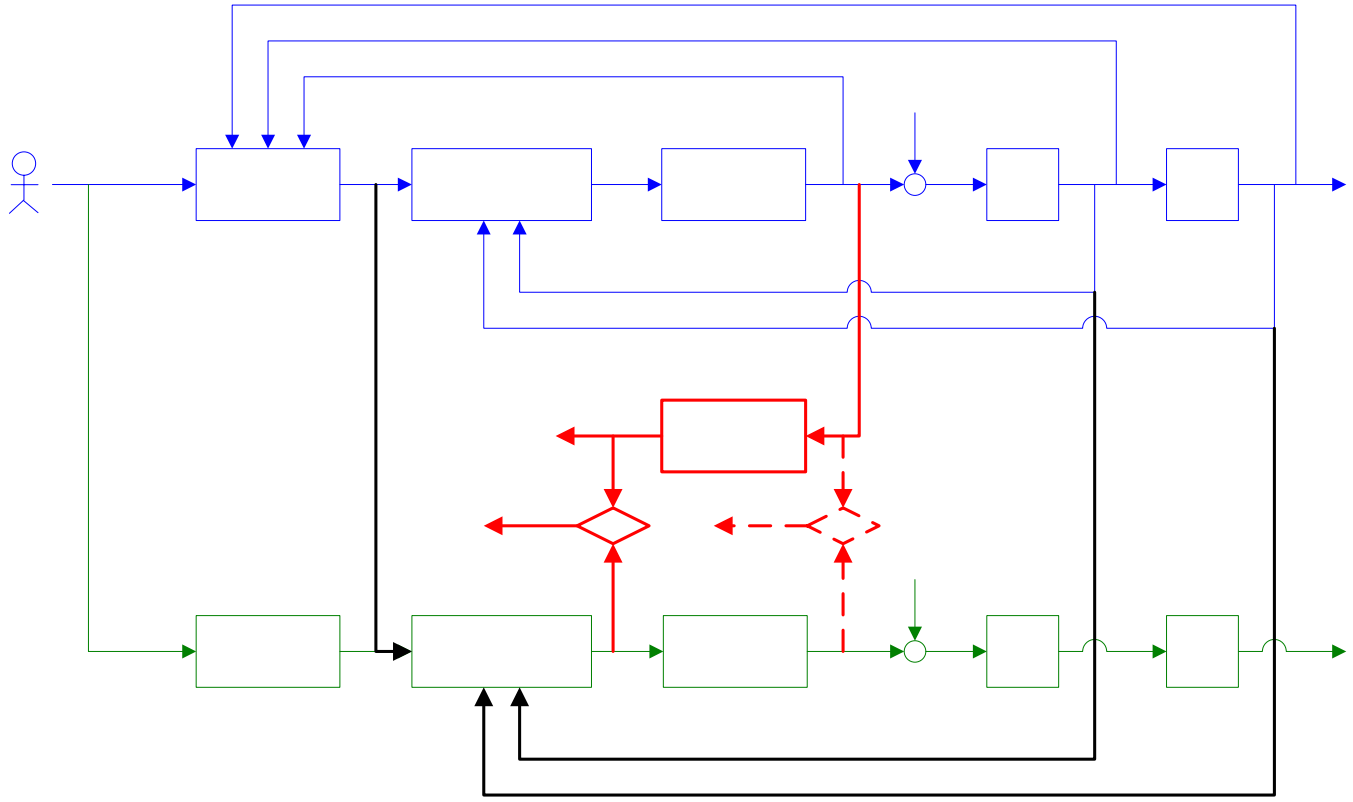
Principles of Model Validation
Concept

The model



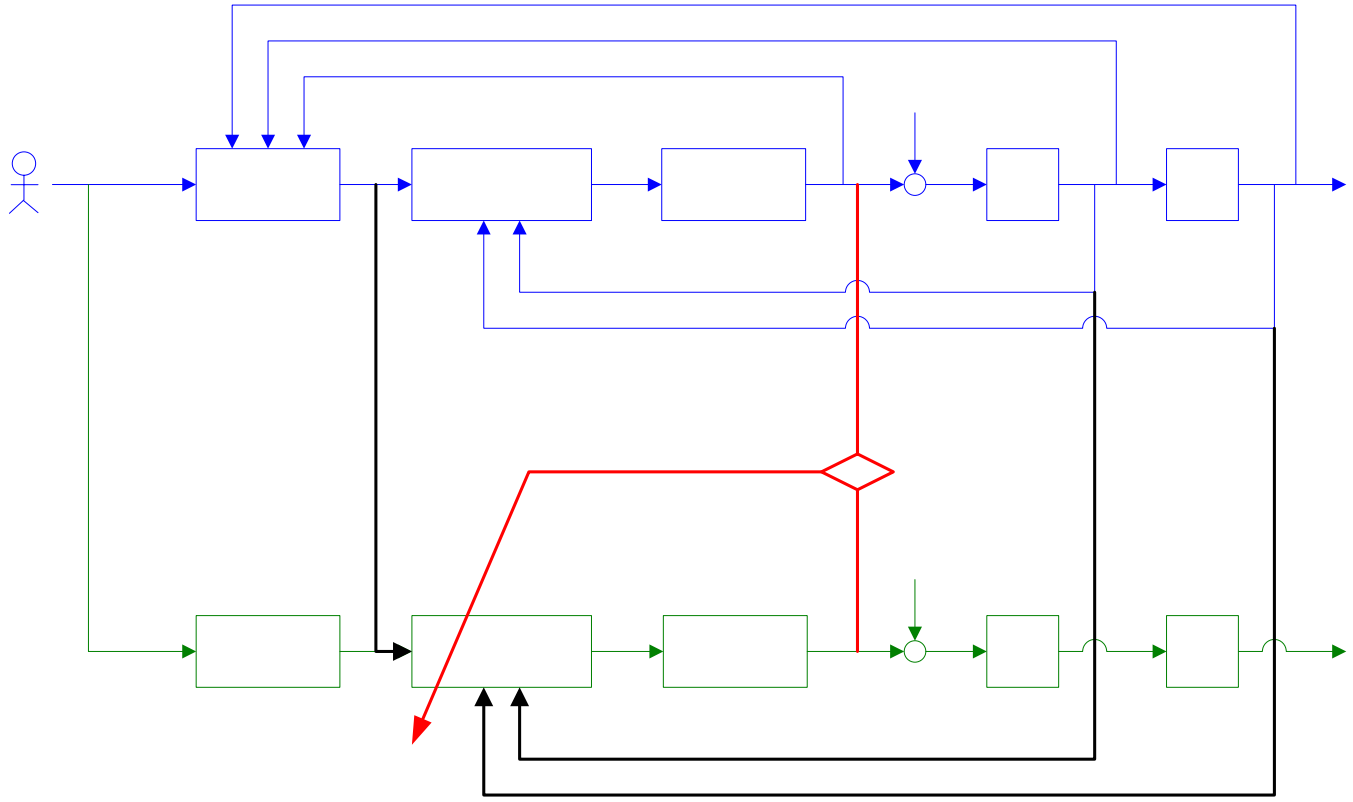
Principles of Model Validation
Concept

Equation Errors



Principles of Model Validation
Concept

Equation-Errors Estimation



Correction of the Aerodynamic Model
Parameters to be estimated

- Assumption of a linear error model

$$c_{mpred} - c_{mflight} = \Delta c_m = \Delta c_{m0} + \Delta c_{m\alpha}\Delta\alpha + \Delta c_{m\delta}\Delta\delta + \Delta c_{m\eta}\,\Delta\eta$$

