High Rate
Science Data Handling

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JPL HIGH RATE SCIENCE DATA HANDLING

- Performed under the auspices (and funding) of the PE&A office.

- Documented in "Data Handling Options for Space Station Freedom Program Office", JPL Document No. JPL D-6746, dated September 19, 1989.

- Methodology
  - Identify User Requirements
  - Establish Baseline SSF capability
  - Evaluate experiments' requirements
  - Identify shortfalls
  - Locate new and emerging technologies that may address problems
  - Develop a system architecture that addresses the problems

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SCIENCE NEEDS

VERSUS

TECHNOLOGY

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SCIENCE NEEDS VS. TECHNOLOGY

- Experiment Needs
  - 2K X 2K by 8 bit @ 1000 frames/sec (Fps)
    Mass Transport
  - 1K X 500K by 5 bit @ 1000 Fps
    Thermophysical Measurements
  - 3K X 1K by 4 bit @ 2000 Fps
    Micogravity Combustion
  - 5K X 5K by 8 bit @ 1000 Fps
    Crystallization of Spheres
  - 200K X 266K by 4 bit @ 6000 Fps
    Pool boiling
  - 10K X 10K by 8 bit @ 1,000,000 Fps
    Containerless Processing
    SCRAM

  Plus a whole host of other rates

- SSF Provisions
  - NTSC - 256K X 256K at 30 Fps
    Broadcast quality
    512K x 512K at 30 Fps
    Studio quality
  - HDTV - Approximately 1K X 1K at 30 Fps
    Broadcast quality
    1K X 1K at 60 Fps
    Studio quality
- Best ruggedized display 2K X 2K at 72 Fps

- Are the needs achieveable?

  Yes, by Film:

  The comparison of film resolution to pixel resolution of a CCD is very difficult. After discussions with scientists at Kodak, I developed an understanding that the boundaries of film resolution are best represented by an ellipse on this chart. Variables such as light source, temperature, handling, time, processing, backing, grain size, etc. affect the results.

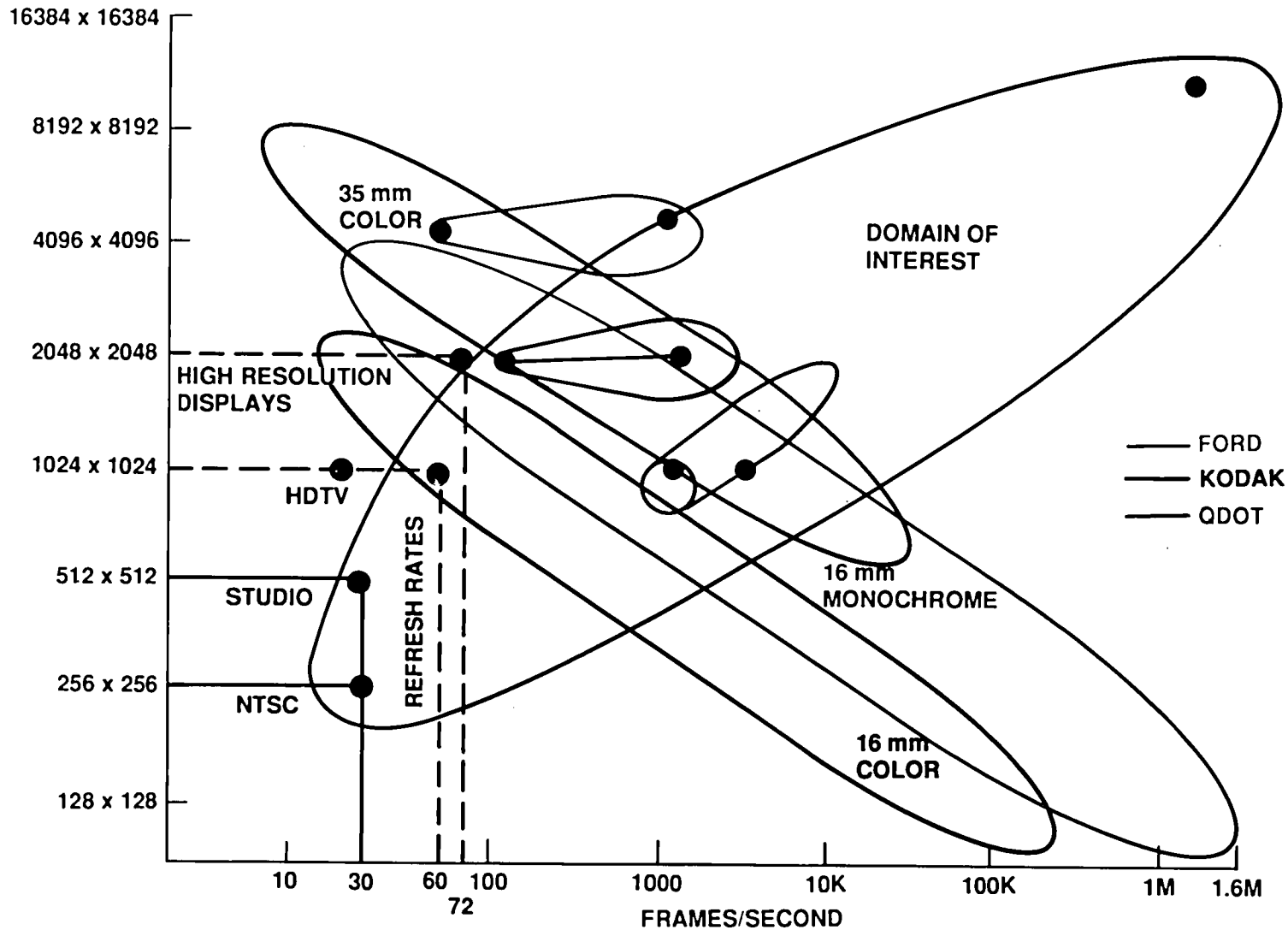
  If one were to go by line pair resolution figures, then 16MM might be considered to produce a resolution of 26K X 20K. This is not a realistic calculation. Reality is much less than that, but published comparisons have not been found.

