1A-14　APC-7におけるNASA-CRMの低速・高迎角時の風洞試験データ
NASA Common Research Model (CRM) wind tunnel data at low speed and high angle of attack conditions in APC-7

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Outline

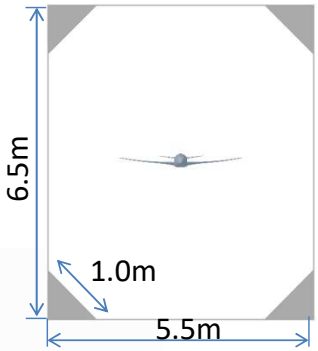
- Explain NASA CRM data measured at JAXA 6.5m×5.5m low speed wind tunnel provided to APC-7.
- Please refer to ‘2A03’ at this symposium, if you want to know details of the wind tunnel results.

- Contents
  - Wind tunnel tests description
    - Wind tunnel and Model description
    - Measurement items and wind tunnel condition
  - Wind tunnel test data
    - Forces and moments
    - Surface pressure data of main wing and h-tail (Steady and Unsteady)
    - Vibration data of main wing and h-tail
    - Oil flow visualization
    - Stereo PIV

JAXA 6.5m × 5.5m low speed wind tunnel (JAXA LWT1)

- Type: Closed circuit（Atmospheric）
- Test section: 6.5m height 5.5m width （Octagonal with corner truncated 1m）
- Maximum Flow speed: 70m/s
- Constructed: 1965

Blockage ratio : 0.29%



Sting Cart

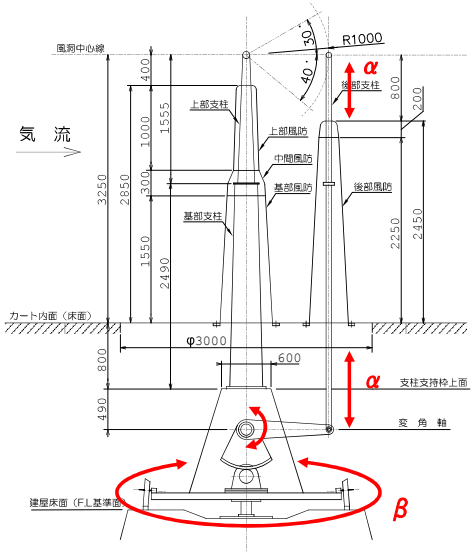
Strut Cart

Blower
ϕ9.3m

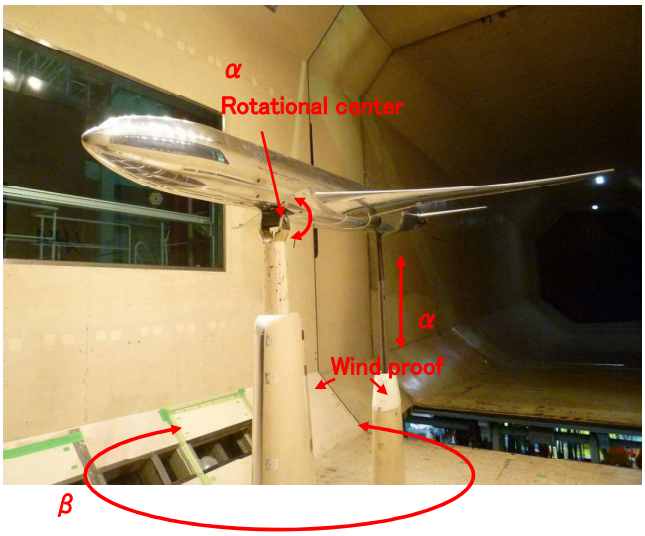
Electric Motor
3,000kW

Strut Cart at JAXA LWT1

- Models are supported with two struts.
- Forces and moments are measured with pyramid-type 6 component balance.



