AUTONOMOUS TRANS-ANTARCTIC EXPEDITIONS: AN INITIATIVE FOR ADVANCING PLANETARY MOBILITY SYSTEM TECHNOLOGY WHILE ADDRESSING EARTH SCIENCE OBJECTIVES IN ANTARCTICA

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A workshop on Antarctic Autonomous Scientific Vehicles and Traverses

Workshop Summary:

•Met at National Geographic Society, Washington DC, February 2001

•Discussed scientific objectives and benefits of the use of planetary rovers

•Concluded that rovers were uniquely valuable

•Concluded that instrumented autonomous planetary-type vehicles have the potential to

- **•Contribute significantly to the way polar science is conducted**
- **•Enable new polar science**
- **•Aid planetary technology development, and**
- **•Engage the public's interest**

Antarctic Rovers--The Central Idea

- **Mars rovers now in development stage seem well designed for ice sheet/sea ice mobility**
  - Autonomous, light weight, large wheels, solar/wind power, miniature instrumentation
- **Antarctica is a good testing ground for long-range Mars rovers**
  - Surface temperature, open space, science tasks, dust/snow
- **Polar traverse science would benefit from autonomous vehicles**
  - Cost, risk to humans, tedious routes, pollution-free operations
- **A natural partnership is apparent:** Development and testing of Mars technical infrastructure in exchange for an Earth science capability
- **Going from concept to a field system is significant programmatic and Technical step**

Scientific Objectives for Initial Rover Projects

•Ice Sheet Mass Balance

Autonomous Rovers equipped with sounding radars can map snow accumulation, isochronous layer depths, ice thickness and subglacial topography and condition over drainage basins.

•Heat and Momentum Exchanges Through Sea Ice

the sea ice field is difficult to map with traditional means due to its roughness and the occurrence of open water and thin ice areas.

