Hy-V Program

- a Virginia Student Launch Initiative

Prof. Chris Goyne
University of Virginia

and

Prof. Chris Hall
Virginia Tech

Virginia Space Grant Consortium
Aerospace Partnerships in Education, Research and Industry

UNIVERSITY of VIRGINIA

VirginiaTech
Invent the Future

ODU

HAMPTON UNIVERSITY 1868

COLLEGE OF WILLIAM & MARY 1693

NASA Wallops Flight Facility
Goddard Space Flight Center

Sept., 2006

Education background

- Key to maintaining competitiveness within international aerospace market: well educated aerospace workforce
- 27% of aerospace workers will retire by 2008 (AIA)
- 66% of aerospace and defense executives report a shortage of skilled workers - aerospace/mechanical and software sectors (Aviation Week, Nov. 2005)
- Conducting a project that will educate and motivate a new breed of aerospace engineers and scientists

Research background

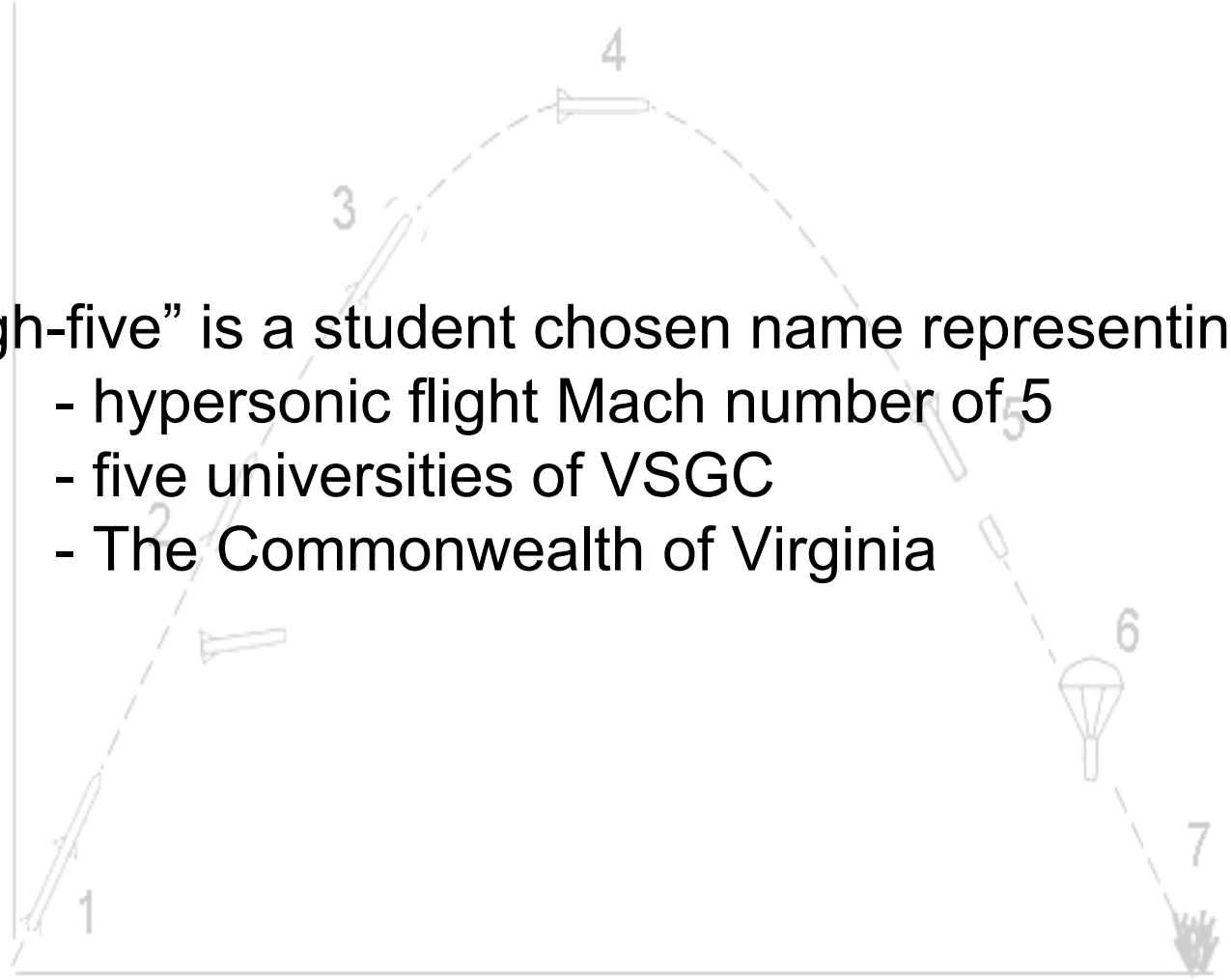
- VSGC partners have significant scramjet research background:
  - University of Virginia: Mach 5 scramjet facility and diagnostics
  - Virginia Tech: Scramjet mixing, ignition and combustion
  - ODU: Scramjet numerical modeling
  - Hampton: Center for AeroPropulsion (CAP)
  - W&M: Physics and diagnostics
  - NASA Langley: Hyper-X, Fundamental research, NASP
- VSGC partners have sounding rocket project background:
  - University of Virginia: UVIRES
  - Virginia Tech: VTSRP
  - ODU: SubSEM launch
  - Hampton: LASP/CU
  - NASA Wallops: Suborbital and orbital projects
- Develop unique scramjet educational and research project

