ISS U.S. NATIONAL LABORATORY AND VALUE IMPACT OVERVIEW

LEO COMMERCIALIZATION AND VALUE CREATION

OUTLINE

Creating a sustainable market in Low Earth Orbit (LEO):

- How do we translate the unique scientific opportunities in LEO into projects that fulfill the congressional mandate?
- Are we helping establish a new LEO economy that benefits Americans and the U.S. economy?
- The ISS U.S. National Lab and CASIS:
  - History and Policy Development
  - Relationship between NASA and CASIS

Creating value:

- Is our program creating value for project sponsors/customers and the public?
- How can we better communicate the value and impact of the ISS U.S. National Lab portfolio?
- How do we improve CASIS portfolio management?

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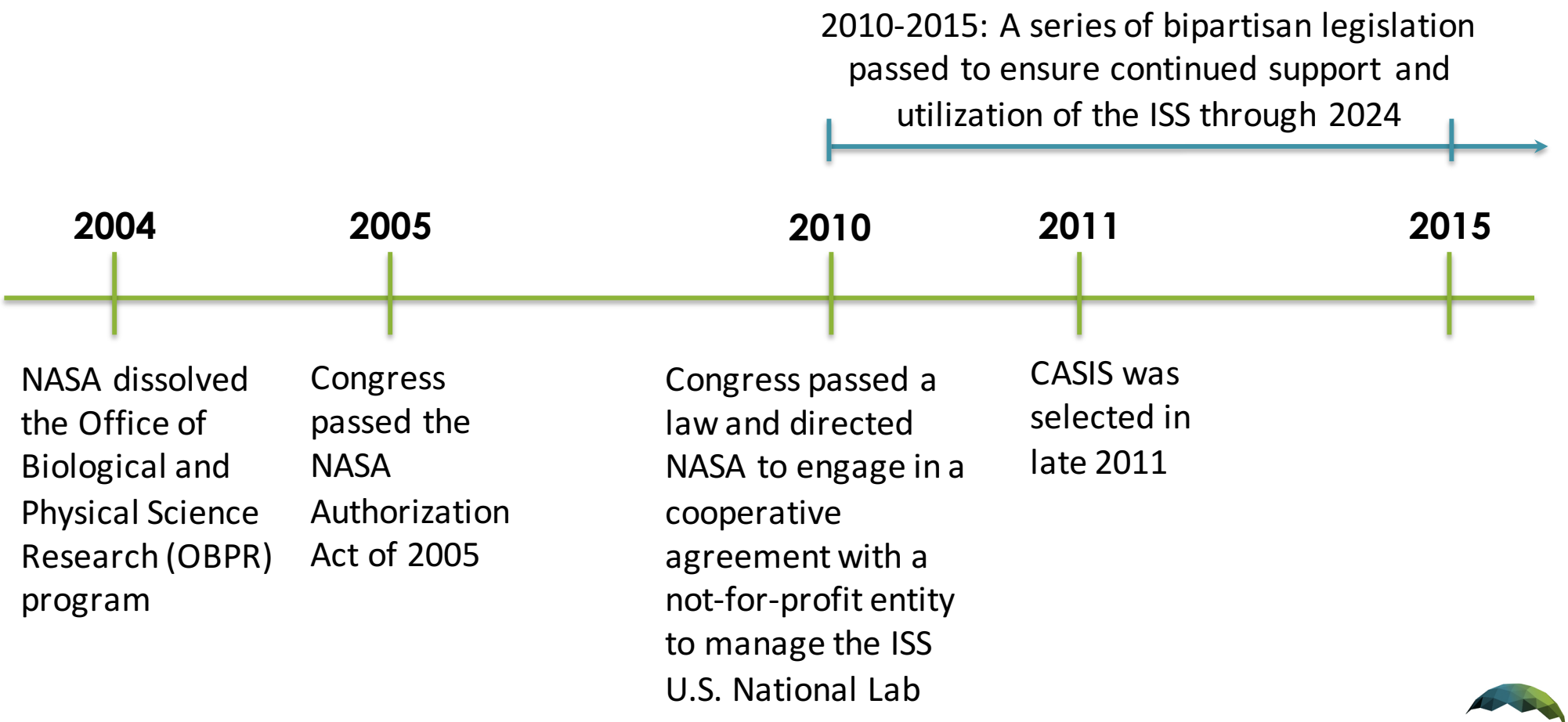
ISS U.S. NATIONAL LAB: A HISTORICAL PERSPECTIVE