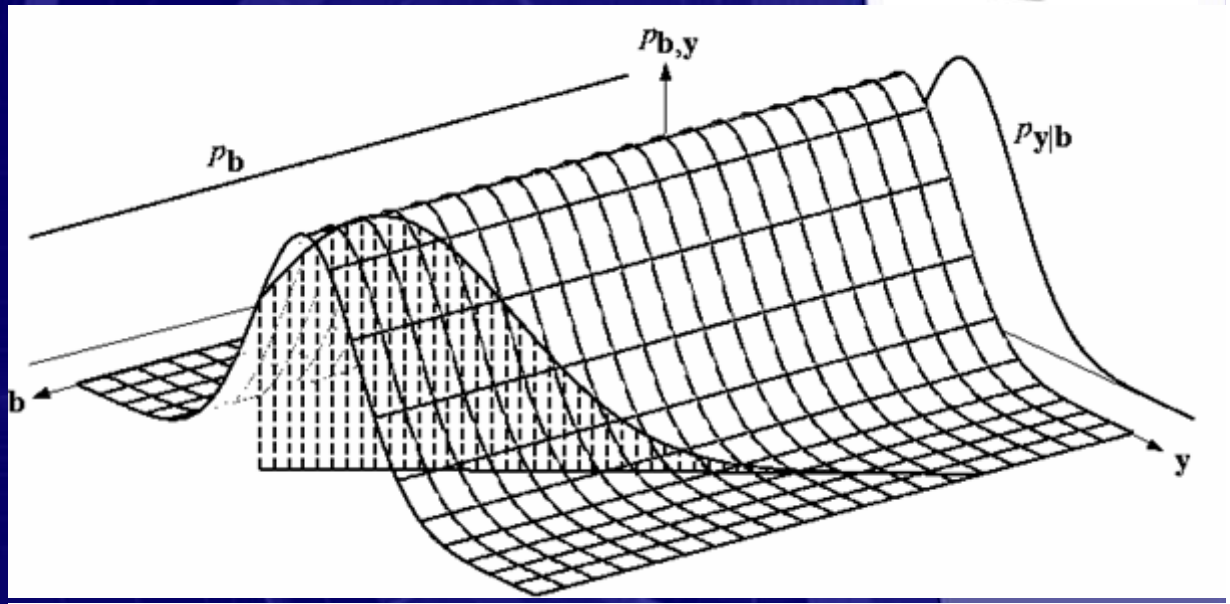
$$c_{lpred} - c_{lflight} = \Delta c_l = \Delta c_{lp}\Delta p + \Delta c_{l\beta}\Delta\beta + \Delta c_{l\xi}\Delta\xi + \Delta c_{l\zeta}\,\Delta\zeta$$

$$c_{npred} - c_{nflight} = \Delta c_n = \Delta c_{np}\Delta p + \Delta c_{n\beta}\Delta\beta + \Delta c_{n\xi}\Delta\xi + \Delta c_{n\zeta}\,\Delta\zeta$$

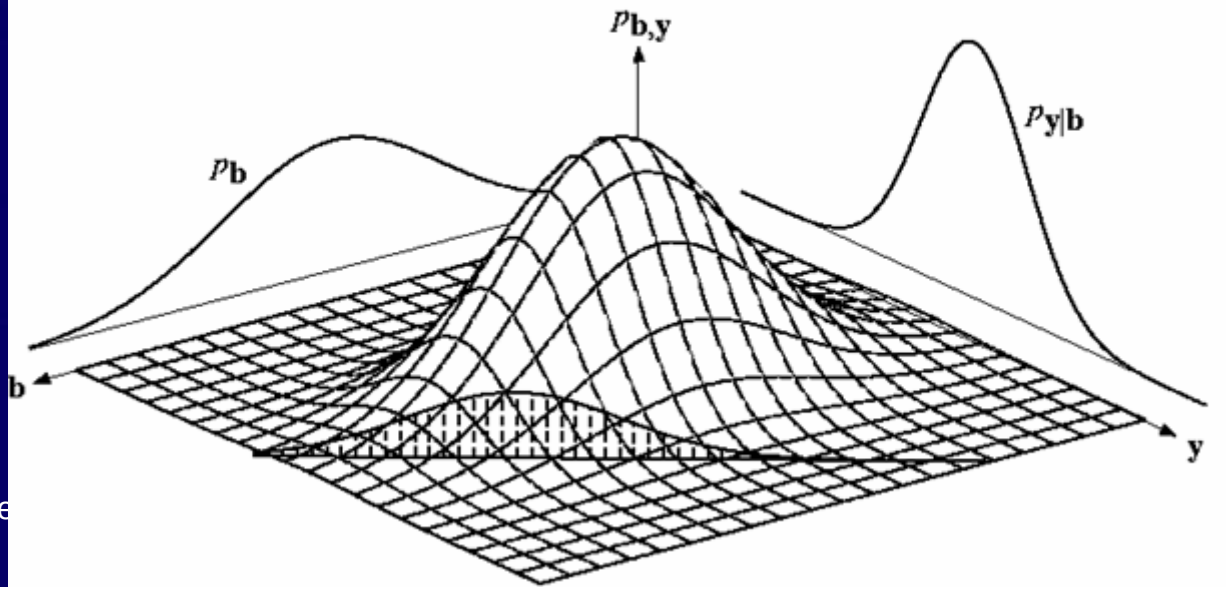
- Correction of input parameters such as
  AoA, AoS, Mach number, cg-position, thrust