Project Overview

- Goal: Conduct flight experiment of scramjet engine at Mach 5 using a sounding rocket

- Research and educational components
- Managed by undergraduate and graduate students and faculty from partner universities
- Seeking collaboration with industry, NASA and DoD
- High school student outreach
- Draw on existing university scramjet research and university sounding rocket experience
- Form the basis for future university hypersonic flight testing

Hy-V



- “high-five” is a student chosen name representing:
  - hypersonic flight Mach number of 5
  - five universities of VSGC
  - The Commonwealth of Virginia

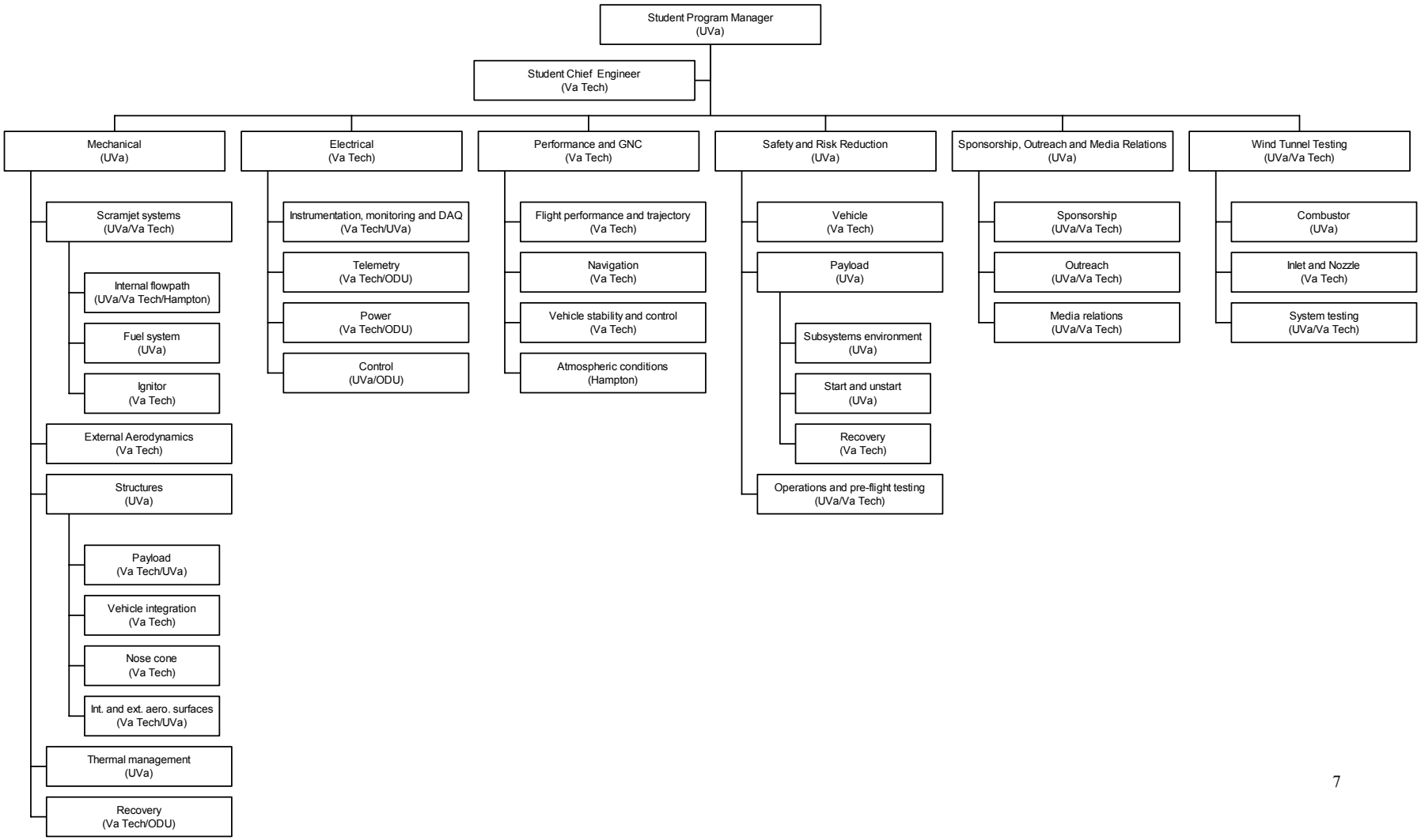
Team and program structure

- **University of Virginia** - scramjet design, wind tunnel tests, systems, program management
- **Virginia Tech** - scramjet design, wind tunnel tests, CFD, systems, launch vehicle
- **ODU** - vehicle integration and systems modeling
- **Hampton** - numerical modeling
- **W&M** – materials and NDE
- **NSROC and NASA WFF**- flight vehicle integration and launch support
- **Seeking Industrial partners**
- **Seeking other NASA groups and DoD participation**
- **High School outreach**

- PI: Prof. Chris Goyne, UVa
- co-PI: Prof. Chris Hall, Va Tech
- Student Program Manager, Student Chief Engineer and Student Technical Managers