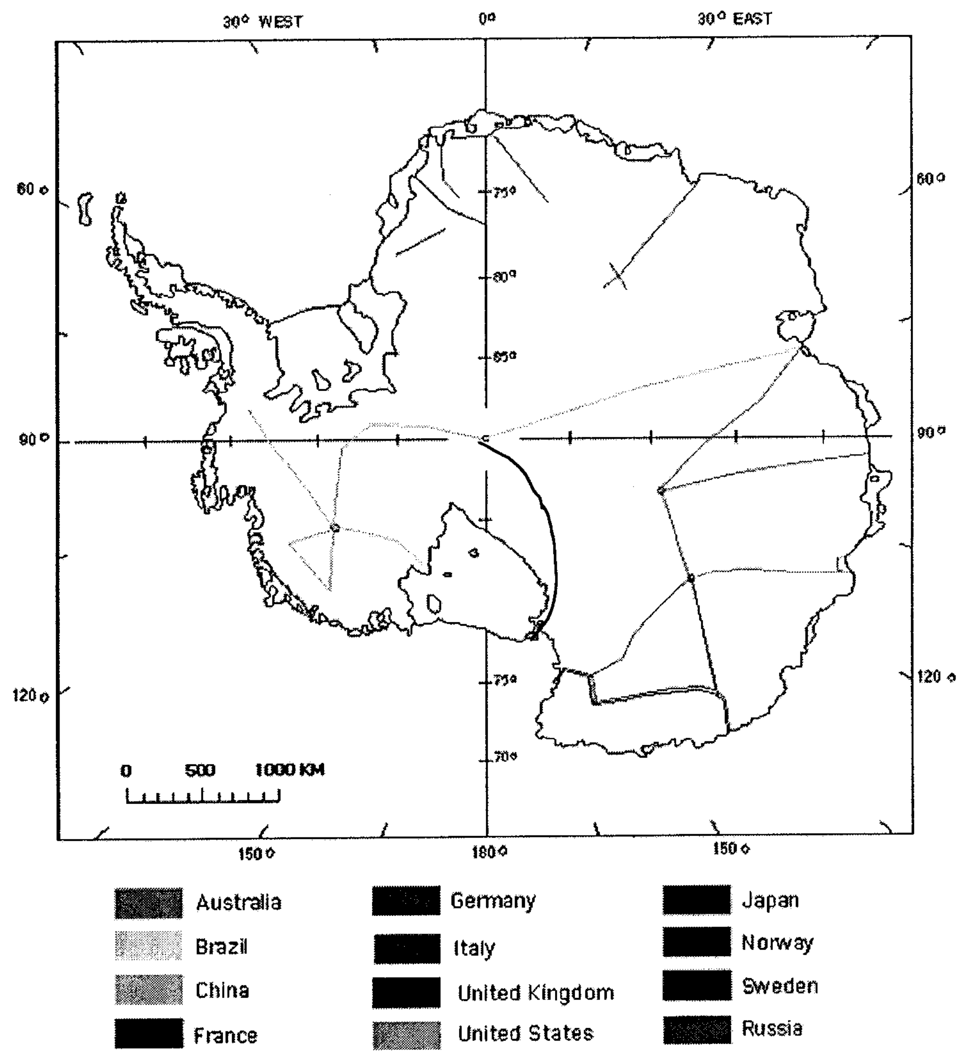
Small-Scale Geophysical Structures

airborne systems are insensitive to small scale phenomena while surface surveys are one-dimensional.

