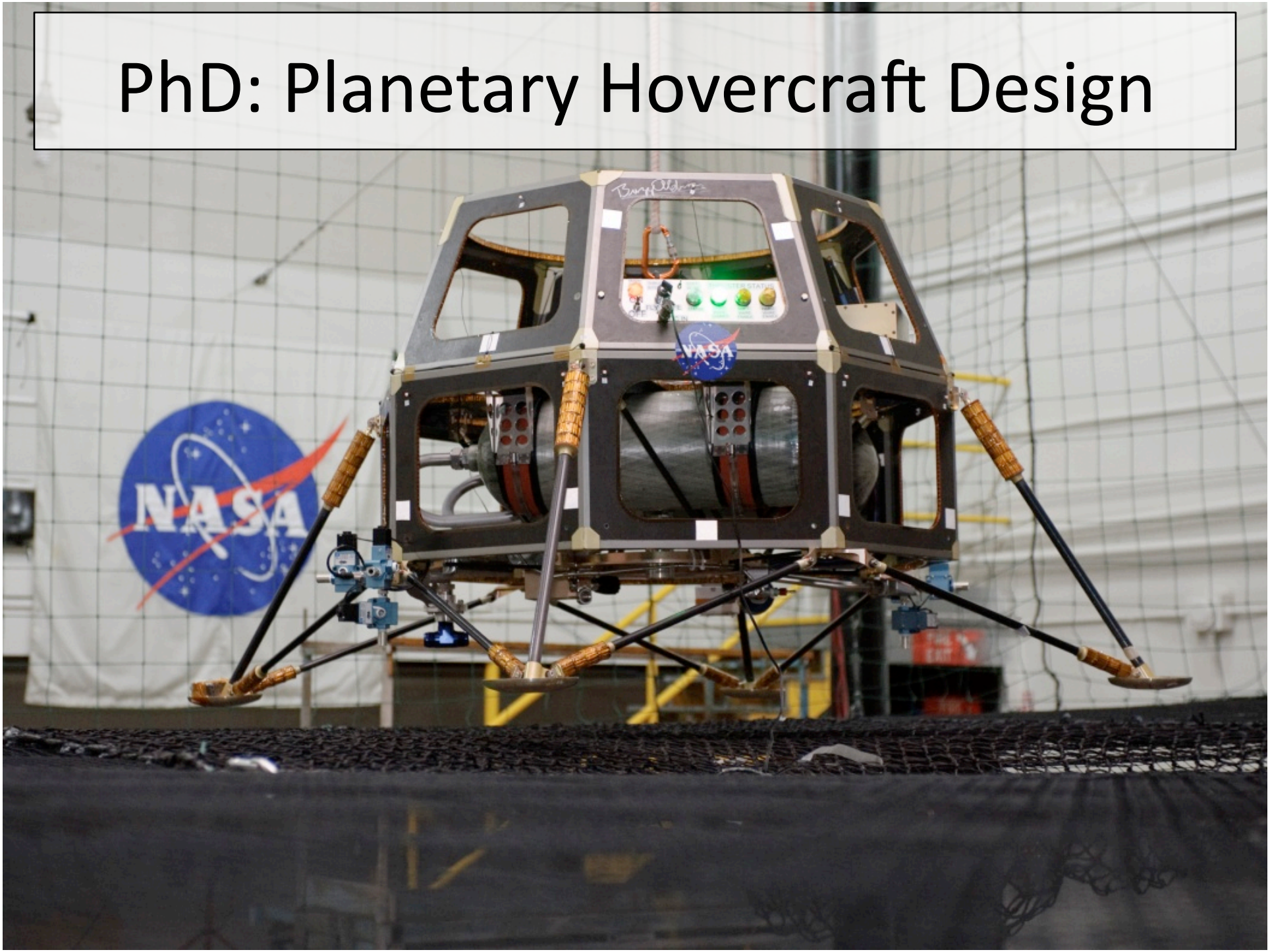
Informal Overview of HTV Project History

