Fiber Placement Machine and Related Advanced Composite Equipment Final Technical Report NASA Contract NAS8-39749

1.0 Background

NASA contract NAS8-39749 was completed in January 2000. The contract period of performance covered six (6) years and included basic program technical support as required by NASA with up to thirty (30) different technical directives identified and issued by NASA for specific Advanced Composite Technology tasks during the course of the contract.

2.0 Discussion

As suggested by the contract COTR, all monthly reports prepared and submitted during the course of this contract have been cataloged by year and included herein to document the activities performed and accomplishments made for each specific task under this contract. A list of each task follows:

Task	Task Description	Total Dollars Expended
Basic	Fiber Placement Machine Operations/Maintenance	$919,959
TD FPM-01	Ablative Combustion Chambers (Fastrac)	$124,061
TD FPM-01	Assorted Panels	$14,765
TD FPM-03	Hydrogen Tank	$23,979
TD FPM-04	18" C/E Vessels	$118,439
TD FPM-05	Cryogenic Feed Line	$118,576
TD FPM-06	Cryo Shock Test	$29,022
TD FPM-07	Composite Dome	$12,393
TD FPM-08	Honeycomb Specimens	$12,393
TD FPM-09	Composite Fabricate Isogrid Structure	$49,767
TD FPM-10	Honeycomb specimens	$41,595
TD FPM-11	Full Scale Ablative Chamber	$48,578
TD FPM-12	Intertank Structure	$191,858
TD FPM-13	Not Issued	
TD FPM-14	Not Issued	
TD FPM-15	Reserved (not used)	
TD FPM-16	Russian debris shield	$31,778
TD FPM-17	Cryo dome and stiffeners	$385,846
TD FPM-18	Cryotest Pressure Vessels	$24,581
TD FPM-19	Honeycomb Test Specimens	$$1,255
TD FPM-20	Low Profile Dome	$15,230
TD FPM-21	Composite Cryotank	$1,350
TD FPM-22	Advanced Composite Structure	

TD FPM-23	Advanced Ablative Chambers	$3,241,468
TD FPM-24	Composite Impact Specimens	$8,230
TD FPM-25	Fabricate Bantum Composite RP Tank	$504,595
TD FPM-26	Fabricate 10K Combustion Chambers	$5,599
TD FPM-27	Bonded Joint Test Article	$31,778
TD FPM-28	Permeability Testing	$15,299
TD FPM-29	Quasi-Isotropic Panels	$8,714
TD FPM-30	Test Specimens	$47
TD FPM-31	Composite Ducts	$44,250
TD FPM-32	X-33 Panels	$35,441
TD FPM-33	Composite Conformal Aerogel Insulated Tank	$74,292

3.0 Conclusion

As shown by the list of technical directives, a wide range of tasks were initiated and completed in support of NASA's Research and Technology Development Programs. From manufacture of test specimens required to support mechanically fastened composite joint studies to manufacture of 60K Nozzle/Combustion Chambers to support the X-34 Liquid Engine, Thiokol provided the Engineering and Manufacturing expertise to complete these tasks in support of NASA. Valuable Technology has been gained with each task completed under this contract. Specific information on the work performed, accomplishments made and recommendations provided following completion of each task; is provided in the monthly technical progress reports contained herein.

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT MARCH 1994

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-30749) for the period of March 1994. This contract was formalized and officially kicked-off on March 28, 1994. This represents the first technical report for this contract. The report covers essentially three days of contractual work activity during March. Subsequent reports will be published and submitted on a monthly basis. The following paragraphs summarizes the significant accomplishments during the initial work period beginning in March, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in April, 1994.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

The work accomplished during March primarily involved orientation of the key engineering and technician personnel with the fiber placement machine (FPM) operations and preparation of the machine and support facilities for upcoming work.

The FPM operation software instructions were evaluated and reviewed in detail by engineering and technician personnel. Engineering also reviewed the FPM maintenance instruction to become familiar with critical machine support requirements.

Cincinnati Milacron was contacted to discuss computer and software support requirements. Contact was made to determine whether PATRAN 3.0 would be compatible with the FPM off-line software package. PATRAN 3.0 is the latest version of a computer software package created by PDA Engineering for pre and post-processing of finite element code. If compatible, PATRAN 3.0 will be utilized for defining component surface geometries for fiber placement winding operations. These surface geometries must be generated using the model definition capabilities of PATRAN. The computer model is then loaded into a Silicon Graphics workstation so that fiber lay-down paths can be defined. After fiber paths are defined, the actual machine instruction code for the FPM is generated. The machine instructions are then loaded into the FPM and the desired component can be fabricated. The FPM off-line software was originally designed to read PATRAN 2.5 neutral files and I-Deas (computer automated design (CAD) software package) universal files. Cincinnati Milacron will evaluate and advise Thiokol on the compatibility of the PATRAN 3.0 code. It is expected that this will not be a problem and that the PATRAN 3.0 code will be usable.

Machine processing operation parameters were reviewed and actual machine operations were performed to re-familiarize the key personnel with the proper procedures for machine operations. A subscale motor exit cone mandrel was loaded into the FPM and 0-degree plies were laid-down for machine operation orientation and practice. Four courses of towpreg material was laid-down. The material system included Hercules IM-7 graphite towpreg impregnated with Hercules 8553-40 resin.

3.0 RECOMMENDATIONS

- Access to a Silicon Graphics computer workstation needs to be established so that models can be generated for the FPM off-line software.
- A copy of the computer software I-Deas and/or PATRAN is required in order to generate surface models.
- An upgrade to the FPM off-line post-processor software is needed so that the FPM will be able to cut-on-the-fly.
- A software maintenance agreement with Cincinnati Milacron is needed to ensure technical support for future software problems.
- A creel cooler is required for the FPM so that the towpreg temperature can be kept at 55 deg. F during machine operations to provide sufficient tack for fiber lay-down stability (currently the room temperature is held at 65-70 deg. F and the mandrels are heated).

4.0 UPCOMING WORK TO BE PERFORMED

The following is a list of upcoming work to be accomplished in April:

Application	Work Activity
Cryogenic tankage	Fabricate flat plates for liquid hydrogen permeability testing and evaluation Fabricate cryogenic pressure vessels for testing
Material data base	Fabricate flat panels for mechanical testing using the following materials IM7G-12k/8553-40 IM7G-12k/3501-6
Machine operation capabilities/parameters	Develop database on machine lay-down rate capabilities
Surface geometry modeling	Develop capability to generate surface models

Approved by: C. Wayne Tanner for

L.I. Pelham
Program Manager

March 1994 Monthly Technical Progress Report

March Monthly Technical Progress Report on Operation/
Maintenance of Fiber Placement Machine

Contract NAS8-39749

Larry I. Pelham

Thiokol Space Operations
Huntsville Office
6767 Old Madison PIke, NW - Suite 490
Huntsville, AL 35806

TWR-68056

Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

NASA - See Handbook NHB2200.2

Report describes technical problems, recommendations, and planned work for the next month.

Fiber Placement

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT APRIL 1994

1.0 INTRODUCTION

This report summarizes the technical activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for the period of April 1994. The following summarizes the significant accomplishments during the work period beginning in April, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in May 1994.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

The work accomplished during April primarily involved fabrication of two flat panels and one cylinder. A fiber placement machine operating procedure was prepared for review. An RFP was sent to Cincinnati Milacron for the Software Maintenance Contract. A request for a creel cooler was submitted for review.

2.1 FABRICATION OF FLAT PANELS

Two 24" x 18 " test panels were fabricated and cure. The panels were 16 plies thick and had the following layup [90,120,60,150,30,120,60,90]s. This layup was designed to simulate a filament wound case layup. The panels were made using a Hercules towpreg system IM7G-12K/8553-40. The two panels were designated A and B. The laydown rates for each of the panels is shown in Table 1.

Table 1
Flat Panel Laydown Rates

Panel	Delay Time (min)	Run Time (min)	Total Time (min)
A	350	137	487
B	60	110	175

Prior to the fabrication of panel A, the power in the building failed causing the chiller to go down and causing the room temperature to rise to 78-79 degrees F. With elevated temperature, the material was adhering to itself, causing stingers, high tensioner loads, and fiber breakage. When the chiller was reset and brought back online and the room temperature was brought down to 69F, the material came off the spools easily and went through the machine fine. During the first ply, problems were incurred trying to get the material to stick to the tool surface. We tried heating the tool with a heat gun and spraying some acetone thinned resin on the surface but the material would not stick. We then applied double stick tape to the surface at the beginning of the 90 degree ply. This allowed the first ply to be layed down. Tensioner #14 kept shutting down and the chucks

would unchuck. We contacted Cincinnati Milacron and described the problem. They recommended that we pull the tensioner, check all the electrical connections, and reseat them. This was done and no further problems with tensioner #14 were encountered. No new problems were encountered. Panel B was then fabricated with no major problems.

2.2 FABRICATION OF A CYLINDER

A 9.08 inch diameter by 24 inch long cylinder was fabricated using IM7G-12K/8553-40 towpreg material. The cylinder surface model was designed using PATRAN 3.0 and I-DEAS. Both models were loaded into the Fiber Placement Offline Programming System (FPOPS) and translated into the bicubic patches. The PATRAN model had only 4 arc patch segments around the cylinder; the FPOPS had problems converging a start point. Cincinnati Milacron recommended using 12 or more arc segments for the cylinder. The I-DEAS model was used to generate the different machine programs (89,45,-45, 0). During the running of the 89 degree course, the FPM would stop about 12 inches into the part laydown with an "Invalid F code" error message. After reviewing the commands, we found that post processor had placed an feedrate of 0.0 in the program. The previous command had a feedrate of 1500 in/min. We manually modified the program and proceeded. We transferred the model and input to Cincinnati Milacron to review. Cincinnati Milacron ran our data on the updated software with no problems. No laydown rates or scrap rate data is available at this time.

2.3 OPERATING PROCEDURE

A fiber placement machine operating procedure was prepared and is being reviewed. This document was prepare to meet NASA requirement to have operating procedures for all hazardous operations. A more detail operating procedure will be written later for new operator training.

2.4 SOFTWARE MAINTENANCE CONTRACT

An RFP was sent to Cincinnati Milacron for the Software Maintenance Contract (SMC). The SMC will allow us to call Cincinnati Milacron when we need consultation in reference to software problems. It will also give us a one time upgrades to our current FPOPS software. The later version of the FPOPS software has been refined to generate more efficient machine programs that will reduce processing time by up to 40%.

2.5 CREEL COOLER

A Request for Purchase for a Creel Cooler is being prepared and will be submitted this month. The Creel Cooler is required to eliminate the recurring problems we have been having with the room temperature being too warm for the material and too cold to lay material on the tool surface.

3.0 RECOMMENDATIONS

- Provide a dedicated Silicon Graphics computer workstation for I-DEAS and/or PATRAN and FPOPS. The current system being utilized is limited in the available memory and hard disk storage for the FPOPS software.

- A copy of the computer software I-DEAS and/or PATRAN is required in order to generate surface models.

- Need upgrade to the FPM off-line post-processor software to be able to cut-clamp-refeed on the fly.

- A creel cooler is required for the FPM so that the towpreg temperature can be kept at 55 deg. F during machine operations to provide sufficient fiber stiffness to greatly reduce fiber machine feed problems. Then the room temperature can be keep at a more reasonable temperature that will enhance fiber tack, compaction, and lay-down stability (currently the room temperature is held at 65-70 deg. F and the mandrels are heated).

4.0 UPCOMING WORK TO BE PERFORMED

The following is a list of upcoming work to be accomplished in May:

Application	Work Activity
Material Database Cylinders	Fabricate 7.625" x 33.0" cylinders. These cylinder will be tested and compared to some previously wound in the filament winding machine.
Material data base	Fabricate flat panels for mechanical testing using the following materials IM7G-12K/8553-40 IM7G-12K/3501-6
Machine operation capabilities/parameters	Develop database on machine lay-down rate capabilities
Surface geometry modeling	Develop capability to generate surface models
Creel Cooler	Procure Creel Cooler
Software Support Contract	Finalize Software Support Contract with Cincinnati Milacron.

Approved by: _____

L.I. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT MAY 1994

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for the period of May 1994. The following paragraphs summarize the significant accomplishments during the work period beginning in May, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in June, 1994.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

The work accomplished during May primarily involved removing a bad disk drive, curing the demonstration cylinder, and fabricating three database cylinders. A fiber placement machine operating procedure was completed and signed-off. A software maintenance contract was established with Cincinnati Milacron. A purchase request for the creel cooler was prepared and approved. An effort to fabricate eight ablative chambers was added to the contract.

2.1 FPM CONTROLLER DISK DRIVE FAILURE

The FPM A975F controller has two 65MB hard drives, Drive 0 and Drive 1; these drives store all the machine executive control routines and part programs. Drive 0 began started reporting disk error by shutting down the machine and reporting a fatal error, it eventually crashed. Before the drive crashed, all of the programs on the hard drives were offloaded. Drive 0 was removed and Drive 1 was reconfigured as Drive 0. The new Drive 0 was reformatted and the executive control routines and the mandatory part programs were reloaded. The hard drive on the FPM is operational, but we did lose about half of the hard disk space. A request has been submitted to locate and procure a replacement drive.

2.2 FABRICATION OF A DEMONSTRATION CYLINDER

The 9.08 inch diameter by 24 inch long cylinder was cured on May 3. The cylinder was spiral wrapped with shrink tape, vacuum bagged, and oven cured. This cylinder was fabricated as a process verification article for the Process/Material Database Cylinders.

2.3 PROCESS/MATERIAL DATABASE CYLINDERS

Three tubes were fabricated and two were cured in May. The tubes were 7.625 inches in diameter and 33 inches long. They were sixteen plies thick and had the following material layup: $[[0]_4,55.125,[0]_2]_S$. An IM6/3501-6 towpreg material system was used. The surface model was generated on I-DEAS in Utah. The laydown rates for the tubes are shown in Table 1 below.

Table 1
Database Tube Laydown Rates

Tube No.	Delay Time (min)	Run Time (min)	Total Time (min)	Percent Up Time
1	89	127	216	58.8 %
2	72	65	137	45.5 %
3	74	61	135	45.2 %

During the fabrication of tube #2, a pneumatic cutter rod broke which took 58 minutes to repair. This was added to the delay time. If this time was taken out of the processing time, the percent up time would have been 82.2%.

The fabrication of tube #3 was delayed for a tour group that was in 4707. If this delay was taken out the processing time, the percent up time would be 64.2%.

There were a couple processing techniques that were investigated. They include: laying a single tow around the ends of the first couple of plies to hold down the previous layer in case the tows had to be removed; heating up the mandrel to enhance tow tack for the first ply; parking the machine when fiber is not being processed to stop the tows from sticking to the redirect rollers and stop the restart roller from breaking the fiber during prefeed.

The material usage was calculated for tube #2 and tube #3. The resin bleed was calculated by subtracting the total material used from the scrap rate and part weight. The material usage is shown in Table 2.

Table 2
Material Usage

Tube No.	Towpreg Used (gms)	Scrap Matl. (gms)	Part Weight (gms)	Resin Bleed (gms) Calc.	Scrap Rate
1	N/A	N/A	1729.4	N/A	N/A
2	2229.9	410.0	1694.6	125.3	18.4 %
3	2185.7	305.6	1689.6	190.5	14.0 %

2.4 OPERATING PROCEDURE

The operating procedure for the FPM is complete and fully approved. The operating procedure will be distributed in June. This document was prepared to meet a MSFC requirement to have operating procedures for all hazardous operations. A more detailed operating procedure will be written later for new operator training.

2.5 SOFTWARE MAINTENANCE CONTRACT

The Software Maintenance Agreement with Cincinnati Milacron was negotiated and is now in effect. The latest version of the FPOPS software will be shipped on June 10.

2.6 CREEL COOLER

The Creel Cooler is in the process of being purchased. Purchase documents are being prepared and the Creel Cooler should be ordered in early June. The Creel Cooler will take 90 days to fabricate and deliver from date-of-purchase.

2.7 ABLATIVE CHAMBERS

An effort to develop and fabricate 8 ablative chambers has been added to the contract. The effort has been planned and the required procurement released.

3.0 RECOMMENDATIONS

- Provide a dedicated Silicon Graphics computer workstation for I-DEAS and FPOPS. The current system being utilized is limited in the available memory and hard disk storage for the FPOPS software.

- A copy of I-DEAS software is needed to develop surface models of the part geometry where a model does not already exist.

- Training for PATRAN 3.0 is needed to more efficiently develop surface models for some of the part geometry. PATRAN 3.0 is being installed on and Silicon Graphics Indy which available in Room 106, Building 4707.

- More materials is needed for the database study. Procurement of the following materials is recommended:

100 pounds	Hercules - IM7/8552
100 pound	Hercules - IM7/8553-45
50 pounds	Hercules - AS4/3501-6

4.0 UPCOMING WORK TO BE PERFORMED

The following is a list of upcoming work to be accomplished in June:

Application	Work Activity
Material Database Cylinders	Continue fabrication of 7.625" x 33.0" cylinders. These cylinders will be tested and compared to some previously wound in the filament winding machine.
Ablative Chambers	Begin receiving tooling and materials relating to the Ablative Chamber effort.
Low Cost Mandrel Development	Start work to use the Fiber Placement Machine to fabricate prototype FP/FW mandrels using structural foam.
Material data base	Fabricate flat panels for mechanical testing using the following materials: IM7G-12K/8553-40 IM7G-12K/3501-6
PATRAN 3.0 Training	Obtain training for PATRAN 3.0 to develop capability to generate surface models for part geometry.
FPOPS Evaluation	Test new version of Fiber Placement Offline Programming System.

Approved by: _____

L.I. Pelham
Program Manager

May 1994 Monthly Technical Progress Report

May Monthly Technical Progress Report on Operation/
Maintenance of Fiber Placement Machine

Contract NAS8-39749

Larry I. Pelham

Thiokol Space Operations
Huntsville Office
6767 Old Madison Pike, NW - SUite 290
Huntsville, Al 35806

TWR-68059

Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

NASA - See Handbook NHB2200.2

Report describes technical problems, recommendations, and planned work for the next month.

Fiber Placement

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT JUNE 1994

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for the period of June 1994. The following paragraphs summarize the significant accomplishments during the work period beginning in June, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in July 1994.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

2.1 OFFLINE PROGRAMMING WORKSTATIONS

A new Silicon Graphics workstation was received and installed in Room 106, Building 4707 with PATRAN 3.0 surface modeling software. This workstation will be used to generate surfaces as input for the Fiber Placement Offline Programming System (FPOPS). The PATRAN software can be used to read in files from other CAD software packages using the IGES format or surfaces models can be generated using its own limited tools. Bob Huff received two days of training on PATRAN 3.0. The class covered the following topics: using the X windows and Motif systems, file system management, accessing and importing geometries, graphics manipulation, display imaging and viewing, use of lists, use of groups and entities, and neutral file output.

An new Silicon Graphics Indigo^2 workstation was received and installed in Room 126B, Building 4707. The new FPOPS software was loaded on the workstation. This workstation will be used to generate the machine command codes used by the Fiber Placement Machine.

2.2 COMPOSITE OPTICAL BENCH AND SUPPORT BRACKETS

One optics bench was fabricated with Fiberite P75/954-3 on the 7.625" x 39" mandrel. The molds for the composite bracket were designed and fabricated. The first set of composite brackets were fabricated using Fiberite M55/954-3. The second set of composite brackets were fabricated using Hercules IM6/3501-6.

2.3 PROCESS/MATERIAL DATABASE CYLINDERS

Four process studies tubes were fabricated and cured in June. The tubes were 7.625 inches in diameter and 33 inches long. They were sixteen plies thick and had the following material layup: $[[0]_4,55,125,[0]_2]_S$. An IM6/3501-6 towpreg material system was used. The laydown rates for the tubes are shown in Table 1 below.

Table 1
Database Tube Laydown Rates

Tube No.	Delay Time (min)	Run Time (min)	Total Time (min)	Percent Up Time
4	37	103	140	73.6 %
5	108	114	222	51.4 %
6	54	109	163	66.9 %
7	55	108	163	66.3 %

During the fabrication of tube #5 a significant number of stringers on the spools reduced the percent up time. Some new processes were tried to improve the laydown rates and aid in tube removal from the mandrel: 1) Teflon tape was placed at the end of the tube laydown area to allow for easier removal of excess resin after the cure, 2) double-sided tape was placed on one end of the tube so that the first ply would stick; excess double-sided tape was removed prior to cure, and 3) the chutes were cleaned more frequently which reduced the number of tow jams.

The material usage was calculated for all of the tubes. The scrap rate and resin bleed were calculated by subtracting the total material used from the scrap rate and part weight. The material usage is shown in Table 2.

Table 2
Material Usage

Tube No.	Towpreg Used (gms)	Scrap Matl. (gms)	Part Weight (gms)	Resin Bleed (gms) Calc.	Scrap Rate
4	2070.8	204.2	1696.7	169.9	9.9%
5	2292.3	204*	1650	438.3*	8.8%
6	2094	243.2	1668.1	182.7	11.6%
7	2223.6	431	1670.1	122.5	19.4%

* Scrap rate may be low as some of the material may have been thrown away without being weighed

The scrap rate for tube #7 was high because of a stringer problem during the ply #8 laydown. Ply #8 is a hoop wrap and the fiber broke at the spools during the laydown. Ply #8 had to be removed which resulted in the removal of ply #7.

Tubes #4 through #7 had the following bagging arrangement: A sheet of teflon fabric was placed around the O.D. of the tube, 1" shrink wrap tape was wrapped spirally with 1/2 overlap from the center to each end, and 2 to 4 layers of 10 ounce breather were layed over the entire part. The following cure cycle was used: 280° F for 35 min, 255° F for 1.5 hours, 380° F for 45 min. 355° F for 3.5 hours. The over temperatures holds were used to get the part up to the hold temperatures.

2.4 SOFTWARE MAINTENANCE CONTRACT

The upgrade FPOPS software to Revision 5 was received and checked-out. A bug was found in the post processor (pproc) portion of the FPOPSR5. The fiber tension was hard coded in at 0.5 lbs. The machine requires the tension to be greater than 1.0 lb to operate. Cincinnati Milacron was notified and is in the process of removing the problem and updating the software.

2.5 CREEL COOLER

The Creel Cooler has been purchased and should be delivered mid-September.

2.6 LOW-COST FOAM MANDREL TOOLING DEVELOPMENT

A prototype foam mandrel was delivered and cured in the Despatch oven. A model of a prototype surface was generated in COSMOS/M and the IGES file sent via the Internet to Silicon Graphics PATRAN (SGPAT) workstation. PATRAN 3.0 was used to develop patches on the surface for the FPOPS software. A 89 degree hoop path will be used as the cutting path to trace the part contour. A pneumatic motor with a router bit will be mounted at the tool-point of the FPM head to cut the foam.

2.7 ABLATIVE CHAMBERS TD-01

Materials for the ablative chambers have been ordered and are all received except for the fiberglass. The mandrel is being fabricated in 4705 by NAS and should be completed by the end of July.

3.0 RECOMMENDATIONS

- More materials are needed for the database study. MSFC procurement of the following materials is recommended:

100 pounds	Hercules - IM7/8552
100 pound	Hercules - IM7/8553-45
50 pounds	Hercules - AS4/3501-6

- Additional spare parts for the FPM are being considered, specifically the need for the following:

  - Compaction rollers (3 ea)
  - Restart rollers (one set of 12)

  The current compaction rollers are showing signs of wear and may cause operational problems in the future. The rough surface on the restart rollers is also wearing off which is resulting in more tow slippage and machine downtime.

- I-DEAS training is recommended for Thiokol employees. I-DEAS is currently available on the Silicon Graphics Crimson in the Computer Graphics room in Building 4707 on a non-interference basis and will be available on the Silicon Graphics Indigo^2 workstation (SGVIPER) sometime this year. In order to efficiently use the I-Deas software package it is recommended that 2 people be trained. The I-Deas software will be used to generate solid models of parts (from scratch).

4.0 UPCOMING WORK TO BE PERFORMED

The following is a list of upcoming work to be accomplished in July:

Application	Work Activity
Material Database Cylinders	Continue fabrication of 7.625" x 33.0" cylinders. These cylinders will be tested and compared to some previously wound in the filament winding machine.
Ablative Chambers	Begin fabricating ablative chamber.
Low Cost Mandrel Development	Machine foam in the Fiber Placement Machine to fabricate prototype FP/FW mandrels using structural foam.
Material Database	Fabricate flat panels for mechanical testing using the following materials: IM7G-12K/8553-40 IM7G-12K/3501-6
I-DEAS Training	Obtain training for I-DEAS to develop capability to generate surface models for part geometry.
FPOPS Evaluation	Evaluate fix to new version of the post processor part of FPOPS.

Approved by: Wayne Tarlton for
L.I. Pelham
Program Manager

Jun 1994 Monthly Technical Progress Report

June Monthly Technical Progress Report on Operation/ Maintenance of Fiber Placement Machine

NAS8-39749

Larry I. Pelham

Thiokol Space Operations
Huntsville Office
6767 Old Madison Pike, NW - Suite 490
Huntsville, AL 35806

TWR-68061

Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

NASA - See Handbook NHB2200.2

Report describes technical problems, recommendations, and planned work for the next month.

Fiber Placement

Unclassified Unclassified Unclassified UL

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
July 1994

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for the period of July 1994. The following paragraphs summarize the significant accomplishments during the work period beginning in July, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in August 1994.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

Supplemental Agreement 2 was fully executed definitizing the efforts in Technical Directives FPM-02 and FPM-03. This authorized the efforts for the " Development/Fabrication of Assorted Advanced Composite Parts" and the "Fabrication of Composite Hydrogen Demonstration Tank."

2.1 OFFLINE PROGRAMMING

We have developed the capability to generate models in Microstation/PC and port them to PATRAN, on the Silicon Graphics, and generate surfaces readable by the Fiber Placement Offline Programming System (FPOPS).

A license for SDRC I-DEAS is being purchased and will be installed on the Fiber Placement Workstation (SGVIPER). I-DEAS will be used to develop solid models of new fiber placement projects where there are no current models.

2.2 COMPOSITE OPTICAL BENCH AND SUPPORT BRACKETS

The mold for the composite brackets was modified with a larger radius to eliminate the fiber bridge seen in the previous brackets. The mandrel for the optical bench is being turned down 0.020" on the diameter to account for the expansion of the aluminum during the cure cycle.

2.3 PROCESS/MATERIAL DATABASE CYLINDERS

One process studies, cylinder 4.808"x46.5", was fabricated to test out the new FPOPSR5 code. The cylinder had a $[7,173,89,91]_2$ layup using IM7/8553-45 towpreg. The FPOPSR5 software was hard coded to insert a fiber tension of 0.50 lbs; the machine program had to be manually edited before it would run on the machine.

The compaction roller was not taped during the part fabrication and worked fairly well. There were only a few times when the towpreg material stuck to the compaction roller.

2.4 SOFTWARE MAINTENANCE CONTRACT

We are still waiting for the fix to the bug that was found in the post processor (pproc) portion of the FPOPSR5. The fiber tension was hard coded in at 0.5 lbs. The machine requires the tension to be greater than 1.0 lb to operate. Cincinnati Milacron was notified and is in the process of removing the problem and updating the software.

2.5 Maintenance

The Bus OverHead (BOH) board in the FPM controller failed the last week in July. A replacement board was ordered and will be installed as soon as it arrives. This board controls the voltage through-out the computer control system.

The hardness of the remaining FPM compaction rollers were measured using a Shore A Hardness tester. This data will be used to determined what type of rollers should be ordered as replacements. The results of these measurements are shown in Table 1.

Table 1
Compaction Roller Hardness Measurements

Roller Description	Shore A Hardness
Yellow Roller	69.4
Blue Roller	81.0
Orange Roller	73.6
White Roller	64.8

2.6 LOW-COST FOAM MANDREL TOOLING DEVELOPMENT

A pneumatic motor was mounted on the FPM head. The motor is actuated by an air line that used to be connected to the main cooling air feed line. The other air devices were shut down by using the dry-run feature on the FPM control. A small cylinder was machined out of a block of External Tank foam.

A complex shaped foam prototype mandrel will be machined in early August and a part fabricated on the foam mandrel. This will prove the FPM's capability to fabricate low cost foam mandrels for prototype part development. The ability to fabricate prototypes parts looks very promising.

2.7 ABLATIVE CHAMBERS TD-01

Most of the Ablative Chamber materials have been received. The fiberglass for the overwrap was returned and the correct fiberglass was received. The tape wrap mandrel was delivered and has been teflon coated. The tape wrapper is being programmed to wrap the first liner.

2.8 ASSORTED COMPOSITE TAPE LAYED PANELS TD-02

The Cincinnati Milacron tape layer is being programmed to lay-up the first set of panels. AS4/3501-6 material will be used for the composite materials kits A3, B3, A4, and B4.

2.9 COMPOSITE HYDROGEN DEMONSTRATION TANK TD-03

The purchase order for the foam mandrel has been issued. The mandrel should be delivered August 22. Received drawings for stainless steel pole bosses from Stan Smeltzer NASA and ROM cost estimates were received from a local machine shop. The pole bosses will be procured in August. A shaft drawing for the 37" foam mandrel has been prepared and the mandrel will be procured in August.

