National Aeronautics and Space Administration

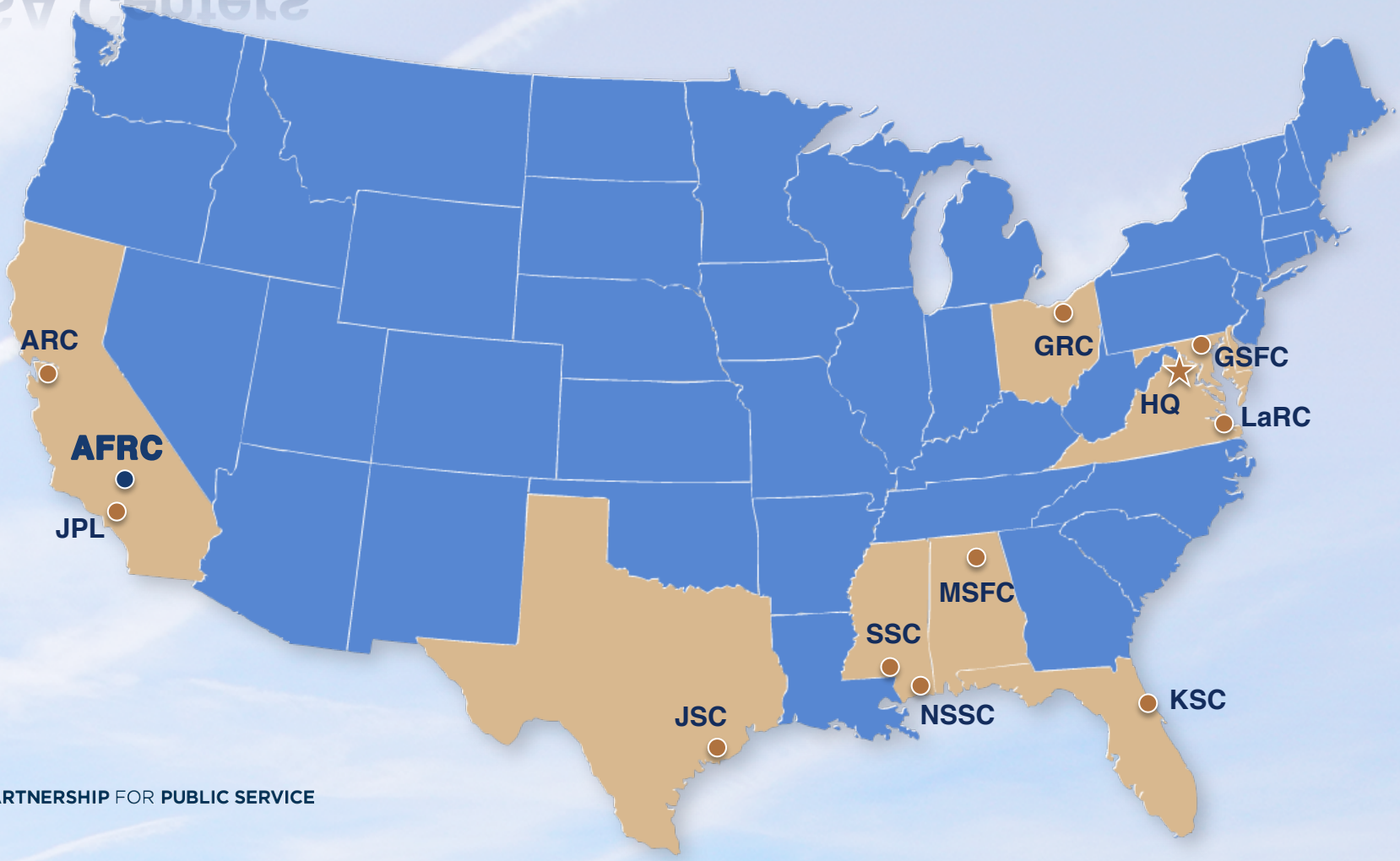
Fiscal Year 2016 Budget Overview

NASA Armstrong Flight Research Center

David McBride, Director

February 2, 2015

NASA Centers



PARTNERSHIP FOR PUBLIC SERVICE

THE BEST PLACES TO WORK in the Federal Government®

NASA rated #1 Large Agency three years running!

Armstrong Flight Research Center rated #27 of 315 Agency Subcomponents!

Fiscal Year (FY) 2015 Budget

NASA

~$18 billion budget

17,000 civil servants

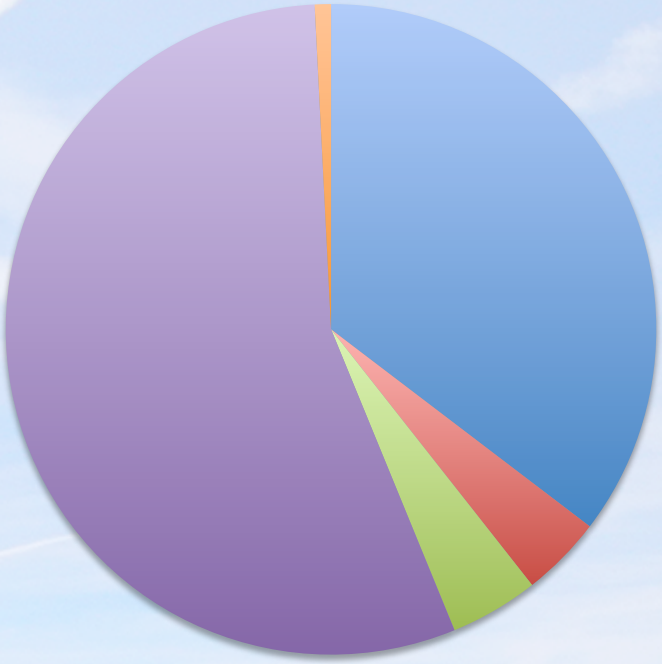
40,000 contractors

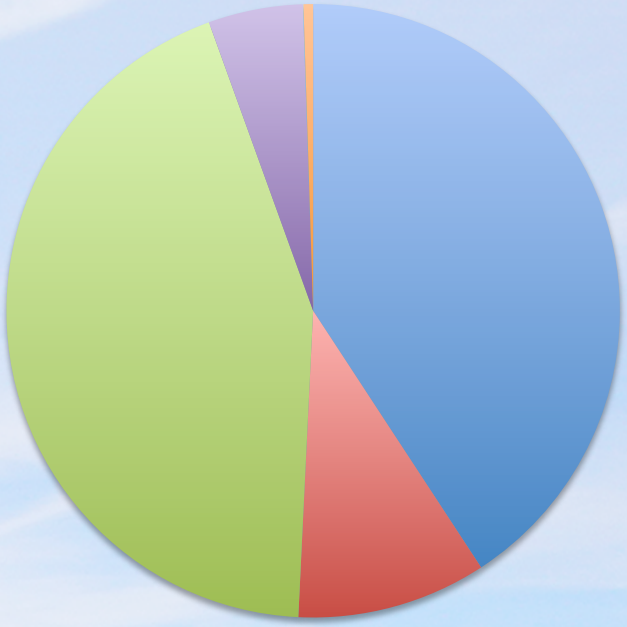
Armstrong

~$248 million budget

550 civil servants

600 contractors





Source: FY2015 Omnibus Appropriation

Fiscal Year (FY) 2016 Budget

NASA

~$18.5 billion budget

17,000 civil servants

40,000 contractors

Armstrong

~$230million budget

550 civil servants

600 contractors

Armstrong Mission

Advancing Technology and Science Through Flight

1. Perform flight research and technology integration to revolutionize aviation and pioneer aerospace technology

2. Validate space exploration concepts

3. Conduct airborne remote sensing and science observations

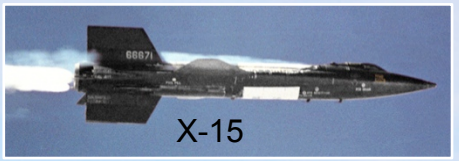
Ikhana MQ-9 Predator B
Unmanned Aircraft System