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ISS U.S. NATIONAL LAB: CASIS AND NASA

Per the law, NASA provides to CASIS:

- Basic financial assistance
- Transportation to/from station
- Payload integration
- Not less than 50% of the U.S. research capacity to ISS U.S. National Lab managed experiments (e.g., crew time, upmass)

Per the Cooperative Agreement with NASA, CASIS provides:

- $15M per year
- Externally reviewed selection and implementation of scientific and education activities (non-exploration)
- Development and implementation of flight support requirements for ISS U.S. National Lab projects
- Non-traditional partnerships, cost-sharing agreements, and other arrangements that help offset federal costs of the ISS U.S. National Lab

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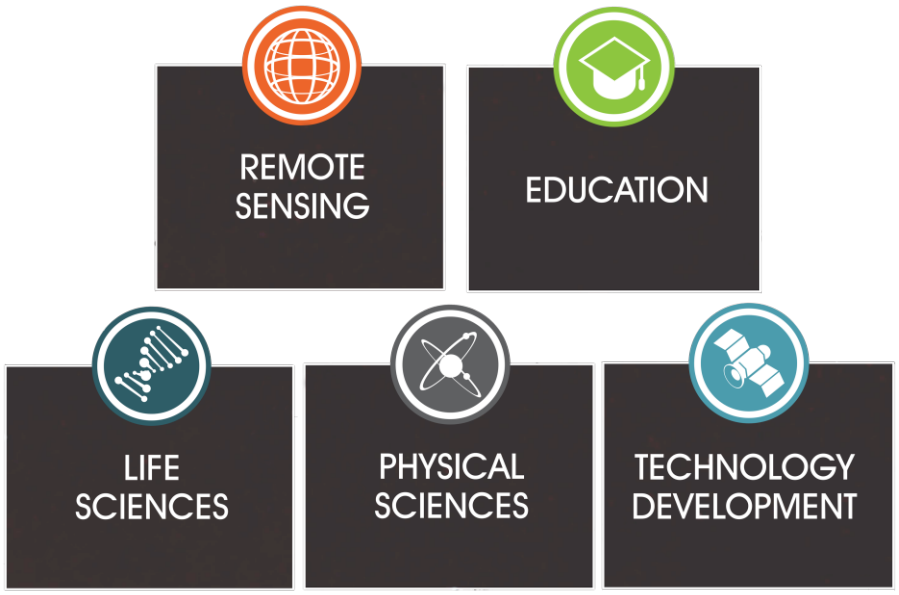
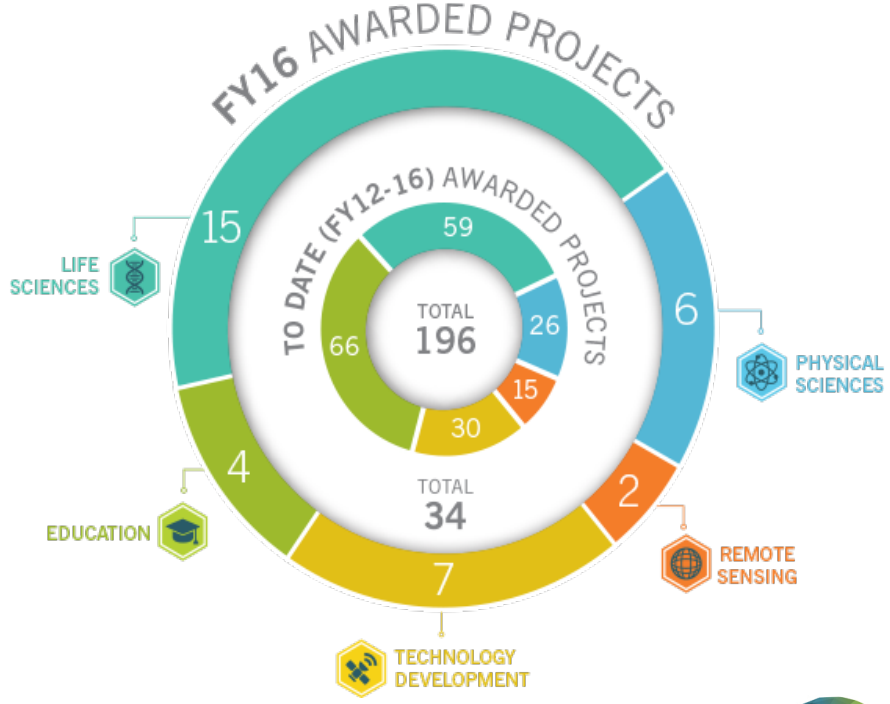
THE ISS U.S. NATIONAL LAB

