LEAP2 and LCATS

Developing the Space Workforce through LEAP2 and LCATS Industry Clusters and International Student Exchange

United Nations / Austria Symposium

Access to Space: Holistic Capacity-Building for the 21st Century

UNOOSA

Graz, Austria

3 – 7 September 2017

WEX Foundation
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Local and International Collaboration Team

UTSA
The University of Texas at San Antonio™

SwRI
SOUTHWEST RESEARCH INSTITUTE

TexPREP

-UTSA-
ADVANCED ROBOTICS
EST 2015

LCATS
Lunar Caves Analog Test Sites

XARC
Exploration Architecture Corporation

LEAP2

SPACE FOUNDATION

S&A

Challenger LEARNING CENTER

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SAN ANTONIO COLLEGE

Scobee Education Center

Wissenschaftsstadt
Darmstadt

KOREA INSTITUTE of CONSTRUCTION TECHNOLOGY
KICT
한국건설기술연구원

TAME
Texas Alliance for Minorities in Engineering

novaetech

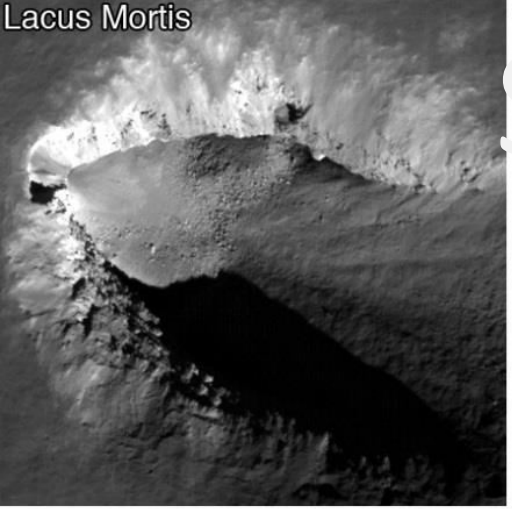
한양대학교
HANYANG UNIVERSITY

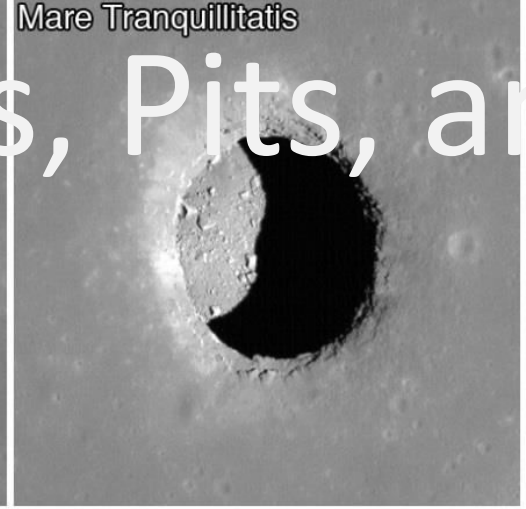
QCM OPEN
quartz crystal microbalance

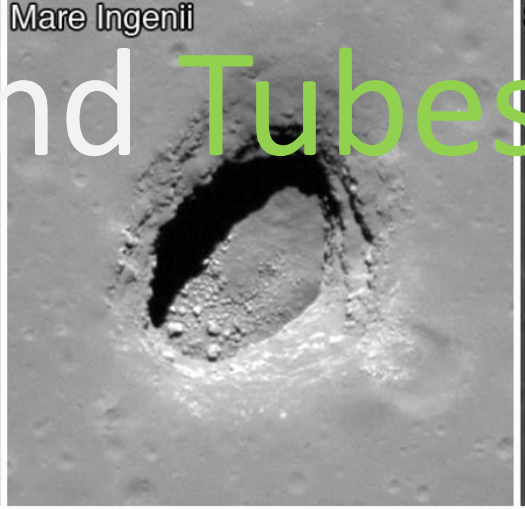
ISERI
INTERNATIONAL SPACE EXPLORATION RESEARCH INSTITUTE