Management structure

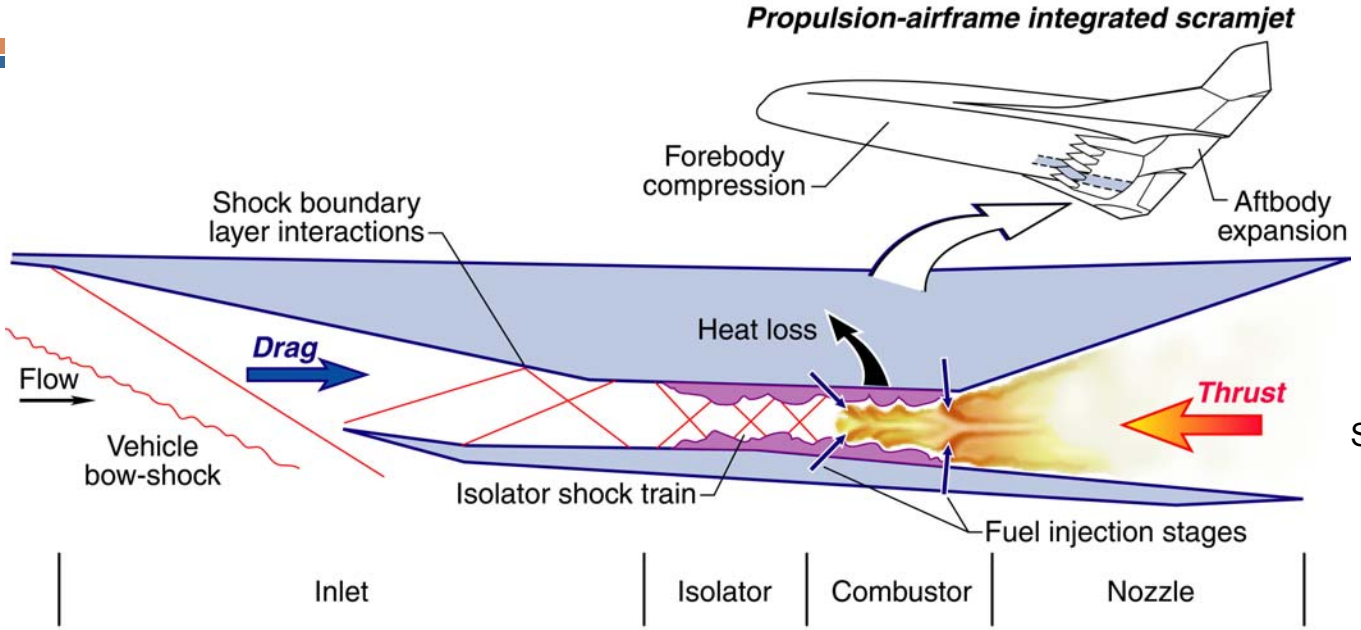
Hy-V Program
Management Structure



Scramjet

- Supersonic Combustion Ramjet
- Jet engines to propel flight vehicles from Mach 4 to ~20
- Reusable space launch vehicles, high speed transport and advanced military aircraft and missiles