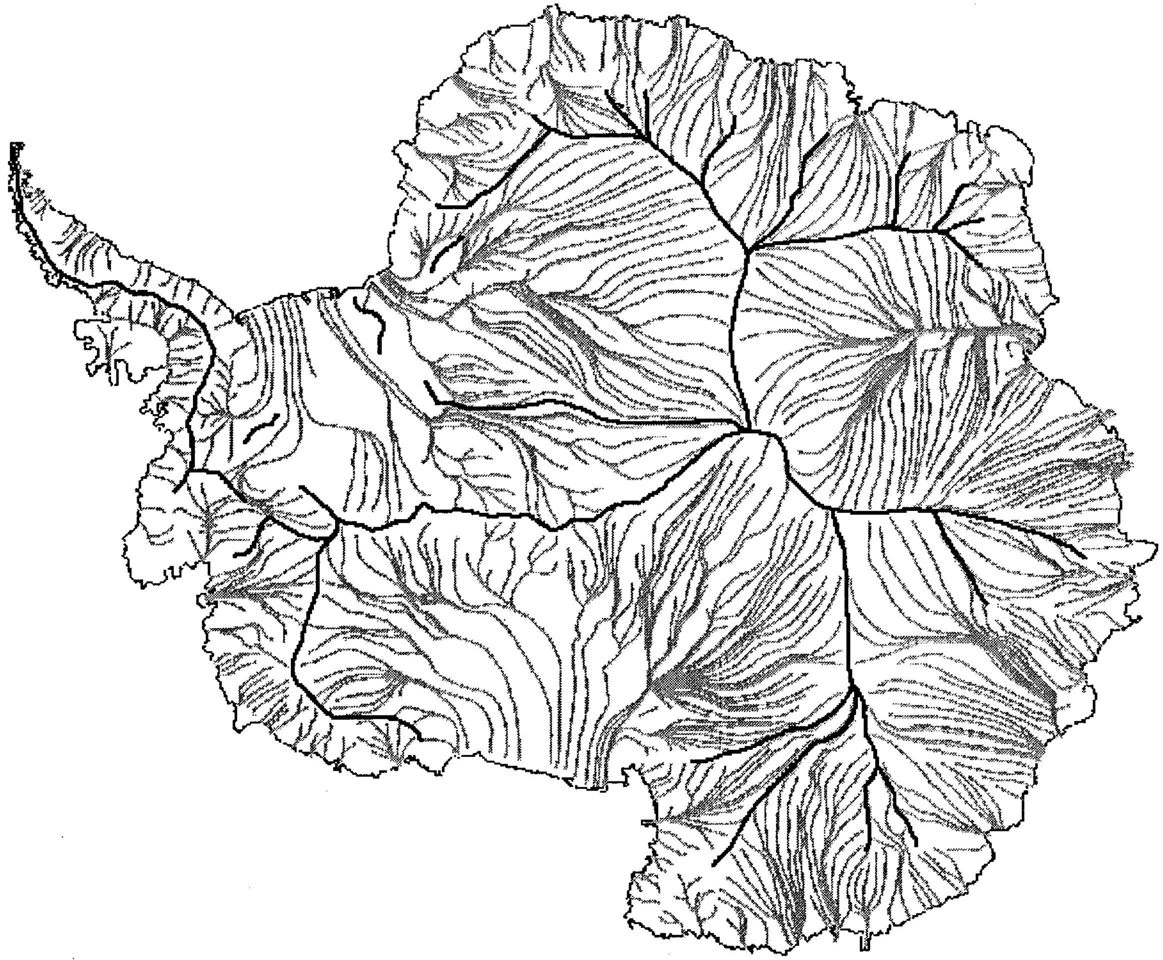
•Snow Surface Chemical Processes

Chemical exchange between the atmosphere and snowpack is complex, and, because of the vast surface area of the polar ice sheets, can have a profound effect

