Germinating the 2050 Cis-Lunar Econosphere

Space 2100:
Projecting our future,
Pondering how it might evolve and what we might start doing now to help it,
Seeding a global discussion, and robusticizing MSFC in the process.

IEEE Aerospace Conference, Big Sky, MT
March 13, 2015

Presented by Jessica Gaskin, MSFC
On behalf of the Space 2100 team

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Late 2012 – MSFC Center Director wanted to engage employees at a grass roots level to shape and share unfettered, creative ideas about Marshall and NASA in the next century, far beyond and unfettered by any current strategic planning efforts.

Two primary goals:
- Grow fresh, futuristic ideas as described above
- Get folks out of their organizational cocoons, which can benefit day-to-day work as well

Guiding principles:
- Annual sprints - quick, conceptual exercises that stay very close to the surface. Within that context, maintain thoroughness and quality.
- The discussion itself and any resulting pollenation is just as important as any conclusions reached.
CAUTION

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(THAT SAID, WE THINK THERE’S STILL VERY GOOD STUFF IN HERE!)
WINTER 2013 SPRINT

Describe the future of space exploration and Marshall’s role in that future through the year 2100.

Define what will the world may look like in 2100? What technologies will be online? How will we be working? What grand challenges will the world be facing?

What might the world be doing in space in 2100? What is NASA's role? What pieces seem "naturally" Marshall?
Working Assumptions
From Now Through 2100

NASA and MSFC continue to exist

U.S. and world economic & political structures evolve rationally

No Technological Singularity

Oh, how could I forget?...

I cannot make ‘em glow blue yet, Captain. Give me another 100 years, give or take!

Houston... You have a problem!
How will the world and space work in 2100? What might NASA’s role be, and what pieces would fit MSFC?

(Process Flow)

X Team (Up to 15 years NASA Civil Service)

Independent Efforts

Y Team (> 15 years NASA Civil Service)

Compare Converge Refine

Present to MSFC Director

The sprint was primed by sharing a lot of articles via Explornet, MSFC’s internal social network

X-Y Characterization:

• Very similar conclusions about what 2100 looks like
• X modeled technology progress by considering historical and social influences
• Y projected based on history of technology
• The two approaches were not coordinated... they just happened!
Team X’s Lenses for Projecting to 2100

U.S. Constitution

Provide for the common defense
Promote the general welfare
Secure the blessings of liberty

Mapped these to NACA & NASA roles

Frontier Theory
Frederick Jackson Turner, 1893

A shifting frontier line between wilderness and settlement led to an innovative, aggressive, and independent mindset

American Generational Theory
Strauss & Howe, 1991

American history as a series of four ~20-year social or mood eras or “Turnings:”

| Crisis      | 1773 American Revolution | … | 2002 War on Terror, Financial |
| High       | 1792 Era of Good Feelings | … | 2027 Supra-national          |
| Awakening  | 1822 Transcendental      | … | 2052 Globalization           |
| Unraveling | 1845 Civil War           | … | 2077 New Colonial            |
Team Y’s Look Back - About 100 Years of Tech

Air travel, space exploration

Gigaflop computing

Nuclear energy

Global communications

Manufactured body parts, vaccines, antibiotics, molecular biology

Evolving understanding of the universe
Team Y’s Look Forward – Gamechangers Beyond 2100

(Breakthroughs are unpredictable, so we assumed conservative progress in these areas. While there could be huge advances by 2100, we didn’t bank on it. If there are, hang on and enjoy the ride!)

**Now**
- Orders of magnitude propulsion & speed increase
- Control of aging
- Superabundant, clean, inexpensive energy
- Human/Machine merging

**What**

**When?**

And when X and Y combined forces...
Earth Technology Themes in 2100

- **Information**: Instant, Immersive
- **Energy**: Abundant, Clean, Economical
- **Manufacturing**: Distributed, Additive
- **AI/Robotics**: AI Exceeds “Human Intelligence”
- **Health**: Disease Management
Earth Social Themes in 2100

Education
Highly Tailored to the Individual

Environment
Food, Water, Population, Climate

Political
Global Responsibility & Cooperation

Employment
Robotic Workforce, Engineering by AI

Security/Privacy
Individual Empowerment & Monitoring
Space Social Themes in 2100

Economics
Space Resources are Significant to Global Economy

International
Big Science, Regulatory & Terrestrial Threats

Exploration
Government, Industry, Academia & Personal

Colonization
Back up to Earth Civilization

Utilization
Significant Industry Presence & Operations in Inner System
Space Technology Themes in 2100
Derived from Earth 2100 Technologies

**Energy**
Carbon neutral, Space-Based Solar

**Manufacturing**
ISRU Based, Additive

**Transportation**
Nuclear, Deep Space
5 AU manned, 500 AU unmanned

**AI/Robotics**
Full Simulation Prior to Build
Robotic Assembly, Highly Autonomous Missions

**Health**
Radiation, Bone Loss Countermeasures
Advanced Habitation & Life Support
What Might NASA’s Role Include in 2100?