- Are there solutions if we are not going to fly film in SSF?

  Yes, work is progressing toward fast, large, digital CCD focal planes:

  - Kodak is producing a 2K X 2K focal plane based on their megapixel camera, which their scientists believe can be developed to a 1000 Fps camera.
  - Ford Aerospace has a 4K X 4K focal plane which could be developed to run at 1000 Fps.
  - Q-Dot has test units designed to run at 1000 Fps, which they plan to evolve into 10,000 Fps.

SCIENCE NEEDS VRS TECHNOLOGY



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TECHNOLOGY ASSESSMENT

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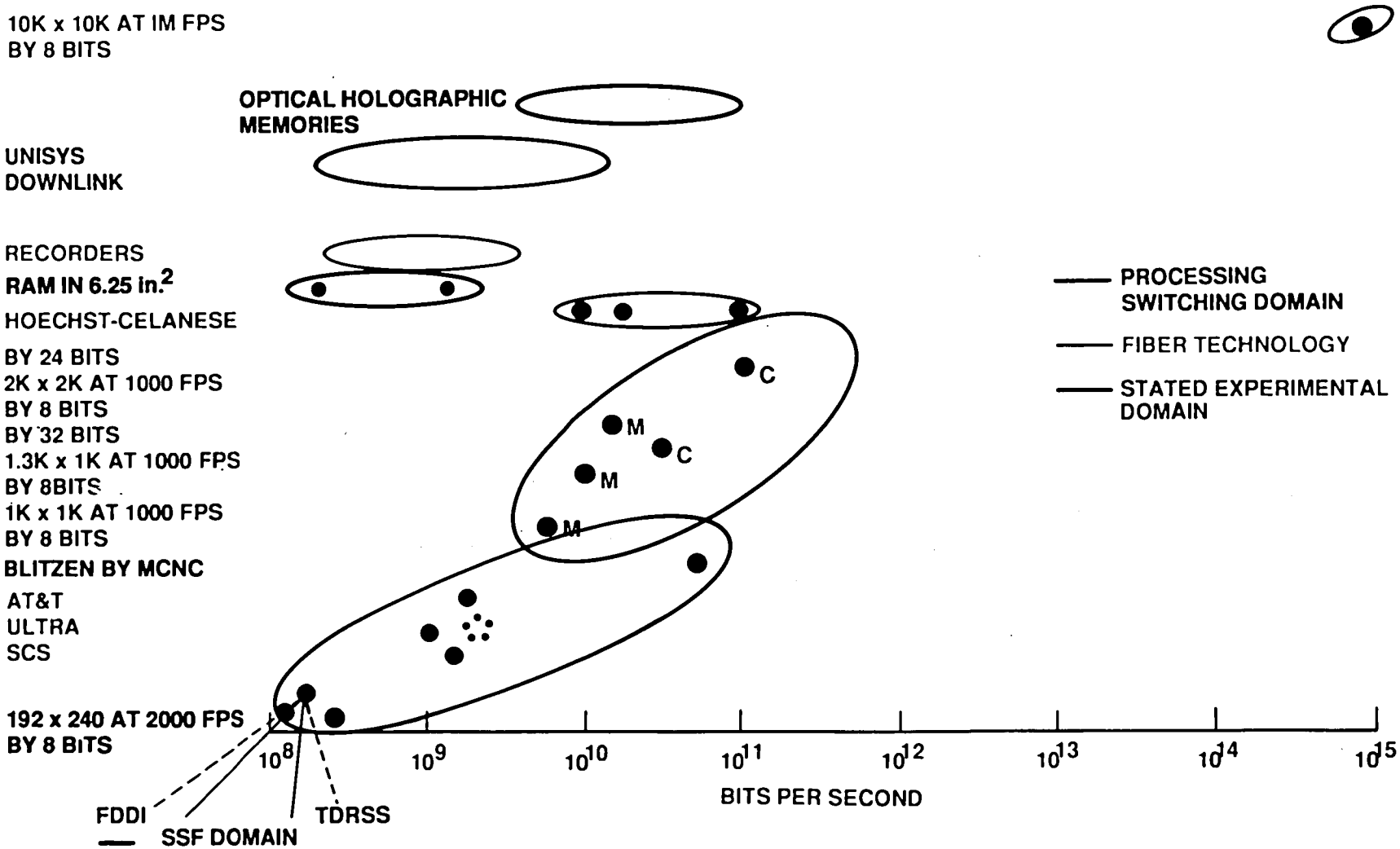
TECHNOLOGY ASSESSMENT