Stratospheric
Observatory for
Infrared Astronomy
(SOFIA)

X-56 Multi-Utility
Technology Testbed

Armstrong Vision

To Separate the Real from the Imagined Through Flight



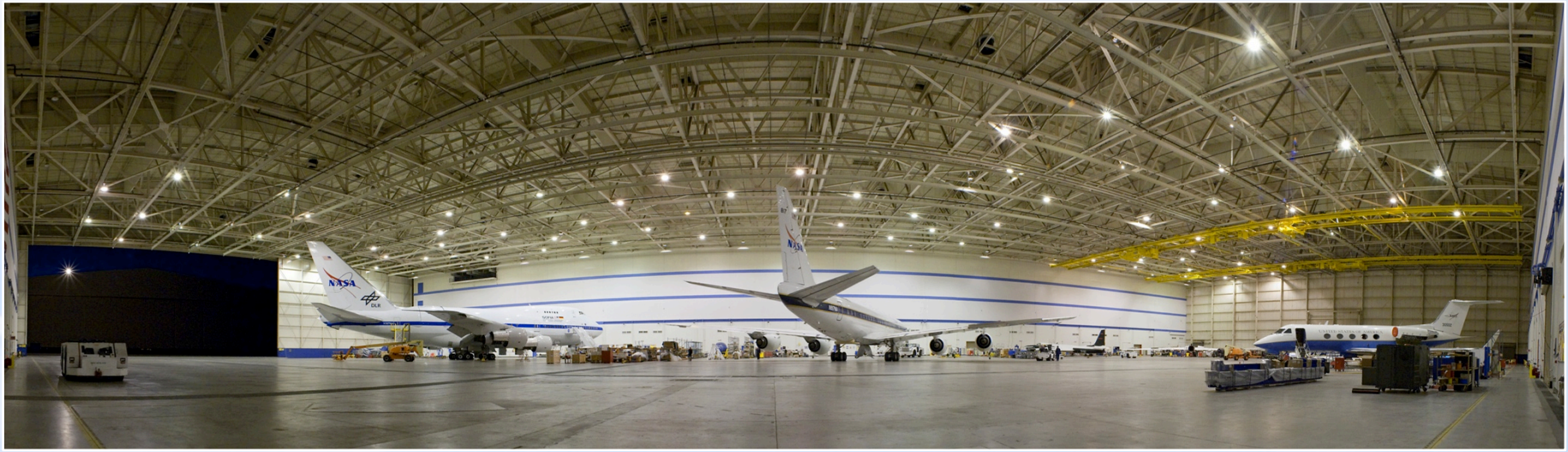
Armstrong Flight Research Center

Edwards AFB, California, main campus:

- Year-round flying weather
- 301,000 acres remote area
- Varied topography
- 350 testable days per year
- Extensive range airspace
- 29,000 feet of concrete runways
- 68 miles of lakebed runways
- Supersonic corridor
- U.S. Air Force Alliance

NASA Armstrong Building 703

Palmdale, California



- U.S. Air Force Production Flight Test Installation (Plant 42)
- Palmdale Site 9 Complex
  - Access to USAF Plant Armstrong Flight Research Center
  - 422,000-square-foot floor space, including 210,000 square feet in central hangar area
  - Home to Stratospheric Observatory for Infrared Astronomy (SOFIA) and airborne science platform aircraft

National Aeronautics and Space Administration

NASA

REACH
NEW
HEIGHTS

BENEFIT
ALL
HUMANKIND

REVEAL
THE
UNKNOWN

Why NASA? … Why Armstrong?

Journey of Discovery

Answering questions about our home planet and life beyond.

Unraveling mysteries that intrigue us as we explore answers to these big questions:

- How did the universe begin and evolve? What will be its destiny?
- Are we alone?
- How did our solar system originate and change over time?
- How and why are Earth's climate and environment changing?
  - Is life sustainable for us on Earth?
  - How is the Global Earth system changing?
  - How will the Earth system change in the future?
- Can we live on another planet?
  - Can we expand human presence to the Solar System and to the surface of Mars?
  - Do we have the required technology?
- Can we continue our national leadership in Aeronautics and Aerospace?
  - Why is aviation so important?
  - What are the challenges?

‘Aeronautics’ the First ‘A’ in NASA

Nation’s Early Aeronautics Research Led to Creation of NASA

7,500 NACA employees

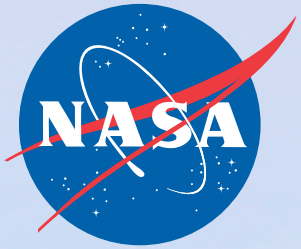
$300 million in NACA research facilities

(Langley, Lewis, Ames, High Speed Flight Station)

NACA research process

National Advisory Committee
for Aeronautics

March 3, 1915



National Aeronautics and
Space Administration

October 1, 1958

NASA
1915-2015

100 Years of Aeronautics Research!

Aeronautics

NASA is With You When You Fly

Ensure the right balance among physics-based analysis, simulation, ground testing, and flight research.

Why is Aviation So Important?

The air transportation system is critical to U.S. economic vitality

$1.5 TRILLION

TOTAL U.S. ECONOMIC ACTIVITY
(civil and general aviation, 2012)

17.7 BILLION

TONS OF FREIGHT TRANSPORTED BY AIR
(All U.S. carriers, 2013)

$76.1 BILLION

POSITIVE TRADE BALANCE
(civil aviation, 2012)

$670.8 BILLION

SPENT BY AIR TRAVELERS IN U.S. ECONOMY
(Foreign and domestic travelers, 2012)

11.5 MILLION

DIRECT AND INDIRECT JOBS
(civil and general aviation, 2012)

741 MILLION

PASSENGERS ON U.S. CARRIERS
(Domestic and international, 2013)

5.4%

OF TOTAL U.S. GROSS DOMESTIC PRODUCT (GDP)
(civil and general aviation, 2012)

What Are the Challenges?

Challenges are driven by emerging global trends

16 BILLION

GALLONS OF JET FUEL BURNED IN 2013
(U.S. Airlines)

360 MILLION

PASSENGERS BEING ADDED IN
ASIA PACIFIC FROM 2009 TO 2014

(market is growing and moving East)

$8.1 BILLION

COST OF DELAYS TO U.S. AIRLINES IN 2013

$9.3 BILLION

SPENT BY AIRPORTS ON NOISE
ABATEMENT SINCE 1982

3%

OF GLOBAL CO_2

AND

5%

WARMING EFFECTS PROJECTED FROM AVIATION BY 2050

NASA is With You When You Fly

Every U.S. aircraft and U.S. air traffic control tower has NASA-developed technology on board.