While NASA's ISS activities are focused on exploration, technology development, and living and working in space, the ISS U.S. National Lab provides a pathway for disruptive, non-exploration R&D, commercial activities, and STEM education activities





CASIS

CASIS SUPPORTING DEVELOPMENT OF LEO MARKET BY BUILDING DEMAND, ENABLING SUPPLY, & FACILITATING INVESTMENT

SUPPLY

COMMERCIAL FACILITIES

NANORACKS · TELEDYNE BROWN ENGINEERING, INC. A Teledyne Technologies Company · HNU PHOTONICS · Alpha Space Test & Research Alliance · Space Tango · MADE IN SPACE · techshot · STARS · BioServe

CASIS™ / ISS U.S. National Lab

DEMAND

SPONSORED PROGRAMS

MASSACHUSETTS LIFE SCIENCES CENTER · National Science Foundation WHERE DISCOVERIES BEGIN · NIH National Center for Advancing Translational Sciences · GENES IN SPACE · mc mass CHALLENGE · BOEING

CUSTOMERS*

nemak · P&G · Houston Methodist LEADING MEDICINE · NOVARTIS · Honeywell · MERCK · Schafer

The Michael J. Fox Foundation for Parkinson's Research · DELTA · BUSINESSINTEGRA · AIRBUS · Lilly · JAMSS AMERICA (JAI) · Milliken

*Not inclusive; these examples represent only a small subset of commercial users

INVESTOR NETWORK

BESSEMER VENTURE PARTNERS · SHERPA CAPITAL · canaan · BINARY CAPITAL · LUX · IQT IN-Q-TEL · STARBURST ACCELERATOR · ARSENAL · venrock · DFJ · SPACE ANGELS NETWORK · NG | VP · BEE PARTNERS · LEMNOS Labs · Breakout Labs · SANTÉ VENTURES

CASIS™

OUR CUSTOMERS: CURRENT AND ON THE HORIZON

Life Sciences

Lilly
iXpressGenes
The Scripps Research Institute
Michael J. Fox Foundation for Parkinson's Research
SANOFI
MAYO CLINIC
AstraZeneca
NANOBIOSYM
Where little things make a big difference
NOVARTIS
MERCK
Be well
Baylor College of Medicine
BAYER
gsk
Methodist
LEADING MEDICINE

Physical Sciences

TARGET
GOODYEAR
P&G
Milliken
GENERAL MILLS
NALCO Champion
An Ecolab Company
nemak
PennState
BASF
We create chemistry
DELTA
GE imagination at work
APPLIED MATERIALS
make possible

Technology

Microsoft
Google
intel
IBM
Astrileux
MADE IN SPACE

Remote Sensing / Aerospace Tech Dev

Honeywell
SRI International
MOREHEAD STATE UNIVERSITY
VISIDYNE
hp
Schafer
Vision
Engineering Solutions
BUSINESSINTEGRA
TOGETHER » IT IS DONE
JAMSS AMERICA
INC.
JAI
NovaWurks
ASTRIUM
AN EADS COMPANY

CASIS

SPONSORED PROGRAMS: NON-CASIS & NON-NASA FUNDING

- Tailored programs aimed at solving BIG PROBLEMS and CHALLENGES and/or driving new innovation by finding and flying cutting-edge research
- Over $20M of independent grant funding generated through sponsored programs (funding goes directly to projects and PIs)

NSF Sponsored Program Solicitations (Multi-Year Program)

NIH NCATS Sponsored Program Solicitation

NIH National Center for Advancing Translational Sciences

PUBLISHED ON TUESDAY, JULY 12, 2016

CASIS and NCATS Collaborate to Promote Human Physiology Research on the International Space Station

Galactic Grant Sponsored Program Competition

CASIS

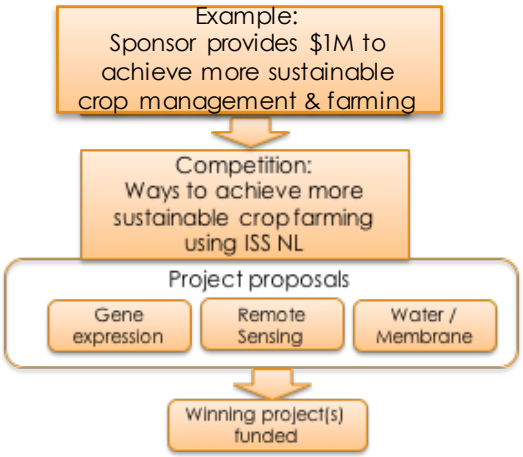
MASSACHUSETTS LIFE SCIENCES CENTER
Investing in the State of Innovation

