National Aeronautics and Space Administration

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# SPACE LAUNCH SYSTEM

**Princeton, Minnesota**
**April 30 – May 4**

# Princeton Public Schools: NASA Outreach Event

**Anthony M. DeStefano**

# Princeton, MN Outreach Tentative Schedule

| Tentative Schedule - Talked to Anthony - Tried to fill in blanks - Email Samantha Heitke with questions/thoughts | | | | | | |
|---|---|---|---|---|---|---|
| **Date** | **Day** | **Time** | **Student Group** | **Location** | **Teacher** | **Presentation** |
| 4.30.18 | Monday | 7:50-2:50 | Advanced Algebra/Geometry + Other HS Students | PAC | Levering, Clark, Moehlmann +? | Assembly |
| | | | | | | |
| 5.1.18 | Tuesday | 8:45-9:30 | 3rd Grade + Student Services Elem. + Harvala | Commons | Mostly 3rd | Assembly |
| | | 9:45-10:25 | 5th Grade + Middendorf + Vrana | Commons | 3rd and 5th | Assembly |
| | | 10:30-11:10 | 4th Grade | Commons | Mostly 4th | Assembly |
| | | 1:00-1:45 | Secondary Student Services | Student Services | Dohrmann | Assembly |
| | | 2:00-2:45 | | | | |
| | | | | | | |
| 5.2.18 | Wednesday | 8:40-9:20 | All 6th Grade | Cafeteria | All 6th grade | Assembly |
| | | 9:30-10:15 | All 7th Grade | Cafeteria | All 7th Grade | Assembly |
| | | 10:20-11:00 | All 8th Grade | Cafeteria | All 8th Grade - commissioned by scienc | Assembly |
| | | 12:35-1:35 | 6th Gr Math/Sci List | Media Center | Blomberg/Mathson | Project __ |
| | | 2:10-3:00 | 8th Gr Math/Sci List | Media Center | Neubauer/Rysavy | Project __ |
| | | 6:00-8:00 | School Board Scholars Banquet | PAC | Julia Espe/Contact | TBD |
| | | | | | | |
| 5.3.18 | Thursday | 7:50-12:45 | PHS, CCE Class | Room # | Moehlmann | Project __ |
| | | 2:10-3:00 | 7th Gr Math/Sci List | Media Center | | |
| | | | | | | |
| 5.4.18 | Friday | 8:30-9:30 | Accelerated Math 5 | Tiger Club room | Gruber | Project __ |
| | | 9:30-10:30 | 5th Grade | ? | Ruzek/Kluempke/Kinney/Berlin | Project #1 or #3 |
| | | 10:30-11:30 | 3rd Grade | Walerius | Walerius | Project __ |
| | | 12:40-1:30 | 5th Grade | Harvala | Yellow Pod (Franson,Skluzacek, Harvala | Project __ |
| | | 1:30-2:30 | 5th Grade | Jensen | Red Pod (Jensen, Keeney, Stenzel) | Project #3 or 4 |

# Outline

- **My Story**
  - High School
    - Graduated high school at PHS in 2007
  - Undergraduate University
    - Originally planned to graduate from St. Cloud State University (SCSU) in 2012, but was denied from all schools
    - Interned at the University of Alabama in Huntsville (UAH) summer 2012 for computational heliophysics
    - Studied abroad in Wonju, South Korea fall 2012 at Yonsei University studying Korean culture, history, and language
      - I took a trip to Fukuoka, Japan with friends from Korea
    - Graduated from SCSU in 2013 with a double major in physics and mathematics with a minor in computer science
    - Applied to UAH and Florida Institute of Technology (FIT) and was accepted to both

# Outline

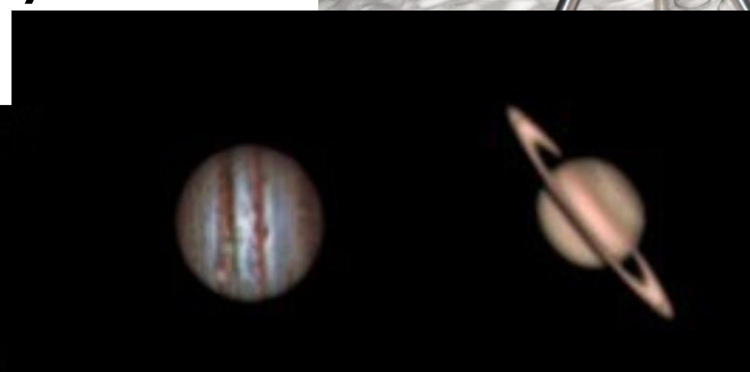
- **My Story**
  - Graduate University – Teaching Assistant
    - I decided to go to UAH for a degree in physics, researching in heliophysics
    - I applied to the NASA Earth and Space Science Fellowship (NESSF) Spring 2014 and was not selected
    - At the end of summer, I took the physics comprehensive exam and passed at the PhD level (there were 3 of 14 students who passed that year!)
    - The first 2 years I worked as a teaching assistant
      - I taught physics and astronomy labs, staffed the physics tutor center, and graded graduate level course work
      - Summer 2015 I taught Physics 3, the first college course I was fully responsible for
    - I was seriously looking into changing research advisors/fields (heliophysics to lightning physics) because I was not able to get a research assistantship (I had no time to do research as a teaching assistant)
    - Before I officially switched, I found out I was awarded the NESSF in heliophysics
      - This fellowship is up to 3 years of funding that covers tuition, travel, and a stipend
      - The second time applying for the NESSF I understood the research topic less, yet the reviewers thought my second project was better

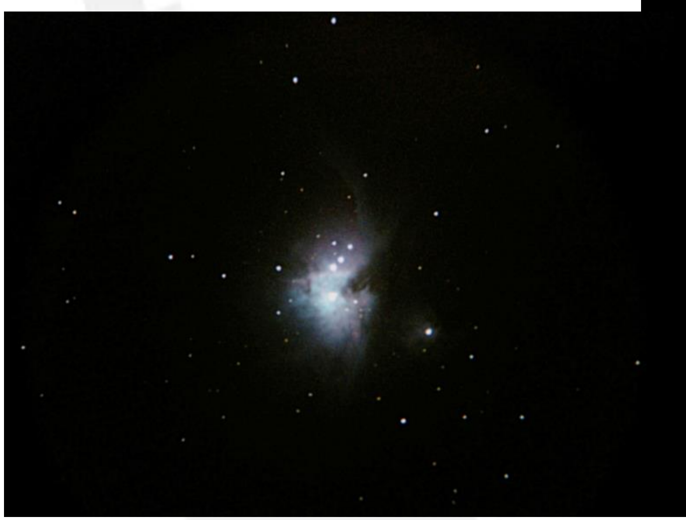
# Outline

- **My Story**
  - Graduate University – Research Assistant
    - During my time as a research assistant I have traveled around the country and the world attending conferences and giving presentations:
      - San Francisco, California (AGU)
      - Savanah, Georgia (APS)
      - Baltimore, Maryland (APS)
      - San Antonio, Texas (SwRI)
      - Princeton, New Jersey (IBEX meeting)
      - Monterey, California (ASTRONUM)
      - Sunriver, Oregon (Blue Waters Symposium)
      - Hermanus, South Africa (Space Weather Summer camp)
      - Neustrelitz, Germany (Space Weather Summer camp)
      - Warsaw, Poland (IBEX meeting)
  - NASA at Marshall Space Flight Center
    - Began working as a civil servant July 2017 in the Natural Environments group (EV44)
    - Our EV44 group consists of:
      - Space environment – cosmic rays, solar energetic particles, trapped radiation belts
      - Terrestrial environment – Earth weather forecasting, winds; sea states, waves, etc
      - Meteor environment – meteor showers, fireballs, cometary debris

# My Story – Astronomy

- My parents gave me a telescope for Christmas when I was in high school – After seeing Saturn with my own eyes, I was hooked!
- I started a new hobby of astrophotography…





# My Story – Mathematics and Programming

- In math class during high school, I became fascinated with fractals because of how simple the rules are, yet how beautiful they are
- I programmed my Ti-83 graphing calculator to generate this fractal (it took more than half the day to calculate!)

# My Story – From high school to SCSU

- I graduated at ~50% in my class… I never studied except for math league and the only consistent A's I earned were in math
- I passed senior English by 0.3%...
- I applied 2 months late to St. Cloud State University, I never had a clear plan – I knew I wanted to do something in astronomy
- SCSU did not have an astronomy program so the next best thing was physics – I started a physics teaching degree, but later changed to a double major in physics and mathematics and a minor in computer science

- It took me 2 solid years to learn how to study… Before this, I had a C average in college
- Once I learned how to study (and in groups!) I started to earn straight A's

# My Story – Highlights and Lowlights in SCSU

- I had a wonderful advisor who helped me beyond expectation and still gives me advice to this day!
- I also worked for her at the SCSU planetarium, creating and making shows for the public – this helped with my public speaking skills tremendously
- I worked as a pre-algebra/algebra tutor at the Math Skills Center – this prepared me for teaching to many diverse students
- I originally planned to graduate in Spring 2012, but I was denied at all 6 schools I applied to because I did not have any research experience…

# My Story – Turn in the Road

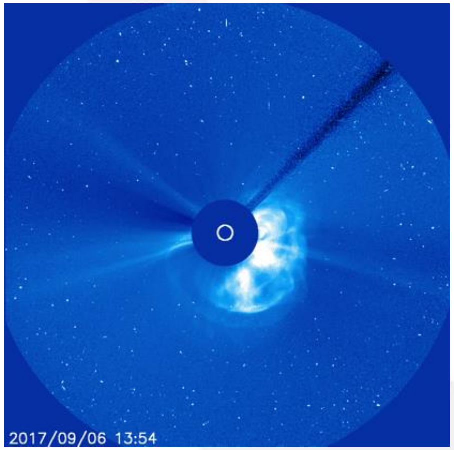
- **Within about a month of getting denied from all 6 graduate schools (the application process is not cheap!), I found out I:**
  - was accepted at an internship in Huntsville, Alabama for computational heliophysics research during 2012 summer and
  - I was also accepted to study abroad in South Korea for the 2012 fall semester

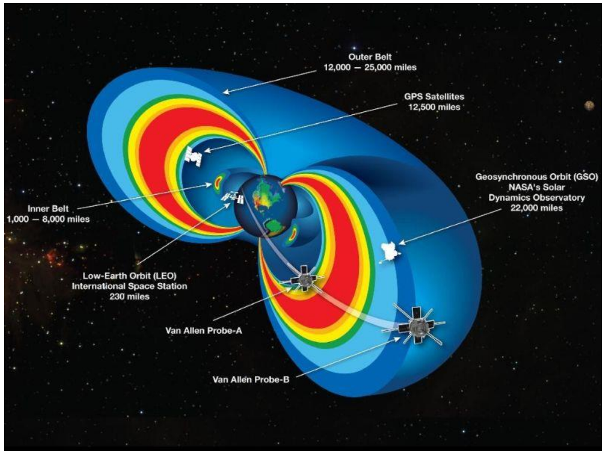
- **Sometimes you need to fail to let blessings fall on you!**
- **Because I decided to minor in computer science, it helped me to excel during the internship where I learned how to program supercomputers**
- **Studying in Korea, I further learned how to read, write, and speak Korean**
- **I also had the opportunity to intern by teaching English as a second language to 5th and 6th graders**

# Working at NASA

- **I started working as an aerospace engineer at NASA at the end of last summer**
  - Our group in the natural environments team consists of experts in:
    - Space environment
    - Terrestrial environment
    - Meteor environment
  - I am apart of the space environment group where I focus on galactic cosmic rays, solar energetic particles, and trapped belt radiation around the Earth





# The Adventure Begins NOW.
# Join Us on The Journey!

#JOURNEYTOMARS

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National Aeronautics and Space Administration

