Space Exploration Systems
Its Place in Lockheed Martin and Its Roles in Exploring the Solar System

2014 International Workshop on Small Satellite and Sensor Technology for Disaster Management (SSTDM)
March 31 – April 2, 2014
Indian Institute of Science (IISc)
Center of Nano Science and Technology Building
Bangalore, India

Wanda Sigur
Lockheed Martin Space Systems Company
Ethics

Our Vision
• Powered by innovation, guided by integrity, we help our customers achieve their most challenging goals

Value Delivery
• Improving security, enhancing quality of life and expanding human knowledge through the application of space technology

Our Value Statements
• Do what’s right
• Respect others
• Perform with excellence
The Men and Women of Lockheed Martin

- 115,000 employees
- 60,000 scientists, engineers and IT professionals
- 500 + facilities across the U.S.
- And operating in 70 countries

Partners helping customers achieve their goals
Space Systems Company Locations

Bangor, WA
- FBM IA&T

Livermore, CA
- Sandia National Labs

Sunnyvale, CA (7,557)
- Solar Array MFG
- Comprehensive Space Vehicle I&T

Palo Alto, CA
- Advanced Tech. Ctr

Santa Cruz, CA
- Test Support

VAFB, CA
Western Launch Range
- Launch Operations

El Segundo, CA
- MILSATCOM

Kauai, HI
- PMRF

Albuquerque, NM
- Sandia Nat’l Labs
- Targets

White Sands, NM
- Missile Range

Denver, CO (3,874)
- Rocket Propulsion Testing
- CHIL
- Comprehensive Space Vehicle I&T
- Space Ops Simulation Center
- Mission Support Area

Louisville, CO
- Coherent Technologies

Centennial, CO
- United Launch Alliance

Houston, TX
- Orion
- United Space Alliance

Stennis, MS
- Propulsion MFG
- Thermal Protection

Michoud, LA
- Orion Structures MFG

KSC/CCAFS, FL (594)
- Eastern Launch Range
- Orion A&T

Valley Forge, PA
- Reentry Systems

Newtown, PA (1,467)
- Commercial Space
- RF & Antenna MFG
- AF Reentry Systems MFG

Arlington, VA
- Washington Operations

Courtland, AL
- Targets & Countermeasures Production

Huntsville, AL
- Missile Defense
- Targets and Counter Measures MFG & Test

Kings Bay, GA
- FBM IA&T

Helensburgh, Scotland
- Trident strategic weapon system engineering & maintenance

**Broad and deep competencies enlivened by a diverse program base**
Space Systems Company Portfolio

Strategic & Missile Defense
- Advanced Programs
- Strategic Missiles
- Missile Defense

Civil Space
- Human Exploration
- Planetary Exploration
- Weather & Environment

Military Space
- Protected Comms
- Narrowband Comms
- Navigation
- Weather
- Early Warning

Special Programs

Commercial Ventures
- Remote Sensing
- Commercial SATCOM
- Wind Energy Management

Advanced Technology
- Optics, RF & Photonics
- Space Sciences and Instruments
Space Systems Mission Facts

Lift
- Over 100 consecutive successful Atlas launches
- Delivery to all orbit regimes

Payloads
- More than 310 payloads over the last 50 years
- 84 payloads, 10 hosted payloads since 2000

Spacecraft
- Built over 800 satellites in 50 years
- 10 year 99% Mission Success rate

Missiles
- 144 successful Trident II D5 missile tests since 1989
- 10-for-10 THAAD intercepts since 2006
Civil Space

Expanding the frontiers of space exploration and Earth observation

- Human space exploration
- Robotic deep space exploration
- Mars orbiters and landers
- Weather and environmental sensing
- Advanced Programs – exploring new frontiers

Image courtesy of NASA
Military Space

Delivering critical national security space capability

- Protected military communications
- Mobile military communications
- Global positioning systems
- Space-based surveillance
Commercial Ventures

Meeting the needs of the global commercial market for space-related products and services

- Commercial satellite telecommunications
- Commercial remote sensing
- Wind energy management
- New technology and business model applications
Lift

• Entrusted with our nation’s most critical assets
• Launched an annualized value exceeding $2.5B/year over the last five years
• Unmatched performance, accuracy and reliability
World Class Facilities

Core infrastructure in place to execute space-based missions

Decades of industry and government investment
Full-Cycle Model Based Enterprise (MBE)

