Summary:
The NASA Senior Advisor for Innovation, Dr. Charles Camarda, has formulated and proposed the Innovative Conceptual Engineering Design (ICED) methodology as a means for both increasing innovation within NASA, and encouraging STEM education in the United States. This methodology involves bringing real-world, open-ended, “epic” engineering challenges to a diverse mix of university, high school, and middle school students. Under the guidance of relevant subject matter experts from academia, industry, and the government; these students will initially work together in-person in a highly collaborative, concurrent engineering environment where creative ideas are rapidly conceptualized, prototyped, tested, and iterated upon. Following this initial workshop, a virtual platform will be used to maintain links between the technical experts with the student teams, as they continue to mature their problem solutions. The main value propositions of such a program are the: (1) Creation of self-sustaining communities focused on solving difficult problems faced by NASA and the nation (2) Inspiration of students to enter STEM-related careers by exposing them to exciting real world problems that require creative solutions (3) Giving the government and industry access to a large source of creative and innovative ideas which may have otherwise been overlooked; and (4) Rapid maturation of these concepts in order to intelligently evaluate and downselect the very best ideas early in the design process, where it will have the most impact on the successful outcome for the project!

Dr. Camarda has proposed that such a workshop be held at MIT in the summer of 2012, with the objective of developing concepts for a sustainable Mars habitat system. Additionally, this particular workshop will feature multimedia-based educational content on the subject areas relevant to Mars habitat design. This content will be developed by teachers from the participating schools and the subject matter experts; and is intended to facilitate further student learning, and accelerate concept development.

Background:
The structure of the proposed ICED program was developed by Dr. Camarda over several years, while participating in a wide range of NASA and Air Force research and development programs. Over the past four years, this program has been successfully field-tested over a wide variety of participant experience levels, ranging from the high school student, through to the young practicing engineer. Past problems addressed include contingency land-landing systems for NASA’s next generation spacecraft, lunar digging and drilling systems, Martian space suit designs, and Martian lava tube exploration robots. These problems were identified by research labs within NASA who provided sponsorship to universities to facilitate these programs.
MIT was the one of the first universities to be involved in the ICED program with the development of the abovementioned contingency land-landing system, in a partnership with the Pennsylvania State University (PSU). This project supported the SM degree of one MIT graduate student, served as the capstone project of one MIT and eight PSU undergraduate students, and provided UROP opportunities to six additional MIT undergraduate students.

As a next phase in the program expansion, the framework depicted in Figure 1 has been proposed. Here, a “Cohort Group” of 5-7 university “Hubs” is created to aid in the development of the “epic” engineering problems to be addressed, based on the direction of a top-level “Joint Program Team” (which consisted of NASA and the Air Force Research Lab during last year’s challenge). This University Cohort Group will also act as a source of mentorship, guidance, and age-appropriate learning curricula from which local high schools and middle schools can access. Moreover, an Executive Advisory Board consisting of key members from each of the participating institutions will facilitate the entire program.

**Phase 1**

![ICED Expansion Framework](image)

Figure 1: ICED Expansion Framework – The university cohort group consists of the Stevens Institute of Technology, Wright State University, Texas A and M, MIT, and the Pennsylvania State University
Professor Olivier de Weck of the Department of Aeronautics and Astronautics and the Engineering Systems Division is the current MIT point of contact. Interestingly, the choice of the Martian habitat design as the baseline engineering challenge was influenced by the direction of the Strategic Engineering Research Group (SERG), which Prof. de Weck directs. It is anticipated that many of the concepts developed through the ICED will contribute directly to graduate research within SERG.

**Program Objectives and Tasks:**
The objectives of the ICED program naturally align with MIT’s goals to “advance knowledge and educate students in science, technology and other areas of scholarship that will best serve the nation and the world in the 21st century”. In particular, the recent initiative introduced by the School of Engineering to collaborate with the Khan Academy to create educational videos clearly has potential to complement the high school and middle school learning content planned for development for the proposed program.

With regard to the implementation of the program, a preliminary task breakdown is as follows:

1. High schools located within the greater Boston area will be identified and engaged to gauge interest in participation within the ICED program. This will inform the number of people chosen to participate within the program, as well as provide points of contact with educators who will eventually participate in the development of learning curricula.

2. From the pool of contacted high schools, approximately five will be formally invited to join the program. Information regarding participant enrolment costs and other administrative and logistic considerations will be provided. The details of these are to be determined.

3. Space habitat, Martian environment, innovate engineering design, and other related experts from around the country will be invited to give talks during the workshop. Past speakers have included:
   - Martian environment and human factors experts from NASA Johnson Space Center
   - Robotics experts from the NASA Jet Propulsion Laboratory
   - Experts on mechanical systems from NASA Goddard Spaceflight Center
   - Multidisciplinary system design and optimization experts from MIT, PSU, and NASA Langley Research Center; and
   - Biologically inspired design experts from Georgia Tech; to name a few

4. MIT graduate and undergraduate students will be invited to participate in the program. Some students will act as mentors, while others will participate directly within the workshop and program itself.

5. Towards the end of the course, educators from the selected high schools will work with the participating subject area experts and MIT students to create learning content for the school students to use, as they continue working on their problem solutions after the workshop.