This chart has no vertical axis. The only axis is the horizontal one, which is calibrated in bits per second on a logarithmic scale. The bits per second is the input or output rate of the devices under consideration.

- There are listed various camera configurations on the left which address the needs on the previous chart.
- The fastest commercially available camera, 192 X 240 @ 2000 Fps, is from Spin Physics.
- The rates of output of these cameras far exceed the Spin Physics camera system.
- They exceed the capabity of FDDI and TDRSS by even larger margins.

- What can be done to close this gap?
  - Transport the data - Fiber technology
    1 Gigabit and greater
  - Process the data
    MCNC - Blitzen chip - 10 GByte/sec I/O
    AMT - DAP 620+ - 1.6 GByte/sec I/O
  - Record the data
    1.9 GByte/sec ingest rate
  - Downlink the data
    1-5 Gbit downlinks can be built
    Airborne receipt can be done
  - Optical holographic memories

TECHNOLOGY ASSESSMENT



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CONCEPTUAL ARCHITECTURE

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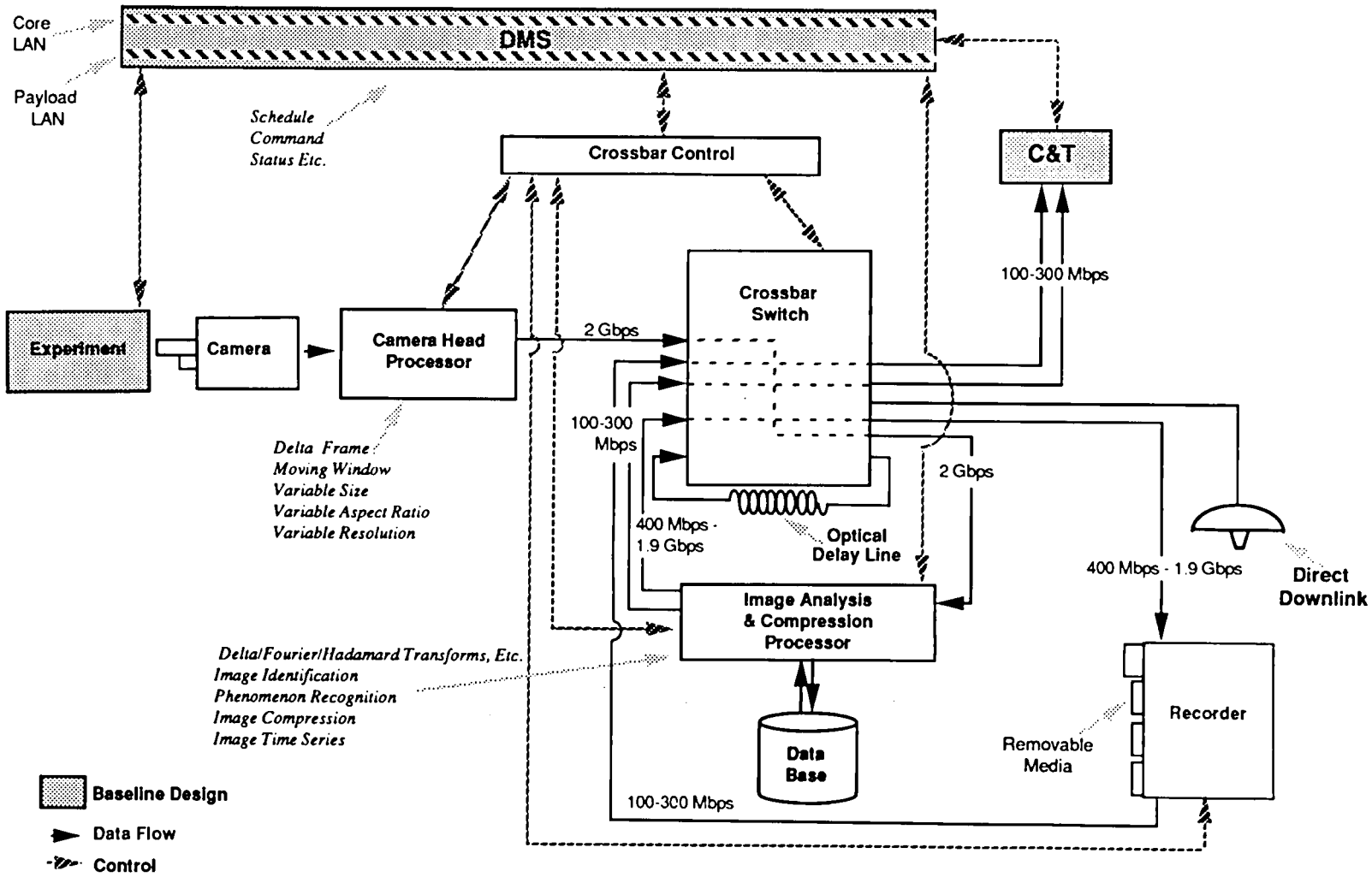
CONCEPTUAL ARCHITECTURE