3.0 RECOMMENDATIONS

- More materials is needed for the database study. Procurement of the following materials is recommended:

100 pounds	Hercules - IM7/8552
100 pound	Hercules - IM7/8553-45
50 pounds	Hercules - AS4/3501-6

4.0 UPCOMING WORK TO BE PERFORMED

The following is a list of upcoming work to be accomplished in July:

Application	Work Activity
Material Database Cylinders	Continue fabrication of 7.625" x 33.0" cylinders.
Ablative Chambers	Continue fabricating the Ablative Chambers.
Assorted Tape Layed Panels	Start fabrication of Material Properties Panels.
Composite Hydrogen Demonstration Tank	Receive mandrel and prepare it for contour machining.
Low Cost Mandrel Development	Continue developing foam mandrel machining techniques. Fabricate composite part using foam mandrel.
Material Database	Fabricate flat panels for mechanical testing using the following materials: IM7G-12K/8553-40 IM7G-12K/3501-6
I-DEAS Training	Obtain training for I-DEAS to develop capability to generate surface models for part geometry.
FPOPS Evaluation	Evaluate fix to new version of the post processor part of FPOPS and measure improvements in the laydown rates.

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Program Manager

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Thiokol Space Operations
Huntsville Office
6767 Old Madison Pike, NW- Suite 490
Huntsville, AL 35806

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT AUGUST 1994

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for the period of August 1994. The following paragraphs summarize the significant accomplishments during the work period beginning in August, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in September 1994.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

A foam mandrel was machined in the Fiber Placement Machine (FPM) and a composite part was fabricated on the foam mandrel. The first ablative chamber was fabricated on the Tape Wrap Machine and overwrapped on the Filament Winding Machine.

A trip was taken to Cincinnati Milacron to discuss FPM technology, off-line programming, and spare parts for the machine.

2.1 OFFLINE PROGRAMMING

The Fortran compiler was loaded on Silicon Graphics Workstation (SGVIPER) and is now available for compiling code.

2.2 COMPOSITE OPTICAL BENCH AND SUPPORT BRACKETS

An engineering model optical bench was fabricated with the modified mandrel. In addition, composite mounting brackets were fabricated.

2.3 PROCESS/MATERIAL DATABASE STUDY

Flat panels for materials testing were layed out and will be programmed and fabricated in September.

2.4 SOFTWARE MAINTENANCE CONTRACT

The upgrade to the post-processor (pproc) was received and loaded. Initial evaluations indicate that the problems with the tension setting have been solved.

2.5 MAINTENANCE

The new Bus OverHead (BOH) board in the FPM controller was replaced, but had a bad timer chip that caused the digit clock on the control console to run six-times faster that normal. A new board was received, installed, and checked out.

The FPM controller hard drive failed and was replaced and reloaded.

A 240 volt/3 amp fuse supplying power to the control console blew and was replaced.

The restart rollers were grit blasted and recoated by Rocketdyne with a flame sprayed nickel coating. The nickel coating bond to the steel appears to be holding, but we are concerned that nickel is not hard enough to last very long.

2.6 LOW-COST FOAM MANDREL TOOLING DEVELOPMENT

The FPM was used to machine a foam mandrel and fabricate a part on that mandrel. The machining of the foam mandrel accomplished by programming the machine in a circumferential (hoop) wrap mode. The graphite/epoxy layed down on the foam mandrel with no significant problems. The mandrel cracked along the knit line in the foam and deformed during cure. It is assumed that the wood inter-structure expanded and caused the foam to move. If the mandrel can be fixed, another part will be fabricated.

2.7 ABLATIVE CHAMBERS TD-01

The first ablative chamber was tape wrapped with silica/phenolic and autoclaved cured. The chamber was then overwrapped with glass/epoxy and oven cured. Final machining and assembly will be done when a canister is available. Problems with the tape wrapper control system have stopped the effort to fabricate further parts.

2.8 ASSORTED COMPOSITE TAPE LAYED PANELS TD-02

The Cincinnati Milacron tape layer was used to lay-up the first set of panels. AS4/3501-6 material was used for the composite materials kits A3, B3, A4, and B4. The kits divided then

2.9 COMPOSITE HYDROGEN DEMONSTRATION TANK TD-03

Three 5.75" bottles were fabricated to determine the integrity of the pole boss to composite bondline. The results of the testing have shown that a tough adhesive is required at the bondline to withstand the cryogenic temperature cycling. The pole boss purchase was put on hold until the pole boss design is finalized. The 37-inch foam mandrel was shipped from General Plastics on August 26th and should arrive in early September. The mandrel shaft was delivered and teflon coated.

3.0 RECOMMENDATIONS

A copy of I-Deas software is needed to generate solid models for projects where part models do not exist.

An overwrapping tool is required to lay down shrink tape and/or peel ply on the parts prior to debulk or cure. The tool will provide an accurate method of laying down an overwrap and save operator time. The cost to purchase a custom built wrapper is approximately $9.8k.

4.0 UPCOMING WORK TO BE PERFORMED

The following is a list of upcoming work to be accomplished in July:

Application	Work Activity
Material Database Study	Fabrication flat mechanical test panels.
Ablative Chambers	Continue fabricating the Ablative Chambers.
Assorted Tape Layed Panels	Start fabrication of Material Properties Panels.
Composite Hydrogen Demonstration Tank	Receive mandrel and prepare it for contour machining
Low Cost Mandrel Development	Continue developing foam mandrel machining techniques. Fabricate composite part using foam mandrel.
I-DEAS Training	Obtain training for I-DEAS to develop capability to generate surface models for part geometry.
FPOPS Evaluation	Continue evaluation of new features of FPOPS and measure improvements in the laydown rates.

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Program Manager

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Huntsville Office
6767 Old Madison Pike, NW Suite 490
Huntsville, AL 35806

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Report describes technical problems, recommendations, and planned work for the next month.

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT SEPTEMBER 1994

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for the period of September 1994. The following paragraphs summarize the significant accomplishments during the work period beginning in September, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in October 1994.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

On September 30, 1994, the contract was modified to exercise the GFY 95 option, extending the contract period of performance through September 30, 1995. In addition, the Technical Directive FPM-02 efforts were revised and Technical Directives FPM-04 and FPM-05 were authorized. Accordingly, Thiokol has contractual direction to proceed with the "Fabrication of 18-Inch Diameter Carbon/Epoxy Advanced Composite Pressure Vessels" and the "Fabrication of Composite Components and Assembly of Feedline".

2.1 OFFLINE PROGRAMMING

Developed interactive menu system using PATRAN Control Language (PCL) to automate the generation of similar surfaces (changes due to material build-up).

2.2 PROCESS/MATERIAL DATABASE STUDY

Thirteen of the fourteen flat panels were fabricated in September. Per NASA instruction the SBS/CTE panels were fabricated using 32 plies. Table 1 shows the panels that were fabricated. The CTE laminate using IM6/3501-6 material should be fabricated on October 3, 1994.

Table 1
Flat Panels for Material Database Study

Panel Name	Material	Panel Dimension	No plies	Ply layup
Tens. Uni -6	IM6/3501-6	14"x12"	8	$[0]_8$
Tens. Uni-3	IM6/954-3	14"x12"	8	$[0]_8$
Comp. Uni-6	IM6/3501-6	8"x7"	16	$[0_{16}$
Comp. Uni-3	IM6/954-3	8"x7"	16	$[0_{16}$
Crossply 3501-6	IM6/3501-6	22"x22"	16	$[\pm 45_{16}$
Crossply 954-3	IM6/954-3	22"x22"	16	$[\pm 45_{16}$

CTE/SBS 954-3	IM6/3501-6	8"x7"	32	$[0_B2$
CTE/SBS 3501-6	IM6/954-3	8"x7"	32	$[0_B2$
Tens. Lam -6	IM6/3501-6	14"x12"	16	$[0_4,55,125.0_2]_S$
Tens. Lam -3	IM6/954-3	14"x12"	16	$[0_4,55,125.0_2]_S$
Comp. Lam -6	IM6/3501-6	8"x7"	16	$[0_4,55,125.0_2]_S$
Comp. Lam -3	IM6/954-3	8"x7"	16	$[0_4,55,125.0_2]_S$
CTE Lam -3	IM6/954-3	8"x7"	32	$[0_4,55,125.0_4,125.55.0_4]_S$

2.3 SOFTWARE MAINTENANCE CONTRACT

A new software maintenance agreement is being established for GFY95. This should be in place in October.

2.4 CREEL COOLER

Engineering Environments Inc. (EEI) completed and delivered the Creel Cooler. It had been painted the color of the GE Fiber Placement Machines (Clinton Teal) and was not Thiokol Machine green. It is in the process of being repainted and should be installed and operational the first week of October.

2.5 FPX MAINTENANCE

No significant problems were reported or machine repair needed this month.

2.6 ABLATIVE CHAMBERS TD-01

The tape wrapper was repaired and the second chamber will be fabricated the first week of October. The work on the first chamber has stopped, as we are waiting for a canister to be delivered so we can refurbish it and bond in the chamber.

2.7 ASSORTED COMPOSITE TAPE LAYED PANELS TD-02

No significant activity to report.

2.8 COMPOSITE HYDROGEN DEMONSTRATION TANK TD-03

The foam mandrel arrived the first week of September from General Plastics.

MSFC's Stan Smeltzer and Seth Lawson are investigating adhesives to be use as a cryogenic shear ply between the stainless steel pole boss and the graphite epoxy pressure vessel. Hysol urethane material (Uralite 3140-42) was chosen for the first set of tests. A test specimen was prepared by bonding the urethane to a flat specimen of 8551-7 with a 300F cure. A 5.75" bottle was fabricated using the urethane as a shear ply between the pole bosses and the composite this bottle will be cryogenically tested in October.

3.0 RECOMMENDATIONS

A copy of I-Deas software is needed to generate solid models for projects where part models do

not exist.

4.0 UPCOMING WORK TO BE PERFORMED

The following is a list of upcoming work to be accomplished in October:

Application	*Work Activity*
Material Database Study	Finish fabrication and cure flat mechanical test panels.
Ablative Chambers - TD01	Continue fabricating the Ablative Chambers.
Assorted Tape Layed Panels - TD02	Procure fabric for Material Properties Panels.
Composite Hydrogen Demonstration Tank - TD03	Evaluate cryogenic shear ply materials and develop a subscale test plan.
18" x 20" Pressure Vessels - TD04	Procure material and tooling. Start fabrication sand mandrels.
LH_2 FeedLine - TD05	Procure material and tooling. Start fabrication of test article.
Hercules Bend Tube	Fabricate 5.5" I.D. tube for Hercules Aerospace

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Huntsville Office
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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT OCTOBER 1994

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for the period of October 1994. The following paragraphs summarize the significant accomplishments during the work period beginning in October, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in November 1994.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

2.1 LESSONS LEARNED

Although not contractually covered by the subject contract, the Hercules Bend Cylinder uses the Fiber Placement Machine and the same labor resources, thereby having direct impact on the efforts under contract NAS8-39749.

The project started October 14. Plies 1-88 were layed down during October with three autoclave debulks. There will be a total of 452 plies when the part is complete. It is estimated that the part will be completed mid-December. Many lessons have been learned as a result of performing this project. First, the compaction rollers and main compaction pressure play an important part in tow gapping and overlapping. We have reduced the number of tows we laydown from eight to four to reduce the tendency to overlap due to wide tow (greater than 0.125). Second, the use of heat debulks and autoclave debulks smoothes out many anomalies that may form during fabrication. Third, fiber-fuzz began to form in the creel cooler and along the fiber path. This needs to be cleared off or fuzz-balls could get in the part and create bumps. Fourth, by starting the laydown slower we do not get as many tow twists.

To meet the Hercules specifications, we had to improve our techniques for placing plies. The experience gained from fabricating this part will improve our fiber placement knowledge and provide a greater number of trained operators.

2.2 PROCESS/MATERIAL DATABASE STUDY

Completed the last panel (CTE laminate using IM6/3501-6 material) for the material database study on October 3.

Table 1
Flat Panels for Material Database Study

Panel Name	Material	Panel Dimension	No plies	Ply layup
CTE Lam -3	IM6/3501-6	8"x7"	32	$[0_4,55,125,0_4,125,55,0_4]_s$

2.3 SOFTWARE MAINTENANCE CONTRACT

An extended software maintenance contract with Cincinnati Milacron has been established. This agreement will provide coverage through September 30, 1995, at which time Cincinnati Milacron will no longer support FPOPS (Fiber Placement Off-line Programming System). They would like us to upgrade to their new software ACES (Automated Composite Environment System).

2.4 CREEL COOLER

The Creel Cooler was repainted to match the machine and installed with minor modifications to the machine and creel cooler. A condensation pump was added to assist in the removal of water from the air conditioning unit.

2.5 FPX MAINTENANCE

During the fabrication of the Hercules Bend Cylinder, the I-Axis controller amplifier board failed. A rebuilt board was ordered and delivered over-night. We installed the board, checked out machine functions, and fabrication resumed.

2.6 ABLATIVE CHAMBERS TD-01

Liquid Engine Combustion Chambers (CC) #001 and #002 have had the silica liner tape wrapped and cured; the "over-wrap" of fiber glass/epoxy has been completed on these billets.

CC Billet #001 has been partially machined. The final machining to fit the "canister" (housing for test-stand and injector assembly) will be completed when the canister is delivered to Thiokol for refurbishment and installation of liner #001.

2.7 ASSORTED COMPOSITE TAPE LAYED PANELS TD-02

Initiated procurement tabbing materials to bond to test specimens.

2.8 COMPOSITE HYDROGEN DEMONSTRATION TANK TD-03

Provided drawings of the 5.9" x 12" pressure vessel mandrel to Stan Smeltzer (ED52). He is trying to design a leak-proof cryogenic polar boss to composite interface. Mr. Smeltzer is rewriting the test plan to include fabrication of three additional 5.9" x 12" pressure vessels to check-out a newly-designed polar boss seal.

3.0 RECOMMENDATIONS

It is recommended that a tension overwrapper (similar to the Hercules's overwrapper) be purchased or designed and fabricated for the FPM to wrap shrink/release tape on parts being fabricated. This would provide for the automation of a process that is currently performed by hand.

4.0 UPCOMING WORK TO BE PERFORMED

The following is a list of upcoming work to be accomplished in November:

Application	*Work Activity*
Material Database Study	Prep samples for testing
Ablative Chambers - TD01	Continue fabricating the Ablative Chambers.
Assorted Tape Layed Panels - TD02	Procure tabbing materials for Material Properties Panels.
Composite Hydrogen Demonstration Tank - TD03	Fabricated 5.9"x12" pressure vessels with new polar boss seal.
18" x 20" Pressure Vessels - TD04	Receive materials and tooling. Start fabrication sand mandrels.
LH$_2$ FeedLine - TD05	Receive materials and tooling. Start fabrication of test article.
Hercules Bend Tube	Fabricate 5.5" I.D. tube for Hercules Aerospace

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Program Manager

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Thiokol Space Operations
Huntsville Office
6767 Old Madison Pike, NW Suite 490
Huntsville, AL 35806

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Report describes technical problems, recommendations, and planned work for the next month.

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT NOVEMBER/DECEMBER 1994

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for November and December 1994. The following paragraphs summarize the significant accomplishments during the work period beginning in November, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in January 1995.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

Received Technical Directives FPM-06 and FPM-07 for the Fabrication of Composite Bottle Cryogenic Shock Test and Fabrication of LH_2 Tank Domes. Proposals are being prepared for both and will be submitted during January 1995.

2.1 MACHINE OPERATIONS

Because the FPM was heavily used during this period some new problems developed. First, the Z-axis cable carrier system developed multiply fatigue cracks on stainless carrier sheet. One of the cable brackets was removed to reduce the possibility of further damage. The complete Z-axis cable carrier system or just the stainless carrier sheet will need to be replaced in the near future. Second, the roller bearings supporting the restart roller shaft had to be replaced. Third, an air cooling port was added to the new chute to lower its temperature during operation in an attempt to eliminate the tendency of the resin for building up in the chute. Fourth, the park and prep button intermittently began to lockout forcing the operators to manually park and prep the machine or power down and reboot the controller. Cincinnati Milacron suggested we perform a complete system software reload and see if that eliminates the problem.

2.2 SOFTWARE MAINTENANCE CONTRACT

Cincinnati Milacron suggested that we upgrade to their new software ACES (Automated Composite Environment System). Realizing we can't afford the purchase price of $500K, they are investigating an option of setting us up as a beta test site for ACES. This would be covered under a new software maintenance contract whose value would increase to about $40K. If we do accept this option, it would require the CATIA CAD for surface generation. Presently CM doesn't have any plans to develop another interface.

2.3 TD FPM-01, ABLATIVE COMBUSTION CHAMBERS

Received request to design and fabricate an I.D. measurement tool. Preliminary estimate showed that this will impact the program by a reduction of approximately one liner.

Combustion Chamber Liner #01 has been installed in Canister #1 and had instrumentation hole machined.

Combustion Chamber Liner #02 has been final machined and is ready to be installed in Canister #2 after the AeroJet Liner can be removed.

Combustion Chamber Liner #03 was fabricated and has been machined and is ready to be removed from the mandrel.

2.4 TD FPM-02, ASSORTED COMPOSITE TAPE LAYED PANELS

Received tabbing materials for the A3, B3, A4, and B4 test specimens. Released work action request to machine and bond tabs to specimens. Test specimens should be completed the first week of February. Proceeding with action to procure material for shield support panels.

2.5 TD FPM-03, COMPOSITE HYDROGEN DEMONSTRATION TANK

Waiting for results of 5.9"x12" pressure vessels cyro shock tests (TD06) before proceeding with polar boss design and 37" bottle fabrication.

2.6 TD FPM-04, 18" X 20" PRESSURE VESSELS

Received tooling and materials for all 25 pressure vessels. During the fabrication of the first sand mandrel, we experienced problems successfully removing the mandrel from the mold. Presently, Frank Ledbetter is investigating an alternate cure that will enable use to remove the mandrel from the mold successfully.

2.7 TD FPM-05, LH2 FEEDLINE COMPONENTS

Received tooling and materials for all test article components. Fabricated and bonded all components to complete the three (3) test articles. Leak testing will be preformed at MSFC this month. Fabrication of flight articles will begin in January.

3.0 RECOMMENDATIONS

It is recommended that Z-axis cable carrier be replaced. the CCR be rebuilt by Cincinnati Milacron, the MCL be reloaded (controller software). and a spare fiber guide chute be fabricated. These recommendations will be discussed in detail with the COTR during January 1995 and appropriate actions will be taken.

4.0 UPCOMING WORK TO BE PERFORMED

The following is a list of upcoming work to be accomplished in January.

Application	Work Activity
Material Database Study	Prep samples for testing
Ablative Chambers - TD01	Continue fabricating the Ablative Chambers.
Assorted Tape Layed Panels - TD02	Procure tabbing materials for Material Properties Panels. Order fabric for panels
Composite Hydrogen Demonstration Tank - TD03	Fabricated 5.9"x12" pressure vessels with new polar boss seal (TD06).
18" x 20" Pressure Vessels - TD04	Determined cure method and start fabrication sand mandrels.
LH_2 FeedLine - TD05	Start fabrication of flight article.

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for L.I. Pelham
Program Manager

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6. AUTHOR(S)
Larry I. Pelham

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Thiokol Space Operations
Huntsville Office
6767 Old Madison Pike, NW Suite 490
Huntsville, AL 35806

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Report describes technical problems, recommendations, and planned work for the next month.

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT JANUARY 1995

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for January 1995. The following paragraphs summarize the significant accomplishments during the work period beginning in January, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in February 1995.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

2.1 MACHINE OPERATIONS

Two methods of repairing the Z-axis cable carrier are being investigated. The first option is to have Cincinnati Milacron replace the fatigued and failing component with upgraded new parts. The second is to completely replace the Z-axis cable carrier with a heavy duty plastic cable carrier. These options will be discussed in detail with the COTR during February 1995 and appropriate action taken. The cut clamp restart was prepared for shipment to Cincinnati Milacron and no cost quote for rebuild was requested. Upon receipt of the quote, the COTR will be informed and appropriate action taken.

2.2 TD FPM-01, ABLATIVE COMBUSTION CHAMBERS

Thiokol's Combustion Chamber (CC) Liner Billet #01 has been installed at the test stand. We are waiting for the delivery of additional O-rings from the test stand for the Liner-to-Canister seal so that CC Liner Billet #02 can be bonded in and returned for testing. The CC Liner Billet #03 was machined to OD and length. We received the Liquid Engine Canister from test stand with Aerojet Liner # 03. The Liquid Engine CC Canister from Aerojet was disassembled, the Liner removed and the CC Canister was then refurbished and cleaned. The CC Liner Billet #04 was fabricated and autoclave cured. The Fiberglass/Epoxy over-wrapp was wound and cured on the billet. The billet was machined to OD and length. Upon completion of the CO_2 vent system is completed on the Tape Wrap Machine, we will tape wrap the CC Liner Billet #05.

Drawings of CC Liner measuring fixture were prepared and fabrication of CC Liner measuring fixture was completed.

The Propulsion Lab indicated that they anticipated a three-week slip in their test schedule.

2.3 TD FPM-02, ASSORTED COMPOSITE TAPE LAYED PANELS

A paper was prepared that reviews the bonding of tab materials to composite specimens. Two adhesive systems were identified for bonding tab materials to the specimens. The first method involves mixing an epoxy adhesive and spreading a thin layer over the tab and composite and placing the system in a clamp. The second method involves placing a fiber glass film adhesive on both the tab and composite surfaces. The system is placed in a clamp and cured in an oven at 250° F. The film adhesive will minimize the flow of the resin out of the bondline and the fabric will also create a constant thickness bondline.

Drawings of the specimen layout on the flat panels were prepared. The requested specimen dimensions were checked against ASTM standard sizes and some anomalies were found. Changes were made to the specimen dimensions and use of tabs per NASA direction. Prepreg fabric from Hercules was identified for the Type I and Type II panels and is on order.

2.4 TD FPM-03, COMPOSITE HYDROGEN DEMONSTRATION TANK

The 37" tank is still on hold until a pole boss concept is developed.

2.5 TD FPM-04, 18" X 20" PRESSURE VESSELS

Waiting for results of Frank Ledbetter's cure study before proceeding with the fabrication of mandrels.

2.6 TD FPM-05, LH2 FEEDLINE COMPONENTS

The remaining 90° elbows have been fabricated, cured and machined. This includes the 90° elbow prototype and flight articles. The 45° elbows have all been layed up but have not been final machined. Three flanges were produced during January with one flange remaining. The third splice group needs to be fabricated.

NASA requested the production of a substantially higher number of composite feedline components than the original statement of work had outlined. Along with the additional production requirements.

MSFC requested that we purchase an alignment fixture for the feedline assembly. We have submitted a CPFF proposal for the additional work.

3.0 RECOMMENDATIONS

It is recommended that the PATRAN contract be renewed. The renewal price is approximately $6000 and is due in May 1995. Majid Babai (NASA) purchased the first year contract. This software is required to generate surfaces to program the fiber placement machine. Without it, we will not have the capability to generate new machine programs. This will be discussed in detail with the COTR during February 1995 and appropriate action taken.

4.0 UPCOMING WORK TO BE PERFORMED

The following is a list of upcoming work to be accomplished in February.

Table 1

Priority	TD	Application	Work Activity
High	FPM-01	Ablative Chambers	Continue fabricating ablative chambers
Med	FPM-02	Assorted Panels	Fabricate specimens from panels already made. Layup and cure Type I and Type II specimens
Low	FPM-03	Hydrogen Tank	On Hold
Med	FPM-04	18° C/E Vessels	Fabricate sand mandrels and start winding vessels
High	FPM-05	Cryogenic Feed Line	Finish fabricating composite feedlines components. Order Alignment Fixture.
Low	FPM-06	Cryo shock Test	On Hold
High	FPM-07	Composite Dome	Hand-layup composite domes for McDonnell Douglas
High	FPM-08	Honeycomb Specimens (Intertank)	Submit CPFF proposal. fabricate panels and assemble test specimens.
None	FPM-09	Fabricate Isogrid	Submit CPFF proposal.
Low	FPM-10	Honeycomb Specimens (CDDF)	Submit CPFF proposal. Start engineering.
None	FPM-12	Intertank structure	Wait for TD

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L.L. Pelham
Program Manager

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Huntsville Office
6767 Old Madison Pike, NW Suite 490
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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT FEBRUARY 1995

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for February 1995. The following paragraphs summarize the significant accomplishments during the work period beginning in February, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in March 1995.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

2.1 MACHINE OPERATIONS

Two new compaction rollers with a teflon bonded outer surface were received from Cincinnati Milacron (CM). The rollers had two different hardness values, 30 and 40 durometer rating. The Cut-Clamp-Restart (CCR) mechanism for the FPM head is still at CM waiting for authorization to proceed the repairs. Talks continued with CM and other vendors for a repair/replacement electrical cable carrier system for the Z-axis. Information and pricing for CM's ACEs software and Dassault's CATIA software have been requested. These items will be discussed in detail with the COTR during March 1995 and appropriate actions will be taken.

2.2 TD FPM-01, ABLATIVE COMBUSTION CHAMBERS

Propulsion Lab delivered Liner #1 to 4707 to have the injector cuts on the inside surface of the liner patched with a high temperature epoxy. The Liner #5 was tapewrapped, bagged, and cured. The Liner is ready to be fiberglass/epoxy overwrapped.

2.3 TD FPM-02, ASSORTED COMPOSITE TAPE LAYED PANELS

The Hercules fabric prepreg material, AG370-8H/8852, was received February 21. The prepreg fabric, 49 pounds, was to be used to fabricate the Type I and Type II debris panels. Practice specimens were prepared from an old composite panel to test the bonding techniques used for the tab to composite bondline. Three specimens were fabricated and pulled using the Instron test machine in 4707. All the tab specimens broke in the tab region which indicated a poor bonding technique. The techniques used were evaluated and changes made. Recommendations to are: The composite material should not be sanded prior to bonding (the tab material should have the gloss removed); the specimens are not to be machined after the bondline has been cured; and a uniform pressure clamping mechanism/system should be used during the cure. To reduce the bonding time, Hysol recommended a rapid cure of the EA9394 adhesive at 150° F for one hour. Detailed specimen layout drawings were prepared and will be used for machining the assorted panels.

2.4 TD FPM-03, COMPOSITE HYDROGEN DEMONSTRATION TANK

The large 37" tank is still on hold until a pole boss concept is developed.

2.5 TD FPM-04, 18" X 20" PRESSURE VESSELS

No activity. Waiting for results of Frank Ledbetter's cure study before proceeding with the fabrication of the mandrels.

2.6 TD FPM-05, LH2 FEEDLINE COMPONENTS

An additional silicone flange cover and a 45° elbow silicone mandrel were cast and cured. The remaining 45° composite elbows were layed up, cured, and are awaiting machining. The first 45° elbow was polished and presented to NASA. An additional straight tube was layed up, cured, machined, and delivered to MSFC personnel for NDE. The alignment fixture for the composite feedline assembly was ordered from B-K Manufacturing. The requested delivery date is March 17th. The last splice group was fabricated and cured and is awaiting machining. The final flange has been layed up and vacuum bagged for an autoclave cure.

2.7 LH2 Tank Domes

BTA was placed on the inside of the aluminum dome tool to allow for the installation of an internal vacuum bag that will eliminate the leak paths through the welds in the tool. The first composite dome was fabricated, cured, and delivered. NASA/McDonnell Douglas was pleased with the quality of first dome. The second dome was layed-up and placed in the freezer to wait for further instructions concerning the layup of the build-up ring.

3.0 RECOMMENDATIONS

Renewal of the PATRAN contract is crucial to the continued operation of the FPM. Without a surface development package, complex parts or cylinders can not be fabricated. The renewal price is $6800 and is due on May 1, 1995.

Tape Placement Machine software should be moved from the VAX to the SGI. This will provide a uniform platform for code development for both machines.

These items will be discussed in detail with the COTR during March 1995 and appropriate actions will be taken.

4.0 UPCOMING WORK TO BE PERFORMED

The following is a list of upcoming work to be accomplished in March.

Table 1

Priority	TD	Application	Work Activity
High	FPM-01	Ablative Chambers	Continue fabricating ablative chambers
Med	FPM-02	Assorted Panels	Fabricate specimens from panels already made.
Low	FPM-03	Hydrogen Tank	On Hold
Med	FPM-04	18" C/E Vessels	Fabricate sand mandrels and start winding vessels
High	FPM-05	Cryogenic Feed Line	Complete machining of parts and write final report.
Low	FPM-06	Cryo shock Test	On Hold
High	FPM-07	Composite Dome	Layup remaining composite domes and panels.
High	FPM-08	Honeycomb Specimens (Intertank)	Fabricate panels and assemble test specimens.
Low	FPM-09	Isogrid Cylinder	Start development work.
Low	FPM-10	Honeycomb Specimens (CDDF)	Start engineering. Lay-down material in April.
Low	FPM-11	Full Scale Ablative Chamber	Procure remaining materials.
Low	FPM-12	Intertank structure	NASA submit TD

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Program Manager

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Thiokol Space Operations
Huntsville Office
6767 Old Madison Pike, NW Suite 490
Huntsville, AL 35806

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Report describes technical problems, recommendations, and planned work for the next month.

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT MARCH 1995

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for March 1995. The following paragraphs summarize the significant accomplishments during the work period beginning in March, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in April 1995.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

Technical Directives FPM-12, FPM-13, and FPM-14 were received. Cost proposals are being prepared and will be submitted during the April reporting period.

2.1 MACHINE OPERATIONS

Two new compaction rollers with a Teflon bonded outer surface were received from Cincinnati Milacron (CM). The rollers had two different hardness values, 30 and 40 durometer rating. The Cut-Clamp-Restart (CCR) mechanism for the FPM head is still at CM waiting for authorization to proceed the repairs. Talks continued with CM and other vendors for a repair/replacement electrical cable carrier system for the Z-axis. Information and pricing for CM's ACEs software and Dassault's CATIA software have been requested. These items will be discussed in detail with the COTR during March 1995 and appropriate actions will be taken.

2.2 TD FPM-01, ABLATIVE COMBUSTION CHAMBERS (ACC)

Bonded ACC Liner #3 into canister for high pressure test. Drilled pressure and ignitor ports in ACC Liner #3. Assembly is ready to be picked up.