Technical overview



Source: NASA LaRC

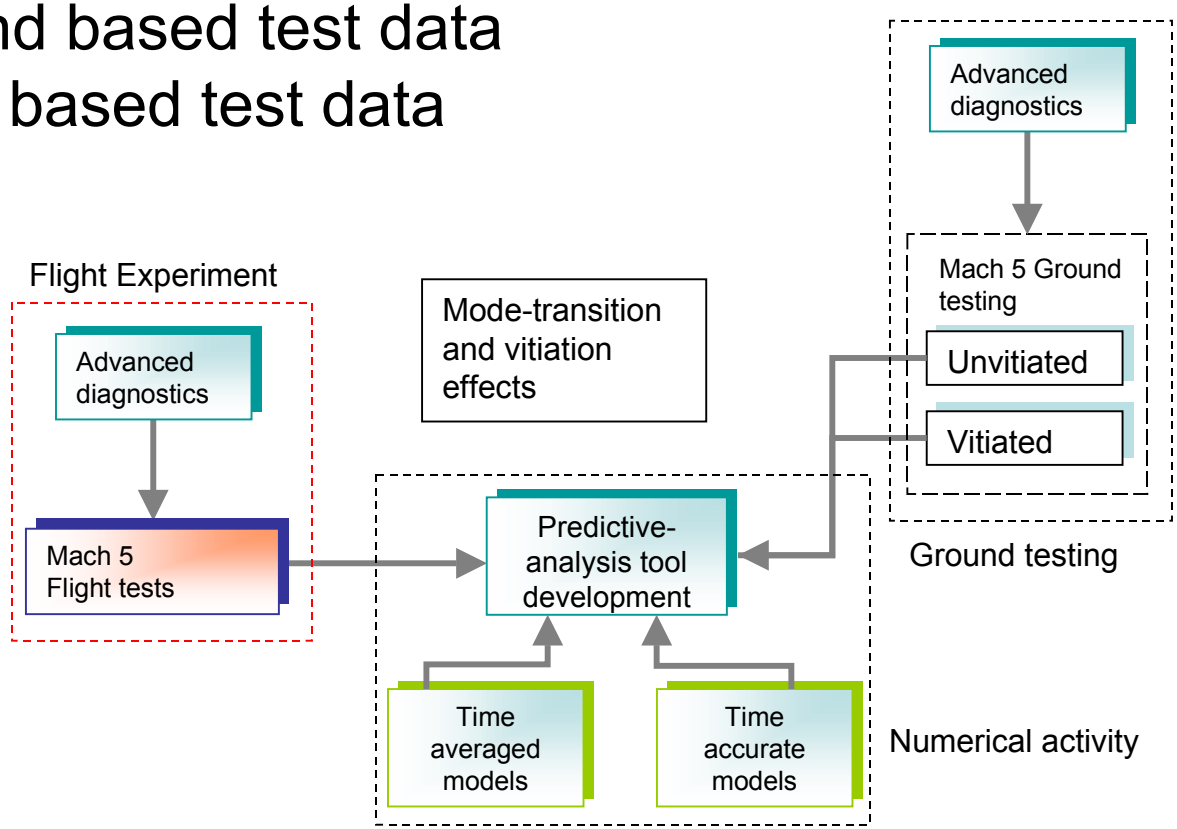
- Scramjet undergoes mode-transition at ~ Mach 5
- Numerical tools for predicting mode-transition and DMSJ combustion are insufficient
- Ground based test data suffer from facility effects
  - vitiates, flow quality, b/c etc.

