

# NASA MSFC Moon-to-Mars Planetary Autonomous Construction Technology (MMPACT) Overview



Corky Clinton, Jennifer Edmunson, Mike Fiske, Mike Effinger  
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# MMPACT Overview

## Moon-to Mars Planetary Autonomous Construction Technologies

### GOAL

**Develop, deliver, and demonstrate on-demand capabilities to protect astronauts and create infrastructure on the lunar surface via construction of landing pads, habitats, shelters, roadways, berms and blast shields using lunar regolith-based materials.**

### APPROACH

- MMPACT is comprised of 3 interrelated elements
  - Olympus – Mike Fiske, Element Lead, Jacobs
    - Autonomous large-scale construction system being developed by ICON
    - Cementitious materials and direct energy sintering technologies
  - Construction Feedstock Materials Development – Dr. Jennifer Edmunson, Element Lead, MSFC
    - Development of materials to support Olympus and MSCC lunar construction efforts.
    - Focuses on materials identification, characterization, and test.
  - Microwave Sintering Construction Capabilities (MSCC) – Mike Effinger, Element Lead, MSFC
- MMPACT is a phased development project targeting an initial proof of concept technology demonstration on the lunar surface based on Phase 1 developments
  - MMPACT will evaluate multiple additive construction and direct energy sintering construction technologies, materials, and construction element forms
  - Mature selected technologies, processes, and operations
  - Demonstrate capabilities in simulated lunar environmental conditions