Machined OD & length of ACC Liner #4.

Silica Shell Liner #5 was cured and overwrapped with fiberglass epoxy. The part was bagged and cured. Machined OD & length of ACC Liner #5.

Silica Shell Liner #6 was tape wrapped/cured then overwrapped with fiberglass epoxy. Machined OD & length of ACC Liner #6.

2.3 TD FPM-02, ASSORTED COMPOSITE TAPE LAYED PANELS

Two sets of practice specimens were prepared and the tab bonding and machining techniques were tested. The samples were pulled in the Building 4707 MTS machine.

2.4 TD FPM-03, COMPOSITE HYDROGEN DEMONSTRATION TANK

The large 37" tank is still on hold until a pole boss concept is developed.

2.5 TD FPM-04, 18" X 20" PRESSURE VESSELS

No activity. Waiting for results of Frank Ledbetter's cure study before proceeding with the fabrication of the mandrels. All the 5.75"x12" bottles have been test. We are waiting for the results to be compiled.

2.6 TD FPM-05, LH2 FEEDLINE COMPONENTS

The remaining splice rings were machined to length and four holes for injection were placed ½" from each end, 90 degrees apart. The remaining three 45° elbows were machined and delivered to NASA for NDE. The legs of the 45° elbows that mate with the Liquid to Gas Conversion (LGC) turbopump inlet were left long to compensate for proper alignment when the full feedline is bonded. Flanges #8 and #9 were also delivered to NASA for NDE. Flange #10 was layed-up and cured. During the cure the autoclave lost vacuum, causing NASA EH35 personnel to terminate the cure. NASA decided that due to the point in the cure cycle when vacuum was lost, another flange needed to be fabricated. The additional flange, Flange #11, was layed-up, cured, machined, and delivered to EH35 personnel. The cure cycles for all of the oven-cured parts were converted from Molygraphics files into Excel 5.0 format. Thiokol will store this information for reference. Semco kits were received and delivered to NASA EH35 personnel in preparation for feedline assembly bonding. The alignment fixture was also received and delivered to the bonding lab. A rough draft of the composite feedline report on the component production is under review.

2.7 TD FPM-07 LH2 Tank Domes

Started fabrication of the first test panel. NASA/McDonnell Douglas have been notified that we will run out of fabric before completion of the first panel. McDonnell Douglas has promised to ship more fabric after the results of their fullscale tank have been reviewed.

2.8 TD FPM-11 Phase I of Full Scale Ablative Chamber Fabrication

The silica/phenolic tape for the tape wrap machine has been ordered and should be received in April. A computer model of the chamber was electronically transferred to Bill Prescott for structural and thermal analysis. The result of this analysis will be use to determine liner thickness and overwrap parameters.

3.0 RECOMMENDATIONS

Renewal of the PATRAN contract is crucial to the continued operation of the FPM. Without a surface development package, no complex parts or cylinders can be fabricated. The renewal price is $6,800 and is due on May 1, 1995.

Tape Placement Machine software should be moved from the VAX to the SGI. This will provide a uniform platform for code development for both machines.

These items will be discussed again in detail with the COTR during April 1995 and appropriate actions will be taken.

4.0 UPCOMING WORK TO BE PERFORMED

The following is a list of upcoming work to be accomplished in April.

Table 1

Priority	TD	Application	Work Activity
High	FPM-01	Ablative Chambers	Continue fabricating ablative chambers
Med	FPM-02	Assorted Panels	Fabricate specimens from panels already made.
Low	FPM-03	Hydrogen Tank	On Hold
Med	FPM-04	18" C/E Vessels	Fabricate sand mandrels and start winding vessels
High	FPM-05	Cryogenic Feed Line	Complete machining of parts and write final report.
Low	FPM-06	Cryo shock Test	On Hold
High	FPM-07	Composite Dome	Layup remaining composite domes and panels.
High	FPM-08	Honeycomb Specimens (Intertank)	Fabricate panels and assemble test specimens.
Low	FPM-09	Isogrid Cylinder	Start preliminary development work.
Low	FPM-10	Honeycomb Specimens (CDDF)	Start engineering. Lay-down material in late April.
Low	FPM-11	Full Scale Ablative Chamber	Procure remaining materials.
High	FPM-12	Intertank structure	Submit proposal
Med.	FPM-13	Non-autoclave Panels	Submit proposal
Med.	FPM-14	Advanced Structural Panels	Submit proposal

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L.I. Pelham
Program Manager

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Thiokol Space Operations
Huntsville Office
6767 Old Madison Pike, NW Suite 490
Huntsville, AL 35806

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT APRIL 1995

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for April 1995. The following paragraphs summarize the significant accomplishments during the work period beginning in April, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in May 1995.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

Proposals were submitted in response to Technical Directives FPM-12, -13, -14, and 01R1. Based on conversations with the MSFC COTR and Contract Specialist, we understand that MSFC will likely negotiate/definitize only Technical Directives FPM-12 and FPM-01R1.

2.1 MACHINE OPERATIONS

The Cut-Clamp-Restart (CCR) mechanism for the FPM head is still at CM waiting for authorization to proceed the repairs. The PATRAN license has expired. Complex parts and cylinder surface models will have to be programmed by an outside source, possibly Utah Thiokol or at Cincinnati Milacron. These items will be discussed in detail with the COTR during May 1995 and appropriate actions will be taken.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01, ABLATIVE COMBUSTION CHAMBERS (ACC)

The #6 ablative combustion chamber was completed and removed from the mandrel. An Aerojet combustion chamber was machined for installation of a copper ring/insert. After the ring was installed, it was sent to the test stand for test. During the test the copper ring was expelled from the chamber, the silica/phenolic was eroded to the canister, and the stainless steel was eroded about 3/4-inch around most of the forward end of the canister. All work is on hold until the Propulsion Lab has a chance to evaluate the injector anomaly.

TD FPM-02, ASSORTED COMPOSITE TAPE LAYED PANELS

Twelve practice test specimens were prepared for testing. Test Panels A3, B3, A4 and B4 are being prepared for machining.

TD FPM-03, COMPOSITE HYDROGEN DEMONSTRATION TANK

The large 37" tank is still on hold until a pole boss concept is developed.

TD FPM-04, 18" X 20" PRESSURE VESSELS

The 5.75" x 12" PV testing is complete. The most consistent burst values were obtained on the bottles that were rotisserie cured and vacuum bagged at the higher temperature.

Thiokol technicians tried to fabricate a sodium silicate/sand mandrel with the 18" x 20" dome mold. The dome section stuck inside the mold and was destroyed while trying to free it from the mold. There still appears to be an undercut in the mold. B&K Manufacturing will be contacted to correct the problem.

TD FPM-05, LH2 FEEDLINE COMPONENTS

Fixtures were fabricated to ensure proper location of holes in base of the flanges. Holes were then machined in the base of the flanges. The holes were placed in the titanium reducer as well as the splice rings.

Remaining work on the composite feedline project includes drilling holes in more of the splice rings as well as machining the full bonded assembly. Due to delay, the first full bonded assembly may not be completed until the first week of May. Further machining will then be required.

TD FPM-07 LH2 Tank Domes

Prepreg fabric should arrive from McDonnell Douglas in mid-May and four (4) more half tank domes will be fabricated. Some cloth-cloth panels may also be fabricated.

TD FPM-08 Fabrication of Composite Honeycomb Test Specimens

Three (3) honeycomb and two (2) flat panels were fabricated and cured. The panels were rough cut and are being machined into specimens. Test specimens 1, 3, 5, 19, 23 and 25 were delivered to NASA on May 1. The remaining specimens will be completed in May.

TD FPM-09 Development/Fabrication of Advanced Composite Isogrid

Preliminary concept definition/design being performed.

TD FPM-10 Fabrication of Tape-Layed Honeycomb Test Specimens

Manpower planning charts were developed and initial panel layouts were prepared. A kickoff meeting was held with Jeff Finckenor and Bill McMahon to review all aspects of the projects before starting.

TD FPM-11 Phase I of Full Scale Ablative Chamber Fabrication

Silica phenolic has been received. The overwrap material, adhesive film, and primer will be order pending the results of an analysis that is currently being performed.

3.0 RECOMMENDATIONS

It is recommended that PATRAN be purchased. The PATRAN license has expired. Compiex parts and cylinder surface models will have to be programmed in Utah or at Cincinnati Milacron.

Also, the repair of the Cut, Clamp, and Restart (CCR) Mechanism is on hold pending additional funding for the base contract.

Tape Placement Machine software should be moved from the VAX to the SGI. This will provide a uniform platform for code development for both machines.

These items will be discussed again in detail with the COTR during May 1995 and appropriate actions will be taken.

4.0 UPCOMING WORK TO BE PERFORMED

The following is a list of upcoming work to be accomplished in May.

Table 1

Priority	TD	Application	Work Activity
High	FPM-01	Ablative Chambers	Revise TD for additional work.
Med	FPM-02	Assorted Panels	Machine specimens from panels already made.
Low	FPM-03	Hydrogen Tank	On Hold
Med	FPM-04	18° C/E Vessels	Fabricate sand mandrels and start winding vessels
High	FPM-05	Cryogenic Feed Line	Complete machining of parts and write final report.
Low	FPM-06	Cryo shock Test	On Hold
High	FPM-07	Composite Dome	When material is received from McDonnell Douglas layup remaining composite domes and panels.
High	FPM-08	Honeycomb Specimens (Intertank)	Bond and machine remaining test specimens.
Low	FPM-09	Isogrid Cylinder	Start developing tooling.
Low	FPM-10	Honeycomb Specimens (CDDF)	Design panel layouts, program TPM and fabricate panels
Low	FPM-11	Full Scale Ablative Chamber	Procure remaining materials and wait for tooling.
High	FPM-12	Intertank structure	Order honeycomb and adhesive

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Program Manager

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Thiokol Space Operations
Huntsville Office
6767 Old Madison Pike, Suite 490
Huntsville, AL 35806

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT MAY 1995

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for May 1995. The following paragraphs summarize the significant accomplishments during the work period beginning in May, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in June 1995.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

2.1 MACHINE OPERATIONS

The Cut-Clamp-Restart (CCR) mechanism for the Fiber Placement Head was rebuilt and received. The PATRAN software license was extended to June 15, 1995. A purchase request for PATRAN 1.2-1 has been submitted. These items will be discussed in detail with the COTR during May 1995 and appropriate actions will be taken.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01, ABLATIVE COMBUSTION CHAMBERS (ACC)

All work is on hold until the Propulsion Lab evaluates the injector anomaly.

TD FPM-02, ASSORTED COMPOSITE TAPE LAYED PANELS

The following specimens will be fabricated.

- 0 degree tensile specimens with tapered tabs (9" 0.5")
- 90 degree tensile specimens with no tabs (10"x 1")
- crossply tensile specimens with no tabs (10"x 1")
- 0 degree compression tabs (5.5"x.25") with no taper on the tabs
- 90 degree compression specimens with no tabs

Rough cutting of the panels has begun. Tabs sheets will be bonded to the rough cut panels and specimens fabricated from the bonded panels.

TD FPM-03, COMPOSITE HYDROGEN DEMONSTRATION TANK

This program is waiting on a pole boss concept to be developed by ED52.

TD FPM-04, 18" X 20" PRESSURE VESSELS

Considerable effort was expended resolving problems with the mold. It appears that the problem has been resolved and the mold can be used for sand mandrel fabrication.

TD FPM-05, LH2 FEEDLINE COMPONENTS

The prototype feedline was machined. The final report, to be submitted soon, will include photographs of prototype feedline assembly.

TD FPM-07 LH2 Tank Domes

The prepreg fabric hasn't arrived from McDonnell Douglas. This program is on hold until fabric is received.

TD FPM-08 Fabrication of Composite Honeycomb Test Specimens

Small holes were drilled in the u-channel tabs to allow injection of the adhesive material into the annular space. Special techniques were developed to bond the splices to the sandwich composite specimens. This technique involved making small buttons of adhesive the height of the desired bondline and letting them cure. Later the adhesive is applied to the surface with the buttons and the splice panels were clamped on and splice panels pressed on pushing the excess material out until the panels touches the button stops.

All samples were completed, delivered to NASA/MSFC and the project has been closed out. Unfortunately, the project overran its estimated budget. Training and inaccurate estimates for specimen bonding and machining were the main reasons for the overrun.

TD FPM-09 Development/Fabrication of Advanced Composite Isogrid

Preliminary work being performed--reviewing reports of previous similar work.

TD FPM-10 Fabrication of Tape-Layed Honeycomb Test Specimens

Discussions were held with NASA/MSFC about the use of metal inserts versus bonding metal tabs. Panel layouts were prepared and process planning paperwork is being developed. A sample sandwich specimen was prepared and cured at an elevated pressure cure (150 psi). The graphite/epoxy prepreg was embedded into the honeycomb core and the sides of the honeycomb were pushed in. Another test will be run at a lower pressure to determine the optimum autoclave pressures for curing composites with a honeycomb core.

TD FPM-11 Phase I of Full Scale Ablative Chamber Material

The remaining materials, adhesive film and primer, were ordered and should be received in June. The overwrap material, graphite/epoxy will be order later to replace what will be use from inventory.

3.0 RECOMMENDATIONS

It is recommended that PATRAN be purchased. The PATRAN license has expired. Complex parts and cylinder surface models will have to be programmed in Utah or at Cincinnati Milacron.

Tape Placement Machine software should be moved from the VAX to the SGI. This will provide a uniform platform for code development for both machines.

These items will be discussed again in detail with the COTR during June 1995 and appropriate actions will be taken.

4.0 UPCOMING WORK TO BE PERFORMED

The following is a list of upcoming work to be accomplished in June.

Table 1

Priority	TD	Application	Work Activity
High	FPM-01	Ablative Chambers	Revise TD for additional work.
Med	FPM-02	Assorted Panels	Machine specimens from panels already made.
Low	FPM-03	Hydrogen Tank	On Hold
Med	FPM-04	18" C/E Vessels	Fabricate sand mandrels and start winding vessels
High	FPM-05	Cryogenic Feed Line	Publish and present final report.
Low	FPM-06	Cryo shock Test	On Hold
High	FPM-07	Composite Dome	When material is received from McDonnell Douglas layup remaining composite domes and panels.
High	FPM-08	Honeycomb Specimens (Intertank)	Completed
Low	FPM-09	Isogrid Cylinder	Start developing tooling.
Low	FPM-10	Honeycomb Specimens (CDDF)	Design panel layouts, program TLM and fabricate panels
Low	FPM-11	Full Scale Ablative Chamber	Procure remaining materials and wait for tooling.
High	FPM-12	Intertank structure	Receive honeycomb and start programming TLM

Approved by:

L.I. Pelham
Program Manager

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Larry I. Pelham

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Thiokol Space Operations
Huntsville Office
6767 Old Madison Pike, Suite 490
Huntsville, AL 35806

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Report describes technical problems, recommendations, and planned work for the next month.

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT JUNE 1995

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for June 1995. The following paragraphs summarize the significant accomplishments during the work period beginning in June, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in July 1995.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

Technical Directive FPM-16, Fabrication of Composite Debris Shielding, and FPM-17, Fabrication of Composite Cryotank Test Specimens, were reviewed. Cost plus fixed fee proposals will be prepared and submitted this month.

Supplemental Agreement 06 to the contract was executed, definitizing and authorizing Technical Directive FPM-12, Fabrication of Composite Intertank. Also, received contract modification 06, adding $93,000 in additional contract funding.

2.1 MACHINE OPERATIONS

A new 2GB hard drive was installed in Fiber Placement Offline Programming Workstation (Silicon Graphics - SGVIPER). The hard drive will provide the additional space required to load PATRAN on SGVIPER. PATRAN was ordered and should be received this month.

The Cut, Clamp, Restart Module (CCRM) was received from Cincinnati Milacron on June 2 and was reinstalled on the fiber placement head. It will be checked out this month.

COMPOSITE DATABASE TEST SPECIMENS

A 3' x 3' panel was fabricated to produce specimens for a static strength characteristics of mechanically-fastened composite joint study. It was fabricated from 12-inch wide Hercules IM6/3501-6 tape. The panel was 32 plies thick containing layers of 0°, +45°, 90° and -45°. Autoclave cure of the panel followed the manufacturer's suggested cure cycle. 126 specimens were cut from this panel. All specimens were delivered to MSFC.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01, ABLATIVE COMBUSTION CHAMBERS (FASTRACK)

Bonded and delivered a combustion chamber to the test stand for Propulsion Lab to test the new injector design. The new injector performed better than the previous one but still caused several gouges due to holes in the fuel injector plate not being parallel with the liner inside surface. The injector will be reworked and the combustion chamber will be patched with "Havaflex" and retested later this month.

TD FPM-02, ASSORTED COMPOSITE TAPE LAYED PANELS

The last remaining specimens were machined and delivered to MSFC. This project is complete.

TD FPM-03, COMPOSITE HYDROGEN DEMONSTRATION TANK

This project is on hold and will probably be revised to accommodate the composite dome required cryostat tests.

TD FPM-04, 18" X 20" PRESSURE VESSELS

Used Elkton Division's sodium silicate/sand mandrel process to fabricated five mandrels. The mandrels were removed from the molds without any problems. The mandrels will be insulated before winding.

TD FPM-05, LH2 FEEDLINE COMPONENTS

Holes were drilled in splice rings to be used for the display article. A group photograph was taken of all personnel who worked on the feedline. We will machine the end of the display article in July. Submission of the feedline report will complete our responsibilities.

TD FPM-07 LH2 TANK DOMES

Prepreg fabric was received from McDonnell Douglas. Panel plies were cut out of the prepreg fabric. One panel set was autoclave cured on June 30.

TD FPM-08 FABRICATION OF COMPOSITE HONEYCOMB TEST SPECIMENS

Aluminum U-channels were machined and small holes drilled in the tops of the channel to allow resin to be injected. The U-channels were then bonded to the specimens. All remaining specimens were delivered to MSFC. This project is complete.

TD FPM-09 DEVELOPMENT/FABRICATION OF ADVANCED COMPOSITE ISOGRID

Preliminary work being performed: reviewing reports of previous similar work.

TD FPM-10 FABRICATION OF TAPE-LAYED HONEYCOMB TEST SPECIMENS

The specimen panels were divided into three distinct groups: 1) Hand layup panels. 2) Tape layed laminate panels, and 3) Tape layed honeycomb panels. One exception is the laminate panels that include the imbedded fiber optic strain gauges. They will be fabricated separately.

The first set of laminate panels using the IM7/F655 composite tape were programmed, tape layed, and cured (Panels 12, 13_B, 31, 37, 43, 49, 30, 36, 42 and 48). The thick specimens (3" wide) did not have dams placed on edges and rolled off edges. These specimens may have to be re-fabricated using dams if the center sections are not flat.

MSFC agreed that other materials could be used in the tab areas for clamping. Carbon Phenolic material is available and will be fabricated into a large thick sheet from which specimens can be cut.

An autoclave/honeycomb test panel was cured to evaluate autoclave pressure on aluminum honeycomb and composite. The honeycomb did not collapse but the sides were pushed in (dams were not locked) and the aluminum honeycomb cut completely through the prepreg composite. There was significant dimpling. The autoclave pressure, if used will need to be held to a minimum level so dimpling is not significant and there is no damage to the composite.

TD FPM-11 PHASE I OF FULL SCALE ABLATIVE CHAMBER MATERIAL

The remaining materials, adhesive film and primer, have been received. The overwrap material, graphite/epoxy, will be ordered later.

TD FPM-12 INTERTANK STRUCTURE (SSTO)

The project was authorized. The honeycomb core material will be ordered this month. NASA is expecting to take delivery of the composite tapelaying tool this month.

3.0 RECOMMENDATIONS

It is still recommended that the Tape Placement Machine software be moved from the VAX to the SGI. This will provide a uniform platform for code development for both machines.

This item will be discussed again in detail with the COTR during July 1995 and appropriate action will be taken.

4.0 UPCOMING WORK TO BE PERFORMED

The following is a list of upcoming work to be accomplished in June.

Table 1

Priority	TD	Application	Work Activity
High	FPM-01	Ablative Chambers	Instrument Chamber for Test.
Med	FPM-02	Assorted Panels	Completed
Low	FPM-03	Hydrogen Tank	On Hold
Med	FPM-04	18" C/E Vessels	Fabricate sand mandrels and start winding vessels
High	FPM-05	Cryogenic Feed Line	Publish and present final report.
Low	FPM-06	Cryo shock Test	On Hold
High	FPM-07	Composite Dome	Fabricate cloth /cloth specimens.
High	FPM-08	Honeycomb Specimens (Intertank)	Completed
Low	FPM-09	Isogrid Cylinder	Start developing tooling.
Low	FPM-10	Honeycomb Specimens (CDDF)	Continue to fabricate panels
Low	FPM-11	Full Scale Ablative Chamber	Procure remaining materials.
High	FPM-12	Intertank structure	Receive honeycomb and start programming TLM

Approved by:

L.I. Pelham
Program Manager

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Larry I. Pelham

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Thiokol Space Operations
Huntsville Office
6767 Old Madison Pike, Suite 490
Huntsville, AL 35806

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Report describes technical problems, recommendations, and planned work for the next month.

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT JULY 1995

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for July 1995. The following paragraphs summarize the significant accomplishments during the work period beginning in July, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in August 1995.

2. SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

2.1 MACHINE OPERATIONS

PATRAN was received and loaded on July 10. The NETLS sitelock was received and loaded on July 18. PATRAN is fully operational on SGVIPER at this time.

The SGVIPER operating system was upgraded from IRIX 5.2 to IRIX 5.3. A small problem was encountered when trying to run the sim module of the fiber placement offline programming system (FPOPS) software. Cincinnati Milacron made some minor changes to the sim source and recompiled the code. The new module was loaded on SGVIPER and is operational.

An IP address was issued for the PC attached to the Tape-laying machine that is connected to the NASA network. Also, an anonymous File Transfer Protocol (FTP) account was set up on MSFC_PELAN so the tape-laying programs could be downloaded from VAXHST to MSFC_PELAN and then to the Tape-laying PC.

COMPOSITE JOINTS TEST SPECIMENS

The remainder of the specimens, Phases A-F and M-R, were delivered to MSFC. The low variation on the test results indicates that the specimens were of a very high quality.

RLV COMPOSITE TEST SPECIMENS

The base contract was funded to support operation of the Fiber Placement Machine to fabricate RLV parts for NASA/Lockheed-Martin.

A 12" x 14" test panel (designated LM Panel #1) was fiber placed using available IM7/8552 towpreg to test out the FPM operation. Two panels were fabricated for NASA/Lockheed-Martin. The first panel was a 39" x 37" panel (designated LM Panel #2) which was fiber placed using 977-2 towpreg material. The panel was 10 plies thick and had the following layup $[0]_{10}$. The second panel was a 25" x 25" panel (designated LM Panel #3) and was fiber placed using 977-2 towpreg material. The panel was 10 plies thick and had the following layup $[+45,-45]_5$. Job records for three more panels have been received from NASA/Lockheed-Martin along with a proposed schedule.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01, ABLATIVE COMBUSTION CHAMBERS (FASTRACK)

Waiting for Propulsion Lab to modify the new injector.

TD FPM-02, ASSORTED COMPOSITE TAPE LAYED PANELS

This project is complete.

TD FPM-03, COMPOSITE HYDROGEN DEMONSTRATION TANK

Technical evaluation of project scope underway.

TD FPM-04, 18" X 20" PRESSURE VESSELS

No activity to report.

TD FPM-05, LH2 FEEDLINE COMPONENTS

Submission of the feedline report and machining the display article will complete our responsibilities for this project.

TD FPM-07, LH2 TANK DOMES

Four large and six small panels were fabricated and cured by MSFC and Thiokol personnel. The large panels were tabbed and machined into 2" x 24" specimens. The small panels were machined into 4" x 4" specimens. A total of 36 - 3" x 24" and 24 4" x 4" specimens were delivered to MSFC for shipping to McDonnell Douglas in California.

TD FPM-08, FABRICATION OF COMPOSITE HONEYCOMB TEST SPECIMENS

This project is complete

TD FPM-09 DEVELOPMENT/FABRICATION OF ADVANCED COMPOSITE ISOGRID

Fabrication on hold until January 1996, reviewing reports of previous similar work.

TD FPM-10, FABRICATION OF TAPE-LAYED HONEYCOMB TEST SPECIMENS

Ten panels were fabricated. These include six AS4/3501-6 tape layed panels and four AS4/3501-6 hand layed panels.

The AE and AF specimens from the AS4/3501-6 and IM7/BMI panels were rough cut and tabbed (panels 34, 40, 41, 42, 43, 47, 48 and 49). The specimens will be final machined and delivered in August.

During the cure of the 3-inch wide uni-panel the edges were significantly rounded creating a crown on the sample. On the next 3-inch wide uni-panel a 0.25" silicone dam material was placed along the edge to keep the vacuum bag from rounding the edge. Future uni-panels will be fabricated with a minimum of 6-inches wide to reduce the tendency of the panel to crown in the center.

Drawings were prepared for a thick sheet of carbon/phenolic (C/P) material. The C/P will be used instead of the aluminum as an insert material on the ends of the sandwich composite specimens. The C/P will be bonded into the sandwich structure to allow a place to grip the specimens. One of the panels will still require an aluminum U-channel insert.

TD FPM-11. PHASE I OF FULL SCALE ABLATIVE CHAMBER MATERIAL

*The remaining materials, adhesive film and primer, have been received. The overwrap material, graphite/epoxy will be ordered later to replace what will be used from inventory.

TD FPM-12, INTERTANK STRUCTURE (SSTO)

The materials have been ordered and received for the intertank project. The Airtech composite tool was received in late July. Materials received include:

-3M Scotch Weld 3439 HS AF structural void filling compound
-3M AF-3002 expanding adhesive.

3.0 RECOMMENDATIONS

Currently there is no funding available for the continuing maintenance of the FPM. Required machine maintenance items include: drive boards, fuses, tow sensors and software maintenance/upgrades (will come due October 95). The cable carrier needs to be replaced.

It is recommended that the Tape Placement Machine software be moved from the VAX to the SGI. This will provide a uniform platform for code development for both machines.

These items will be discussed again in detail with the COTR during August 1995 and appropriate actions will be taken.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

The following is a list of upcoming work to be accomplished in August.

Table 1

Priority	TD	Application	Work Activity
High	FPM-01	Ablative Chambers	Instrument Chamber for Test
	FPM-02	Assorted Panels	Completed
Med	FPM-03	Hydrogen Tank	Fabricate one 5.75 x 12 Pressure Vessel for Leak Test
Med	FPM-04	18" C/E Vessels	Fabricate sand mandrels and start winding vessels
Med	FPM-05	Cryogenic Feed Line	Publish and present final report
Low	FPM-06	Cryo shock Test	On Hold
High	FPM-07	Composite Dome	Fabricate cloth/cloth specimens
	FPM-08	Honeycomb Specimens (Intertank)	Completed
	FPM-09	Isogrid Cylinder	On Hold until January 1996
Low	FPM-10	Honeycomb Specimens (CDDF)	Continue to fabricate panels
Low	FPM-11	Full Scale Ablative Chamber	Procure remaining materials
High	FPM-12	Intertank structure	Receive honeycomb and start programming TLM

4.2 SUBMITTED PROPOSALS AND ROMS

TD FPM-16, RUSSIAN DEBRIS SHIELD AND TUBES

A proposal for this effort was prepared and submitted to MSFC.

TD FPM-17, SSTO TANKS, STIFFENERS AND SPECIMENS

Proposals for Phase I and Phase II efforts were prepared and submitted to MSFC.

Approved by: Wayne Tucker for

L. I. Pelham
Program Manager

July 1995 | Monthly Technical Progress Report

July Monthly Technical Progress Report on
Operation/Maintenance of Fiber Placement Machine.

NAS8-39749

Larry I. Pelham

Thiokol Space Operations
Huntsville Office
6767 Old Madison Pike, Suite 490
Huntsville, AL 35806

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Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

NASA - See Handbook NHB2200.2

Report describes technical problems, recommendations, and planned work for the next month.

Fiber Placement

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT AUGUST 1995

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for August 1995. The following paragraphs summarize the significant accomplishments during the work period beginning in August, discusses recommendations for MSFC consideration. and lists upcoming work to be performed in September 1995.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

Technical Directive No. FPM-18, Fabrication of Composite Cryo-Test Pressure Vessels. was received. A proposal for this effort will be developed and submitted during September 1995.

2.1 MACHINE OPERATIONS

The Thiokol-owned SDRC I-Deas software was loaded on SGVIPER (NASA/MSFC Silicon Graphics Workstation) and is operational. The PATRAN PCL menus were moved from SGPAT to SGVIPER and are operational. A patch renumbering program was generated using the UNIX awk utility and is still being debugged.

New air filters for the creel cooler were ordered. received and installed

RLV COMPOSITE TEST SPECIMENS

Eight (8) panels were fabricated for the RLV program. The panels are listed below:

LM_Panel #4 - 39" x 37" (11 ply. IM7/8552 $[0]_{HO}$)
LM_Panel #5 - 25" x 25" (12 ply, IM7/8552 [45,-45,45,-45,45,-45]s)
LM_Panel #6 - 25" x 25" (12 ply, IM7/977-2 [45,-45,45,-45,45,-45]s)
LM_Panel #7 - 16" x 24" (45 ply, IM7/977-2 $[0,45,90,-45,0,-45,90,45,0]_S$)
LM_Panel #8 - 17" x 25" (45 ply, IM7/977-2 $[0,45,90,-45,0,-45,90,45,0]_S$)
LM_Panel #9 - 17" x 25" (45 ply, IM7/8552 $[0,45,90,-45,0,-45,90,45,0]_S$)
LM_Panel #10 - 17" x 25" (45 ply, IM7/8552 $[0,45,90,-45,0,-45,90,45,0]_S$)
LM_Panel #11 - 17" x 25" (45 ply, IM7/8552 $[0,45,90,-45,0,-45,90,45,0]_S$)

Preliminary work has begun in developing a 36" diameter fiber placeable cryogenic tank. The concept tank will have cone shaped ends with a pole boss flush to the outer surface to allow fiber placement. Initial studies show that the tank can be fiber placed. Unfortunately. full coverage of the tank using the FPOPS pgen module has problems. CM will be contacted to determine if the pgen module can be fixed or other variables can be tuned to allow the surface to be covered compietely.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01, ABLATIVE COMBUSTION CHAMBERS (FASTRACK)

Two of the fired chambers were sectioned and are being examined by NASA M&P to evaluate the char depth in support of the X34 design.