Strut support



Wind tunnel model

- NASA Common Research Model
  - Scale to assumed aircraft：4.32%
  - Length: 2.711m
  - Span length: 2.539m
  - Reference area: 0.716m^2
  - Reference cord: 0.303m
  - Applied trip dots
    - ✓ Location ：Wing, horizontal tail, Nose.
    - ✓ Height：11.4 [in/1000]

- Used horizontal tail with pressure transducers
  - ✓ Pressure taps: 12
  - ✓ Kulite transducers: 10
- Bonded Kulite transducers on the main wing
  - ✓ Kulite transducers: 4

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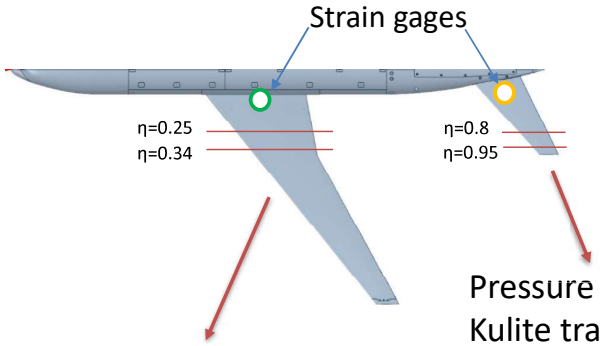
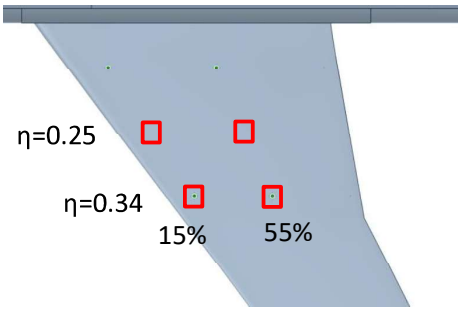
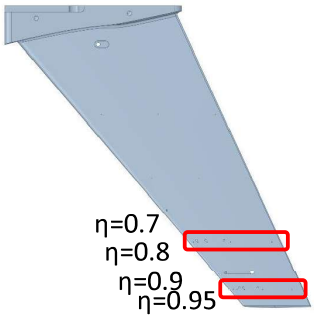
Locations of pressure taps, kulite transducers, and strain gages on the main wing and horizontal tail



Kulite transducers on the wing



Pressure taps and Kulite transducers on the horizontal tail



Pressure Tap			
Port	η	Location	Cord, %
1	0.8	Leading edge	0
2	0.8	Upper	5
3	0.8	Upper	10
4	0.8	Upper	20
5	0.8	Upper	45
6	0.8	Upper	90
7	0.95	Leading edge	0
8	0.95	Upper	5
9	0.95	Upper	10
10	0.95	Upper	20
11	0.95	Upper	45
12	0.95	Upper	85

Kulite			
Port	η	Location	Cord, %
1	0.7	Upper	5
2	0.8	Leading edge	0
3	0.8	Upper	10
4	0.8	Upper	20
5	0.8	Upper	40
6	0.9	Lower	12.5
7	0.95	Leading edge	0
8	0.95	Upper	15
9	0.95	Upper	20
10	0.95	Upper	40

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Measurement data sets

Test id	Model	Test conditions	Measurement items	Provided to APC
Sting Cart Test	NASA CRM	V=60m/s Re=1.06 × 10^6	Forces and Moments Oil flow visualization PIV（x-z Section）	APC6 APC6 APC7
1st Strut Cart Test	NASA CRM Main wing：Kulite transducers horizontal tail :pressure taps and Kulite transducers	V=53-60m/s Re=1.06 × 10^6	Forces and Moments Oil flow visualization Steady pressures Unsteady pressures Vibration of the wings	APC7
2nd Strut Cart Test	NASA CRM	V=53-58m/s Re=1.06 × 10^6	Stereo PIV （y-z Section）	APC7

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Wind tunnel results

- Stall characteristic at high AoA
  - Forces and Moments
  - Oil flow visualization
- Steady and Unsteady pressures, and vibrations of wing and h-tail
  - Steady pressures on wing and h-tail
  - Unsteady pressures on wing and h-tail
  - Vibration of wing and h-tail
- Velocity distributions between wake of main wing and h-tail
  - PIV（x-z section）
  - Stereo PIV（y-z section）