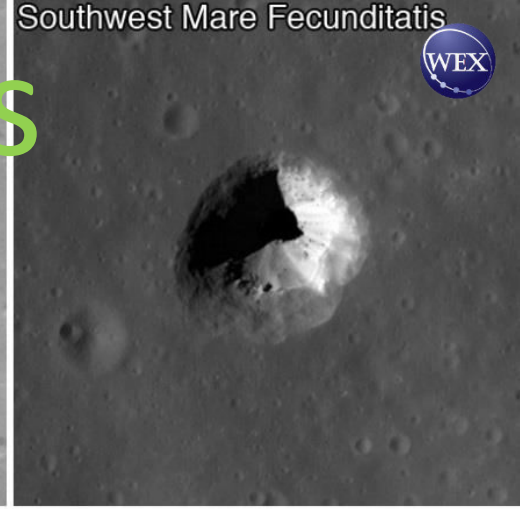
SocialPath

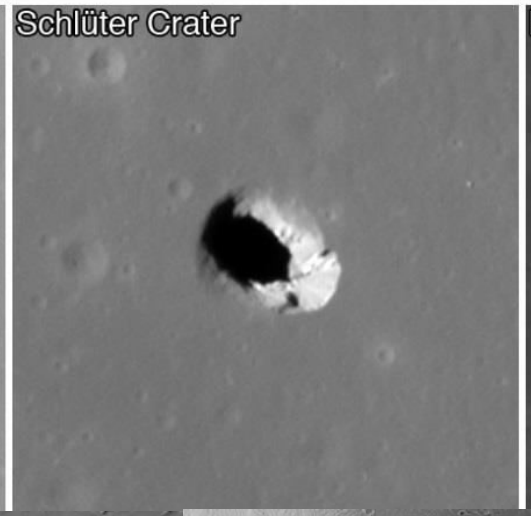
Skylights, Pits, and Tubes



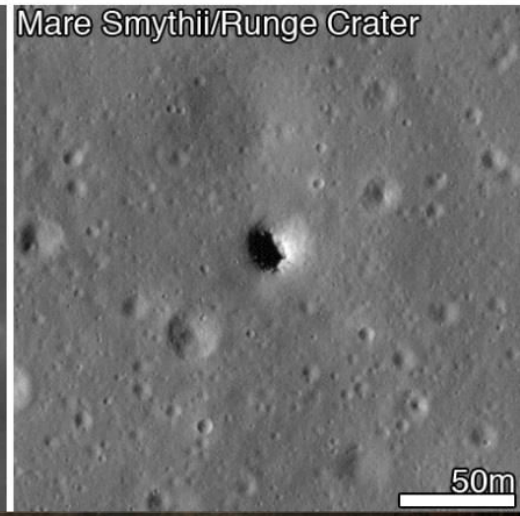


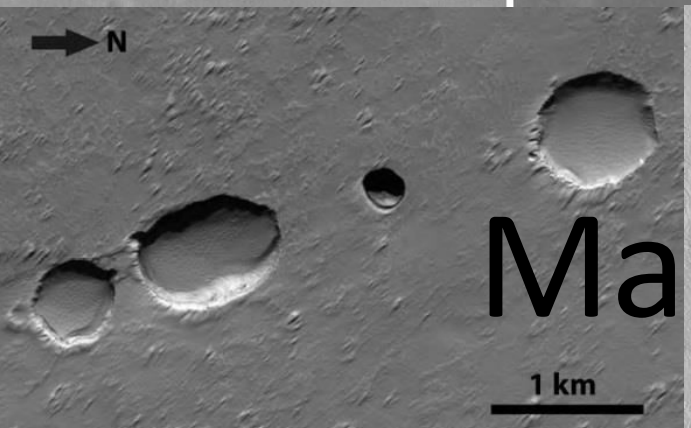




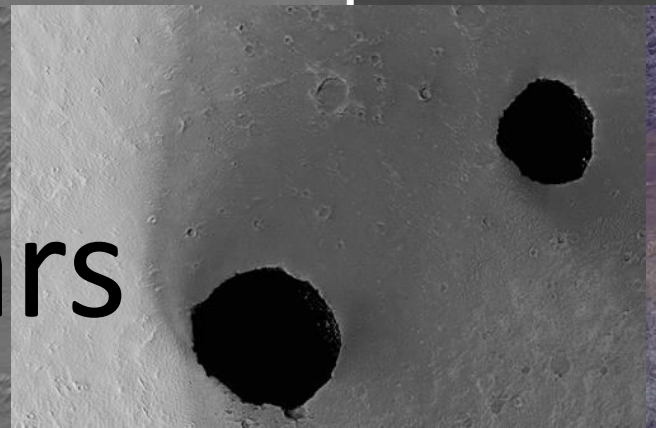


Moon



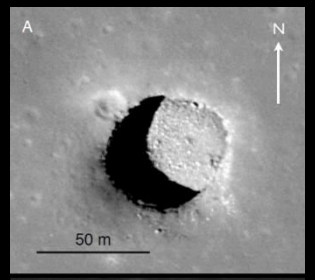


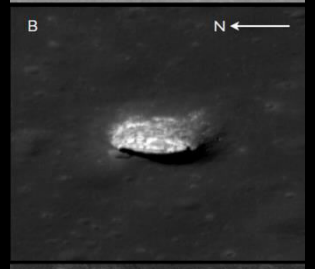
Mars

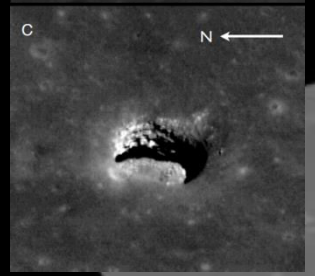


Earth

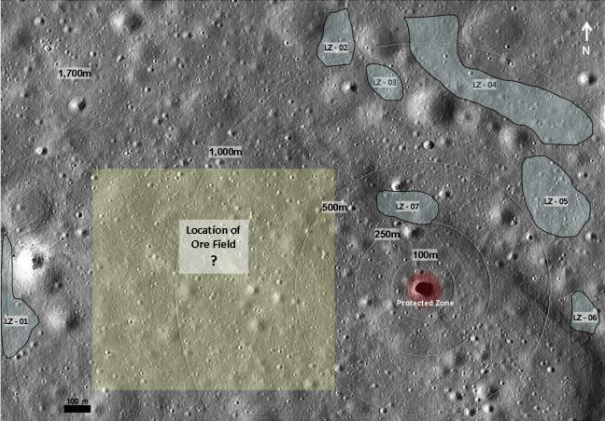
Marius Hills Skylight







Surface mining operations



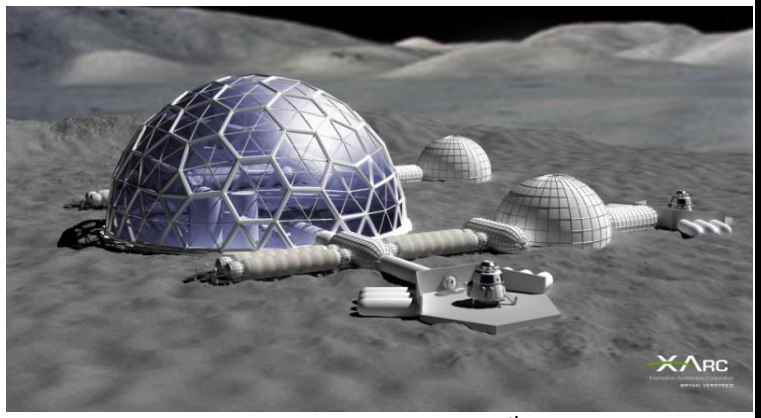
Remote Sensing Measurements: 2008 – 2018

Scientific Robotic Reconnaissance Missions: 2018 – 2020

Human & Robotic Reconnaissance: 2020 – 2025

Long Duration Stay Outpost: 2025 – 2050

Settlement Construction Begins: 2050+



Settlement Phase: Latter Part of the 21st Century