TD FPM-03, COMPOSITE HYDROGEN DEMONSTRATION TANK

This project is still on hold and may be revised to accommodate the composite dome for ED52's cryostat tests

TD FPM-04, 18" X 20" PRESSURE VESSELS

Designed and submitted for fabrication the handling cart for the sand mandrel molds. It will be used to load the molds into the oven and also remove the hot molds from the oven. Its design will allow for simpler demolding of the sand mandrel as well. Ordered and received five gallons (minimum order) of TETA curing agent. This curing agent is combined with epoxy resin to bond the sand mandrel components together. Bonded first two sand mandrels together and in process of laying up the NBR rubber on the first one.

TD FPM-05, LH2 FEEDLINE COMPONENTS

No significant activity to report.

TD FPM-07 LH2 TANK DOMES

Three panels were fabricated. Specimen fabrication is on hold until more tab material is available (it is on order).

TD FPM-09 DEVELOPMENT/FABRICATION OF ADVANCED COMPOSITE ISOGRID

Fabrication on hold until January 1996, reviewing reports of previous similar work.

TD FPM-10 FABRICATION OF TAPE-LAYED HONEYCOMB TEST SPECIMENS

Completed panels 33 and 45 of the IM7/8551-7 series of panels. The 8" x 1" specimens were machined and had tabs bonded onto them. The 1" x 0.75" specimens were also machined. These samples were delivered to Jeff Finckenor, ED52. Two carbon/phenolic panels were fabricated by the Material Testing and Processing group. These will be used in fabrication of the 3" wide honeycomb specimens.

TD FPM-11 PHASE I OF FULL SCALE ABLATIVE CHAMBER MATERIALS

Support stands were design and fabricated. These stands will be used to provide additional support to the mandrel while it is in the machine.

TD FPM-12 INTERTANK STRUCTURE (SSTO)

Conducted a test to determine the amount the adhesive (3M AF 3024) expands into the honeycomb core when cured. The test consisted of having one, two or three plies sandwiching the honeycomb core material. Upon oven cure, the block with three plies on top and bottom only filled 0.252 inches from each surface with less expansion for the one and two ply structures. Before fabrication of the actual panel, a trial skin drape forming will be performed to evaluate the formability of pre-layed, non-cured skin.

3.0 RECOMMENDATIONS

Currently, there is no funding available for the continuing maintenance of the FPM. Machine maintenance items include: drive boards, fuses, and tow sensors. The Cable Carrier needs to be replaced. Also, future software problem resolutions after September will be billable directly from Cincinnati Milacron. It is recommended that FUNDING be made available to lease the new Acraplace software. It is estimated that the software lease rate will run between $35k - $50k per year. This software will require development of a translator for generation of the surface model input, since it uses CATIA software running on an IBM RISC workstation.

It is still recommended that the Tape Placement Machine software be moved from the VAX to the SGI. This will provide a uniform platform for code development for both machines.

These items will be discussed again in detail with the COTR during September 1995 and appropriate actions will be taken.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

The following is a list of upcoming work to be accompliished in September.

Table 1

Priority	TD	Application	Work Activity
High	FPM-01	Ablative Chambers	Instrument Chamber for Test.
	FPM-02	Assorted Panels	Completed
Med	FPM-03	Hydrogen Tank	Fabricate one 5.75 x 12 Pressure Vessel for Leak Test
Med	FPM-04	18° C/E Vessels	Start winding vessels
Med	FPM-05	Cryogenic Feed Line	Publish and present final report.
	FPM-06	Cryo shock Test	Canceled
High	FPM-07	Composite Dome	Fabricate dome..
	FPM-08	Honeycomb Specimens (Intertank)	Completed
	FPM-09	Isogrid Cylinder	On Hold Until January 1996.
Low	FPM-10	Honeycomb Specimens (CDDF)	Continue to fabricate panels
Low	FPM-11	Full Scale Ablative Chamber	Procure any remaining materials.
High	FPM-12	Intertank structure	Receive honeycomb and start fabricating panels

4.2 SUBMITTED PROPOSALS AND ROMS

CRYO-TANK PRESSURE VESSELS

A two phase ROM was submitted to MSFC to fabricate twelve 5.75" x 12" bottles (Phase I) and twenty-eight 5.75" x 12" bottles (Phase II).

FIBER PLACED SUBSCALE INTERTANK AND PANELS

ROM Proposal was submitted to Jeff Finckenor to fiber place a honeycomb tank and flat panels.

Approved by:

L.L. Pelham
Program Manager

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Thiokol Space Operations
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6767 Old Madison Pike, Suite 490
Huntsville, AL 35806

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT SEPTEMBER 1995

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for September 1995. The following paragraphs summarize the significant accomplishments during the work period beginning in September, discusses recommendation for MSFC consideration, and lists upcoming work to be performed in October 1995.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

Received Technical Directive FPM-15, Analysis Sand Fabrication of X-34 Ablative Combustion Chamber; FPM-18, Fabrication of Composite Cryo-Test Pressure Vessels (CDDF); and FPM-19, Fabrication of Fiber-Placed Honeycomb Test Specimens (CDDF). A proposal was submitted for Technical Directive FPM-18.

Received full-executed Modification No. 08, exercising the GFY96 option and extending the period of performance through September 30, 1996. Modification No. 08 also authorized and definitized Technical Directives FPM-16 and FPM-17 (Phase I only). Received Modification No. 09, adding general contract funding.

2.1 MACHINE OPERATIONS

The fiber placement machine was hit by lightning on September 13, 1995. The power surge burned out three fuses and damaged the power supply to the X, K, and C drive boards. The power supply was sent to Cincinnati Milacron, repaired and shipped back; the FPM is now operational.

RLV COMPOSITE TEST SPECIMENS

Five panels were fabricated for the RLV program. The panels were generated per LM Job Record 7195 and are listed below.

LM_Panel #12 - 27" x 26" (8 ply, IM7/977-2 [0,+45,90,45]s)
LM_Panel #13 - 27" x 26" (8 ply, IM7/977-2 [0,+45,90,45]s)
LM_Panel #14 - 27" x 26" (8 ply, IM7/977-2 [0,+45,90,45]s)
LM_Panel #15 - 27" x 26" (8 ply, IM7/977-2 [0,+45,90,45]s)
LM_Panel #16 - 27" x 26" (8 ply, IM7/977-2 [0,+45,90,45]s)

Continued development work on the 36" diameter fiberplaced cryogenic tank. A point boundary for a zero degree ply was generated so the tank could be fabricated in two shells. Since pgen lays from point-to-point on the surface, a number of

points needed to be identified to create a smooth semicircle on the cone ends. Aa spreadsheet is being developed to identify points along the 45 degree path. The pole boss design changed again so half the plies are on top of the boss and half are below. We have received the new drawings and are creating the two new surfaces. A 48" x 72" flat plate was mounted to the flat mandrel to fabricate 39" x 39" panels. The existing flat panel mandrel was not large enough to accommodate the panels (42" x 130").

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01, ABLATIVE COMBUSTION CHAMBERS (FASTRAK)

One chamber was bonded into the stainless steel canister and is ready for test. The instrumented chamber thermocouple installation is proceeding on schedule and will be completed in early October.

TD FPM-03, COMPOSITE HYDROGEN DEMONSTRATION TANK

This project is still on hold and will probably be revised to accommodate the composite dome for ED52's cryostat tests.

TD FPM-04, 18" x 20" PRESSURE VESSELS

Designed a sand mandrel handling cart to safely handle the hot sand molds and a cure cart (TFWM003) that will facilitate the curing of the 18" x 20" pressure vessels in a Blue M oven. Two sand mandrels were fabricated with the NBR bladders and are ready to cure. One will be cured for pattern program check-out. The other will be co-cured with the pressure vessel.

TD FPM-05, LH2 FEEDLINE COMPONENTS

A draft of the final report is being reviewed.

TD FPM-07, LH2 TANK DOMES

The tab material arrived and the tabs were bonded to the three SSTO panels. One-half tank dome was fabricated and delivered. The dome included splice buildups in the cylinder section where the skirt will attach. This completes the work required for this TD.

TD FPM-09 DEVELOPMENT/FABRICATION OF ADVANCED COMPOSITE ISOGRID

Fabrication is on hold until January 1996; reviewing reports of previous similar work.

TD FPM-10 FABRICATION OF TAPE-LAYED HONEYCOMB TEST SPECIMENS

The BMI panels were autoclave cured. The oven-cured BMI panels still need to be cured and the remaining panels machined.

TD FPM-11 PHASE I OF FULL-SCALE ABLATIVE CHAMBER MATERIALS

Waiting for completion of the winding of the first chamber to assess how much fiber and resin will be required to complete the program.

TD FPM-12 INTERTANK STRUCTURE (SSTO)

The Composite Intertank tool arrived. The tool was cleaned up and checked out. A computer model of the tool surface was generated for programming the splice joints and intertank skins. Two 6-ply composite test panels were fabricated to validate the fabrication process.

3.0 RECOMMENDATIONS

A maintenance budget for the FPM is critical. Currently, there is no funding available for maintenance of the FPM. The recent power supply failure due to lightning strike is a good example of the types of problems that may be encountered in the future.

Cincinnati Milacron will no longer support the FPOPS software for the FPM. It is recommended that funding be made available to lease the new Acraplace software. It is estimated that the software lease will cost between $35k - $50k per year. Discussions have been held with Intergraph and Cincinnati Milacron about writing a translator from Microstation and/or EMS to the Fiber Placement Language (FPL) that is used by Acraplace.

These items will be discussed again in detail with the COTR during October 1995 and appropriate actions will be taken.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

The following is a list of upcoming work to be accomplished in October.

TABLE 1

PRIORITY	TD	APPLICATION	WORK ACTIVITY
High	FPM-01	Ablative chambers	Instrument chamber for test
	FPM-02	Assorted panels	Completed
Med	FPM-03	Hydrogen tank	On hold
Med	FPM-04	18" C/E vessels	Start winding vessels
Med	FPM-05	Cryogenic feedline	Publish and present final report
	FPM-06	Cryo shock test	Canceled
	FPM-07	Composite dome	Completed
	FPM-08	Honeycomb specimens (intertank)	Completed

TABLE 1			
PRIORITY	**TD**	**APPLICATION**	**WORK ACTIVITY**
Low	FPM-09	Isogrid cylinder	On hold until January 1996
Low	FPM-10	Honeycomb specimens (CDDF)	Continue to fabricate panels
Low	FPM-11	Full-scale ablative chamber	Procure any remaining materials
High	FPM-11	Intertank structure	Receive honeycomb and start fabricating panels
Med	FPM-12	Intertank structure	Receive honeycomb and start fabricating panels
High	FPM-16	Russian debris shield	Design tooling
High	FPM-17	Cryo dome and stiffeners	Fab panels and domes

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Program Manager

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Huntsville Office
6767 Old Madison Pike, Suite 490
Huntsville, AL 35806

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT OCTOBER 1995

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for October 1995. The following paragraphs summarize the significant accomplishments during the work period beginning in October, discusses recommendation for MSFC consideration, and lists upcoming work to be performed in November 1995.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

Proposal in response to Technical Directive FPM19, Fabrication of Fiber-Placed Honeycomb Test Specimens was submitted.

2.1 MACHINE OPERATIONS

RLV COMPOSITE TEST SPECIMENS

Six (6) panels were fabricated for the RLV program. The panels were generated per LM Job Record 7197 and 7200 and are listed below:

LM_Panel #19 - 42" x 40" (8 ply, IM7/977-2 [0,+45,90,-45]s)
LM_Panel #20 - 42" x 40" (24 ply, IM7/977-2 [0,+45,90,-45,-45,90,+45,0]3)
LM_Panel #21 - 37" x 36" (8 ply, IM7/977-2 [0,+45,90,-45]s)
LM_Panel #22 - 37" x 36" (8 ply, IM7/977-2 [0,+45,90,-45]s)
LM_Panel #23 - 37" x 36" (8 ply, IM7/977-2 [0,+45,90,-45]s)
LM_Panel #24 - 37" x 36" (8 ply, IM7/977-2 [0,+45,90,-45]s)

A 48"x 72" flat plate was mounted to the flat mandrel to fabricate the 42" x 40" panels. The existing flat panel mandrel (42" x 130") was not large enough to accommodate the panels.

Assistance was provided for design of the pole boss and mandrel shaft. The pole boss design changed so that half the plies are on top of the pole boss and half are below. Changes were also made to the mandrel to allow for tow drop offs in the bottom ply stack on the cylinder section. We received revised drawings and created the new surfaces. A menu in PATRAN was developed to generate solid model surfaces for each ply of the tank.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01, ABLATIVE COMBUSTION CHAMBERS (FASTRAK)

Thermocouples were installed in the instrumented chamber. The chamber was delivered to the CT Lab for scanning.

TD FPM-03, COMPOSITE HYDROGEN DEMONSTRATION TANK

This project is still on hold and will be revised to accommodate the composite dome for ED52's cryostat tests.

TD FPM-04, 18" x 20" PRESSURE VESSELS

The Sand Mandrel Handling Cart (TFWM002) was delivered October 10, 1995. The Cure Cart (TFWM003) will be delivered November 1, 1995. Sam Russell (MSFC/EH13) indicates that some of the pressure vessels need to be delivered in early November to facilitate testing schedules. Since PV's need to be fabricated by mid November and the horizontal winder is heavily scheduled, it was decided to use the polar winder to fabricate the PV's. Patterns have been developed to facilitate the fabrication of the required pressure vessels on the polar winding machine. An NBR bladder has been cured on the first sand mandrel. That mandrel was then used to check out the winding patterns that were developed for the polar winder.

TD FPM-05, LH2 FEEDLINE COMPONENTS

The final report is in final rewrite.

TD FPM-09 DEVELOPMENT/FABRICATION OF ADVANCED COMPOSITE ISOGRID

Fabrication is on hold until January 1996; reviewing reports of previous similar work.

TD FPM-10 FABRICATION OF TAPE-LAYED HONEYCOMB TEST SPECIMENS

The BMI panels were cured and then post-cured. The honeycomb specimens for samples AA-AB from panel #26, an IM7/8552 panel, have been delivered to the machine shop. The BMI panels for all of the 8" x 1" specimens were delivered to the machine shop.

TD FPM-11 PHASE I OF FULL-SCALE ABLATIVE CHAMBER MATERIALS

Based on the amount of materials used on the first chamber a bill of materials is being developed for the remaining two chambers.

TD FPM-12 INTERTANK STRUCTURE (SSTO)

Tape layed splice panels to optimize processing procedure. After these preliminary panels had identified optimal fabricating and bagging procedures, the two splice panels that will be used to make the splices were produced. The first panel is designated as Panel #1.02. Problems with the Despatch oven caused the second panel, Panel #2.00, to see an extended debulk at a temperature between 120° and 130°F prior to curing. Received honeycomb core for the intertank panels. Performed drape forming study using a practice skin.

TD FPM-16 SPACE STATION DEBRIS SHIELD

Initial development of the debris shield tube mandrel was performed. Fit tolerances are being evaluated based on thermal expansion of the mandrel and the thickness of the composite layup.

TD FPM-17 LH2 TANK DOMES & PANELS

The CJ5C specimens were completed and given to NASA to deliver to McDonnell Douglas. The CJ5M specimen panels were fabricated and the tabs bonded to the panels. A new technique was used to bond the tabs to the panels. FM300-2 film adhesive was used instead of EA9394 paste. The tabs were held on the panels using spring clamps. The panels and tabs were then cured for one hour at 250°F. There were places along the outer edge of the tab to film adhesive bondline where the film adhesive did not bond. A better clamping technique will need to be developed before bonding more panels. One of the tab strips moved during the cure and will need to be trimmed. Matched drilled holes will be placed through the tab; film adhesive and composite panel and pins will be placed prior to cure to ensure no movement of the tabs.

3.0 RECOMMENDATIONS

It is recommended that the new Acraplace software be leased. The software maintenance/lease rate will be $35k per year. It is also recommended that an IBM RISC station and CATIA CAD software be purchased as a front end to Acraplace.

These items will be discussed again in detail with the COTR during October 1995 and appropriate actions will be taken.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

The following is a list of upcoming work to be accomplished in November.

TABLE 1

PRIORITY	TD	APPLICATION	WORK ACTIVITY
High	FPM-01	Ablative chambers	Install instrument chamber for test
Med	FPM-03	Hydrogen tank	On hold
Med	FPM-04	18" C/E vessels	Continue winding vessels
Med	FPM-05	Cryogenic feedline	Publish and present final report
Low	FPM-09	Isogrid cylinder	On hold until January 1996
Low	FPM-10	Honeycomb specimens (CDDF)	Continue to fabricate & machine panels
Low	FPM-11	Full-scale ablative chamber	Procure any remaining materials
High	FPM-11	Intertank structure	Start fabricating panels
High	FPM-16	Space Station debris shield	Design tooling
High	FPM-17	Cryo dome and stiffeners	Fab panels and domes

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Program Manager

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Thiokol Space Operations
Huntsville Office
6767 Old Madison Pike, Suite 490
Huntsville, AL 35806

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT NOVEMBER 1995

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for November 1995. The following paragraphs summarize the significant accomplishments during the work period beginning in November, discusses recommendation for MSFC consideration, and lists upcoming work to be performed in December 1995.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

2.1 MACHINE OPERATIONS

While checking out a program, the FPM was found to be misaligned. The bolts holding the head to the wrist were checked and three of the four bolts were loose. All four bolts were retightened and four additional bolts were installed to secure the head (there are eight bolt holes but only four were used when the FPM was installed by Cincinnati Milacron).

RLV COMPOSITE TEST SPECIMENS

The 24" x 24" RLV 7198 panels were programmed. We are now waiting on the fabrication of RLV Tank #1.

Lockheed Martin subcontracted the programming to Cincinnati Milacron (CM). NASA/Lockheed-Martin (NASA/LM) was not satisfied with the gap that was being generated by our Offline Programming Software (FPOPS). Interfacing between CM and Thiokol has begun so that proper alignment and machine parameters are used. Machine commissioning data table values were transferred to CM so that their post processor would develop programs for our machine setup.

A flat panel program was generated by CM using the ACES software and downloaded to test in our machine. The panels consisted of a 0, 45, 90, 135 and 180 plies. The fabricated panel had all plies laying in different locations (as though they were shifted). CM suggested that we perform an LBA alignment on the FPM. The LBA alignment was performed and the FPM is within $\pm$ 0.010" tolerance at this time. The FPM still has a problem with the prefeeding tow. The tows are not fed out properly at the beginning of the course-- resulting in the tow being too short. Modifications to the tow prefeed distance and tow restart distance will be made to get the proper tow feedout.

The RLV tank arrived November 30, 1995, from Lockheed-Martin. There was a crack around the circumference of the sand mandrel.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01, ABLATIVE COMBUSTION CHAMBERS (FASTRAK)

No significant activity to report.

TD FPM-03, COMPOSITE HYDROGEN DEMONSTRATION TANK

No significant activity to report.

TD FPM-04, 18" x 20" PRESSURE VESSELS

Problems with the IM7/977-2 prepreg are causing delays. During winding, the material is fraying off the spools as it is being delivered. In extreme cases, this fraying is causing fiber breakage. To overcome this problem, an air conditioner for the creel is needed. An appropriate side mount air conditioner has been identified. No funding sources have been identified. To minimize the fraying, the material is either wound while still frozen or allowed to lose some tack before winding.

A pathfinder PV and serial number 001-002 was wound, cured, and washed out. Serial number 001-002 was fabricated with a XOOOXOOXOX lay up. The X represents a 30° helical layer and the O represents one hoop ply.

TD FPM-05, LH2 FEEDLINE COMPONENTS

The final report is still in final rewrite.

TD FPM-09 DEVELOPMENT/FABRICATION OF ADVANCED COMPOSITE ISOGRID

Fabrication is on hold until January 1996; reviewing reports of previous similar work.

TD FPM-10 FABRICATION OF TAPE-LAYED HONEYCOMB TEST SPECIMENS

Tab material was machined and bonded to the 8" x 1" BMI specimens. The Tetrahedron press was used to cure the AF 191-K film adhesive. The machine shop has been requested to cut the 1" x 0.75" and the 6" x 1.5" honeycomb BMI samples.

TD FPM-11 PHASE I OF FULL-SCALE ABLATIVE CHAMBER MATERIALS

Resin and release tape was order and is expected to be received in December.

NDE Intertank panel was started. The ID skin was tape layed with the artificial defects. The OD skin was layed with the 36 ply build-ups on each end. The OD skin also had artificial defects. The OD skin and build-ups are ready for the application of the glasscloth, film adhesive, and honeycomb core.

TD FPM-12 INTERTANK STRUCTURE (SSTO) (Cont.)

Tests were conducted to determine the expansion of the core splice adhesive for vented honeycomb material. Based on an earlier test using 1, 2, and 3 layers of the AF 3024 and non-vented core, it was decided that a vented core test was necessary because the Intertank honeycomb is vented. This test again used 1, 2 and 3 layers of AF 3024 to sandwich the core, but it also had a 5 ply thick 8552 prepreg laminate outside of the 3024 to help simulate the actual Intertank part cross-section. The samples were cured and cut into four pieces so that inside cells could be examined and photographed.

The core filler material, EC 3439, was tested to determine its cure characteristics. A 4.5" x 4.5" block of 0.5" thick non-vented core was used for one of the samples. This was completely filled with the EC 3439. The application was performed with a spatula (no other special tooling). The composition of the EC 3439 was paste-like. This core was then placed in a lay-up similar to the actual panel lay-up with prepreg on the outside, a layer of scrim cloth, and then a layer of AF 191-K next to the filled core. The second sample used the same lay-up, except that it was done with vented core and a 1" border of the core was not filled with EC 3439. This was done to determine the extent the core filler material would expand into unfilled adjacent cells. Both samples were cured and machined into four pieces so that the inside cells could be examined. Photographs were taken of these samples as well.

TD FPM-16 SPACE STATION DEBRIS SHIELD

A kick off meeting was held with Greg Olsen (the NASA Principal Engineer) to discuss the drawings and design parameters. A decision was made to make the shield without the buildup areas to reduce the tool and fabrication costs. The tube design was to be established based on hardware that Greg provided. Test panels were fabricated to measure the cured ply thickness of the composite fabric being used (AG3760-8H/8852). Four test panels were fabricated with different ply thicknesses: 4 plies, 6, plies, 8 plies, and 12 plies. Initial estimates place the average ply thickness at 0.0155".

TD FPM-17 LH2 TANK DOMES & PANELS

FM 300-2M film adhesive was ordered for bonding tabs to the 2" x 24" specimens. This adhesive will also be used to bond stiffeners for a later part of the project. The FM 300-2M cure temperature of 250°F was desirable since the stress free temperature will be at least 100°F closer to the cryogenic temperatures the samples and stiffeners will be exposed to.

The CJ5C 2" x 24" specimens were shipped to McDonnell Douglas. The CJ5M 2" x 24" samples have been rough cut from the three panels layed-up. These samples had the tabs bonded to them using FM 300-2M adhesive. Bonding pressure was generated using spring clamps. A bonding apparatus that will ensure proper bonding pressure is being designed by the Fiber Placement Machine lead engineer. The CJ6M panel material has been cut and is awaiting lay-up.

3.0 RECOMMENDATIONS

It is recommended that the new Acraplace software, ACES, be leased. The software lease rate will be $35k per year. It is also recommended that an IBM RISC station (~$25k) with CATIA CAD software (~$22k) be purchased to run as a front end to the ACES software. Procurement of an ACES lease and CATIA will ensure that quality parts can be fabricated and assistance from CM will be available for future projects.

These items will be discussed again in detail with the COTR during December 1995 and appropriate actions will be taken.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

The following is a list of upcoming work to be accomplished in December.

TABLE 1

PRIORITY	TD	APPLICATION	WORK ACTIVITY
High	FPM-01	Ablative chambers	Install instrument chamber for test
Med	FPM-03	Hydrogen tank	On hold
Med	FPM-04	18" C/E vessels	Continue winding vessels
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Low	FPM-10	Honeycomb specimens (CDDF)	Continue to fabricate & machine panels
Low	FPM-11	Full-scale ablative chamber	Procure any remaining materials
High	FPM-11	Intertank structure	Complete first panel
High	FPM-16	Space Station debris shield	Design tooling
High	FPM-17	Cryo dome and stiffeners	Fab panels and domes

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Huntsville Office
6767 Old Madison Pike, Suite 490
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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT DECEMBER 1995

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for December 1995. The following paragraphs summarize the significant accomplishments during the work period beginning in December, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in January 1996.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

Received Modification No. 11, providing $385,000 in allotted funding. Submitted a cost proposal in the amount of $12,413 in response to Technical Directive FPM-03R1, Fabrication of Composite Hydrogen Demonstration Tank.

2.1 BASIC MACHINE OPERATIONS

RLV COMPOSITE TEST SPECIMENS

Cincinnati Milacron generated the programs for the RLV Cryotank. Some changes to the programs were made to optimize the lay-down. The 89 and 91 degree hoop plies were designed to always start in the cylinder section and go to the end of the cone, this way the tows were always being dropped off. The only exceptions were the full length hoop plies. Tows were added at one end and dropped off on the other. Lockheed-Martin requested that Cincinnati Milacron tighten-up the tow width so that no gaps were present in the cylinder section of the part. The full length plies and the remaining short plies were reprogrammed with a 0.125" tow width. Plies 1 through 32 were layed during December. The part was autoclave debulked by Lockheed/Martin during the Christmas break.

No RLV test panels were fabricated this month as the tank was being fabricated

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01, ABLATIVE COMBUSTION CHAMBERS (FASTRAK)

No technical effort performed.

TD FPM-03, COMPOSITE HYDROGEN DEMONSTRATION TANK

No technical effort performed.

TD FPM-04, 18" x 20" PRESSURE VESSELS

Two (2) 18" bottles were fabricated and the process is now defined.

TD FPM-05, LH2 FEEDLINE COMPONENTS

The final report is in final rewrite.

TD FPM-09 DEVELOPMENT/FABRICATION OF ADVANCED COMPOSITE ISOGRID

Fabrication is on hold until February 1996; reviewing reports of previous similar work.

TD FPM-10 FABRICATION OF TAPE-LAYED HONEYCOMB TEST SPECIMENS

The 8" x 1" BMI specimens (Samples AE-B & AF-B) have been delivered to Jeff Finckenor, NASA. These 16 samples completed the 8" x 1" samples for all three material types. The 1" x 0.75" BMI specimens (Samples AC-B & AD-B) have been machined and will be delivered.

TD FPM-11 PHASE I OF FULL-SCALE ABLATIVE CHAMBER MATERIALS

Resin and release tape were received. Awaiting fabrication of next chamber to evaluate remaining supplies that need to be procured.

TD FPM-12 INTERTANK STRUCTURE (SSTO)

Completed fabrication and cure of the NDE Intertank panel. NASA performed NDE on this panel and then returned it. Requested machining of the four structural specimens from this panel. The second Intertank panel was also fabricated and cured. To help eliminate wrinkles in the ID skin when it is drape formed over the tapered core, the ID skin will be layed up in two four-layer pieces.

TD FPM-16 SPACE STATION DEBRIS SHIELD

The inner tube mandrel and a shield mold were designed and tool drawings were generated. Both drawings are in review and should be released this month.

TD FPM-17 LH2 TANK DOMES & PANELS

Machining of the CJ5M samples was completed. These have been packaged and are awaiting shipment to McDonnel/Douglas. The CJ6M panels were layed-up and cured. Lay-up of the CJ6C panels has been requested.

3.0 RECOMMENDATIONS

It is still recommended that the new Acraplace software, ACES, be leased as soon as possible. The software lease rate will be $35k per year. It is also recommended that funding be located to procure an IBM RISC station (~$25k) with CATIA CAD software (~$22k) as a front end to generate models. FPL (Fiber Placement Language), for the ACES software. Procurement of ACES lease and CATIA will ensure that quality parts can be fabricated and assistance from CM will be available for future projects.

These items will be discussed again in detail with the COTR during January 1996 and appropriate actions will be taken.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

The following is a list of upcoming work to be accomplished in January.

TABLE 1

PRIORITY	TD	APPLICATION	WORK ACTIVITY
High	FPM-01	Ablative chambers	Install instrument chamber for test & fabricate 3 additional chambers
Med	FPM-03	Hydrogen tank	Fabricate low profile dome
Med	FPM-04	18" C/E vessels	Continue winding vessels
Med	FPM-05	Cryogenic feedline	Publish and present final report
Low	FPM-09	Isogrid cylinders	On hold until February 1996
Low	FPM-10	Honeycomb specimens (CDDF)	Continue to fabricate & machine panels
Low	FPM-11	Full-scale ablative chamber	Procure any remaining materials
High	FPM-11	Intertank structure	Continue fabricating panels
High	FPM-16	Space Station debris shield	Design and procure tooling
High	FPM-17	SSTO Cyrodome & Stiffeners	Fab panels and domes
Med	FPM-18	Cryotest Pressure Vessels	Receive bosses & start winding
Med	FPM-19	Honeycomb Test Specimens	Fab panels and domes

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L. I. Pelham
Program Manager

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Larry I. Pelham

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Thiokol Space Operations
Huntsville Office
6767 Old Madison Pike, Suite 490
Huntsville, AL 35806

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT JANUARY 1996

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for January 1996. The following paragraphs summarize the significant accomplishments during the work period beginning in January, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in February 1996.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

Received Modification 11 to the contract which added $385,000 in allotted funding.