Basic Principles of Estimators

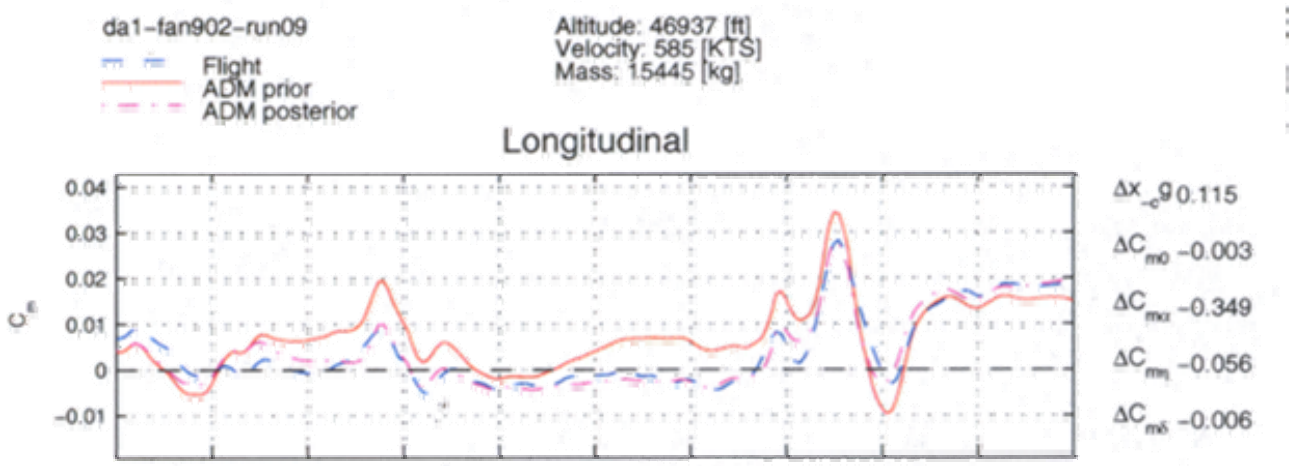
- Maximum Likelihood



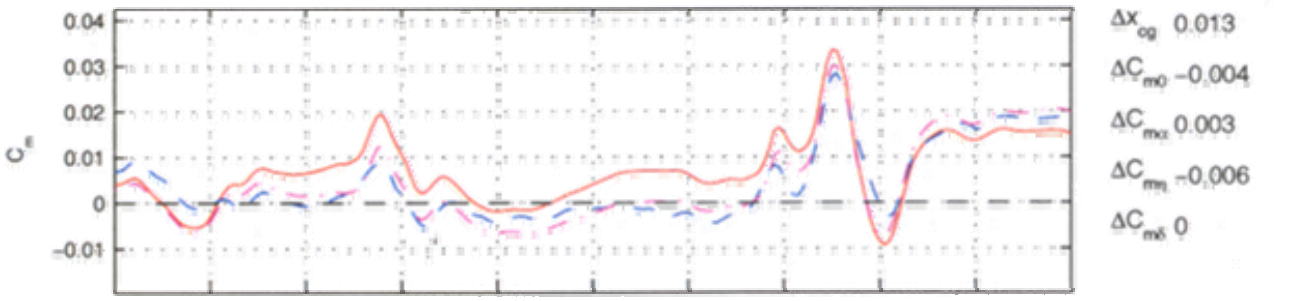
- Bayesian Estimation



Principle of Operation
Bayesian Estimation



Maximum Likelihood

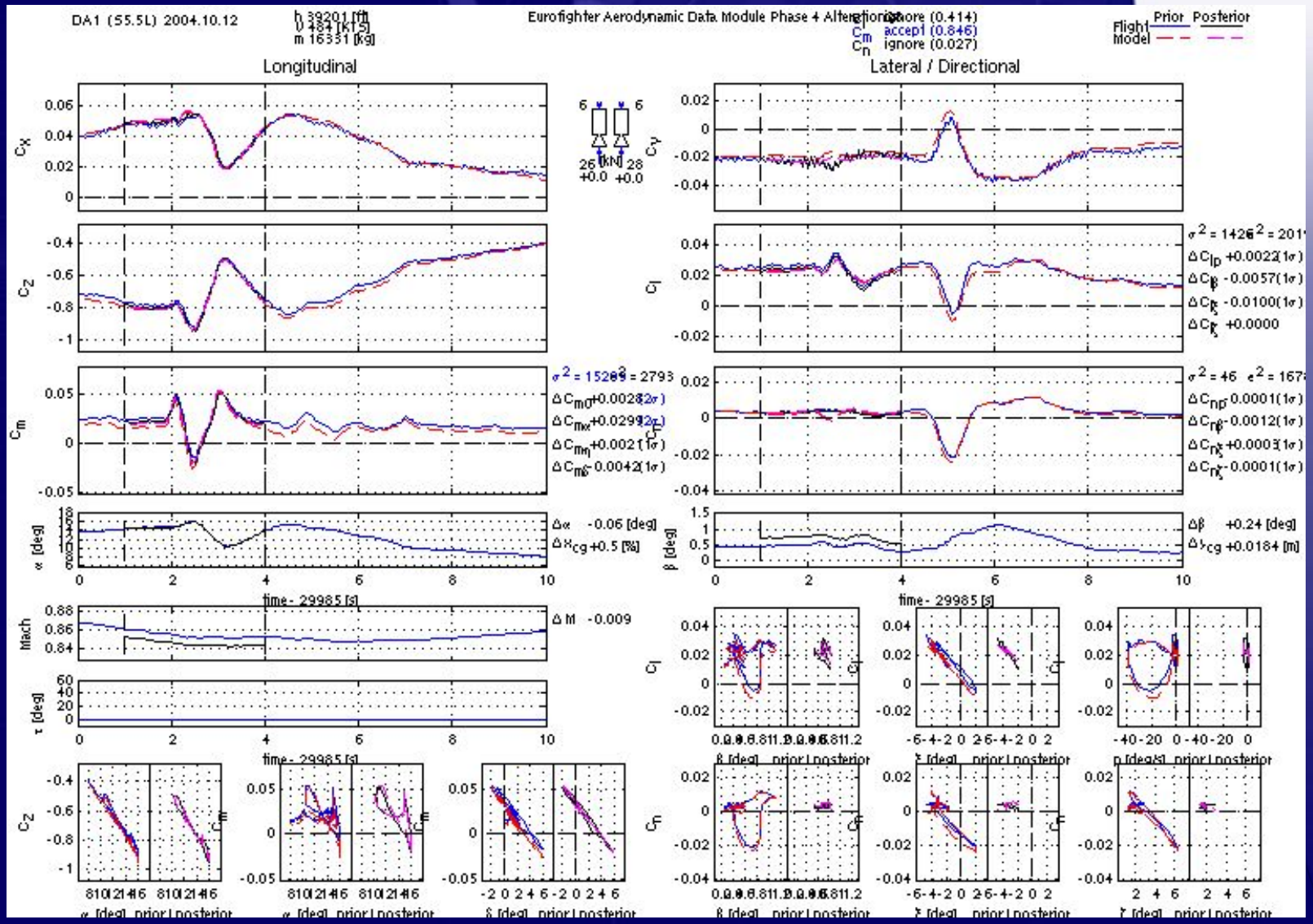


Bayesian

5. Actual Flight Test

- Scenarios
- Simulation
- Flight Test Safety Review
- Taxi Test
- Test Flight

Application Outputs
Time History Plot