THE MASSACHUSETTS LIFE SCIENCE CENTER
AND CENTER FOR THE ADVANCEMENT OF SCIENCE IN SPACE
GALACTIC GRANT COMPETITION SOLICITATION

LEVERAGING AND ATTRACTING EXTERNAL FUNDING

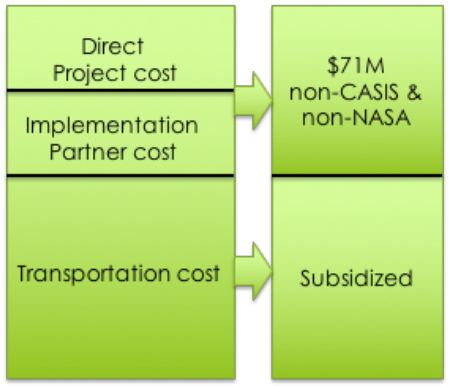
<u>INDEPENDENT (THIRD PARTY) FUNDING</u> GOING DIRECTLY TO FLIGHT AND STEM PROGRAMS: Over $20M of non CASIS and non NASA funding generated through <u>sponsored programs</u>

- **NSF** – fluid dynamics and combustion science
- **NCATS** – organ on chip technologies
- **Boeing/Mass challenge** – innovative startups
- **Mass Life Sciences Center** – life science in Massachusetts
- **Other fortune 500 sponsored programs are imminent**



<u>SKIN IN THE GAME:</u> $71M of external funding (non CASIS and non NASA) generated to support flight project cost

- **$2.6M** – from an advanced material company
- **$1.7M** – from a technology manufacturing company
- **$1.3M** – from a remote sensing company



CASIS™

CREATING A SUSTAINABLE MARKET IN LEO: BUILDING DEMAND

Why our customers are using the ISS U.S. National Lab:

- Drug development: better targeting and **"quick to fail models"**
- Better **drug delivery systems**: increased access of therapies
- **Accelerated disease modeling**: aging and chronic disease
- Regenerative medicine: repair, restore, or replace **damaged tissues and organs**
- **Crop science: growing crops** with less land, water, and other natural resources
- Fundamental material properties: **novel materials and better manufacturing** processes
- **Remote sensing and satellite technology** capability: maritime security, weather, agriculture productivity, energy, urban development, and national security

CASIS™

CREATING A SUSTAINABLE MARKET IN LEO: BUILDING DEMAND

Our customers are focused on projects that can lead to the creation of new markets:

- Microgravity enabled materials: **telecommunication** and **semi-conductor manufacturing**
- 3D-metal printing and other **additive manufacturing** capacity
- A new **de-orbiting market** focused on **debris management and orbit efficiencies**
- Platform for **validating technologies for an entirely new commercial LEO market**

CASIS™

CREATING A SUSTAINABLE MARKET IN LEO: ENABLING SUPPLY

The creation of demand supports new payload facilities and capabilities on the supply side:

- **Internal research microgravity platforms** for life and physical science projects
- **Cubesat deployers** enabling small sat maturation
- **Cell culturing systems** for molecular biology and tissue engineering
- **Bone densitometer** for rodent research projects
- **Additive manufacturing** facilities are creating **3D** printing
- **Remote Sensors**, antenna and other assets
- **External Platforms** for accelerated degradation testing

CASIS™

CREATING A SUSTAINABLE MARKET IN LEO: FACILITATING INVESTMENT

Investment network has provided opportunities for our customer base:

- **More than 50** investors have been recruited into the CASIS network
- Nearly **100** company-investor introductions have been made since Jan 2016
  - This network creates a more efficient path for innovative entrepreneurs to attract capital
- The network yielded investments in commercial space start-ups of over **$1M**

CASIS™

VALUE IMPACT PROCESS GOALS AND METHODOLOGY

Ensuring credibility, transparency and independence

- Utilized consulting expertise
- Evaluated over 200 best practice examples from leading organizations
- Convened unpaid, non-COI independent subject matter expert panel

Value Impact methodology

- Created an assessment framework with metrics based on best practice
- To date, 60 ISS U.S. National Lab/CASIS projects were evaluated as part of a baseline retrospective analysis
- Projects are scored and placed on the impact/feasibility matrix
- Continuous process for all ISS U.S. National Lab/CASIS managed projects

CASIS™

CREATING VALUE: USE OF SUBJECT MATTER EXPERTS TO ENSURE CREDIBILITY AND OBJECTIVITY

These experts have over 420 years of combined experience and have have managed research centers with over $21.9 billion in R&D investment.