2.1 BASIC MACHINE OPERATIONS

RLV COMPOSITE TEST SPECIMENS

The Fiber Placed RLV Composite Cryotank was completed. Plies 33 -72 were layed, thus completing the fiber placement portion of the fabrication. The part was delivered to Lockheed-Martin for autoclave cure and washed. The second tank is scheduled to be fabrication in mid February.

NASA/Lockheed-Martin requested a feasibility study on fabrication of a 6' x 7' curved panel. A model was developed using FPOPS which indicates that a part could be fabricated on the FPM. Only the 0 and 90 degree plies were generated and downloaded.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01, ABLATIVE COMBUSTION CHAMBERS (FASTRAK)

No technical effort performed. Waiting for authorization to fabricate 3 additional chambers.

TD FPM-03, COMPOSITE HYDROGEN DEMONSTRATION TANK

Waiting for authorization to proceed with dome fabrication and for NASA to indicate the specifications for the outer ring build-up. The outer reinforcement ring will be co-cured with the main dome in the autoclave. An inside reinforcement will be layed onto the cured part and then cured.

TD FPM-04, 18" x 20" PRESSURE VESSELS

Three pressure vessels were fabricated in January. On one of the tanks, the sand collapsed during cure resulting in the cylinder section having a slightly smaller diameter than the dome tangent points. Upon further investagation, it was determined that the sand mandrel had absorbed moisture during staging causing it to steam off during cure and softening the sodium silacate binder. Mandrels will now be fabricated just prior to use.

TD FPM-05, LH2 FEEDLINE COMPONENTS

Technical directive effort is complete and will not be reported on any further.

TD FPM-09 DEVELOPMENT/FABRICATION OF ADVANCED COMPOSITE ISOGRID

Fabrication is on hold until February 1996; reviewing reports of previous similar work.

TD FPM-10 FABRICATION OF TAPE-LAYED HONEYCOMB TEST SPECIMENS

Finished machining the IM7/8552 and AS4/3501-6 AA & AB specimens. Delivered all of the AC & AD specimens to NASA.

TD FPM-11 PHASE I OF FULL-SCALE ABLATIVE CHAMBER MATERIALS

Awaiting fabrication of next chamber to determine supplies that need to be procured.

TD FPM-12 COMPOSITE INTERTANK STRUCTURE

Fabricated Intertank Panels #3 and #4 and started Panel #5. Perform a test to ensure that the strain gages could withstand a cure of 4 hours at 200°F. NASA's Ricky Wilbanks tested the instrumented part that was placed in the oven for this cycle and said that the strain gage was functioning properly. The panels will be instrumented before final assembly so that only two panels will be left to be instrumented when the full structure is assembled. The entire assembly will then be cured at 200°F for 4 hours to cure the core splice adhesive between the panels. Machined and match drilled structural test specimens from the NDE panel to produce End Joint Test Specimens 97M55527-(1-4). Trying to resolve problems with the tape layer, constantly breaking the paper backing. This problem is causing delays that may impact the schedule.

TD FPM-16 SPACE STATION DEBRIS SHIELD

The mandrel and shield has been ordered and should be received February 1996. The outer tube mandrel drawing has been completed but has not been ordered. We will wait to get some thickness measurements from the first tube before finalizing the design.

TD FPM-17 LH2 TANK DOMES & PANELS

Layed-up and cured CJ6C panels. Started process planning on the 1/8" Exaggerate Gap panels. The FM 300-2M for bonding the tabs to the specimens will be shipped February 12, 1996.

TD FPM-18 CRYOGENIC PRESSURE VESSELS

Waiting for NASA/MSFC, to deliver the required pole bosses before fabrication can begin.

TD FPM-19 FIBERPLACED HONEYCOMB TEST PANELS

Project is on hold until March 1996; waiting for completion of tape layed honeycomb panels.

3.0 RECOMMENDATIONS

It is recommended that the new Acraplace software. ACES. be leased as soon as possible. Acraplace software has features that will allow us to more acurrately generate program and fabricate parts we can not currently program. The software lease rate will be $35k per year. It is also recommended that funding be located to procure an IBM RISC station (~$25k) with CATIA CAD software (~$22k) as a front end to generate models. FPL (Fiber Placement Language), for the ACES software. Procurement of ACES lease and CATIA will ensure that quality parts can be fabricated and assistance from Cincinnati Milacron will be available for future projects.

NASA/MSFC is considering shutting down VAXHST. The Cincinnati Milacron Tape Laying software resides on VAXHST and can be moved to one of the Silicon Graphics Workstations for a ~$22k porting fee. This move is recommended to get it off the VAX and also to improve the programming speed.

These items will be discussed again in detail with the COTR during February 1996 and appropriate actions will be taken.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

The following is a list of upcoming work to be accomplished in February 1996.

TABLE 1

PRIORITY	TD	APPLICATION	WORK ACTIVITY
High	FPM-01	Ablative chambers	Install instrument chamber for test & fabricate 3 additional chambers
Med	FPM-03	Hydrogen tank	Fabricate low profile dome
Med	FPM-04	18" C/E vessels	Continue winding vesseis
Med	FPM-05	Cryogenic feedline	Publish and present final report
Low	FPM-09	Isogrid cylinders	On hold until February 1996
Low	FPM-10	Honeycomb specimens (CDDF)	Continue to fabricate & machine paneis
Low	FPM-11	Full-scale ablative chamber	Procure any remaining materials
High	FPM-11	Intertank structure	Continue fabricating paneis

TABLE 1			
PRIORITY	**TD**	**APPLICATION**	**WORK ACTIVITY**
High	FPM-16	Space Station debris shield	Design and procure tooling
High	FPM-17	SSTO Cyrodome & Stiffeners	Fab panels and domes
Med	FPM-18	Cryotest Pressure Vessels	Receive bosses & start winding
Med	FPM-19	Honeycomb Test Specimens	Fab panels and domes

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L. I. Pelham
Program Manager

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Larry T. Pelham

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Thiokol Space Operations
Huntsville Office
6767 Old Madison Pike, Suite 490
Huntsville, AL 35806

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT FEBRUARY 1996

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for February 1996. The following paragraphs summarize the significant accomplishments during the work period beginning in February, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in March 1996.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

2.1 BASIC MACHINE OPERATIONS

RLV COMPOSITE TEST SPECIMENS

Five panels (28,29,30, 31 & 32) were fabricated . The last two panels had band overlap problems so the panel 33 program was modeified to have a large band width. Fabrication of three more panels is planned .

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01, ABLATIVE COMBUSTION CHAMBERS (FASTRAK)

No technical effort performed. Waiting for authorization to proceed with the three additional chambers.

TD FPM-03, COMPOSITE HYDROGEN DEMONSTRATION TANK

Modification to the TD is in process; waiting for authorization to proceed with dome fabrication.

TD FPM-04, 18" x 20" PRESSURE VESSELS

Eight pressure vessels have been fabricated. The sand mandrels collapsed during the cure of the second and third pressure vessels. Steps have been incorporated into the process to eliminate mandrel failure. Since implementation of process modifications, no mandrel problems have been encountered. Improvements have been made in the mandrel washout process as well. A process that once took soaking overnight can now be accomplished in approximately 2 hours.

TD FPM-09 DEVELOPMENT/FABRICATION OF ADVANCED COMPOSITE ISOGRID

Fabrication is on hold until April 1996; reviewing reports of previous similar work.

TD FPM-10 FABRICATION OF TAPE-LAYED HONEYCOMB TEST SPECIMENS

Bonded the BMI skins to 1.5" honeycomb for the production of the AA & AB specimens.

TD FPM-11 PHASE I OF FULL-SCALE ABLATIVE CHAMBER MATERIALS

Awaiting fabrication of next chamber to evaluate remaining maerials that need to be procured.

TD FPM-12 COMPOSITE INTERTANK STRUCTURE

Fabricated Intertank Panels #5 through #11. This provided eight panels that were produced with the perforated release film finish on both the ID and OD sides of the panels. It was decided to wait until after the Intertank was fully assembled to instrument it. Submitted drawings detailing location of defects for the Intertank NDE panel. Machined the splice panels into the 48 splices that will be used to bond the panels together. Performed a test with honeycomb that showed that in a vertical orientation neither the AF 3024 core splice adhesive nor the EC 3439 core filler dropped to a low enough viscosity during cure to cause from in between the panels.

TD FPM-16 SPACE STATION DEBRIS SHIELD

The inner tube mandrel was received. The debris shield mandrel was received from B&K Machine and Tool and was degreased. The tool surface of the debris shield mandrel was scratched during degreasing and will need to be fixed.

TD FPM-17 LH2 TANK DOMES & PANELS

Layed-up and cured the CJ5CA cloth-cloth joint, circumferential stagger, exaggerated gap and CJ5MA cloth-cloth joint meridional stagger, exaggerated gap panels. Tabbed and machined the CJ6M cloth-cloth joint meridional direction stagger and the CJ6C cloth-cloth joint circumferential direction stagger panels to produce the 2" x 24" specimens.

TD FPM-18 CRYOGENIC PRESSURE VESSELS

Waiting for required pole bosses before fabrication can begin.

TD FPM-19 FIBERPLACED HONEYCOMB TEST PANELS

Project will proceed upon completion of tape layed honeycomb panels.

3.0 RECOMMENDATIONS

It is recommended that the new Acraplace software, ACES, be leased as soon as possible. Acraplace software has features that will allow us to more acurrately generate program and fabricate parts we can not currently program. The software lease rate will be $35k per year. It is also recommended that funding be located to procure an IBM RISC station (~$25k) with CATIA CAD software (~$22k) as a front end to generate models, FPL (Fiber Placement Language), for the ACES software. Procurement of ACES lease and CATIA will ensure that quality parts can be fabricated and that assistance from Cincinnati Milacron will be avaiiable for future projects.

It is recommended that the Cincinnati Milacron Tape Laying software resides on VAXHST be moved to one of the Silicon Graphics Workstations for a ~$22k porting fee.

These items will be discussed again in detail with the COTR during March 1996 and appropriate actions will

be taken

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

The following is a list of upcoming work to be accomplished in March.

TABLE 1

PRIORITY	TD	APPLICATION	WORK ACTIVITY
High	FPM-01	Ablative chambers	Install instrument chamber for test & fabricate 3 additional chambers
Med	FPM-03	Hydrogen tank	Fabricate low profile dome
Med	FPM-04	18" C/E vessels	Continue winding vessels
Low	FPM-09	Isogrid cylinders	On hold until April 1996
Low	FPM-10	Honeycomb specimens (CDDF)	Continue to fabricate & machine panels
Low	FPM-11	Full-scale ablative chamber	Procure any remaining materials
High	FPM-12	Intertank structure	Fabricating test panels
High	FPM-16	Space Station debris shield	Fabricate and assemble
High	FPM-17	SSTO Cyrodome & Stiffeners	Fab panels and domes
Med	FPM-18	Cryotest Pressure Vessels	Receive bosses & start winding
Med	FPM-19	Honeycomb Test Specimens	Fab panels and domes

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Program Manager

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Thiokol Space Operations
Huntsville Office
6767 Old Madison Pike, Suite 490
Huntsville, AL 35806

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT MARCH 1996

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for March 1996. The following paragraphs summarize the significant accomplishments during the work period beginning in March, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in April 1996.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

Modification 12 to the contract was fully executed. This modification authorized and definitized the efforts described in Technical Directives FPM-01R2, Development/Fabrication of Advanced Composite Ablative Chambers; FPM-03R1, Fabrication of Composite Hydrogen Demonstration Tank; and FPM-20, Fabrication of a Low Profile Composite Dome.

2.1 BASIC MACHINE OPERATIONS

PROCUREMENT

Gear Lube for FPM was received. Sixteen (16) rolls of Cellowrap were received. Ten (10) rolls of A575 High shrink tape were received. Ten (10) rolls of Wrightlon 4500 shrink tape were received.

MAINTENANCE

Some of the cutting blades on the FPM Cut, Clamp & Restart (CCR) assembly were replaced. Three of the towpreg sensors do not work properly and have been removed.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-04, 18" x 20" PRESSURE VESSELS

Three pressure vessels were fabricated. The problems associated with sand mandel cracks and wash-out have not reoccurred.

TD FPM-09 DEVELOPMENT/FABRICATION OF ADVANCED COMPOSITE ISOGRID

Fabrication is on hold until Bill McMahon completes reviewing reports of previous similar work.

TD FPM-10 FABRICATION OF TAPE-LAYED HONEYCOMB TEST SPECIMENS

Delivered the 6" x 15" AA & AB honeycomb specimens to NASA ED personnel. J. Finckenor has requested a replacement AE-B-A-F-8 specimen. This will require the tape laying of another Panel #55 which is a BMI panel that will need to be cured separately

TD FPM-12 COMPOSITE INTERTANK STRUCTURE

Performed surface preparation on the Intertank panels and splices. Bonded the Intertank structure using EA 9394. The adhesive was allowed to room-temperature cure for 48 hours. The Intertank was then moved to the Productivity Enhancement Complex where it was cured at 230°F to cure the AF 3024 core splice adhesive located between the panels.

TD FPM-16 SPACE STATION DEBRIS SHIELD

Outer mandrel was received from Lynco Grinding. Outer tubes and braces were fabricated. Metal and plastic components were received from B&K tooling. Demonstration unit was assembled and delivered to Joel Williamsen. The fabrication effort is now complete.

TD FPM-17 LH2 TANK DOMES & PANELS

Machined the cloth-cloth joint circumferential stagger, exaggerated gap 2" x 24" specimens (CJ5CA) from the three hand layed panels. These were sent to McDonnell Douglas along with the CJ5M, CJ6C and CJ6M samples. Prepared the paperwork for the cloth-tape transition test specimens. The 32-inch dome tool will be modified by Hardie-Tynes Manufacturing in preparation for the next two composite domes to be layed-up.

TD FPM-18 CRYOGENIC PRESSURE VESSELS

Still waiting for NASA/MSFC to deliver the required pole bosses before fabrication can begin.

TD FPM-19 FIBERPLACED HONEYCOMB TEST PANELS

Project is on hold until results of the tape layed honeycomb panels can be evaluated.

TD FPM-20 LOW PROFILE COMPOSITE DOME

Kick-off meeting was held. Material was identified and will be ordered next month.

3.0 RECOMMENDATIONS

It is still recommended that the new Aerospace software, ACES, be leased as soon as possible. Aerospace software has features that will allow us to more accurately generate program and fabricate parts. The software lease rate will be $47k per year. It is also recommended that funding be located to procure CATIA for the Silicon Graphics. A quote was received from a VAR (Value Added Reseller) of CATIA software for $26,000 The annual maintenance from CATIA is $3000. Two weeks of training on CATIA will run $3,500 for up to four people (held at MSFC). It is essential that we upgrade to the new software system to be able to use the FPM to its fullest potential.

It is still recommended that the Cincinnati Milacron Tape Laying software that resides on VAXHST be moved to and one of the Silicon Graphics Workstations for a ~$22k porting fee.

These items will be discussed again in detail with the COTR during April 1996 and appropriate actions will be taken.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

The following is a list of upcoming work to be accomplished in March.

TABLE 1

PRIORITY	TD	APPLICATION	WORK ACTIVITY
High	FPM-01	Ablative chambers	Install instrument chamber for test & fabricate 3 additional chambers
Med	FPM-03	Hydrogen tank	Fabricate low profile dome
Med	FPM-04	18" C/E vesseis	Continue winding vessels
Low	FPM-09	Isogrid cylinders	On hold until April 1996
Low	FPM-10	Honeycomb specimens (CDDF)	Continue to fabricate & machine panels
Low	FPM-11	Full-scale ablative chamber	Procure any remaining materials
High	FPM-12	Intertank structure	Fabricating test panels
High	FPM-16	Space Station debris shield	Complete & closeout
High	FPM-17	SSTO Cyrodome & Stiffeners	Fab panels and domes
Med	FPM-18	Cryotest Pressure Vesseis	Receive bosses & start winding
Med	FPM-19	Honeycomg Test Specimens	Lay-out Panels & Cylinder
Med	FPM-20	Low Profile Dome	Order materials & tooling

Approved by:

L. Y. Pelham
Program Manager

REPORT

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MARCH 1996 MONTHLY TECHNICAL PROGRESS REPORT

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March Monthly Technical Progress Report on Operation/Maintenance of Fiber Placement Machine

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Larry I. Pelham

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Thiokol Space Operations
Huntsville Office
6767 Old Madison Pike, Suite 490
Huntsville, AL 35806

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT APRIL 1996

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for April 1996. The following paragraphs summarize the significant accomplishments during the work period beginning in April, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in May 1996.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

Dispatched proposals for Technical Directive FPM-21, Fabrication of Composite Cryotank Structure, and FPM-22, Cost Effective Production of Advanced Composite Structures. Received Modification 14 adding $357,000 in allotted funding to the contract.

2.1 BASIC MACHINE OPERATIONS

SOFTWARE SUPPORT

Information on the SGI version of CATIA (V4.1.6) was submitted to the COTR. A source of funding has been identified for NASA to procure the software. This software is one step to upgrading the FPOPS (Fiber Placement Off-line Programming System) to ACE (Automated Composite Environment). In the meantime, software support is required from Cincinnati Milacron on an as needed basis.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01, ABLATIVE COMBUSTION CHAMBERS (FASTRAK)

Received authorization to fabricate four additional chambers. Required materials are being procured.

TD FPM-03, COMPOSITE HYDROGEN DEMONSTRATION TANK

Layed up the two top surface reinforcement rings and cured the dome. The kit for the underneath build-up rings was cut and the surface where the rings will be attached was grit blasted.

TD FPM-04, 18" x 20" PRESSURE VESSELS

Two pressure vessels were fabricated (PV#019-020 & PV#021-022).

TD FPM-09 DEVELOPMENT/FABRICATION OF ADVANCED COMPOSITE ISOGRID

Fabrication is on hold pending review of previous similar work.

TD FPM-10 FABRICATION OF TAPE-LAYED HONEYCOMB TEST SPECIMENS

Tape layed and cured the replacement Panel #55. This will be used to obtain another AE-B-A-T-8 specimen set. This effort was completed and no further reports will be generated.

TD FPM-11 PHASE I OF FULL-SCALE ABLATIVE CHAMBER MATERIALS

Awaiting fabrication of next chamber to evaluate remaining supplies that need to be procured for the last chamber.

TD FPM-12 COMPOSITE INTERTANK STRUCTURE

The intertank structure is complete and is being instrumented for test.

Generated tape laying programs for the fabrication of the joint doubler panels. Fabrication of these panels will begin as soon as material is received.

TD FPM-16 SPACE STATION DEBRIS SHIELD

Completed.

TD FPM-17 LH2 TANK DOMES & PANELS

Machining of the 2" x 24" CJ5MA specimens was completed. The panels for the cloth-tape transition specimens were layed up and cured. These panels have had tabbing material bonded to them and are in the process of being machined. The 32 inch dome tool was modified by Hardie-Tynes Manufacturing Co. The tool was polished and release coated in preparation for lay-up. Preliminary drawings for the stiffener tool and one of the tank wall simulator tools have been prepared.

TD FPM-18 CRYOGENIC PRESSURE VESSELS

Still waiting for Robert Carrigan. NASA. to deliver the required pole bosses before fabrication can begin.

TD FPM-19 FIBERPLACED HONEYCOMB TEST PANELS

Project is on hold until results of the tape layed honeycomb panels can be evaluated.

TD FPM-20 LOW PROFILE COMPOSITE DOME

The material (SGP370-8H/8552 prepreg fabric. 39 pounds) for the project was ordered . Two or three possible vendors have been found that can fabricate an aluminum 3:1 elliptical dome mandrel.

3.0 RECOMMENDATIONS

It is recommended that the new Acraplace software. ACES. be leased as soon as possible. Acraplace software has features that will allow us to more accurately generate programs and fabricate parts that we can not currently program. The software lease rate will be $47k per year. It is also recommended that funding be located to procure CATIA for the Silicon Graphics. It is essential that we upgrade to the new software system to be able to use the FPM to its fullest

potential.

It is recommended that the Cincinnati Milacron Tape Laying software that resides on VAXHST be moved to one of the Silicon Graphics Workstations for a ~$22k porting fee.

These items will be discussed again in detail with the COTR during May 1996 and appropriate actions will be taken.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

The following is a list of upcoming work to be accomplished in May.

TABLE 1

PRIORITY	TD	APPLICATION	WORK ACTIVITY
High	FPM-01	Ablative chambers	Install instrument chamber for test & fabricate 3 additional chambers
Med	FPM-03	Hydrogen tank	Complete low profile dome
Med	FPM-04	18" C/E vessels	Continue winding vessels
Low	FPM-09	Isogrid cylinders	On hold until May 1996
Low	FPM-11	Full-scale ablative chamber	Procure any remaining materials
High	FPM-12	Intertank structure	Fabricating doubler panels
High	FPM-17	SSTO Cyrodome & Stiffeners	Fab panels and domes
Med	FPM-18	Cryotest Pressure Vessels	Receive bosses & start winding
Med	FPM-19	Honeycomb Test Specimens	Lay-out Paneis & Cylinder
Med	FPM-20	Low Profile Dome	Receive materials & tooling

Approved by: _____
L. I. Pelham
Program Manager

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Larry I. Pelham

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Thiokol Space Operations
Huntsville Office
6767 Old Madison Pike, Suite 490
Huntsville, AL 35806

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT MAY 1996

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for May 1996. The following paragraphs summarize the significant accomplishments during the work period beginning in May, discusses recommendations for NASA/MSFC consideration, and lists upcoming work to be performed in June 1996.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

Modification 14 to the contract was issued providing $357,000 in funding. $347,000 was allotted for the basic and $10,000 was allotted for Technical Directive FPM-19 (Phase II).

2.1 BASIC MACHINE OPERATIONS

SOFTWARE SUPPORT

A temporary software contract with Cincinnati Milacron (CM) was established and Bob Meier (CM programmer) is making minor modifications to the codes used to fabricate the RLV Tank.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01, ABLATIVE COMBUSTION CHAMBERS (FASTRAK)

Silica/Phenolic tapewrap material was received. Completed tapewrap and cure of the first of four 7K chambers.

TD FPM-03, COMPOSITE HYDROGEN DEMONSTRATION TANK

Layed-up the two underneath reinforcement plies on the dome. One layer of FM 300-2M film adhesive was used to ensure the adhesion of the two layers. The dome was autoclave cured and NASA/MSFC EH and ED lab personnel were informed that it is now available for machining.

TD FPM-04, 18" x 20" PRESSURE VESSELS

No pressure vessels were fabricated in May.

TD FPM-09 DEVELOPMENT/FABRICATION OF ADVANCED COMPOSITE ISOGRID

Two foam mandrels were machined on the filament winding machine to match the contour of the 5.75" x 12" collapsible steel mandrel. These two mandrels were then wound with AS4 graphite fiber and an E-Beam curable resin system. They were then transported by NASA/MSFC to a curing site in New Jersey for cure. After curing, they will be sent back to NASA/MSFC for further testing.

TD FPM-11 PHASE I OF FULL-SCALE ABLATIVE CHAMBER MATERIALS

Awaiting fabrication of next chamber to evaluate remaining supplies that need to be procured for the last chamber.

TD FPM-12 COMPOSITE INTERTANK STRUCTURE

Received 8H IM7/8552 prepreg cloth for the production of the intertank interface doubler panels. The cloth was used for reinforcement of the outer layers of the laminate to minimize fiber breakout during machining. The first of two doubler panels was layed up and autoclave cured.

TD FPM-17 LH2 TANK DOMES & PANELS

One tank dome was layed-up on the modified 32 inch dome tool. This consisted of four layers of prepreg cloth [+45/-45,0/90]s in the dome region and seven layers of unidirectional tape [60,90,-60,0,60,90,60] in the cylindrical region.

The stiffener drawings (TFPM004) were completed and signed off. Received three stiffener tools were acquired. The drawings for the midspan pop-off tank wall simulator tool (TFPM008), the hoop pop-off tank wall simulator tool (TFPM006) and the box beam tool (TFPM005) were completed, fabrication is underway. Two debulk and cure bagging tools for the stiffeners were fabricated by Torr Technologies and delivered. Two carts for the bagging tools and stiffener tools were also ordered and received.

A total of 11 stiffener parts were fabricated in May (Stiffeners #1 through #11). Stiffener #1 had a large resin dry region and will be used to fabricate a 40" crippling test stiffener part. We lost the vacuum bag on Stiffener #3 and the part was a total loss. Stiffener #3 was used for machining practice.

TD FPM-18 CRYOGENIC PRESSURE VESSELS

Robert Carrigan and Stan Smeltzer, NASA/MSFC, have decided to re-scope their effort. They would like to make flat panels and still use the tow materials they have ordered. We are in the process of revising the technical directive to accommodate that change.

TD FPM-19 FIBERPLACED HONEYCOMB TEST PANELS

Project is on hold until results of the tape layed honeycomb panels can be evaluated.

TD FPM-20 LOW PROFILE COMPOSITE DOME

The prepreg material arrived and was labeled and placed in storage. The dome tool is being manufactured and should be delivered the last week of June.

3.0 RECOMMENDATIONS

It is recommended that the new Acraplace software, ACES, be leased as soon as possible. Acraplace software has features that will allow us to more accurately generate programs and fabricate parts that we can not currently program. The software lease rate will be $47k per year. It is also recommended that funding be located to procure CATIA for the Silicon Graphics. It is essential that we upgrade to the new software system to be able to use the FPM to its fullest potential.

Also, it is recommended that the Cincinnati Milacron Tape Laying software that resides on VAXHST be moved to one of the Silicon Graphics Workstations for a ~$22k porting fee.

These items will be discussed again in detail with the COTR during June1996 and appropriate actions will be taken.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

The following is a list of upcoming work to be accomplished in June.

TABLE 1

PRIORITY	TD	APPLICATION	WORK ACTIVITY
High	FPM-01	Ablative chambers	Install instrument chamber for test & fabricate next 3 chambers
Med	FPM-04	18" C/E vessels	Continue winding vessels
Low	FPM-09	Isogrid cylinders	Review ongoing efforts
Low	FPM-11	Full-scale ablative chamber	Procure any remaining materials
High	FPM-12	Intertank structure	Fabricating remaining doubler panel
High	FPM-17	SSTO Cyrodome & Stiffeners	Fab stiffeners, panels, and domes
Med	FPM-18	Cryotest Pressure Vessels	Receive bosses & start winding
Med	FPM-19	Honeycomb Test Specimens	Lay-out Panels & Cylinder
Med	FPM-20	Low Profile Dome	Receive tooling

Approved by:

L. Y. Pelham
Program Manager

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Larry I. Pelham

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Thiokol Space Operations
Huntsville Office
6767 Old Madison Pike, Suite 490
Huntsville, AL 35806

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT JUNE 1996

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for June 1996. The following paragraphs summarize the significant accomplishments during the work period beginning in June, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in July 1996.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

Received Modification 15 to the contract, definitizing and authorizing Technical Directives FPM-21 and FPM-22. $52,850 was added to contract value, and $144,554 was added to allotted funding. Received Technical Directive FPM-23 and submitted proposals in response to Technical Directives FPM-23 and FPM-24.

2.1 BASIC MACHINE OPERATIONS

FIBER PLACEMENT OFF-LINE PROGRAMING SYSTEM

The Silicon Graphics workstation (SGVIPER) was moved from the open area in room 226 above the composite lab to another office area to accommodate NAS personnel.

Cincinnati Milacron has fixed the minor changes in the previous codes per Lockheed-Martin request.

ADVANCED COMPOSITE EQUIPMENT

Training was received by Thiokol technicians on the operation of the midsized autoclave in Building 4707.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01, ABLATIVE COMBUSTION CHAMBERS (FASTRAK)

Tape wrapped and overwrapped two of the four additional Fastrack combustion chamber liners. Installed original liner No. 5 into the canister for testing of the Propulsion Lab's new injector.

TD FPM-03, COMPOSITE HYDROGEN DEMONSTRATION TANK

The dome was completed.

TD FPM-04, 18" x 20" PRESSURE VESSELS

One sand mandrel with fiberglass was fabricated.

TD FPM-09 DEVELOPMENT/FABRICATION OF ADVANCED COMPOSITE ISOGRID

Started development of winding programs to machine grooves in the foam mandrels

TD FPM-11 PHASE I OF FULL-SCALE ABLATIVE CHAMBER MATERIALS

Completed.

TD FPM-12 COMPOSITE INTERTANK STRUCTURE

Generated tape laying programs for the fabrication of the joint doubler panels.

TD FPM-17 LH2 TANK DOMES & PANELS

Completed fabrication of the 56 stiffener segments required for the 6 box beam, 25 hoop, and 25 midspan tank wall simulators. Fabricated hoop tank wall simulator (HTWS) segments #1-11 and midspan tank wall simulators (MTWS) pieces Nos. 1-6 and Nos. 20-23. Stiffeners and tabs were bonded to HTWSs No. 1 and Nos. 3-6. Stiffeners and tabs were also bonded to MTWSs Nos. 1-5 and Nos. 20-23. A crate was fabricated for shipping the tank wall simulators. HTWSs Nos. 1 and 3-6 along with MTWSs Nos. 1-5 and No. 20-23 were scheduled to be delivered by July 2.

TD FPM-18 CRYOGENIC PRESSURE VESSELS

We are supporting the revision of effort to accommodate additional test panels.

TD FPM-19 FIBERPLACED HONEYCOMB TEST PANELS

Project is on hold until results of the tape laved honeycomb panels can be evaluated.

