# Application of System Identification Technique to Small UAVs with Novel Avionics

○ Masaru Naruoka, Takuma Hino, and Takeshi Tsuchiya
(Department of Aeronautics and Astronautics, The University of Tokyo)

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## Introduction

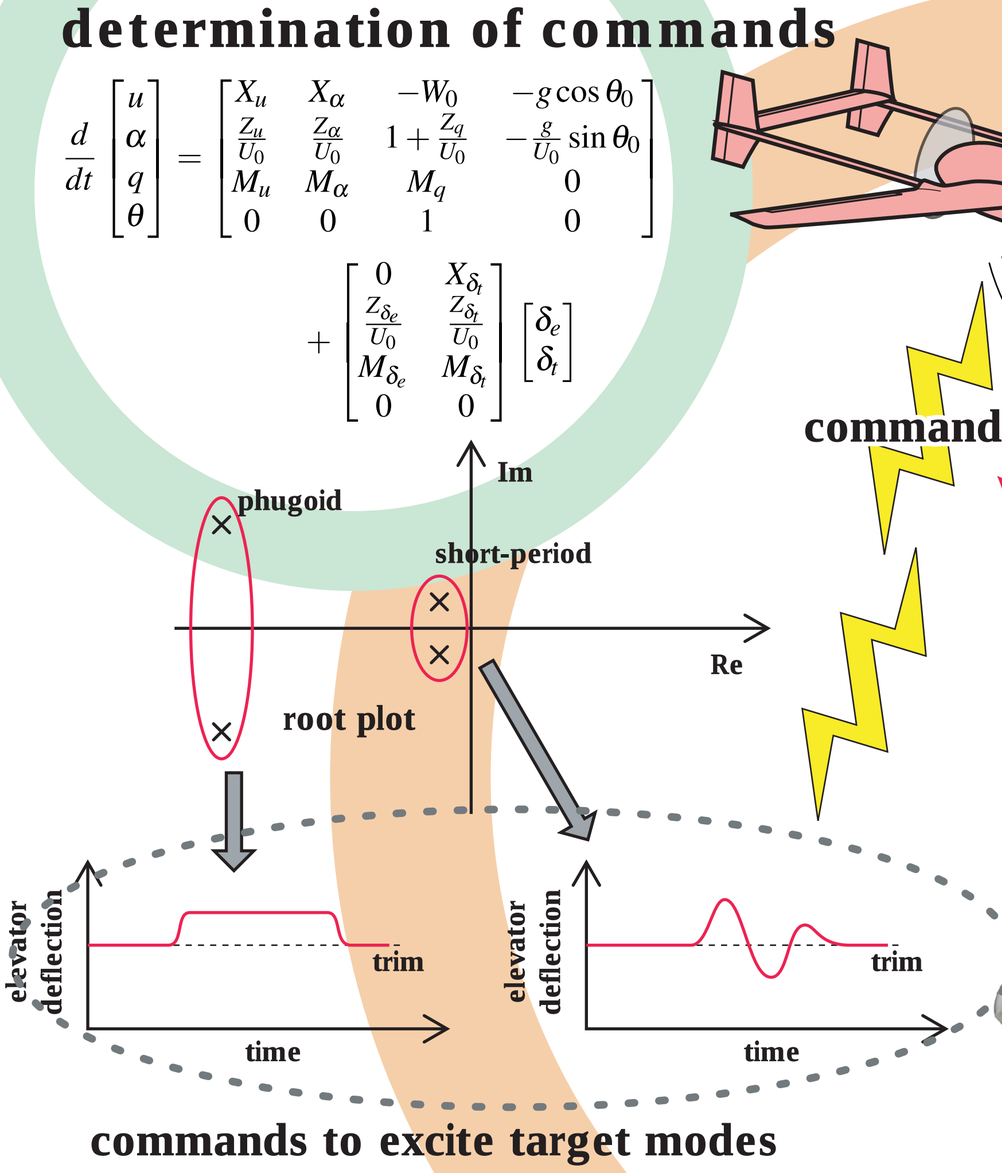
**In order to control small UAVs, whose wingspans are about one meter, more intelligently, it is important to get their accurate mathematical models of the flight dynamics with the system identification technique, which is easier to perform than conventional wind-tunnel tests. However, small UAVs have difficulties to port the technique from large aircraft due to the restriction of their payload. The objective of this study is application of the technique with a new developed avionics.**

