



A Lunar Volatiles Miner

Matthew E. Gajda, Gerald L. Kulcinski,
John F. Santarius, Gregory I. Sviatoslavsky,
and Igor N. Sviatoslavsky

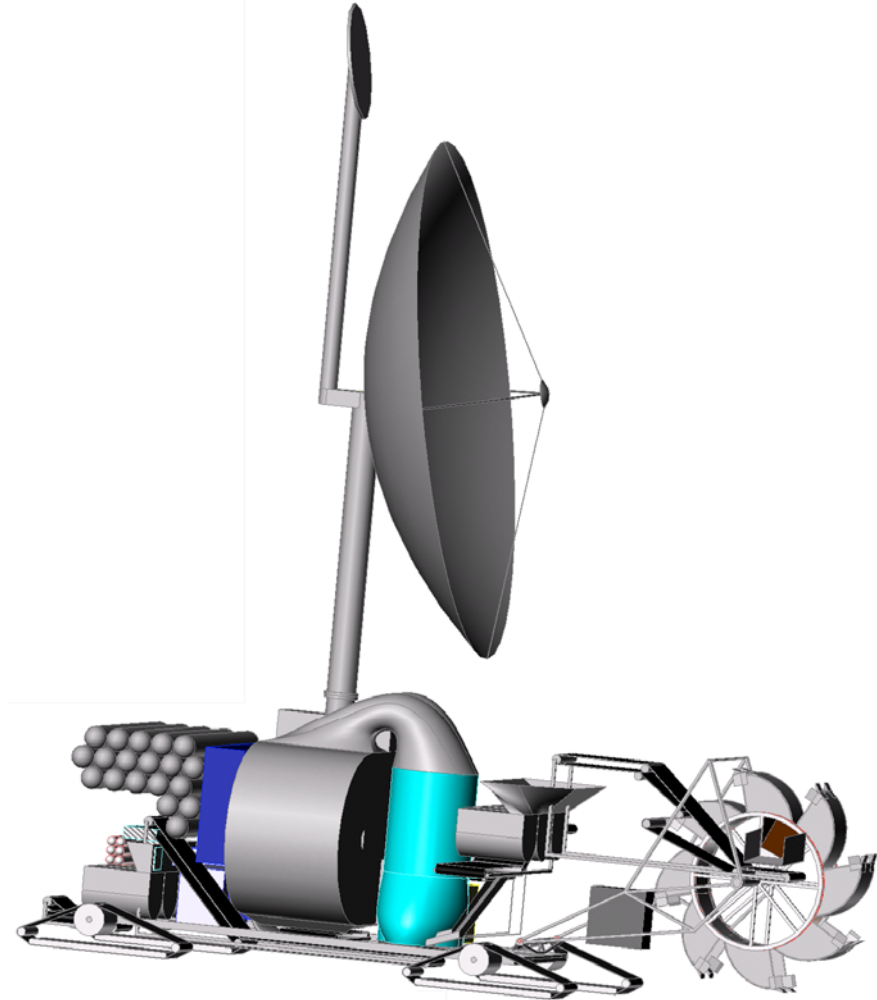
*Engineering Physics Department
University of Wisconsin – Madison*

Tuesday, March 7

Earth & Space 2006

Outline

- Introduction
- Background
- Design Parameters
- Mark III Overview
- Mark III Schematics
- Results
- Conclusion

