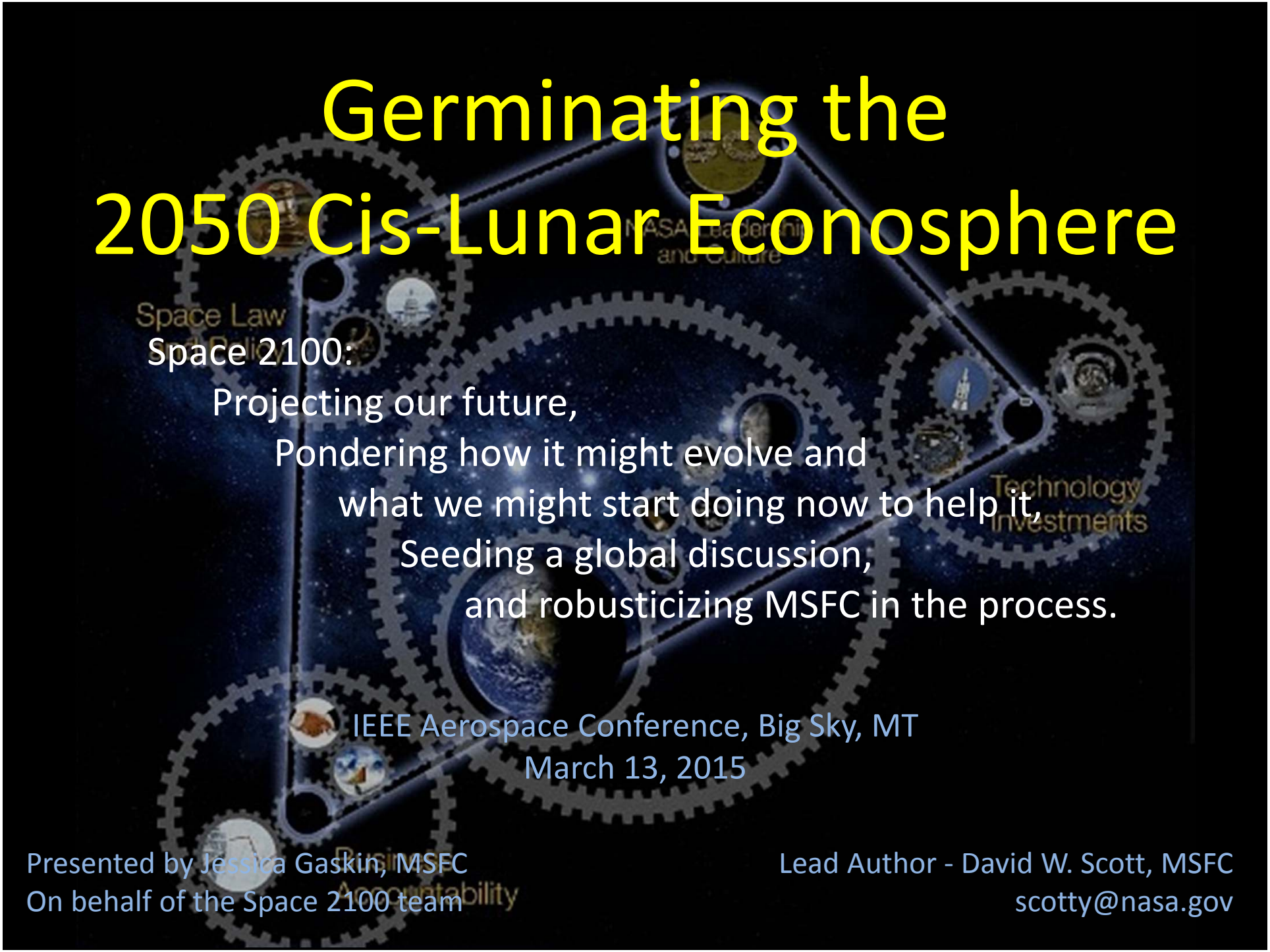
Germinating the 2050 Cis-Lunar Econosphere



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

Lead Author - David W. Scott, MSFC
scotty@nasa.gov

SPACE 2100 ORIGINS

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

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

Oh, how could I forget?…

or similar man-made crisis

and

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?

