

CAVES AS SCIENTIFIC DESTINATION AND HUMAN RESOURCE

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INTRODUCTION

- **CAVES ARE NOT RARE!**
- **THEY ARE SCIENTIFICALLY
SIGNIFICANT**
- **THEY ARE AN IMPORTANT
HUMAN EXPLORATION RESOURCE**



CAVES ON MARS?

HOW CRAZY IS THIS?

CAVES ARE NOT RARE!

- PLANETS WITH SURFACES HAVE SUBSURFACES!
- CAVES ARE JUST **BIG HOLES** IN THE SUBSURFACE.
- A CAVE **WILL** BE DIFFERENT FROM THE SURFACE.
- SOLID SURFACES CRACK.
 - ❖ CRATERING
 - ❖ PLATE TECTONICS
 - ❖ TIDAL FORCES
 - ❖ VOLCANISM

CAVES FORM IN MANY DIFFERENT WAYS:

- EPIGENESIS
- HYPOGENESIS
- VOLCANISM
- CRUSTAL MOVEMENTS
- VOLATILE DEPOSITION AND FLOW
- OTHER DISSOLUTION MECHANISMS?

PROSPECTING FOR SUBSURFACE CAVITIES

- MAGNETOMETRY
- RESISTIVITY
- MICRO-CONDUCTIVITY
- GROUND-PENETRATING RADAR
- SEISMIC TECHNIQUES
- IMAGING, ORBITAL OR OTHER
- RIDGE WALKING!

EXTRATERRESTRIAL CAVES AS SCIENTIFIC TARGETS



UNDERGROUND SCIENCE

- * **GEOLOGY**
- * **MINERALOGY**
- * **GEOCHEMISTRY**
- * **PALEONTOLOGY**
- * **BIOLOGY**

A grayscale scanning electron micrograph (SEM) showing a dense, complex network of biological structures. The image features various textures, including fibrous strands, granular clusters, and elongated, tube-like formations. The overall appearance is highly detailed and organic, suggesting a microscopic view of a natural or synthetic material.

LIFE

IN THE

UNDERGROUND

CAVES AS HABITATS / GREENHOUSES





CAVE RESOURCES

- MINERALS
- GEOTHERMAL POWER
- VOLATILES
 - ❖ GASES
 - ❖ WATER
 - ❖ PERMAFROST

TECHNOLOGY DEFICITS

- COMMUNICATION, NAVIGATION, RAPID SURVEY
 - ROBOTIC MOBILITY: WIGGLERS, CRAWLERS, FLIERS, AND OOZERS
 - HUMAN MOBILITY IN PRESSURIZED SUITS
 - SHIRTSLEEVE INDOOR ENVIRONMENT
 - ROBUST MINIATURIZED INSTRUMENTATION
 - SOPHISTICATED AND CLEAN DRILLING TECHNOLOGIES
 - POWER, POWER, AND (YES!) POWER



SELF-DEPLOYING IN-CAVE CELLULAR NETWORK



- SELF-DEPLOYING
- NODAL LINE OF SIGHT
- COMMUNICATION
- MONITORING
- MAPPING
- SELF-REPAIRING
- SELF "FEEDING"

HUMAN MOBILITY

(OR THE LACK, THEREOF)



GETTIN' AROUND

- BENDING
- CLIMBING
- SQUEEZING THROUGH
- TEARING AND RIPPING
- HOLDING
- MANIPULATING
- MICROMANIPULATING



SHIRTSLEEVE INDOOR ENVIRONMENT

INFLATABLE CAVE LINERS

- MOLDABLE TO COMPLEX SURFACES
- EASILY DEPLOYED
- SIMPLE TO REPAIR
- EASILY REPLACED
- CHEAP
- LIGHTWEIGHT
- LOW BULK

LAVA TUBE LINERS

- LAVA TUBES ON EARTH
- LAVA TUBES ON THE MOON
- VOLCANOES ON MARS
- VOLCANOES ON IO, VENUS AND ?
- NATURAL SKYLIGHTS
- TOPOLOGICALLY SIMPLE

Hornito Habitat



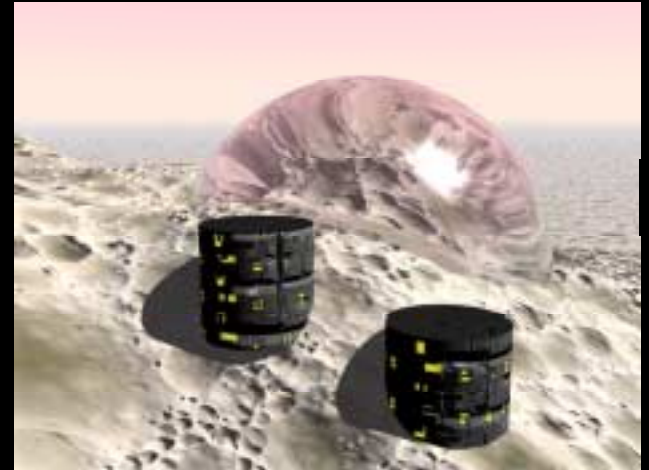
Block Tube with Inflatable Walls

AIR LOCKS

- **SHAPE-CONFORMING**
- **EASILY DEPLOYABLE**
- **AEROSOL CAN OF "AIRLOCK-IN-A-DRUM" ?**
- **RIGID, CONVENTIONAL AIRLOCK DOOR ARRANGEMENT**

