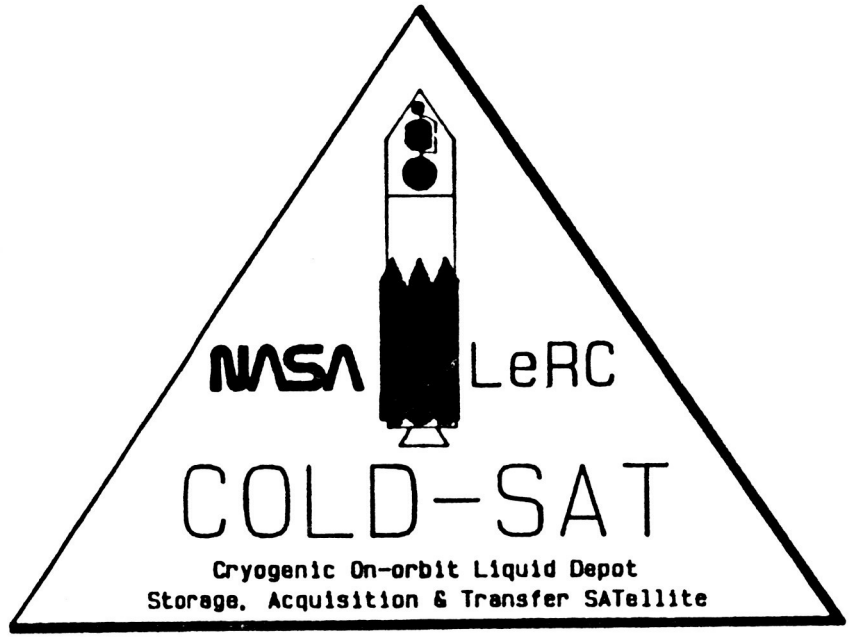
LeRC CRYOGENIC FLUID MANAGEMENT PROGRAM OVERVIEW