NASA Armstrong is committed to transforming aviation by

- Dramatically reducing its environmental impact
- Maintaining safety in more crowded skies
- Paving the way to revolutionary aircraft shapes and propulsion

Six Aeronautics Research Strategic Thrusts

What Led to This Strategic Direction?

The World Wants to Travel More …

1. Safe, Efficient Growth in Global Operations

2. Innovation in Commercial Supersonic Aircraft

While Being Fuel Efficient and Reducing Environmental Impacts …

3. Ultra-Efficient Commercial Vehicles

4. Transition to Low-Carbon Propulsion

And Taking Advantage of the New Technologies

5. Real-Time System-Wide Safety Assurance

6. Assured Autonomy for Aviation Transformation

What is NASA Aeronautics Working On?

Research Activities Reflect NASA's Vision to Ultimately Transform Aviation

- Air traffic management tools to reduce delays and save fuel
- Aircraft shapes that reduce aviation's impact on the environment
- Data that reveals the real impacts of alternative jet fuels
- Tests of new technologies that increase autonomy in the aviation system
- Technologies that lower the effects of sonic booms
- Ground tests on ways to detect and prevent engine icing in jet engines

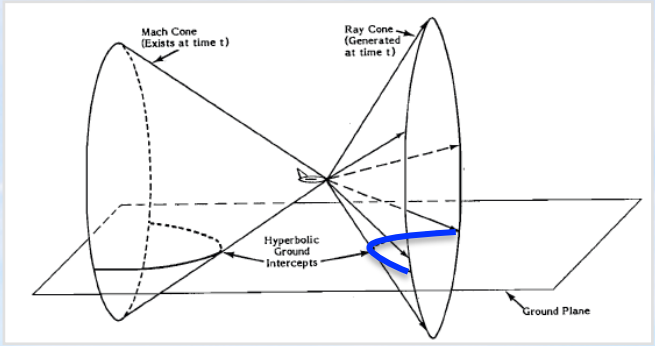
Innovation in Commercial Supersonic Aircraft

Understand how people react to various sonic-boom noise levels

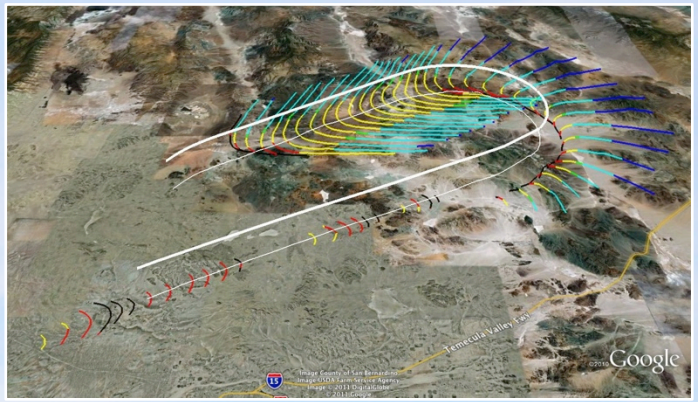
Flight research on the F-15 and F-18 aircrafts to understand sonic booms and how to make over-land supersonic flight possible

Low boom supersonic aircraft

F/A-18



Sonic-boom generated Ray Cone



Sonic boom prediction display

Ultra-Efficient Commercial Vehicles

Pioneer technologies for leaps in fuel efficiency, reducing environmental impact

Testing lightweight structures, new wing concepts, and new electric engine technologies

X-48B
Blended Wing
Body

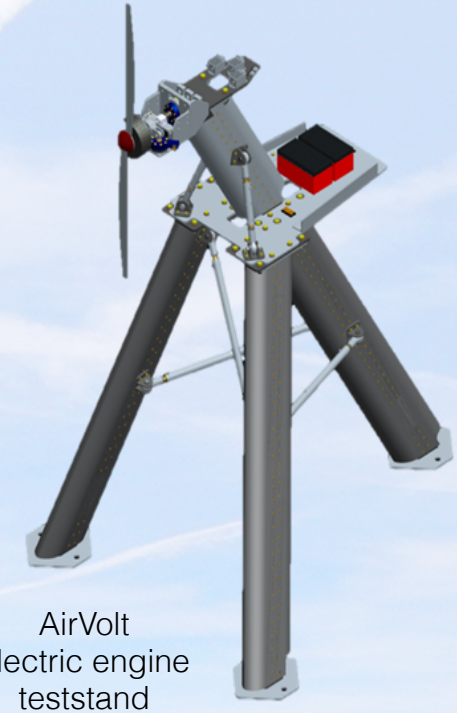
X-56A Multi-Utility
Technology
Testbed

Gulfstream III Adaptive
Compliant Trailing Edge Flap

Ultra-Efficient Commercial Vehicles

Pioneer technologies for leaps in fuel efficiency, reducing environmental impact

Testing lightweight structures, new wing concepts, and new electric engine technologies



AirVolt electric engine teststand

Leading Edge Asynchronous Propeller Technology (LEAPTech)

Transition to Low-Carbon Propulsion

Characterize low-sulfur fuels to understand its environmental benefits

Successful flight testing of a new low-sulfur fuel on the DC-8 in 2014

HU-25 Falcon from NASA's Langley Research Center joins up with NASA's DC-8 during ACCESS II flight tests.

Real-Time System-Wide Safety Assurance

Develop aircraft systems that detect, display problems before safety is affected

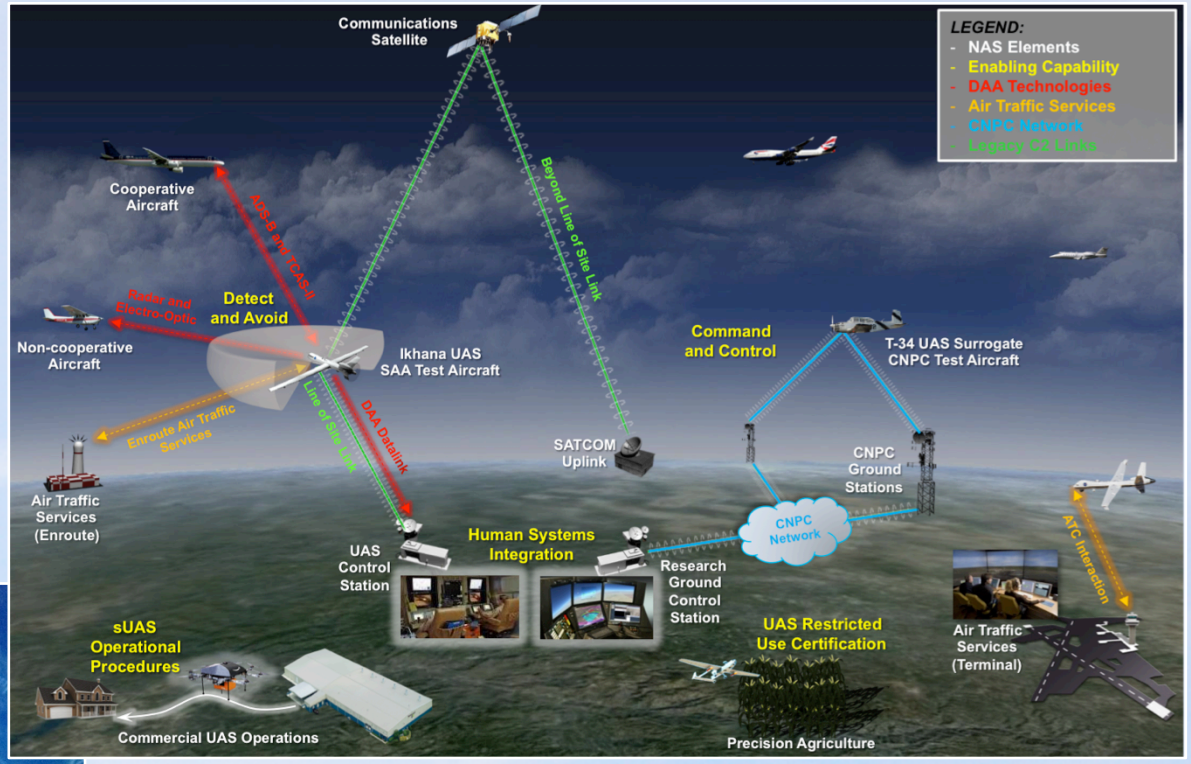
Steps taken to conduct ground engine testing in 2015 on the C-17 aircraft to monitor affects of volcanic ash using new health monitoring sensors

