# SEAL TECHNOLOGY AT ROCKETDYNE

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Rocketdyne's related activities and presentation include:

1. The seal codes currently in use at Rocketdyne and their capabilities.
2. The seal testing currently planned.
3. The fluid-film bearing activity currently underway and planned.

## Rocketdyne Seal Technology

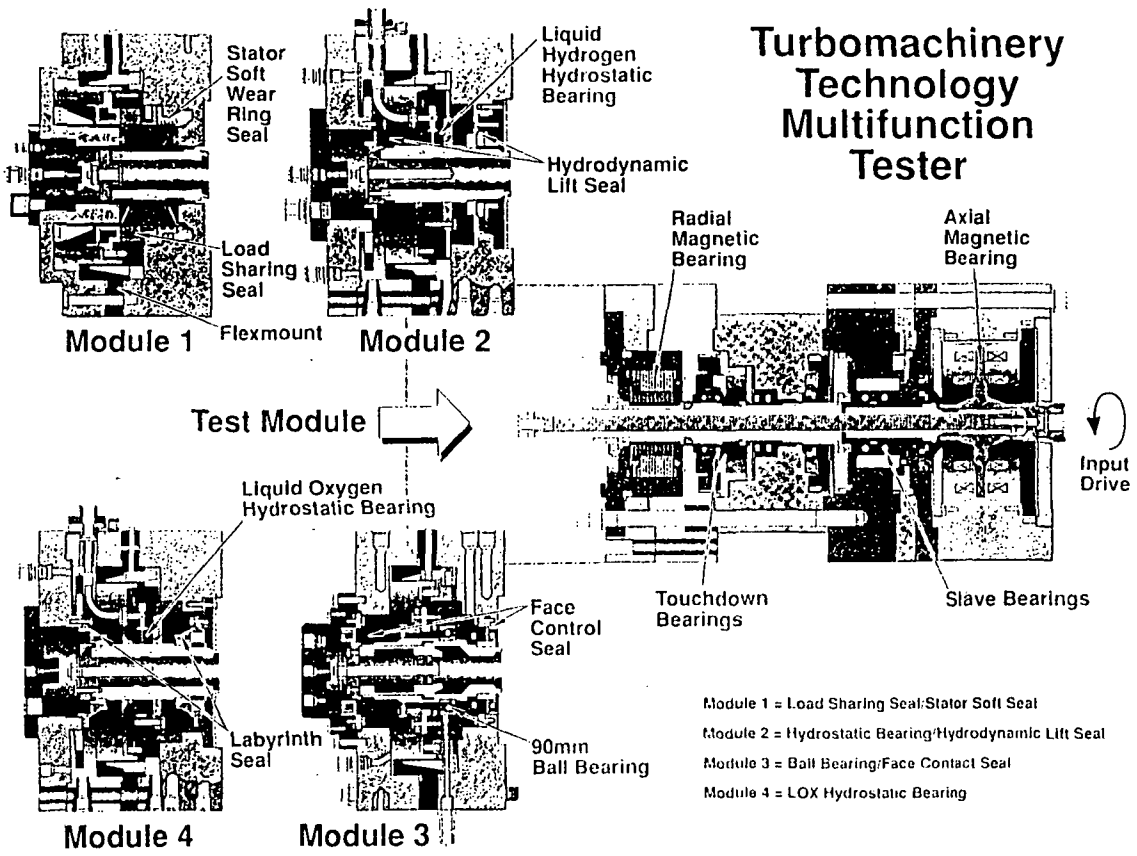
- Rocketdyne has a large collection of seal analysis codes
  - Floating ring seals
    - Static equilibrium
    - Dynamic response
  - Face seals
    - Steady state performance
    - Stability analysis
  - Load sharing seals
    - CFD codes for labyrinth and annular seals
    - Bulk-flow analysis for rotordynamic coefficients

## Rocketdyne Seal Technology

- Rocketdyne code development is ongoing
  - Barotropic fluid properties
  - Phase change
  - Brush seal performance
  - Large scale roughness
  - Asymmetric boundary conditions