# SPACE LAUNCH SYSTEM UPDATE

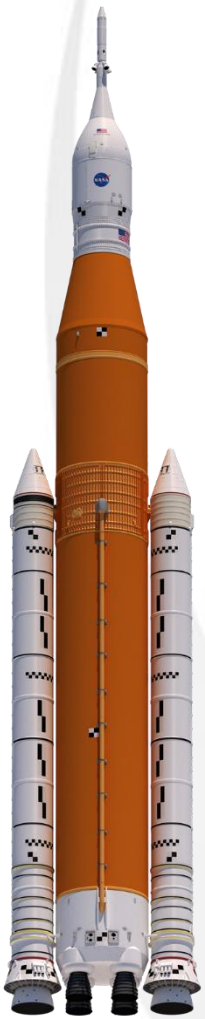
**SLS Ambassador Program**

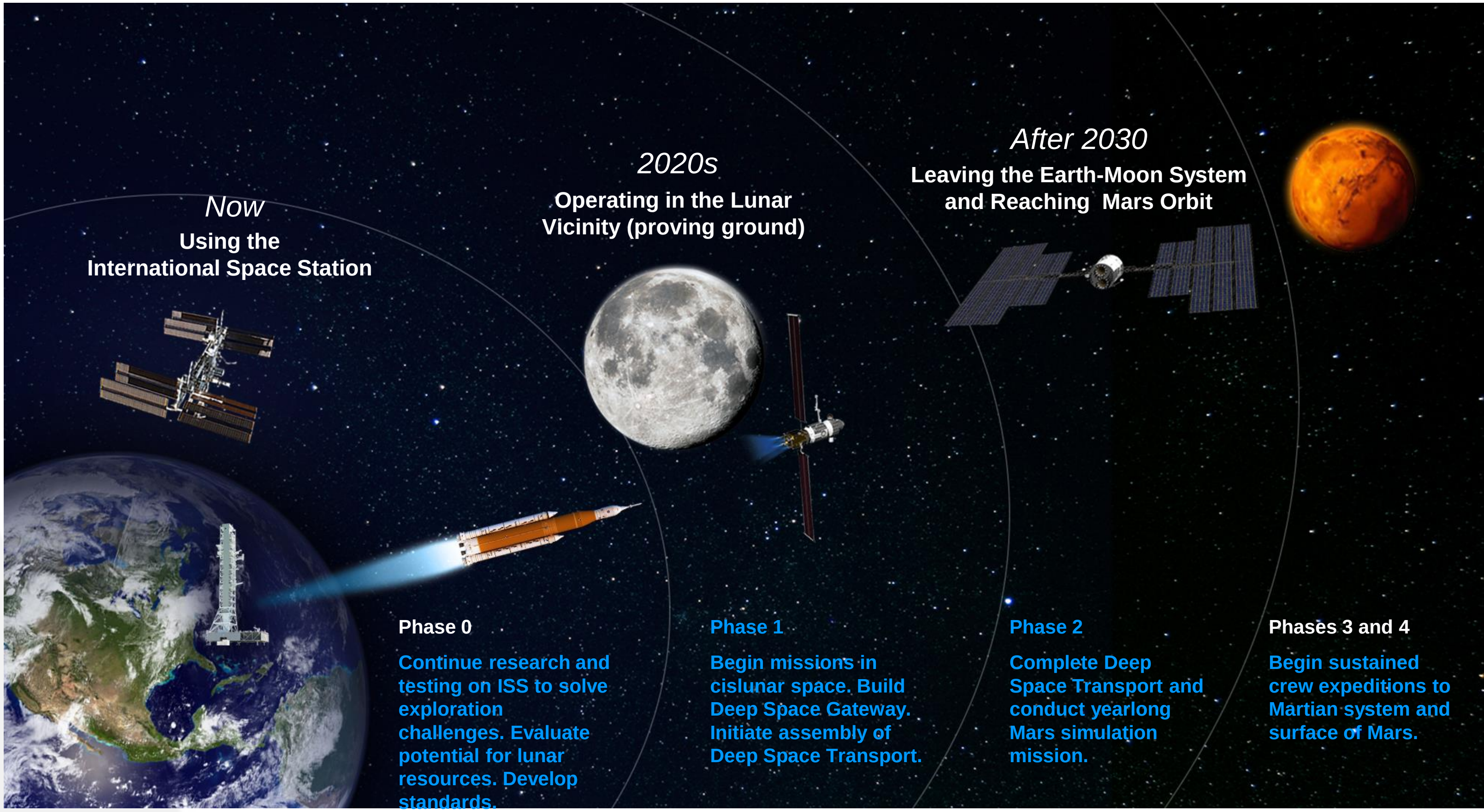
*Anthony M. DeStefano*

*April 30 – May 4*

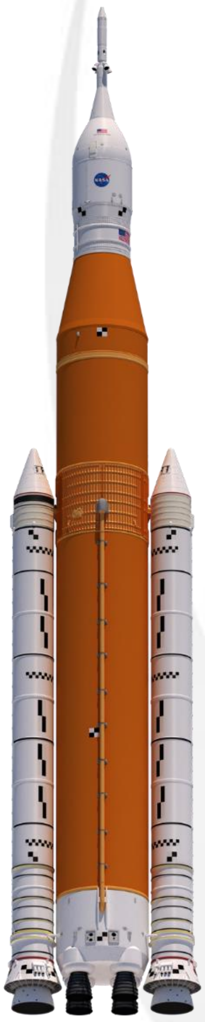
# A PHASED APPROACH

## SLS: THE FOUNDATIONAL CAPABILITY FOR A GENERATION



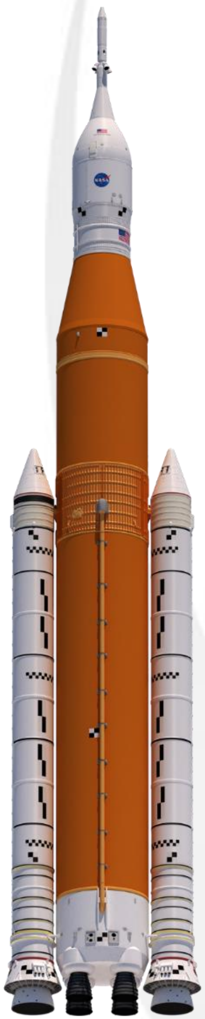


# SLS BLOCK 1 CONFIGURATION FOR EM-1

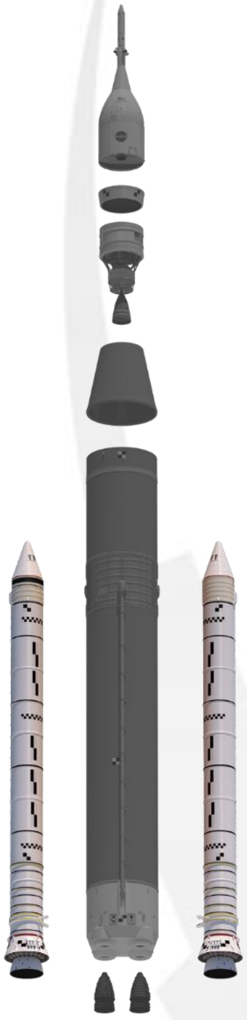


# SLS NATIONWIDE TEAM

## WORKING WITH OVER 1100 CONTRACTORS IN 42 STATES

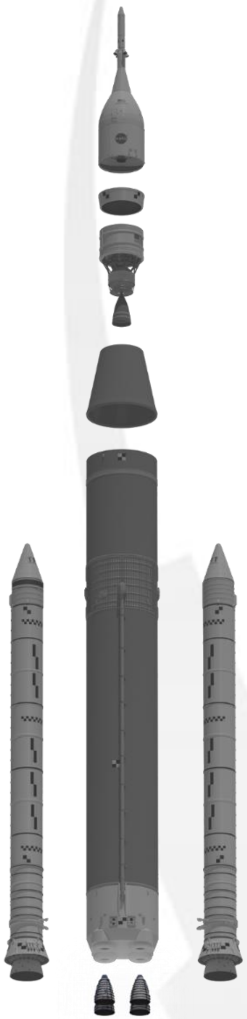


# BUILDING A BIGGER, BETTER BOOSTER

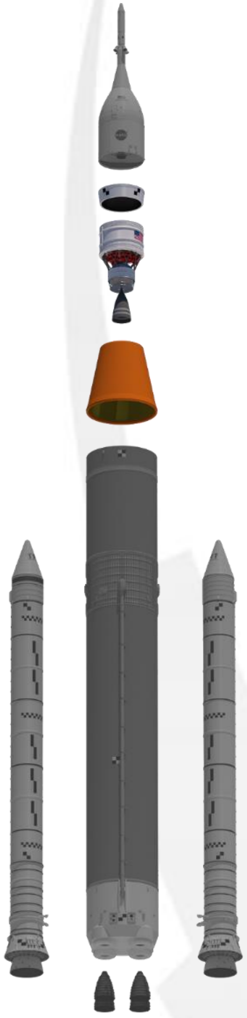


# FUELING THE FLAMES

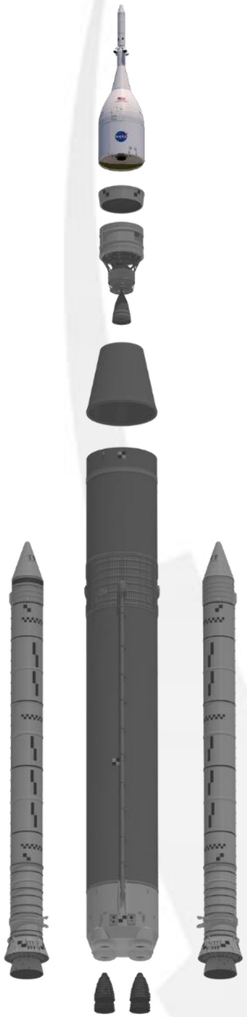
# DESIGNED FOR PERFORMANCE

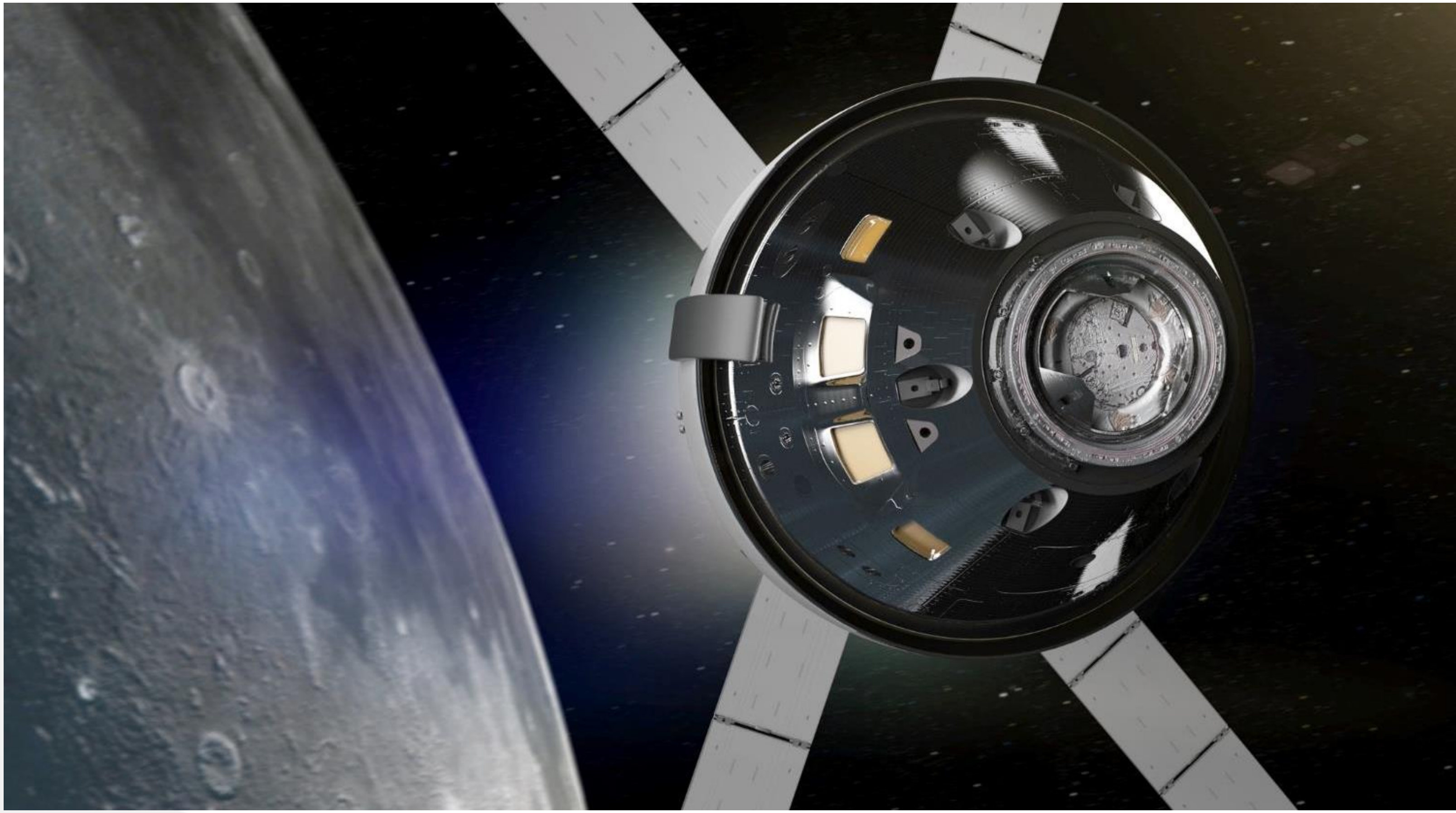


# EM-1 IN-SPACE STAGE



# RETURNING TO DEEP SPACE



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National Aeronautics and Space Administration

HEO Overview

# Lunar Orbital Platform-Gateway and Deep Space Transportation Plan


Mark Geyer
Deputy Associate Administrator
Human Exploration & Operations Mission Directorate


Feb. 27, 2018

SPACE POLICY DIRECTIVE 1

"Lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities.

Beginning with missions beyond low-Earth orbit, the United States will lead the return of humans to the Moon for long-term exploration and utilization, followed by human missions to Mars and other destinations."

## STRATEGIC PRINCIPLES FOR SUSTAINABLE EXPLORATION

- **FISCAL REALISM**
  Implementable *with the buying power of current budgets*

- **COMMERCIAL PARTNERSHIPS**
  Leveraging the unique capabilities of NASA and the private sector, use partnerships to develop safe, reliable, and cost-effective space systems, while simultaneously developing a commercial LEO space economy

- **SCIENTIFIC EXPLORATION***: Exploration enables science and science enables exploration;* leveraging scientific expertise for human exploration of the solar system

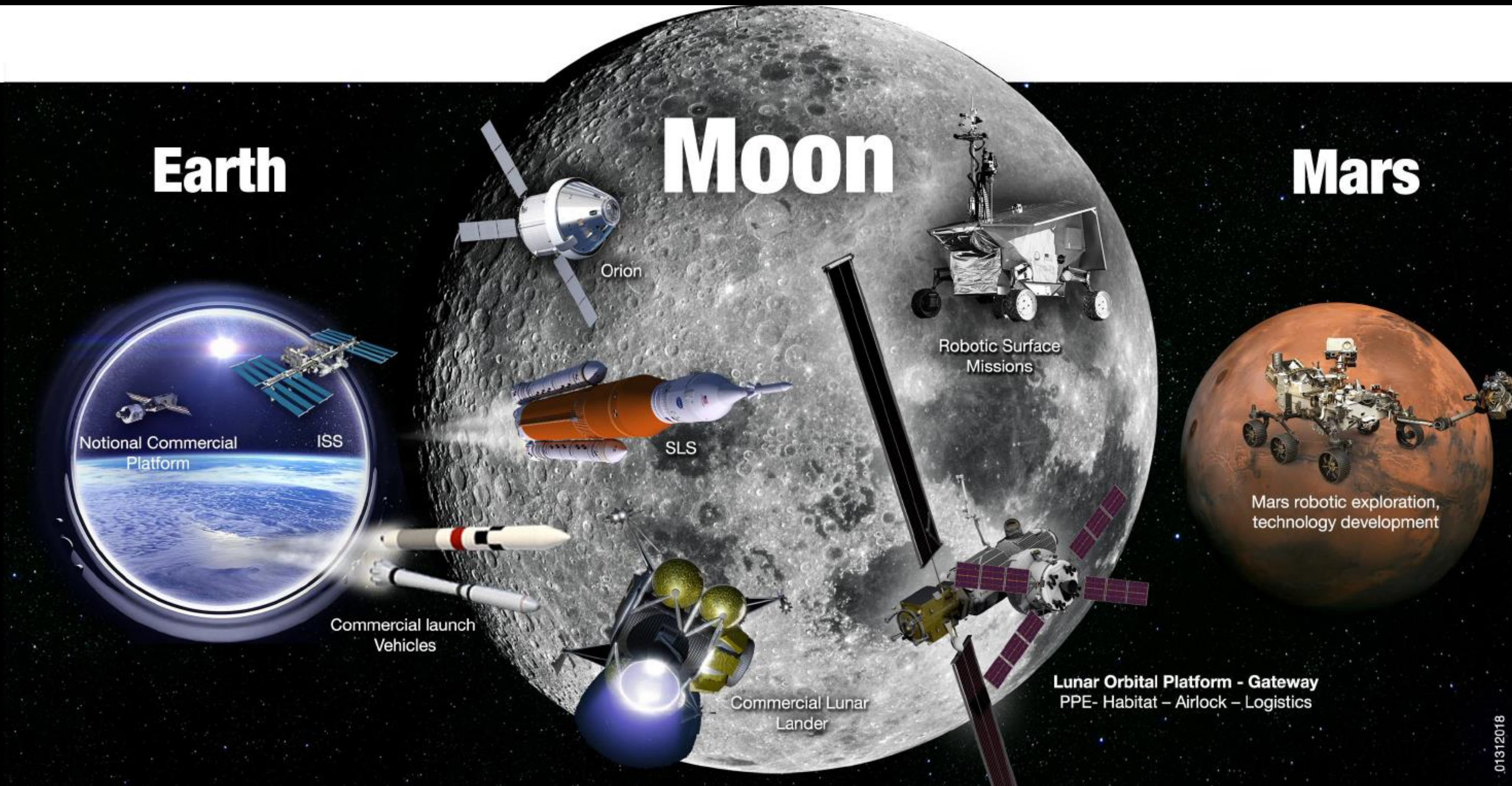
- **TECHNOLOGY PULL AND PUSH**
  Application of high TRL technologies for near term missions, while focusing sustained investments on *technologies and capabilities* to address the challenges of future missions

- **GRADUAL BUILD UP OF CAPABILITY**
  *Near-term mission opportunities* with a defined cadence of compelling and integrated human and robotic missions, providing for an incremental buildup of capabilities for more complex missions over time

- **ARCHITECTURE OPENNESS AND RESILIENCE**
  Resilient architecture featuring multi-use, evolvable space infrastructure, minimizing unique developments, with each mission leaving something behind to support subsequent missions

- **GLOBAL COLLABORATION AND LEADERSHIP**
  Substantial *new international and commercial partnerships,* leveraging current International Space Station partnerships and building new cooperative ventures for exploration; and

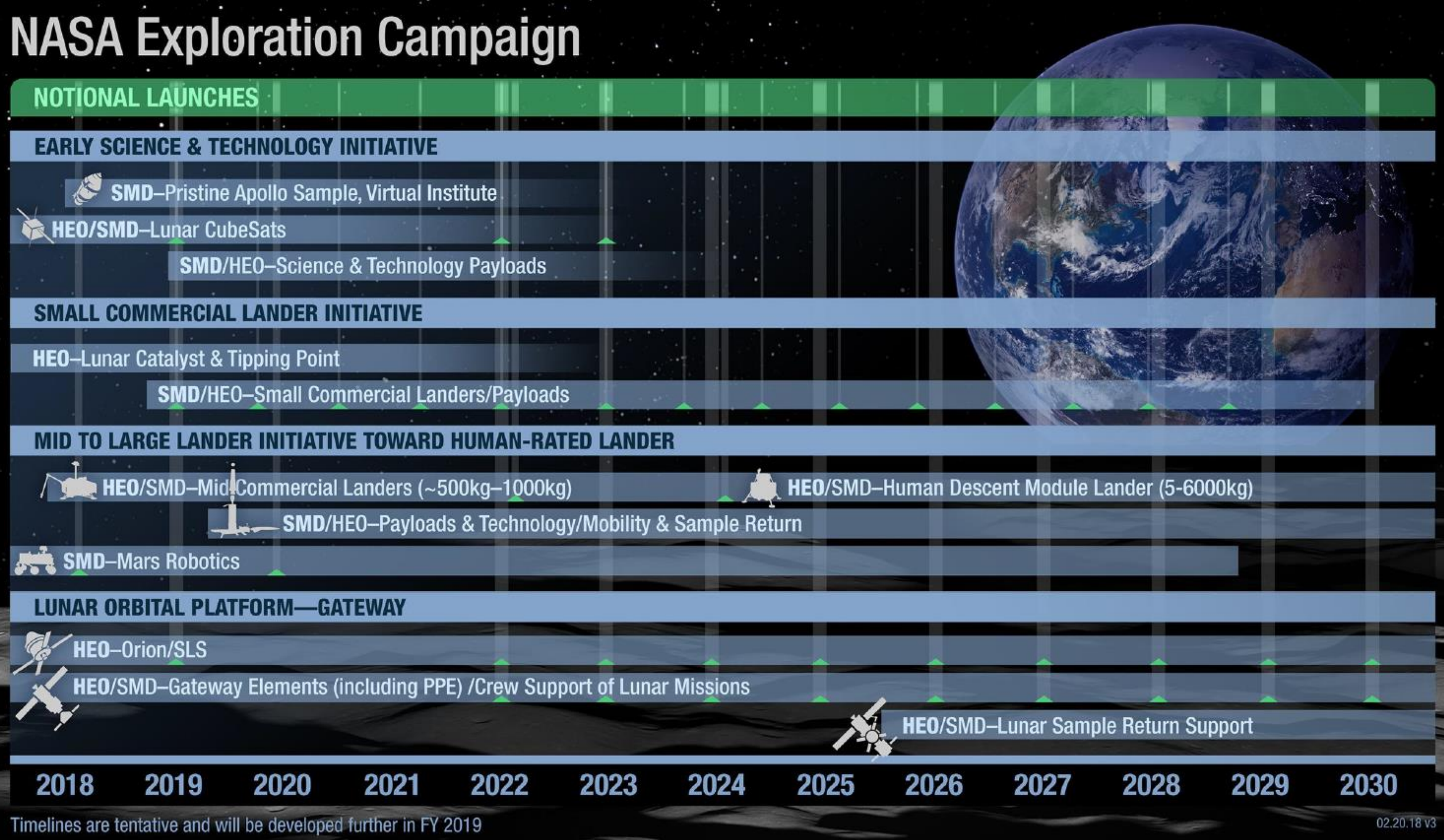
- **CONTINUITY OF HUMAN SPACEFLIGHT**
  *Uninterrupted expansion of human presence into the solar system* by establishing a regular cadence of crewed missions to cislunar space during ISS lifetime