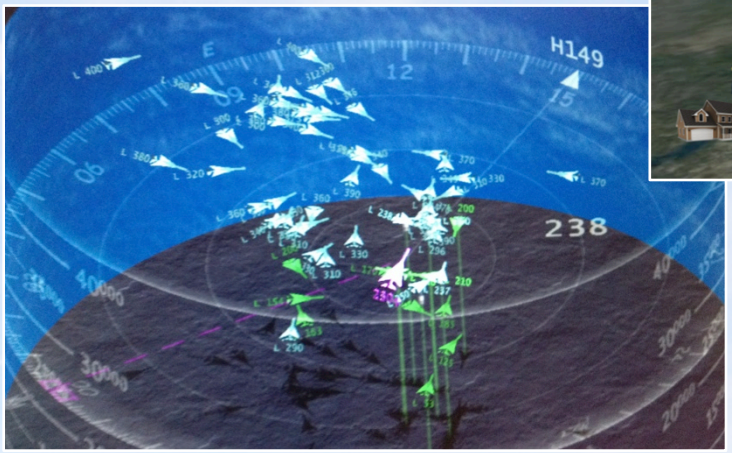
A U.S. Air Force C-17 is used for Vehicle Integrated Propulsion Research (VIPR) testing.

Assured Autonomy for Aviation Transformation

Develop autonomous systems in harmony with humans and reap benefits of flight

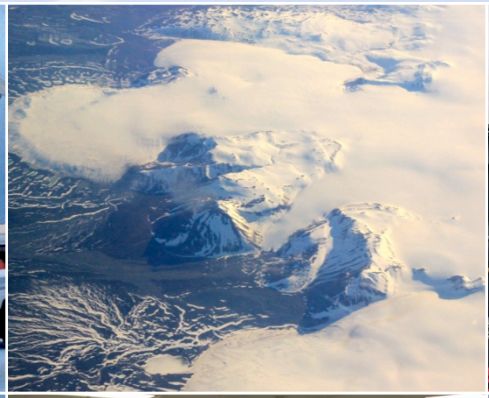
Developing practices, procedures, and information to use unmanned aircraft systems in the National Airspace alongside commercial airlines and also closer to the ground





Earth Right Now

Your Planet is Changing. We're On It.





Your Planet is Changing. We're On It.

From land, air, and space, NASA monitors Earth's vital signs all over the globe.

NASA's research yields many benefits, including

- Improved environmental prediction
- Natural hazard and climate change preparedness

NASA Earth Science

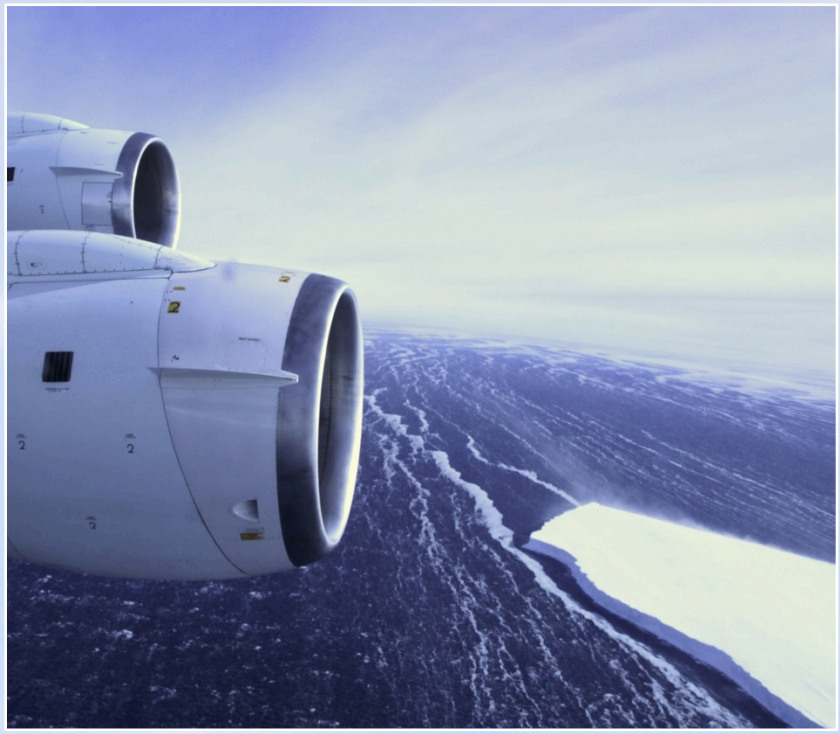
Focus areas and NASA Armstrong's role

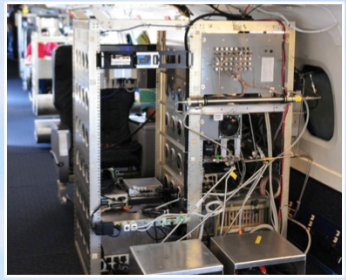
Airborne Science Program focuses on

1. Weather
2. Climate change and variability
3. Earth surface and interior
4. Water and energy cycle
5. Carbon cycle and ecosystems
6. Atmospheric composition

Armstrong's role is

1. Obtain high-resolution measurements
2. Support new space-based sensor development
3. Satellite calibration and validation
4. Develop next-generation earth scientists and engineers



