

# Falcon Hypersonic Technology Vehicle (HTV-2)

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# Falcon Hypersonic Technology Vehicle – HTV-2

## Program Objectives

Develop and test an unmanned, rocket-launched, maneuverable, hypersonic air vehicle that glides through the Earth's atmosphere up to Mach 20 speed.

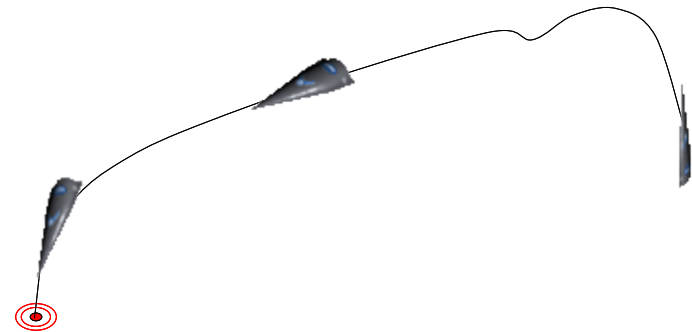
## Performance Metrics

- High lift-to-drag ratio, advanced carbon-carbon aeroshell.
- High-temperature materials and structures.
- Precision navigation, guidance, and control.
- Proper function of onboard sensors and off-board auxiliary measurements to characterize:
  - Vehicle state.
  - Flight environment.
  - Aerodynamic and aerothermal performance.
  - GNC system performance.



## Program Status

- Flight #1 completed 22 April 2010:
  - Preliminary review of data indicates the HTV-2 achieved controlled flight within the atmosphere at over Mach 20.
  - Lost vehicle telemetry approximately 9 minutes into the mission.
- Flight #2 planned for 10-17 Aug 2011.





# HTV-2 flight #1

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## **Inaugural launch of the Minotaur IV booster**

- Demonstration of the ability to fly at extreme angles of attack up to 89 degrees to meet stringent release requirements for the HTV-2.

## **Extensive data captured for critical areas of interest**

- Aerothermal, aerodynamic, thermal protection, navigation, guidance, and control in the hypersonic flight regime.
- Successful demonstration of the first ever use of an autonomous flight termination system.