Winter 2013 Sprint

(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

Most participants from technical organizations

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

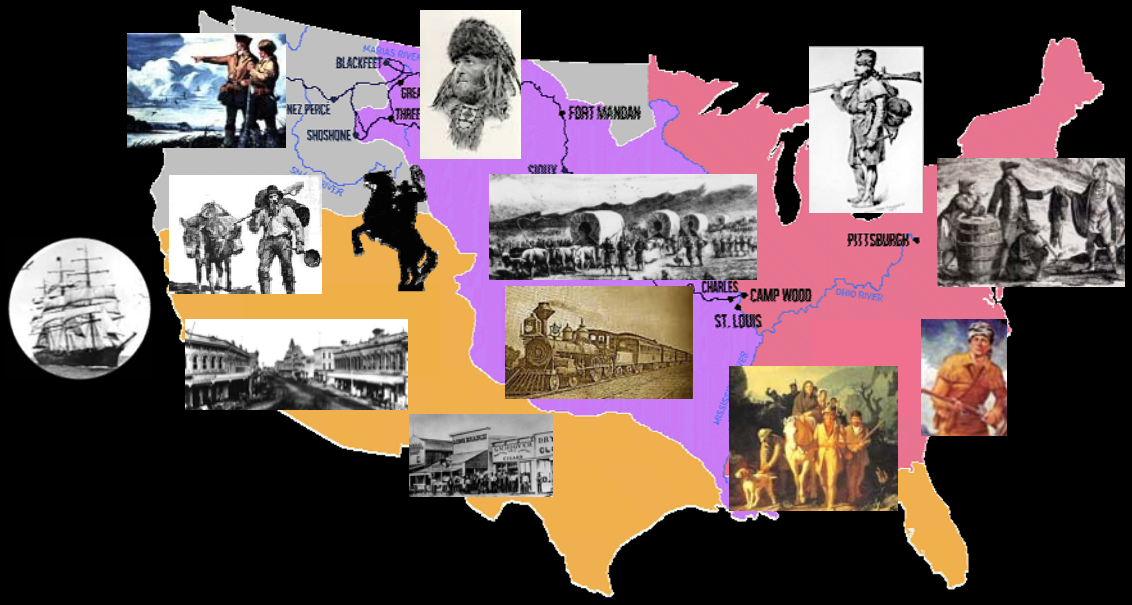
U.S. Constitution

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

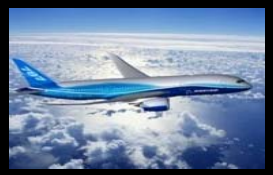
American Generational Theory

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

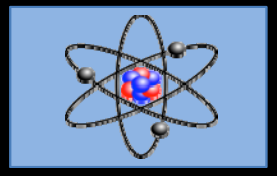



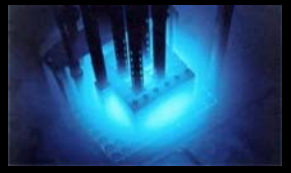

Air travel, space exploration





Gigaflop computing



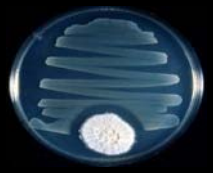
Nuclear energy





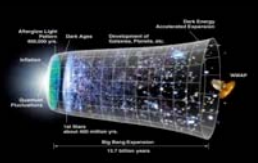
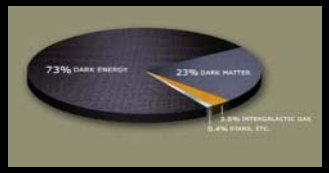

Global communications



Manufactured body parts, vaccines, antibiotics, molecular biology



Evolving understanding of the universe

Team Y's Look Forward – Gamechangers Beyond 2100

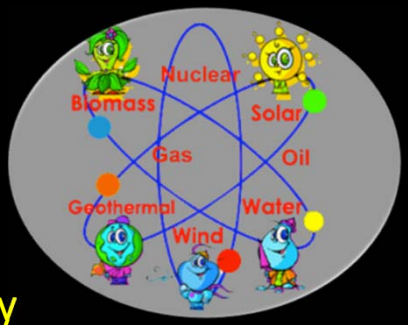
(Breakthroughs are unpredicatable, so we assumed conservative progress in these areas. While there *could* be huge advances by 2100, we didn't bank on it. If there are, hang on and enjoy the ride!)