## Rocketdyne Seal Technology

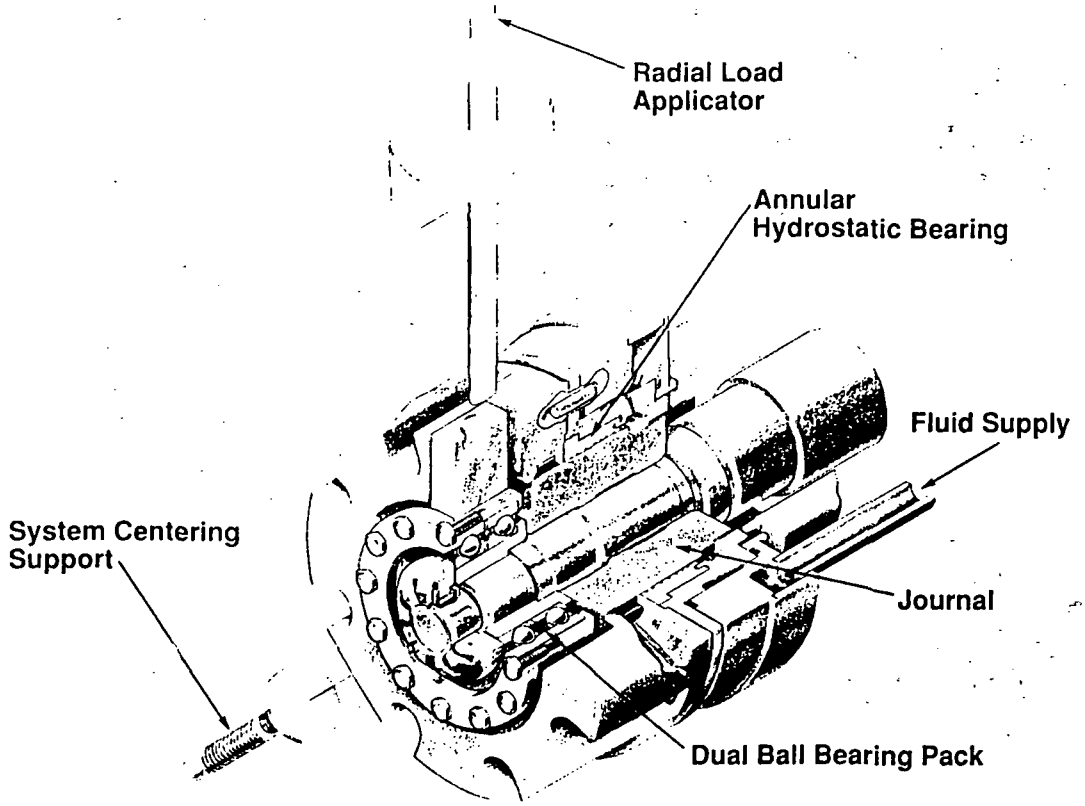
- Rocketdyne has both contract and internal funding for seal testing
  - Contract efforts
    - AFAL LOX/H2 Turbomachinery Technology
      - Extraction of rotordynamic coefficients for knurled damping seal in LH2
      - Dynamic testing of floating ring seal in LH2
      - Dynamic testing of spiral groove face seal in LH2
    - NASP
      - Extraction of rotordynamic coefficients for knurled damping seal in LOX
    - NASA MSFC NRA (with University of Akron)
      - Flow visualization and measurement in knurled damping seal




## Rocketdyne Seal Technology

- IR&D funded testing
  - Brush seal performance in LH2
  - Brush seal coatings (with Texas A&M)
  - Flow in large scale roughness (with Texas A&M)
  - Transient load capacity of knurled damping seal in LOX