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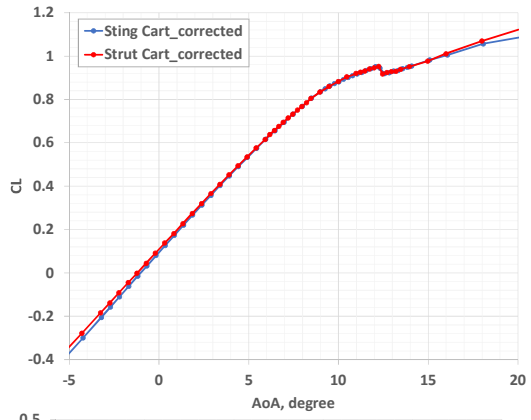
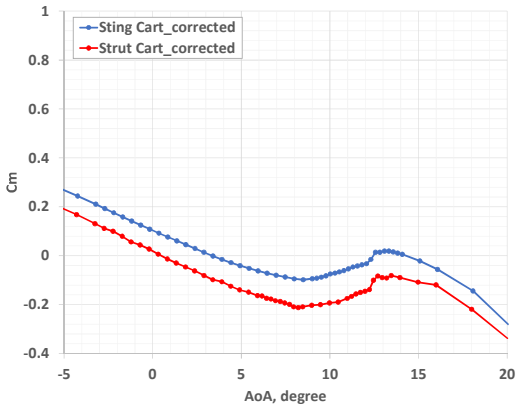
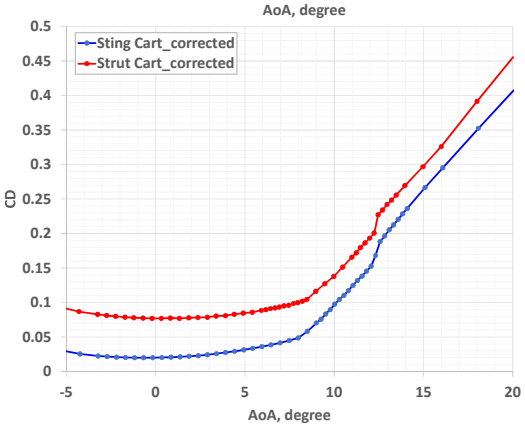
Comparisons of aerodynamic data between two supports



