PRESENTATION 4.2.8

# MANUFACTURING PROCESSES


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| COORDINATOR: | PAUL MUNAFO | NASA/MSFC |
| CONTRIBUTORS: | JAY BENNET | NASA/JSC |
| | DAVID BROWER | LOCKHEED/HOUSTON |
| | STAN LEVINE | NASA/LeRC |
| | RAY WALKER | P&W/WEST PALM BEACH |
| | JOHN WOOTEN | ROCKWELL/ROCKETDYNE |


## MANUFACTURING PROCESSES

### ISSUES

- o PROCESS DEVELOPMENT FREQUENTLY LAGS BEHIND MATERIAL DEVELOPMENT
- o HIGH FABRICATION COSTS
- o FLEX JOINTS (BELLOWS) A CONTINUING PROGRAM
- o SRM FABRICATION-INDUCED DEFECTS
- o IN-SPACE ASSEMBLY WILL REQUIRE SIMPLIFIED DESIGNS

### PROPOSED ACTIONS/PROGRAMS

- o FABRICATE ADVANCED COMPOSITE DEMO ARTICLE(S)
- o FABRICATE DEMO RCS THRUSTER USING IRIDIUM-COATED RHENIUM
- o NEAR-NET SHAPE FABRICATION
- o SMART MANUFACTURING
- o DEVELOP NEW FLEX JOINT
- o RHEOLOGY STUDY OF SOLID PROPELLANT FLOW CHARACTERISTICS
- o COVALENT BONDING PROCESS FOR INSULATOR/PROPELLANT
- o MANUFACTURE OF LARGE INTEGRATED COMPONENTS (MODULES)



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## MANUFACTURING PROCESSES (CONT'D)

### MAJOR OBJECTIVES

- o LARGE-SCALE DEMO ARTICLES
- o REDUCED FABRICATION COSTS
- o RELIABLE, EASY-TO-ASSEMBLY FLUID COUPLINGS
- o IMPROVED SRM PROCESSING
- o MODULAR COMPONENTS

### MILESTONES

| | |
|---|---|
| IMPROVED BELLOWS | 1993 |
| JOINING TECHNIQUE FOR RHENIUM THRUSTERS | 1993 |
| SIMPLIFIED COUPLINGS | 1994 |
| NET-SHAPE HARDWARE DEMO | 1994 |
| RHEOLOGY STUDY OF PROPELLANT CASTING | 1995 |
| CERAMIC MATRIX COMPOSITE ROTOR | 1996 |

## MANUFACTURING PROCESSES

## RECOMMENDATIONS/FINDINGS

O ESTABLISH BROAD-BASED PEER GROUPS TO REVIEW TECHNOLOGY DEVELOPMENT PROGRAMS

- o PROGRAM MANAGER AS FOCAL POINT
- o FELLOW TECHNOLOGISTS (M'F'G, MAT'LS, NDE)
- o USERS/DESIGNERS
- o GUIDE THE DEVELOPMENT PROCESS
- o INDEPENDENT TEAM FOR PROGRAMMATIC DECISIONS
- o FUNCTIONS THROUGHOUT PROGRAM -- FROM ADVOCACY TO IMPLEMENTATION

## MANUFACTURING PROCESSES

## RECOMMENDATIONS/FINDINGS (CONT'D)

O IMPLEMENT REVIEW/REPORTING SYSTEM SIMILAR TO THAT NOW USED IN IR&D

- o CURRENT AND PLANNED PROGRAMS
- o STANDARD FORMAT
- o COULD REPLACE ANNUAL SYMPOSIA

O INCORPORATE TECHNOLOGY TRANSFER INTO DEVELOPMENT PLAN FOR IMPROVED EQUIPMENT

- o WOULD PROVIDE "PEER" SUPPORT FOR CONTINUED DEVELOPMENT
- o WOULD ASSURE CONSISTENCY BETWEEN DEVELOPED EQUIPMENT AND USER NEEDS
- o WOULD PROVIDE FOR ORDERLY, PLANNED TRANSFER OF RESPONSIBILITY FROM DEVELOPER TO USER

## RECOMMENDATIONS/FINDINGS (CONT'D)

O HARDWARE DEMONSTRATION PROGRAMS SHOULD BE PERFORMED FOR COMPOSITES

- o SHOULD NOT STOP AT THE COUPON LEVEL
- o "PHASE 2 OFTEN NOT FUNDED"
- o DEMO ARTICLES SHOULD BE USED FOR PROPERTY DETERMINATION
- o INVOLVE PROPULSION/DESIGN ELEMENTS