LEAP2

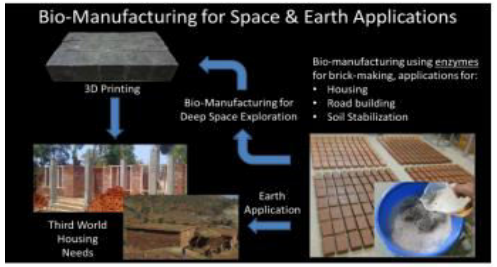
Lunar Ecosystem and Architectural Prototype

Lunar Site Development Phases of the Marius Hills Skylight for Human Settlement

Lunar Site Technology Development Research Currently Underway by LEAP2 Consortium Members

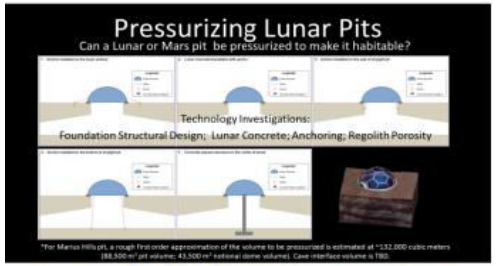
One of the various pit access concepts being investigated

Simulant research; polymeric pavers for landing pads

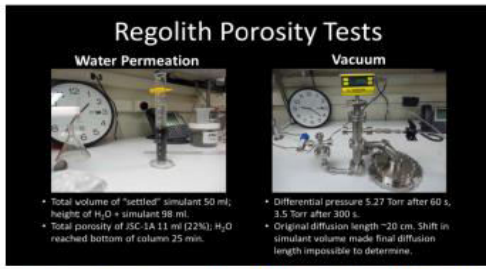


Dual-use technology for terrestrial sustainability

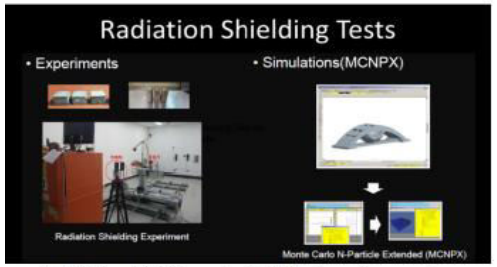
3D printed habitats using in-situ resources for construction



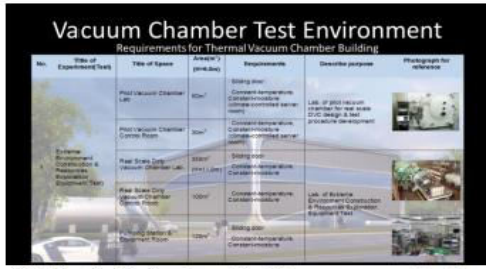
Dome structural foundation and anchoring investigations



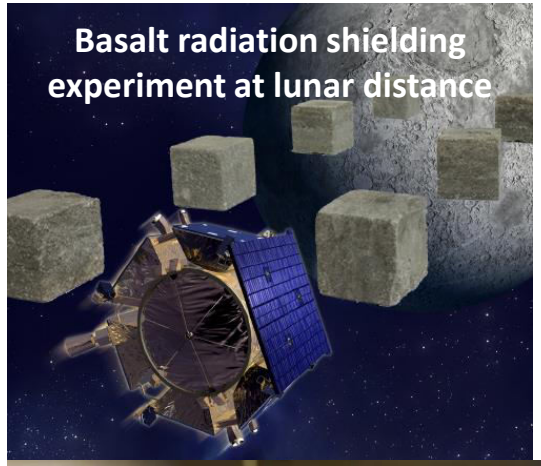
Dome pressurization and regolith porosity research [4]