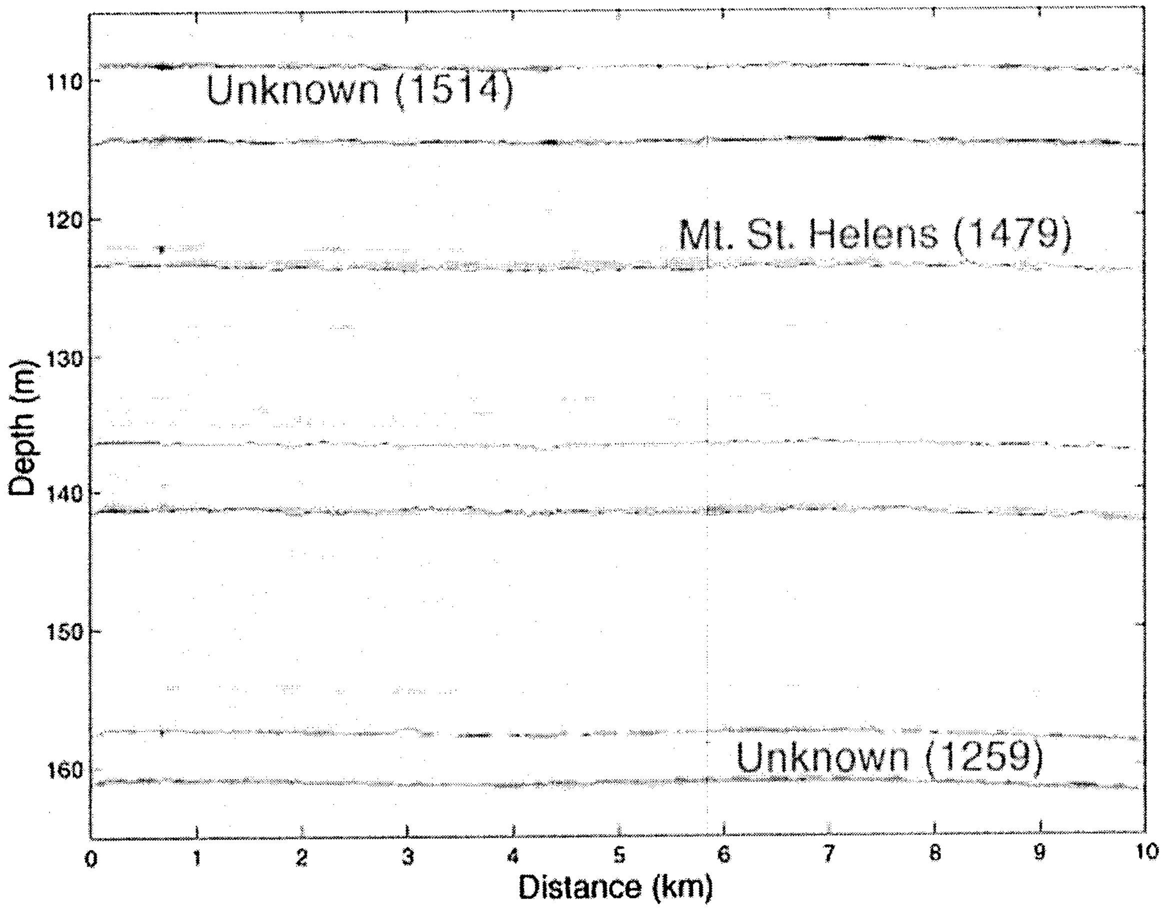
Contemporary Traverses



Antarctic Drainage Basins



Radar Mapping of Volcanic Isochrons in Greenland



Task Categories for Polar Rovers

Detailed and Tedious Routes. Mapping routes such as "mowing the lawn" for detailed information in a region are notoriously difficult for operator-controlled systems

Polar Night. Numerous surface processes are thought to occur during the dark of polar winter, but current sampling is restricted to few year-round coastal stations.

Difficult or Hazardous Routes. Medium and long-range traverses across sea ice are challenging by virtue of ridges and open-water areas, and a similar situation occurs in heavily crevassed areas of the ice sheet.

Extremely Remote and/or Inhospitable Routes. Some areas of East Antarctica and several mountainous areas are so remote that airborne support is logistically difficult, but they could be readily accessible to rovers.

