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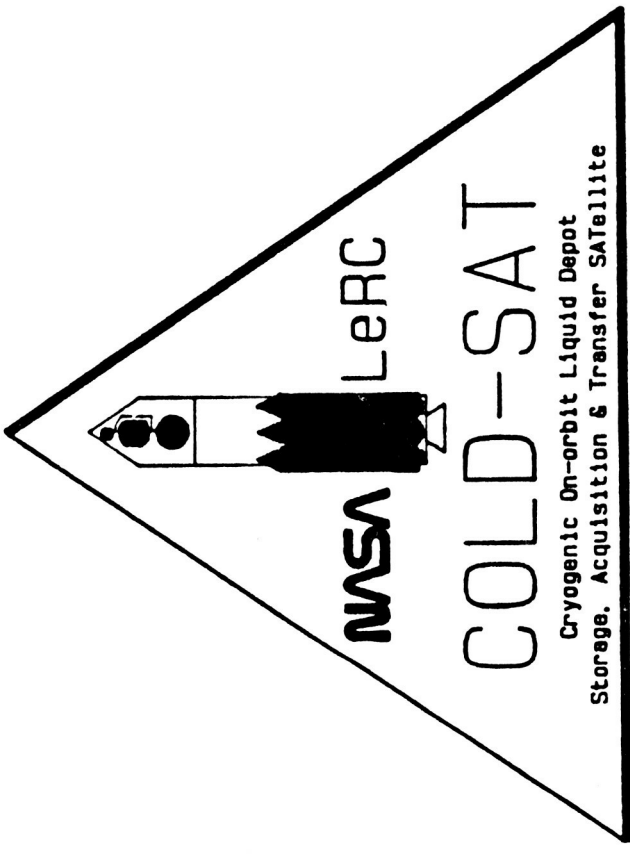
SPACE FLIGHT
SYSTEMS
DIRECTORATE

SPACE EXPERIMENTS DIVISION



LERC CRYOGENIC FLUID MANAGEMENT
PROGRAM OVERVIEW

ND 315-753



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

E.P. Symons

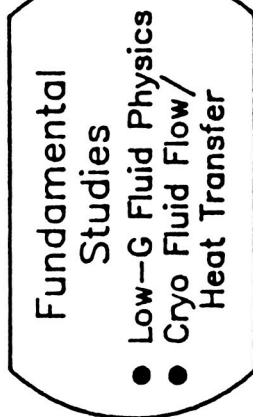
**LeRC CRYOGENIC FLUID MANAGEMENT PROGRAM OVERVIEW
AGENDA**

- 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

1960 to 1973



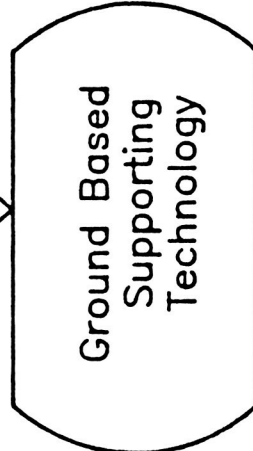
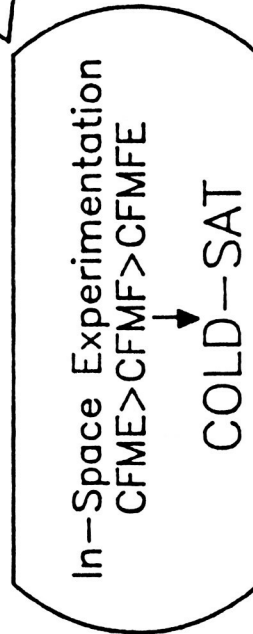
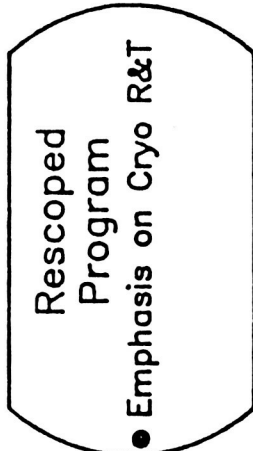
Mostly In-House