Now	What	When?
	Orders of magnitude propulsion & speed increase	
 	Control of aging	
 	Superabundant, clean, inexpensive energy	 
	Human/Machine merging	

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

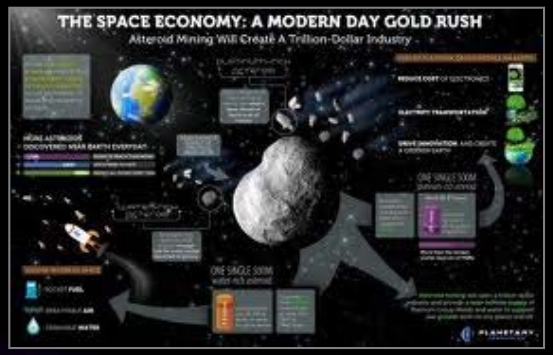
Employment
Robotic Workforce, Engineering by AI

Security/Privacy
Individual Empowerment & Monitoring

Space Social Themes in 2100

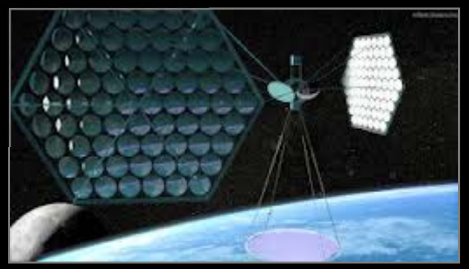
International
Big Science, Regulatory &Terrestrial Threats

Economics
Space Resources are Significant to Global Economy



Exploration
Government, Industry, Academia & Personal

Colonization
Back up to Earth Civilization



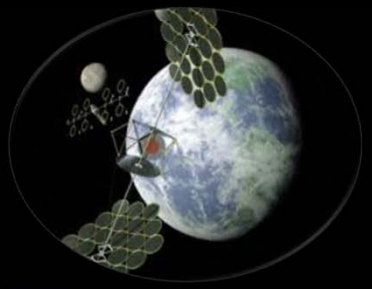
Utilization
Significant Industry Presence & Operations in Inner System

Space Technology Themes in 2100

Derived from Earth 2100 Technologies

Transportation

Nuclear, Deep Space
5 AU manned, 500 AU unmanned

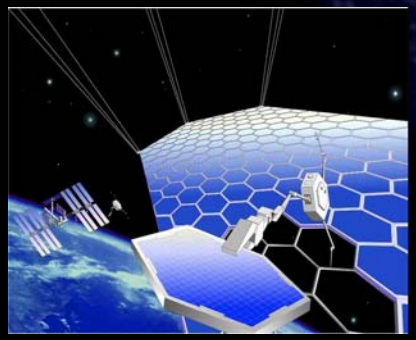


Energy

Carbon neutral,
Space-Based Solar

Manufacturing

ISRU Based, Additive



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?

Earth Situation	
Resource Limits	New Technologies
Space Situation	
Abundant Resources	Expanding Frontier

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

2000 - 2025	2025 - 2050	2050 - 2075	2075 - 2100

>> Social Trends and Evolving Technologies

- Government/International Cooperation
- Additive Manufacturing
- DIY / Open Source Movement
- De-emphasis on Formal Education
- Growth of Private Space Market

- Energy Independence
- Streamlining of Government Processes
- International Cooperation
- Global Market/Bazaar (Bidding for Common Resources)

- Fusion Economy
- Thorium power
- Growing Infrastructure for Space Economy
- Suborbital Flights for Intercontinental Travel