Presented At:
Cryogenic Fluid Management Technology Workshop
April 28, 1987

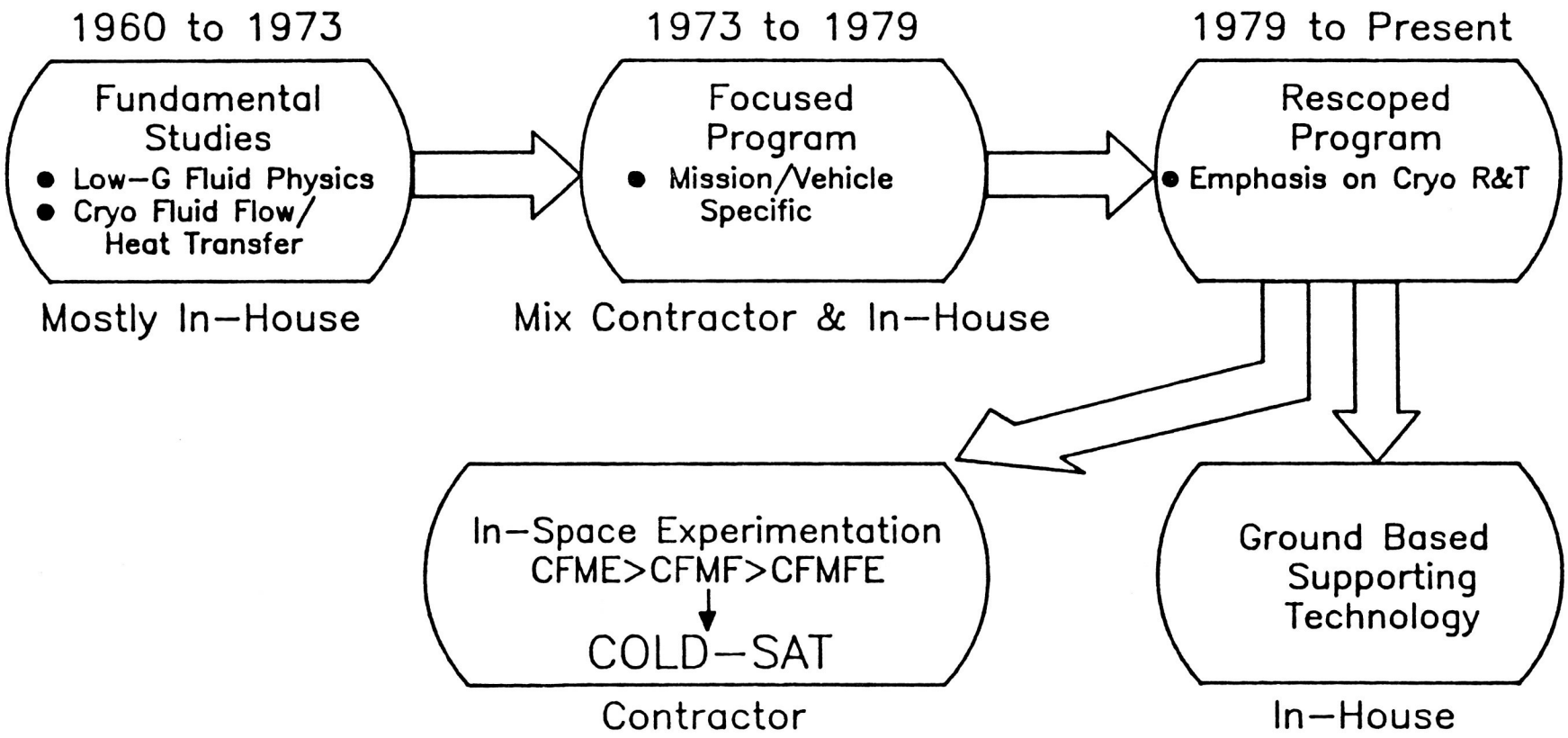
E.P. Symons

LeRC CRYOGENIC FLUID MANAGEMENT PROGRAM OVERVIEW AGENDA

- BACKGROUND
- PROGRAM OBJECTIVE/APPROACH
- PROGRAM ELEMENTS
  - TECHNOLOGY REVIEW, ANALYSIS AND COST ESTIMATION (TRACE)
  - MODELING, ANALYSIS AND NONFLIGHT EXPERIMENTS (MANE)
  - FLIGHT EXPERIMENT DEVELOPMENT (FED)
- PRELIMINARY FLIGHT EXPERIMENT TECHNOLOGY OBJECTIVES
- TECHNOLOGY APPLICATIONS
- SUMMARY

LeRC CRYOGENIC FLUID MANAGEMENT PROGRAM OVERVIEW

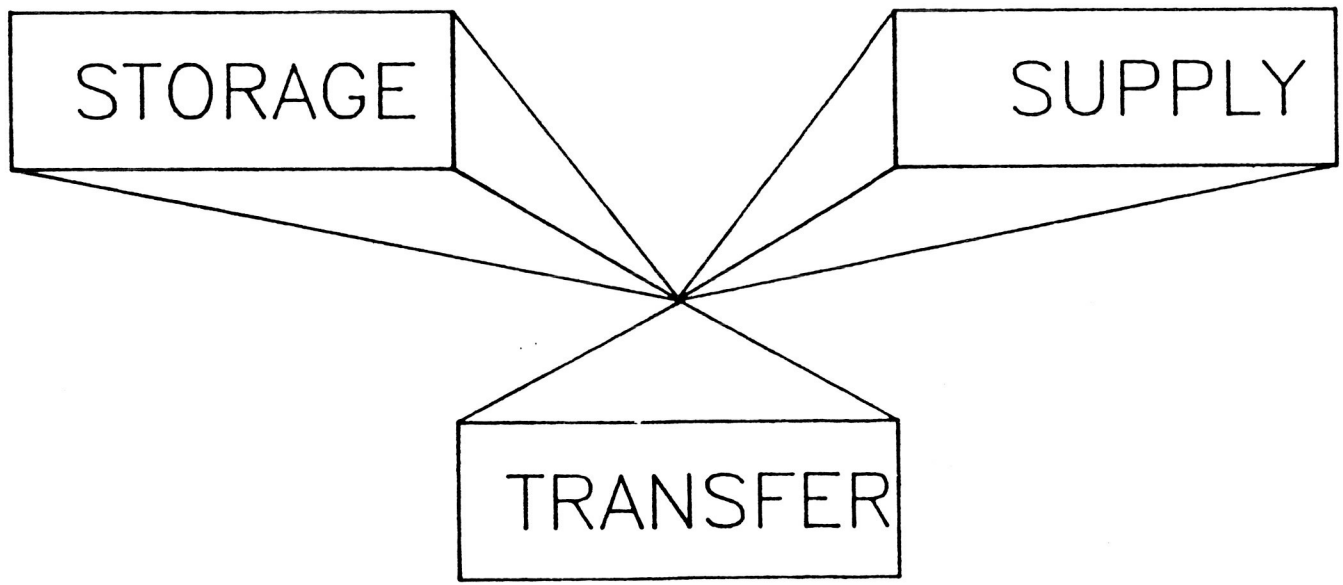
BACKGROUND



Current program built on strong foundation

LeRC CRYOGENIC FLUID MANAGEMENT PROGRAM OVERVIEW

BROAD OBJECTIVE: PROVIDE TECHNOLOGY TO ENABLE DESIGN OF EFFICIENT SYSTEMS FOR MANAGING FLUIDS IN THE SPACE ENVIROMENT INCLUDING CRYOGENIC LIQUID STORAGE, SUPPLY (ACQUISITION/POSITIONING), AND TRANSFER