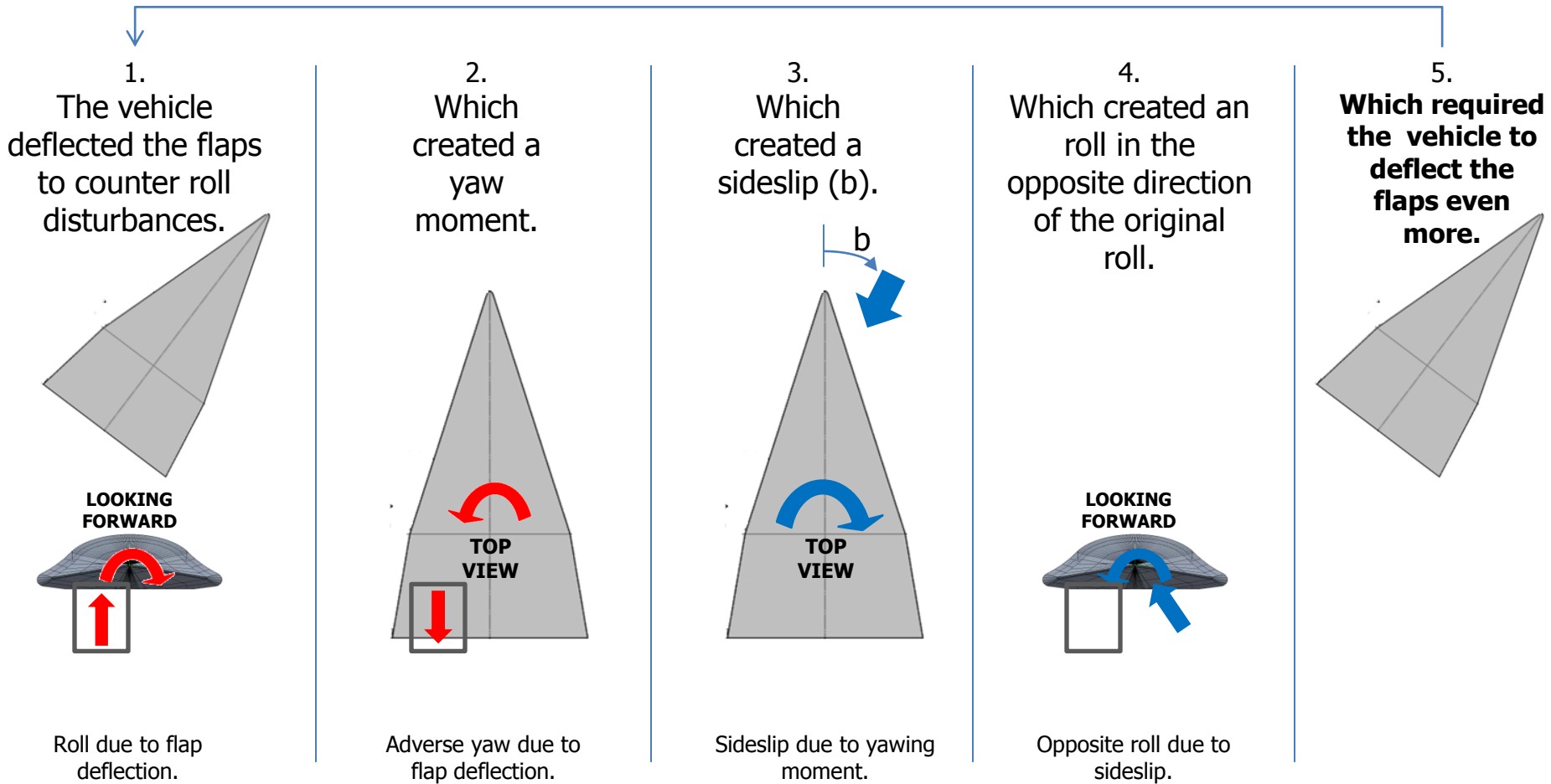
## **Flight dynamic anomaly observed during pull-up phase of flight**

**“Higher than predicted adverse yaw coupled into roll that exceeded the available roll control capability.”**

**(Paulson, 2010, 1)**



# Roll-yaw coupling



**6.) Eventually, the adverse roll moment from the sideslip and disturbances overwhelmed the roll moment available from the differential flap deflections.**



# HTV-2 flight #1 investigation

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## **Independent Engineering Review Board (ERB)**

- ERB chartered to examine data collected during flight #1.
- Extensive six-month review concluded the week of 13 Sep 2010.
- Probable cause and contributing factors to flight anomaly identified.

## **Key findings**

- Higher-than-predicted yaw, which coupled into roll thus exceeding the available control capability at the time of the anomaly.
- This resulted in flight control authority limitations to operate at the angle of attack the vehicle was programmed to fly for the speed and altitude where the anomaly occurred.

## **Remediation plan**

- Decrease the angle of attack.
- Adjust the vehicle's center of gravity.
- Use onboard reaction control to augment vehicle flaps.
- Can be implemented via software, ballast and flight profile changes.



# Summary, conclusions, and the path forward

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## **ERB conclusion**

- Probable cause and contributing factors identified.
- Closure of anomaly investigation phase.
- Recommendation of implementation of remediation actions.
- Effectiveness of remediation strategy to be reviewed at MDR.

**Flight test report to be completed on 15 Jan 2011.**

## **Remediation actions**

- Engineering fixes (CG, AoA, RCS).
- Scientific fixes (aero model, autopilot, controls).
- Systems engineering and process.

## **No major redesign needed for flight #2**

- High confidence in schedule completion.
- Flight #2 planned for 10-17 Aug 2011.



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