1973 to 1979



Mix Contractor & In-House

1979 to Present

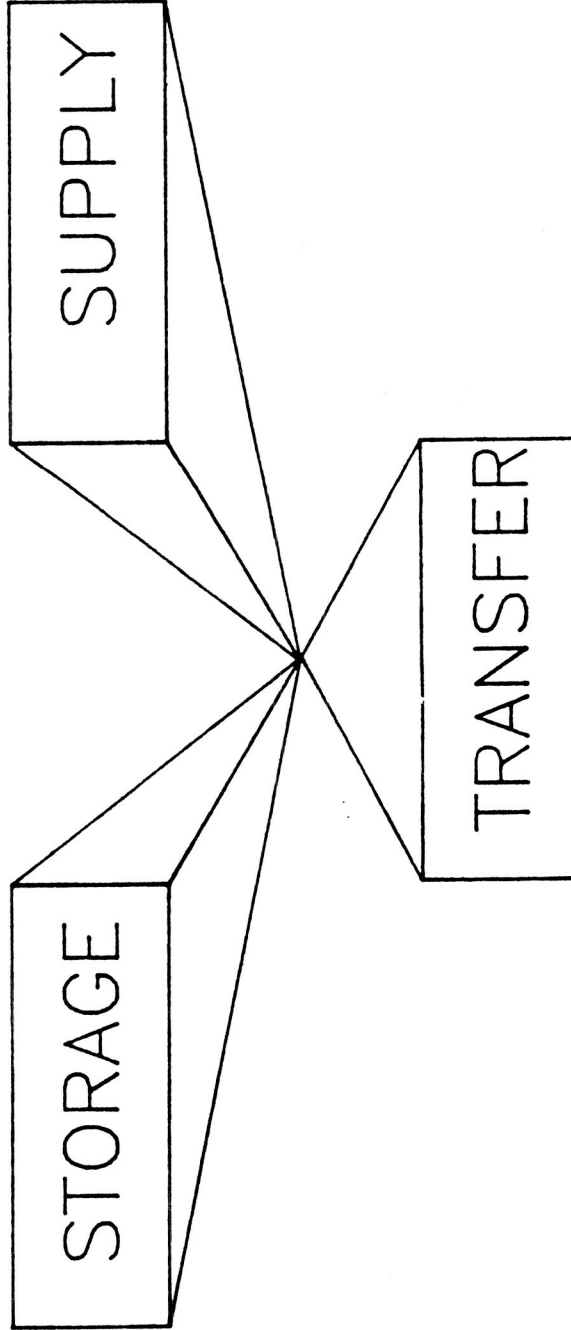


Current program built on strong foundation

LeRC CRYOGENIC FLUID MANAGEMENT PROGRAM OVERVIEW

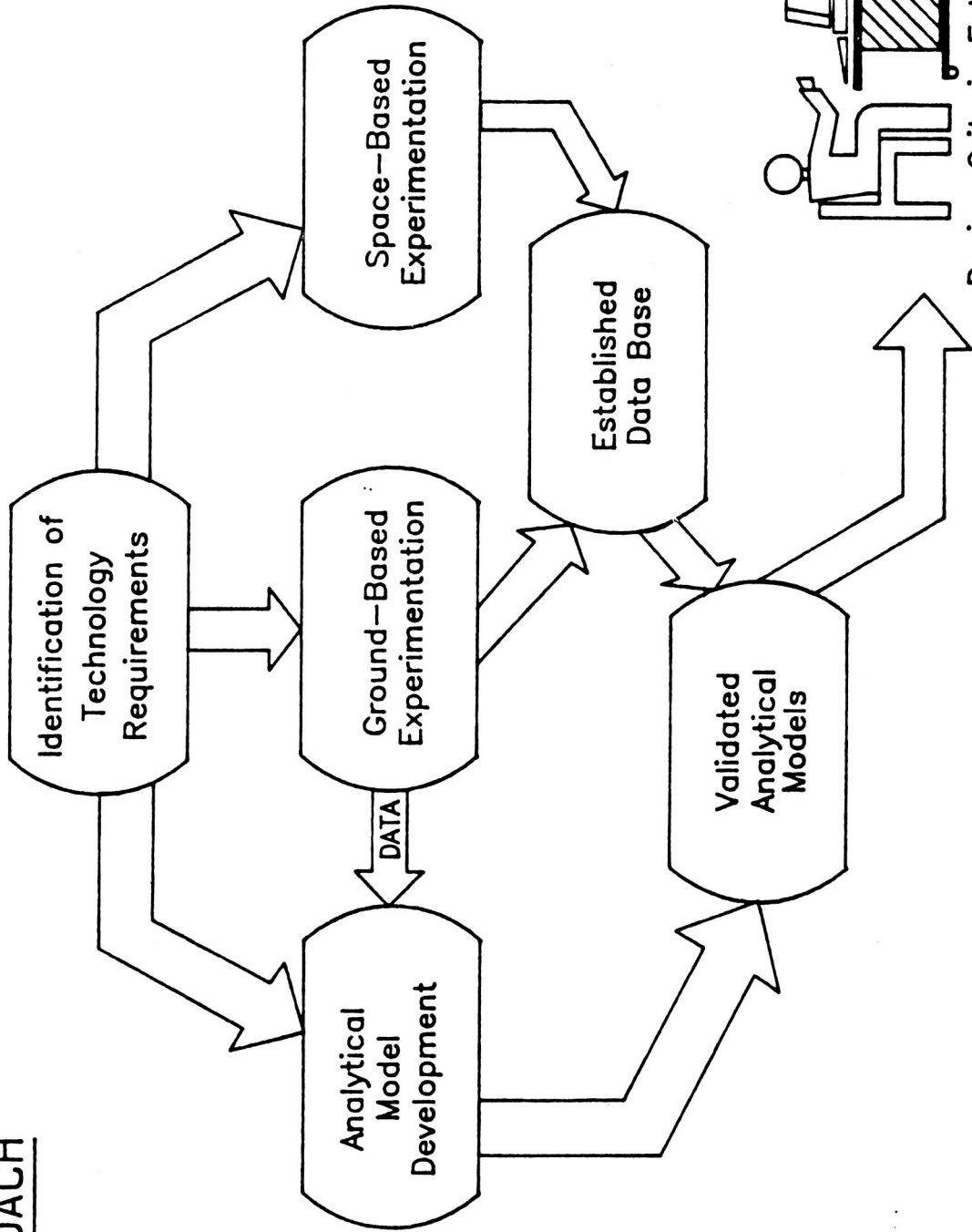
BROAD OBJECTIVE:

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



LeRC CRYOGENIC FLUID MANAGEMENT PROGRAM OVERVIEW

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

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

LIQUID IRANSEER

- 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

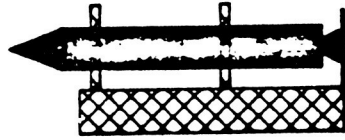
- INSTRUMENTATION
 - QUANTITY GAGING