- Life-extending Medical Research and Technologies
- Self-Sustaining Outposts for Research and Long Duration Missions
- Space Colonization

>> Opportunities enabled by evolving technologies and social trends

- Large Scale Launch Vehicles (SLS, SLS Block II)
- In-Space and Propulsion Technology Development
- Cooperation with DoD, DoE, NOAA
- Additive Manufacturing
- Support Private Space

- Renewable Energy Source and Production R&D
- International Collaboration on Large Scale Projects
- Asteroid Mining
- Build Cislunar Infrastructure
- Define Constraints of Global Marketplace (e.g. Earth Orbits, Radio

- Leverage Advanced Space Propulsion Research for Power Generation Technology
- Provide Low-cost Access to Space for Academia and Small Business
- Build Rendezvous and Rescue Vehicles for Commercial Space Tourism/Commerce
- Launch Interstellar Robotic Probe

- Robotic Missions for Interstellar Space Colony Construction
- Enable Individual Research through Citizen Outreach and Partnerships
- Inflatable, Low-Cost Payloads for Individual Research Initiatives

2000 - 2025	2025 - 2050	2050 - 2075	2075 - 2100

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)

Winter 2014 Sprint

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?

2 Independent Teams

Mostly new members

CS & Contractors

Diverse Disciplines

Compare

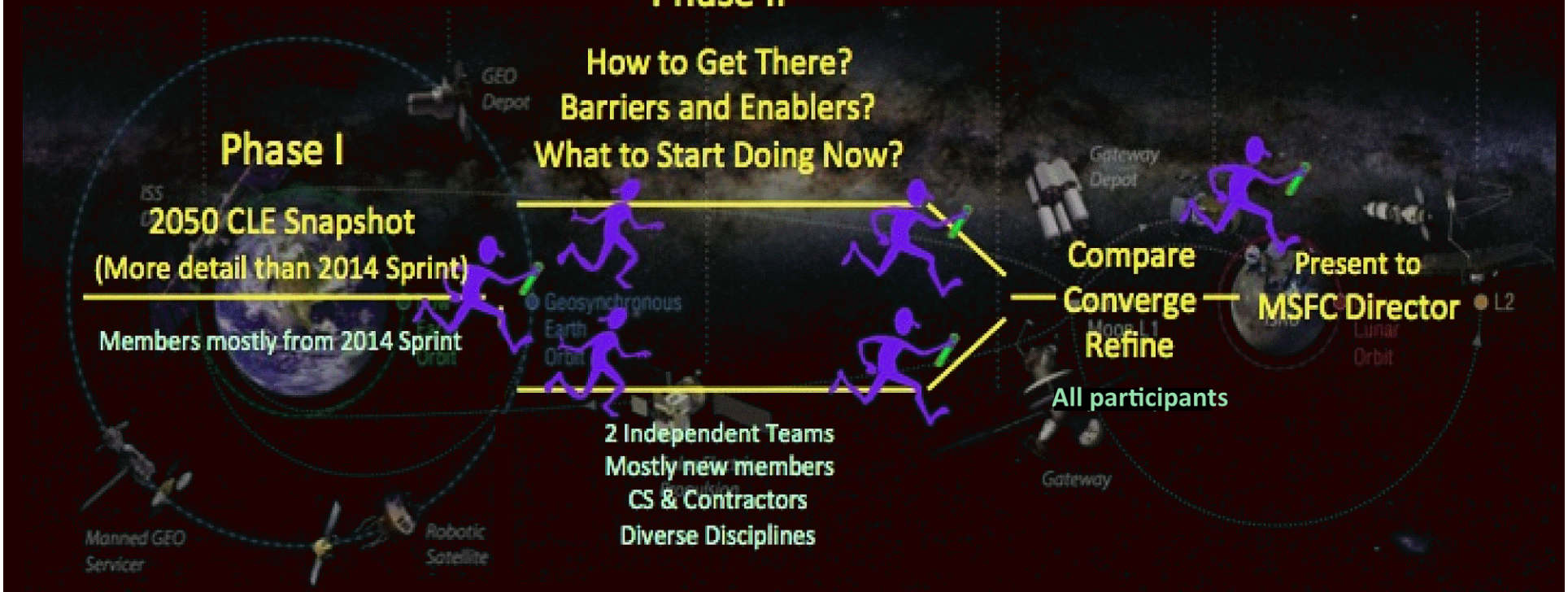
Converge

Refine

All participants

Present to

MSFC Director



2050 Cis-Lunar Econosphere

Winter 2014 Sprint

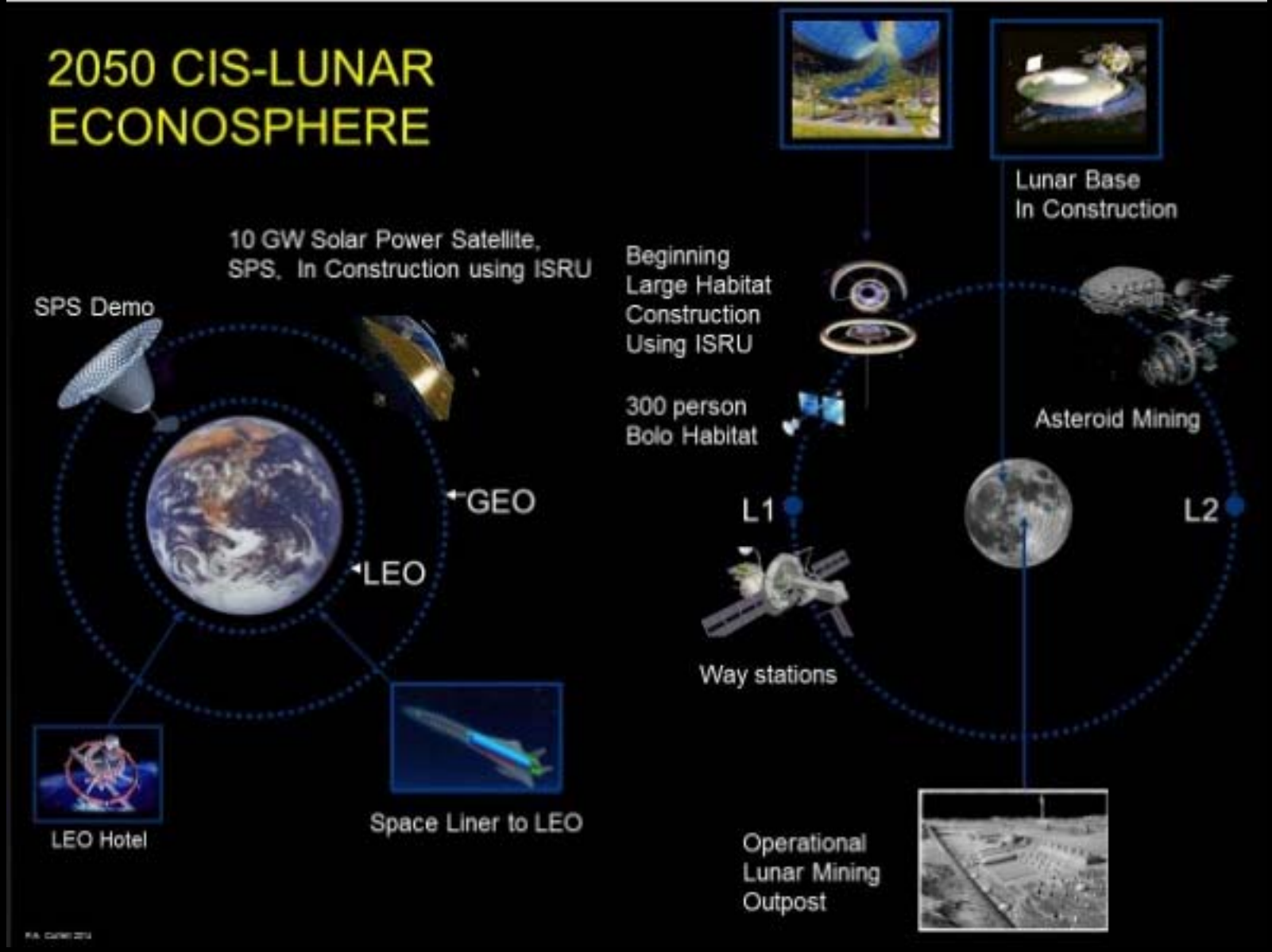
(Process Discoveries)