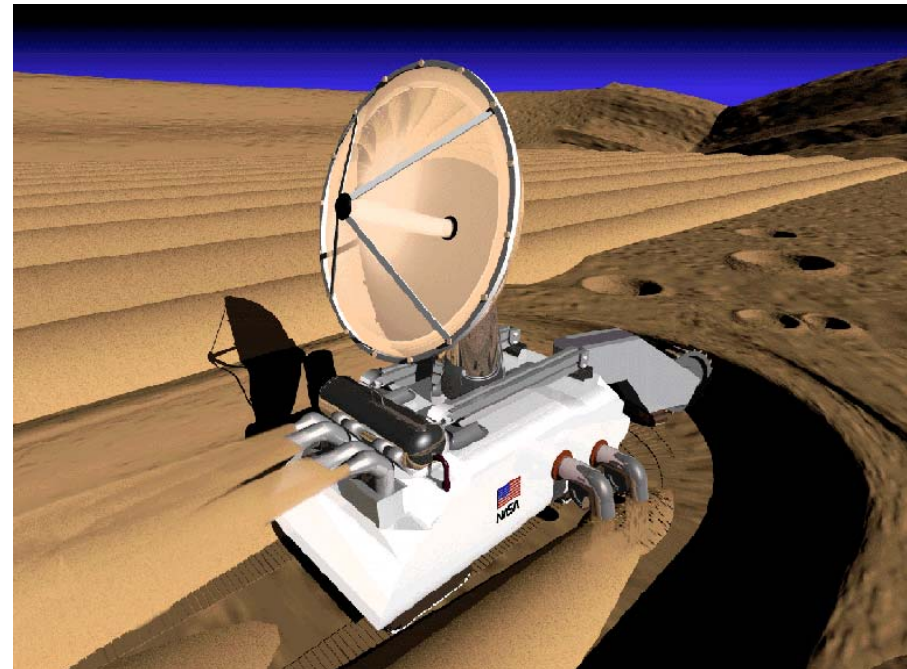


Introduction

- Excavate lunar regolith
- Sort regolith and process small fines (< 100 μ m)
- Heat small fines to 700 °C
 - Solar wind volatiles extracted: H₂, ⁴He, ³He, CO₂, CO, CH₄, N₂, H₂O
- Store volatiles

Background*

- Mark II designed in early 1990's
 - Empty Mass: 18 tonnes
 - Power usage: 200 kW_e
- Mine 1 km², 3 m deep, per year
- Extract 1650 kg of volatiles every Earth day



*Sviatoslavsky, I. N. (1993 February). *The Challenge of Mining He-3 on the Lunar Surface: How All the Parts Fit Together*. Proceedings of Space 94, The 4th International Conference and Exposition of Engineering, Construction and Operations in Space, Albuquerque, NM

Volatiles Extracted

- Life support
 - Atmosphere
 - Water
 - Food
- Water support for over 750 inhabitants per miner