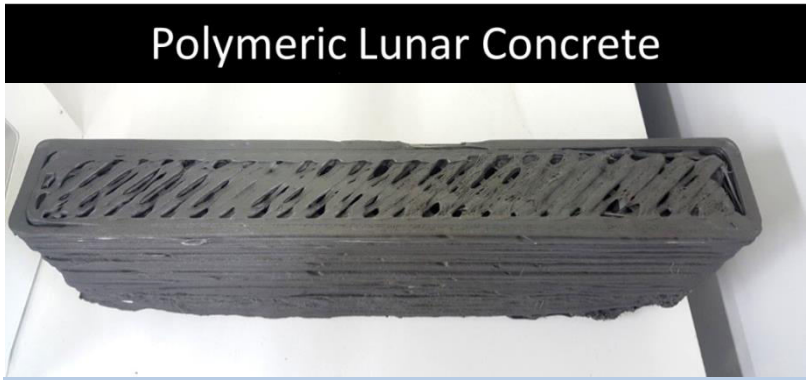


Radiation shielding potential of polymeric concrete



Building facility investment for 50 cu. m. vacuum chamber





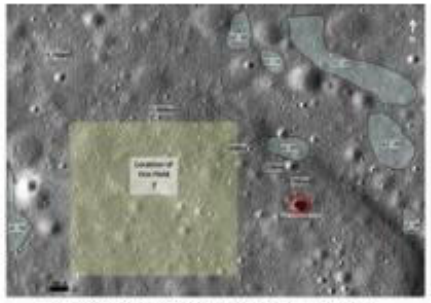
3D Printed Lunar Simulant Concrete Beam

LCATS Mission Reference Framework

Lunar Ecosystem and Architectural Prototype

STEM Education Framework

The discovery of large cave features on both the moon and Mars are significant for human settlement on distant planets . Caves offer protection from the extreme harsh environments on these planetary bodies.



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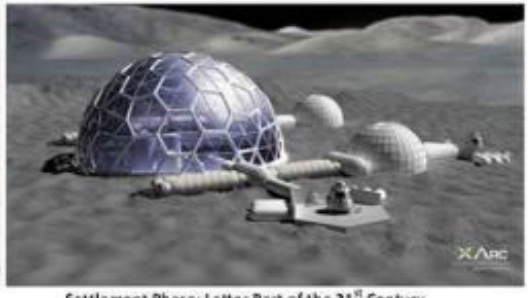
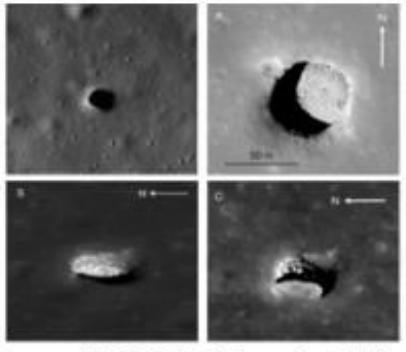


Settlement Phase: Latter Part of the 21st Century

Lunar site development phases of the Marius Hills Skylight for human settlement

LEAP2 is a commercial lunar settlement program that addresses space architecture issues in lunar exploration, economic development, mining, and sustainment at a specific lunar site identified as the Marius Hills Skylight. Projects within the LEAP2 program address various technology solutions and missions for achieving multi-generational program goals to develop the site for human settlement.

The Marius Hills Skylight is a large deep pit, approximately 48m x 57m wide x 45m deep, formed from a lava tube ceiling collapse.



Images: NASA/GSFC/Arizona State Univ.

The entrance to a lava tube cave is indicated by a large overhang at the pit's northeast side. Mineral resources in the surrounding area have been postulated for surface mining. The potential for long term habitation and settlement within the protection of the lava tube form the basis for economic development of the site.

LCATS Alignment with LEAP2

- By attaching the LCATS program to actual technology, engineering and science investigation challenges throughout the various LEAP2 site development growth phases the student learning experiences align with mission priorities for:
  - planetary surface systems engineering
  - mission operations
  - science experiments
  - science instrumentation
- Allows students to freely advance ideas for technology concept investigations.

The LCATS Experience

- Create a sustainable testing environment where secondary school students are encouraged to discover, learn, explore and achieve through an informal experiential space exploration research experience
- Acquaint students with professional opportunities in Space-STEM through sustained research, field experiences, and mentorship

LCATS Student Project Research Examples

LCATS Student Space Exploration Mission Year 1

MISSION 1 Remote Sensing Phase	MINI-CUBE
	The Mini-Cube program is a classroom laboratory at the edge of space. A Mini-Cube is a 5 cubic centimeter plastic cube that can be modified in any manner by a team or group of teams to accommodate their experiment(s) and is flown to an altitude of 100,000 feet or 20 miles by high altitude balloon to the "edge of space." The cube can hold 4 or more trays or racks of experiments and the total weight cannot exceed 240 grams. The Mini-Cube program flights are done by JP Aerospace in California. They provide opportunities for students to fly experiments on high altitude balloons for a minimum cost of $320 per cube. They launch from the Nevada desert twice a year, usually in September and again in April or May. JP Aerospace handles the entire flight aspect of the mission including FAA clearance, platform building, recovery, and video/pictures leaving students to concentrate on the science aspect of the mission. Mini-Cubes are usually shipped to JP