- *Dr. Carol Linden, Director of the Office of Regulatory Science and Innovation, FDA (former Deputy Director at Department of Health and Human Services Biomedical Advanced Research and Development Authority)*
- *Dr. Daniel Gerstein, Former Under Secretary (Acting) for the Science &Technology Directorate, Department of Homeland Security*
- *Mr. Ron Kurjanowicz, Independent Consultant, RJK Consulting (former Chief of Staff at the Defense Advanced Research Projects Agency and Senior Advisor to Secretary of the Air Force for Science, Technology, and Engineering)*
- *Dr. A.M. Rajendaran, Chair and Professor, Department of Mechanical Engineering, University of Mississippi*
- *Dr. Frank David, Founder and Managing Director, Pharmagellan (former Healthcare Investment Banker at Leerink Partners and Director of Strategy at AstraZeneca's Oncology Innovative Medicines)*
- *Dr. James Houston, Director Emeritus of the Engineer Research and Development Center, United States Army Corps of Engineers (former Director)*
- *Dr. Adam Cox, Senior Advisor, Department of Homeland Security Science and Technology (former Director of Advanced Research Projects Agency at Department of Homeland Security Science and Technology Directorate)*
- *Mr. Mark Lister, Founder and President, StratTechs, Inc. (former Chairman of the Naval Research Advisory Committee and member of the Secretary of the Navy Advisory Panel)*
- *Dr. Mario Barrow, Senior Director of Innovation, Sanofi Pasteur (former Scientist and Project Officer at Department of Health and Human Services Biomedical Advanced Research and Development Authority)*
- *Dr. Frank Herr, Head, Ocean Battlespace Sensing Department, Office of Naval Research (former Director of Sensing and Systems Division at Office of Naval Research)*
- *Dr. Joanne Andreadis, Senior Advisor, Office of Public Health Preparedness and Response, Centers for Disease Control and Prevention (former Innovation Lead for the Office of Strategy and Innovation at Centers for Disease Control and Prevention)*
- *Dr. John Lamattina, Senior Partner, PureTech Health (former President of Pfizer R&D)*

CREATING VALUE: A BALANCED SCORECARD FRAMEWORK

IMPACT AND FEASIBILITY FACTORS:

Three Impact Benefit Categories Measured Against Feasibility and Risk

IMPACT FACTORS

Economic
- Application Leverage
- Market Innovation
- New Revenue Potential

Innovation
- Discovery Science
- Research Leadership
- Unique Niche

Humankind/ Social
- Enduring Capability
- Catalytic
- Quality of Life

FEASIBILITY FACTORS

Feasibility
- Project Clarity
- Resource Commitment
- Technical Approach
- Commercialization

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EVALUATION: ECONOMIC MEASURES AND SCORING GUIDELINES

Economic Benefits	1	4	7	10
Application Leverage Are the projects' outcomes leverageable across other applications, needs, customers or markets?	Outcomes focused on a single application, need, customer or market – no ability to leverage	Outcomes may have modest ability to be leveraged, but there is no documentation or proof of such; team is not working peripheral opportunities	Plan explicitly recognizes potential for leverage across multiple applications, needs, customers and/or markets, but focus beyond primary and secondary applications is weak	Plan is designed with multiple applications, needs, customers and/or markets in mind and the research plan specifically targets multiple channels to market
Market Innovation Will the projects' outcomes stimulate new markets or significantly change existing ones?	Is unlikely to have any impact on market dynamics	Will likely have no more impact than that of any other routine investment in a particular field	May have significant impact on the target market – could lead to a strong or even dominant positioning if successful	Has the potential to be a game-changer; is expected to either create a totally new market or disrupt existing ones
New Revenue Potential To what extent will the project lead to incremental partner revenue after introduction?	Is unlikely to produce significant revenue	Is expected to produce incremental revenues, but these will not likely be materially significant to the partner	Is expected to produce a materially-relevant increase in revenues	Is expected to generate materially-relevant and significant revenues for the partner