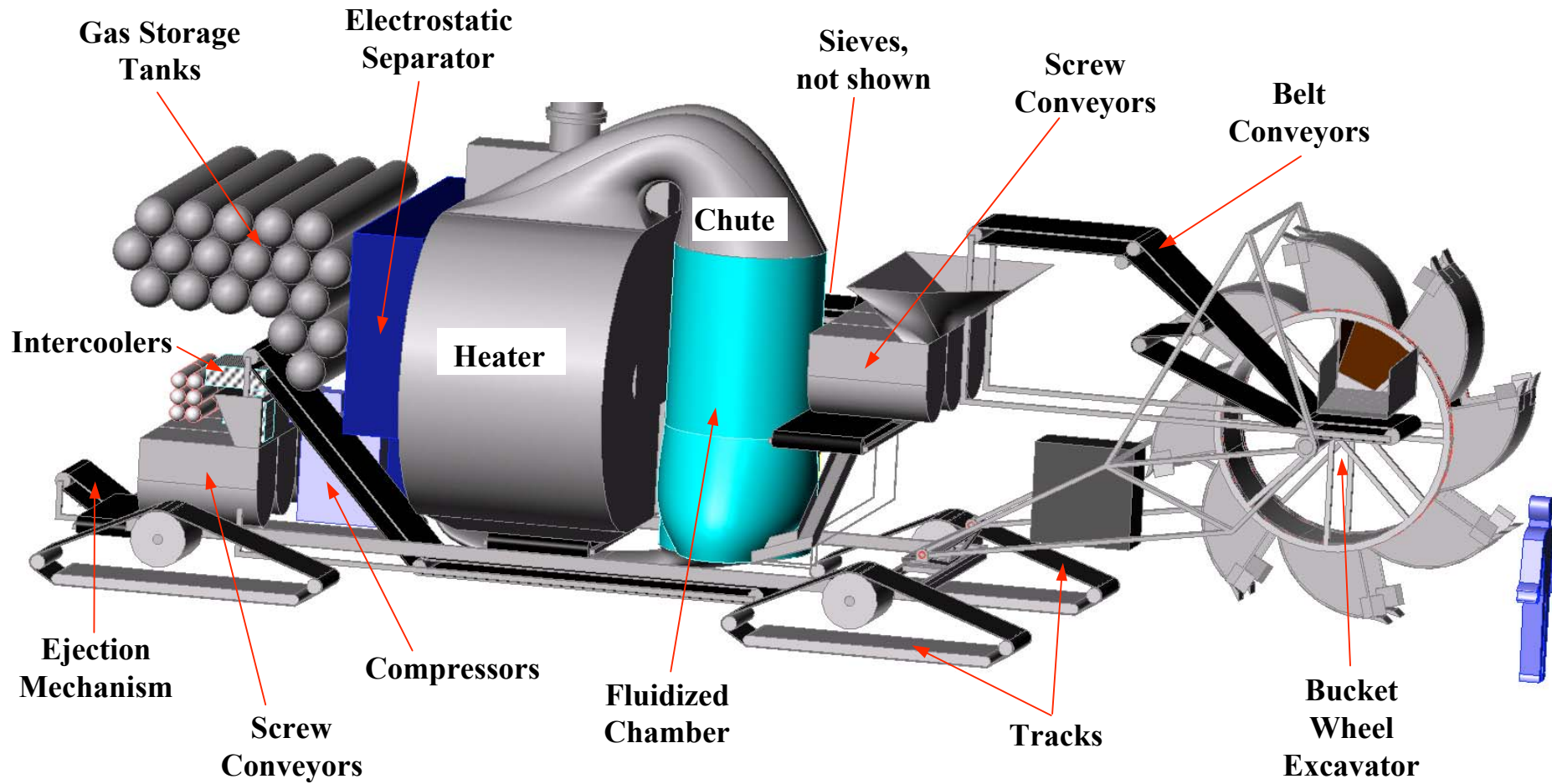
Mass of Volatiles Extracted (tonnes/yr)	
H ₂ O	108.9
N ₂	16.5
CO ₂	56.1
H ₂	201.3
⁴ He	102.3
CH ₄	52.8
CO	62.7
³ He	0.033