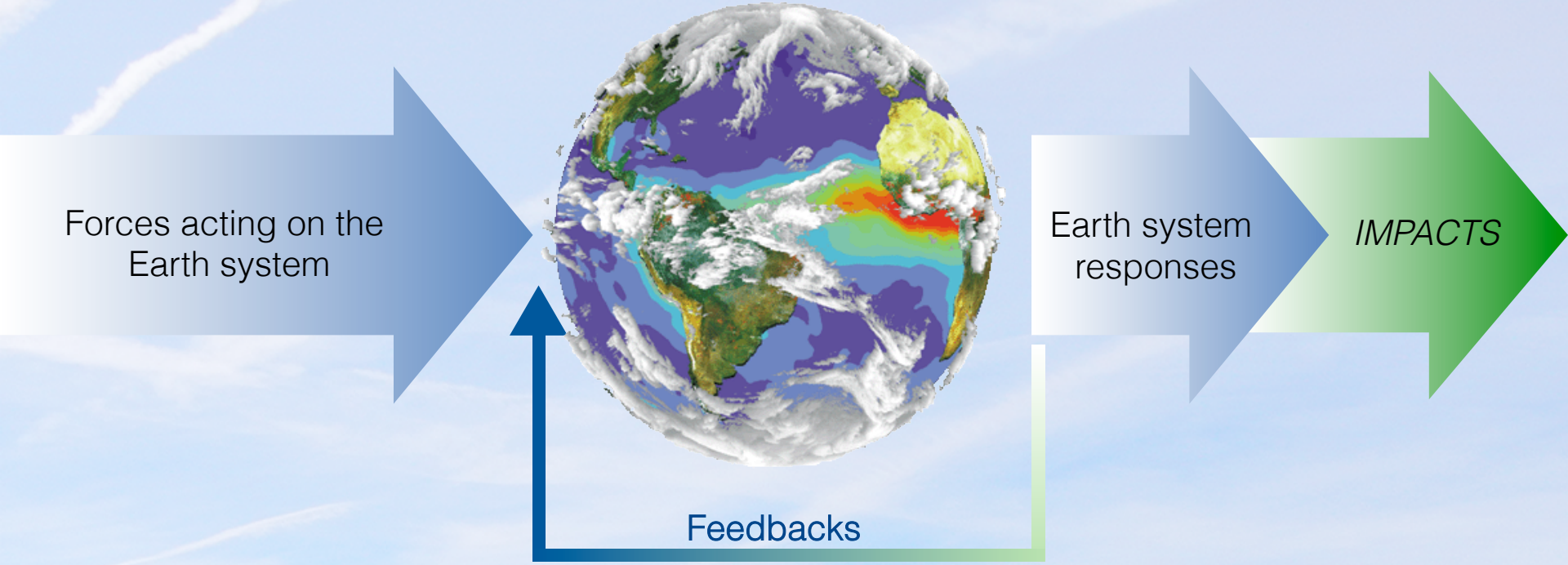


NASA Earth Science

Earth as a dynamic system

How is the Global Earth System changing?

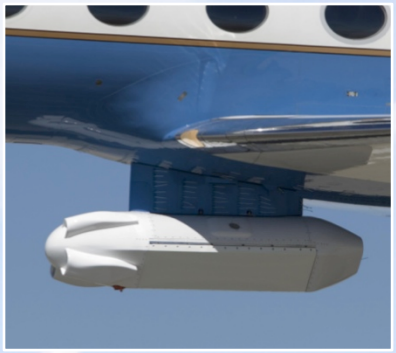
How will the Earth System change in the future?



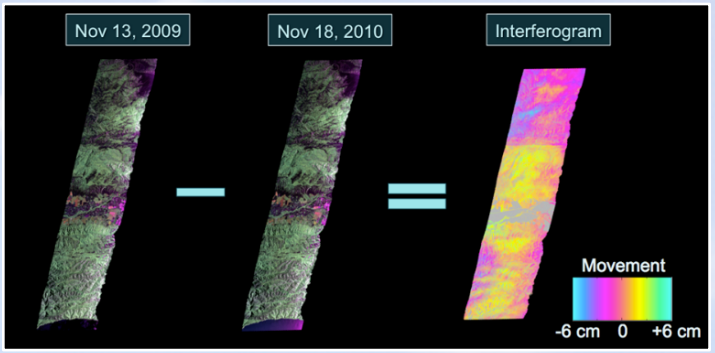
Not just 'What's Happening, but why it's happening'

Satellite Development and Global Earth Studies

Understanding Earth's systems, global climate change



UAVSAR pod under NASA's Gulfstream III



UAVSAR images of San Andreas fault

Uninhabited Aerial Vehicle Synthetic Aperture Radar

Joint venture with Jet Propulsion Lab using an airborne radar to study earth science with emergency response potential

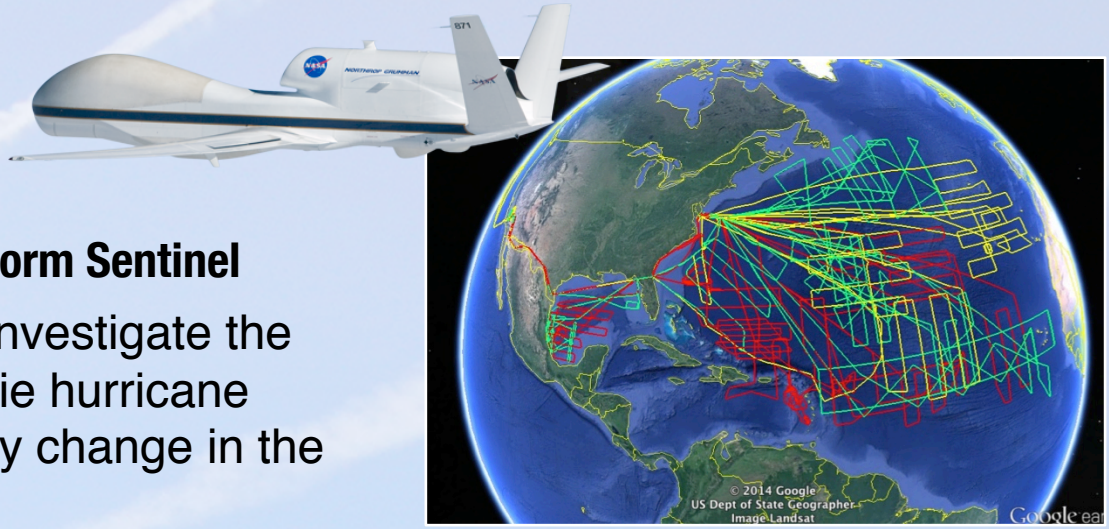
Student Airborne Research Program

32 undergraduates participated in the 2014 program, which provides experience in every aspect of a science mission, from upload of sensors to collecting science data

Students participate in NASA's 2014 Student Airborne Research Program.

Satellite Development and Global Earth Studies

Developing tools to enhance predictions of weather and climate



NASA Global Hawk's Hurricane and Severe Storm Sentinel mission flight paths.

Hurricane and Severe Storm Sentinel

Five-year mission to investigate the processes that underlie hurricane formation and intensity change in the Atlantic Ocean basin

Sea ice is seen from NASA's DC-8 flying science laboratory during a low-level flyover of the Weddell Sea off Antarctica.

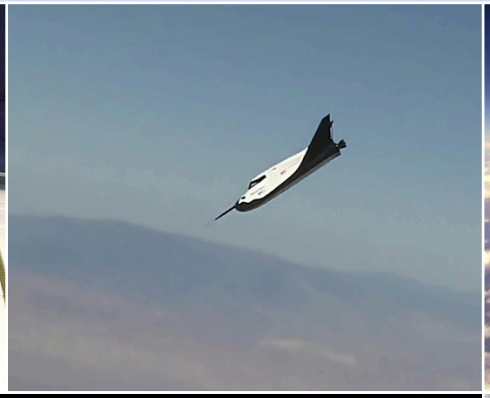
Operation IceBridge

Six-year field campaign, the largest airborne survey of Earth's polar ice

Human Exploration

NASA's Journey to Mars








NASA's Journey to Mars

Answering fundamental questions about life beyond Earth.

This endeavor will improve lives on Earth by advancing

- Scientific discovery
- New technologies
- Economic opportunities
- U.S. leadership in the peaceful, international exploration of Space

Space Launch System and Orion Flight Test

PA-1
May 6, 2010
Launch

Boilerplate Orion-MPCV Crew Module. Launch Abort System Pad Abort test.

