



UNIVERSITY OF COLORADO BOULDER GRAND CHALLENGE UPDATE

The CU-Boulder Grand Challenge is built around two premises: (1) Success in space has transformed the human experience in all its dimensions, and (2) CU-Boulder and its partners are positioned to lead this continued transformation throughout the 21st century.

Background

Through large-scale engagement across the campus, 35 proposals were submitted as ideas for the CU-Boulder Grand Challenge. The majority of these proposals fell into five categories:

1. *Sustainable Space*: The development, utilization, and sustainability of the space environment.
2. *Earth Lab*: The integration, analysis and application of Earth Observations to understand and address complex environmental challenges.
3. *Integrated Remote and In-Situ Sensing Systems (IRISS)*: Integrating satellite, airborne, and in-situ observations for scientific and societal purposes with a particular focus on UAV sensing.
4. *Water*: Ensuring adequate high-quality water at global and local scales.
5. *Exploration*: The development and deployment of capabilities to explore beyond the near-earth environment.

Relevant Strengths and Opportunities

Strengths

By coupling our unique strengths in the Earth and space sciences with those in the social sciences, humanities, and the arts, the greatest and most immediate impact that we can have on our region and the nation is to leverage these strengths in ways that will most benefit society – by creating new scientific and technological innovations, forecasting and addressing the societal implications of those innovations, and developing an exceptionally prepared workforce.

Opportunities

CU-Boulder is uniquely qualified to explore, understand, and be the solution-provider to both AeroSpace-enabled science and technology problems as well as their applications to complex local, regional, national, and global issues. In particular, CU-Boulder is:

- Preparing our students to be leaders in meeting the challenges and capitalizing on the opportunities of the AeroSpace-enabled economic, technological, and societal future
- Pioneering AeroSpace-enabled science and technology to develop integrated sensing systems that will transform our ability to observe and address the Earth's environment from global to local scales
- Developing an information infrastructure to derive the maximum benefits from our extensive national assets
- Linking new integrated sensing science and technology with the information infrastructure to provide real-time solutions to societal problems

External Advisory Committee and Campus Steering Committee Recommendations

Commonalities between the two sets of recommendations include support for Integrated Sensing and Earth Lab, both described in more detail below, as well as for the establishment of the Colorado Alliance for Space Exploration (CASE) as a Federally Funded Research and Development Center (FFRDC), but separate from the Grand Challenge.

- *Integrated Sensing and In-Situ Sensing Systems:* The central challenge in current-generation sensing is engineering integrated systems with coordinated platforms that can collect data over multiple scales—on demand, not just opportunistically. Developing systems that will integrate data collection and analyses from a multitude of diverse sensing capabilities, along with the ability to observe any place at any time, will be transformative. It will result in improved weather forecasting, climate modeling, land use, and disaster mitigation and will have immediate and profound effects on commerce, public safety, and environmental science. New sensing science and engineering capabilities will create new opportunities for products and new markets in such diverse fields as agriculture, transportation, natural resource management, and entertainment. Fundamental to this challenge is continued success in space-based observations, which requires that we have a sustained capability to operate successfully in the near-Earth space environment. This, in turn, requires that we address challenges that place our ability to operate in space at risk.
- *Earth Lab:* Currently, there is no national or international leader for the synthesis and analysis of Earth observation and other data to answer outstanding questions about the pace and pattern of global change. Earth Lab will streamline the data gathering, analysis and interpretation from end to end, while educating a new generation of data scientists who lead in business, industry, government, and academics. The research focus of this synthesis center is to identify and forecast Earth System dynamic processes through the integration, exploration, analysis, and application of Earth observations, linking space-based, piloted and autonomous aircraft, and field-based measurements with model scenarios. These activities will accelerate discovery, risk assessment, and solution development for maintaining the resilience of Earth System processes in the face of change.