TD FPM-20 LOW PROFILE COMPOSITE DOME

The dome tool is expected in July.

3.0 RECOMMENDATIONS

It is still recommended that the new Acraplace software, ACES, be leased as soon as possible. Acraplace software has features that will allow us too more accurately generate programs and fabricate parts that we cannot currently program. The software lease rate will be $47k per year. It is also recommended that funding be located to procure CATIA for the Silicon Graphics. It is essential that we upgrade to the new software system to be able to use the FPM to its fullest potential.

Also, it is still recommended that the Cincinnati Milacron Tape Laying software that resides on VAXHST be moved to one of the Silicon Graphics Workstations for a ~$22k porting fee.

These items will be discussed again in detail with the COTR during July 1996 and appropriate actions will be taken.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

The following is a list of upcoming work to be accomplished in July.

TABLE 1

PRIORITY	TD	APPLICATION	WORK ACTIVITY
High	FPM-01	Ablative chambers	Install instrument chamber for test & fabricate next 2 chambers
Med	FPM-04	18" C/E vessels	Continue winding vessels
Low	FPM-09	Isogrid cylinders	Machine foam mandrels
High	FPM-12	Intertank structure	Fabricating remaining doubler panel & test specimens
High	FPM-17	SSTO Cyrodome & Stiffeners	Fab stiffeners, panels, and domes
Med	FPM-18	Cryotest Pressure Vessels	Locate material & start panels
Med	FPM-19	Honeycomb Test Specimens	Lay-out Panels & Cylinder
Med	FPM-20	Low Profile Dome	Prep tooling & start layup

Approved by: _____

L. I. Pelham
Program Manager

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Thiokol Space Operations
Huntsville Office
6767 Old Madison Pike, Suite 490
Huntsville, AL 35806

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT JULY 1996

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for July 1996. The following paragraphs summarize the significant accomplishments during the work period beginning in July, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in August 1996.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

Submitted a cost plus fixed fee proposal in reponse to Technical Directive FPM-23, Phase 1 of Liquid Engine Combustion Chamber Fabrication.

2.1 BASIC MACHINE OPERATIONS

FABRICATION OF FIBER PLACED TEST SPECIMENS

The fiber placed CDDF panels are being prepared for machining.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01, ABLATIVE COMBUSTION CHAMBERS (FASTRAK)

Completed tapewrap and overwrap of the two remaining "Fastrack" combustion chambers liners. Machined and installed the one liner into canister for testing of the NASA/MSFC's Propulsion Lab's new injector.

TD FPM-03, COMPOSITE HYDROGEN DEMONSTRATION TANK

Machined and delivered four 3" x 3" apparent strain specimens from a 5H IM7/8552 panel. Fabricated two 30" square panels from the 5H IM7 prepreg. These panels were machined into ten 5" x 30" strips to be used to minimize fiber breakout when holes were drilled through the flange area of the dome. Delivered the dome and machining strips to NASA/MSFC.

TD FPM-04, 18" x 20" PRESSURE VESSELS

No activity.

TD FPM-09 DEVELOPMENT/FABRICATION OF ADVANCED COMPOSITE ISOGRID

Foam pressure vessel mandrels, 5.75' x 12", were machined using the filament winder. Currently winding tow into isogrid.

TD FPM-12 COMPOSITE INTERTANK STRUCTURE

Fabrication of the second structure will begin as soon as manpower is available.

TD FPM-17 LH2 TANK DOMES & PANELS

Tank Wall Simulator Specimens: Bonded stiffeners to Hoop Tank Wall Simulators (HTWS) #7-9. HTWSs #10-16 and Midspan Tank Wall Simulators (MTWS) #6-10 and 24-27 were machined. Stiffeners were also bonded to these samples. HTWSs #7-16 and MTWSs #6-10 and 24-27 were delivered to McDonnell Douglas Huntsville. Layed-up and cured HTWSs #17-20 and MTWSs #11-13 and 28-30.

Stringer Crippling Specimens: Stringer Crippling Specimens (SCS) #02 & 03 were layed-up. Silicone pads are being used during the debulks, heated and non-heated, and during cure to evenly distribute pressure on the SCS surface. The machining of SCSs #01-03 has started. A total of six SCSs are needed.

32-Inch Composite Dome: Layed-up and cured a 32-inch composite dome.

TD FPM-18 CRYOGENIC PRESSURE VESSELS

Technical Directive was revisied to accommodate additional test panels. No panels were fabricated in July.

TD FPM-19 FIBERPLACED HONEYCOMB TEST PANELS

Project is on hold until results of the tape layed honeycomb panels can be evaluated.

TD FPM-20 LOW PROFILE COMPOSITE DOME

The dome tool arrived and was sanded down to a smooth surface finish. Grit sandpaper (180 through 640) was used to sand the surface of the aluminum mandrel. The ply laydown was discussed with NASA/MSFC and the ply kit layouts on the fabric roll drawn up.

TD FPM-21 COMPOSITE CRYOTANK

The sand mandrel is being fabricated by a Lockheed-Martin subcontractor. The mandrel should be delivered in early August. Cincinnati Milacron is ready to regenerate the programs once the mandrel arrives and is checked out. The 0 and 90 degree plies will be flipped per Lockheed-Martin's request.

TD FPM-22 ADVANCED COMPOSITE STRUCTURES

Assisted NASA/MSFC in the evaluation and procurement of Thiokol TCR prepreg material.

3.0 RECOMMENDATIONS

It is still recommended that the new Acraplace software, ACES, be leased as soon as possible. Acraplace software has features that will allow us to more accurately generate programs and fabricate parts that we cannot currently program. The software lease rate will be $55k per year. It is also recommended that funding be located to procure CATIA for the Silicon Grapnics. It is essential that we upgrade to the new software system to be able to use the FPM to its fullest potential.

It is also recommended that the Cincinnati Milacron Tape Laying software that resides on VAXHST be moved to one of the Silicon Graphics Workstations for a ~$22k porting fee.

The large autoclave lifting stand seal is leaking and needs to replaced/repaired. The lifting stand is currently rated for 400 pounds, with a waiver. Schedules of the FPM projects that require use of the large autoclave may be affected.

These items will be discussed again in detail with the COTR during August 1996 and appropriate actions will be taken.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

The following is a list of upcoming work to be accomplished in August.

TABLE 1

PRIORITY	TD	APPLICATION	WORK ACTIVITY
High	FPM-01	Ablative chambers	Install chambers as required for test
Med	FPM-04	18" C/E vessels	Continue winding vessels
Low	FPM-09	Isogrid cylinders	Wind foam mandrels
High	FPM-12	Intertank structure	Fabricating remaining doubler panel & test specimens
High	FPM-17	SSTO Cyrodome & Stiffeners	Fab stiffeners, panels, and domes
Med	FPM-18	Cryotest Pressure Vessels	Locate material & start panels
Med	FPM-19	Honeycomb Test Specimens	Lay-out panels & cylinder
Med	FPM-20	Low Profile Dome	Prep tooling & start layup
Med	FPM-21	Composite Cryotank	Fiber Place Tank
Med	FPM-22	Advanced Composite Structure	Support Tom Delay

Approved by: _____

L. I. Pelham
Program Manager

July 1996 Monthly Technical Progress Report

July Monthly Technical Progress Report on Operation/Maintenance of Fiber Placement Machine

NAS8-39749

Larry I. Pelham

Thiokol Space Operations
Huntsville Office
6767 Old Madison Pike, Suite 490
Huntsville, AL 35806

TWR-68109

Marshall Space Flight Center
Marshall Space Flight Center, AL

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4

Fiber Placement

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT AUGUST 1996

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for August 1996. The following paragraphs summarize the significant accomplishments during the work period beginning in August, discusses recommendations for MSFC consideration, and lists upcoming work to be performed in September 1996.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

Executed Modification 16, authorizing the performance of Technical Directives FPM-23 and FPM-24, Phase I of Liquid Engine Combustion Chamber Fabrication and Fabrication of Composite Impact Test Samples (CDDF). The Modification added $421,125 in contract value and $10,000 in allotted funding.

2.1 BASIC MACHINE OPERATIONS

FABRICATION OF FIBER PLACED TEST SPECIMENS

Delivered the completed fiber-placed CDDF panels and cylinders.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01, ABLATIVE COMBUSTION CHAMBERS (FASTRAK)

Delivered installed Fastrak combustion chamber liner to Propulsion Lab for testing of new injector. Per NASA direction, the combustion chambers liner that was used for the injector check-out tests has been removed from the damaged canister. The canister damage was mapped and photographed and delivered to the NAS machine shop for repair.

TD FPM-03, COMPOSITE HYDROGEN DEMONSTRATION TANK

Received the Cryostat composite dome from the machine shop. Holes had been drilled in the flange area. In the process of machining these holes, machining oil had dripped onto the part. The composite was wiped with alcohol and acetone and then vacuum bagged. It will be placed in an oven to help bake out the absorbed oil.

TD FPM-04, 18" x 20" PRESSURE VESSELS

No pressure vessels were fabricated in July.

TD FPM-09 DEVELOPMENT/FABRICATION OF ADVANCED COMPOSITE ISOGRID

Completed support of Ernest Foster (Tuskeegee University) in the fabrication of the isogrid cylinders structures.

We are in the process of removing the foam mandrel from one of the 5.75" x 12" pressure vessels that was wound for the E-beam cured study. While removing some of the foam, it was noted that the outer surface of resin began to craze. We believe that the cause of the cracks is due to the thick resin rich outer surface.

TD FPM-12 COMPOSITE INTERTANK STRUCTURE

Located sufficient tape layed study material to produce replacement specimens AF-4-O-T-52, AE-B-A-T-8, AA-B-O-T-8, AA-3-O-H-8 and AA-3-O-T-8. The length of the AA specimens will be shorter than the original 6" samples. This change has been approved by NASA ED52 personnel.

TD FPM-17 LH2 TANK DOMES & PANELS

Tank Wall Simulator Specimens Layed-up and cured Midspan Tank Wall Simulators (MTWS) #14 and 31 and Hoop Tank Wall Simulators (HTWS) #21-27. MTWSs #11, 13 and 28-31 and HTWSs#17-21 were received from the machine shop, had stiffeners bonded to them, and were delivered to McDonnell Douglas. HTWSs #22-27 have been received from the machine shop and are awaiting bonding. Three additional stiffener segments, Stiffeners #58-60, have been layed-up and cured.

32-Inch Composite Dome Shipped final 32-inch composite dome on the tool to McDonnell Douglas.

Stringer Crippling Specimens Bonded stiffeners to Stringer Crippling Specimens (SCS) #01-03 and delivered to McDonnell Douglas. Layed-up and cured SCSs #04-06. McDonnell Douglas changed the requested length of the SCSs from 40" to 20". SCSs #04-06 had not been rough cut prior to receiving this information so there was sufficient trim area to permit two of the smaller SCSs being produced from each of SCSs #04-06. The stiffeners for these SCSs were trimmed to 18" to correspond to the shorter SCS length.

TD FPM-18 CRYOGENIC PRESSURE VESSELS

The fiber placement machine has been brought back on line. Specific panel fabrication information was compiled from Robert Carrigan (NASA) for programming and fabrication instructions.

TD FPM-19 FIBERPLACED HONEYCOMB TEST PANELS

Project is on hold until results of the tape-layed honeycomb panels can be evaluated.

TD FPM-20 LOW PROFILE COMPOSITE DOME

The low profile dome fabrication was completed with support from Raf Ahmed (NASA). Some minor changes were made to the ply stacking to enhance the stiffness in the dome area.

TD FPM-21 COMPOSITE CRYOTANK

Awaiting Lockheed-Martin to delivery of the sand mandrel.

TD FPM-22 ADVANCED COMPOSITE STRUCTURES

Assisted Tom Delay (NASA) in the evaluation and procurement of more Thiokol TCR prepreg material. Had discussions with Mr. Delay concerning his interest in UV/EB cured epoxy resins.

3.0 RECOMMENDATIONS

It is still recommended that the new Acraplace software, ACES, be leased as soon as possible. Acraplace software has features that will allow us to more accurately generate programs and fabricate parts that we cannot currently program. The software lease rate will be $55k per year. It is recommended that funding be located to procure CATIA for the Silicon Graphics. It is essential that we upgrade to the new software system to be able to use the FPM to its fullest potential.

It is still recommended that the Cincinnati Milacron Tape Laying software that resides on VAXHST be moved to one of the Silicon Graphics Workstations for a ~$22k porting fee.

These items will be discussed again in detail with the COTR during September 1996 and appropriate actions will be taken.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

The following is a list of upcoming work to be accomplished in September

TABLE 1

PRIORITY	TD	APPLICATION	WORK ACTIVITY
High	FPM-01	Ablative chambers	Install chambers as required for test
Med	FPM-04	18" C/E vessels	Continue winding vessels
Low	FPM-09	Isogrid cylinders	Wind foam mandrels
High	FPM-12	Intertank structure	Fabricating remaining doubler panel & test specimens
High	FPM-17	SSTO Cyrodome & Stiffeners	Complete stiffeners, panels, and domes
Med	FPM-18	Cryotest Pressure Vessels	Locate material & start panels
Med	FPM-19	Honeycomb Test Specimens	Lay-out Panels & Cylinder
Med	FPM-20	Low Profile Dome	Prep tooling & start layup
Med	FPM-21	Composite Cryotank	Fiber Place Tank
Med	FPM-22	Advanced Composite Structure	Support Tom Delay
Med	FPM-23	Advanced Ablative Chambers	Design Winding Mandrel

Approved by: _____

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Program Manager

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Huntsville Office
P. O. Box 9033
Huntsville, AL 35812

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT SEPTEMBER 1996

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine Operations and Maintenance Project (Contract No. NAS8-39749) for September 1996. The following paragraphs summarize the significant accomplishments during the work period beginning in September, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in October 1996.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

Received fully executed Modification 17 exercising the Government fiscal year 1997 option, extending the period of performance through September 30, 1997. Modification 17 also incorporated Technical Directives FPM-18R1 and FPM23-R1 and increased the contract value by $1,044,477 and allotted funding by $300,000.

2.1 BASIC MACHINE OPERATIONS

PLASMA COATED FOAM MANDREL

Met with Plasma Processes, Inc. to coordinate the permeability testing of 0.030" thick and 0.050" thick thermally sprayed aluminum disks.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01 ABLATIVE COMBUSTION CHAMBERS (FASTRAK)

Waiting for NAS to refurbish the canisters.

TD FPM-09 FABRICATION OF ADVANCED COMPOSITE ISOGRID STRUCTURES

Met with NASA EH33 personnel to define direction of research. It was decided the isogrid stiffeners should be approximately one tow wide and the axial, or zero degree, stiffeners should be eliminated for the initial phases of this study. The two foam mandrels that had been machined for the Tuskegee University isogrid structure research will be remachined to the single-tow stiffener pattern.

TD FPM-12 FABRICATION OF COMPOSITE INTERTANK STRUCTURE

The second doubler panel was fabricated using two 8H IM7/8552 cloth skins co-cured with the tape laid 26-ply IM7/8552 core. The two doubler panels are awaiting delivery to NAS for machining.

The NDE intertank panel was machined into segments that will be used for hypervelocity impact testing. An additional panel to be used for hypervelocity impact testing will be fabricated using the remaining intertank honeycomb core.

The replacement honeycomb specimens have been machined and tabs are being bonded to the samples. Met with the NASA project engineer to discuss the fabrication process for the remaining test samples. The lay out for the

E-series, F-series, G-series and H-series panels is complete. The carbon/phenolic inserts for the F and H-series panels have been machined.

TD FPM-17 COMPOSITE CRYOTANK TEST SPECIMENS

Fabricated additional stiffener segments to provide sufficient stiffeners for the tank wall simulator and stringer crippling specimens. Upon receipt of these stiffeners from the machine shop, they were bonded to the remaining stringer crippling specimens and tank wall simulators. Stringer crippling specimens 4A, 4B, 5A, 5B, 6A and 6B were shipped to McDonnell Douglas along with hoop tank wall simulators #23-27 and midspan tank wall simulator #14. This completed the requirements for the tank wall simulator and stringer crippling specimens.

TD FPM-18 COMPOSITE CRYOTANK PRESSURE VESSELS

The search effort to locate the 50 pounds of the AS4/3501-6 towpreg was unsuccessful. The freezers in the Productivity Enhancement Complex and Building 4720 were searched. Generated WARs and programs for the fiberplacement of the first two permeability panels. The panels are 26" x 25" with a [90,+45,0,-45]s2 ply orientation. Panel 01 has been fiberplaced and removed from the lay-up mandrel. Panel 02 has been started and will be cured with Panel 01.

TD FPM-21 FABRICATION OF COMPOSITE CRYOTANK STRUCTURE

Awaiting delivery of 36-inch mandrel from Lockheed Martin.

TD FPM-22 COST EFFECTIVE PRODUCTION OF ADVANCED COMPOSITE STRUCTURES (CDDF)

The 100 yards of fabric and 77 pounds of basket weave of TCR prepreg were received. Faced a flange to aid machining of the foam mandrels that will be used in this study and then machined the foam blanks. A drawing for a lay-up flange tool was generated. The request for procurement has been submitted for the fabrication of the tooling.

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

The T300 graphite fiber for the 60K overwrap was received. The quantity received represents approximately 50 percent of the amount needed to complete this project. The Epicure W Cure Agent, the EPON 828 epoxy resin and 6-inch wide cure tape were also received along with the drum dollies, valves, and heater.

TD FPM-24 COMPOSITE IMPACT TEST SAMPLES (CDDF)

Met with ED lab personnel who indicated a need for 80 samples from two ply configurations for a total of 160 specimens. It was decided that one 80.75" x 40.75" panel could be tape laid to produce the 80 3" x 9.75" samples for each type. Panel 24A was the designation given to the panel possessing the [0, 45, 90, -45]3s ply orientation. The panel for the specimens with only 0 and 90 degree plies was designated Panel 24B. The ply orientation for Panel 24B was [0, 90]6s. These panels were tape laid and autoclave cured and are awaiting post cure prior to machining.

3.0 RECOMMENDATIONS

It is recommended that the new Acraplace software, ACES, be leased to improve the programming capabilities of the fiber placement machine. The software lease rate will be $55k per year. It is also recommended that, upon

the purchase of the new ACES software, a new CAD interface be developed by a cooperative NASA/Intergraph team.

It is recommended that the Cincinnati Milacron Tape Laying software that resides on VAXHST be moved to one of the Silicon Graphics workstations for a $22k porting fee. Discussions with Lockheed Martin personnel revealed that the only reason this VAXHST is maintained is for this software. Moving the software to a SG workstation should not only reduce the costs by reducing the time to generate tape layer programs but also because the VAXHST can be shutdown.

These items will be discussed again in detail with the COTR during October 1996 and appropriate actions will be taken.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM09	Low	Isogrid Cylinders	Modify foam mandrels and wind
FPM12	Med	Intertank Structure	Fabricate support specimens, hypervelocity impact samples
FPM17	Low	SSTO Specimens	Fabricate display articles
FPM18	High	Cryotank PV's	Fiberplace flat panels
FPM19	Med	Honeycomb Specs	Start programming of FPM
FPM21	High	Composite Tank	Fiberplace tank
FPM22	Med	Adv Comp Structur	Assist with fiber wet-out study and TCR study
FPM23	High	Liq Comb Chmbrs	Fabricate Fastraks and mtl property specimens
FPM24	Med	Comp Impact Specs	Machine Panels 24A & 24B

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Program Manager

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Huntsville Office
P. O. Box 9033
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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT OCTOBER 1996

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for October 1996. The following paragraphs summarize the significant accomplishments during the work period beginning in October, discusses recommendations for MSFC consideration. and lists the upcoming work to be performed in November 1996.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

Received Technical Directive No. FPM-25, Fabrication of Bantam Composite RP Tank. Technical Directive effort is determined to be out of scope and a cost proposal will be developed.

Fabricated the majority of the remaining IM7/8551-7 panels to support the intertank (Technical Directive FPM-12). Completed fabrication of the first four fiber placed panels for the composite cryotank pressure vessels (Technical Directive FPM-18). Work has started on production of the material property specimens for Technical Directive FPM-23 as well as the first of the 7K liners. Delivered the composite impact specimens from Panel 24A (Technical Directive FPM-24).

2.1 BASIC MACHINE OPERATIONS

Four tensioners and four sensors were removed from the Fiber Placement Machine and were packaged for shipment to Cincinnati Milacron for repair. The bellows sleeve for the X-axis screw on the FPM sheared off. This bellows sleeve is used to protect the ball screw. It was removed so the panel that was being fabricated could be completed. Two replacement bellows were ordered and one was placed on the machine upon receipt.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01 ABLATIVE COMBUSTION CHAMBERS (FASTRAK)

Still waiting on refurbished canisters.

TD FPM-09 FABRICATION OF ADVANCED COMPOSITE ISOGRID STRUCTURES

Understand that scope may be increased.

TD FPM-12 FABRICATION OF COMPOSITE INTERTANK STRUCTURE

Fabricated hypervelocity intertank-splice specimens. These specimens represented the same bonding procedure as the full scale intertank. Two segments were bonded together using one layer of AF 3024 core splice adhesive between the panels. The splices were bonded to the segments using EA9394 and the assembled specimens were cured at 225/F to cure both the core splices and EA9394 adhesives.

The phenolic blocks for the F and H series specimens and cure dams for the F series panels were machined. The E, F and G IM7/8551-7 replacement panels were then tape layed, assembled, and cured. The tape layer programs for the E-H series panels were written to compensate for the tape widths varying from 2.995" to 3.040" so that the programs can be used for all three materials. An additional autoclave cured F panel will be fabricated using IM7/8552 3-inch tape.

TD FPM-17 COMPOSITE CRYOTANK TEST SPECIMENS

The display hoop and midspan tank wall simulators have been received from the machine shop. Stiffeners will be bonded to these articles and they will be displayed, per NASA request, in the automated composites production labs in the Productivity Enhancement Complex.

TD FPM-18 COMPOSITE CRYOTANK PRESSURE VESSELS

Completed fiber placement and cure of IM7/8551-7 towpreg Panels 03 and 04. Panel 03 was 26-inches x 25-inches and Panel 04 was 14-inches x 13-inches, both with a [90, 45, 0, -45] lay-up. Cure charts and a spreadsheet detailing material usage and panel weights were developed and will be delivered to the principal investigator. Several discussions were held about pole boss investigations at cryogenic temperatures. Atkins and Pearce in Covington, Kentucky, have been contacted to provide samples of braided components to determine if that process can be used to manufacture composite pole bosses.

TD FPM-21 FABRICATION OF COMPOSITE CRYOTANK STRUCTURE

Lockheed Martin is researching various mandrel fabrication alternatives. Fabrication of a foam mandrel is the most recent concept that will be investigated to produce the 36 inch diameter bottle.

TD FPM-22 COST EFFECTIVE PRODUCTION OF ADVANCED COMPOSITE STRUCTURES (CDDF)

A test matrix was prepared to develop resin options for cryogenic applications which rapidly gel under UV and develop full cure under modest oven exposure. Initially, the material baseline will be established by evaluating T_g and tensile strength of current production (thermally cured) toughened epoxies. Additionally, the cure rate and photoinitiator of Loctite UV cured resins will be evaluated. A series of formulation variations will be prepared, holding photoinitiator concentration and base epoxy resin (Epon 828) constant, and using no

latent thermal initiator. The variables investigated will be concentrations of aliphatic epoxy resin/diluent, Heloxy 505 and conventional rubber toughener. After cure, the T_g and tensile strength will be evaluated and compared to the baselines. A test bottle will be wound and burst if targets are met. Follow-on testing could include optimization of cure time by varying photoinitiator concentration, latent catalyst concentration, UV exposure time, UV lamp intensity, oven cure time, and oven cure temperature.

Two aluminum lay-up flange tools were procured. An additional aluminum ring was machined to aid lay-up on these tools.

A TCR flow characteristics study was conducted to see if the excess resin that bleeds off during cure would be sufficient to wet-out the braided material that had been procured. TCR prepregged cloth was laid onto the SXI Telescope Tube mandrel and then the dry, braided fiber material was placed over it. Shell 828 resin was painted on one half of the length of mandrel, the other half left dry. The TCR prepreg had sufficient resin flow to wet the braid where, by visual inspection, there was no discernible difference between the resin and non-resin wetted ends.

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

The first 7K Silica Liner (#01) has been tape wrapped, vacuum bagged and cured. All of the silica material properties test panels, the structural properties and 45/ ply angle thermal property panels, were assembled, vacuum bagged, and cured along with 7K liner #01. The first shipment of the 3,400 lbs of silica tape for the 40K liners has been received and stored. This will fabricate approximately nine 40K liners before the remaining material is ordered to complete the last nine for a total of eighteen.

Approximately 35 epoxy prepreg tapes were produced and all of the panels from this prepreg were layed-up and cured. The test specimens will be machined from the panels and delivered to NASA/MSFC personnel. The napkin ring specimen modifications are in design to accommodate testing the stainless steel, film adhesive, and graphite/epoxy bondline. The double lap shear stainless steel tabs and spacers are in design for the double lap shear testing.

TD FPM-24 COMPOSITE IMPACT TEST SAMPLES (CDDF)

Both panels, Panel 24A and Panel 24B, were post cured for two hours at 350°F. Machined Panel 24A into 96 3-inch by 9.75-inch test specimens. These specimens were cleaned, bagged, and delivered. The samples from Panel 24B have been rough cut and are being final machined. Panel 24B will produce 96 specimens as well, exceeding the 80 required per each configuration.

3.0 RECOMMENDATIONS

It is still recommended that the new ACES Acraplace fiber placement machine software be leased to improve fabrication capabilities. It is also recommended that the tape laying software be ported to the Silicon Graphics machine.

4.0 UPCOMING WORK

The following is a list of upcoming work to be accomplished in November.

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM09	Low	Isogrid Cylinders	Modify foam mandrels and wind
FPM12	Med	Intertank Structure	Fabricate support specimens
FPM17	Low	SSTO Specimens	Fabricate display articles
FPM18	Low	Composite PVs	Outline program objectives
FPM19	Low	Fiberplaced Specimens	Start programming of machine
FPM21	Low	Composite Cryotank	Fabricate tank when mandrel arrives
FPM22	Med	Adv Comp Structures	Provide labor and technical support
FPM23	High	Liq Comb Chambers	Fabricate panels and 7K liners
FPM24	Med	Comp Impact Specs	Machine Panel 24B specimens

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Huntsville Office
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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT NOVEMBER 1996

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for November 1996. The following paragraphs summarize the significant accomplishments during the work period beginning in November, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in December 1996.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

Contractual

Cost plus fixed fee proposal in the amount of $322,839 was submitted in response to Technical Directive FPM-25, Fabrication of Bantam Composite RP Tank. Received, reviewed, and released Modification 18, which added $61,760 in contract funding.

Technical Performance

Completed fabrication of the IM7/8551-7 and IM7/8552 panels for the honeycomb support specimens (FPM-12). Completed overwrap and cure of four Fastraks that are now prepared to be machined (FPM-23). Delivered 96 3" x 9.75" specimens from Panel 24B to fulfill the requested amount of impact test samples (FPM-24).

2.1 BASIC MACHINE OPERATIONS

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01 ABLATIVE COMBUSTION CHAMBERS (FASTRAK)

Waiting on NAS to refurbish the canisters.

TD FPM-09 ADVANCED COMPOSITE ISOGRID STRUCTURES

Effort will be revised to add scope that will include 2 to 3 eighteen-inch pressure vessels with internal isogrids.

TD FPM-12 FABRICATION OF COMPOSITE INTERTANK STRUCTURE

Delivered the replacement specimens from the AA-AF panels. The E, F and G IM7/8551-7 panels were oven cured. These panels exhausted the supply of this epoxy 3" tape purchased for this project. Another F series panel was fabricated using the IM7/8552 3" prepreg and autoclave cured. The composite splices for the G series IM7/8551-7 specimens will also be produced from the IM7/8552 tape. The E-series IM7/8551-7 specimens from Panels 1A and 1O were machined. Have started machining the F-series IM7/8551-7 and IM7/8552 panels, Panels 4, 5 and 4_2. Production of the skins for the F-series AS4/3501-6 samples has also begun.

TD FPM-17 COMPOSITE CRYOTANK TEST SPECIMENS

The display hoop and midspan tank wall simulators were completed and are located in the automated composites production lab in the Productivity Enhancement Complex. Torr Technologies indicated that the bags would be repaired due to the fact the silicone lot that was used for this application did not meet the manufacturer's established durometer and elongation criteria.

TD FPM-18 COMPOSITE CRYOTANK PRESSURE VESSELS

Technical discussions held to determine desired direction of future research.

TD FPM-19 FIBER PLACED HONEYCOMB TEST SPECIMENS

Received specifications of honeycomb to be purchased.

TD FPM-21 FABRICATION OF COMPOSITE CRYOTANK STRUCTURE

Waiting on Government-furnished 36-inch mandrel.

TD FPM-22 COST EFFECTIVE PRODUCTION OF ADVANCED COMPOSITE STRUCTURES (CDDF)

A sample has been requested of the Loctite UV cured resin.

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

Stainless steel Double Lap Shear, Tensile Button, and Napkin Ring specimens have been received. Machining of all of the composite test specimens was completed and the samples were delivered for testing. The first four Fastraks, 7KC1 - 7KC4 have been overwrapped with fiberglass/epoxy and are ready for machining. Fastrak Liner #5 has been tape wrapped and cured and is awaiting overwrap. Liner #6, 7KC6, is being tape wrapped.

TD FPM-24 COMPOSITE IMPACT TEST SAMPLES (CDDF)

The 96 3" x 9.75" specimens from Panel 24B were machined and delivered. This completed the requirement of the specimens for this project. A total of 192 3" x 9.75" specimens were produced, 96 with a [0,45,90,-45]3s orientation and 96 with a [0,90] 6s lay-up.