EVALUATION: INNOVATION MEASURES AND SCORING GUIDELINES

Innovation Benefits	1	4	7	10
Discovery/Science Will the projects' outcomes lead to new knowledge / tools and / or open new solution pathways that would not have been possible without this project?	• Unlikely to generate new knowledge / tools; has been tried before	• Results in modest updates to existing knowledge / tools • Makes modest contribution to a new solution pathway	• Could lead to a significant advance in knowledge/tools and/or the opening of a new solution pathway	• Could lead to a major advance in knowledge/tools and multiple new solution pathways
Research Leadership Does the research provide the partner organization with a leadership position?	• Does not maintain partner as a recognized player in a scientific/ technology area/field	• Elevates or maintains partner as a recognized player in a scientific/technology area/field	• Elevates or maintains partner as one of a few recognized leaders in a scientific/technology area/field	• Elevates or maintains partner as the undisputed leader in a scientific/ technology area/ field
Unique Niche Does the project provide a critical solution in an area where there is little incentive for other government, commercial, and/or academic investment?	• Offering competes directly with other entities in a commodity market; must compete on cost & schedule • Relationship of research is not related to ISS advantages	• Several organizations provide similar solutions or components of solutions • Work may not need the specific conditions found on the ISS to succeed	• Only one or two other organizations could tackle this type of work • ISS conditions are critical to exploration of nature of science	• No other organization currently provides this type of solution • Research could not be conducted / simulated anywhere else

EVALUATION: HUMANKIND/SOCIAL MEASURES AND SCORING GUIDELINES

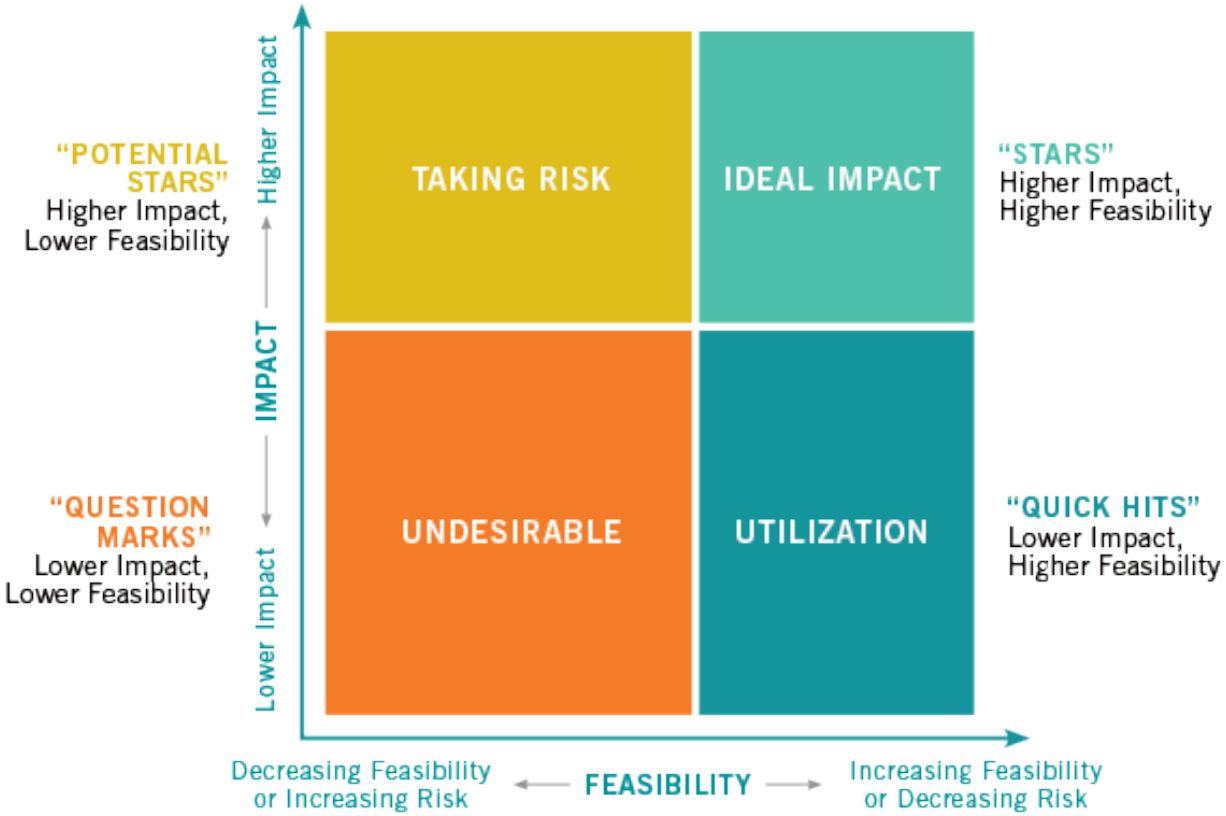
Humankind/Social Benefits	1	4	7	10
Building Enduring Capability for the Nation At project completion, will the project develop new capabilities, processes, infrastructure, or human capital to help prepare the nation for the challenges of the 21st Century?	• Does not add to a competency, infrastructure or capability • Continues in the same vein as previous efforts	• Helps sustain an existing competency, infrastructure or capability of interest to the community	• Supports the development of a new or significantly improved competency, infrastructure or capability that is important to the community	• Contributes to development of a world-class competency, infrastructure or capability of significant value to the community
Catalytic Will the project directly drive (motivate / stimulate) likeminded endeavors?	• Success is unlikely to motivate partner or other organizations to pursue similar projects • No causal link	• As a direct result of this project, other organizations may pursue similar projects in this area, although modest in nature • Causal link is vague at best	• As a direct result of this project, other organizations are likely to pursue projects in this area, and these are expected to be meaningful to the community potentially resulting in early formation of consortia built around the project concepts	• Many organizations motivated to pursue this area because of CASIS pioneering effort • Large consortia built around project concepts • Direct and quantifiable causal link
Value of Statistical Injury What is the dollar amount (as defined by the value of statistical life / injury index) of injury / death that will be prevented by this project?	• Not expected to save lives or prevent injury • $0	• Expected to modestly save lives and / or prevent injury • >$50M	• Expected to significantly save lives and / or prevent injury • >$500M	• Expected to profoundly save lives and / or prevent injury • >$1B