**In LEO**
Commercial & International partnerships

**In Cislunar Space**
A return to the moon for long-term exploration

**On Mars**
Research to inform future crewed missions


NASA Exploration Campaign
NOTIONAL LAUNCHES
EARLY SCIENCE & TECHNOLOGY INITIATIVE
SMD–Pristine Apollo Sample, Virtual Institute
HEO/SMD–Lunar CubeSats
SMD/HEO–Science & Technology Payloads
SMALL COMMERCIAL LANDER INITIATIVE
HEO–Lunar Catalyst & Tipping Point
SMD/HEO–Small Commercial Landers/Payloads
MID TO LARGE LANDER INITIATIVE TOWARD HUMAN-RATED LANDER
HEO/SMD–Mid Commercial Landers (~500kg–1000kg)
HEO/SMD–Human Descent Module Lander (5-6000kg)
SMD/HEO–Payloads & Technology/Mobility & Sample Return
SMD–Mars Robotics
LUNAR ORBITAL PLATFORM—GATEWAY
HEO–Orion/SLS
HEO/SMD–Gateway Elements (including PPE) /Crew Support of Lunar Missions
HEO/SMD–Lunar Sample Return Support
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Timelines are tentative and will be developed further in FY 2019
02.20.18 v3

# LUNAR ORBITAL PLATFORM – GATEWAY OVERVIEW

**Used as a staging point for missions to the lunar surface and to destinations in deep space**

- **Includes four main capabilities:**
  - **Power and Propulsion Element (PPE)**
    - First LOP-G capability targeted for launch readiness in 2022
    - Spaceflight demonstration of advanced solar electric propulsion spacecraft for industry and NASA objectives; developed through public-private partnership
    - Will provide transportation and controls for lunar orbital operations, power to future lunar orbiting elements, and communications

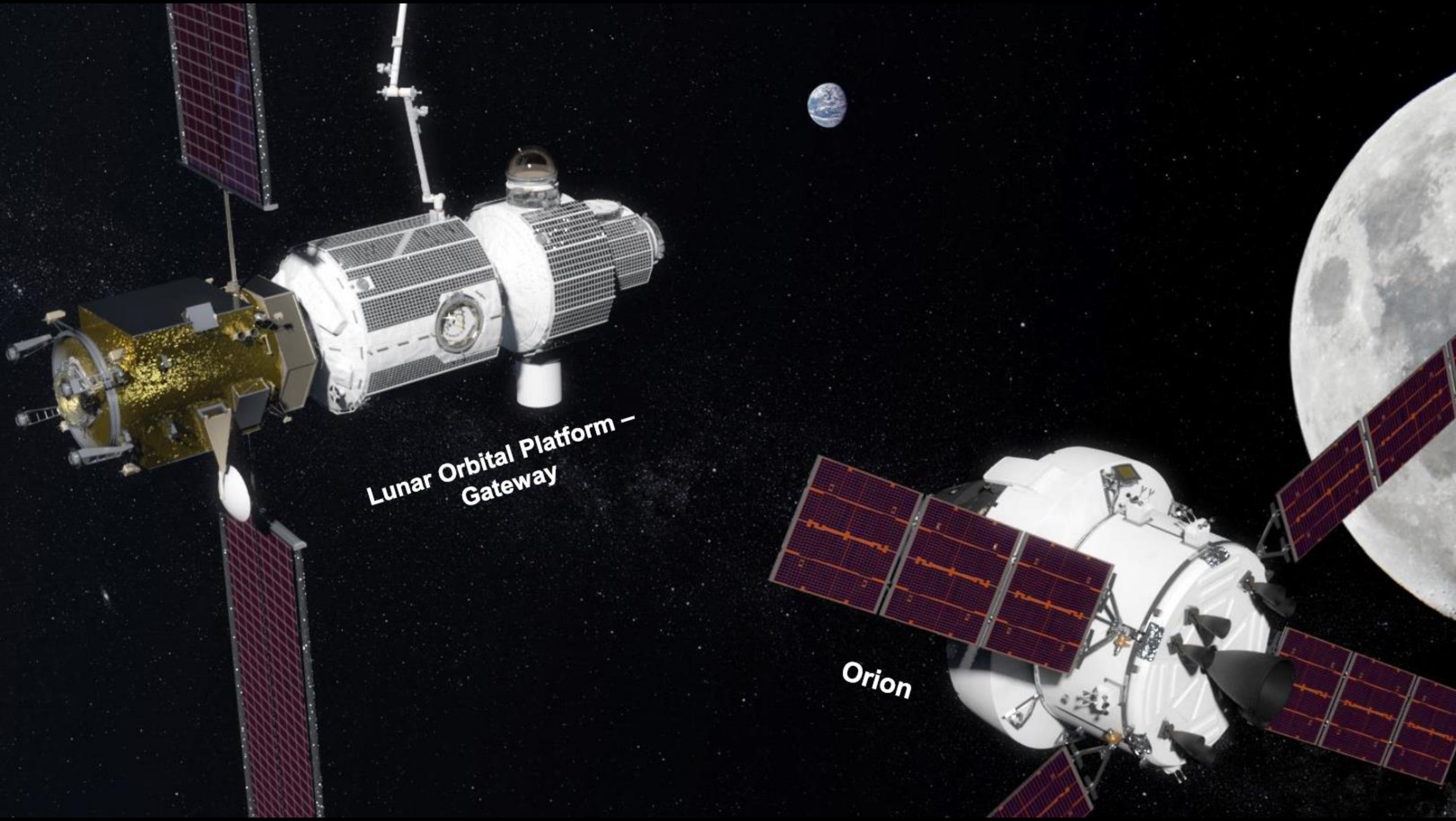
- **PPE will perform requirements studies, acquisition planning, and partnership approaches in coordination with STMD**
  - Award contract(s) for PPE spacecraft development
  - Make final selections for further PPE industry studies from NextSTEP BAA Appendix C submittals
  - Conduct reviews for requirements and preliminary design, and procurement of long lead items
  - Establish acquisition strategy for launch vehicle

# LUNAR ORBITAL PLATFORM-GATEWAY OVERVIEW (CONTINUED)

– **Habitation**
  - Provides habitable volume and short-duration life support functions for crew in cislunar space
  - Docking ports allow for attachment to the PPE, other LOP-G elements and visiting vehicles
  - Offers attach points for external robotics, external science and technology payloads or rendezvous sensors
  - Provide accommodations for crew exercise, science/utilization and stowage
  - Planned launch date—2023

– **Airlock**
  - Provides capability to enable astronaut EVAs as well as the potential to accommodate docking of additional elements, observation ports, or a science utilization airlock
  - Planned launch date—2024

– **Logistics**
  - Deliver cargo to enable extended crew mission durations, science utilization, exploration technology demonstrations, potential commercial utilization, and other supplies
  - Planned launch date—2024


Lunar Orbital Platform –
Gateway
Orion

# ADVANCED CISLUNAR AND SURFACE CAPABILITIES OVERVIEW

- **Use innovative approaches to combine lunar robotics, a cislunar presence, and lunar landing capabilities**
  - Involve commercial and international participation to enhance U.S. leadership and establish U.S. preeminence to, around, and on the Moon; engage non-traditional U.S. industry partners and sectors

- **Partner with SMD's new Lunar Discovery and Exploration Program to build and launch instruments that serve lunar science, long-term exploration and utilization needs**
  - Build upon initial SMD-led commercial contracts for lunar transportation services
    - Small rovers to payloads in the 500kg range, which will be delivered on public-private partnership developed lunar landers
  - Progress to a large public-private partnership lander in the 5000-6000kg class, heading towards utilization and a human landing long term
  - Explore options for surface capabilities that enable exploration and utilization by NASA and the commercial sector

# ADVANCED CISLUNAR AND SURFACE CAPABILITIES
# FY 2018 AND FY 2019 PLANS

- Issue joint RFI with SMD in February 2018 regarding emerging commercial capabilities, short and long term mission plans, and commercial sector opportunities to enable regular access to the lunar surface, and innovative public-private partnership acquisition approaches

- Solicit a March 2018 NextSTEP announcement for lander risk reduction activities and concepts that start with an initial capability of landing a minimum of 500kg payload(s) on the lunar surface

- Initiate discussions with international partners to establish interest in LOP-G and ACSC

- Evaluate Lunar CATALYST partnerships efforts that can be directly linked to ACSC
  - Encourage the development of robotic lunar landers that can be integrated with U.S. commercial launch capabilities to the lunar surface

- Begin initial planning of a series of robotic demonstration missions expected to start at the 500kg payload class in the early half of the 2020s with the expectation of larger (5000-6000kg) class in the second half of he 2020s

# COMMERCIAL LEO DEVELOPMENT OVERVIEW AND PLANS

- **Overview**
  - Support U.S. private industry to encourage development of LEO capabilities that can be used by NASA, international, and commercial customers
    - NASA would rely on commercial partners for its low Earth orbit research and technology demonstration requirements after ending direct U.S. financial support for ISS in 2025
  - Focus on enabling, developing, and deploying commercial platforms and other capabilities
  - There are options available that would achieve the vision of a commercial LEO economy where NASA is one of many customers
  - Goal is for there to be no "gap" in LEO capabilities for users, providing uninterrupted provision of microgravity research laboratory services

- **FY 2018 and 2019 Plans**
  - Announce an open competition for commercial module(s)/platform(s) attached to ISS or free-flying in LEO, and other capabilities which would be partially or fully funded by private industry
  - Make upgrades to ISS, as necessary, to support the awards
  - Conduct additional activities to further support commercialization of ISS and LEO

# COMMERCIAL CREW

## Boeing

## SpaceX

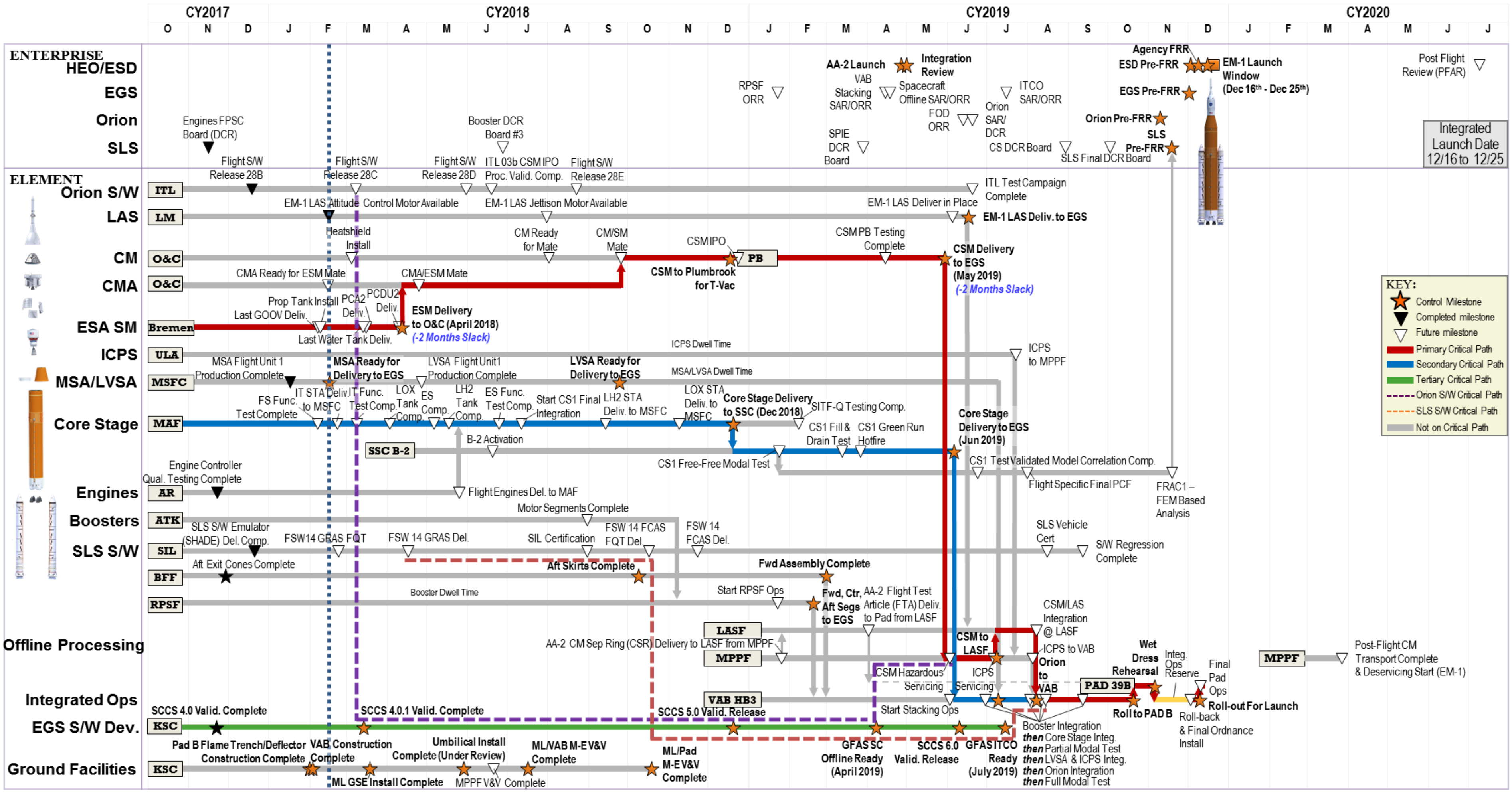
NASA's Deep Space Exploration System, including SLS, Orion, and modernized ground support facilities at Kennedy Space Center, is an asset that belongs to the American people.

It is foundational to extending human presence into the solar system.

Last update: 02/16/18

December Month End Data

# EM-1 INTEGRATED MISSION MILESTONE SUMMARY




NASA

# Journey Through the Constellations

NASA/MSFC Natural Environments Branch EV44
Anthony M. DeStefano
Princeton, MN Outreach Event
April 30 – May 4, 2018

**A multicultural glance at the stars in our night sky**

# "GREEK" STAR MAP

Babylonian, Greek, and Egyptian — Star Knowledge of the Mediterranean Sea

## SPRING Stars

*Leo*, Lion & *Bootes*, Herdsman
*Corona Borealis*, Northern Crown
*Virgo*, Maiden & *Libra*, Scales
*Coma Berenices*, Queen's Hair
*Arcturus*, (bright star in) Bootes
*Hydra*, Water Snake
*Corvus*, Crow
*Crater*, Cup

## SUMMER Stars

*Scorpius*, Scorpion & *Sagittarius*, Centaur-Archer
*Cygnus*, Swan & *Lyra*, Harp & *Aquila*, Eagle
*Summer Triangle*, (sky landmark)
*SagA** (center of Milky Way galaxy)
*SagA** (supermassive black hole)
*Ophiuchus*, Serpent-Bearer
*Delphinus*, Dolphin
*Hercules*, Hero


## WINTER Stars

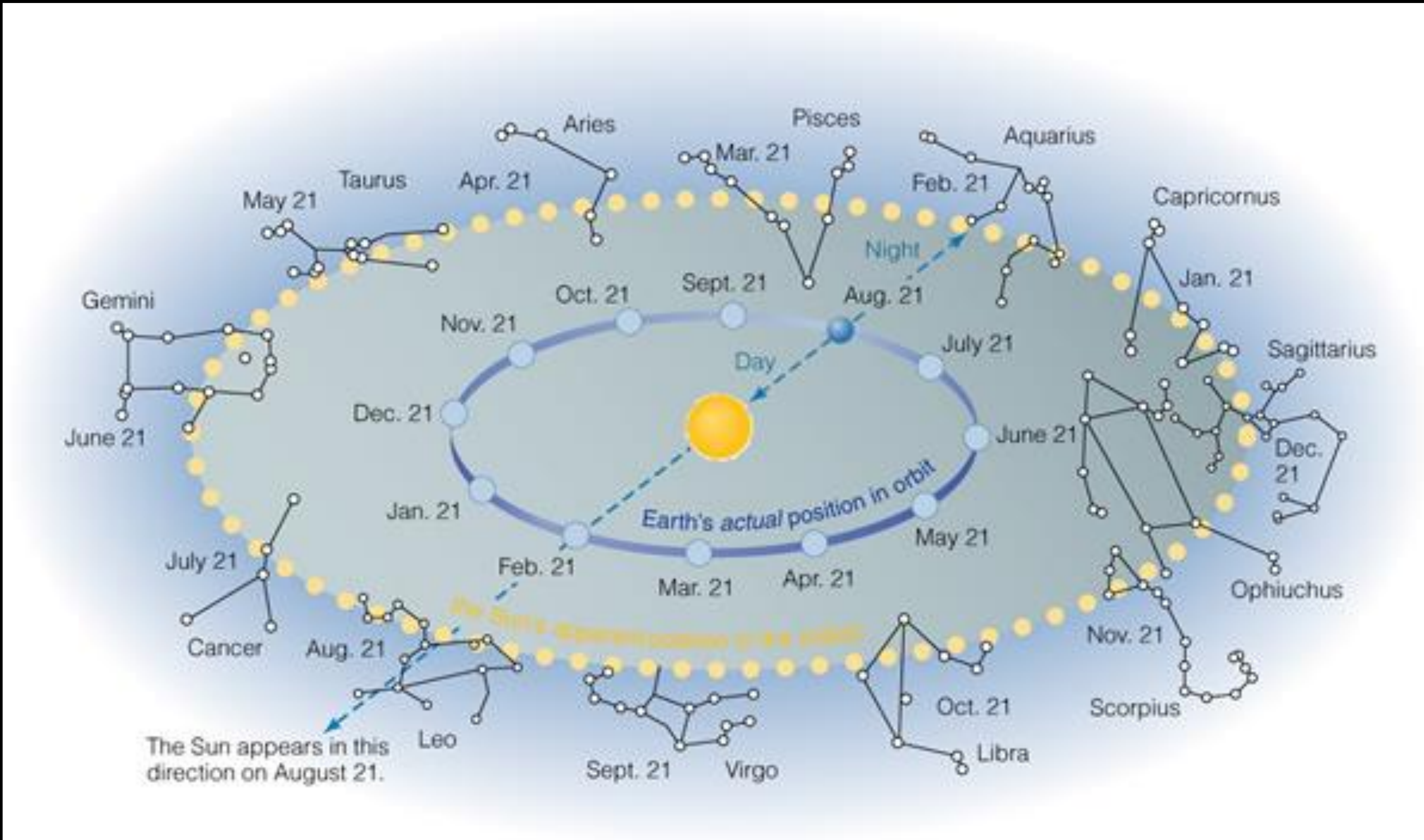
*Orion*, Hero-Hunter & *Taurus*, Bull
*Canis Major*, Big Dog & *Canis Minor*, Little Dog
*Gemini*, Twins & *Auriga*, Charioteer
*Lepus*, Hare & *Cancer*, Crab
*Winter Circle*, (sky landmark)
*Sirius*, (bright star in) Canis Major