⇨ **Use flight to validate or calibrate ground test data**

Approach

- Develop accurate numerical prediction tools for mode-transition and DMSJ combustion using:

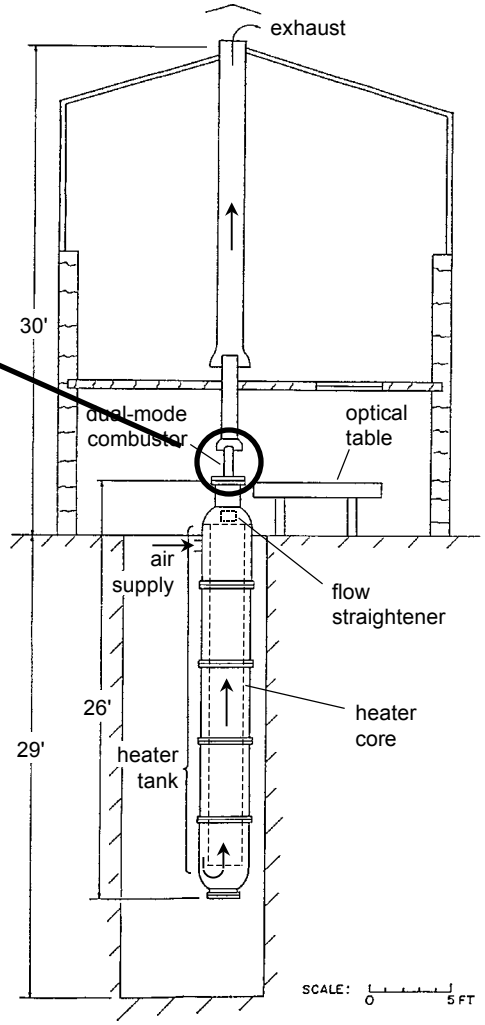
⇨ Generic isolator/combustor geometry
- Ground based test data
- Flight based test data



Flight experiment

Terrier-Improved Orion suborbital rocket
(Source: NASA Wallops)

- Tentative launch date: July, 2009



UVa scramjet wind tunnel

Conditions:

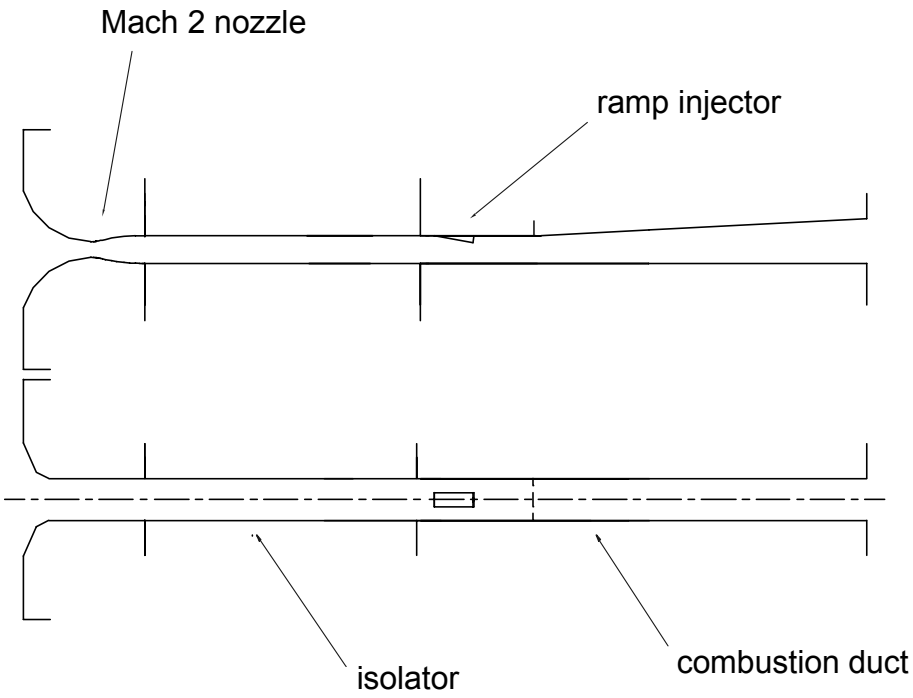
$M_{flight} = 5$

$M_{combustion} = 2$

Altitude = 50,000 - 100,000 ft

$t_{test} \approx$ 10-30 sec.