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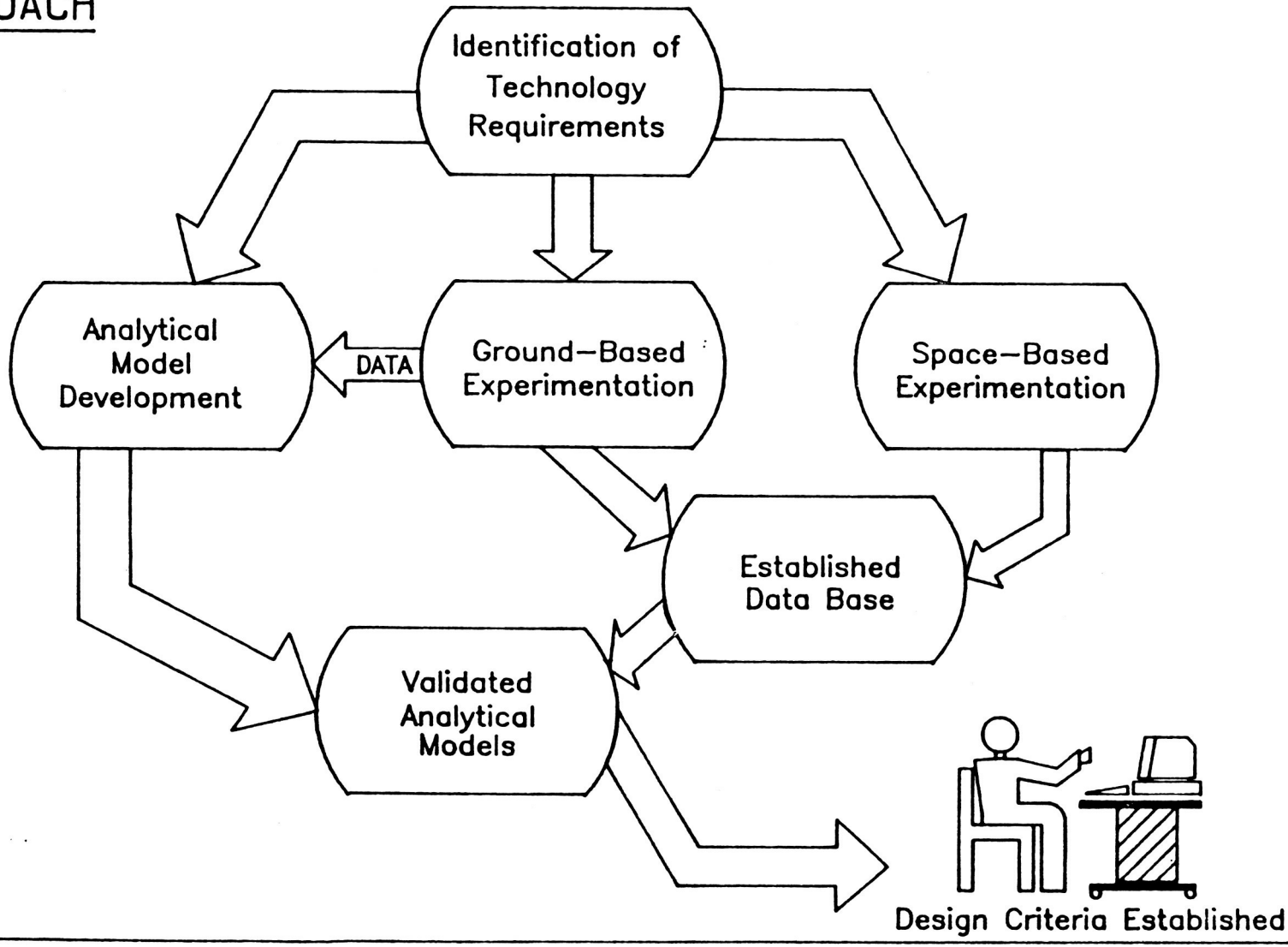
APPROACH