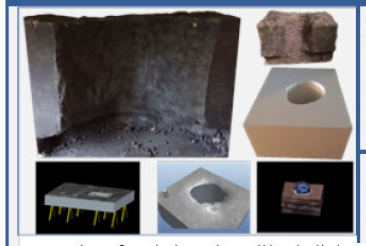
The Quartz Crystal Microbalance openQCM is a mass sensor device designed for use in liquid or in air. It is a highly sensitive and fully open-source scientifi biologic depositi

LEAP2 Reimag Moon, t

LCATS using A surface On the impacts lunar la over the Use the can be Scobee

LCATS YEAR 1 PROJECTS REMOTE SENSING PHASE

LCATS Student Space Exploration Mission Year 2

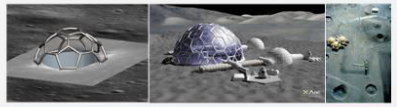
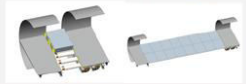
MISSION 2 Reconnaissance Phase	Lunar Pit Access
	One of the first challenges for reconnaissance at the Marius Hills Skylight is getting instruments, payloads and eventually astronauts down the pit hole and then back out in an unobtrusive manner which maintains integrity of the initial pristine site for science investigations. One example of a solution to this problem is development of a robotic zipline concept with a grappling and anchoring platform to enable offloading of instruments and robots to lower them down the pit.
	LEAP2 Need: Development of reconnaissance phase technologies needed to support entering and examining the site robotically and by astronauts for in situ investigations.

Examples of Scaled Marius Hills Skylight Lunar Terrain Models

LCATS Student Challenge: Construct a scaled for terrain contour studies and testing of robotic model for use as a simulated environment to tes terrain model. Create 3D computer model to aid an appropriately scaled prototype robot to test o deployment for entering the lunar pit.

LCATS YEAR 2 PROJECTS RECONNAISSANCE PHASE

LCATS Student Space Exploration Mission Year 3

MISSION 3 Habitation and Human Settlement Phase		Space Architecture
Project Areas	Sample Student Lunar Habitation Projects	The site development options for the Marius Hills lunar site are varied and many functional human activity end-uses exploiting this geological feature are possible for the site, ranging from mining camp to tourist hotel destination, or basic outpost for science investigations. Visualization of settlement concepts using drawings, sketches, 3D CAD modeling, and 3D printing are encouraged to bring various concepts to life.
 Habitation: Long Range Concepts for Settlement	Visualization of settlement concepts, drawing, sketching, 3D CAD modeling, 3D printing 	
 Habitation: Inflatable's	Design and construct inflatable structures 	**LEAP2 Need:** Needed are advanced technologies and materials for various habitation and infrastructure construction concepts for short duration crewed missions and eventual long term habitation of the Marius Hills lunar site.
 Habitation: Pressurized Volumes & Human Factors	Build habitat mockups for interior configuration and crew quarter layouts, or acquire commercially available shelters and reconfigure for human factors experiments and interior outfitting concepts 	

LCATS Student Challenge: Design and prototype a lunar habitation concept for any human presence phase at the MH Skylight. Investigate new technologies and materials; construct scaled model; where feasible construct full-scale prototype to act as a test-bed to prove concept.