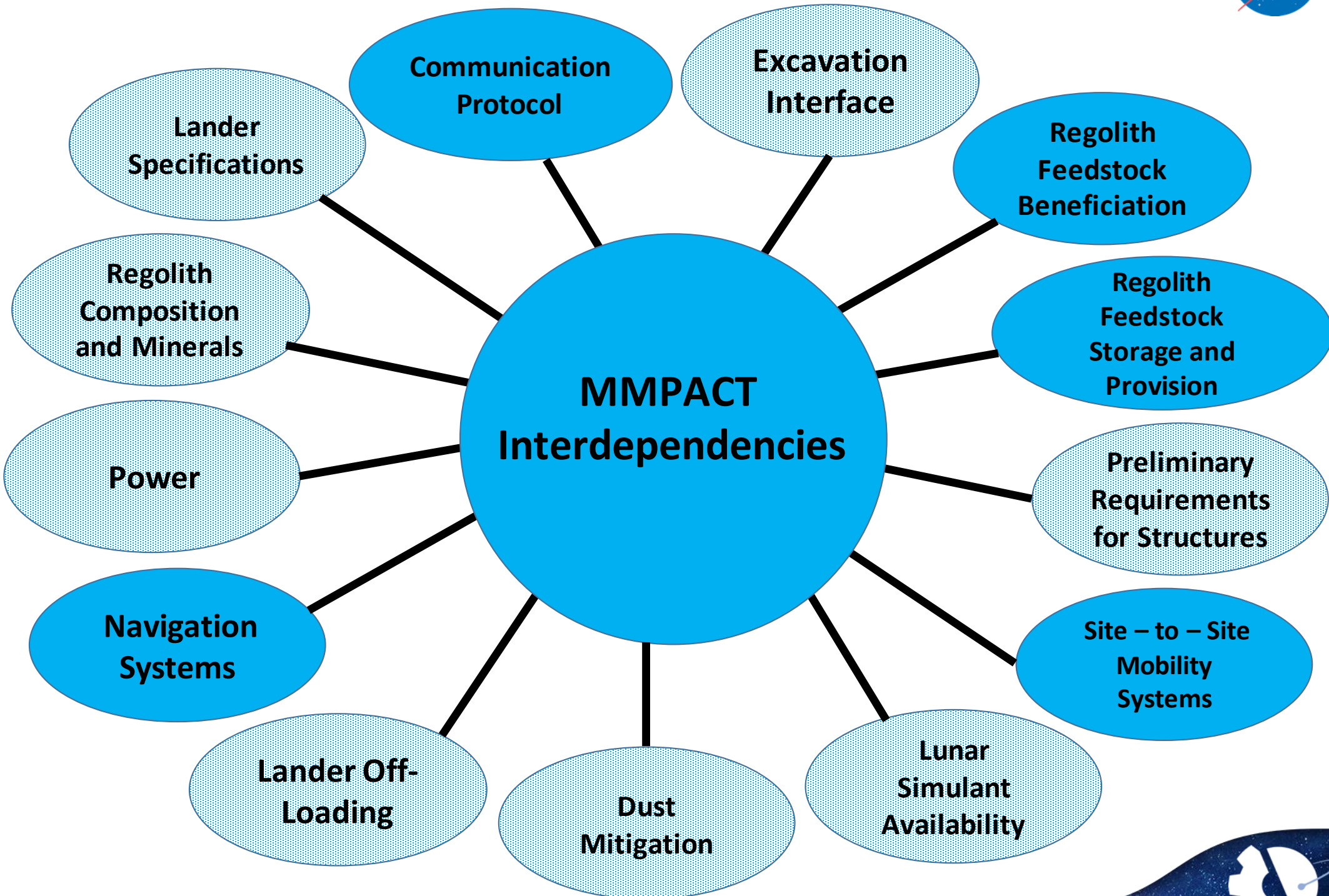


# Common Key Functional Requirements Development

- Developed individual requirements for Earth-based and Lunar construction with SEArch+
- Identified Common Technology Development Interests with SEArch for Earth-based and Lunar Construction Capabilities (Venn Diagram)
- Followed similar approach with ICON and DoD organizations for SBIR Proposal
- Results yielded shared set of key functional requirements that would benefit the goals of NASA, ICON, DoD, and SEArch+
  - Long-distance communication, monitoring, and control
  - Increased autonomy/automation of operations
  - Increased transportability / mass reduction
  - Expanded environmental range
  - Design for field reparability
  - Dust mitigation
  - Shielding / Ballistic Protection
  - Job-site Mobility
  - Off-foundation construction / foundation delivery
  - Multi-material printing & related control systems
  - Improved user experience/ease of operation (i.e. reduced training load)
  - Software Design Platform



# MMPACT Interdependencies



# MMPACT Technology Development

- MMPACT technologies will be matured in phases
  - Phase 1:
    - Olympus and Construction Materials Development Elements
      - L'SPACE student design competition Lunar Landing Pad print – Complete
      - Preliminary concepts for Landing Pads and Habitats to inform Olympus engineering decisions for ICON
      - Design, develop, downselect and demonstrate prototype Materials Deposition Head and Mobility System
      - Candidate materials identification, test, characterization and downselect
    - MSCC will demonstrate microwave manufacturing to TRL 6
      - Horn design, fabrication, and test
      - Thermal management
      - Solar heating/sintering testing
      - Site preparation
      - Prototype mobility system
  - Phase 2: Options
    - Lunar Surface Proof of Concept Construction Technology Demonstration 1 (circa 2026)
      - Demonstrate Olympus Materials Deposition Head on CLPS Lander
      - Demonstrate Microwave construction system on CLPS lander
  - Future Developments: Scale up selected deposition technology for subscale infrastructure construction demo on the lunar surface in the late 2020s.