3.0 RECOMMENDATIONS

It is recommended that the new ACES Acraplace fiber placement machine software be leased to improve fabrication capabilities. It is also recommended that the tape laying software be ported to the Silicon Graphics machine.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM09	Med	Isogrid Cylinders	Modify foam mandrels and wind
FPM12	Med	Intertank Structure	Fabricate support specimens
FPM17	Low	SSTO Specimens	Place tooling in storage
FPM18	Low	Composite PVs	Outline program objectives
FPM19	Low	Fiberplaced Specimens	Procure honeycomb/program FPM
FPM21	Low	Composite Cryotank	Fabricate tank when mandrel arrives
FPM22	Med	Adv Comp Structures	Provide labor and technical support
FPM23	High	Liq Comb Chambers	Fabricate panels and 7K liners
FPM24	Med	Comp Impact Specs	Supply cure charts/process document
FPM25	High	Composite RP-1 Tank	Generate tool drawings/procure mtl

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT DECEMBER 1996

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for December 1996. The following paragraphs summarize the significant accomplishments during the work period beginning in December, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in January 1997.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

Received Technical Directive FPM-09R1, revised scope for the Development/Fabrication of Advanced Composite Isogrid Structure. A proposal will be developed and dispatched.

Received spray coated mandrels and permeability samples (TD FPM-00). Received router and vacuum system to aid isogrid fabrication (TD FPM-09). Continued honeycomb support specimen work (TD FPM-12). Continued fabrication of 7K liners, 40K inserts and started work on bonding specimens (TD FPM-23). Started tooling design and procurement processes and ordered prepreg (TD FPM-25).

2.1 BASIC MACHINE OPERATIONS

Procured request for IM7/954-3 and IM7/977-3 prepreg fabrics.

PLASMA COATED FOAM MANDRELS

The plasma coated foam mandrels and permeability samples were received from Plasma Processes. J. Vickers, NASA EH33 was contacted to set up a meeting to discuss the over wrap process.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01 ABLATIVE COMBUSTION CHAMBERS (FASTRAK)

Waiting on NAS to refurbish the canisters.

TD FPM-09 ADVANCED COMPOSITE ISOGRID STRUCTURES

The new router and vacuum system was received. These were found to require minor modifications to pick up the foam particles. The end plate of the vacuum system was removed and a brush installed around the circumference to allow for better pick up of the heavier foam particles. This approach was tested and worked well. Preliminary patterns were developed for the grid machining and reviewed by NASA/MSFC. NASA/MSFC selected their optimal pattern which will be fully developed.

TD FPM-12 FABRICATION OF COMPOSITE INTERTANK STRUCTURE

Delivered the remainder of the replacement specimens from the AA-AF specimens. Completed machining of the IM7/8551-7 and IM7/8552 F-series panels. Started fabrication of the E-series and H-series AS4/3501-6 panels. Working on filling the area between the phenolic blocks and the core for the IM7/8551-7 autoclave cured panels. NASA/MSFC is checking into the status of the aluminum C-channels for the H-series specimens.

TD FPM-17 COMPOSITE CRYOTANK TEST SPECIMENS

Awaiting the delivery of the reusable silicone bags that are being repaired at Torr Technologies.

TD FPM-21 FABRICATION OF COMPOSITE CRYOTANK STRUCTURE

Lockheed Martin is investigating the feasibility of producing a foam mandrel.

TD FPM-22 COST EFFECTIVE PRODUCTION OF ADVANCED COMPOSITE STRUCTURES

A meeting to discuss various tooling approaches was held with. To support ongoing mandrel investigations, information on companies that fabricate expanded polystyrene foam was forwarded provided.

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

Completed fabrication of Fastrak chambers #7KC5 and 7KC6. The new PPG 1062 fiberglass was used for the over wrap of #7KC6. It stayed under tension better during processing then the Owens Corning 158B material that was used for the previous liners. By visual inspection, this appeared to be the best 7K CC. Delivered two of the 7K CC Liners to the machine shop for final machining. Received 40K CC Liner #01(A) from the test stand and 40K Liner #02(A) was picked up. Completed fabrication of the first 40K Insert Billet #01B. The stainless steel components for the bond test were received. from. These components were prepped for bonding by hand cleaning with 1, 1, 1, vapor degreasing with 1, 1, 1, grit blasting and priming with BR127 primer.

TD FPM-24 COMPOSITE IMPACT TEST SAMPLES

Generated cure charts for Panels 24A and 24B as well as the post cure cycle for both panels.

TD FPM-25 BANTAM COMPOSITE RP TANK

All phases of work on this program were initiated. Aided NAS and NASA/MSFC personnel in producing drawings for a new cradle for the large autoclave. The cradle is being procured. Drawings for the vessel half mandrel were generated and turned over to Thiokol Utah procurement personnel. Work was begun on the drawings for the neck mandrel and neck flange. The TCR prepreg to be used was ordered. The cloth was T-650 3K fabric and was selected due to its availability and certification.

3.0 RECOMMENDATIONS

It is still recommended that the new ACES Acraplace fiber placement machine software be leased to improve fabrication capabilities. It is also recommended that the tape laying software be ported to the Silicon Graphics machine.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM09	High	Isogrid Cylinders	Modify foam mandrels and wind
FPM12	Med	Intertank Structure	Fabricate support specimens
FPM17	Low	SSTO Specimens	Place tooling in storage
FPM18	Low	Composite PVs	Outline program objectives
FPM19	Low	Fiberplaced Specimens	Procure honeycomb/program FPM
FPM21	Low	Composite Cryotank	Fabricate tank when mandrel arrives
FPM22	Med	Adv Comp Structures	Provide labor and technical support
FPM23	High	Liq Comb Chambers	Fabricate 7K liners & 40K inserts
FPM25	High	Composite RP-1 Tank	Procure tooling and materials

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Larry I. Pelham

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Huntsville Office
P. O. Box 9033
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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
JANUARY 1997

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for January 1997. The following paragraphs summarize the significant accomplishments during the work period beginning in January, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in February 1997.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

A proposal, in the amount of $41,801, was submitted in response to Technical Directive FPM-09R1, Development/Fabrication of Advanced Composite Isogrid Structure (CDDF), Revision 1.

Intertank passed proof test and honeycomb support specimen fabrication is ongoing (TD FPM12). Continuing fabrication of 40K Combustion Chamber (CC) liners and installed a new 7K CC liner in the canister and delivered it to the test stand (TD FPM-23). Encountered difficulty in procuring a CRES Bantam RP-1 Tank vessel half mandrel so material specification was changed to aluminum (TD FPM-25).

2.1 BASIC MACHINE OPERATIONS

PLASMA COATED FOAM MANDRELS

Met with NASA to discuss overwrap ply orientation, thickness, cure techniques and desired surface finish of the finished part. Work will begin when the requirements are finalized.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01 ABLATIVE COMBUSTION CHAMBERS (FASTRAK)

Still waiting on the refurbishment of the canisters.

TD FPM-03 COMPOSITE HYDROGEN DEMONSTRATION TANK

Awaiting delivery of the dome so that a center cap/repair can be fabricated.

TD FPM-09 ADVANCED COMPOSITE ISOGRID STRUCTURES

Patterns were generated to start machining and winding of the isogrids. Met with NASA to discuss project requirements. The grid pattern size and depth were established. Machining of the foam blanks will start when NASA procures the bits to machine the proper contour into the foam.

TD FPM-12 FABRICATION OF COMPOSITE INTERTANK STRUCTURE

The intertank was tested and passed the 260 kip proof load. Started process planning for second hypervelocity impact panel. Fabricated E-series BMI panel and completed fabrication of the F-series AS4/3501-6 specimens. This completed the fabrication of the F-series specimens. Received the aluminum C-channel for the H-series specimens and the aluminum splice material for the G-series panels.

TD FPM-17 COMPOSITE CRYOTANK TEST SPECIMENS

Received reusable cure bags from Torr Technologies. Instead of replacing the entire bag in the frame, additional silicone was placed over the tears along the edges.

TD FPM-19 FIBER PLACED HONEYCOMB TEST SPECIMENS

Honeycomb will be ordered in preparation for fabrication. The honeycomb may be a long lead time material which will allow sufficient time for programming of the machine.

TD FPM-21 FABRICATION OF COMPOSITE CRYOTANK STRUCTURE

Awaiting delivery of the mandrel by Lockheed Martin.

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

Completed fabrication of 40K Inserts #02B and 03B. Received 40K CC Liner #2A back after testing by the Propulsion Lab. Picked up six 7K CC liners from machine shop where they will be stored until they are ready for testing. Removed tested liner and installed Liner #02B into the 7K CC Canister. Pressure port and igniter holes were drilled in 7K CC Liner #02B and it was delivered to the test stand personnel.

TD FPM-25 BANTAM COMPOSITE RP TANK

Submitted procurement requests for FM 300-2M film adhesive and EA9394. Received 1000 lbs of TCR prepreg. Encountered severe difficulty in procuring the vessel half mandrel. A large database of vendors was developed before the decision was made to fabricate the mandrel from aluminum instead of CRES. The decision to go to aluminum was made to reduce the cost of the mandrel. The autoclave cradle procurement was awarded. NASA added work that includes fabrication of material property specimens and adding level sensors to the internal baffles.

3.0 RECOMMENDATIONS

It is still recommended that the new ACES Acraplace fiber placement machine software be leased to improve fabrication capabilities. It is also recommended that the tape laying software be ported to the Silicon Graphics machine.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM09	High	Isogrid Cylinders	Modify foam mandrels and wind
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FPM19	Low	Fiberplaced Specimens	Procure honeycomb/program FPM
FPM21	Low	Composite Cryotank	Fabricate tank when mandrel arrives
FPM22	Low	Adv Comp Structures	Provide labor and technical support
FPM23	High	Liq Comb Chambers	Fabricate 7K liners & 40K inserts
FPM25	High	Composite RP-1 Tank	Procure tooling/mtls. Fab mtl samples

Approved by: L. I. Pelham
Program Manager

January 1997 Monthly Technical Progress Report

January Monthly Technical Progress Report on Operation/Maintenance of Fiber Placement Machine

NAS8-39749

Larry I. Pelham

Thiokol Space Operations
Huntsville Office
P. O. Box 9033
Huntsville, AL 35812

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Marshall Space Flight Center
Marshall Space Flight Center, AL

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Fiber Placement

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT FEBRUARY 1997

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for February 1997. The following paragraphs summarize the significant accomplishments during the work period beginning in February, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in March 1997.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

Received Modification 20 to the contract authrizing and definitizing Technical Directive FPM-09R1, Development/Fabrication of Advanced Composite Isogrid Structure (CDDF), Revision 1. Contract value was increased by $41,399, and funding was increased by $30,000.

2.1 BASIC MACHINE OPERATIONS

PLASMA COATED FOAM MANDRELS

Over wrapped the first plasma sprayed mandrel with IM7/977-2 and cured it. One layer of EA9628 film adhesive was used to aid adhesion of the overwrap to the mandrel. This bottle was delivered for testing.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01 ABLATIVE COMBUSTION CHAMBERS (FASTRAK)

Received refurbished canisters.

TD FPM-03 COMPOSITE HYDROGEN DEMONSTRATION TANK

Waiting delivery of the dome so that a center cap/repair can be fabricated.

TD FPM-09 ADVANCED COMPOSITE ISOGRID STRUCTURES

Completed fabrication of two isogrid structures. The first structure was made using a foam mandrel with a helical grid pattern that had been painted with white paint to serve as a release. This bottle was autoclave cured at 35 psi. Visual inspection revealed that overall this was an acceptable part but in trying to remove the white paint residue by water blasting some of the internal grid structure was damaged. It was decided to use sand sealer for the second bottle which not only contained the helical grid pattern but also had hoops passing through the nodes. This structure was wound and cured. The next structure to be fabricated will have axially aligned tows instead of hoops.

TD FPM-12 FABRICATION OF COMPOSITE INTERTANK STRUCTURE

The machining of the 43" x 3.25" F-series for the IM7/8551-7, IM7/8552 and AS4/3501-6 was completed. The IM7/8552 skins for panel #2 have been tape laid to the size of the non-tapered main acreage of the honeycomb that was used for the intertank segments.

TD FPM-18 SUBSCALE COMPOSITE CRYO-TEST PRESSURE VESSELS

Waiting direction from new NASA/MSFC principal investigator into the direction of the remainder of this study.

TD FPM-19 FIBER PLACED HONEYCOMB TEST SPECIMENS

Need to order honeycomb core and meet with NASA/MSFC principal investigator to define project goals.

TD FPM-21 FABRICATION OF COMPOSITE CRYOTANK STRUCTURE

Waiting delivery of the provided mandrel.

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

The first two 40K combustion chambers were received from the machine shop along with the 40K combustion chamber inserts numbers 01B and O2B to be placed in the machined chambers. The first two 60K (with a 15 to 1 expansion ratio exit cone) were tape wrapped and cured and are ready to be machined. The extension rods to complete non-ambient napkin ring testing have been manufactured and delivered. Fabrication of the aft ring for overwrapping the 15:1 60K was awarded with a delivery in March. Furnished a copy of the spreadsheet detailing overwrap thickness and wind angle to R. Sullivan, NASA/MSFC ED24. Fast-response thermocouples were procured for attachment to the third 40K that is to be test fired early in March. NASA/MSFC identified top-dead-center of the chamber for the precise location of these thermocouples. Investigating if vendor supplied data on the EA 9628 adhesive strength is sufficient.

TD FPM-25 BANTAM COMPOSITE RP TANK

Revised the drawing for the tank half mandrel to include the change to 6061 aluminum. The tank mandrel procurement was awarded. The drawings for the neck mandrel and flange mandrel are being checked. Have started work on the design of the drill fixtures for the skirt and nozzle drill fixtures. Have also started on the material property specimens. Completed fabrication of the 9" x 1" 0°, 45° and 90° tensile specimens. The 0° and 90°compression sample panels along with the tensile seam specimen panels have been laid up. Two containers of Pyromark high temperature paint were delivered to Santek Engineering who anticipates delivering the autoclave cradle in early March. The tank lay-up has changed from a 4-ply wall thickness with 2 plies laid the length of the tank from the skirt to a 6-ply wall thickness with a belly band to help join the two halves.

3.0 RECOMMENDATIONS

It is still recommended that the new ACES Acraplace fiber placement machine software be leased to improve fabrication capabilities. It is also recommended that the tape laying software be ported to the Silicon Graphics machine.

4.0 AUTHORIZED AND FUNDED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM09	High	Isogrid Cylinders	Modify foam mandrels and wind
FPM12	Med	Intertank Structure	Fabricate support specimens
FPM18	Low	Composite PVs	Outline program objectives
FPM19	Low	Fiberplaced Specimens	Procure honeycomb/program FPM
FPM21	Low	Composite Cryotank	Fabricate tank when mandrel arrives
FPM23	High	Liq Comb Chambers	Fabricate 60K Liners
FPM25	High	Composite RP-1 Tank	Procure tooling/mtls. Fab mtl samples

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Huntsville Office
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Huntsville, AL 35812

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT MARCH 1997

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for March 1997. The following paragraphs summarize the significant accomplishments during the work period beginning in March, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in April 1997.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

2.1 BASIC MACHINE OPERATIONS

PLASMA COATED FOAM MANDRELS

Discussed with UAH and NASA areas on the first overwrapped bottle that showed on up on thermography scans as possessing unevenly distributed characteristics. The regions showing this were the transitions from the cylindrical section to the domes. This could be due to the fact that the hoop plies stop there forming resin rich areas between the helical plies or that the adhesive film properties become significant due to the fact that there are fewer layers of overwrap. This bottle has been turned over to NASA to perform NDE and then eventually cut the structure so that the cross-section can be visually examined. Fabrication of the second bottle is on hold until the analysis of the first is completed.

NEXT GENERATION SPACE TELESCOPE (NGST) SUPPORT PLATE

NASA has requested that Thiokol fabricate an approximate 20-inch diameter, 1-inch tall honeycomb plate to be used for the support structure for a prototype NGST normal incidence mirror. NASA will supply the honeycomb and adhesives for this project. An existing 21-inch aluminum mandrel from another program will be used to fabricate the encapsulating ring to be placed around the core to give the plate an all graphite/epoxy shell.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01 ABLATIVE COMBUSTION CHAMBERS (FASTRAK)

Waiting request from NASA to bond new 7K liner into repaired canisters.

TD FPM-03 COMPOSITE HYDROGEN DEMONSTRATION TANK

Waiting delivery of the dome so that a center cap/repair can be fabricated.

TD FPM-09 ADVANCED COMPOSITE ISOGRID STRUCTURES

Filament wound the third isogrid structure. This pattern had axially aligned tows along with the helical pattern to form the internal grid structure. This IM7/8552 bottle was cured in the autoclave at 35 psi. Upon examination after cure, it was determined that there was insufficient compaction on the axially aligned tows prior to overwrap. This is due to the fact that these tows are not wound under tension like the hoops or helicals. Intermediate steps including heated debulks may be required to aid compaction of the axial grid tows during processing and prior to overwrap.

TD FPM-12 FABRICATION OF COMPOSITE INTERTANK STRUCTURE

Autoclave cured an AS4/3501-6 E-series panel, Panel 2A. The AS4/ 3501-6 H-series panel was cured and post-cured. Cured the second hypervelocity impact panel, HI-2, and received specimen machining pattern for this panel. From this panel, NASA has requested the fabrication of six 8-inch by 8-inch joint specimens using the splice and bonding technique used to produce the intertank. The remaining panel material will be cut into 8-inch by 8-inch single panel specimens.

TD FPM-18 SUBSCALE COMPOSITE CRYO-TEST PRESSURE VESSELS

Waiting direction from new NASA principal investigator as to the direction of the remainder of this study.

TD FPM-19 FIBER PLACED HONEYCOMB TEST SPECIMENS

No activity.

TD FPM-21 FABRICATION OF COMPOSITE CRYOTANK STRUCTURE

Waiting delivery of the required mandrel.

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

Fourteen EA 9628 steel-to-steel button samples were delivered to NASA. The third 40K combustion chamber (cc) underwent a thirty second test firing. Fast response thermocouples were placed in five locations on the exterior of this chamber. The two near the end of the exit cone that were to be used for measuring air temperature were taped to the part by NASA test stand personnel giving a part temperature instead of the desired air temperature. This cc has been returned to the PEC. Silica inserts were installed in 40K cc #01 and cc 02, and they were delivered to NAS for machining. The first 60K was delivered to NAS to machine the outside diameter for the graphite/epoxy overwrap. The third 60K cc Liner #03 was tape wrapped, vacuum bagged, and autoclave cured. Upon removal from the mandrel, inspection revealed low resin flow areas in the forward end of the combustion chamber. The preliminary investigation did not show any abnormal data on the processing or cure cycle. The cause and corrective action items on the discrepancy report for 60K cc liner #03 will not be completed until a C.T. scan is performed to determine the extent of the discrepant area. Tape wrapping has started on 60K cc liner #04.

TD FPM-25 BANTAM COMPOSITE RP TANK

Hand laid and autoclave cured the panels for the three tensile ply seam specimens. The specimens were machined and delivered to NASA. Also cured the panels for the compression specimens, the tank wall portion of the belly band samples and the 3-direction tension buttons. Received drawing from NASA and generated procurement request for the manhole bolt ring. This ring will now be mechanically-fastened to the tank. Submitted procurement request for the neck and flange mandrel for the tank. Drawings for the skirt and neck drill fixtures along with the stub shaft have been generated and are in review.

3.0 RECOMMENDATIONS

It is recommended that the tape laying software be ported to the Silicon Graphics machine. It is also recommended that CATIA be purchased so that the new FPM software can be utilized.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM09	High	Isogrid Cylinders	Modify foam mandrels and wind
FPM12	Med	Intertank Structure	Fabricate support specimens
FPM18	Low	Composite PVs	Outline program objectives
FPM19	Low	Fiberplaced Specimens	Procure honeycomb/program FPM
FPM21	Low	Composite Cryotank	Fabricate tank when mandrel arrives
FPM23	High	Liq Comb Chambers	Fabricate 60K Liners
FPM25	High	Composite RP-1 Tank	Design/procure tooling, Fab mtl samples

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Thiokol Space Operations
Huntsville Office
P. O. Box 9033
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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT APRIL 1997

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for April 1997. The following paragraphs summarize the significant accomplishments during the work period beginning in April, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in May 1997.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

Received Technical Directive FPM-26, Fabrication of Upperstage 10K Combustion Chambers. NASA/MSFC has been advised that this is outside the authorized scope of the contract and that a CPFF proposal is forthcoming. A proposal was submitted in the amount of $245,890.

2.1 BASIC MACHINE OPERATIONS

NEXT GENERATION SPACE TELESCOPE (NGST) SUPPORT PLATE

Hand laid and autoclave cured two IM7/8552 [0, 60, -60]s skins for the fabrication of the support plate. Also fabricated an approximate 21 inch diameter IM7/8552 composite ring that will be used to enclose the honeycomb core. It was decided to use 108GL/8552 cloth and FM 300-2K to bond the skins to the core. Designed a cure fixture to align the stainless steel inserts when they are bonded into the honeycomb plate. Also designed a fixture for the encapsulating ring to maintain roundness of the ring to the bottom skin during cure.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01 ABLATIVE COMBUSTION CHAMBERS (FASTRAK)

Waiting for a request from NASA to bond new 7K liner into repaired canisters.

TD FPM-03 COMPOSITE HYDROGEN DEMONSTRATION TANK

Waiting delivery of the dome so that a center cap/repair can be fabricated.

TD FPM-12 FABRICATION OF COMPOSITE INTERTANK STRUCTURE

Completed the intertank hypervelocity impact specimens. There were a total of 19 8-inch by 8-inch single panels and 6 bonded splice samples fabricated using the IM7/8552 prepreg tape and the remaining intertank aluminum core segment. Machined the remainder of the E-series specimens for the AS4/3501-6 and BMI systems.

TD FPM-18 SUBSCALE COMPOSITE CRYO-TEST PRESSURE VESSELS

Awaiting indication from new NASA principal investigator as to the direction of the remainder of this study.

TD FPM-19 FIBER PLACED HONEYCOMB TEST SPECIMENS

No significant composite processing activity.

TD FPM-21 FABRICATION OF COMPOSITE CRYOTANK STRUCTURE

Waiting delivery of the required mandrel, possibly a foam structure that will be machined using the fiber placement machine.

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

Completed autoclave cure on 60K Combustion Chamber Silica Liner #04. This billet showed some of the same "dry" (limited resin flow) areas in the forward end as Liner #03. A -carbon/phenolic tape wrap billet was also cured and displayed the same problem. The tape wrap machine possessed an uneven air temperature distribution from the pre-heat nozzles, causing the phenolic resin to partially cure along the edge of the prepreg tape, carbon or silica. MSI located an inoperable control circuit board that controls the heat and air flow, repaired it and reprogrammed the control parameters. Delivered 60K Liners #02-04 for contour machining. The 40K Liners #01 and 2 were returned after the machining of the second set of silica inserts. Investigating machine shops to perform both the machining of the 60K silica billets as well as the machining of the finished combustion chambers. Investigating the possibility of using AS4, the original overwrap fiber, or T-700 carbon fiber, which has the same tensile modulus of 33 ksi that the T-300 possesses, to use for the overwrap due to the limited availability of the baselined T-300. Submitted procurement requests for 500 lbs of MX2600 silica/phenolic 2.5-inch tape, 1,250 lbs of MX2600 silica phenolic 3.5-inch tape and 1,100 lbs of the T-300 for the overwrap. The aft overwrap ring was received from the machine shop after modifications were made to permit the ring to be inserted further into the exit cone. NASA has requested that the 60K mandrels be modified to allow for tag-ends and that the first three 60Ks be instrumented.

TD FPM-25 BANTAM COMPOSITE RP TANK

Fabricated five flammability specimens and delivered them as well as 3-direction tension buttons. Continuing work on belly band specimens. Performed stress analysis on stub shafts. Cure cart design is being reviewed by Utah stress personnel. Received the neck drill fixture. The skirt drill fixture and stub shaft procurements were awarded. NASA has requested that modifications be made to the cart to allow it to be used for painting the tank and also during shipment of the completed tank to Stennis.

3.0 RECOMMENDATIONS

It is recommended that the tape laying software be ported to the Silicon Graphics machine. It is also recommended that CATIA be purchased so that the new FPM software can be utilized.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
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FPM21	Low	Composite Cryotank	Fabricate tank when mandrel arrives
FPM23	High	Liq Comb Chambers	Fabricate 60K Liners
FPM25	High	Composite RP-1 Tank	Fab mtl samples. Start tank component fab

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Huntsville Office
P. O. Box 9033
Huntsville, AL 35812

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Marshall Space Flight Center
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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
May 1997

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for May 1997. The following paragraphs summarize the significant accomplishments during the work period beginning in May, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in June 1997.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

A cost plus fixed fee proposal was dispatched for both the increased scope and cost growth relating to the RP Tank task.

2.1 BASIC MACHINE OPERATIONS

NEXT GENERATION SPACE TELESCOPE (NGST) SUPPORT PLATE

The plate was bonded together and the skins were machined to the diameter of the encapsulating ring. The cure fixture was fabricated for aligning the three stainless steel inserts during cure. The three inserts were bonded into the plate and the completed plate was delivered to J. Redmon of NASA.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01 ABLATIVE COMBUSTION CHAMBERS (FASTRAK)

Waiting for a request from NASA to bond new 7K liner into repaired canisters.

TD FPM-03 COMPOSITE HYDROGEN DEMONSTRATION TANK

Awaiting delivery of the dome so that a center cap/repair can be fabricated.

TD FPM-09 ISOGRID STRUCTURE

Awaiting direction from NASA principal investigator.

TD FPM-18 SUBSCALE COMPOSITE CRYO-TEST PRESSURE VESSELS

Awaiting indication from new NASA principal investigator as to the direction of the remainder of this study.

TD FPM-19 FIBER PLACED HONEYCOMB TEST SPECIMENS

TD FPM-21 FABRICATION OF COMPOSITE CRYOTANK STRUCTURE

Waiting delivery of the required mandrel, possibly a foam structure that will be machined using the fiber placement machine.

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

The test "bumblebee" billet containing silica and carbon tape to check the wrap and cure was cured. This billet showed the same "low" Resin Flow as 60K #05 and the UUEC Carbon Test Billet. An infra-red camera was used to check temperature distribution of the Tape Wrap Machine Nozzles on the next test billet. The test billet appeared to retain more heat than necessary so additional CO_2 was used when wrapping the next test billet. The use of additional CO_2 cooling resulted in more uniform temperatures and no build-up of residual heat in the wrapped billet. Upon curing though, this new test billet did not look any different than the previous one. Investigation into these wrap and cure anomalies is continuing

Meeting was held with NASA about the instrumentation of the first three 60K Combustion Chambers. NASA requested that there be 8 Type S and 16 Type K thermocouples used on each chamber. The Type S thermocouples will be the thermocouple used closest to the interior of the chamber in the plug configuration. NASA is still requesting tag ends for the chambers because they will be required for the X-34. NASA has also requested that fast response thermocouples be attached to the 40K chamber in the test stand.

The overwrap mandrel for the 60Ks was received from Summa Technology. The test fit indicated that six more springs will need to be ordered.

TD FPM-25 BANTAM COMPOSITE RP TANK

The RP-1 tank mandrel was received and prepared for use. Received stub shafts and skirt drill fixture. Lay-up/cure cart drawing has been released for cart fabrication. Manhole end trimmer drawing has been submitted for release. Drawings for hub shafts, saddles, and the splice trimmer are being produced. All of the scheduled belly band test specimens have been provided. Skirt lay-up is scheduled to begin early next month.

3.0 RECOMMENDATIONS

It is recommended that the tape laying software be ported to the Silicon Graphics machine. It is also recommended that CATIA be purchased so that the new FPM software can be utilized. Cincinnati Milacron has already generated the required processor for the FPM to work with CATIA.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM09	Med	Isogrid Cylinders	Modify foam mandrels and wind
FPM12	Med	Intertank Structure	Fabricate support specimens
FPM18	Low	Composite PVs	Outline program objectives
FPM19	Low	Fiberplaced Specimens	Procure honeycomb/program FPM
FPM21	Low	Composite Cryotank	Fabricate tank when mandrel arrives
FPM23	High	Liq Comb Chambers	Fabricate 60K Liners
FPM25	High	Composite RP-1 Tank	Fabricate tank skirt

Approved by: L. I. Pelham
Program Manager

Monthly Technical Progress Report on
Operation/Maintenance of Fiber Placement Machine

Larry I. Pelham

PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Thiokol Space Operations
Huntsville Office
P.O. Box 9033
Huntsville, AL 35812

TWR-68120

SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Marshall Space Flight Center
Marshall Space Flight Center, AL

SUPPLEMENTARY NOTES

NASA - See Handbook NHB2200.2

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Fiber Placement

3

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
June 1997

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for June 1997. The following paragraphs summarize the significant accomplishments during the work period beginning in June. discusses recommendations for MSFC consideration. and lists the upcoming work to be performed in July 1997.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

2.1 BASIC MACHINE OPERATIONS

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01 ABLATIVE COMBUSTION CHAMBERS (FASTRAK)

Waiting for a request from NASA to bond new 7K liner into repaired canisters.

TD FPM-03 COMPOSITE HYDROGEN DEMONSTRATION TANK

Awaiting delivery of the dome so that a center cap/repair can be fabricated.

TD FPM-09 FABRICATION OF COMPOSITE INTERTANK STRUCTURE

Waiting on NASA principal investigator to dictate priority on remaining support specimens.

TD FPM-18 SUBSCALE COMPOSITE CRYO-TEST PRESSURE VESSELS

Awaiting indication from new NASA principal investigator as to the direction of the remainder of this study.