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

Diverse teams created their own culture:

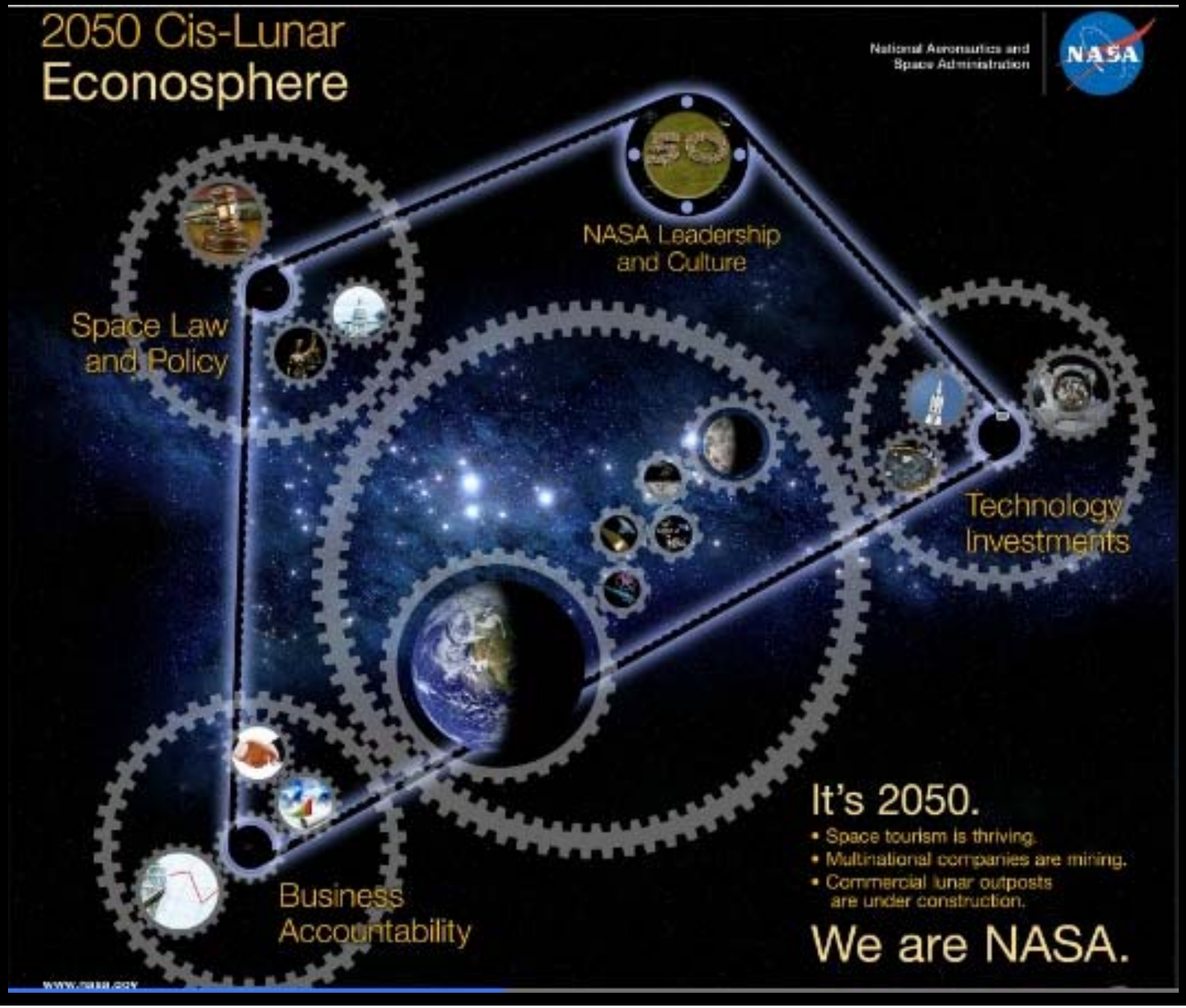
- Conversations flowed; standard processes were not followed
- All ideas were built-upon ("plussing") . . . . . but
- Terminology was simpler due to language differences (technical, law, business), and refreshed our memory of our own disciplines' roots
- Fear was broken down by accepting risk of "crazy" ideas