## FALL Stars

*Pegasus*, Winged Horse
*Andromeda*, Princess & *Perseus*, Hero
*Aries*, Ram & *Pisces*, Fishes & *Capricorn*, Seagoat
*Cetus*, Sea Monster & *Aquarius*, Water Carrier
*Pleiades*, (open star cluster), Seven Sisters & *Lacerta*, Lizard
*Fomalhaut*, (bright star in) *Piscis Australis*, Southern Fish
*Andromeda Galaxy*, M31 (neighboring spiral galaxy)

## NORTH ~ All Season

*Little Dipper ~ Ursa Minor*, Little Bear
*Polaris - the North Star* in Ursa Minor
*Big Dipper~Ursa Major*, Great Bear
*Cassiopeia*, Queen
*Cepheus*, King
*Draco*, Dragon



Aries
Pisces
Aquarius
Mar. 21
Taurus
Apr. 21
Feb. 21
Capricornus
May 21
Night
Jan. 21
Gemini
Oct. 21
Sept. 21
Aug. 21
Nov. 21
July 21
Sagittarius
Day
Dec. 21
June 21
June 21
Dec. 21
Earth's actual position in orbit
Jan. 21
May 21
July 21
Feb. 21
Mar. 21
Apr. 21
Ophiuchus
Cancer
Aug. 21
Nov. 21
Oct. 21
Scorpius
Leo
Libra
The Sun appears in this direction on August 21.
Sept. 21
Virgo

# How do you connect the dots?

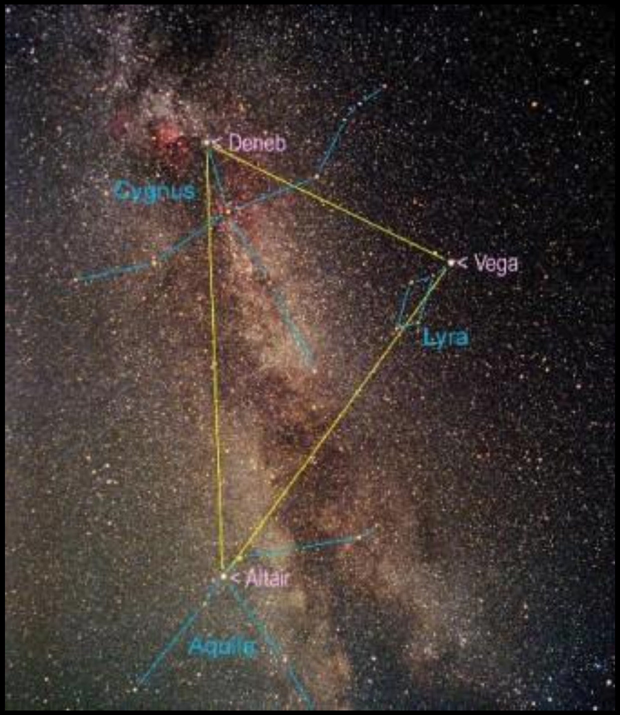
- Cultures around the would see the sky differently than we do. The day-to-day objects we see or our beliefs influence what we imagine in the sky
- What do you picture in the night sky?

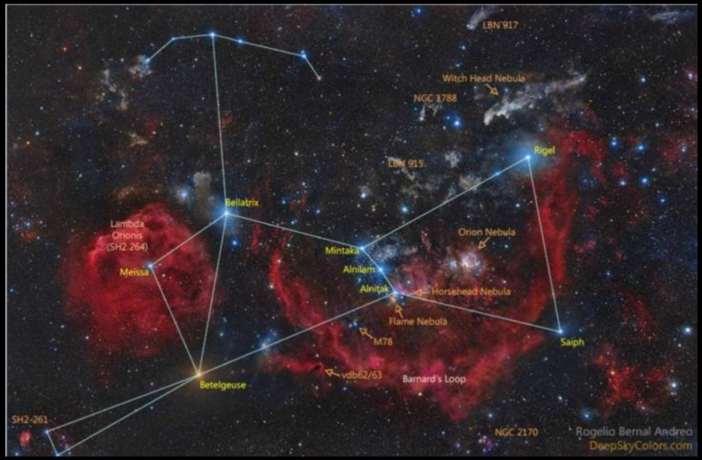
–Your dog or cat?

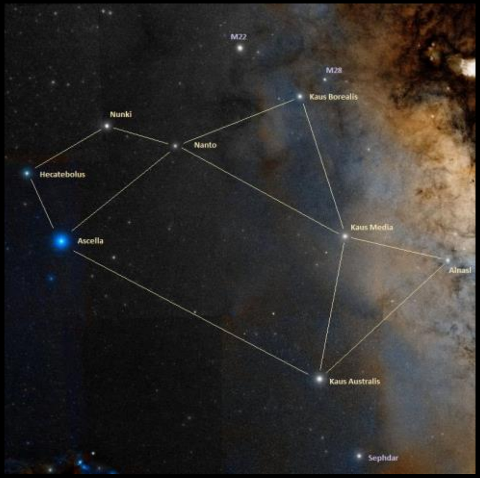
–An airplane?

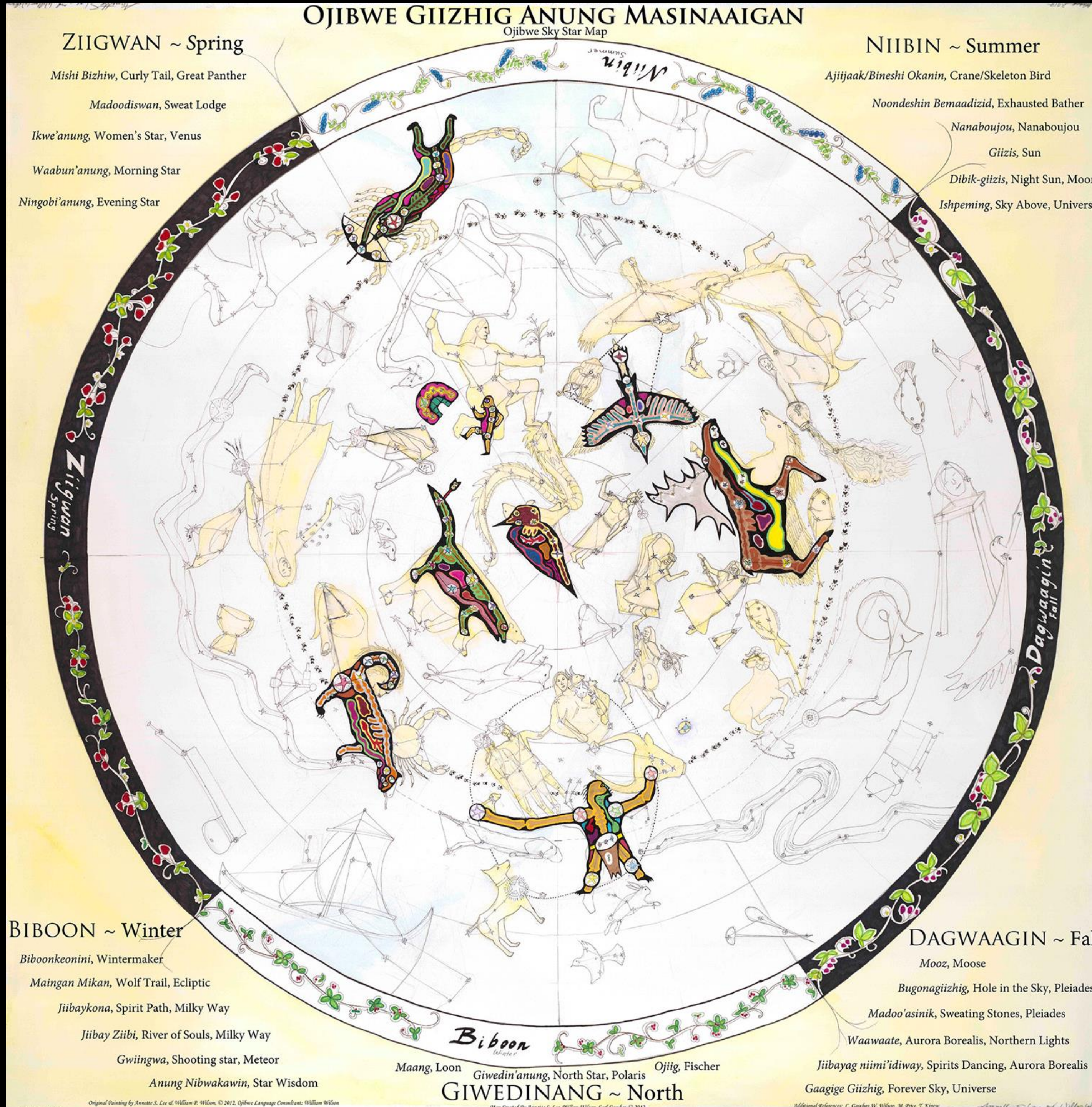
–A skyscraper?

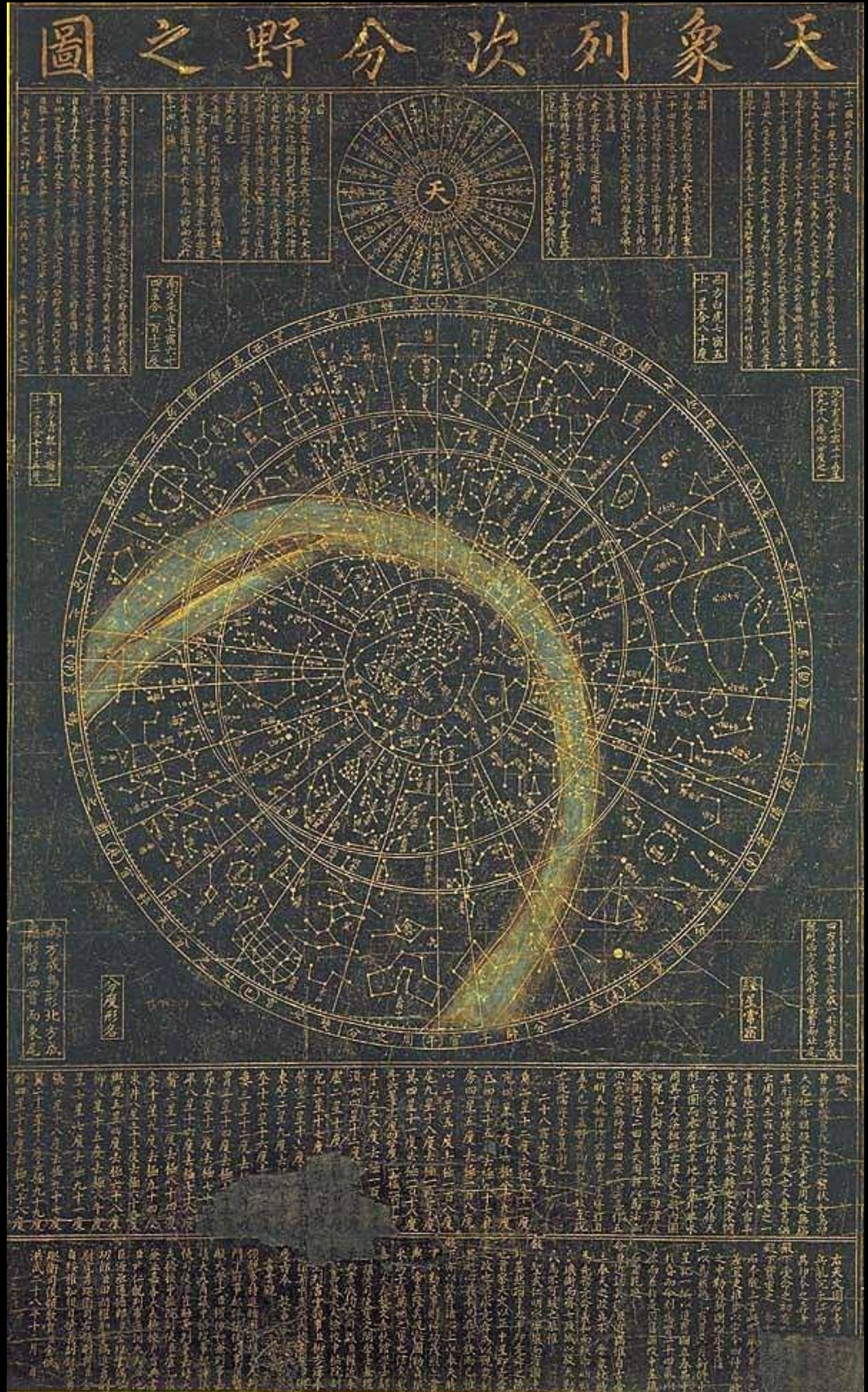
–A cell phone?



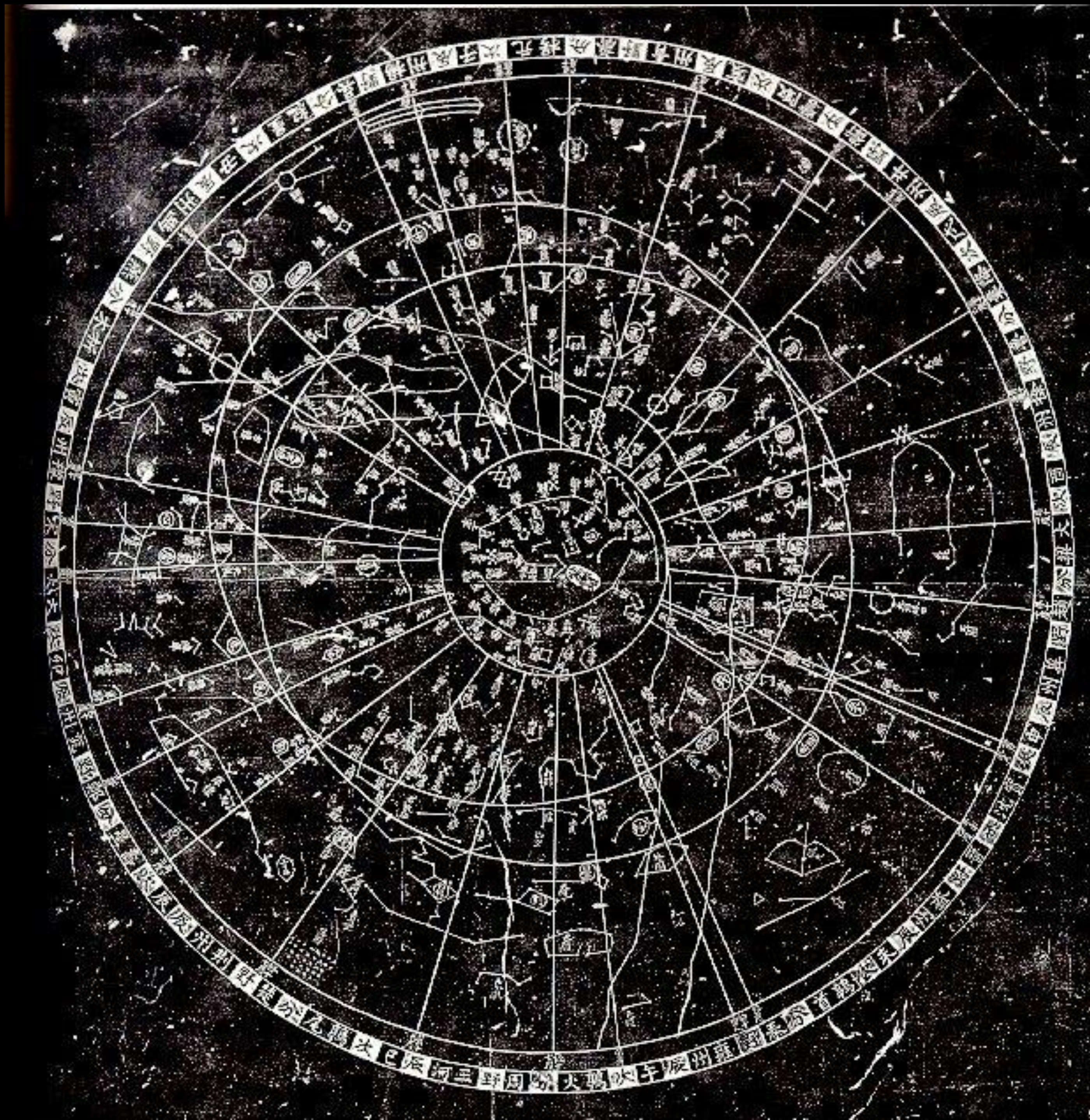




OJIBWE GIIZHIG ANUNG MASINAAIGAN
Ojibwe Sky Star Map
ZIIGWAN ~ Spring
Mishi Bizhiw, Curly Tail, Great Panther
Madoodiswan, Sweat Lodge
Ikwe'anung, Women's Star, Venus
Waabun'anung, Morning Star
Ningobi'anung, Evening Star
NIIBIN ~ Summer
Ajiijaak/Bineshi Okanin, Crane/Skeleton Bird
Noondeshin Bemaadizid, Exhausted Bather
Nanaboujou, Nanaboujou
Giizis, Sun
Dibik-giizis, Night Sun, Moon
Ishpeming, Sky Above, Universe
Niibin
Summer
Ziigwan
Spring
Dagwaagin
Fall
Biboon
Winter
BIBOON ~ Winter
Biboonkeonini, Wintermaker
Maingan Mikan, Wolf Trail, Ecliptic
Jiibaykona, Spirit Path, Milky Way
Jiibay Ziibi, River of Souls, Milky Way
Gwiingwa, Shooting star, Meteor
Anung Nibwakawin, Star Wisdom
DAGWAAGIN ~ Fall
Mooz, Moose
Bugonagiizhig, Hole in the Sky, Pleiades
Madoo'asinik, Sweating Stones, Pleiades
Waawaate, Aurora Borealis, Northern Lights
Jiibayag niimi'idiway, Spirits Dancing, Aurora Borealis
Gaagige Giizhig, Forever Sky, Universe
Maang, Loon
Giwedin'anung, North Star, Polaris
Ojiig, Fischer
GIWEDINANG ~ North
Original Painting by Annette S. Lee & William P. Wilson, © 2012, Ojibwe Language Consultant: William Wilson