**Space industry support analogous to what NACA did for aeronautics** (e.g., low-mid TRL projects, mishap investigation, support diverse stakeholders)

**Push boundaries**
- Pursue breakthroughs in space-related knowledge, capabilities, and resources
- Conduct Exploration & Science where the business case doesn’t yet close

What Areas Seem “Naturally” MSFC?

- High risk, high payoff science & technology
- Inner solar system transportation technologies
- Self-supporting habitats & technologies
- Self-repairing, self-reproducing space systems
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<td><strong>Social Trends and Evolving Technologies</strong></td>
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<td>• Government/International Cooperation</td>
<td>• Energy Independence</td>
<td>• Fusion Economy</td>
<td>• Life-extending Medical Research and Technologies</td>
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<td>• Additive Manufacturing</td>
<td>• Streamlining of Government Processes</td>
<td>• Thorium power</td>
<td>• Self-Sustaining Outposts for Research and Long Duration Missions</td>
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<td>• DIY / Open Source Movement</td>
<td>• International Cooperation</td>
<td>• Growing Infrastructure for Space Economy</td>
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<td>• De-emphasis on Formal Education</td>
<td>• Global Market/Bazaar (Bidding for Common Resources)</td>
<td>• Suborbital Flights for Intercontinental Travel</td>
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<td>• Growth of Private Space Market</td>
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<td><strong>Opportunities enabled by evolving technologies and social trends</strong></td>
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<td>• Large Scale Launch Vehicles (SLS, SLS Block II)</td>
<td>• Renewable Energy Source and Production R&amp;D</td>
<td>• Leverage Advanced Space Propulsion Research for Power Generation Technology</td>
<td>• Robotic Missions for Interstellar Space Colony Construction</td>
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<td>• In-Space and Propulsion Technology Development</td>
<td>• International Collaboration on Large Scale Projects</td>
<td>• Provide Low-cost Access to Space for Academia and Small Business</td>
<td>• Enable Individual Research through Citizen Outreach and Partnerships</td>
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<td>• Cooperation with DoD, DoE, NOAA</td>
<td>• Asteroid Mining</td>
<td>• Build Rendezvous and Rescue Vehicles for Commercial Space Tourism/Commerce</td>
<td>• Inflatable, Low-Cost Payloads for Individual Research Initiatives</td>
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<td>• Additive Manufacturing</td>
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<td>• Support Private Space</td>
<td>• Define Constraints of Global Marketplace (e.g. Earth Orbits, Radio)</td>
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WINTER 2014 SPRINT

SCENARIO
It’s 2050.

Space tourism is thriving.
Multinational companies are mining.
Commercial lunar outposts are under construction.

We are NASA.

Space is open for business.
WINTER 2014 SPRINT

CHALLENGE
Outline NASA’s role in the space economy of 2050.
How do we enable commercial activity in space?
What practices are needed?
How do they differ from those today?
Consider commercial agreements, international partnerships, intellectual property, safety, security and regulations.
We are committed to economic success.

Space is open for business.
2050 Cis-Lunar Econosphere (CLE)
(Process Flow)

**Phase I**
- 2050 CLE Snapshot
  (More detail than 2014 Sprint)
  Members mostly from 2014 Sprint

**Phase II**
- How to Get There?
- Barriers and Enablers?
- What to Start Doing Now?
- Compare
- Converge
- Refine
- Present to MSFC Director
- All participants

Winter 2014 Sprint
The Technology issues to get to 2050 are relatively easy!
(or at least straightforward)

Diverse teams created their own culture:

Conversations flowed; standard processes were not followed

All ideas were built-upon ("plussing")

Terminology was simpler due to language differences (technical, law, business), and refreshed our memory of our own disciplines’ roots

Fear was broken down by accepting risk of “crazy” ideas
Phase 1 Results – A Snapshot of the “What”
Phase 2 Results - How We Might Germinate the 2050 CLE
aka “The Gear Chart”
In response to a request from NASA’s Advanced Exploration Office (AES), Space 2100 has pondered which technologies will be critical for totally self-sufficient exploration of the solar system (~60 years from now?), particularly those at the intersections of the three major categories below. (The index numbers refer to a “Top 30” list derived during the Sprint.)
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(THAT SAID, WE HOPE THAT A) YOU FOUND GREAT STUFF IN HERE, AND B) YOU’LL HELP GROW THE CONVERSATION!)