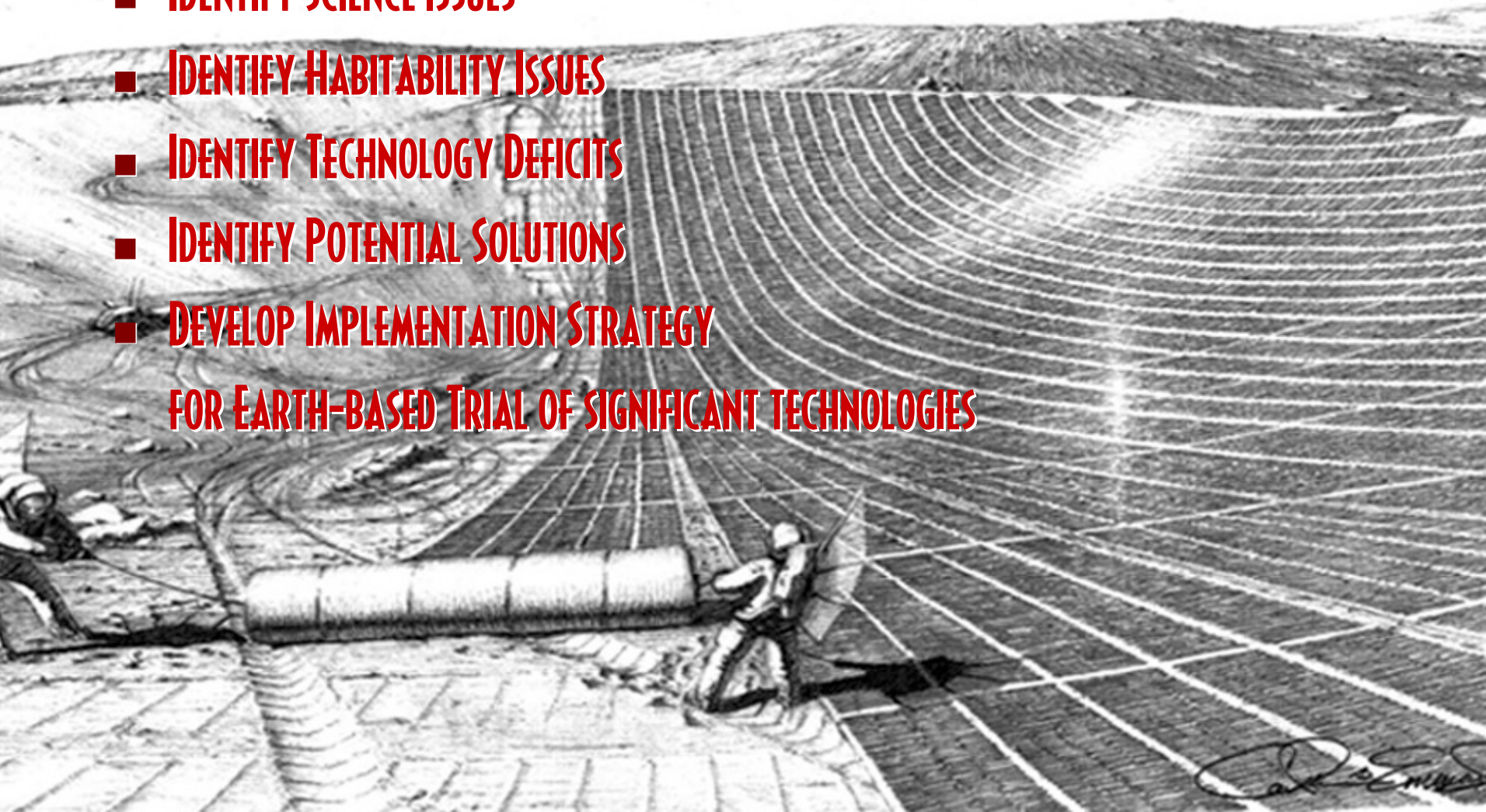
POWER AND PHOTONS

- SOLAR POWER
- NUCLEAR POWER
- GEOTHERMAL POWER
- NATURAL LIGHT
- LIGHT PIPING
- ARTIFICIAL LIGHTS



PHASE I: THE PLAN

- IDENTIFY SCIENCE ISSUES
- IDENTIFY HABITABILITY ISSUES
- IDENTIFY TECHNOLOGY DEFICITS
- IDENTIFY POTENTIAL SOLUTIONS
- DEVELOP IMPLEMENTATION STRATEGY
FOR EARTH-BASED TRIAL OF SIGNIFICANT TECHNOLOGIES



PRISTINE EARTH CAVES AS MODEL SYSTEMS

- IDEAL TECHNOLOGY TEST-BED
- IDEAL DEVELOPMENT SITES FOR PLANETARY PROTECTION PROTOCOLS
- PERFECT “DRESS REHEARSAL” FOR ASTRONAUT TRAINING
- COMMERCIAL AND MINING APPLICATIONS
- MYRIAD EDUCATIONAL AND PUBLIC OUTREACH OPPORTUNITIES.

PHANTASIES OF PHASE II

A futuristic scene featuring a metallic, humanoid figure floating in a vast, blue liquid environment. The figure has a complex, segmented design with yellow and grey components. To the left, a large, jagged, metallic structure resembling a cliff or a piece of machinery extends into the liquid. In the background, a large, blue, spherical object, possibly a planet or moon, hangs in a clear blue sky. The overall atmosphere is one of advanced technology and exploration.

- BUILD AND TEST AIRLOCK
- BUILD AND TEST INCUBE INFLATABLE
- BUILD AND TEST CELLULAR INFO/COMM NETWORK
- DEMONSTRATE HUMAN USE AND PLANT GROWTH IN SYSTEM
- **CONSTRAINED BY A STRINGENT PLANETARY PROTECTION PROTOCOL**

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