UVa direct connect DMSJ

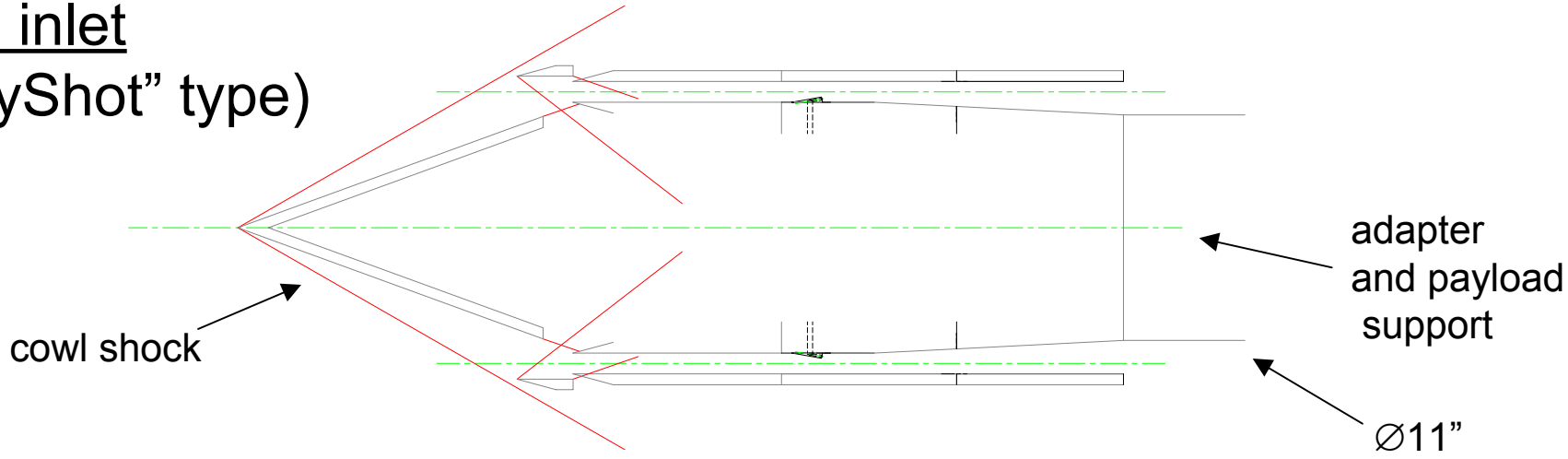


Facility:

- Continuous flow
- Clean-air
- $T_o \approx 1{,}200$ K ≡ Mach 5
- Vitiation capability: CO_2, H_2O
- Hydrogen and ethylene fuel
- Indefinite test time
- Existing hardware