LeRC CRYOGENIC FLUID MANAGEMENT PROGRAM OVERVIEW
PROGRAM ELEMENTS

- TECHNOLOGY REVIEW, ANALYSIS AND COST ESTIMATION (TRACE)
- MODELING, ANALYSIS AND NONFLIGHT EXPERIMENTS (MANE)
- FLIGHT EXPERIMENT DEVELOPMENT (FED)

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LeRC CRYOGENIC FLUID MANAGEMENT PROGRAM OVERVIEW
TECHNOLOGY REVIEW, ANALYSIS AND COST ESTIMATION (TRACE)

- IDENTIFICATION OF TECHNOLOGY REQUIREMENTS
  - NASA IN-SPACE CRYOGENIC FLUID MANAGEMENT COMMITTEE (1979)/CONTRACTOR STUDIES
  - CRYOGENIC FLUID MANAGEMENT TECHNOLOGY WORKSHOP
  - TECHNOLOGY ROADMAP
- FLIGHT EXPERIMENT FEASIBILITY
  - PLANNED LAUNCH OF SPACECRAFT ON ELV
  - THREE PARALLEL FEASIBILITY CONTRACTS
    - TRADE OF EXPERIMENT REQUIREMENTS VS. SPACECRAFT CONSTRAINTS
    - DEVELOP CONCEPTUAL DESIGNS
    - ESTIMATE DEVELOPMENT/LAUNCH/FLIGHT COSTS
    - IDENTIFY NEW TECHNOLOGY REQUIREMENTS
- FLIGHT EXPERIMENT DEFINITION
  - SELECTION OF CO-INVESTIGATORS
  - EXPERIMENT REQUIREMENTS DEFINED
  - PRELIMINARY LIST OF CANDIDATES TO FEASIBILITY CONTRACTS
  - CONTINUED ITERATION LEADING TO FINAL SELECTED EXPERIMENTS

LeRC CRYOGENIC FLUID MANAGEMENT PROGRAM OVERVIEW MODELING, ANALYSIS AND NONFLIGHT EXPERIMENTS (MANE)

- MODELING AND ANALYSES
  - IDENTIFICATION OF MODEL REQUIREMENTS
  - CRYOTRAN DEVELOPMENT/DOCUMENTATION
  - LIMITED MODEL VALIDATION
- NONFLIGHT EXPERIMENTS
  - FACILITY PREPARATION/TEST APPARATUS DESIGN
  - PREPARE TEST PLANS/PROCEDURES
  - INSTRUMENTATION EVALUATION
  - COMPONENT TESTING
  - CHILLDOWN/NO-VENT FILL
  - TANK PRESSURE CONTROL/THERMAL CONTROL
  - LIQUEFACTION

LeRC CRYOGENIC FLUID MANAGEMENT PROGRAM OVERVIEW
FLIGHT EXPERIMENT DEVELOPMENT (FED)

- LONG LEAD COMPONENT DEVELOPMENT
- AGENCY APPROVALS
- SPACECRAFT DEVELOPMENT
- ELV ACQUISITION
- INTEGRATION/LAUNCH
- FLIGHT OPS/DATA ANALYSIS

LeRC CRYOGENIC FLUID MANAGEMENT PROGRAM OVERVIEW
PRELIMINARY FLIGHT EXPERIMENT TECHNOLOGY OBJECTIVES (CONT.)

LIQUID SUPPLY

- PRESSURIZATION SYSTEM PERFORMANCE
  - AUTOGENOUS (INCLUDING PARA/ORTHO COMPOSITION
  - HELIUM
  - MECHANICAL (PUMPS/COMPRESSORS)

- FLUID ACQUISITIONING/EXPULSION
  - FINE MESH SCREEN LIQUID ACQUISITION DEVICE (LAD) PERFORMANCE
  - FLUID SETTLING AND OUTFLOW VIA IMPULSE ACCELERATION
  - FLUID SETTLING AND OUTFLOW UNDER LOW-GRAVITY CONDITIONS
  - IMPACT OF HEAT ADDITION ON LAD PERFORMANCE
  - LONG-TERM CONTAMINATION/DEGRADATION OF LAD

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PRELIMINARY FLIGHT EXPERIMENT TECHNOLOGY OBJECTIVES (CONT.)