EFT-1
December 5, 2014
Launch

Orion-MPCV Crew Module Delta IV Heavy Launch Vehicle. Beyond LEO, high-speed reentry.

EM-1
September 2018
Launch

70 MT SLS Orion-MPCV unmanned Moon fly-by.

AA-2
December 2019
Launch

EFT-1 Orion-MPCV Crew Module re-flown on Abort Test Booster. Launch Abort System Ascent Abort test.

EM-2
December 2020
Launch

70 MT SLS Orion-MPCV manned Moon orbital mission.

Exploring Mars

Developing technologies and new capabilities to enable human exploration

NASA Armstrong's F/A-18A Full Scale Advanced Systems Testbed aircraft pitches up during a Launch Vehicle Adaptive Control validation flight.

Launch Vehicle Adaptive Control

Adding ability for an autonomous flight computer system to retune itself while it's flying the rocket

Orion Launch Abort Test

Providing emergency crew escape functions during launch

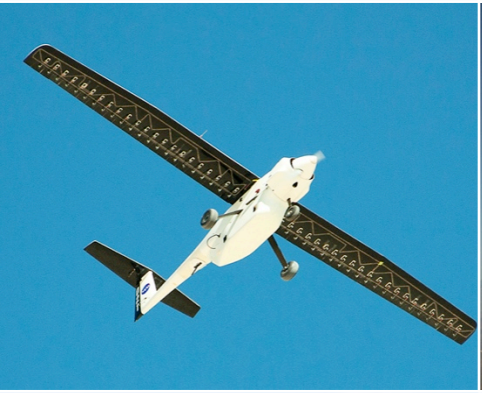
Orion PA-1 Launch Abort System

Technology

Technology Drives Exploration








Technology Drives Exploration

NASA delivers innovative solutions that dramatically improve the agency's capabilities while supporting the innovation economy.

These solutions generate tangible benefits that create jobs, earn revenue, and save lives.

Exploring Mars

Enabling commercial cargo and crew

Flight Opportunities

Low-cost access to suborbital space for science research payloads

Masten's rocket-powered Xombie technology demonstration vehicle rockets skyward during a flight test of Astrobotic Technology's autonomous landing system.

Providing Benefits Around the World

Saving lives, creating jobs, preserving resources, and more

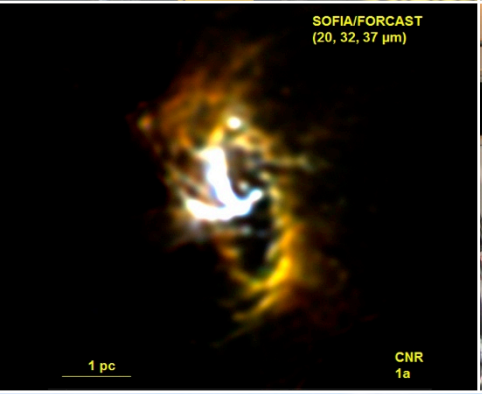
Tow Glider Air-Launch Concept

Efficient way of launching a payload from a towed glider into orbit

Towed Glider Air-Launch Concept

Solar System and Beyond

Journey of Discovery



Infrared Astronomy Above the Clouds

Making discoveries about our solar system and the universe

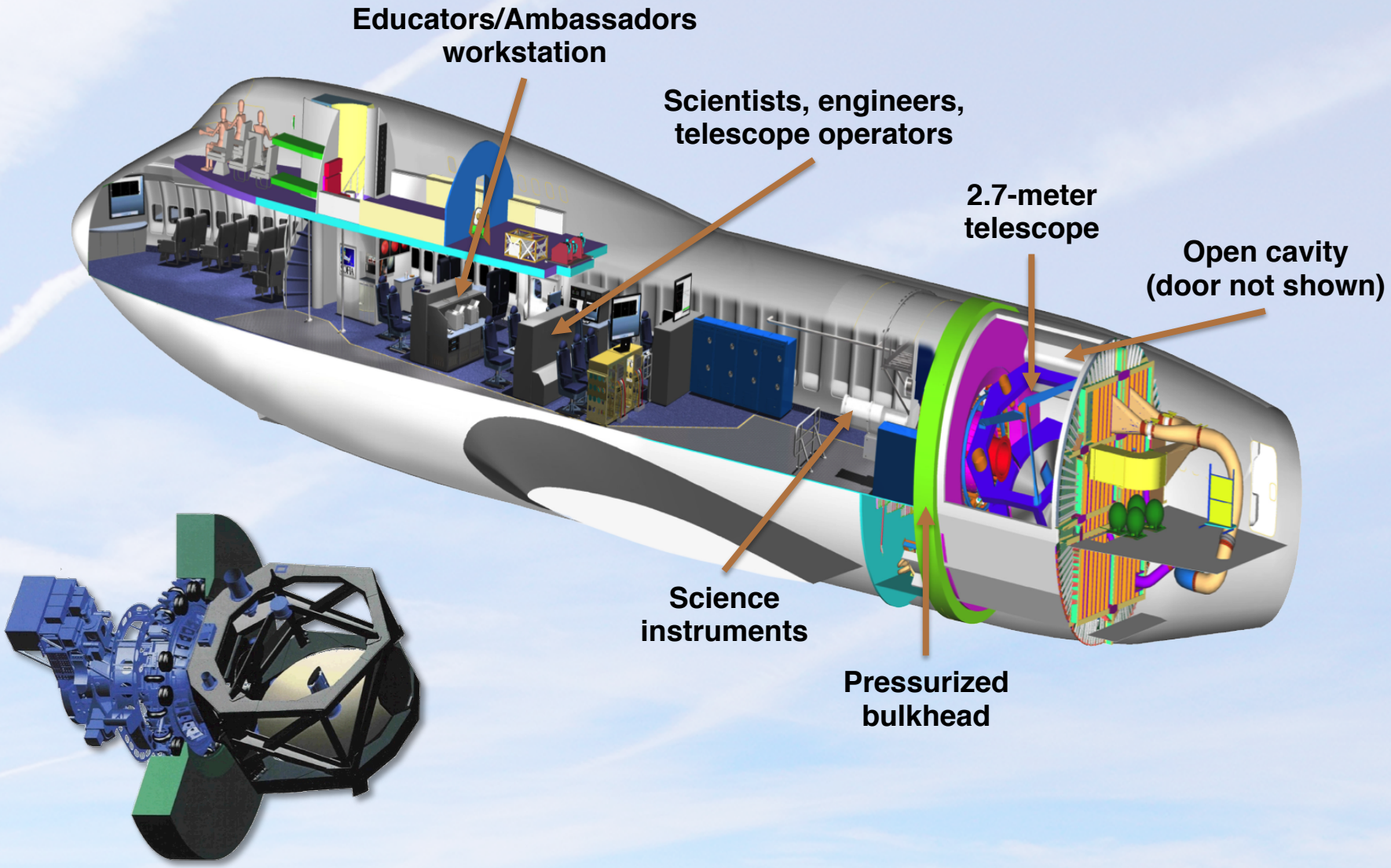
Stratospheric Observatory for Infrared Astronomy (SOFIA)

World's largest flying observatory features a 100-inch primary mirror and telescope that weighs 37,500 pounds. Missions fly above 99% of the Earth's water vapor, which blocks much of the infrared radiation.