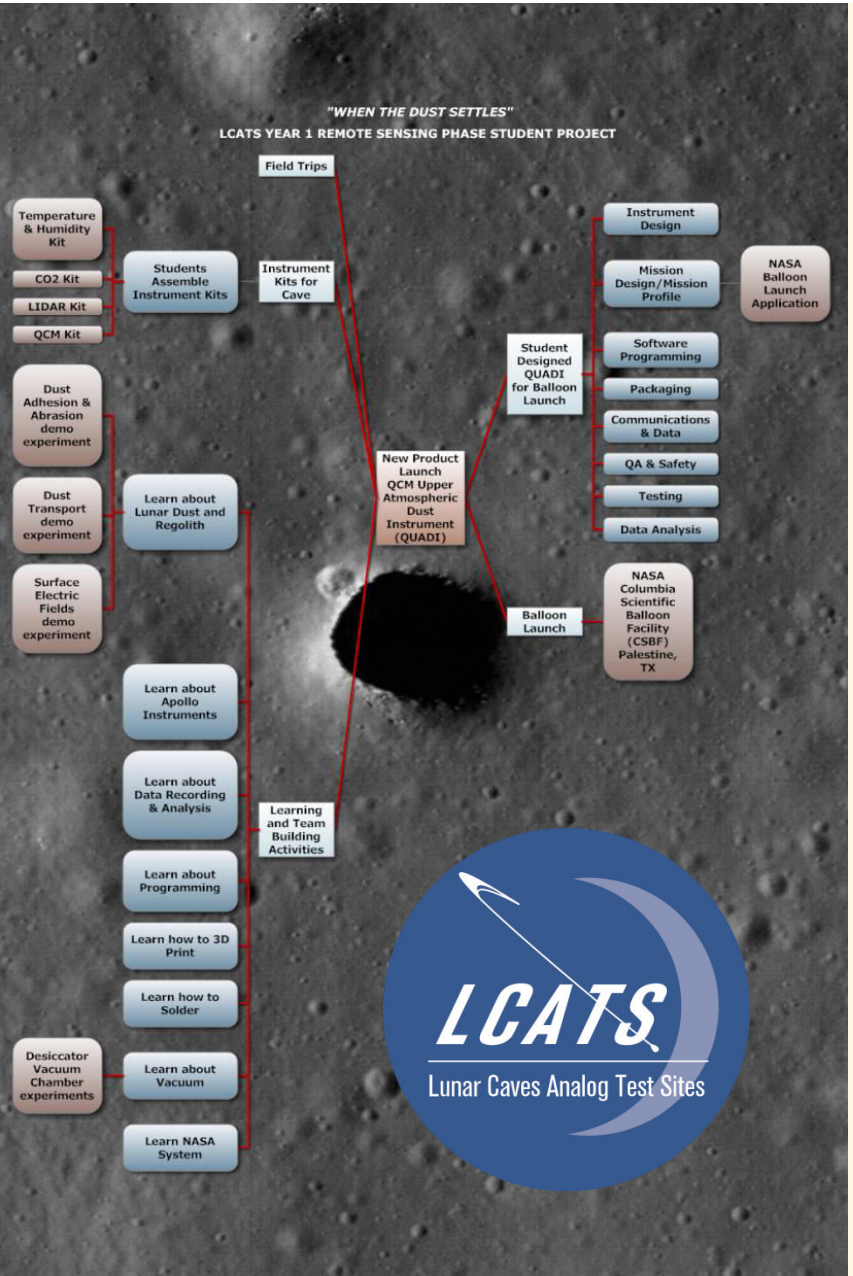
LCATS YEAR 3 PROJECTS HABITATION PHASE

Year 4

Cohort 1 writes comic book chronicling their experience

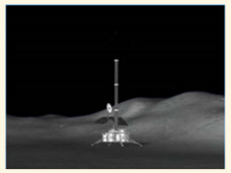
- LCATS operates within the LEAP2 framework by working with host schools in lower-income and high-needs communities to recruit female and economically disadvantaged students to pursue higher education and careers in human space exploration.
- A central thesis of the LCATS program is to allow students to form consulting teams for a potential 3 year experience of cohorts progressing through the LEAP2 phases of lunar site development
- The LEAP2 site development framework provides student cohorts a sustained Space-STEM learning experience over the course of three years, intended to mimic a multi-year systems engineering implementation of the LEAP2 mission
- Student challenges are project-based, mission oriented, field tested student learning experiences
- Local Texas caves in the area and region are utilized as analog environments for fielding student experiments and technology challenges through simulated mission operations

“When the Dust Settles”



“When the Dust Settles”, is a LCATS Year 1, Remote Sensing Phase project theme. Students learn about issues of lunar dust and measurement techniques. The Quartz Crystal Microbalance (QCM) investigation for learning about dust particle measurements is an example how LCATS student technology projects add to and feed development of LEAP2™ technology research.

LEAP2/LCATS QCM EDUCATION DEVELOPMENT PROGRAMS



Cave QCM

Program: LCATS
Level: Middle School
Purpose: Basic Introduction to QCM Function
Activity: Assembly of QCM Sensor Kit
Deployment: Dust measurements in cave environment
Timeframe: Sep - Oct 2018; Cave Field Trip Oct 2018
Development Team:
- WEX Foundation
- UTSA TxPREP
- UTSA Advanced Robotics
- Southwest Research Institute
- Novaetech

Lunar QCM

Program: XARC LEAP2
Level: University Undergrad/Graduate
Purpose: Flight hardware design for lunar environment
Activity: Design, fabrication, and deployment of a Near Surface Lunar Dust Instrument (NSLDI) with QCM and Langmuir Probe measurements
Deployment: Commercial Lunar Lander
Timeframe: Phase 0 Concept Design June - Dec 2017; prep for Phase I SBIR proposal Jan 2018; Launch TBD 2020+
Development Team:
- XArc
- WEX Foundation
- UTSA Advanced Robotics
- University of Central Florida
- Southwest Research Institute
- Novaetech

QCM TECHNOLOGY EDUCATION SENSOR DEVELOPMENT VISION & STRATEGY

Stratosphere QCM

Program: LCATS
Level: Middle School
Purpose: Instrument Design
Activity: Design and fabrication of QCM Upper Atmosphere Dust Measurement Instrument
Deployment: High Altitude Balloon Launch
Timeframe: Nov 2017-May 2018; Launch June 2018
Development Team:
- WEX Foundation
- UTSA TxPREP
- UTSA Advanced Robotics
- Southwest Research Institute
- Novaetech

LEO QCM

Program: LCATS-SEP (Student Exchange Program)
Level: High School
Purpose: Flight hardware design for space environment
Activity: Design and build a CubeSat with QCM / Langmuir Probe payload for Low Earth Orbit (LEO) particle/plasma measurements
Deployment: International Space Station
Timeframe: Summer 2018; Launch TBD
Development Team:
- WEX Foundation
- UTSA TxPREP
- UTSA Advanced Robotics
- University of Central Florida
- Southwest Research Institute
- Novaetech
- KICT