Eleanor Crane

31 August 2009

Group Talk #1

PhD: Planetary Hovercraft Design



PhD: Project History & Development

- ARC started work on the Modular Common Bus (MCB) in early 2007
- Key motivations:
  - Either orbiter or lander
  - Mission lifecycle < 2 years, $100 million
  - Enable more science and workforce development via increased mission frequency
  - Stay small enough to launch on a Minatour V or, possibly, a Falcon 1/1E
  - Utilize COTS or DOD hardware to keep new hardware development, hence costs, down

http://www.iafastro.org/iac/archive/browse/IAC-07/B4./2./7065/

PhD: MicroLunar Lander

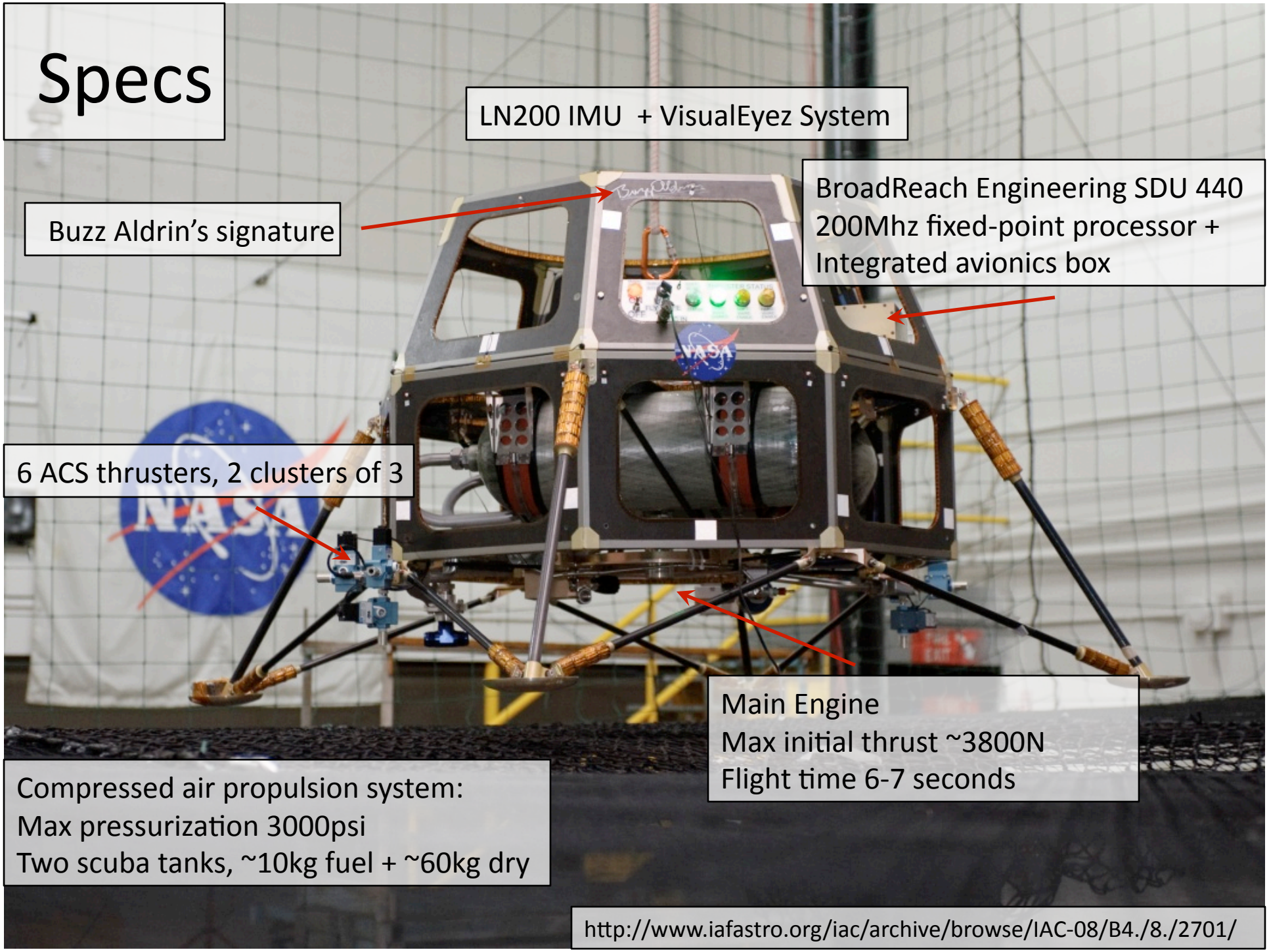
- Design Case: Lunar Lander between 60-135kg landed mass
- Leverage from
  - XSS-11: avionics system and software methodology
  - Kinetic Kill Vehicle (missile defense interceptor) high thrust-to-weight propulsion system
  - DSMAC system modified for lunar landing

Falcon 1 Stack

PhD: Prototype HarDware

- Design philosophy favors integration early in the design process, spiral design, with several iterations as opposed to a traditional waterfall approach
- HTV was developed as a testbed for:
  - Composite structure manufacture and assembly
  - Landing leg assembly
  - Coldgas propulsion system
  - Avionics integration
  - Software development