SOFIA

SOFIA Platform Layout

Boeing 747-SP



SOFIA Scientific Areas of Interest

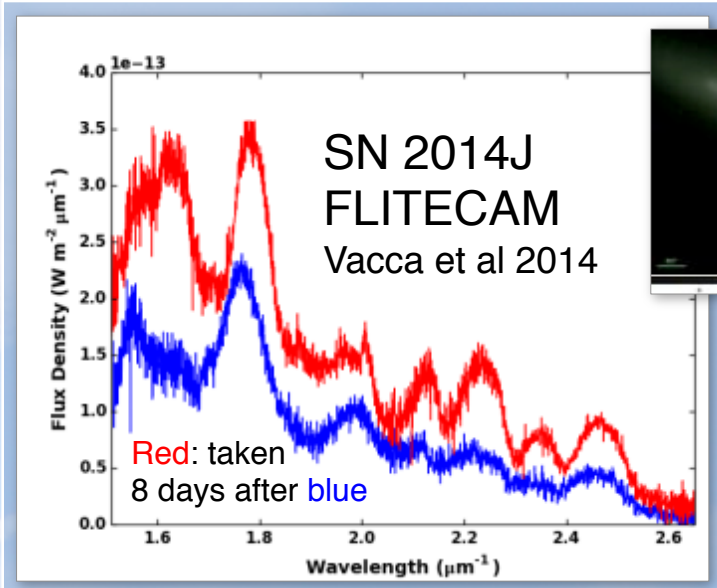
Galaxies and the Galactic Center

Interstellar Medium of the Milky Way

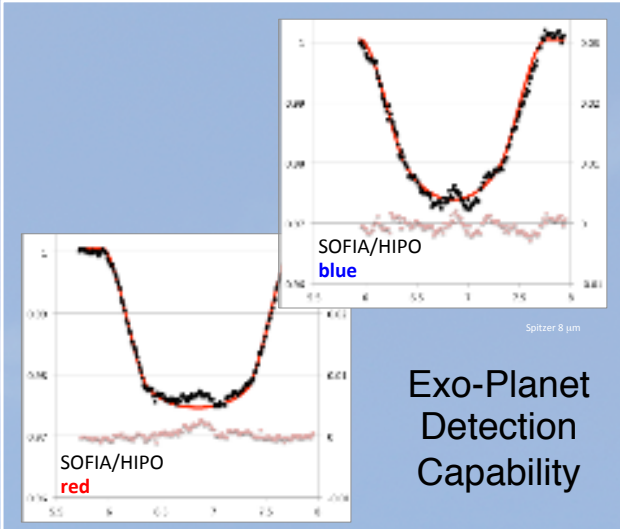
Formation of Stars and Planets

Planetary Science

2014: Start of Operations Phase and Cycle 2 Science

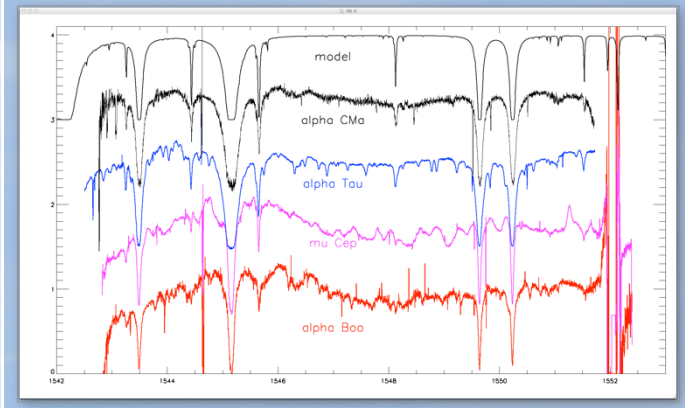


- Supernova Observation.
- Continuous wavelength coverage, spanning regions inaccessible from ground!
- Strong evolving features

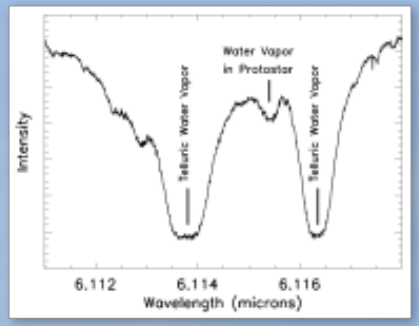


Exo-Planet Detection Capability

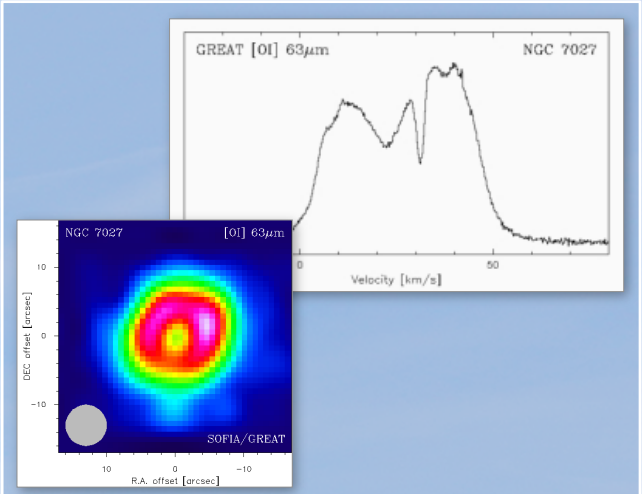
Stellar spectra



Water in protostar



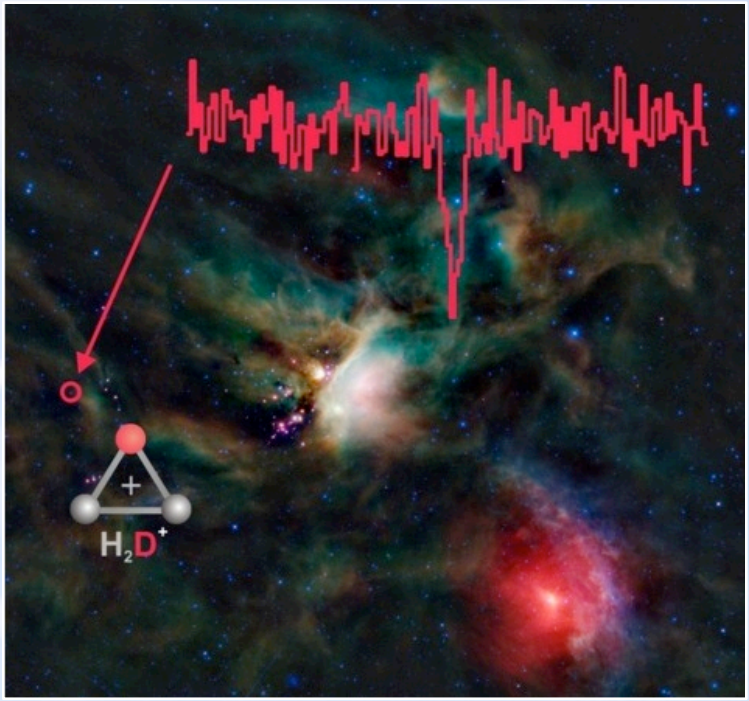
SOFIA/EXES: Unprecedented mid-IR resolution!