# Annular Hydrostatic Bearing Transient Tester



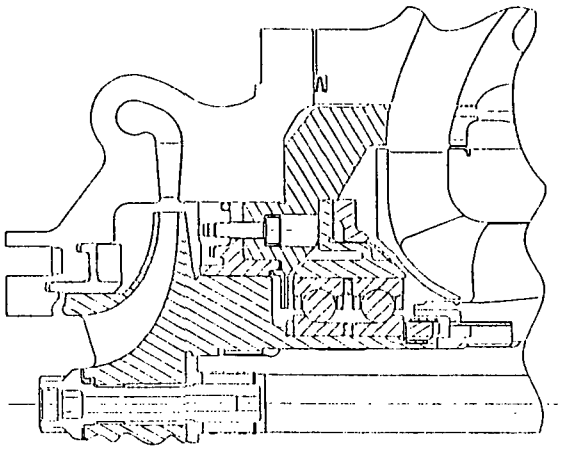

# HPOTP PUMP END BEARING CONVERSION

## Plans

- **Design annular LOX hydrostatic bearing/seal**
  - Tapered, knurled sterling silver damping bearing
- **Eliminate ball bearings No. 1 and No. 2**
- **IR&D to design and fabricate retrofit hardware**
- **Contract to assemble and test on TTB**
- **Design substantiated with component tests in Long Life tester**
  - K-monel and Inconel 718 journals
  - 60 start transient simulations per bearing in LOX
- **Tribometer tests measure friction and wear in GOX**
- **Ignition data provided by White Sands testing**
- **Future plans include upgrading tester to measure coefficients**

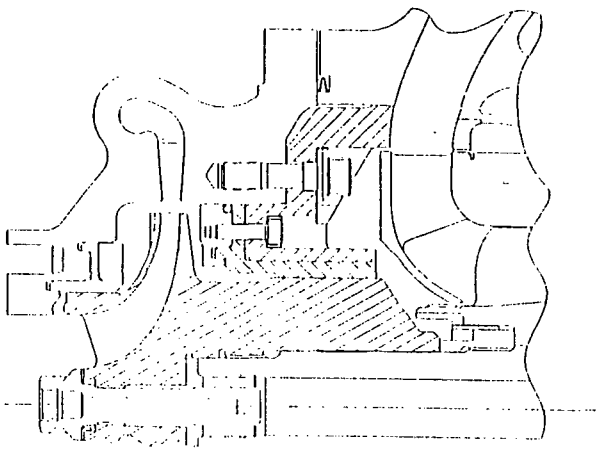
# HPOTP PUMP END BEARING CONVERSION

Flight Phase II Configuration



- Twelve parts & bolt pattern removed

Hydrostatic Bearing Retrofit



- Replaced by three parts

# EXPERIMENTAL VERIFICATION OF ROTORDYNAMIC ANALYSIS

## MSFC Program Status

- **Complementary damping bearing development initiated in October**
  - Verifies rotordynamic coefficient calculations for hydrostatic bearings
- **Tests four hydrostatic bearings in modified long life tester**
  - HCFC test fluid
  - **Two bearings internally fed through the shaft**
    - Conventional and damping designs TBD
  - **Two bearings externally fed through the stator**
    - Conventional and damping designs TBD
- **Extracts all rotordynamic coefficients**
  - Measures leakage and frictional torque
- **Conceptually designs new HPOTP turbine end package**
  - Includes lowest whirl ratio bearing tested
  - Provides manufacturing estimate

# HYDROSTATIC BEARING TECHNOLOGY
## Review

- **Problem**
  - Present turbopumps limited by rolling element bearing life
- **Goal**
  - Develop reliable, long life, cryogenic fluid-film bearings
- **Benefits**
  - Eliminate rolling element bearing DN limits and life constraints
  - Add flexibility to optimize rotor mechanical arrangement
  - Increase damping for more stable operation
  - Reduce overhauls and maintenance costs
- **Rocketdyne committed to multiyear IR&D development program**
  - 1990 expenditure of $1.726M
  - 1991 commitment of $2.275M
- **NASA and AFAL contracts in place to further advance technology**

## HYDROSTATIC BEARING DEVELOPMENT INTEGRATION PLAN

| Issue | Task | Funding Source |
|---|---|---|
| Code | Code development & verification | IR&D |
| Material | Material development (tribology) | |
| Environment | Non-contacting bearing study | |
| Lift-off | Transient life testing | |
| Coefficients | Cryogenic bearing development | |
| Tester Demo | Dual rotor support demonstration | |
| T/P Demo | Generic turbopump demo,MK29FD | |
| Coefficients | LOX/$H_2$ MFT bearing development | AFAL |
| T/P Demo | HPOTP pump end retrofit | SSME IR&D |
| Type/Coeff | Int/ext feed damper brg comparison | MSFC |
| T/P Demo | HPOTP turbine end retrofit | OPEN |
| Coefficients | LOX bearing coef. testing | NASP |
| Coefficients | ADP bearing validation | MSFC |
| T/P Demo | ADP $LH_2$ turbopump | MSFC |