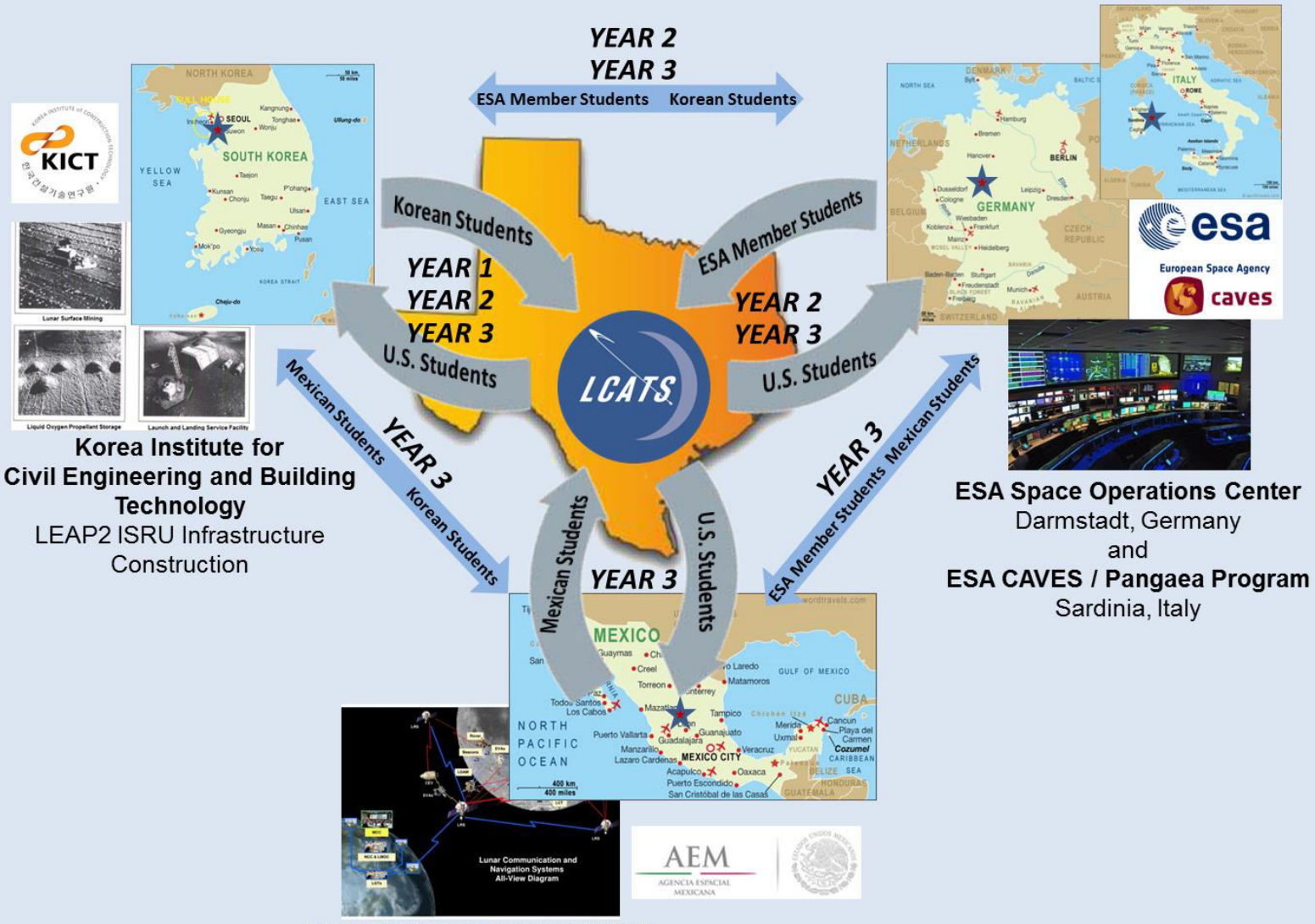
A Model for Global Space-Workforce Capacity Building

- Goal is to replicate the LCATS model into a global network of LEAP2 Space-STEM communities
- Each community develops LEAP2 technologies relevant to their community's particular area of interest depending on aerospace resources of the community

Current network of identified LEAP2/LCATS space-industry clusters

LCATS-SSEP Pilot Program for Space-Workforce Capacity Building

Lunar Caves Analog Test Sites – Summer Student Exchange Program (LCATS-SSEP)



Korea Institute for Civil Engineering and Building Technology
LEAP2 ISRU Infrastructure Construction

ESA Space Operations Center
Darmstadt, Germany
and
ESA CAVES / Pangaea Program
Sardinia, Italy

Mexican Space Agency (AEM)
LEAP2 Communications Architecture

LCATS-SSEP Student Experience

YEAR1 *- Student summer program in Seoul, South Korea for In-Situ Resource Utilization (ISRU), testing excavation methods and 3D printed habitat technologies, robotics, and drilling.*

YEAR2 *- Student summer program in Europe; combination of mission control operations in Darmstadt, Germany, and mission simulation and performance skills in cave environment in Sardinia, Italy.*

YEAR3 *- Student summer program in Mexico learning about satellite communications and lunar communication architectures.*

YEAR1-3 *- International students from partner international organizations join US students in San Antonio, Texas, USA, for summer program to build CubeSat satellites which will be launched from the International Space Station.*

LCATS-SSEP Exchange Matrix Modelling

YEAR1		US	Korea	
Total Class Size (in host country)		20	10	
Student Exchanget Allocation		6	6	
US Cubesat-1 Workshop	Distribution of		6	
Korean ISRU-1 Workshop	exchange students per	6		
	allocation total check	6	6	
Workshops International Mix				Class Size
San Antonio, TX	US Cubesat-1	14	6	20
Seoul, Korea	Korean ISRU-1	6	4	10