SOFIA/GREAT: Newly commissioned H-channel [OI] 63μm map

SOFIA Southern Hemisphere Deployment Science Snapshot

First detection of para-H_2D^+ toward an embedded low-mass Protostar



Red spectral line:
para-H2D+ (1.370 THz, 219 μm)

Circle:
position of continuum source IRAS 16293-2422 A/B

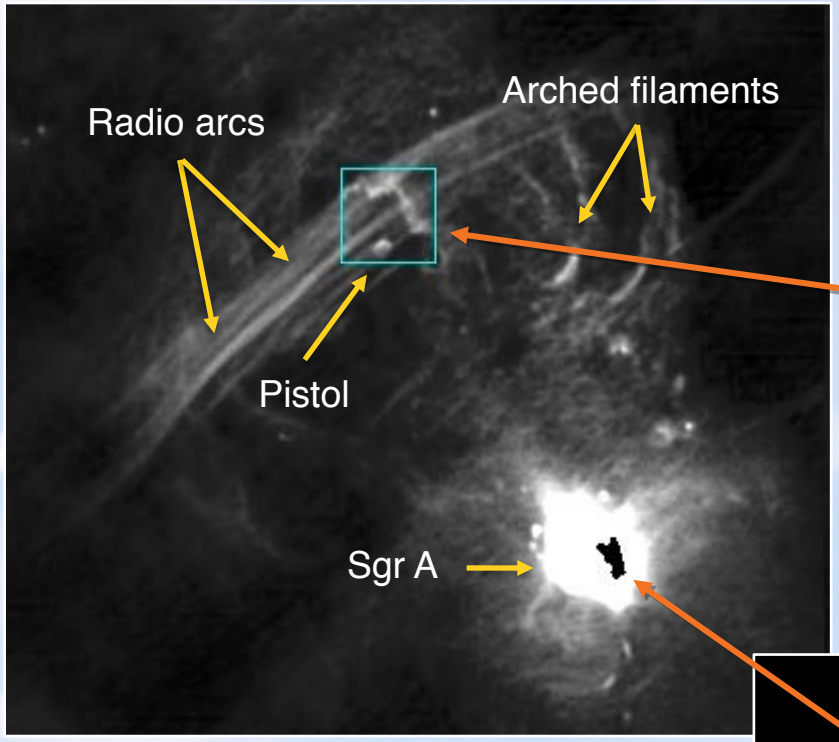
Summary:

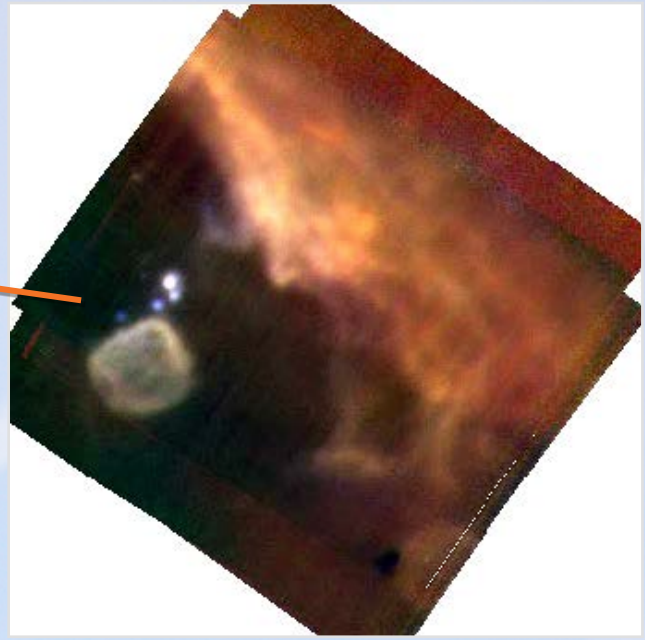
- Interstellar deuterated para- triatomic hydrogen (H2D+) has been detected for the first time by SOFIA/GREAT
- The detection of this absorption line measures the physical conditions of the local environment of a binary protostar system.

Details:

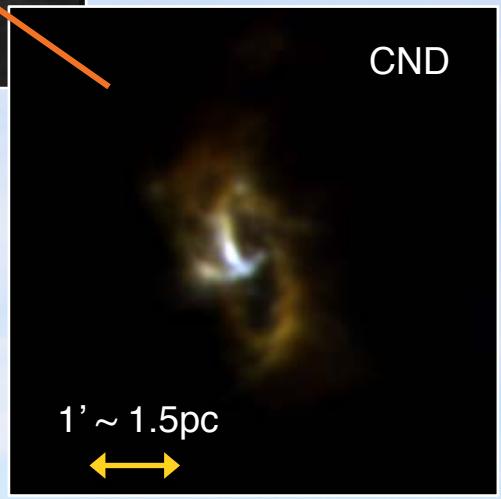
- At the low temperatures found in star forming molecular clouds, deuterium-containing molecules such as H2D+ are formed more readily than in other environments.
- Such deuterated molecules are therefore one of only a few spectros-copic probes of early stages of star formation
- H2D+ exists in two different forms, depending on its nuclear spin state, called ortho and para.
  - › Before this para observation, only the ortho form had been observable (via ground-based telescopes).
  - › Earth's atmosphere is opaque at spectral line wavelengths of para-H2D+

Science Results: Galactic Center (FORCAST)





19.7 mm (blue)
31.5 mm (green)
37.1 mm (red)

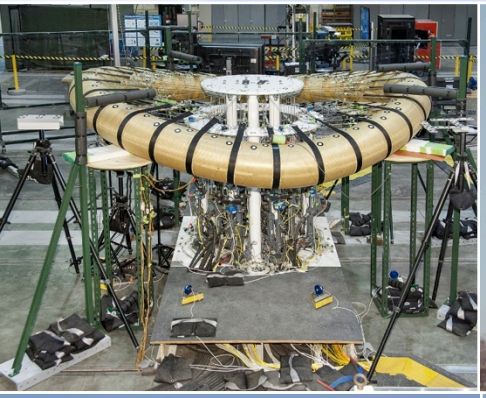


ABOVE: Radio image showing the bright radio source, Sgr A*, which coincides with the super-massive Black Hole at the center of the galaxy. RIGHT: CircumNuclear Disk (CND) that feeds material onto the central parsec.

ABOVE: The Pistol star, possibly the most luminous star in our galaxy! The bubble surrounding it is a result of mass loss from the star.

Courtesy: T. Herter

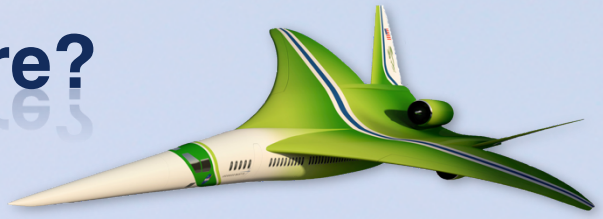
Armstrong Test Infrastructure

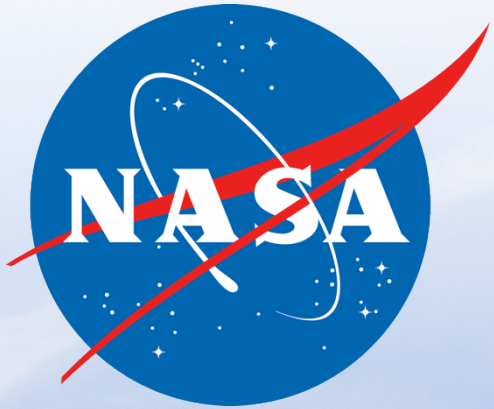






Where Are We Going in the Future?

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