Mark III Design Goals

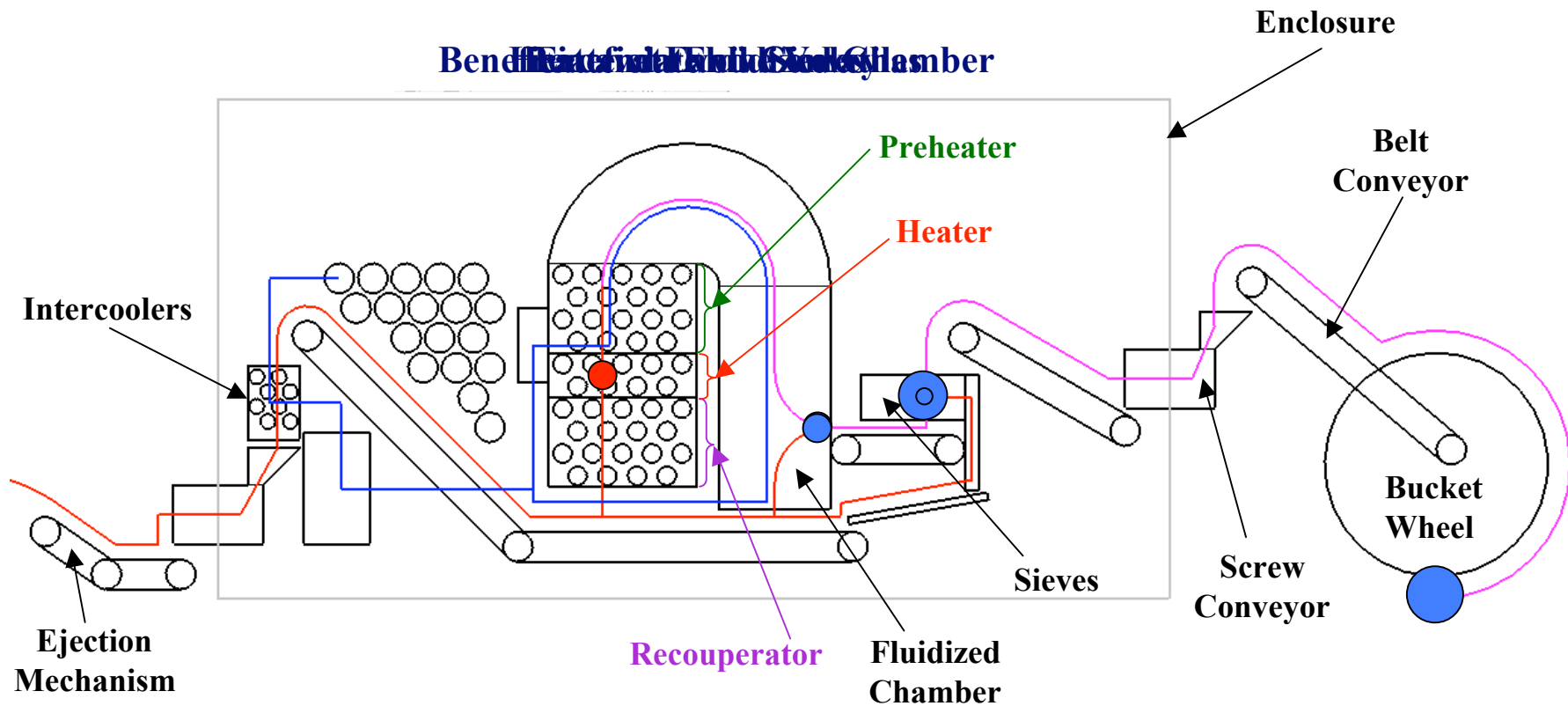
- Only designed the miner
- Same processing capabilities as Mark II
- Empty Mass: < 10 tonnes
- Gas loss: < 10%
- Base camp maximum of 10 km away
- Can drive on 20° side-slope