- Begin with SSF baseline
  - Experiment
  - DMS
  - C&T

- Add:

1. A control structure. This could reside within the DMS, but we did not wish to alter the DMS.
2. Camera to view the experiment
3. Processors
   - Camera head
   - Router or switch
   - Image analysis
4. Network (may include the router in 3)
5. Recorders
6. Random store - Holographic memory or parallel disk
7. Direct downlink

Conceptual Architecture



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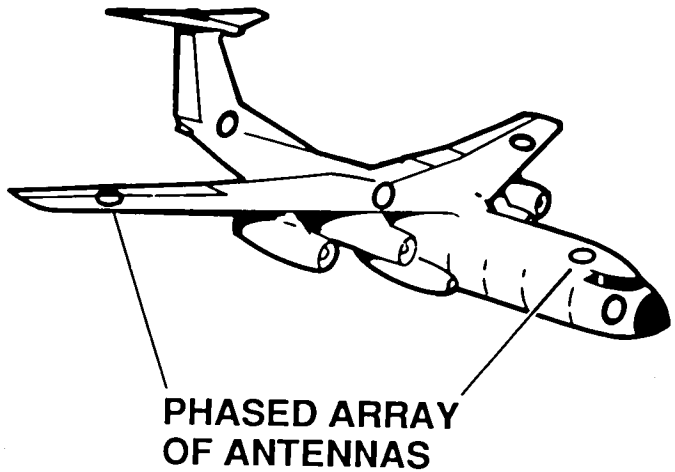
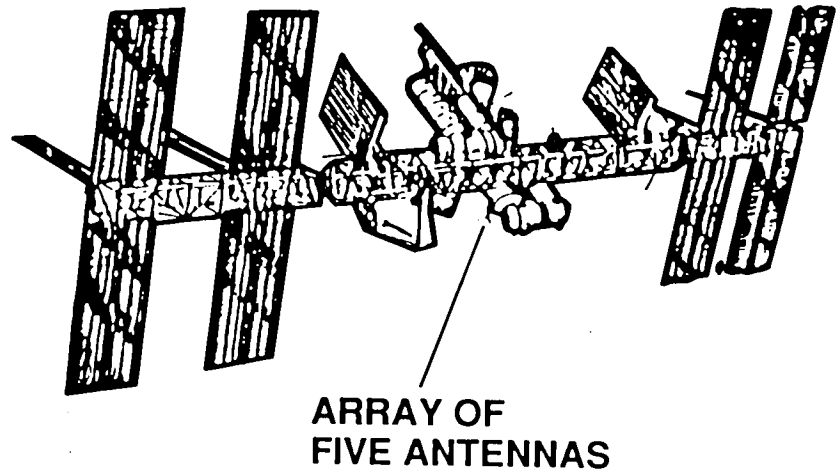
DIRECT DOWNLINK CONCEPT