EVALUATION: FEASIBILITY AND RISK SCORING GUIDELINES

Feasibility and Risk	1	4	7	10
Project Clarity How well is the project described and laid-out – is it clear what the team will do (given the paperwork and briefing)?	• Difficult to know what will result • Significant disconnects	• Documentation incomplete or poorly detailed • Many uncertainties	• Well documented project • Most aspects easily understood	• Project documentation clear and easily understood
Resource Commitment Partner (beyond NASA) is providing a meaningful amount of the necessary project funding and, assuming R&D success, has the resources to complete and commercialize the results?	• Effort suffers from a lack of financial commitment or resources from partner • Partner has no financial ability to commercialize results	• Partner financial commitment is modest, but meaningful • R&D costs are covered, but partner has limited funds to commercialize results if project is successful	• Partner financial commitment is significant • Partner has sufficient resources to continue investing in commercialization requirements	• Partner has placed a "large financial bet" on this project's outcome – they are very vested and motivated • Partner has commercialization reserves set-aside to push effort into market
Technical Approach / Feasibility Is the execution plan reasonable (appropriately experienced team, robust research methodology) and likely to succeed technically?	• Plan has some ambiguities with aspects that are unproven	• Plan appears comprehensive, but complex • Most aspects have positive past experience, some uncertainties exist	• Comprehensive plan with positive past experience; minor uncertainties exist	• Proven plan; no execution uncertainties exist
Commercialization Feasibility Is there a clear path / mechanism to enable the commercialization and use of the technology or capability?	• Low probability that results will be advanced or deployed • Important technical, operational and / or business issues unresolved • Notional commercialization path only	• Technical, operational and business issues are significant, but manageable • Commercialization partner has a good start on a commercialization plan	• No major technical, operational or business issues remain • Commercialization partner has a clear, thorough and achievable plan • End user has defined an acquisition path	• End user is waiting for the capability and has budgeted for its acquisition / purchase and sustainability • Commercialization partner is on course with its logical commercialization plan and has funded all remaining activities

CREATING VALUE: CONSTRUCT USED TO BETTER MANAGE THE CASIS PORTFOLIO

We assess the composition of our portfolio and make better decisions going forward



