HyShot II – Flight Data Validation (revisited)

The flight conditions are **UNKNOWN**.

Extensive analysis by the Australian team attempted to back the flow conditions from a model of the trajectory!
HyShot II – Stochastic Inverse Problem

Our approach is based on inference; we solve a stochastic inverse problem (Bayesian)

Observation: two chambers are present (fueled and unfueled data)

1. Build a forward model for the unfueled combustor
2. Use measurements to infer the flight data (conditioned by the forward model)
3. Predict the fueled side of the engine
Given noisy measurements of pressure and temperature infer:

- Flight Mach number
- Angle of attack
- Vehicle altitude and their uncertainties.
HyShot II – Bayesian Estimation

Prior distribution of parameters

\[ \pi(P_0, M_0) \]

Smart et. al.

Measurement Uncertainties

\[ \pi(P_{S_i}|P_0, M_0) \]

Observation

Model prediction (Cold Joe)

Bayes’ Formula

\[ \pi(P_0, M_0|P_{S_i}) \propto \pi(P_0, M_0).\pi(P_{S_i}|P_0, M_0) \]

Posterior distribution of parameters

\[ \pi(P_0, M_0|P_{S_i}) \]

Bayesian estimate

\[ \hat{M}_0, \hat{P}_0 \]
Computed pressure as function of flight Mach # and AoA (Fixed h=32km)
HyShot II – Inverse Analysis

Posterior Distributions

Intake Sensor

Smart et. al.
HyShot II – Inverse Analysis

Posterior Distributions

Intake Sensor + 1 Combustor Sensor

Smart et. al.
HyShot II – Inverse Analysis

Posterior Distributions

Intake Sensor + 2 Combustor Sensors

Smart et. al.
HyShot II – Inverse Analysis

Posterior Distributions

Intake Sensor + 3 Combustor Sensors
HyShot II – Inverse Analysis

Posterior Distributions

Intake Sensor + 4 Combustor Sensors
HyShot II – Inverse Analysis

Posterior Distributions

Intake Sensor + 5 Combustor Sensors

Smart et. al.
Bayesian
HyShot II – Inverse Analysis - Verification

A good match is expected by construction!

![Graph showing pressure (KPa) vs sensor number with flight experiment and predictions with calibrated flight conditions](image)
HyShot II – Inverse Analysis - Verification

The diagram shows the probability density function (pdf) of $P_3$ for two scenarios:
- Black line: flight experiment
- Blue line: predictions with calibrated flight conditions

The x-axis represents $P_3$ ranging from 33 to 37, and the y-axis represents the pdf from 0 to 1.4.