ANTENNA PLACEMENT

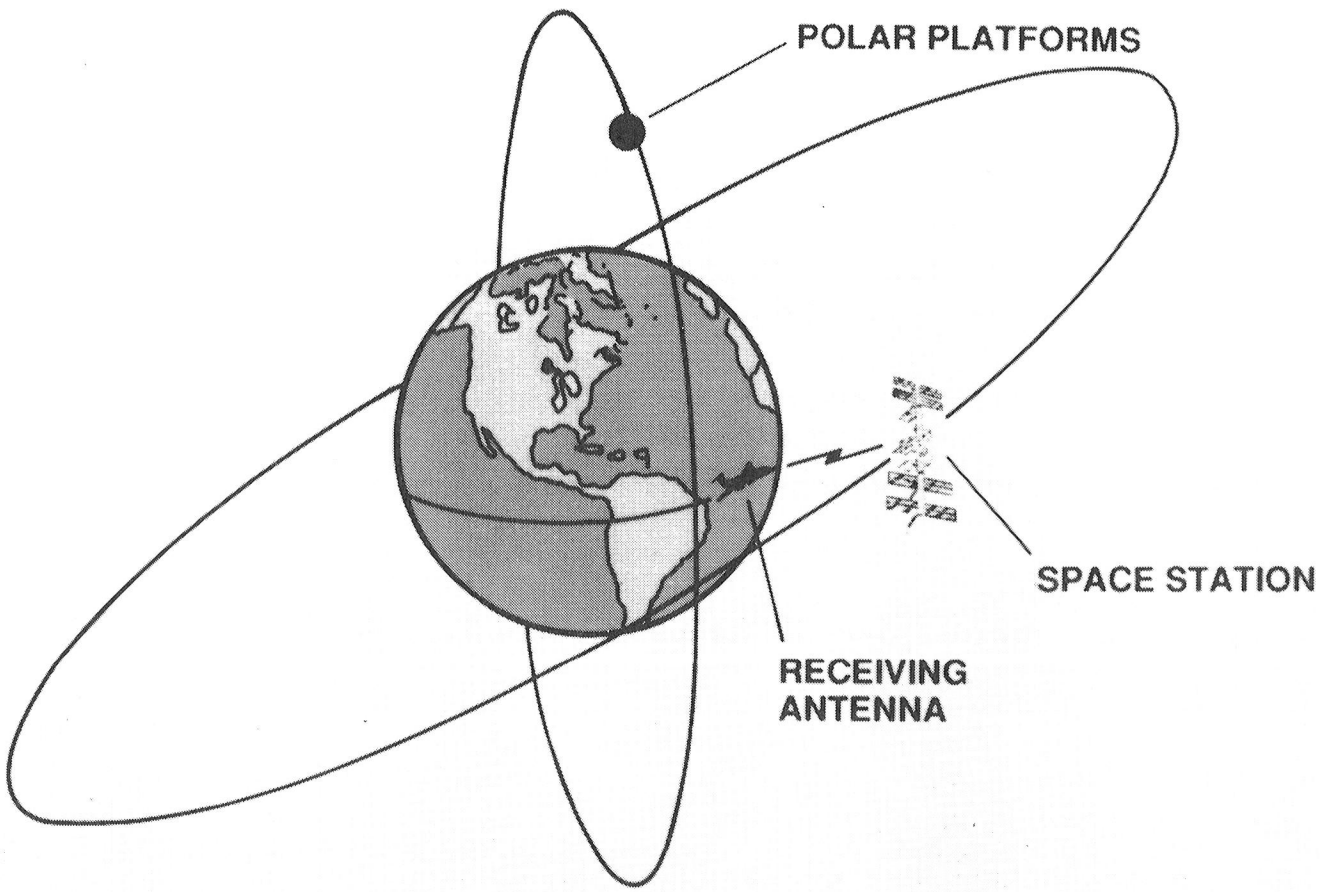


ON AIRCRAFT



ON SPACE STATION

CONCEPTUAL FLY-UNDER



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CONCLUSIONS

- Science needs will exceed capacity of existing or planned systems to transmit to earth.
- Capability to generate image data will continue to exceed capacity to transmit to earth.
- The need for mechanisms to capture, route, process, manage, analyze and store High Rate Data are common to many experiments.
- Technology for these mechanisms can be made available.
- The scientist must actively participate in the development.
- The system must be easily adaptable to changes in requirements and technology.