천상열차분야지도

Celestial Planisphere map, 14$^{th}$ century



淳祐天文図
Suzhou Star Chart,
12th century

# Ininew Achakos Masinikan

Cree Star Map-Book

## Sikwan ~ Spring

*Mahtootisan*, Sweat Lodge

*Tepahkoop Pinesisuk*, Seven Birds

*Misewa*, All that is ~ the Universe

*Tipiska Pisim*, Night Sun - Moon

*Kotawew Pisim*, Eclipse

*Pisim*, Sun

## Nipin ~ Summer

*Nipin Pinisew*, Summer Thunderbird

*Niska/Niska Meskinaw*, Goose/Goose's Path

*Nipinesis Meskinaw*, Summer Birds' Path

*Achak Sipi*, Spirit River, Milky Way

*Achakosuk*, Stars

*Askiy*, Earth


## Pipon ~ Winter

*Mistapew*, Giant & *Wesakayckak*, Teacher

*Mikanuk Meskinaw*, Wolves Path, Milky Way

*Cheepiuk Wawatawin*, Spirits Still, Northern Lights

*Cheepiuk Nemitowak*, Spirits Dancing, Northern Lights

*Ahtimah Achakosuk*, Dog (Wolf, Coyote, Fox & Pups) Stars

*Keewatin*, Altar for Sweat Lodge, Polaris

*Seeseekwun*, Rattle

## Takwakin ~ Fall

*Kokominakasis*, Grandmother Spider

*Pakone Kisik*, Hole in the Sky, Pleiades

*Achakos Ahkoop*, Star Blanket, Pleiades

*Mahtootisan Assiniuk*, Sweating Stones, Pleiades

*Pipon Pinisew*, Winter Thunderbird

*Mista Muskwa*, Bear & *Ochek*, Fisher

*Makinak*, Turtle

## Kiwetinohk ~ North

*Original Painting by Annette S. Lee & William P. Wilson, 2016*

April 2016

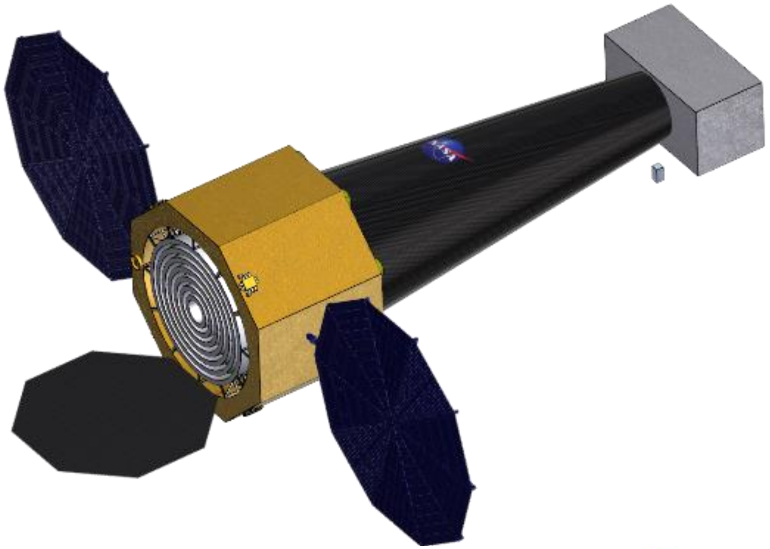
# NASA's Advanced Concepts Office: Spacecraft Design Exercise

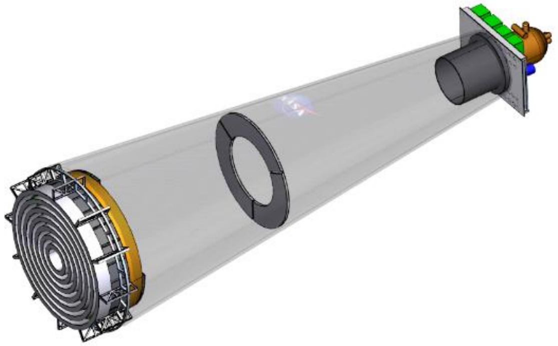
NASA/MSFC Natural Environments
Branch EV44
Anthony M. DeStefano
Princeton, MN Outreach Event
April 30 – May 4, 2018

# Welcome

- We want to demonstrate how the iterative design process works without requiring the extensive analyses typically required during the design process. To that end, we've developed the following exercise.

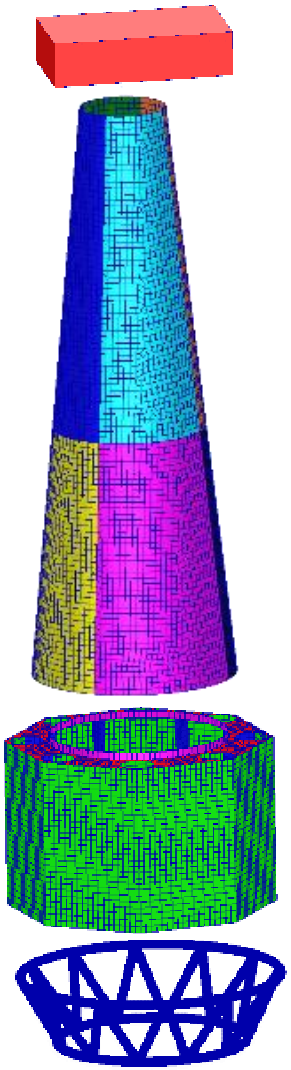
- In this exercise, you assume the role of one of ACO's subject matter experts. You have been asked to attend a conceptual design session. You are designing a satellite for a customer that has multiple design objectives. You will use your "knowledge" of your discipline, represented by the simple equations and tables below, to provide mass, power, and cost estimates for your discipline.





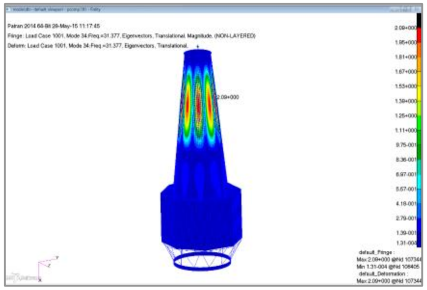
# Structures Expert

- In a typical study, the structures experts will estimate the mass of a conceptual design by developing a simplified structural model of the design, typically in MSC/NASTRAN. By subjecting the model to the loads seen in launch and flight, the expert can whittle the structural mass to a minimum that meets launch and flight requirements.
- In this exercise, use the equations below to estimate the structural mass and cost. There typically isn't a power requirement for structural analysis. You will have to work with the other teams to get some of the values you'll need for your portion of the study.



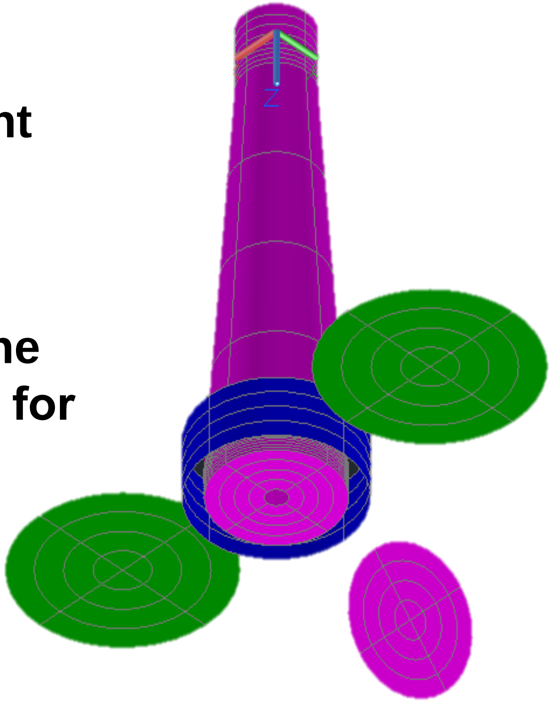
$$m_{structures}\ (kg) = \frac{m_{thermal} + m_{power} + m_{avionics} + m_{science}}{4}$$

$$\$_{structures} = \$1000 \times m_{structures}$$



# Thermal Expert

- In a typical study, the thermal experts will estimate the mass, power, and cost requirements for a conceptual design by developing a simplified thermal model of the design, typically in Thermal Desktop. By subjecting the model to the thermal loads seen at launch and in flight, the expert can devise a system that will keep sensitive equipment operating in their ideal temperature ranges.
- For this exercise, use the equations below to estimate the thermal system's mass, cost, and power requirements. You will have to work with the other teams to get some of the values you'll need for your portion of the study.



$$p_{thermal}\,(W) = \frac{p_{avionics} + p_{science}}{4}$$

$$\$_{thermal} = \$12000 \times m_{thermal}$$

$$m_{thermal}\,(kg) = \frac{p_{thermal}}{100}$$

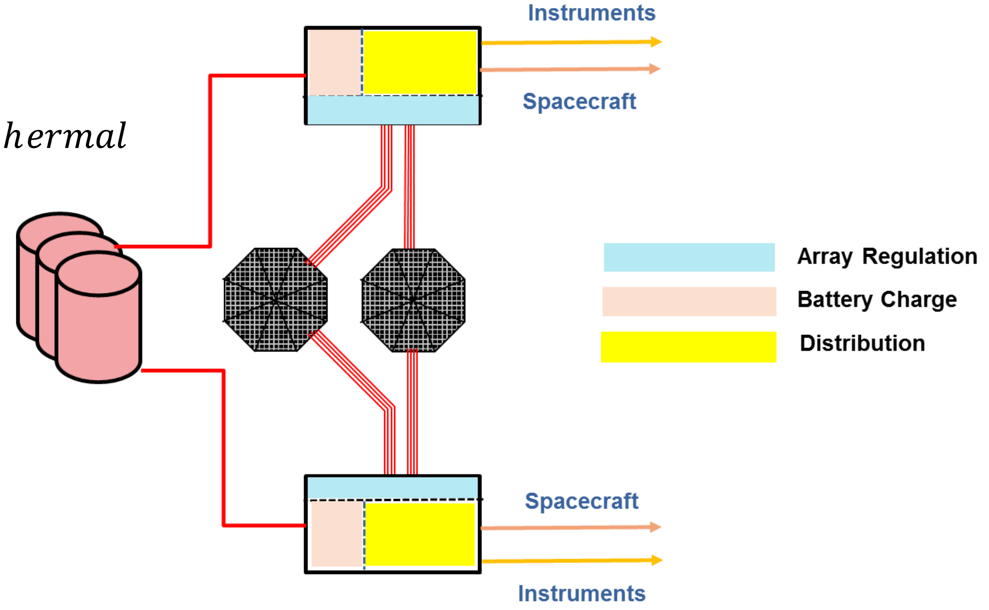
# Power Expert

- In a typical study, the power experts will select and size components that meet the power requirements for the science payload, avionics systems, and thermal control systems.
- For this exercise, use the equations below to estimate the power system's mass, cost, and power requirements. You will have to work with the other teams to get some of the values you'll need for your portion of the study.

$$p_{TOTAL}(W) = p_{avionics} + p_{science} + p_{thermal}$$

$$m_{power}\,(kg) = \frac{p_{TOTAL}}{10}$$

$$\$_{power} = \$500 \times m_{power}$$

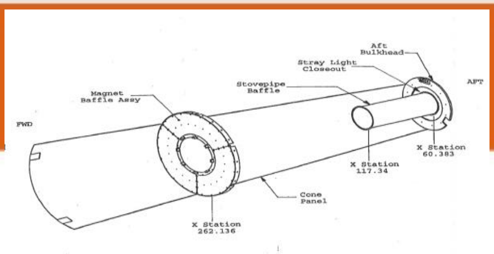


# Avionics Expert

- In a typical study, the avionics experts will select and size components that meet the avionics objectives.
- For this exercise, you will select one of five avionics packages, labeled A, B, C, D, and E. Each of the packages has a corresponding mass, power requirement, and cost. Each package also meets different objectives, listed as 1, 2, 3, 4, and 5. During the exercise you will have to justify your selection balancing the avionics objectives with their cost, mass, and power requirements. To meet the overall needs of the customer you may have to change the package you choose. You will have to inform the other groups of your decision.

| *Avionics Package* | $m_{avionics}$ *(kg)* | $p_{avionics}$ *(W)* | $\$_{avionics}$ *($)* | *Objectives Met* |
|---|---|---|---|---|
| *A* | 500 | 900 | $900,000 | 1,2,3,4,5 |
| *B* | 500 | 600 | $750,000 | 1,2,3,4 |
| *C* | 700 | 400 | $300,000 | 1,2,3 |
| *D* | 750 | 1000 | $250,000 | 1,2 |
| *E* | 1000 | 200 | $100,000 | 1 |

# Science Payload Expert

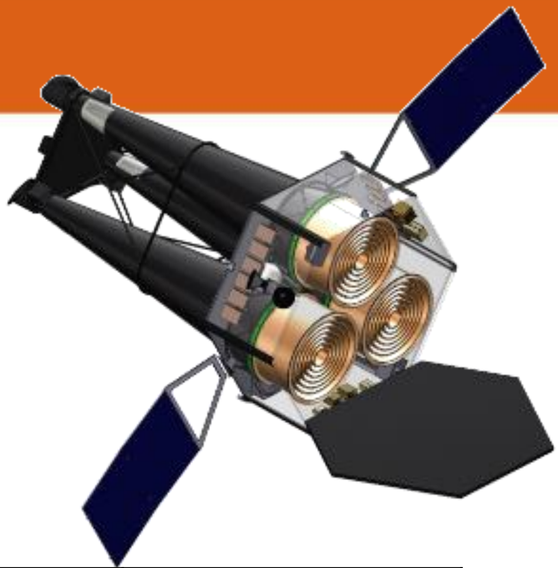



- **In a typical design study, ACO will work with the customer to define the science objectives. As the design becomes more mature, the customer may wish to modify the design to accomplish more science objectives.**
- **For this exercise, you will select one of five science packages, labeled A, B, C, D, and E. Each of the packages has a corresponding mass, power requirement, and cost. Each package also meets different objectives, listed as 1, 2, 3, 4, and 5. During the exercise you will have to justify your selection balancing the science objectives with their cost, mass, and power requirements. To meet the overall needs of the customer you may have to change the package you choose. You will have to inform the other groups of your decision.**

| *Science Payload* | $m_{science}$ *(kg)* | $p_{science}$ *(W)* | $\$_{science}$ *($)* | *Objectives Met* |
|---|---|---|---|---|
| *A* | 300 | 900 | $900,000 | 1,2,3,4,5 |
| *B* | 270 | 600 | $750,000 | 1,2,3,4 |
| *C* | 150 | 400 | $300,000 | 1,2,3 |
| *D* | 110 | 1000 | $250,000 | 1,2 |
| *E* | 200 | 200 | $100,000 | 1 |

# Exercise 1

- Find a solution. No subsystem constraints, meet all the science objectives.



| | | | |
|---|---|---|---|
| Science Payload | | | |
| Avionics Package | | | |
| System | $m_{system}$ | $p_{system}$ | $\$_{system}$ |
| Structures | | N/A | |
| Thermal | | | |
| Power | | N/A | |
| Avionics | | | |
| Science | | | |
| Total | | | |

# Exercise 2

- **Find a solution. Minimize the total mass of the system.**

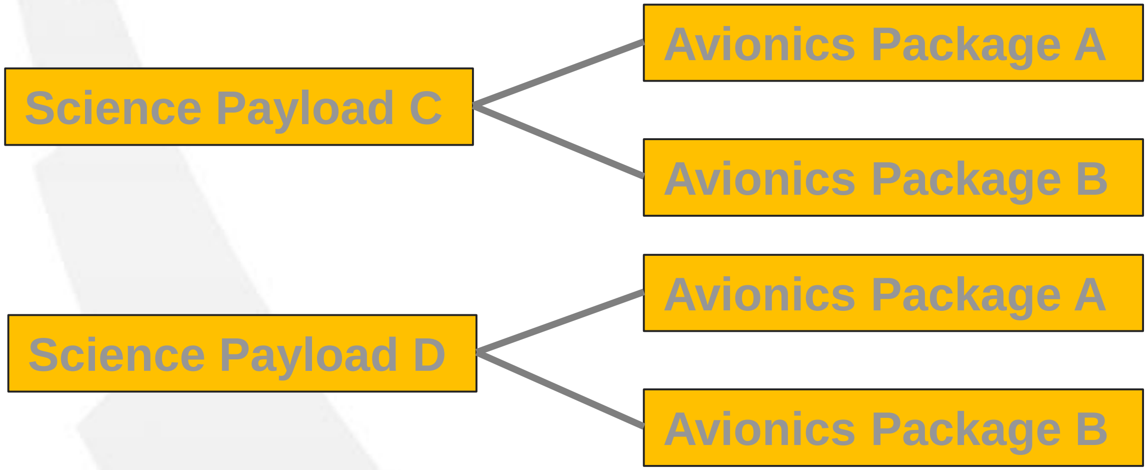
| | | | |
|---|---|---|---|
| Science Payload | | | |
| Avionics Package | | | |
| System | $m_{system}$ | $p_{system}$ | $\$_{system}$ |
| Structures | | N/A | |
| Thermal | | | |
| Power | | N/A | |
| Avionics | | | |
| Science | | | |
| Total | | | |