Understanding and exploring complex systems before they are built

- Rapid development to improve responsiveness, productivity, quality and affordability
- Visual evaluation of design concepts over the entire product lifecycle
- Validate, integrate and operate test designs through wholly immersive simulations
- Comprehensive visual work instructions

CANEUS SSTDM 2014
Advanced Technology Center

Harnessing technologies that enable the future

• Focus on customers’ demanding requirements
• Expertise across numerous technologies
• Integrated multidisciplinary approach
• Solar and space physics instrumentation
Advanced Technology Development

Innovative technologies that enable current and future missions

- Nanotechnology
- Optics & Electro-Optics
- Telecommunications
- Modeling & Simulation
- Phenomenology
- Precision Pointing & Control
- Materials

Continual investment in leading edge technologies
Lockheed Martin's
Solar System Exploration
“If you want a nation to have space exploration ambitions, you've got to send humans.”

Neil deGrasse Tyson
How Hard Could It Be?

If Earth was the size of a Classroom Globe, ISS is ¼” away

If Earth was the size of a Classroom Globe, ISS is ¼” away

International Space Station (ISS)
460 km

& the moon is at 50 yd...

Moon
384,000 km
X 835

Asteroids
5,000,000 km
X 10,870

Low-Earth Orbit (LEO)

Cis-Lunar Space
Environment to test and prove exploration capabilities and operations

Mars is 10 mi away!

Mars
55,700,000 km
x 121,100

Deep Space
Human journeys of exploration and discovery, taking us farther into space than ever before
Stepping Stones

A series of exploration missions building incrementally towards the long term goal of exploring Mars.

Each mission will address science objectives relating to the formation of the solar system and the origins of life.

- **2016**
  - Asteroid survey

- **2017**
  - Asteroid scout
  - SLS test flight

- **2023**
  - Deimos scout

- **2024, 2025, 2029**
  - Plymouth Rock: Humans explore asteroids like 1999 AO10 and 2000 SG344

- **2031 – 2035**
  - Red Rocks: explore Mars from Deimos

- **2018 – 2023**
  - L2 Farside: Explore the Moon’s far side from Earth-Moon L2 point

Deimos photo credit: NASA-JPL, UoA
Magellan

Launched in 1989

Produced most detailed surface & gravity maps of Venus ever captured. Tested Aerobraking

Credit: NASA/JPL
Stardust

Returned dust samples from a comet. Asteroid Flyby

Launched in 1999

Credit: NASA/JPL
Mars Odyssey

Launched in 2001
Martian longevity record

Provided Distribution of elements and radiation map. Landing site characterization. Search for water & Support for Mars rovers

Credit: NASA/JPL-Caltech
Mars Reconnaissance Orbiter

Launched in 2005
Data relay since Jul 2008

Future Landing site examination. High data rate communications relay.
20 – 30 cm resolution

Credit: NASA/JPL-Caltech
Phoenix

Launched in 2007
“Follow the water”

Confirmed ice in soil & atmospheric snow. Successful robotic arm digging & science operations
Mars Science Laboratory

Launch in 2011
Successful landing in Gale Crater

Study Mars' climate & geology, and collect data for a human mission to Mars
Objective:
Determine:
• Contribution of solar activity to atmospheric loss
• Loss of volatiles to space effect on Mars climate
• Current state of atmosphere
OSIRIS-Rex
(Origins Spectral Interpretation Resource Identification Security Regolith Explorer)

Objective:
Return 60 grams of Bennu asteroid regolith

Schedule:

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Launch</td>
<td>Sep 2016</td>
</tr>
<tr>
<td>Rendezvous</td>
<td>Jan 2020</td>
</tr>
<tr>
<td>EDL</td>
<td>Sep 2023</td>
</tr>
</tbody>
</table>
**Objective:**
Understand the formation and evolution of terrestrial planets through the interior structure and processes of Mars.

**Schedule:**
- **Launch**: Mar 2016
- **Rendezvous**: Sep 2016
- **EOM (End of Mission)**: Sep 2018
Exploration Systems

- Space Launch System (SLS)
- Orion Program
- Ground System Development
Deep Space Exploration Vehicle

The Orion MPCV will be capable of sustaining a crew of astronauts on deep-space missions – from 6 days (lunar flyby) to up to 900 days (Mars exploration) when paired with additional propulsion and habitation systems.
Orion

Launch Abort System
- Protection for the CM
- Jettison after first stage flight

Objective:
Take humans safely beyond LEO ...

... and return them safely back to Earth
Space Launch System

Objective:
Lift Crew & Cargo for Human Exploration
Working towards new opportunities for international collaboration