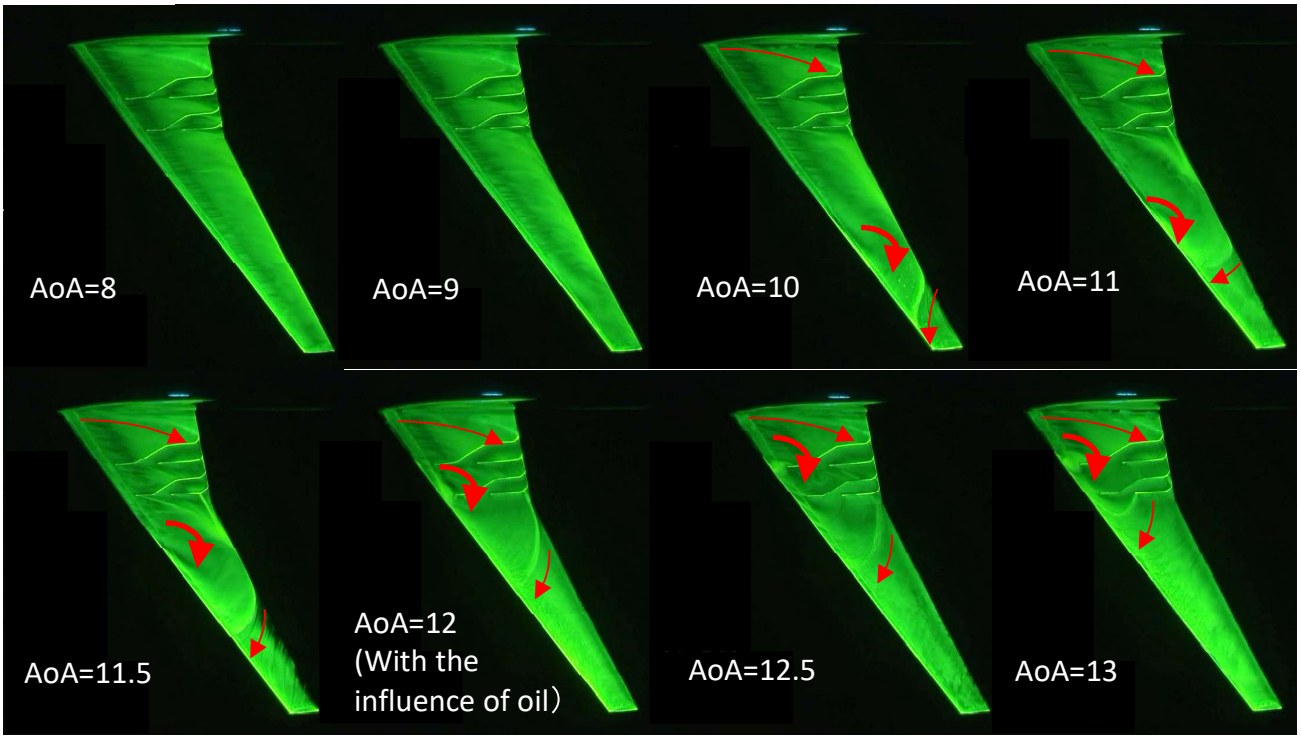




- CL increases linearly to 8.5 degrees, and CL decreases drastically at AoA=12.5.
- The tendency is almost the same for sting cart data and strut cart data. The difference of CD and Cm are influenced on aerodynamic forces received at the strut.
- The repeatability of CL, CD, and Cm are 0.005, 0.001, and 0.01 respectively.

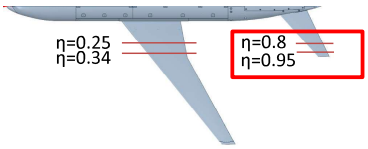
※Sting cart data are referred to AIAA2019-2190

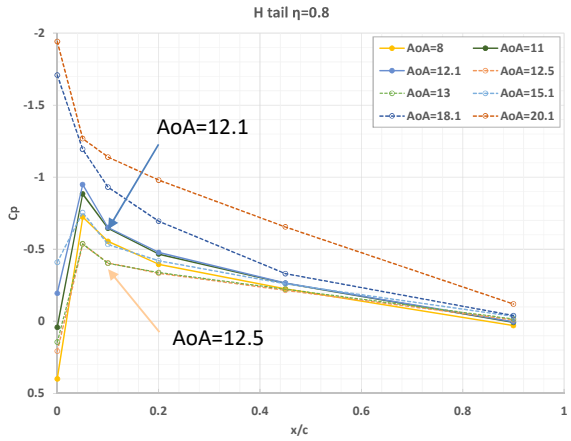
Oil flow visualization at AoA=8-13 degrees

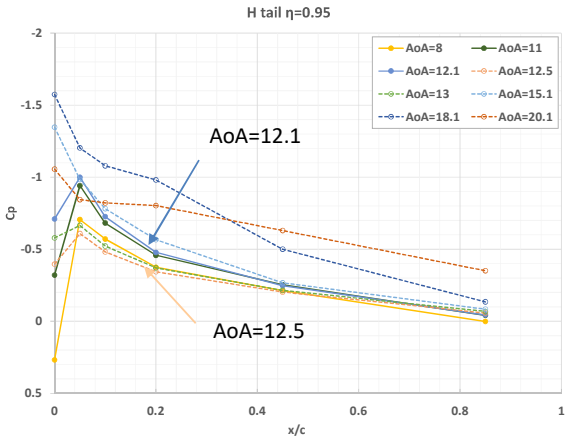


Though the separation area is outside of the kink on the main wing at AoA=11.5degree, the separation area spreads near wing root at stall angle.