Phase 1 Results – A Snapshot of the "What"



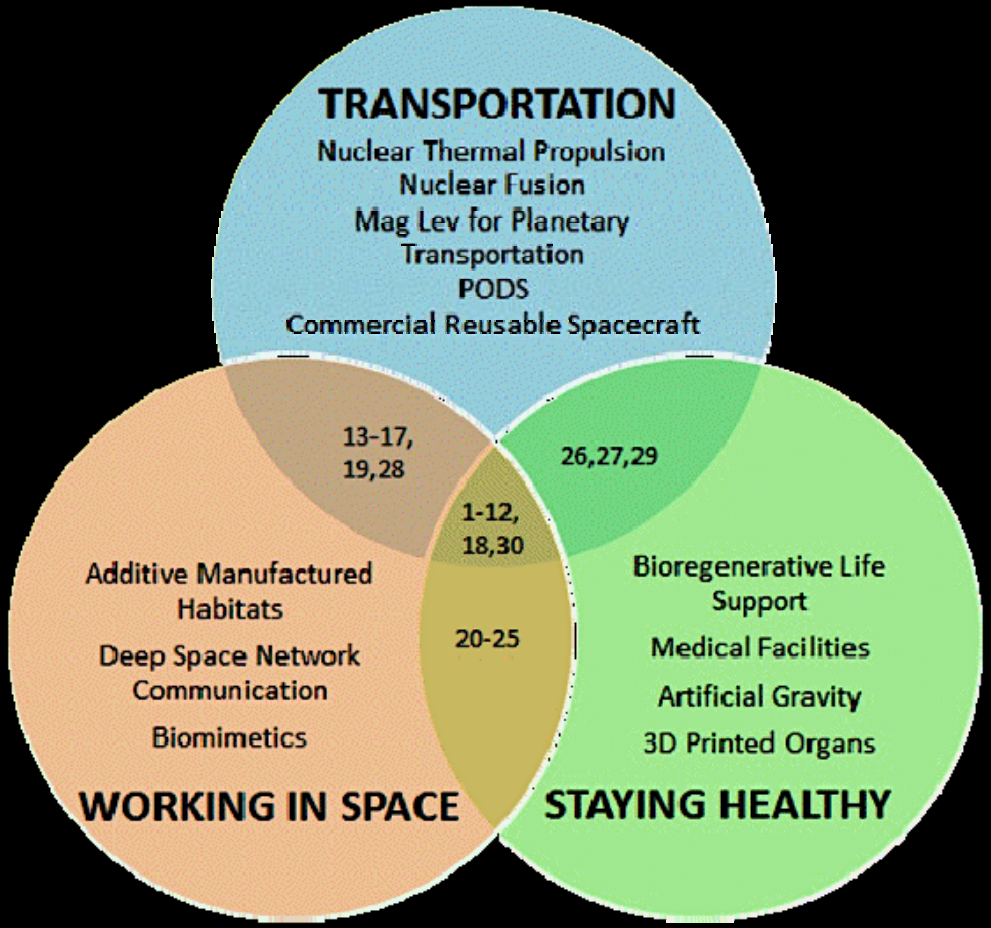
Phase 2 Results - How We Might Germinate the 2050 CLE

aka "The Gear Chart"



A Word or Three About Our 2015 Sprint

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.)



We *love* this job!

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(THAT SAID, WE HOPE THAT A) YOU FOUND GREAT STUFF IN HERE, AND B) *YOU'LL* HELP GROW THE CONVERSATION!)