# Exercise 2

- **Find a solution. Minimize the total mass of the system.**

## HINT : Use a Trade-Tree to identify Options

**Low Mass Science Options** | **Low Mass Avionics Options**




Draft – 050616 – Work In Progress

# Exercise 3

- **Total power can't be any more than 1.4 kW. Design a system that meets the most science objectives.**

| | | | |
|---|---|---|---|
| Science Payload | | | |
| Avionics Package | | | |
| **System** | $m_{system}$ | $p_{system}$ | $\$_{system}$ |
| Structures | | N/A | |
| Thermal | | | |
| Power | | N/A | |
| Avionics | | | |
| Science | | | |
| Total | | | |

# Aeronautics ... The First "A" in NASA


*Practical Aeronautics, Inc.*
*P.O. Box 461434*
*Aurora, Colorado 80046*

*(719) 659-7319*
*PracticalAero.com*

# Language of Aerodynamics

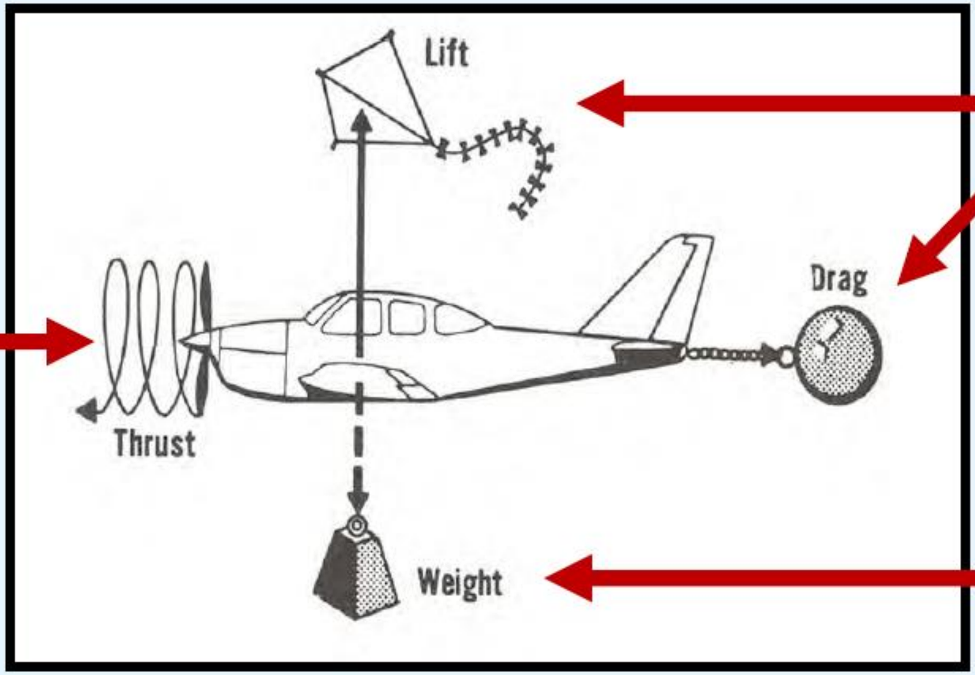
- Aerodynamics … the science dealing with the flow of air
- Let's introduce the terminology ...


- F-15 and Boeing 737

# Four Forces Acting on an Airplane

- **Force (F) ⇨ push or pull acting upon an object -- in our case, an airplane**

***Lift (L) and Drag (D) are aerodynamic forces***

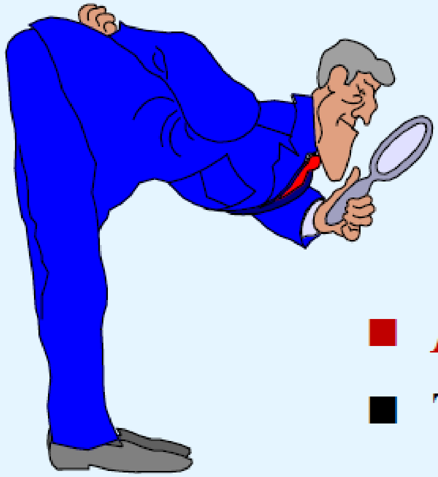



***Propulsion system provides Thrust (T)***

***Force due to gravity is Weight (W)***

# Temperature (T) and Pressure (p)

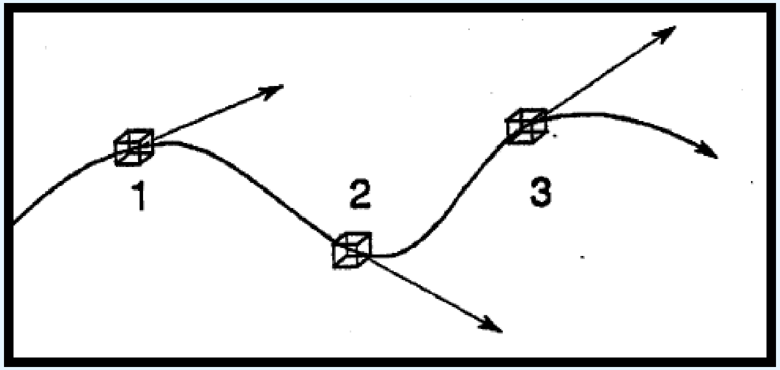
- Temperature (T) ⇨ measure of how fast the air molecules are moving
- Pressure (p) ⇨ due to molecular collisions ...
  - When a nitrogen molecule (for example) collides with a surface, momentum is exchanged and a force is generated on that surface
  - Pressure acts perpendicular to the surface

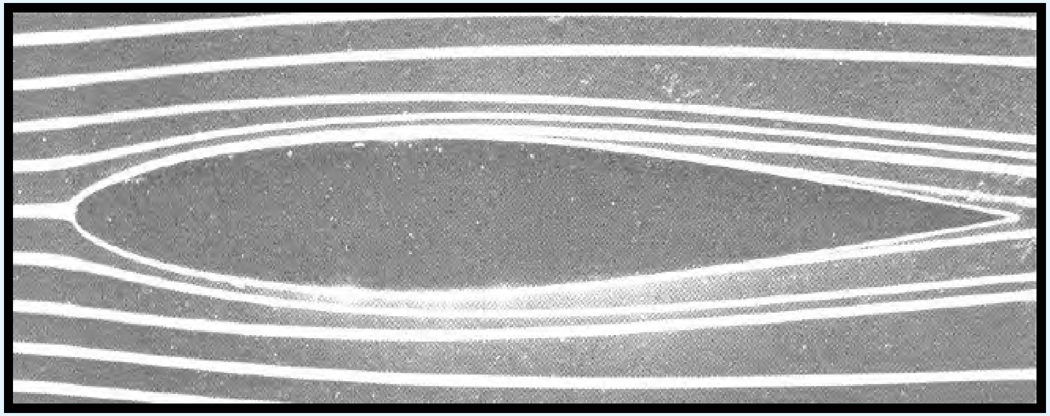


- *Pressure (p) and temperature (T) are directly related*
- The harder the impact (high T), the higher the pressure

# Flow Velocity (V) and Streamlines

- *Velocity ⇨ magnitude (speed) plus direction* … it is a "vector"
- Velocity can change (magnitude and/or direction) in the "flow field" surrounding a body
- Streamline ⇨ shows path the fluid follows … velocity vector is tangent at each point along a streamline

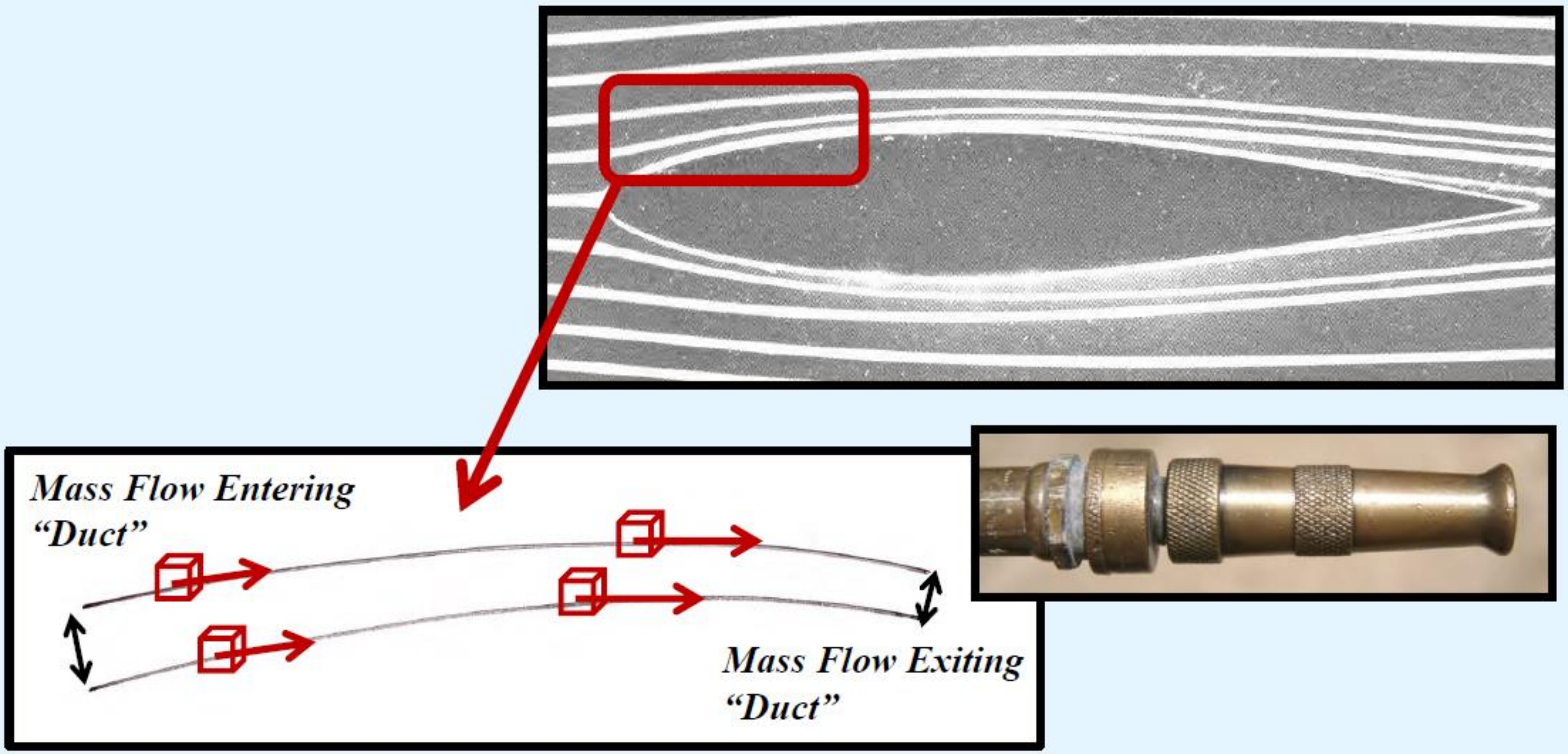


- Streamlines passing around an "airfoil" or cross section of a wing (more later)
- *An Album of Fluid Motion*
- ONERA photo by Werle

# Interpreting Streamline Patterns …

- **Mass is conserved between streamlines …**
  - ***Converging streamlines (see below) ⇨ velocity is increasing***
  - ***Diverging streamlines ⇨ velocity is decreasing***

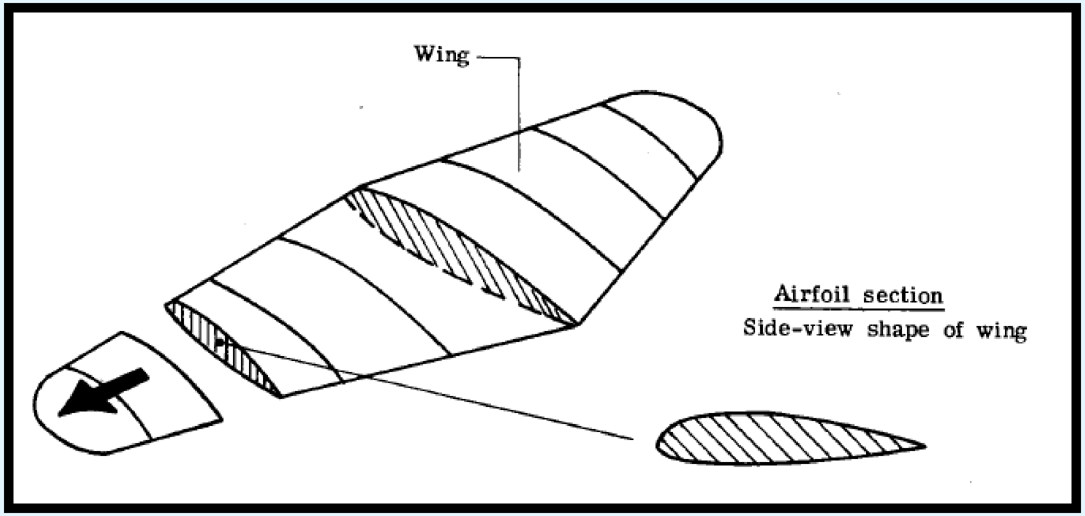


# Relationship Between Velocity and Pressure

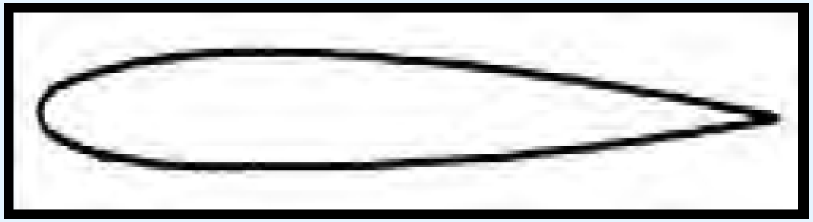
- Using Newton's 2nd Law (a law of physics), Bernoulli showed velocity (V) and pressure (p) are inversely related
- *When velocity increases ⇨ pressure decreases*
- *When velocity decreases ⇨ pressure increases*

- Relationship called "Bernoulli's Principle"
- In 1738, Daniel Bernoulli published his work in *Hydrodynamics*

# More Language … Airfoil




- *An airfoil is a cross section of a wing*
- Cross section is parallel to x-z plane (defined later)

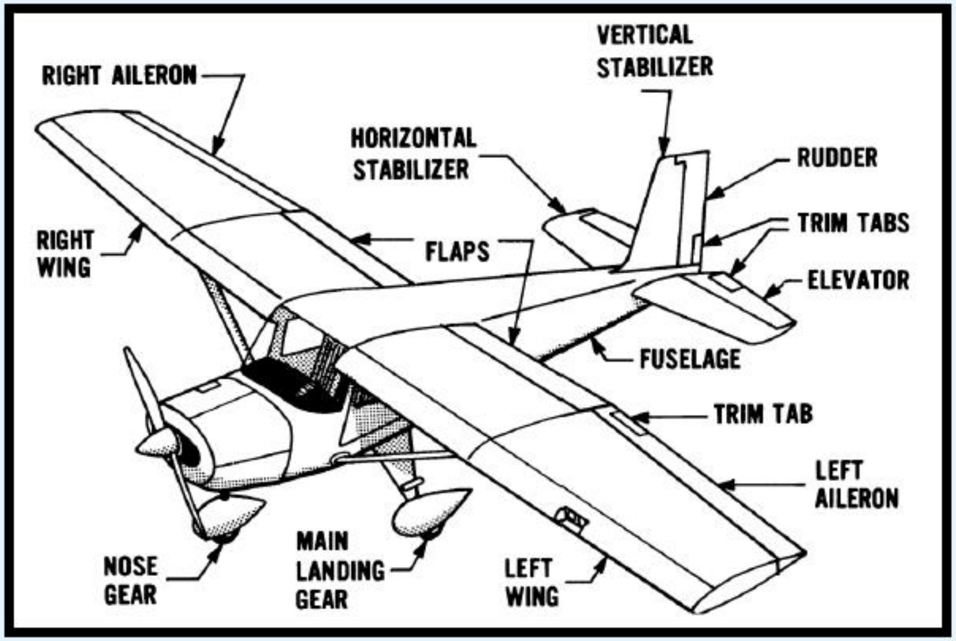


*Symmetric Airfoil*

*Cambered Airfoil*

# Airplane Components

- France had a strong influence on the language of aeronautics
- "Fuselage" ⇨ spindle-shaped
- "Empennage" ⇨ feathers of an arrow (below)
- "Aileron" ⇨ little wing