These two initiatives are inherently integrated, and they have direct links to the sustainable space concept. The observing capabilities developed through and exploited by IRISSE will provide the fundamental information required for the analyses of Earth Lab, while Earth Lab's (big-) data analytics will serve as the foundation upon which transformation from observation to meaningful and actionable information will be built.

The EAC favored major elements of the Water proposal as the first application of IRISSE and Earth Lab, while the Steering Committee did not support an explicit focus on water. Alternatively the Steering Committee expressed strong support for Sustainable Space, assuming the proposal could be better defined with achievable goals.

Sample Project Outcomes

The following sample project goals could be undertaken:

- *By 2016 Project Water:* Soil moisture proofing with Tempest Unmanned Aerial System (UAS), and NASA's Soil Moisture Active Passive (SMAP) satellite. Collect on-demand soil-moisture data to 5-cm depth with 15-m resolution from small UAS to compare to the 40-m resolution of SMAP. Within one year incorporate these observations into soil-moisture models to examine near-surface water dynamics
- *By 2017 Project Snow:* Bistatic GPS snow-depth measurement over western Boulder County. Collect snow-depth data with ground-based and airborne (UAS) bistatic GPS sensing. Within one year, incorporate these observations into hydrologic models of surface and ground water evolution.
- *By 2017 Project Storm:* Supercell evolution from convection initiation to tornadogenesis. Discover critical conditions for convection initiation (CI) supercell formation and tornadogenesis to increase the 2015 average tornado warning time by factor two.

- *By 2017 Project Make:* A cross-campus, interdisciplinary educational space and curriculum. Provide students with a hands-on, interdisciplinary environment that exposes them to implementation, policy, societal, and economic challenges.
- *By 2018 Project Ancestor:* Demonstrate local UAS-based archeological research in 20+ countries. Lead an international revolution in local anthropological and archeological research by native researchers with novel sensing systems and strategies enabled by low-cost UAS.
- *By 2019 Project Wildfire:* Focus fire science, modeling technology, multiscale sensing, emergency response, disaster management, and public policy into a transformational program with cross-cutting research thrusts. Develop integrated UAS and sensor technologies to safely and cost-effectively provide measurements of fuel state, microphysical fire behavior, mesoscale fire weather, and fire effluent chemistry to validate multiscale numerical models and provide real-time forecasting for sound policy and operational decisions
- *By 2020 Project Ice:* Second Marginal Ice Zone Observations and Processes Experiment. Goal: Answer the question: Has Earth passed the tipping point for the complete melting of the Arctic sea ice in summer? Objective: Combine satellite observations with observations from UAS teams conducting surface mapping with continuous observations of the ocean surface and subsurface, and Lagrangian tracking of drifting ice pack
- *By 2020 Project Earth:* develop the world's leading data analysis capability and infrastructure for combining in situ, satellite, UAS, and other data sets of varying size, coverage and sampling into an integrated framework targeted at addressing specific societally-relevant scientific questions.
- *Ongoing - Project Synthesis:* integrate the policy, law, business, entrepreneurial, social, humanistic and other elements to develop the observation, analysis, and educational infrastructure responsibly and effectively.

Expected Institutional Outcomes

- Develop a new educational curriculum that encompasses technical, legal, social, psychological, artistic, and societal issues associated with remote observation (from space and air) that attracts new and engages current students.
- Develop new campus and external research and educational partnerships resulting in new and diverse streams of revenue sources.
- CU-Boulder is recognized as the national leader in developing new observing technologies, techniques of integration, applications to societal issues, and a workforce that is prepared to understand and be leaders of a new economic and societal future.
- Develop, influence, and inspire public policy, law, Colorado entrepreneurship, creative activities, etc. as they relate to the full range of remote sensing observation and application throughout the next five years.

CU Boulder has unlimited potential to lead the transformation and support the new AeroSpace-enabled economy and society. Further elevating our presence in AeroSpace innovation provides the most direct and efficient way for us to build and sustain the tremendous intellectual capital of our campus and our region for the benefit of society.