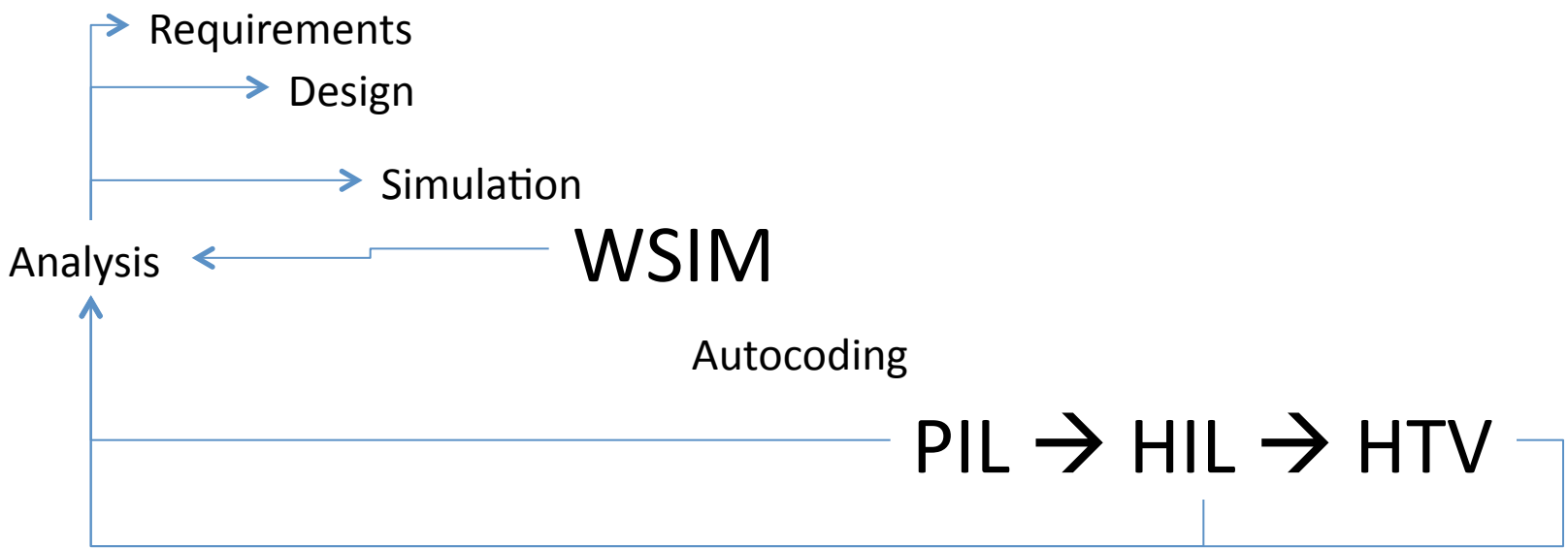
Specs



http://www.iafastro.org/iac/archive/browse/IAC-08/B4./8./2701/

Software Process

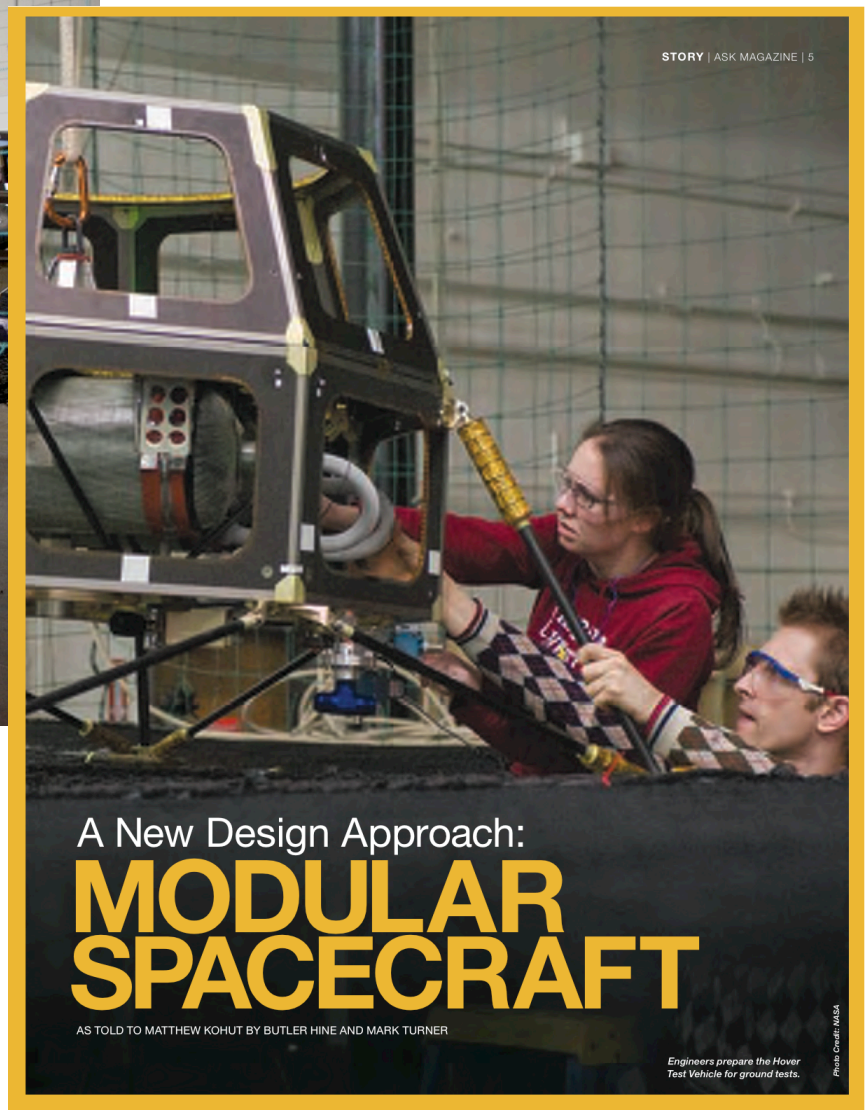
- Model-based design
  - Graphical programming language → compiled C-code via autocoding
- Original development done in SystemBuild
  - Later switched to Simulink



Sweet Movies

On YouTube under “NASA's Micro Lunar Lander Hover Test”

We’re popular on the tour circuit….



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A New Design Approach:

MODULAR SPACECRAFT

AS TOLD TO MATTHEW KOHUT BY BUTLER HINE AND MARK TURNER

Engineers prepare the Hover Test Vehicle for ground tests.

Photo Credit: NASA

Aviation Week: 5 Jan 2009

Discount Space

Ames is developing a low-cost, common multimission spacecraft

MICHAEL MECHAM/MOFFETT FIELD, CALIF.

When NASA Ames Research Center and Northrop Grumman won the right to build a low-cost penetrator for studying the Moon's surface composition, they worked on a tight schedule. They had just six months to build and test the instruments and a mission budget cap of $79 million.

That's a pittance compared with many space programs. Yet with borrowed technology and adaptive techniques, the team's Lunar Crater Observation and Sensing Satellite kept to its cost and deadline schedule. LCross is set for launch in April with the Lunar Reconnaissance Observer (LRO) mission.