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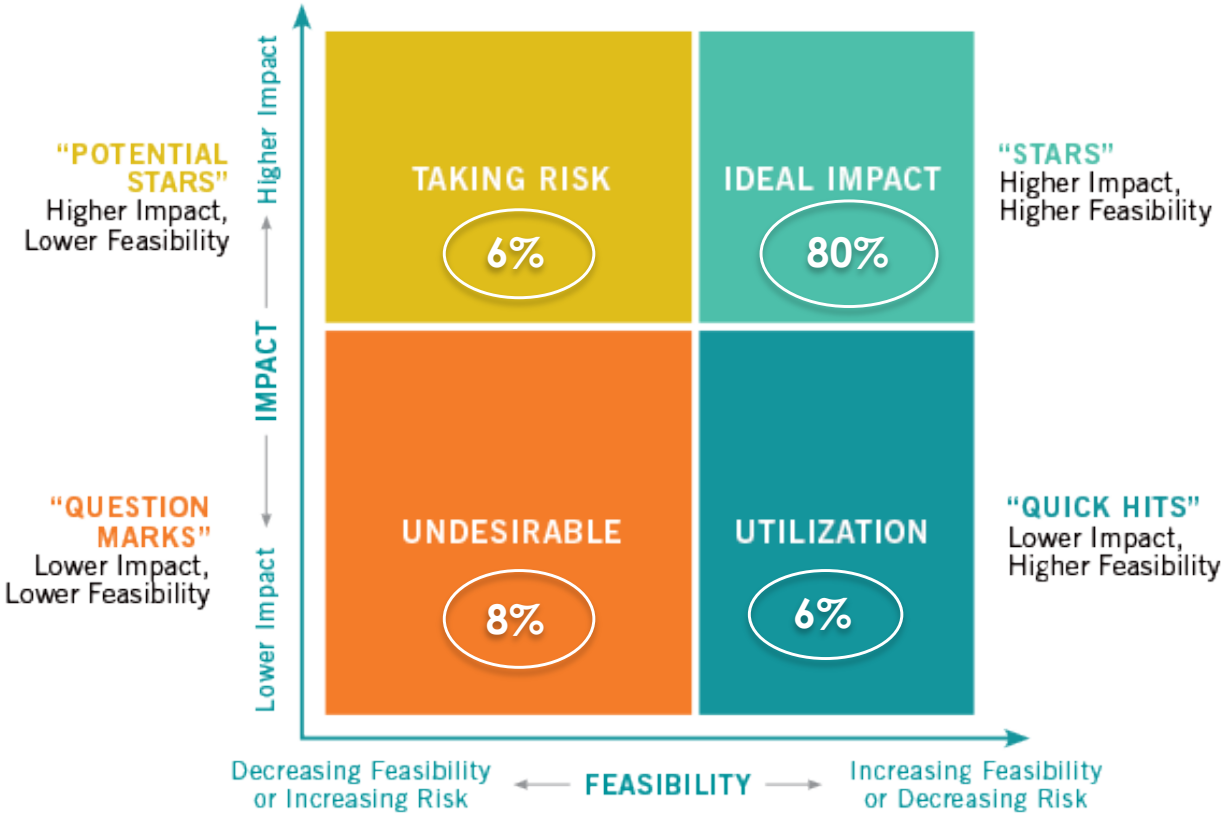
CREATING VALUE: CONSTRUCT USED TO BETTER MANAGE THE CASIS PORTFOLIO

Our first baseline results: total investment % in each quadrant



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VALUE IMPACT OUTCOMES DIRECTLY TIED TO THE ISS U.S. NATIONAL LAB

Impacts generated to better communicate value

Baseline economic, innovation, and humankind/impact measures

- Projected revenue increase of $700M (timelines dependent on project and organization's development cycle)
- Accelerated time to market projected to be more than one year
- Selling into multi-billion dollar markets: total addressable market of more than $50B
- $71M of external funding leverage (non-NASA non-CASIS)
- More than $20M of independent funding generated through Sponsored Programs
- 19 new solution pathways
- An additional 11 quality-adjusted life years (QALY) projected for 27 million people
- Total peer-reviewed ISS U.S. National Lab publications: 89

CASIS

CONCLUSION AND WHAT DOES THE FUTURE LOOK LIKE?

We are making progress on creating a sustainable LEO marketplace:

- CASIS cultivates demand and supply as well as facilitates investment to enable economic development of LEO
- The creation of a vibrant and sustainable supply and demand market in LEO supports the use of ISS through 2024 and future stations beyond

We are creating value:

- We have completed a baseline value impact review and will continue to validate results going forward
- We use the value impact methodology to improve/inform our portfolio and ISS U.S. National Lab results
- The ISS U.S. National Lab is a platform for value creation for the American public and the U.S. economy