LIQUID TRANSFER

- TRANSFER LINE CHILLDOWN
- THERMAL CONDITIONING OF LIQUID OUTFLOW
- RECEIVER TANK
  - CHILLDOWN WITH SPRAY
  - NO-VENT FILL
  - VENTING OF NONCONDENSIBLE GAS
  - NO-VENT REFILL
  - PARTIAL LAD FILL
  - LOW-GRAVITY VENTED FILL
- SUPPLY TANK
  - NO-VENT REFILL INCLUDING TOTAL COMMUNICATION LAD
  - NO-VENT FILL INCLUDING TOTAL COMMUNICATION LAD

LeRC CRYOGENIC FLUID MANAGEMENT PROGRAM OVERVIEW
PRELIMINARY FLIGHT EXPERIMENT TECHNOLOGY OBJECTIVES (CONT.)

MISCELLANEOUS

- FLUID HANDLING
  - FLUID DUMPING/TANK INERTING
  - FLUID DYNAMICS/SLOSH CONTROL
  - LIQUEFACTION/CONDENSATE COLLECTION

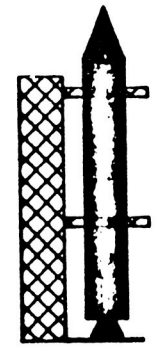
- INSTRUMENTATION
  - QUANTITY GAGING
  - MASS FLOW/QUALITY METERING
  - LEAK DETECTION

- CRYOGENIC COMPONENT LIFE

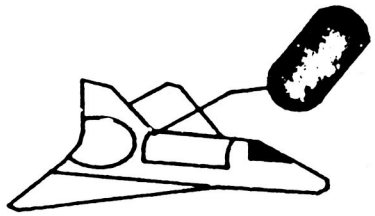
LeRC CRYOGENIC FLUID MANAGEMENT PROGRAM OVERVIEW

POTENTIAL APPLICATIONS:

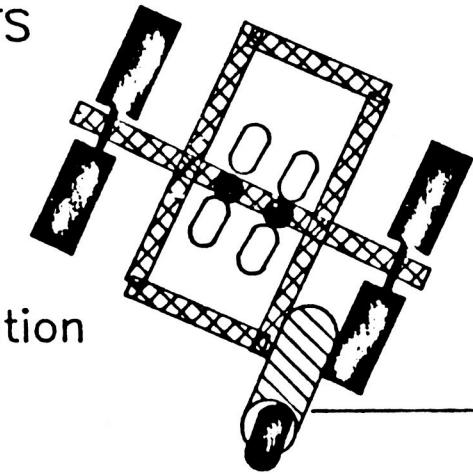
- EARTH–TO–ORBIT TRANSPORT AND IN–SPACE STORAGE OF CRYOGENIC LIQUIDS
- ON–ORBIT FUELING OF PROPULSIVE STAGES
- SUBSYSTEM FLUID REPLENISHMENT
- EXPERIMENT AND SATELLITE RESUPPLY OF REACTANTS, COOLANTS AND PROPELLANTS



Earth–to–Orbit "Tanker"



STS or Space Station Servicing



OTV or Satellite Servicing Bay

LeRC CRYOGENIC FLUID MANAGEMENT PROGRAM OVERVIEW SUMMARY

- LONG HISTORY OF RELATED GROUND-BASED TESTING/ANALYSES
- ADDITIONAL FOCUSED GROUND-BASED CRYOGENIC TESTING REQUIRED
- CERTAIN ENABLING TECHNOLOGY REQUIRES IN-SPACE EXPERIMENTATION
- PROPOSED TO LAUNCH CRYOGENIC FLIGHT EXPERIMENT/SPACECRAFT ON ELV
- PLAN TO SEEK AGENCY NEW START

SPEAKER: E. PATRICK SYMONS/LEWIS RESEARCH CENTER

Peter Mason/Jet Propulsion Laboratory:

Is it proposed that this flight experiment, the COLD-SAT, be limited to liquid hydrogen, or are you expecting to do helium experiments also?

Symons:

Right now, our plan is to limit it to liquid hydrogen only.

Mason:

I concluded that probably makes sense then, because we can do the helium experiments on the shuttle.

Symons:

That's right. We really do not want to get into the helium. I think as you saw earlier that the work at Ames and Goddard is primarily devoted towards helium. We certainly do not want to duplicate that. They have a plan to fly the SHOOT experiment which will provide the technologies for transferring superfluid helium in space.

Stephen Castles/Goddard Space Flight Center:

It is my understanding that Johnson is going to be producing an updated SINDA, called SINDA 85, and I think that it is supposed to be released this fall. I was wondering if you were going to try to build your CRYO-TRAN development analysis routine on that. I believe that the SINDA 85 may become an industry standard and it has some SIN-FLOW and other routines that might be useful.

Symons:

We are currently working on a SINDA model, and we plan to use the SINDA 85. We still need to have some additional capability that SINDA 85 does not have, and I think that is where our contribution would be.