## System Identification of small UAVs

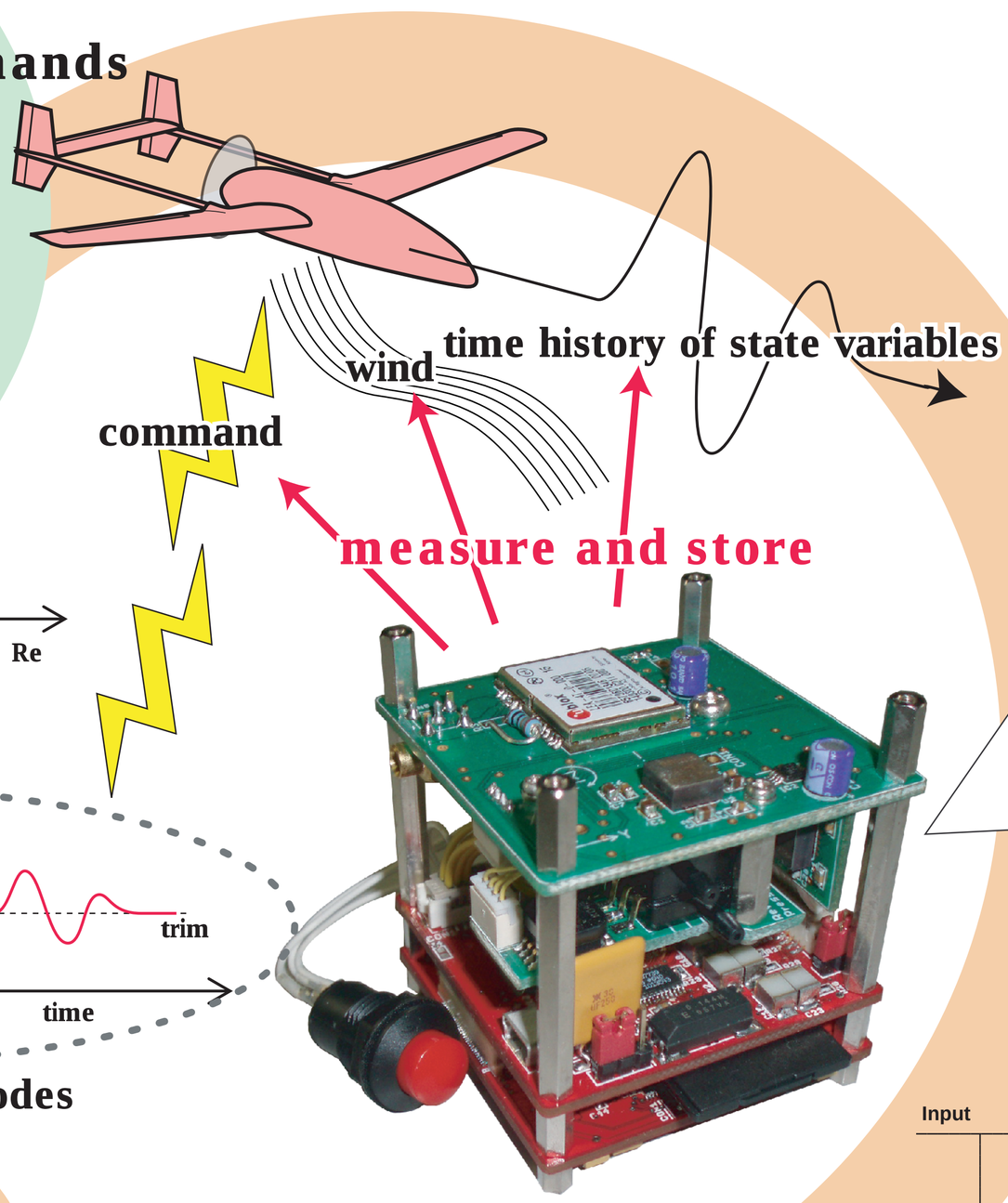
**(This illustration takes the linearized longitudinal dynamics as an example)**