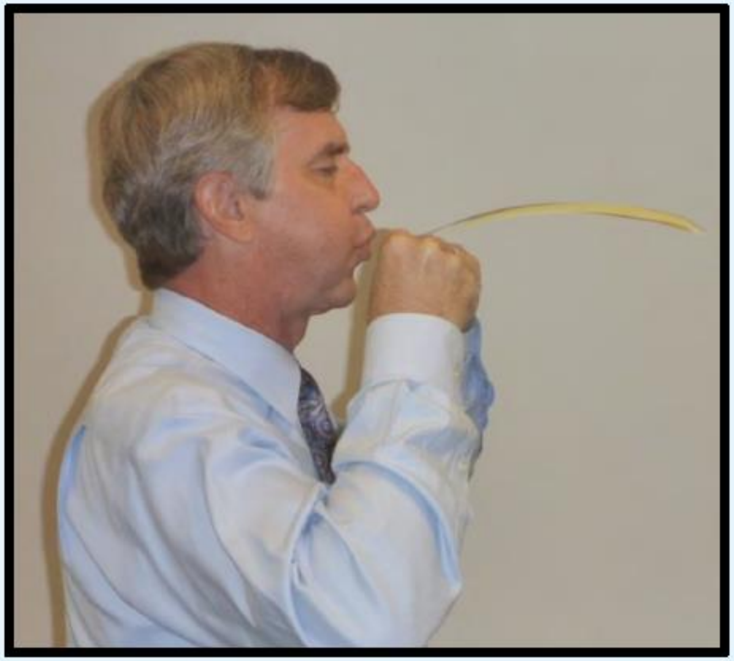




- "Tricycle" gear sketch from FAA's *Pilot's Handbook of Aeronautical Knowledge*
- "Taildragger" or "conventional" gear on Cessna 140

# Lift (L) -- An Aerodynamic Force

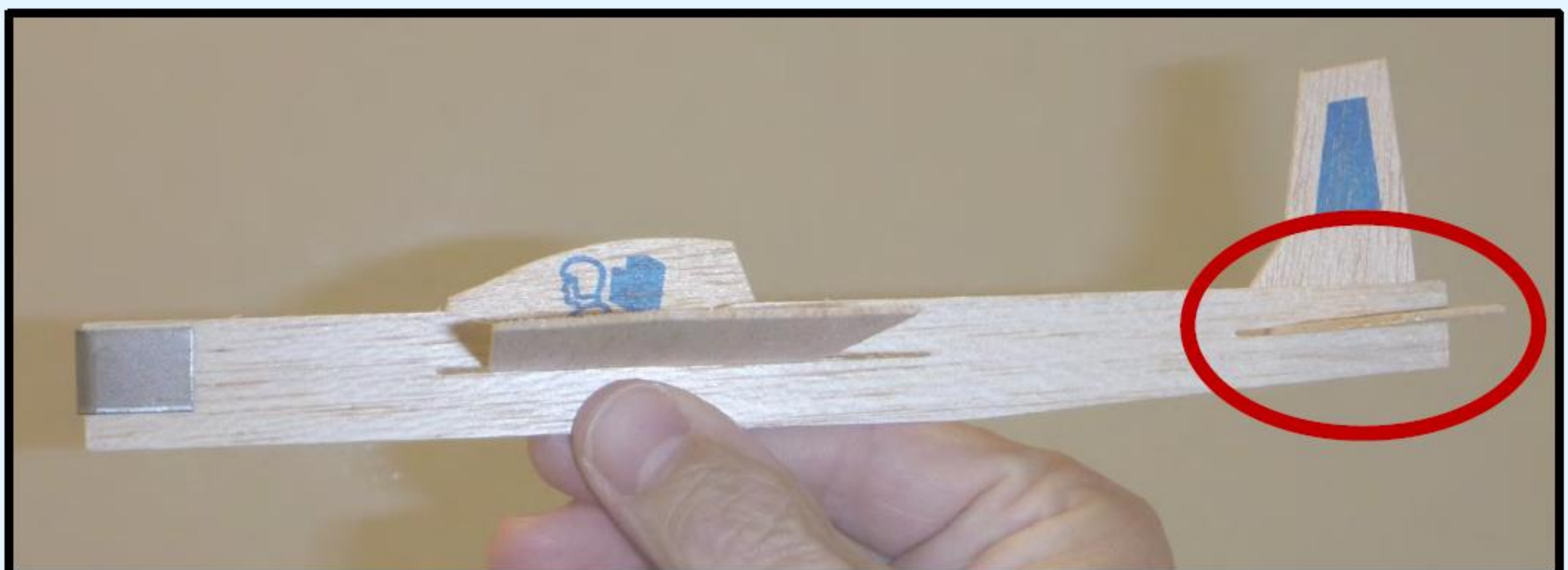
- **Application of Bernoulli's principle!**
- **Wings are shaped to cause air to move faster over the upper surface … the faster moving air exerts less pressure**
- ***Lift is generated by creating a pressure difference between the upper and lower surface of a "wing" ... low pressure on the top, high pressure on the bottom***



- **F-22A in a "pull-up"**
- **Recall … pressure and temperature are directly related**
- **Moisture in air condenses on upper surface due to low pressure and temperature**

# Your Glider

- How would you characterize its geometry?
- How does your glider generate lift?
- Hint ... examine the angle that the horizontal stabilizer makes to the fuselage



Name: ______________________________

Team: ______________________________

PRACTICAL AERONAUTICS

http://practicalaero.com/

**Goals for this morning:**
- Introduce some fundamental aerodynamic concepts
- Introduce basic test and analysis methods
- Have fun and be inspired!

With the help of your instructors and classmates, complete the following:

#1 – What is *aeronautics*?

#2 – What is *aerodynamics*?

#3 – What is air made out of?

#4 – What does air weigh?

#5 – What are three important properties of air (or any other *fluid*)?

#6 – What is a *force*?

#7 – What 4 forces act on powered airplanes?

#8 – Which two forces are *aerodynamic* forces?

#9 – Where does the force of *lift* come from?

#10 – What is an *airfoil* and what are two general types of airfoils?

SLS SPACE LAUNCH SYSTEM

-- Break -- (remove gliders from bags and *carefully* assemble them during the break)

#11 – What are the 4 primary components (pieces) of your glider?

#12 – What are the forces for an aircraft with no thrust like your glider?

#13 – What is the airplane designer trying to do about lift and drag?

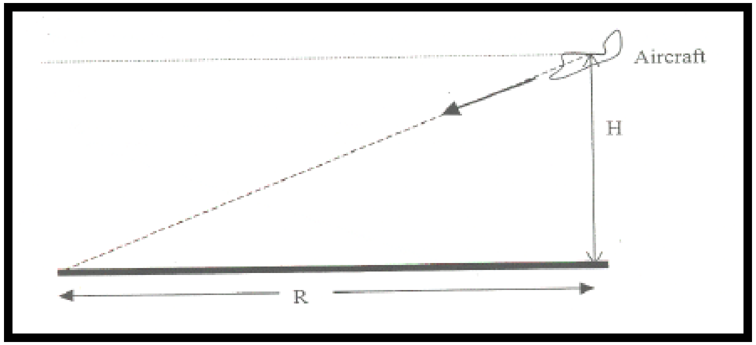
#14 – What is the *glide ratio* and why is it important to pilots?

#15 – What are the 3 rotational motions of an airplane?

#16 – How do you get your glider to fly straight?

#17 – How can you experimentally determine the maximum glide ratio for an airplane?
HINT: See the diagram below.

#18 – Each team will do some test flights to find the glide performance of their balsa glider by calculating the ***glide ratio*** (the glide range R divided it by the glide height H). Afterwards, each group will describe to the class their results and their test & analysis methods. Use the table below.



Glider Flight Test Data Card

Team: ______________________________

**Test Equipment:**
- One glider per team as the test item
- Tape measure, masking tape, and calculator

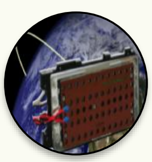
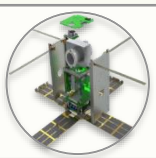
**Test Report Will Include:**
- Your team's test methods
- A summary of the data you collected and how you decided on your overall Test Result
- Test Result – the glide ratio (one number) for your glider!

| Test Run Number | Release Height H (ft) | Glide Range R (ft) | Glide Ratio R/H |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |

Test Result: ______________________________

# EM-1 Secondary Payload Selection

- **19 NASA center-led concepts were evaluated and 3 were down-selected for further refinement by AES toward a Mission Concept Review (MCR) planned for August 2014**
- **Primary selection criteria:**
  - Relevance to Space Exploration Strategic Knowledge Gaps (SKGs)
  - Life cycle cost
  - Synergistic use of previously demonstrated technologies
  - Optimal use of available civil servant workforce

| **Payload** *NASA Centers* | **Strategic Knowledge Gaps Addressed** | **Mission Concept** |
|---|---|---|
| **BioSentinel** ***ARC****/JSC*  | **Human health/performance in high-radiation space environments** • Fundamental effects on biological systems of ionizing radiation in space environments | Study radiation-induced DNA damage of live organisms in cis-lunar space; correlate with measurements on ISS and Earth |
| **Lunar Flashlight** ***JPL****/MSFC/MHS*  | **Lunar resource potential** • Quantity and distribution of water and other volatiles in lunar cold traps | Locate ice deposits in the Moon's permanently shadowed craters |
| **Near Earth Asteroid (NEA) Scout** ***MSFC****/JPL*  | **NEA Characterization** • NEA size, rotation state (rate/pole position) **How to work on and interact with NEA surface** • NEA surface mechanical properties | Slow flyby/rendezvous and characterize one NEA in a way that is relevant to human exploration |

# EM-1: Near Earth Asteroid (NEA) Scout concept

**WHY NEA Scout?**

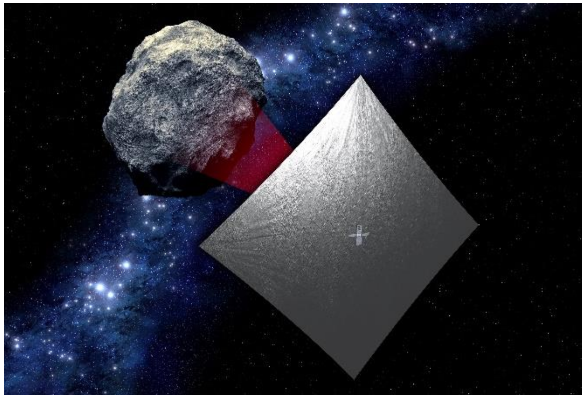
- Characterize a NEA with an imager to address key Strategic Knowledge Gaps (SKGs)
- Demonstrates low cost reconnaissance capability for HEOMD (6U CubeSat)

**LEVERAGES:**

- Solar sail development expertise (NanoSail-D, Sunjammer, LightSail-1)
- CubeSat developments and standards (INSPIRE, University & Industry experience)
- Synergies with Lunar Flashlight are in review (Cubesat bus, solar sail, communication system, integration & test, operations)

**MEASUREMENTS:** *NEA volume, spectral type, spin mode and orbital properties, address key physical and regolith mechanical SKG*

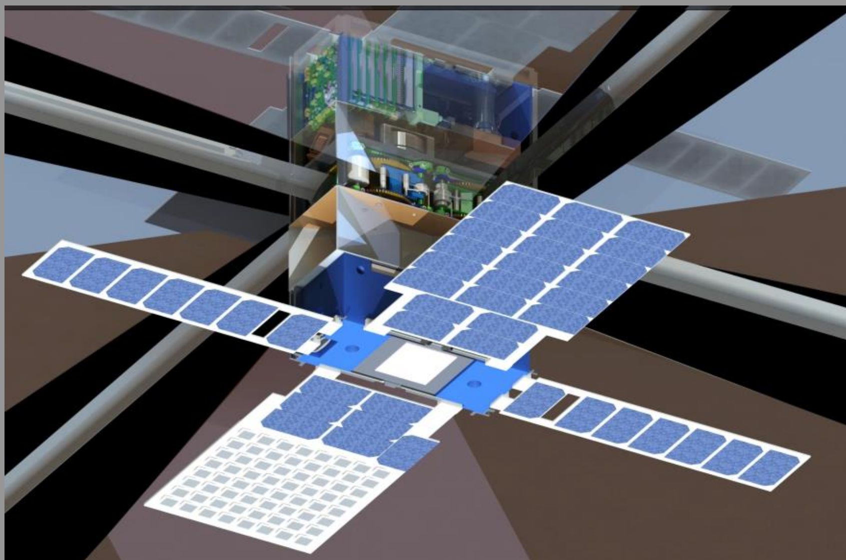
- ≥80% surface coverage imaging at ≤50 cm/px
- Spectral range: 400-900 nm (incl. 4 color channels)
- ≥30% surface coverage imaging at ≤10 cm/px



**Key Technical Constraints**:

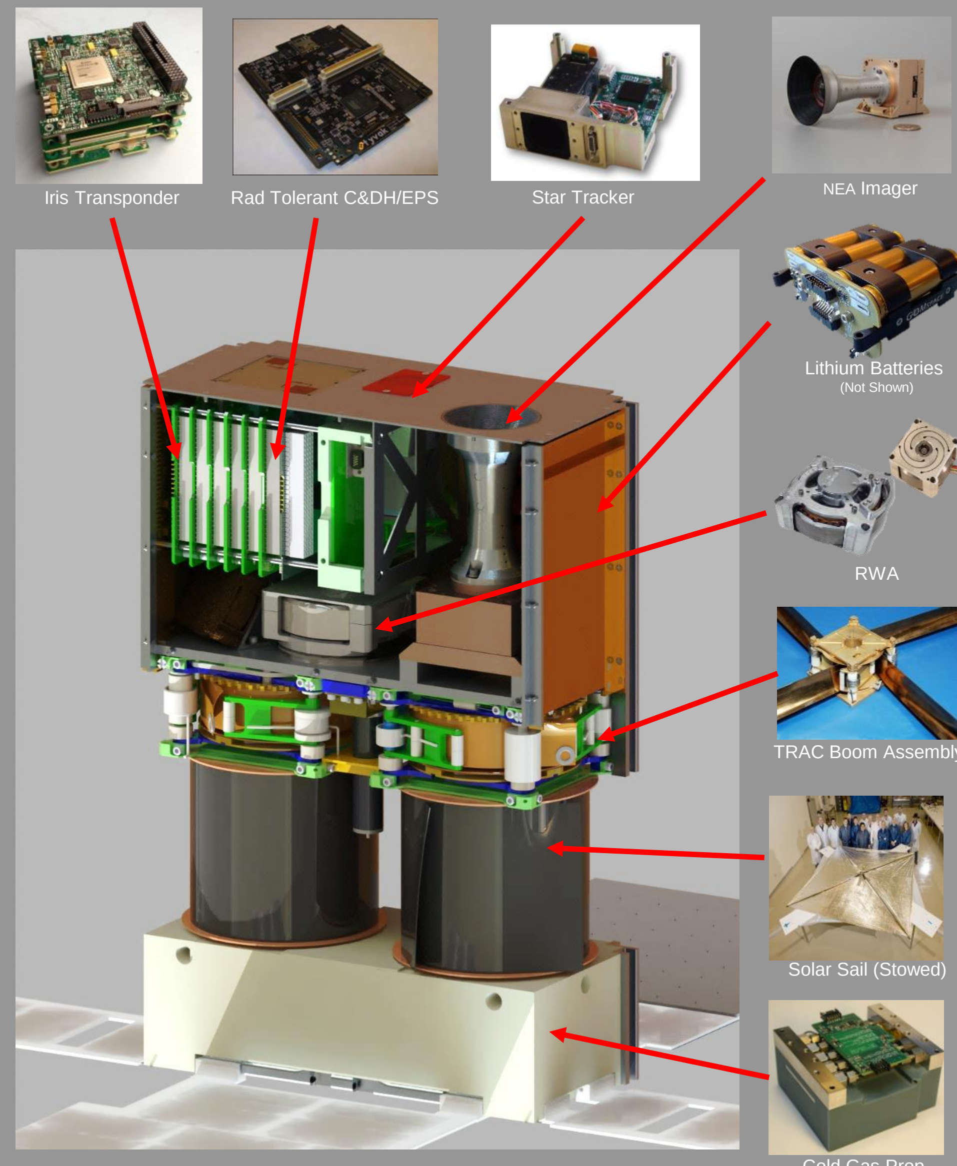
- 6U Cubesat and ~80 $m^2$ sail to leverage commonalities with Lunar Flashlight, expected deployer compatibility and optimize cost
- Target must be within ~1 AU distance from Earth due to telecom limitations
- Slow flyby with target-relative navigation on close approach