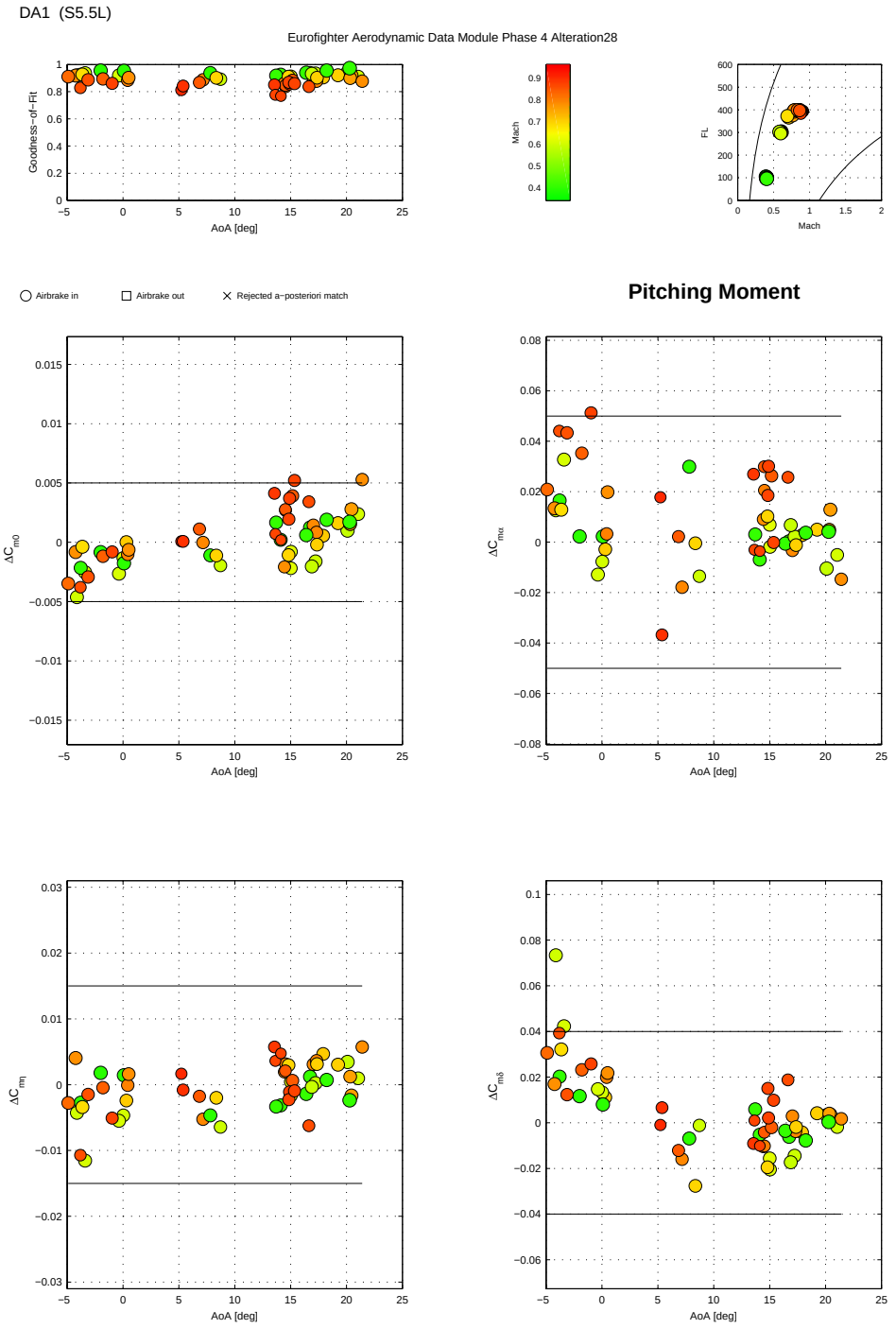
Application Outputs
Summary Plot

- Accounting both a-priori knowledge and good matching
- Correcting/estimating both error model and input parameters
- Obtaining a good matching between Measurement and Prediction by PE

⇒ Set of estimated Parameters within tolerance bounds

⇒ No impairing of Clearance during Flight Test

⇒ Evolutionary (more probable) correction of aerodynamic model for future analysis



6. Results & Lessons

Conclusion

Bayesian PE as post-flight Analysis Tool

- Accounting for a-priori knowledge on all estimated parameters in form of tolerance bounds

⇒ Bayesian Estimation ≠ Maximum Likelihood Estimation

- Casting engineering knowledge into a mathematical corset

⇒ Reduce operator influence, as no arbitrary decision on parameter inclusion/exclusion must be made

⇒ Reducing unnecessary exceeding of clearance during flight test