Mark III Components*

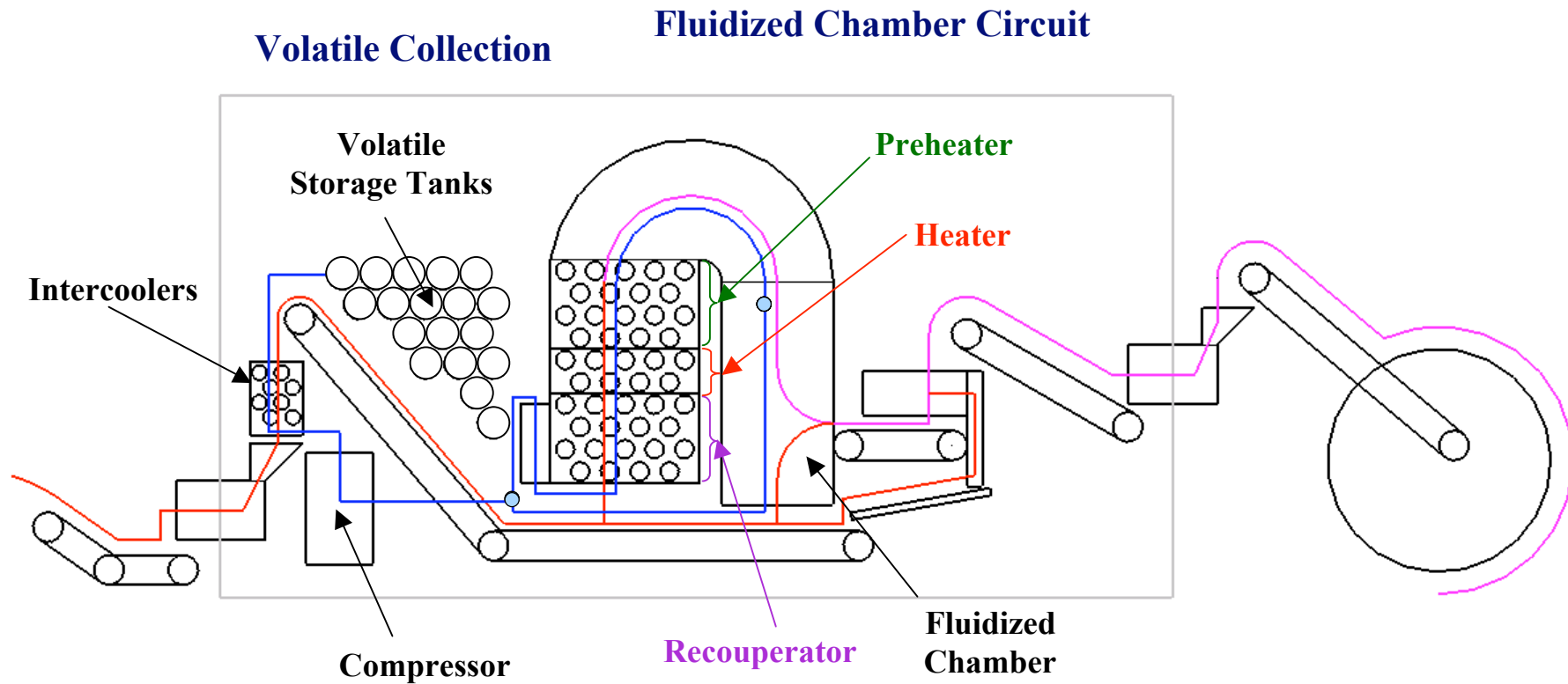


*Enclosure, solar collector, and RF rectenna not shown

Regolith Flow Schematic

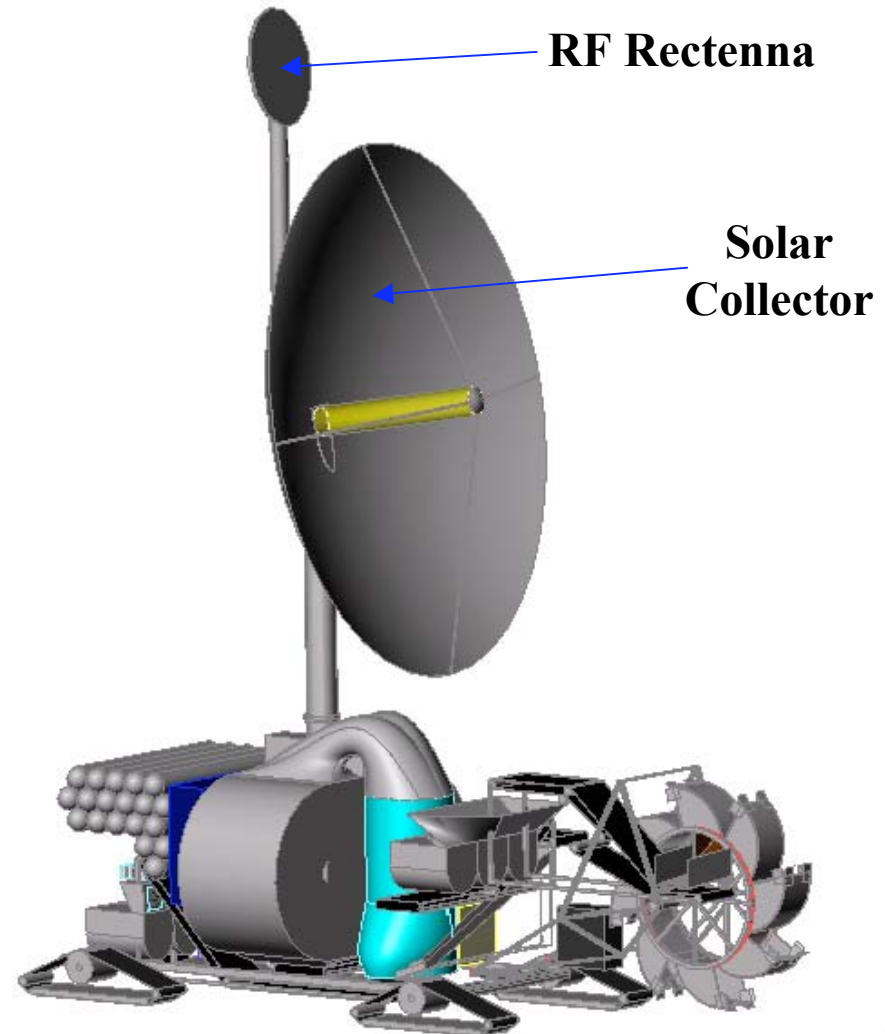


Volatile Flow Schematic



Energy Overview

- Regolith Heater energy
 - Beamed concentrated solar energy
 - 12.3 MW thermal