# NEA Scout Flight System Overview



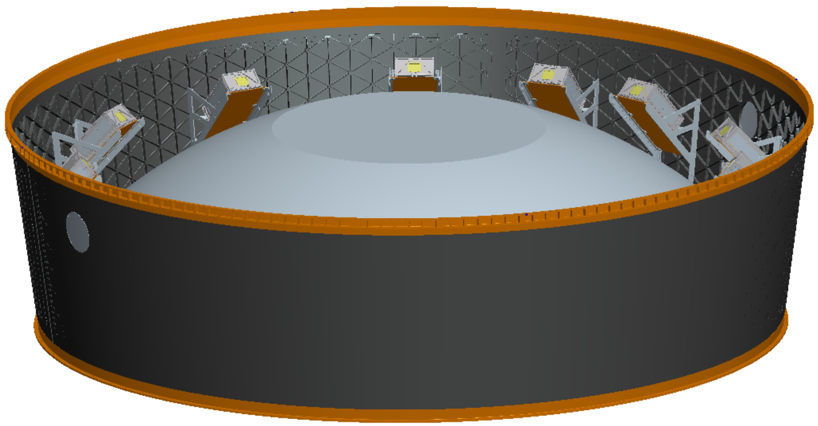
Deployed Configuration

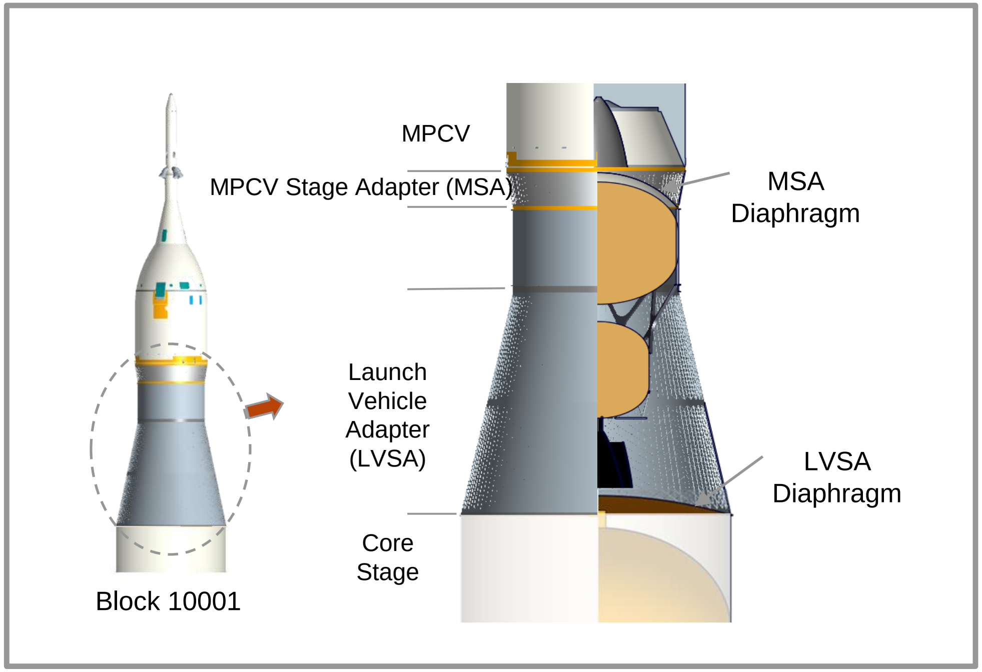
**Bus:** JPL Deep Space NanoSat Bus (based on INSPIRE)
**Propulsion:** MSFC ~80 $m^2$ Solar Sail (based on NanoSail-D)
**Payload:** COTS NEA Imager, e.g. MSSS ECAM M-50
**Command & Data Sys.:** Radiation tolerant LEON3 architecture
**Attitude Control:** 3-Axis Control (Zero-momentum spin cruise)
**Electrical Power:** ~35W (@1 AU) solar panels
**Telecom:** JPL Iris, Inspire LGA (2 Pair) + Microstrip Array HGA



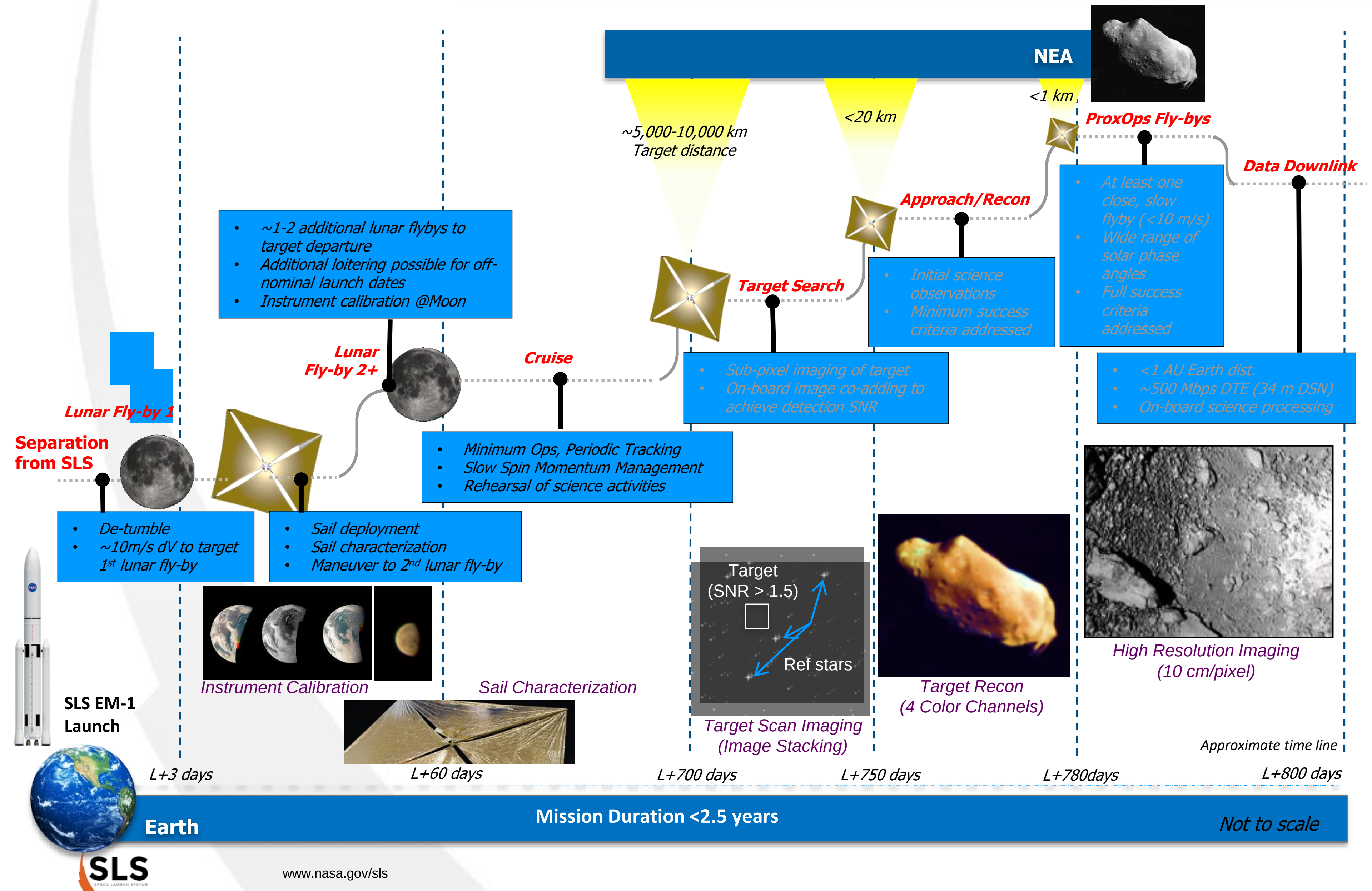
# SLS Integration

- Notional Launch on SLS EM-1 (July 2018)
- Secondary payloads will be integrated on the MPCV stage adapter (MSA) on the SLS upper stage.
- Secondary payloads will be deployed on a trans-lunar trajectory after the upper stage disposal maneuver.

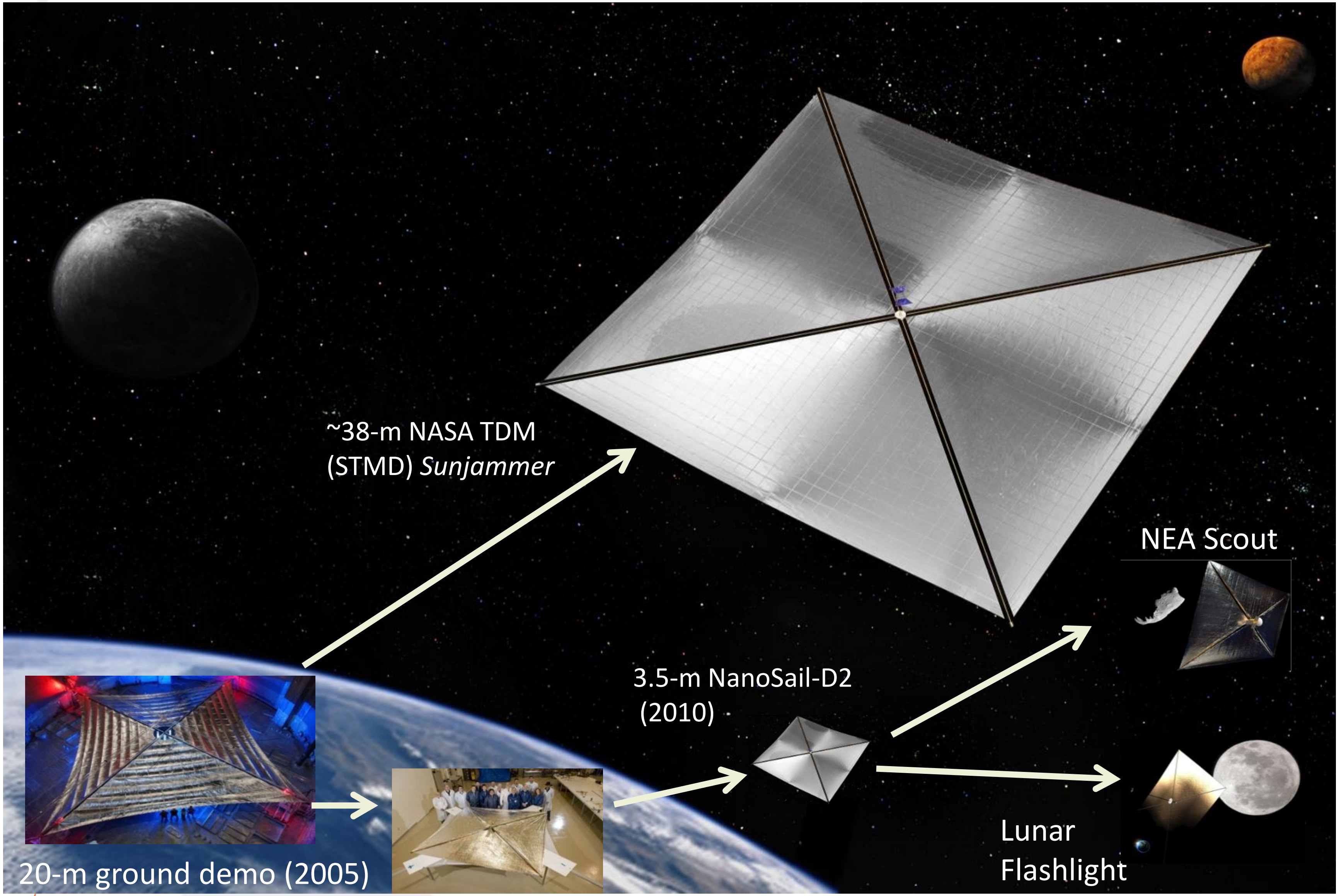




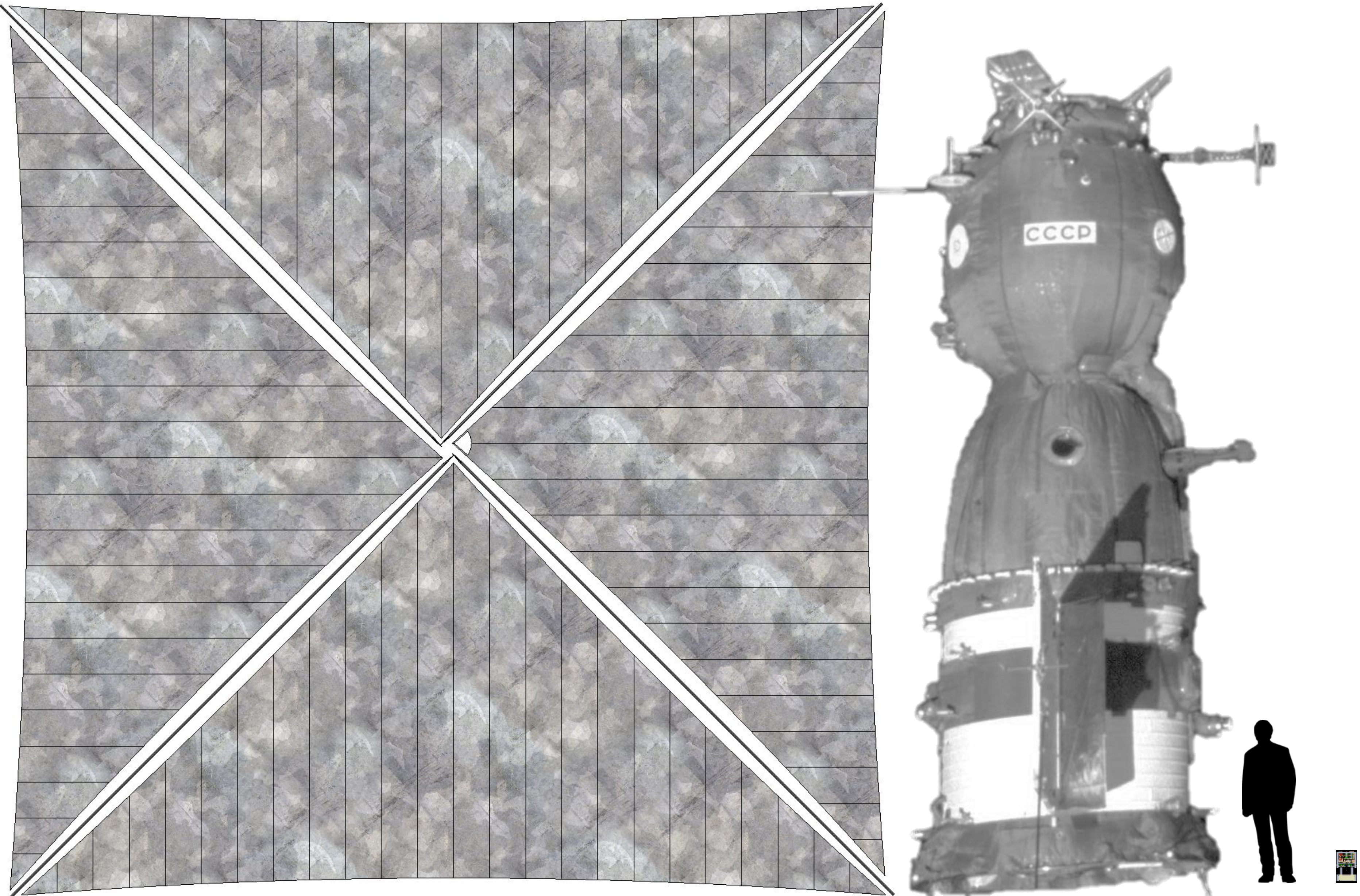
# NEA Scout ConOps Summary



# Solar Sail Development History

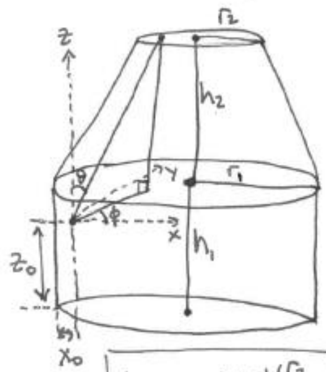


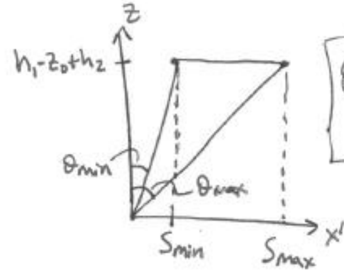
# Approximate Scale



# NASA Mathematics Lab

Secondary payload/Avionics box Geometrical factor calculation



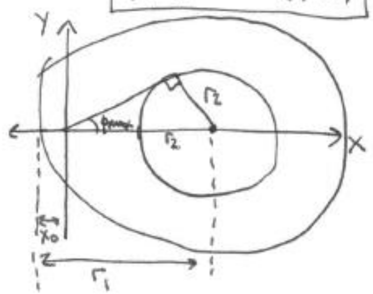

$$\theta_{\substack{min\\max}} = \tan^{-1}\left(\frac{S_{\substack{min\\max}}}{h_1+h_2-z_0}\right)$$

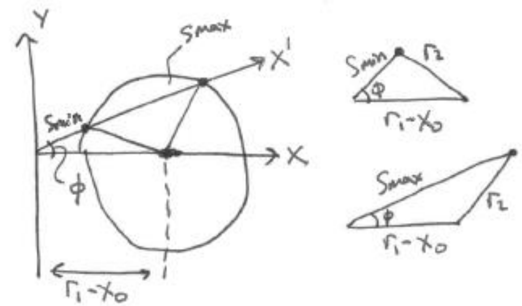
Parameters:

$h_1 =$ $r_1 =$

$h_2 =$ $r_2 =$

$$\phi_{max} = \sin^{-1}\left(\frac{r_2}{r_1-x_0}\right)$$




$$r_2^2 = S^2 + (r_1-x_0)^2 - 2S(r_1-x_0)\cos\phi$$

$$\Rightarrow S = (r_1-x_0)\cos\phi \pm \sqrt{(r_1-x_0)^2\cos^2\phi - \{(r_1-x_0)^2 - r_2^2\}}$$

$$S_{\substack{max\\min}} = (r_1-x_0)\cos\phi \pm \sqrt{r_2^2 - (r_1-x_0)^2\sin^2\phi}$$

% of space visible

$$= \frac{1}{4\pi}\int_{-\phi_{max}}^{\phi_{max}} d\phi \int_{\theta_{min}(\phi)}^{\theta_{max}(\phi)} d\theta \sin\theta$$

$$= \frac{-1}{2\pi}\int_0^{\phi_{max}} d\phi \cos\theta \Big|_{\theta_{min}}^{\theta_{max}} = \frac{1}{2\pi}\int_0^{\phi_{max}} d\phi \left(\cos\left(\tan^{-1}\left(\frac{S_{min}}{h_1+h_2-z_0}\right)\right) - \cos\left(\tan^{-1}\left(\frac{S_{max}}{h_1+h_2-z_0}\right)\right)\right)$$

Note: $\cos(\tan^{-1}(x)) = \frac{1}{\sqrt{1+x^2}}$

$$\therefore = \frac{1}{2\pi}\int_0^{\sin^{-1}\left(\frac{r_2}{r_1-x_0}\right)} d\phi \left\{\left[1+\left(\frac{(r_1-x_0)\cos\phi - \sqrt{r_2^2-(r_1-x_0)^2\sin^2\phi}}{h_1+h_2-z_0}\right)^2\right]^{-1/2} - \left[1+\left(\frac{(r_1-x_0)\cos\phi + \sqrt{r_2^2-(r_1-x_0)^2\sin^2\phi}}{h_1+h_2-z_0}\right)^2\right]^{-1/2}\right\}$$