Pressure distributions on h-tail

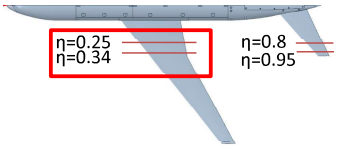


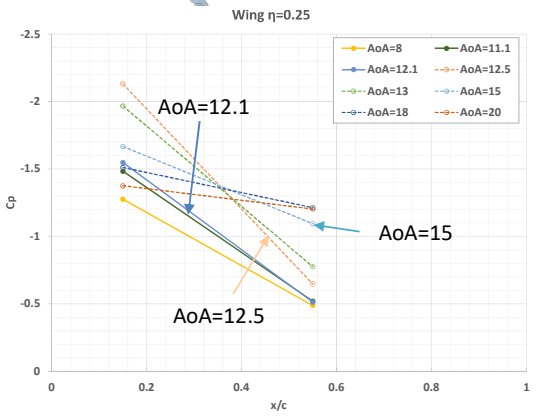


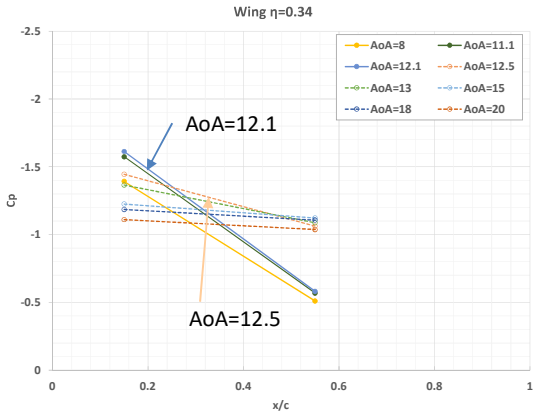


- At the stall angle, the lift of the h-tail is reduced.

Pressure distributions on main wing



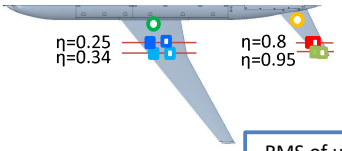




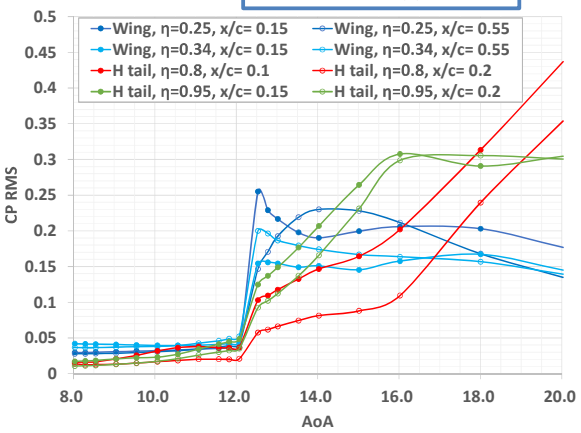
- At the stall angle, the suction is reduced, so that the flow separation on the main wing is confirmed.

※The data is interfered with existence of the Kulite transducers.

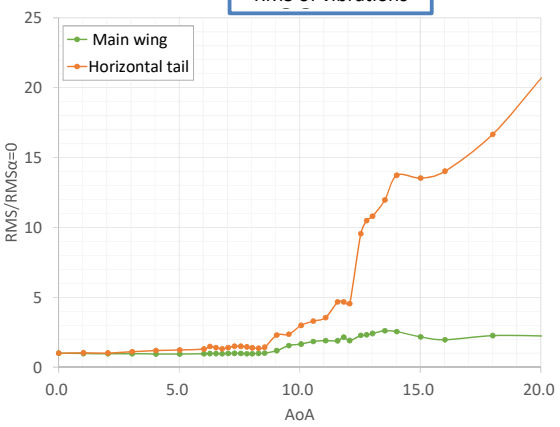
RMS variations of unsteady pressures and vibrations of wing and h-tail