- Miner Electric power
 - Beamed radio frequency (RF) waves
 - Overall RF conversion efficiency ~50%

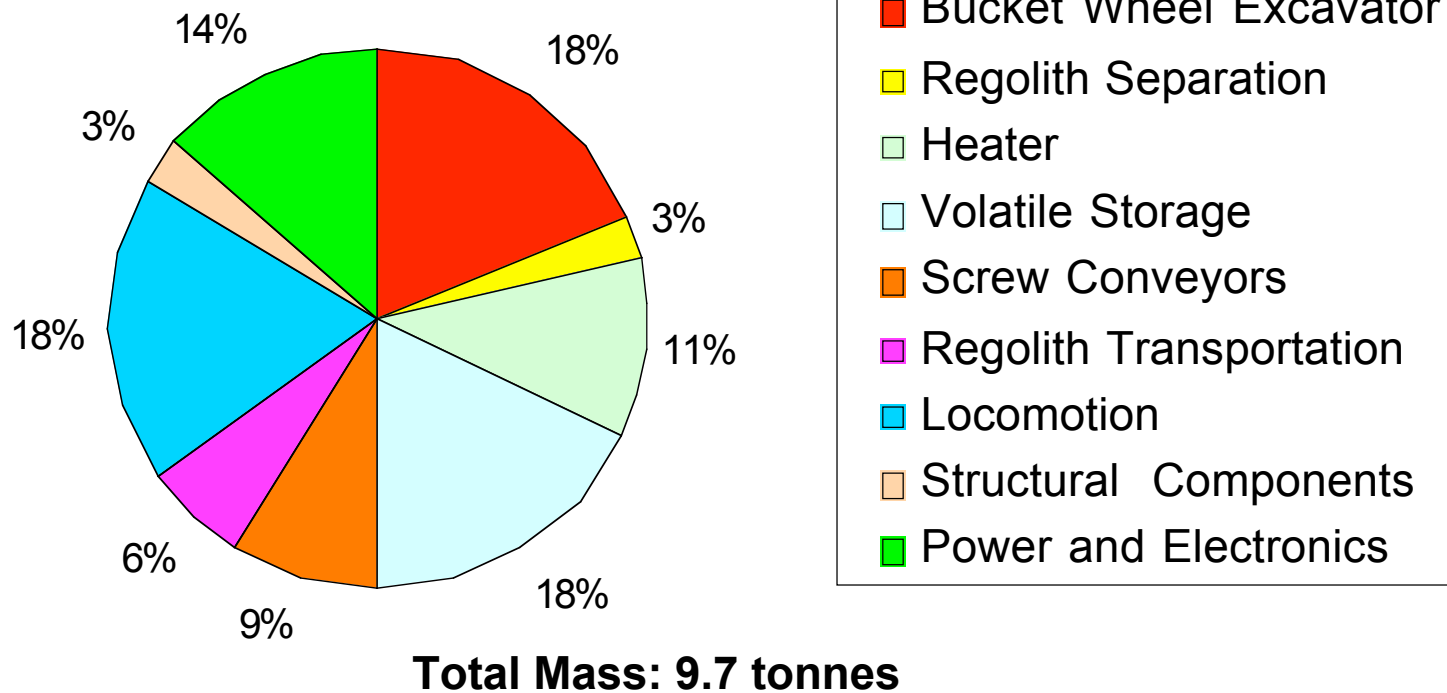


Results

- Gas loss: 9.9%
- Can handle 30° side-slope
- Size:
 - Length: 13.5 m
 - Width: 5.4 m
 - Height: 4.9 m
- Mass: 9.7 tonnes
- Power Usage: 350 kW_e