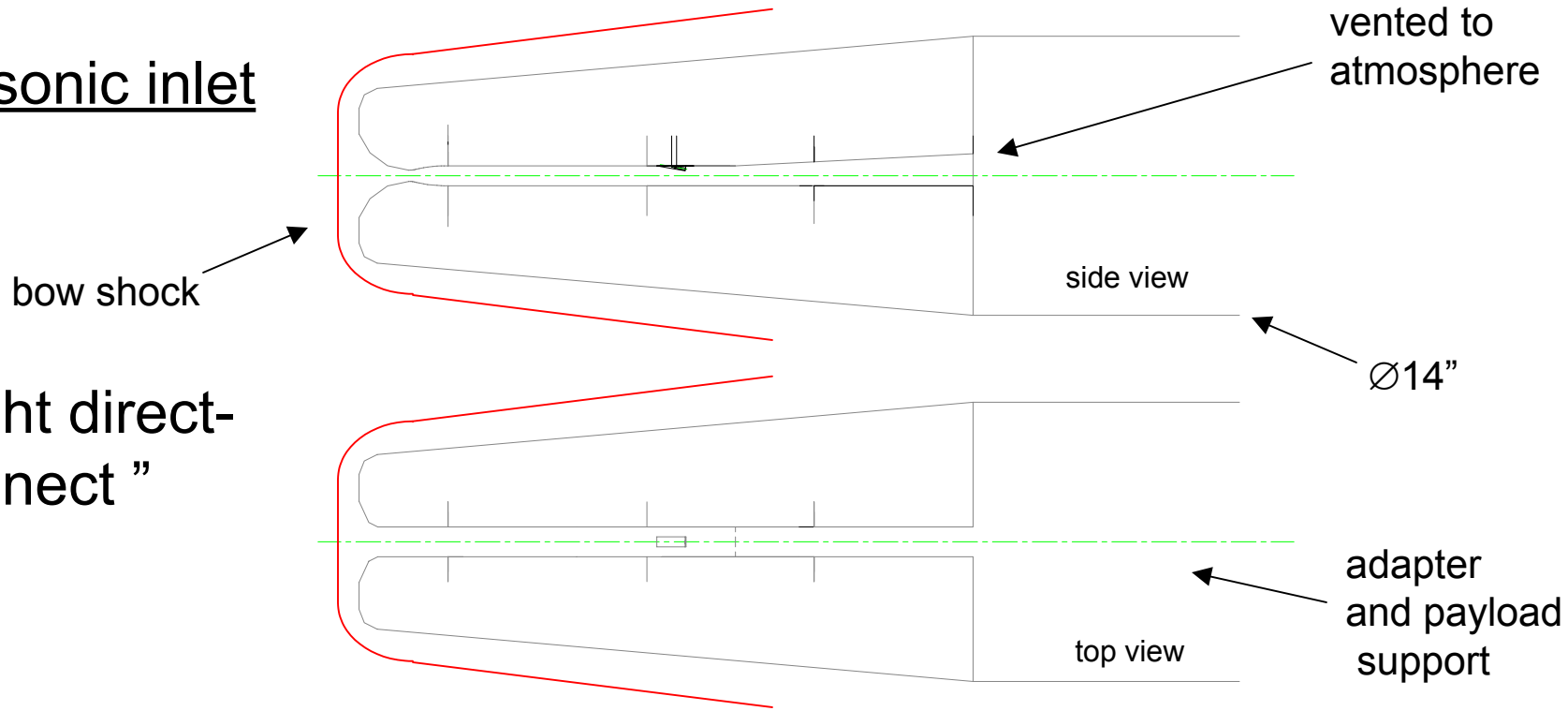
Candidate flight geometries

2D inlet
("HyShot" type)