RMS of unsteady pressures



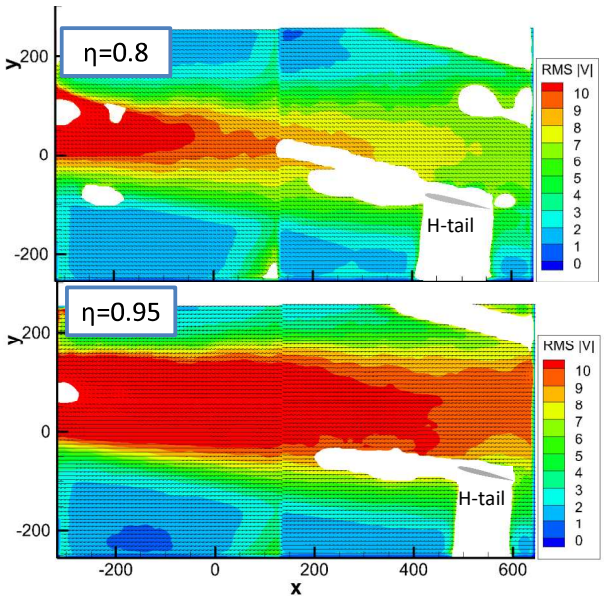
RMS of vibrations

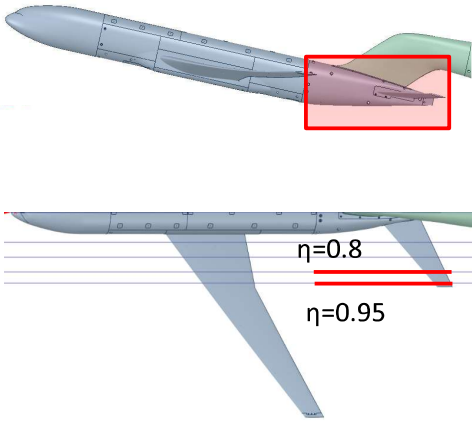


- The RMS of unsteady pressures of wing and h-tail increases drastically at the stall angle of 12.5 degrees. With that increases, vibration of h-tail increases.
- Vibration of main wing increases from angles of 9 degrees. H-tail vibrates slightly also.

PIV results at the sting cart test

☐ At the sting cart test, PIV measurements are conducted. At the post stall angles, we confirmed separation flow effects on η=0.8 and 0.9 of the horizontal tail.

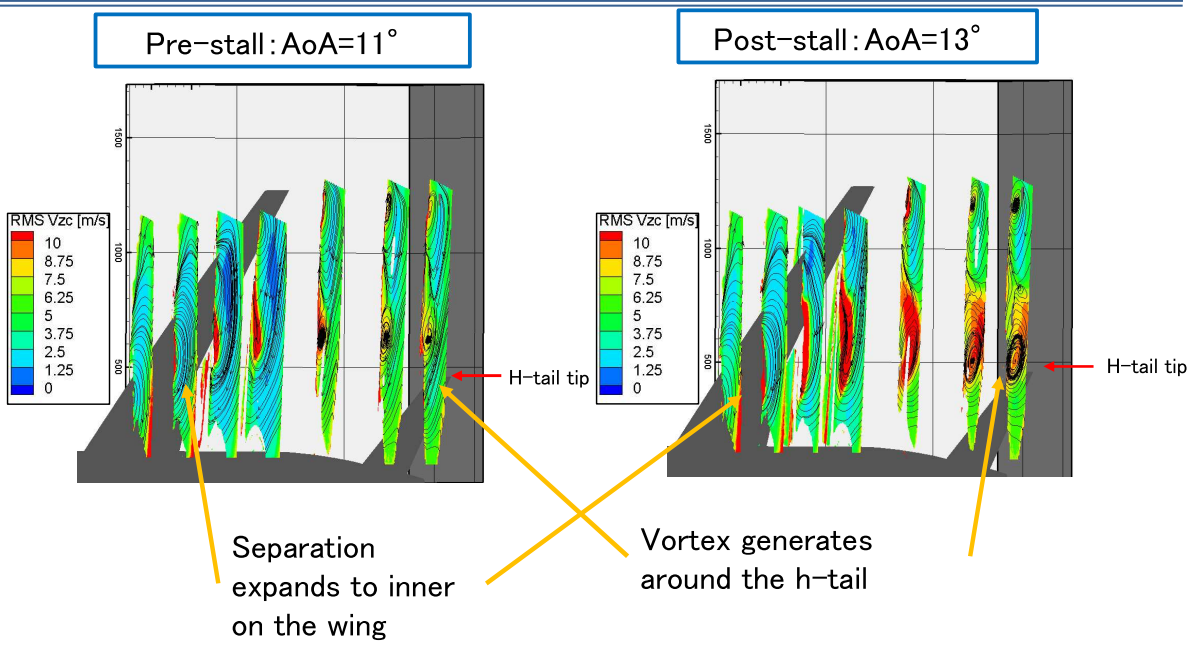




V=60m/s, AoA=12.5degrees

Horizontal tails with pressure taps and Kulite transducers at η=0.8,0.95 are manufactured.

Stereo PIV results



- PIV data are measured at pre-stall and post-stall angle of attack.
- At post-stall, separation flow on the main wing interfere with the h-tail.