# MMPACT-Olympus Phase 1 Milestone Schedule



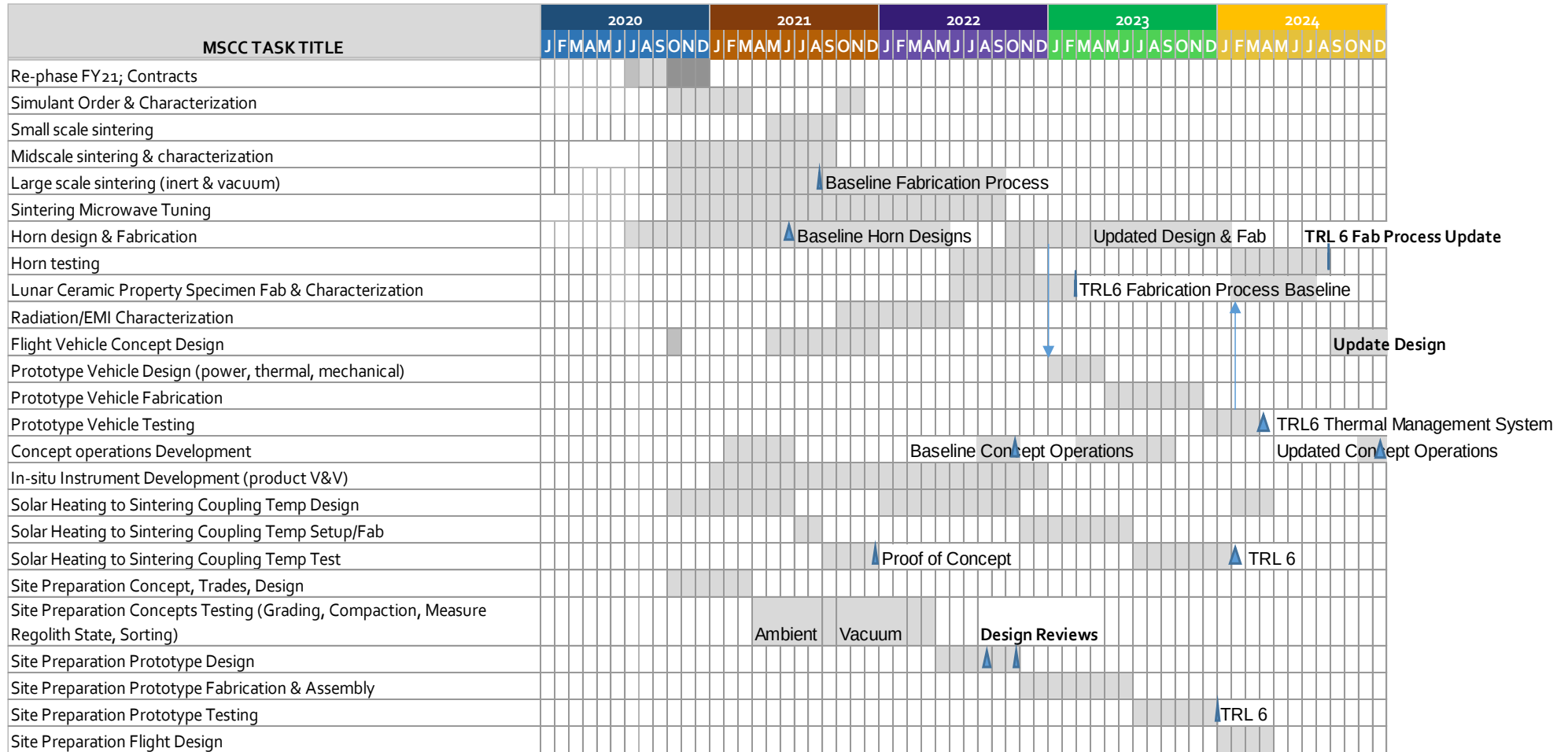
| TASK TITLE                                                        | Task Owner     | 2020 |   |   |   |   |   |   |   |   |   |   |   | 2021 |   |   |   |   |   |   |   |   |   |   |   | 2022 |   |   |   |   |   |   |   |   |   |   |   |  |
|-------------------------------------------------------------------|----------------|------|---|---|---|---|---|---|---|---|---|---|---|------|---|---|---|---|---|---|---|---|---|---|---|------|---|---|---|---|---|---|---|---|---|---|---|--|
|                                                                   |                | J    | F | M | A | M | J | J | A | S | O | N | D | J    | F | M | A | M | J | J | A | S | O | N | D | J    | F | M | A | M | J | J | A | S | O | N | D |  |
| Architectural Design Study with Bjarke Ingles Group (BIG)         | ICON           |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |  |
| Architectural Design Study with SEArch+                           | ICON           |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |  |
| Phase IIB SBIR Schedule of Milestones                             |                |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |  |
| Fabricate 20' Dia subscale 3d printed landing pad                 | ICON           |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |  |
| Draft set of Mission Requirements to inform further decomposition | ICON           |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |  |
| Materials ID complete                                             | NASA Materials |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |  |
| Mobility System & Printhead Trade Study                           | ICON           |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |  |
| Materials characterization complete                               | NASA Materials |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |  |
| Engineering Design Concept Review                                 | ICON           |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |  |
| Initial Prototype of Subsystems, Mobility and Printhead           | ICON           |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |  |
| Integration of Control System with Mobility System                | ICON           |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |  |
| Delivery of Printed Samples (beams, sub-scale structures)         | ICON           |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |  |
| Printed materials Testing                                         | NASA Materials |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |  |
| CLPS lander materials evaluation & selection                      | NASA Materials |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |  |
| Technical Prototype Demonstration at ICON                         | ICON           |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |  |
|                                                                   |                |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |   |   |   |   |   |   |  |

^ "Award" / Kickoff  
(Sept 1, 2020)

 ICON  
 NASA Construction Feedstock Materials Development



# MMPACT-MSCC Phase 1 Milestone Schedule





Technology Drives Exploration