Ames Director Brig. Gen. (ret.) S. Pete Worden—who headed the Air Force Space Command's fast-paced Responsive Space Program and was part of its 1994 Clementine smallsat lunar mapping mission—helped Ames win LCross. He has his sights set on developing common low-cost platforms that can carry sensors for missions to the Moon, asteroids or elsewhere. When he became Ames's director in April 2006, Worden asked the center's satellite design team to develop a modular system called the Common Spacecraft Bus for orbiters or landers.

"This would be different from LCross," says team member Chris Boshwizen. "[And] cheaper—the spacecraft, payload launch, operations and science [all] for less than $50 mi

Ideas are flowing on how common spacecraft might fulfi missions, particularly for the Lunar Science Institute mar Ames and for the International Lunar Network headquar Marshall Space Flight Center in Huntsville, Ala.

On the private space front, Odyssey Moon Ventu tap the Common Spacecraft Bus team for technolo pursues the $30-million Google Lunar X-Prize (*AW&S* 2008, p. 22).

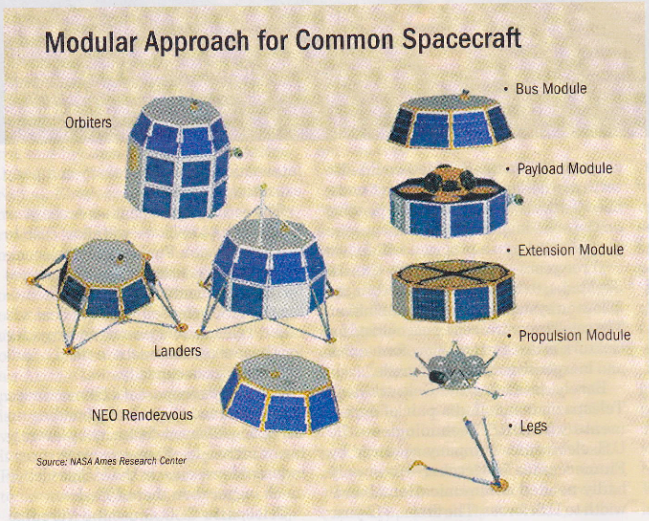
The 12-member spacecraft development team began its first prototype, the Hover Test Vehicle (HTV), last ber. This took just eight months from final design to a Insect metaphors pepper the team's jargon. With its fi attached, the octagonal-shaped aluminum/composite bus might be loaded in the payload fairing with its legs toward the rocket. That's the "live bug" configuration it would look like a beetle viewed from the top. Or it loaded with the bus's back on the bottom and the legs up—a "dead bug" configuration. Dead bugs would ha flipped over for a safe landing.

