Contour Crafting
Simulation plan for planetary infrastructure buildup

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What is Contour Crafting?
A CC machine
Full-scale concrete structures
Strength of a 4-layer section
Supportless structures
Vault structure implementation by CC
Lunar structures
Planetary applications

Basic infrastructure elements:
- Landing pad
- Blast protection wall
- Roads
- Shade walls
- Hangars

Other structures:
- Human habitat
- Green house
- Laboratories
- Fuel vessels
END OF BRAKING PHASE

THRUST 5,900 LB
LANDING RADAR POSITION NO. 1
23,000 FT.

THRUST 5,400 LB
HIGH GATE
7,100 FT.

THRUST 4,000 LB
LANDING RADAR POSITION NO. 2
6,500 FT.

VERTICAL VELOCITY 22 FPS
VERTICAL DESCENT 200 FT TO TOUCHDOWN
668 FT

VERTICAL VELOCITY 5 FPS
1,500 FT

LUNAR SURFACE
2.6 NAUTICAL MILES
APOLLO LUNAR MODULE COMPARED TO ALTAIR LDAC-2

<table>
<thead>
<tr>
<th>Lunar Module</th>
<th>Altair LDAC-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall height</td>
<td>7.04m</td>
</tr>
<tr>
<td>Width at tanks</td>
<td>4.22m</td>
</tr>
<tr>
<td>Width at footpads</td>
<td>9.45m</td>
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Altair Lunar Lander

Crew Size: 4 astronauts

Duration: 7 days (sortie), 210 days (lunar colony missions)

Stages: 2
Height: 9.9 m
Footprint: 14.9 m

Ascent stage mass: 6141 kg
Ascent stage thrust: 24.5 kN
Descent stage mass: 37,045 kg
Descent stage thrust: 83.0 kN
Large Lander - MALEO Site Office
Landing pad design
Landing pad, apron and blast wall
Road construction
Hangar construction
Sulfur Concrete
Infrastructure Design

Environmental Forces

- Lander thrust
- Micro-meteorites
- Thermal issues
  - Low thermal conductivity
  - Regional variation
  - Sunlit vs. shaded
  - Diurnal
- Dust
- Vacuum
- Moon gravity
- Radiation (solar protons & galactic cosmic rays)
Infrastructure Design
Materials and Methods

ISRU Materials:
• Sulfur concrete
• Molten regolith
• Tensile reinforcement

Methods:
• Layered without formwork
Infrastructure Design

Landing Pad and Apron

Boundary Conditions and Loadings:
• Lander thrust and fuel heat
• Solar energy
• Structure / regolith interface

Issues:
• Repeated heating / thrust
• Ejecta from fuel / dust
• Hard landing
• Micrometeorites
• Buckling / cracking
Boundary Conditions and Loadings:
- Rocket fuel heat and thrust
- Ejecta from exhaust / dust
- Structure / regolith interface

Issues:
- Nearby storage / facilities
- Distant settlement
- Shape
- Deterioration
Boundary Conditions and Loadings:

• Solar energy
• Rovers
• Structure / regolith interface

Issues:

• Maximum payload
• Traction
• Buckling/cracking
Infrastructure Design

**Hangar / Storage**

Boundary Conditions and Loadings:
- Self weight
- Solar Energy
- Micrometeorites
- Structure / regolith

Issues:
- Thermal stress / strain
- Stability
- Crack propagation
- Radiation protection
Four dissimilar problems, one unified tool.

Abaqus / SIMULIA

- Implicit and explicit solvers
- Computational fluid dynamics
- Coupled Lagrangian-Eulerian analyses
- Heat transfer
- Shape optimization
- Shock, blast, contact, damaged plasticity, fracture, adaptive remeshing, etc.
Dual use – terrestrial applications

- Emergency shelters
- Construction in regions with limited water supply
- Autonomous shielding against radiation
Thank you

Questions?