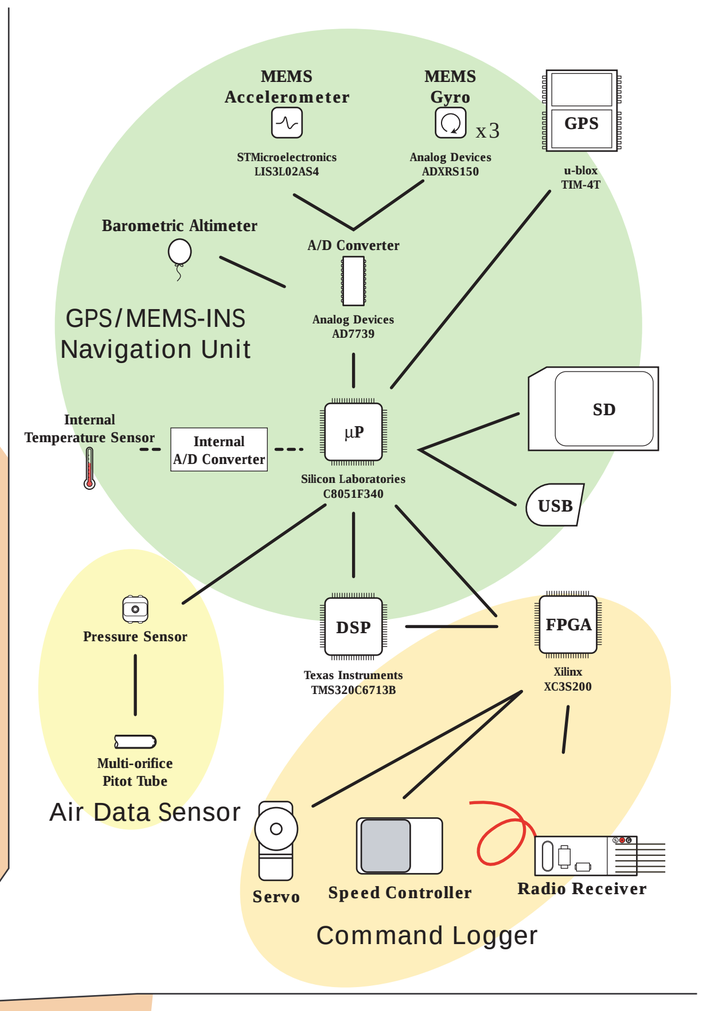
### 1 Model postulation and determination of commands

$$\frac{d}{dt}\begin{bmatrix} u \\ \alpha \\ q \\ \theta \end{bmatrix} = \begin{bmatrix} X_u & X_\alpha & -W_0 & -g\cos\theta_0 \\ \frac{Z_u}{U_0} & \frac{Z_\alpha}{U_0} & 1+\frac{Z_q}{U_0} & -\frac{g}{U_0}\sin\theta_0 \\ M_u & M_\alpha & M_q & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} + \begin{bmatrix} 0 & X_{\delta_t} \\ \frac{Z_{\delta_e}}{U_0} & \frac{Z_{\delta_t}}{U_0} \\ M_{\delta_e} & M_{\delta_t} \\ 0 & 0 \end{bmatrix} \begin{bmatrix} \delta_e \\ \delta_t \end{bmatrix}$$




commands to excite target modes

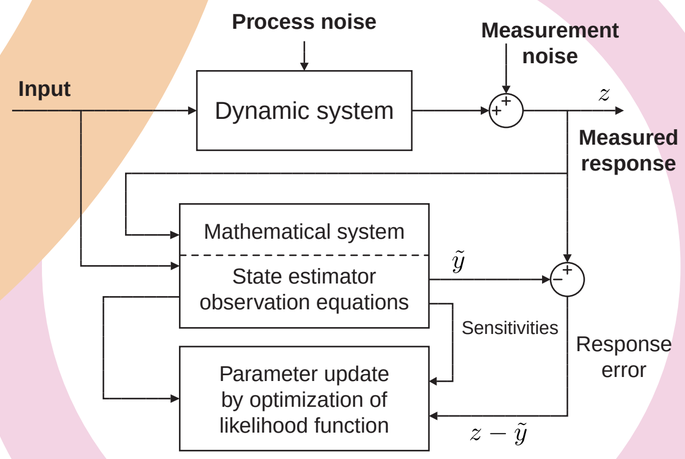



### 2 Command execution and collection of flight data with the developed avionics in flight tests

### 3 Analysis of flight data to estimate parameters

## Filter Error Method




## Experiment Result

### Target UAV

wingspan 1.18 m
gross weight 1.55 kg

| Symbol | Experiment | Simplified estimation |
|---|---|---|
| $X_u$ | $-4.07\times10^{-1}$ | −3.60 |
| $X_\alpha$ | $1.97\times10^{1}$ | 2.26 |
| $Z_u$ | $-1.89\times10^{-1}$ | −1.10 |
| $Z_\alpha$ | $-2.53\times10^{1}$ | −148 |
| $Z_q$ | $-1.33\times10^{1}$ | −3.06 |
| $Z_{\delta_e}$ | −2.00 | −9.66 |
| $M_u$ | $-6.37\times10^{-2}$ | 0 |
| $M_\alpha$ | $-2.07\times10^{1}$ | −46.2 |
| $M_q$ | −3.07 | −8.49 |
| $M_{\delta_e}$ | $-3.10\times10^{1}$ | −120 |

**Most of parameters are in well agreement with results of a simplified estimation in magnitude.**

## Conclusion

**In this study, the system identification methodology for small UAVs is demonstrated. The results of the analysis of the longitudinal motion of the target UAV shows that the system identification technique can be applied with the proposed avionics.**