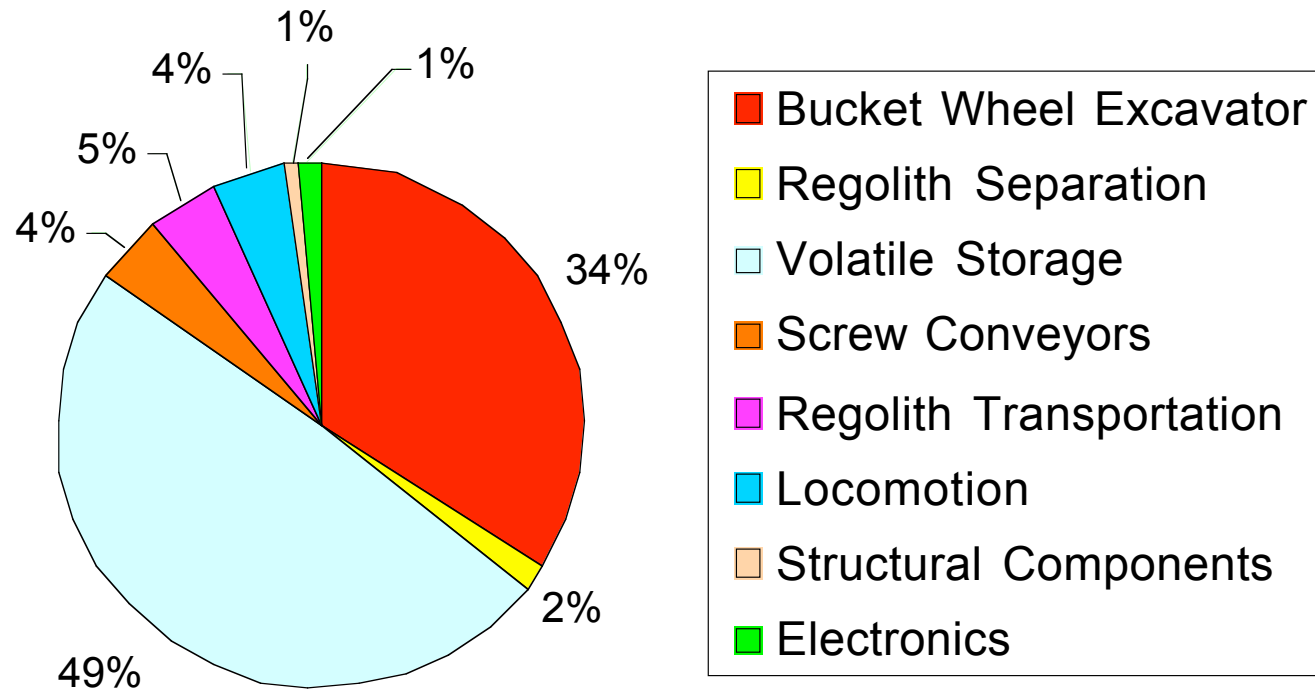
Mass Evenly Distributed

Component Mass Distribution



Volatile Storage Dominates Power Usage

Component Power Distribution



Total Power Usage 350 kW_e

Mark III Compared to Mark II

	Mark II	Mark III
Internal Pressure	0.1 MPa	0.015 MPa
Gas Storage Tank Pressure	15 MPa	20 MPa
Size	19.7 m _ 10 m _ 10 m	13.5 m _ 5.4 m _ 4.9 m
Mass	18 tonnes	9.7 tonnes
Electrical Power Usage	200 kW _e	350 kW _e



Conclusion

- Cut the mass by nearly half
- Retained capabilities of Mark II
- Categorized mass and power
- Identified areas of improvement



Acknowledgements

- Funding
 - Walter E. Kistler
 - Gerald A. Soffen Memorial Fund for the Advancement of Space Science Education
 - www.nasa-academy.org/soffen
- Technical Assistance
 - Ron Ross (JPL)
 - Harrison H. Schmitt

Questions?