Task Categories for Polar Rovers, cont'd

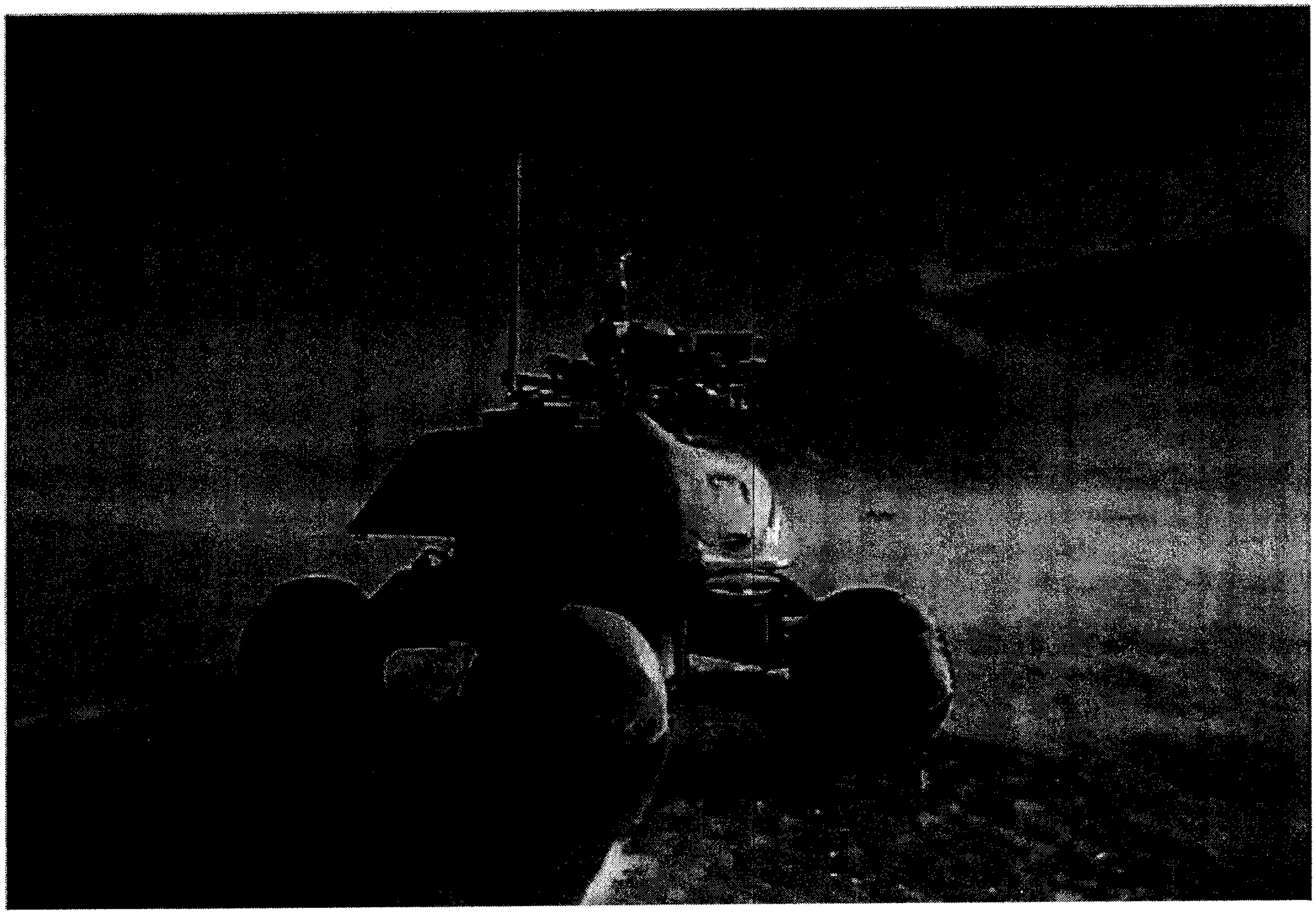
Routes Involving Simple Instrumentation. Quick acquisition of simple data sets may be crucial to comparing data sets or to cal/val for a satellite data set.

Instrumentation Requiring Slow Traverse Speed. Certain geophysical observables, e.g. magnetometer and gravimeter data, must be taken at the surface at a speed much slower than aircraft speed.

Augments of Manned Scientific Traverses. Manned traverses are increasingly capable in scientific breadth, but they are inherently one-dimensional.

Measurements Not Compatible with Presence of Humans or Combustion Engines. One aspect of the traditional traverse is the generation of pollutants by both the humans and the combustion engines involved.

CMU's NOMAD in Antarctica



ROBOTIC CHALLENGES OF POLAR TRAVERSES

Robotic capabilities (ultimate) for Antarctic deployment:

- Capability for untended traverses of about 100 days,
- Control of position at the meter level,
- Crevasse and sastrugi detection and avoidance,
- 24 hour per day operations,
- Route selection and decision making,
- Self-diagnosis and recovery,
- Power,
- Environment: wind, blowing snow, deep snow,
- Operations with cameras pointed at the sun,
- Communications

Are There Worthwhile Polar Rover Jobs to be Done?

Science: Yes.
The autonomous rover similar to the version being developed for planetary exploration can enhance current science and open new windows of study.

Technology: Yes.
The Antarctic autonomous rover poses a grand challenge to the autonomous vehicle community with spin-off value in a number of areas.

Public Interest: Yes.
There is enormous potential in capturing public attention in autonomous vehicles undertaking long and challenging traverses across the ice sheet.

Where Do We Go From Here?

- **More Workshops?**
  - International involvement?
- **Collaborations Among Agencies?**
- **Design of an Inexpensive First Project?**
- **Robotic systems are very expensive: why?**
  - Significant NASA, DARPA, private $$, still little off-the-shelf
  - Inherent costs?
  - Failure of technology transfer?
  - Engineering for engineering's sake?