The 68-kg. (150-lb.) HTV went development in a co paint hangar here. It is fur der Marshall's Lunar Net fort, which aims to acceler tinational Moon operations the cooperation of NASA, I seven space-faring nations Mar. 17, 2008, p. 56).

During an *Aviation Week Technology* visit, Ames's H was testing the spacecraft' software to assure an initial ing on the Moon and then allo hicle to move—hop, actually the surface.

Encased in a safety net, t type carried two standard filled with air compressed to to simulate a lunar lander's lant propulsion system.

The compressed air



In its Common Spacecraft B Ames stacks modular sections low-cost orbiters or landers.

through a single main nozzle and four smaller side-mounted stability nozzles. Other test elements gave evidence of a scrounger mentality in keeping with a low-cost space program. An air bag sensor from a BMW was employed for motion sensing. On the spacecraft's sides, LED lights were read by overhead cameras that were linked to the HTV's controller so its location could be tracked to within a millionth of an inch.

The compressed gas fired with an ear-piercing bang and the vehicle shot off its launch pad. The control algorithms, based on the Mathworks Matlab programming language, were a work in progress. But Alan Weston, Ames's chief of spacecraft design, expects the HTV will be ready to ship to Marshall early this year for a series of Lunar Network tests.

The ground test control box from Broadreach Engineering of Golden, Colo., is derived from the Air Force Research Laboratory's Experimental Satellite System-11 (XSS-11) micro-satellite program built by Lockheed Martin Astronautics. And the hover test article's thrusters and inertial measurement unit come from those developed by Northrop Grumman for the XSS-11.

The first application for the common spacecraft is likely to be Ames's Lunar Atmosphere and Dust Environment Explorer (Ladee) mission, which is set for launch in 2011.

Depending on mission requirements, the common bus is envisioned as a combination of modules. Simple missions might use a "featherweight" 50-kg. payload module. The addition of a second module on top creates the "small" version, with a weight up to 130 kg. Adding an extension ring to the bottom of the main payload module creates the "large" orbiter and would weigh 150-200 kg. Ladee will use the full orbiter configuration.

The basic concept envisions power flowing from body-fixed solar arrays. But the larger orbiter could carry folding panels.

The space-qualified propulsion system will be a standard bipropellant with a dry mass of just 7 kg., says Boshwizen.

Launch possibilities vary. A Minotaur 5-class vehicle would serve government customers well. The extended version of Falcon-1, proposed by Space-X, could work for civil payloads, although the company isn't focused on that vehicle currently.

The plug-and-play approach of the Common Spacecraft Bus lends itself to NASA Class D missions. They are the agency's most risk-tolerant, exactly the atmosphere that LCross was developed under and one that is aligned with the Defense Dept.'s Operational Response Spacecraft initiative.

Such low-cost, quick-response spacecraft lend themselves to NASA's Small Explorer Program to tackle asteroid rendezvous, lunar atmosphere studies and other robotic endeavors where quick reaction and low-cost make the whole thing possible. Weston expects Ames will partner with the Goddard Space Flight Center on most of them. And it will team with major contractors such as it did with Northrop Grumman on LCross.

"The contractor has the infrastructure," he says. "We don't. But we can design the mission. I see the [concept] catching on, slowly but surely."

Odyssey Moon Ventures will tap into the Common Spacecraft Bus as it pursues the Google Lunar X-Prize.

NASA AMES RESEARCH CENTER

Aviation Week: 5 Jan 2009

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MICHAEL MECHAM/M

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Modular Ap

Orbiters

Landers

NEO Rendezvous

Propulsion Module

Legs

Source: NASA Ames Research Center

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Recent Activity

- Focus on IMU-only flights
- Future plans hope to transition to drop-testing and incorporation of cameras onto vehicle