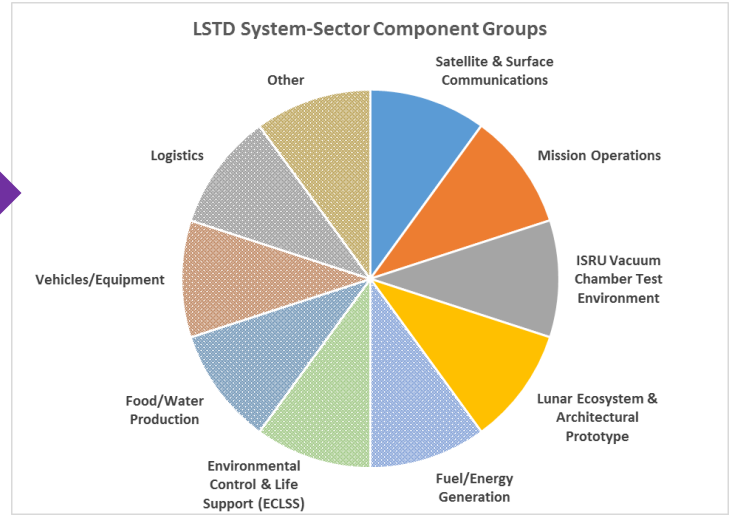
YEAR2		US	Korea	ESA	
Total Class Size (in host country)		20	12	12	
Student Exchanget Allocation		15	9	9	
US Cubesat-2 Workshop	Distribution of		3	6	
Korean ISRU-2 Workshop	exchange students per	5		3	
ESA CAVES-1 Workshop	workshop	5	3		
ESA ESOC-1 Workshop		5	3		
	allocation total check	15	9	9	
Workshops International Mix					Class Size
San Antonio, TX	US Cubesat-2	11	3	6	20
Seoul, Korea	Korean ISRU-2	5	4	3	12
Sardinia, Italy	ESA CAVES	5	3	4	12
Darmstadt, Germany	ESA ESOC-1	5	3	4	12

YEAR3		US	Korea	ESA	Mexico	
Total Class Size (in host country)		20	15	15	15	
Student Exchanget Allocation		16	12	12	12	
US Cubesat-3 Workshop	Distribution of		3	4	3	
Korean ISRU-3 Workshop	exchange students per	4		4	3	
ESA CAVES-2 Workshop	workshop	4	3		3	
ESA ESOC-2 Workshop		4	3		3	
AEM SpaceComm-1 Wkshp		4	3	4		
	allocation total check	16	12	12	12	
Workshops International Mix						Class Size
San Antonio, TX	US Cubesat-3	10	3	4	3	20
Seoul, Korea	Korean ISRU-3	4	4	4	3	15
Sardinia, Italy	ESA CAVES-2	4	3	5	3	15
Darmstadt, Germany	ESA ESOC-2	4	3	5	3	15
Mexico City , Mexico	AEM SpaceComm	4	3	4	4	15

LEAP2/LCATS Global Space-Industry Cluster Assesstments

LEAP2 and LCATS Space Industry Clusters

To expand the LCATS and LEAP2 initiative, our research seeks to identify, map, and analyze additional potential collaborating corporate, industry and governmental agency players representing other space architecture components needed for lunar site technology development. Aspects examined include local, regional, and international factors from the perspective of evolving a global space-STEM education network beneficial to the local community of the collaborating organization relevant to their expertise in system component development.



OTHER SPACE AGENCIES AND NEW ENTITIES

Courtesy Astrobotic

HOST COUNTRY A LCATS/LEAP2 Cluster Analyses	TASK 1 Background Research			TASK Cluster		Task 3 Reporting
	Month1	Month2	Month3	Month4	Month5	Month6
	DATA TYPE, SOURCE	DATA COLLECTION	DATA MANAGEMENT	CLUSTER ANALYSES	ANALYSES	REPORT
Secondary Data: Industry, Agencies	INDUSTRY SECTOR CODES	INDUSTRY DATA	INDUSTRY	LQ, SYSTEM-SECTOR	STATISTICAL SUMMARY	TECHNICAL
	SPACE AGENCIES, PATENTS	AGENCY, PATENT DATA	PROGRAMS, PATENTS	TABLES, NARRATIVES	PROGRAM SUMMARY	DATA VISUALIZATION
Secondary Data: Factors, STEM	ECONOMIC FACTORS	FACTOR DATA	FACTORS	CA, BACKGROUND	DATA SUMMARY	NARRATIVE
	SPACE-STEM PROGRAMS	PARTICIPATION DATA	ACTIVITIES	LCATS/LEAP2 POTENTIALS	LUNAR SITE TECH DEVELOPMENT FRAMEWORK	LCATS/LEAP2 NETWORK
GIS Mapping and Data Visualization	SHAPEFILES	GEOCODING INDUSTRY, PROGRAMS	GEOCODING ALL DATA	GEOCODING LQ, LCATS/LEAP2	GEOCODING ANALYSES	GIS REPORT
Data Management Platform						REPORT AND DATA

Cluster Assessment Overview

Global data on space industry sectors and occupations are collected by industry classification codes and run through various analyses, including location quotients, geographic cluster analysis, and Geographic Information System (GIS) analytics.