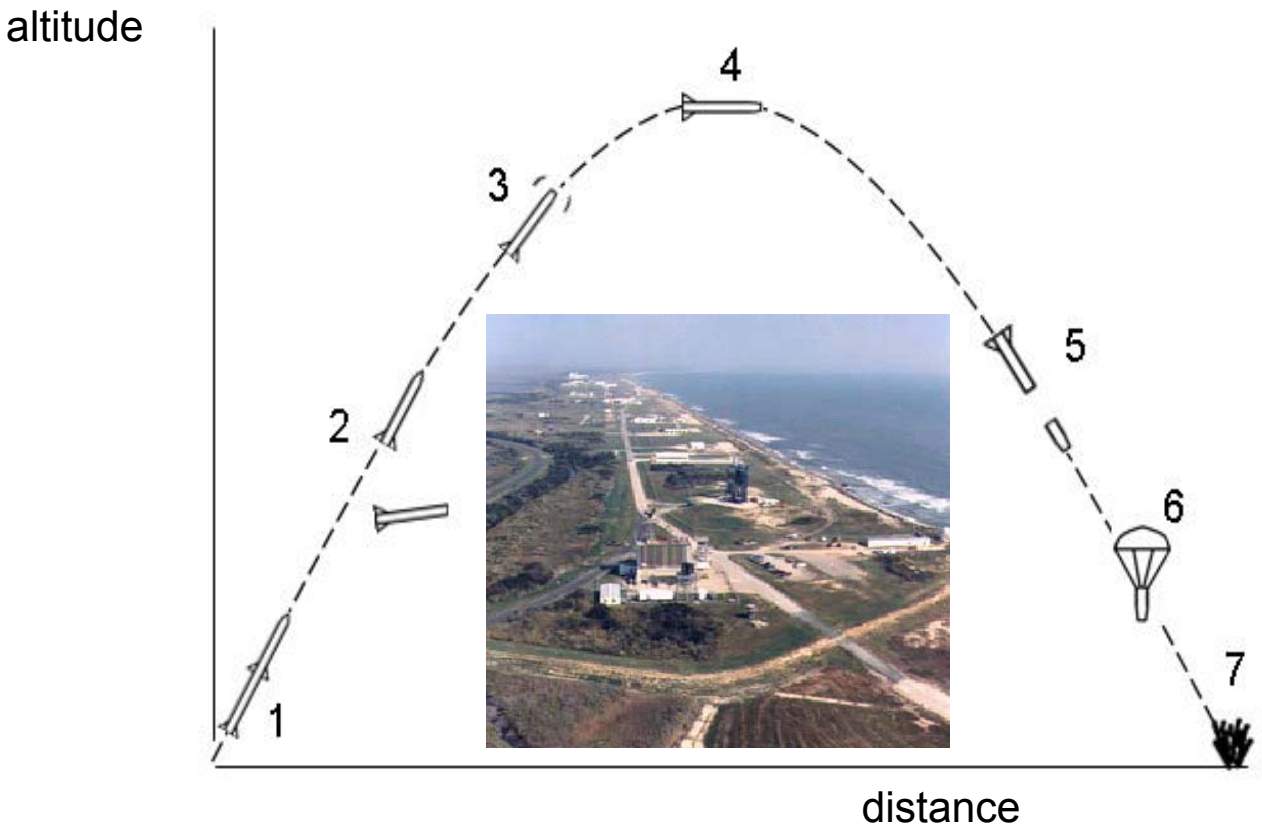
- Same scale and geometry combustor
- Two (or more) flow paths available for different fuels/geometries
- Low drag and nose heat transfer
- UVa inflow conditions not as closely matched (still full scale)
- More susceptible to angle of attack and yaw changes
- Instrumentation within cowl possibly difficult

Candidate flight geometries



- UVa direct connect geometry fully matched (full scale)
- Inlet remains unstarted - no risk of unstart from mode-transition
- “Blunt cone” external surfaces for aero. and materials expts.
- Inflow conditions closely match direct connect experiments

Mission profile



1) launch, 2) staging, 3) nose cone separation, 4) fuel-on, 5) recovery, 6) parachute, and 7) splash-down.

Flight profile to match UVa conditions

- Subsonic inlet geometry:
  - Mach 5
  - 53,000 ft

- Supersonic inlet geometry:
  - Mach 5
  - 92,000 ft (both suppressed trajectory)

- Both profiles achievable with Terrier-Orion rocket
- Use nose cone to protect payload – sep. prior to test
- ≈ 300 lb payload
- ≈ 10-30 sec. test window
- Recover experiment for materials inspection

Project status

- NASA Wallops donated a Terrier-Improved Orion sounding rocket and basic launch range support
- VSGC committed $50k seed funding, and student scholarships worth $90k over three years
- Looking to partner with NASA, DoD and industry
- $1.2 million proposal pending with NASA Aeronautics
- Additional $800k pending for supporting wind tunnel expts.
- VSGC funded four undergraduate student scholarships, 05-06
  - two students at UVa and two at Va Tech, Summer ’06+
- Design work started in June, 2006; launch is July, 2009

Project status cont.

- UVa Engineering Foundation very involved in fundraising

- Project design office has opened at UVa with approx. 7 engineering undergraduate students this semester

- Two undergraduate design teams at Va Tech being organized

- UVa featured Hy-V Program at 2006 Team America Rocketry Challenge (world's largest rocket competition for high schools students)

Questions?

Prof. Chris Goyne
Department of Mechanical and Aerospace Engineering

Ph: 434-982-5355
goyne@virginia.edu