 - MASS FLOW/QUALITY METERING
 - LEAK DETECTION

- CRYOGENIC COMPONENT LIFE

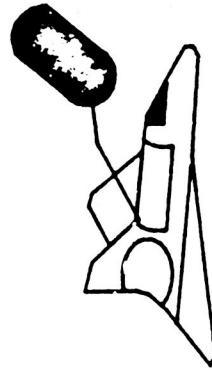
LeRC CRYOGENIC FLUID MANAGEMENT PROGRAM OVERVIEW

POTENTIAL APPLICATIONS:

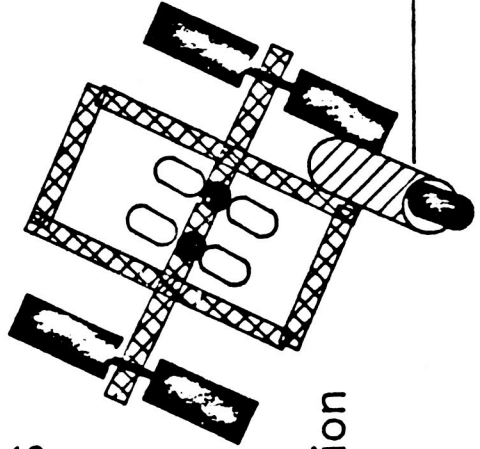
- EARTH-TO-ORBIT TRANSPORT AND IN-SPACE STORAGE OF CRYOGENIC LIQUIDS
- ON-ORBIT FUELING OF PROPULSIVE STAGES
- SUBSYSTEM FLUID REPLENISHMENT
- EXPERIMENT AND SATELLITE RESUPPLY OF REACTANTS, COOLANTS AND PROPELLANTS



Earth-to-Orbit "Tanker"



STS or Space Station Servicing



OTV or Satellite Servicing Bay

ORIGINAL PAGE IS
OF POOR QUALITY

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.