O PROPULSION SYSTEMS FOR IN-SPACE ASSEMBLY SHOULD BE DESIGNED TO MINIMIZE COMPLEX OPERATIONS

- o MODULAR DESIGN
- o EASY-TO-ASSEMBLE COUPLINGS

### FABRICATE ADVANCED COMPOSITE DEMOS

| Issues | Major Objectives |
|---|---|
| o Full-scale fabrication not demonstrated for advanced composites.<br>o Properties obtained from coupons not representative. | o Full scale demo articles for advanced compostites.<br>o Component tests.<br>o Destructive evaluation of mechanical properties. |
| **Candidate Programs** | **Significant Milestones** |
| o Screen and match materials/components.<br>o Subscale feasibility tests.<br>o Select demo article configuration(s).<br>o Build and test demo articles.<br>o Destructive evaluation. | o Screen and match: 1991-1992<br>o Select demo articles: 1993<br>o Build and test: 1996 ⟶ |

## FABRICATION OF RCS THRUSTERS

### Issues

- Advanced (optimized) thrusters require material combinations which currently can not be welded.

### Major Objectives

- Develop joining techniques for rhenium thrusters.

### Candidate Programs

- Select candidate materials to join to rhenium.
- Select candidate joining processes.
- Fabricate and evaluate samples.
- Transfer findings to hardware fabrication program.

### Schedule

- Material selecton: 1991
- Process selection: 1991
- Sample fabrication/evaluation: 1992
- Hardware applications: 1993

## NEAR-NET SHAPE FABRICATION PROCESSES

### Issues

- High fabrication costs for complex components.

### Major Objectives

- State-of-the-art of near-net shape forming processes.
- Choose most promising applications.
- Demonstration tests.
- Technology transfer.

### Candidate Programs

- Literature survey.
- Prioritize candidate processes and applications.
- Conduct/evaluate fabrication requirements.
- Fabricate and test component.

### Schedule

- Literature survey: 1991-1992
- Fabrication experiments: 1992-1993
- Demonstration tests: 1993-1994
- Program implementations: 1994 ⟶

## SMART MANUFACTURING TECHNOLOGY

### Issues

- High Fabrication costs for Low-Volume-Components.

### Major Objectives

- Cost-effective manufacturing in a low-volume production environment.
  - Analytically-based process development.
  - Rapid transition from laboratory to manufacturing.

### Candidate Programs

- Computer simulation of manufacturing processes.
- Material processing data base.
- Process control utilizing process sensor technology.
- Standardization of computer language.
- Rapid prototyping by stereolithography.
- Flexible processing cells.

### Schedule

- Identify near-term applications: 1992
- SRM, ALS, External Tank applications: 1992 →
- SEI: Long term

## MODULAR ASSEMBLY

### Issues

- Frequent flex joint (bellows) problems.
- Current manufacturing procedures too complex for in-space assembly.

### Major Objectives

- High-reliability flex joints.
- Modular components.
- Simple-to-assemble couplings.

### Candidate Programs

- Improved bellows fabrication.
- Design/Test snap-together couplings.
- Manufacture of large integrated components (modules).

### Schedule

- Bellows fabrication optimized: 1993
- Simplified couplings: 1994
- Demo modular components: Long term

## SRM MANUFACTURING TECHNOLOGY

### ISSUES

1. Debonds at insulator (propellant and insulator) case interfaces.
2. Flow-induced anomalies in the propellant during casting result in localised fast burning areas.
3. Continuous Casting:
   a: Scale-up effect unknown on physical properties when comparing subscale to fullscale.
   b: Orientation (radial vs. circumferential vs. axial) effect on mechanical and ballistic properties not known.

### MAJOR OBJECTIVES

1. Improved bonding methods.
2. Improved understanding of flow during casting, leading to improved ballistic and mechanical properties of propellant.
3. Determine the mechanism that leads to the scale-up and orientation variability phenomena; develop processes that will provide more homogenous propellant.

### CANDIDATE PROGRAMS

1. Develop an insertion material to form covalent bonds with the two materials.
2. Rheology study of propellant flow during casting.
3. Analytical study of scale-up and orientation phenomena; empirical, configuration-specific determination of optimum processing for specific SRM designs.

### SCHEDULE

1. Continuous through 1995.
2. Continuous through 1995.
3. Analytical study: Contiuous through 1996.
   Emprical study: Early in production.