TD FPM-19 FIBER PLACED HONEYCOMB TEST SPECIMENS

No significant composite processing activity.

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

The low resin flow condition witnessed on the 60K Liners #03 and #04 was attributed to the lack of a sufficient seal against the pressure, 150 psi. employed during autoclave cure. This problem was corrected by replacing the stainless

steel bolts used on the mandrel and placing an extra seal of RTV silicone on the mating surfaces of the mandrel. Liner #05 was tape wrapped and vacuum bagged for autoclave cure. Determined that the chamber can be baked at 530°F to aid separation of the flange from the chamber. The flange from 40K #03 was removed, using this treatment, so that it can be placed on one of the 60K chambers. The first flange received from Summa Technology for the 60Ks possessed too small of internal diameter and will be machined to drawing requirements by NASA. A pin ring disk was fabricated to help ensure vacuum bag integrity during the oven cure of the overwrapped chambers.

Plies were cut for a 10" x 12" silica/phenolic test panel that will be delivered to Southern Research Institute for elevated temperature material testing. Five hot gas specimens were machined from the remaining exit cone material from the first full-size combustion chamber. Also, machined tensile button samples from this exit cone. Five of these buttons were exposed to ambient, and then five each at temperatures of 300°F, 500°F, and 800°F for a period of 20 minutes. These were delivered to NASA along with a 20-ply EA 9628 panel to be used for Dynamic Mechanical Analysis (DMA) specimens. T300/828-W prepreg tape was generated for the overwrap material shear (G_{12}) property samples. Four balanced-ply laminates were hand-laid and oven cured from this material. These panels were tabbed using 0.090" carbon/epoxy bonded on with EA9394. The panels were machined and the ASTM D3518 specimens delivered to NASA.

TD FPM-25 BANTAM COMPOSITE RP-1 TANK

The T650/UF 3325 composite skirt was autoclave cured and removed from the tool. O-rings for the neck and neck flange mandrels were fabricated for use on full half-tank mandrel assembly. The first tank half was cured and removed from the tool. NASA had requested more samples for testing the belly band splice and a panel for these samples was cured with this first tank half. The segments for the composite baffle vane production were hand laid, autoclave cured and delivered to the machine shop. The center splice support to be used to position the tank halves concentric during joining was received. NASA decided to fabricate the saddles for the lay-up cart, the manhole tank half trimmer and the tank splice trimmer in-house. The hub shaft design and analysis was completed and a procurement issued for the fabrication of two shafts.

3.0 RECOMMENDATIONS

It is recommended that the tape laying software be ported to the Silicon Graphics machine. It is also recommended that CATIA be purchased so that the new FPM software can be utilized. Cincinnati Milacron has already generated the required post processor for the FPM to work with CATIA.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	Med	Basic Effort	Fiberplace LOX tank
FPM09	Med	Isogrid Cylinders	Machine foam mandrels and wind
FPM12	Med	Intertank Structure	Fabricate support specimens
FPM18	Low	Composite PVs	Outline program objectives
FPM19	Low	Fiberplaced Specimens	Procure honeycomb/program FPM
FPM23	High	Liq Comb Chambers	Fabricate 60K Liners
FPM25	High	Composite RP-1 Tank	Fabricate tank halves

Approved by: _____

Larry I. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
September 1997

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for July 1997. The following paragraphs summarize the significant accomplishments during the work period beginning in July, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in September 1997.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS

In support of NASA's in house effort for the reusable launch vehicle program, Composite Technology has completed oven cure of Liquid Engine Combustion Chamber 60K#04 and autoclave cure of Liquid Engine Combustion Chamber Liner 60K#07. Fifty-two chambers will be fabricated for this project.

As part of NASA's Bantam program, we are under contract to fabricate an RP-1 tank for the Bantam Propulsion Test Article (PTA). Prior to bonding of the two tank halves it was discovered that the cylinder sections of the two tank halves were porous and permeable. Investigation identified three possible causes of the permeability. NASA decided to correct the problems and rebuild the tank components. The two tank halves and the skirt have been rebuilt.

Dispatched a proposal in response to Technical Directive FPM-23R4 for the fabrication of 34 additional 60K combustion chambers.

2.1 BASIC MACHINE OPERATIONS

FIBERPLACED LIQUID OXYGEN (LOX) TANK

In support of the basic operations of the Fiber Placement Machine (FPM) contract, Thiokol is performing tasks required for the fabrication of a honeycomb composite Liquid Oxygen tank. Concluded work includes fiber placement of a carbon/epoxy outer skin on a demonstration unit to be used as proof-of-concept article. Presently, we are working with Cincinnati Milacron to generate the programs for the production of the LOX tank and investigating the fabrication of a second demonstration article with both the inner and outer skins being fiber placed.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-01 ABLATIVE COMBUSTION CHAMBERS (FASTRAK)

Waiting for a request from NASA to bond new 7K liner into repaired canisters.

TD FPM-03 COMPOSITE HYDROGEN DEMONSTRATION TANK

Waiting delivery of the dome so that a center cap/repair can be fabricated.

TD FPM-09 ISOGRID STRUCTURE

Waiting direction from NASA primary investigator on investigation.

TD FPM-12 FABRICATION OF COMPOSITE INTERTANK STRUCTURE

Waiting on NASA principal investigator to dictate priority on remaining support specimens.

TD FPM-18 SUBSCALE COMPOSITE CRYO-TEST PRESSURE VESSELS

Waiting indication from new NASA principal investigator as to the direction of the remainder of this study.

TD FPM-19 FIBER PLACED HONEYCOMB TEST SPECIMENS

NASA principal investigator is determining specimen design.

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

The 40K Combustion Chambers (=1&#2) that were test fired have been returned to the PEC. Performed free-standing post cure on 60K#01 and oven cure of overwrap on 60K#02. Overwrapped liner and oven cured 60K#04. Autoclave cured 60K Liner #07 (fill length 30 to 1). Liner and mandrel were delivered to NAS for contour machining. Received 60K Liner #05 which was mated with Flange #05 and placed in the Entec Horizontal Winding Machine. Developed, after several trial iterations, a new pattern for this chamber with the actuator attachment region. This pattern will be used to overwrap Liner #05.

The panels that will be used to produce the carbon/epoxy overwrap specimens were hand laid using the T300/828-W prepreg. NASA will approve the cutting plans and the samples will be machined to Southern Research Institute specifications.

TD FPM-25 BANTAM COMPOSITE RP-1 TANK

Prior to bonding the tank halves it was discovered that the cylinder sections of the two tank halves were porous and permeable. Three potential causes for the porosity were identified and corrected. The tank halves and the skirt have been remade. All pieces show no evidence of excessive porosity or permeability.

3.0 RECOMMENDATIONS

Software Activities

It is recommended that the tape laying software be ported to the Silicon Graphics machine. It is also recommended that CATIA be purchased so that the new FPM software can be utilized.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	Med	Basic Effort	Fiberplace LOX tank/demo
FPM09	Low	Isogrid Cylinders	Machine foam mandrels and wind
FPM12	Low	Intertank Structure	Fabricate support specimens
FPM18	Low	Composite PVs	Outline program objectives
FPM19	Low	Fiberplaced Specimens	Procure honeycomb/program FPM
FPM23	High	Liquid Comb Chambers	Fabricate 60K Chambers
FPM25	High	Composite RP-1 Tank	Assemble tank and bond components

Approved by:

L. I. Pelham
Program Manager

Monthly Technical Progress Report on
Operation/Maintenance of Fiber Placement Machine

Larry I. Pelham

Thiokol Space Operations
Huntsville Office
P. O. Box 9033
Huntsville, AL 35812

TWR-68127

Marshall Space Flight Center
Marshall Space Flight Center, AL

NASA - See Handbook NHB2200.2

Fiber Placement

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
November 1997

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for November 1997. The following paragraphs summarize the significant accomplishments during the work period beginning in November, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in December 1997.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

On November 5, 1997, a NASA/MSFC 60K composite combustion chamber (60K01) fabricated by Thiokol Science and Engineering Huntsville Operations failed during the chamber's second test in MSFC East Test Stand 116. The low-cost combustion chamber was produced for the NASA/MSFC Factrac Engine Program. The thrust chamber assembly consists of a one piece composite chamber, throat and exit cone. The contoured assembly is manufactured by tape wrapping with silica/phenolic, autoclave curing, contour machining, over-wrapping with a filament wound carbon/epoxy structural shell and oven curing. The failure occurred in the silica/phenolic liner and in the bond line between the carbon/epoxy structural over-wrap and the liner. The initial failure occurred in the silica liner approximately two inches aft of the throat area along the ply surface around the circumference of the liner. Then the bondline between the carbon/epoxy over-wrap to the silica liner failed causing the exit cone portion of the liner to be ejected from the test stand. MSFC Center Director, Dr. Wayne Littles, appointed Frank Key, Deputy Director of the Materials and Processes Laboratory, to head a failure investigation team.

Due to the test failure of a Thiokol-fabricated combustion chamber, a letter was dispatched to the Contracting Officer advising that we will continue to support the investigative efforts in the short term based on the assumption that said costs are allowable. NASA/MSFC was advised that a long-term, intensive investigation on Thiokol's part would required a contract adjustment. A unique work order has been established to accumulate said labor charges.

Received Modification 26, adding $40,000 in incremental funding.

2.1 BASIC MACHINE OPERATIONS

SEMI-CONFORMAL MINI TANK

NASA was given a schedule for the Fiber Placement Machine (FPM) tasks required to produce the Semi-Conformal Mini Tank. Completed machining of the Semi-Conformal Mini Tank (SCMT) foam mandrel. The program was offset -1.5" in the longitudinal axis from the original alignment point due to the supplied mandrel being a shorter length than indicated on the model used for the program. The customer requested that this modification be made. The component was then delivered to the customer. The dome contour on the Semi-Conformal Mini Tank (SCMT) mandrel produced from the FPM routing does not match templates produced from

CATIA part files. The coordinate measuring machine is being used to determine the machined dome geometry to determine the source of the discrepancy.

Cincinnati Milacron (CM) has indicated that there is insufficient information on the supplied CATIA models to determine the drop-off location at each end for the interior plies of both the inner and outer skin for the SCMT. NASA has been made aware of this situation and is in the process of printing hard copies of the latest CATIA models for Thiokol.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

The silica/phenolic billet for combustion chamber #12 has been tape wrapped. The additional cured silica/phenolic test panel to support the structural testing requested by Southern Research(SORI) has been shipped.

Bondline testing will be done to evaluate secondary bonding to the combustion chambers. Two T-300/828-W test panels have been cured and are ready for delivery to the machine shop to produce carbon/epoxy-napkin ring samples. More T-300/828-W prepreg tape will be produced for the carbon/epoxy double lap shear and tensile button samples. The silica/phenolic samples are being machined. The silica/phenolic octagonal filament winding mandrel has been machined and is ready for testing the feasibility of a carbon/phenolic overwrap for the combustion chambers.

The overwrap on Combustion Chamber 60K #007 was oven cured. There was a recordable vacuum drop during this cycle and a formal discrepancy report will be generated documenting it.

TD FPM-25 BANTAM COMPOSITE RP-1 TANK

The alteration to the RP Tank feedline nozzle has been completed. When the tank was filled for the second pressure test. the gasket at the manhole end of the tank failed to seal. NASA has requested that Thiokol bond the inner bolt ring to the tank manhole. This will eliminate the need for a gasket at the manhole end. NASA has requested ten double-notch shear samples and five short-beam shear samples. A .250-thick panel is in the machine shop.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. CATIA has been purchased and installed. Training on CATIA and the new Cincinnati Milacron Acraplace software should be purchased to ensure maximum use of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	High	Basic Effort	Fiberplace demo/Rout foam mandrel
FPM23	High	Liquid Comb Chambers	Support failure investigation
FPM25	High	Composite RP-1 Tank	Support tank testing and delivery

Approved by:

L. I. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
December 1997

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for December 1997. The following paragraphs summarize the significant accomplishments during the work period beginning in December. discusses recommendations for MSFC consideration. and lists the upcoming work to be performed in January 1998.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

Thiokol is continuing to support the investigation by providing the information to the investigating board as requested. NASA has developed a test matrix for the investigation. Tests are being done on eight different sets of tag-end specimens as well as five sets of test panels. Thiokol is responsible for sectioning fired hardware. fabricating test panels. machining test specimens and tag ends. and testing mechanical properties. In an attempt to better understand and strengthen the bond-line between the silica/phenolic and the graphite/epoxy, the investigating board had us overwrap an existing liner. The process was modified in an attempt to provide the strongest bond-line. After the part was removed from the mandrel. cracks were identified in the silica/phenolic at the throat. The suspected cause of the crack is the stress induced by thermal mismatch between the silica and the graphite.

2.1 BASIC MACHINE OPERATIONS

SEMI-CONFORMAL MINI TANK

The fiber placement machine programs for fiber placing the inner and outer skins of the two foot demonstration cylinder were generated. The 6-ply [90. -30. -30]s inner and outer skins were fiber placed using the IM7/1522 slit tape and the part was turned over to the customer.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

At the direction of the NASA investigation board. 60K #12 has been fabricated in an attempt to provide the strongest bondline possible. The liner was run through a dry cycle on the overwrap mandrel. overwrapped. and cured. After the part was removed from the mandrel. cracks were identified in the silica/phenolic at the throat. The suspected cause of the crack is the stress induced by thermal mismatch between the silica and the graphite.

60K #01 FAILURE INVESTIGATION

Two 7.6 in. diameter silica/phenolic cylinders have been tape wrapped and cured. These cylinders will be machined and overwrapped with carbon/epoxy to simulate the stresses in the 60K chambers. The intention is to continue fabricating cylinders to evaluate different processing conditions and materials.

NASA's original test matrix for the 60K failure investigation scheduled eight different sets of tag-end specimens as well as 5 sets of test panels. Thiokol is responsible for fabricating test panels, machining test specimens and tag ends, and testing mechanical properties. All the test specimens from the original test matrix have been fabricated and machined. Sectioning of fired hardware is continuing.

TD FPM-25 BANTAM COMPOSITE RP-1 TANK

When the tank was filled for the second pressure test, the gasket at the manhole end of the RP-1 Tank failed to seal. NASA and Thiokol-SEHO have created a raised area on the inside and outside of the composite manhole using EA9394. The bolt ring will now be sealed to the raised areas using polysulfide.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. CATIA has been purchased and installed. Training on CATIA and the new Cincinnati Milacron Acraplace software should be purchased to ensure maximum use of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	High	Basic Effort	Fiberplace demo/Rout foam mandrel
FPM23	High	Liquid Comb Chambers	Support failure investigation
FPM25	High	Composite RP-1 Tank	Support tank testing and delivery

Approved by:

L. I. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
January 1998

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for January 1998. The following paragraphs summarize the significant accomplishments during the work period beginning in January, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in February 1998.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

Thiokol is continuing to support the 60K liquid engine combustion chamber investigation. NASA has transitioned the Investigating Board to a Tiger Team. The Tiger Team will be responsible for evaluating materials and process changes and implementing the correct fix. Thiokol is responsible for fabrication of any required test panels, machining of test specimens and tag ends, and testing to determine mechanical properties.

During testing, the composite RP-1 tank failed at the belly band. The failure occurred at 109 psi which is 147% of the design pressure and 98% of the intended maximum test pressure. An investigation has been initiated by NASA. The full size and scope of this investigation has not been determined. Thiokol will fabricate test samples in support of the investigation.

2.1 BASIC MACHINE OPERATIONS

CONTRACTUAL ACTIVITIES

Modification 27, authorizing and definitizing Technical Directive FPM-23R3, Instrumentation of 60K Chambers, was fully executed adding $32,706 to contract value. Negotiation of the proposal for Technical Directive FPM-23R4, Fabrication of 34 Additional 60K Chambers, was completed in the amount of $2,112,677 (cost = $1,965,236 and fee = $147,441). Negotiation confirmation and Certificate of Current Cost or Pricing Data has been delivered to NASA/MSFC.

NASA/MSFC's Bill McMahon requested a ROM estimate for the fabrication and machining of 60 15-inch by 10-inch panels. The panels will produced using 3" IM7/8552 tape, possess a quasi-isotropic layup and be a minimum of 12 plies thick.

SEMI-CONFORMAL MINI TANK

Downloaded the fiber placement machine programs for the Semi-Conformal Mini Tank (SCMT) from the Cincinnati Milacron (CM) web site. The inner mold line program will be modified and then loaded onto the FPM for performing a dry run. CM indicated that both the inner and outer mold line programs for the SCMT will use eight tows with a bandwidth of 1.016 inches. The overlap was set at 0.5 to minimize gaps in the regions where tows will be dropped. The Semi-Conformal Mini Tank will be fiber placed using the IM7/1522 material.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

All combustion chamber operations are being performed under the direction of the 60K #01 failure initiative until directed otherwise by NASA. Waiting on revised drawings of the combustion chamber for designing a thrust vector control bonding fixture.

60K #01 FAILURE INVESTIGATION

Completed tape wrap of 60K liner #13, started tape wrap of 7.6-inch diameter simulation billet, completed overwrap cure of 60K #08, worked fault tree closures relevant to adhesive film performance, and collected digital images to be placed on the timeline generated for the 40Ks and 60K #01 processing.

Test Specimen Fabrication

Thiokol/SEHO is fabricating test panels, machining test specimens and tag ends, and testing mechanical properties for the 60K failure investigation. Chamber 60K #4 has been sectioned at 0°, 90°, 180° and 270° and bondline samples from it tested. A microscopy sample was also machined from this chamber. Sectioning of 60K #12 has been completed. Tensile buttons and double notch shear samples from the 60K #12 bondline were machined and delivered. Three more double notch shear samples from the 60K #12 witness panels have been machined. The cut-off exit cone portion of 60K liner #07 was cut into four-inch rings for dry cycle testing. Some of the rings were cut prior to exposure to dry cycles. A test method was set up with the ring being clamped in one location and a hanging scale used to register load required to produce enough extension in the ring to release a saw blade that was placed in the area that was cut. All of the rings required more load after the dry cycle to produce the same deformation. Test panels have been laid up and cured to demonstrate the effect of a rubber shear ply on the bondline properties. SC1008 phenolic resin was used in these panels to bond the rubber to the silica phenolic. Tensile buttons and double notch shear samples from these panels have been delivered to NASA and tested. Panels were laid up to test the effect of a thicker rubber shear ply(.090 in.) on the bondline between the silica/phenolic and the carbon/epoxy overwrap. SC1008 phenolic resin was also used in these panels to bond the rubber to the silica/phenolic. Tensile buttons from these panels have been delivered to NASA. A silica filled NBR sample has been ordered to evaluate the use of a NBR shear ply between the silica/phenolic and the carbon/epoxy overwrap. NASA has requested tensile buttons to evaluate the effect of a new grit blasting media, Biasil™, on the bonding of the flange. Zirclean™ is presently used but the manufacture has stopped producing it. The Reusable Solid Rocket Motor programs are having to make this change as well and Biasil™ is the leading replacement candidate. The first set of tensile buttons was delivered this week. Another set of tensile buttons is being bonded to evaluate the effect on the silica/phenolic to stainless steel bond. For the evaluation of a fiberglass/epoxy overwrap, E-glass fiberglass/epoxy prepreg was produced and staged for 5 days. Also for the evaluation of a fiberglass/epoxy overwrap, S2 fiberglass was ordered. Prepreg resin flow tests were completed on the silica/phenolic (Fiberite MX-2600) bias tape used in the fabrication of the 60K liners and compared with the resin flow on BP Chemical Co. (FM5504) 3.5-inch bias tape that was left over from the fabrication of the 40K liners. The recently received MX-2600 averaged 12.5% and the FM-5504 averaged 14.6 %.

Liquid Engine Combustion Chamber Status

Generated and presented closures to the NASA 60K board for fault tree items regarding the manufacture of 60K #01. Completed tape wrap and vacuum bagging of 60K liner #13. The modified autoclave cure cycle with the stress relief annealing step was performed on 60K-13 and 7.6" cylinder billet #4. The vacuum bag was removed from 60K-13 and the billet visually inspected. No defects or anomalies were found and the billet is ready to be contour machined for the carbon/epoxy overwrap. Machined 0.5" off the end of 60K Liner #08, performed dry cycle,

overwrap and oven cure of 60K #008. Upon completion of cure. 60K #008 showed only hairline cracks visually and by computed tomography (CT). Provided the NASA Propulsion System Team with the cure chart and thermocouple location for the 60K # 008 overwrap cure. 60K #008 was then delivered for cold flow testing where it was exposed to approximately -85°F. Liner 60K #09 was placed through CT. solvent wiped. alcohol wiped and placed in a Blue M oven and the dry cycle performed. Flange #11 was primed in preparation for use on this chamber. All processing of 60K #009 was suspended when cracks were identified on 60K #008 post-cold flow testing. Based on this event. the NASA "Tiger Team" has decided to focus on production of overwrapped silica-phenolic cylinders that model the throat of the combustion chamber.

Combustion Chamber Throat Cylinders

Autoclave cured two 36 inch, MX 2600 (silica/phenolic), test billets using 7.6-inch diameter mandrels and 2.5-inch tape wrapped at a 40-degree ply angle. These silica-phenolic cylinders are machined to an outside diameter of approximately 9.4 inches. This models the thickness of the MX-2600 in the throat of 60K #001. The first two MX 2600 cylinders billets were overwrapped with the T300/828-W material. These cylinders were processed using the same dry and cure cycles as 60K #012. The first cylinder was 18" in length and filament wound with a wind angle of 77° to a ply thickness of 0.75". After the cylinder was cured. two inches were cut off of each end. After the first end was cut off. an axial crack in the silica phenolic was noticed. A 36" cylinder was wound with a 17° wind angle to a 0.125-inch thickness. Completed tape wrap of a 18-inch billet (Cylinder #3) using the remaining BP Chemical FM-5504 silica/phenolic tape used on the 40K Liner billets. Cylinder #3 autoclave cured using the original 60K cure cycle and then machined. It was then inspected with CT and is being run through the dry cycle. Tape wrapped a 40-degree ply angle 7.6-inch diameter test billet (Cylinder #4) with MX-2600 silica/phenolic material that was subjected to the modified cure cycle along with 60K #13 combustion chamber billet. This silica/phenolic billet was machined into three 12 inch cylinders. 4A,4B,and 4C. Cylinder #4A, the first 12" cylinder representing this modified cure cycle. was inspected using CT. overwrapped with T300/828-W and oven cured. This cylinder also possessed axial cracks when the ends where machined off. Another 7.6" billet (Cylinder #5) was tape wrapped with MX-2600 material and cured along with the FM-5504 (old material) billet #3 using the original 60K cure cycle. Two more cylinder billets (#6 and #7) have been tape wrapped using MX2600 material.

TD FPM-25 BANTAM COMPOSITE RP-1 TANK

Thiokol and NASA have completed the adjustments necessary to eliminate the gaskets at the manhole end of the tank. NASA's stress analysis of the composite nozzle flange showed a negative margin caused by the weight of the feedline. NASA evaluated the options to alleviate the stress and decided to support the feedline at the test stand to alleviate the stress permitting the pressure test to be rescheduled. During the pressure test. the RP-1 Tank failed at the belly band. The failure occurred at 109 psi which is 147% of the design pressure and 98% of the intended maximum test pressure. A failure investigation has been initiated by NASA. The size and scope of this investigation has not been determined. Thiokol will fabricate test samples in support of the investigation.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. CATIA has been purchased and installed. Training on CATIA and the new Cincinnati Milacron Acraplace software should be purchased to ensure maximum use of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	High	Basic Effort	Fiberplace SCMT
FPM23	High	Liquid Comb Chambers	Support Chamber Investigation
FPM25	High	Composite RP-1 Tank	Failure Investigation/Fab samples

Approved by:

L. I. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
February 1998

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for February 1998. The following paragraphs summarize the significant accomplishments during the work period beginning in February, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in March 1998.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

Thiokol is continuing to support the 60K liquid engine combustion chamber investigation by providing information to the NASA Tiger Team as requested. This includes cylinder fabrication to simulate the combustion chamber throat condition and flat panels for bondline testing.

Thiokol is supporting the composite RP-1 tank failure investigation. Specimens were fabricated that modeled the belly band bondline for the test article.

2.1 BASIC MACHINE OPERATIONS

SEMI-CONFORMAL MINI TANK

The Semi-Conformal Mini Tank (SCMT) mandrel was loaded into the fiber placement machine and a trial run performed. The program was offset in the x-axis to ensure the machine would not make contact with the mandrel. The program successfully followed the contour of the mandrel. The SCMT fiber placement has been delayed until completion of mating hardware. Compiled process documentation for the SCMT foam mandrel machining and delivered the quality records to MSFC. The quality records included the shop traveler, a list of FPM trained personnel, and an operational procedure. MSFC has also requested a preliminary schedule for fiber placement activities related to the SCMT.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

A preliminary drawing has been generated for the combustion chamber thrust vector control bonding fixture. MSFC requested that this bonding fixture generated for the combustion chamber thrust vector control also locate the G-G attachment in the throat. The necessary design modifications were included and a procurement request was submitted for the fixture. Thiokol Drawing #1T720001. These drawings are being checked to determine if the tolerances will meet engine build-up requirements prior to award of procurement. A lift procedure for the combustion chamber and flange using the forklift in the winding lab was written and is being reviewed for signatures. Delivered the combustion chamber overwrap process shop travelers, which included cure charts and material certificates of conformance, on completed chambers to MSFC.

Test Specimen Fabrication

MSFC requested tensile buttons to evaluate the effect of a new grit blasting media, Biasill™, on the bonding of the flange. Zirclean™ is presently used. The second set of tensile buttons that was bonded to evaluate the effect on the silica/phenolic to stainless steel bond was delivered. Test results show no significant difference between Zirclean™ and Biasill™. The use of a silica-filled NBR shear ply between the silica/phenolic and the carbon/epoxy overwrap is also being evaluated. A roll of 0.030" CDS10044A NBR was obtained from Thiokol/Utah. Tensile buttons(3.5 in.) have been fabricated and delivered to MSFC to evaluate co-curing of one layer of CDS10044A NBR with the overwrap. This test yielded poor results so a new set of buttons were fabricated to test 0.030 inch pre-cured NBR in the bondline and also to evaluate the effect of a higher pressure. Tensile buttons were fabricated and delivered to MSFC to test pre-cured 0.120 in. thick NBR in the bondline. Tensile buttons were machined from Cylinder 1B and 2 locations in Cylinder 6B to test the bondline. These cylinder buttons have delivered to MSFC. Four sets of three test samples have been requested to evaluate Zentron™ material properties. Four test panels were fabricated to produce the Zentron™ fiberglass material property specimens.

Liquid Engine Combustion Chamber Status

60K Combustion Chamber #05 has been machined for an insert in the forward end and was picked up from 4705 machine shop along with the insert. The insert was bonded in and will be delivered back to 4705 this week for final machining. Met with MSFC EH53 personnel about design of a transportation cart with a breakover fixture. This cart will permit liner/chamber operations to be performed in a more controlled environment.

Combustion Chamber Throat Cylinders

The autoclave cure cycle on 7.6" test cylinder billets #6 and 7 and one FM-5504 3 ½" X 2.0" X 12" flat panel was completed. Cylinder #6 was machined for over-wrap but Cylinder #7 was initially held for evaluation. It appears that #7 had a leak allowing the nitrogen (autoclave pressure medium) to enter the part during cure and prevent the phenolic resin from flowing against the surface of the wrap mandrel, similar to 60K CC Liners #3 and #4. Tape wrap using MX-2600 material was completed on cylinder #8 and on a combustion chamber insert billet to be used to reline 60K #005. The autoclave cure cycle for these parts had to be aborted at the 180-degree hold because of a seal leak around the fan shaft of the autoclave. The billets were unloaded from the autoclave and returned to the tape wrap lab for disposition. Billet #8 and the insert were restarted and autoclave cured along with cylinder billet #9 and a 4.5" X 24" tensile test specimen flat panel. The billets were stripped and sent to be machined for installation or over-wrap and test.

Cylinder #3, the FM 5504 cylinder, was overwrapped with AS4-W 12K/EPON 828-Curing Agent W and cured. This cylinder was cut to remove the ends. No cracks were detected upon visual inspection. All of the other cylinders produced for this test matrix showed cracks at this point. It was then decided to overwrap the next cylinder, 5A, with AS4. This cylinder was cracked when it was removed from cure. For the evaluation of a fiberglass/epoxy overwrap, Owens Corning 721B ZenTron™ was used to overwrap Cylinder #5B. The ends were machined off of this cylinder and no cracks were detected upon visual inspection. The center section of this cylinder was cold flow tested along with the overwrapped and bare segments of Cylinder #3, the one fabricated using the 40K FM 5504 material. The cold flow test was conducted to determine if the throat material selection will be able to withstand the -85°F extreme the chamber will see during X-34 flight. Cylinder 5B, the MX 2600 silica phenolic with the Zentron S2 glass overwrap, cracked during the cold flow test. Both the AS4 overwrapped and the non-overwrapped segments of Cylinder #3, the FM 5504 silica-phenolic, did not crack when subjected to this test. Cylinder 5B was not cracked after cure and even though it cracked in cold soak, it was decided to evaluate a lower yield fiberglass (Owens Corning 449™-250 yards/lb.) The lower yield fiberglass was to be evaluated for ease of processing. Cylinder 5C was fabricated with a tool release placed on the cylinder that enabled the T300/828-W overwrap to be removed from the cylinder without damaging it. Cylinder 5C was not cracked when the overwrap was removed. This T300/828-W overwrap was

also cold flow tested. The use of a silica filled CCS10044A NBR ply between the silica phenolic and the carbon/epoxy overwrap is being evaluated. Cylinder 6A, the cylinder with this silica filled NBR shear ply, was overwrapped and oven cured. The ends were machined off of this cylinder and this cylinder also did not have any cracks in the silica-phenolic that could be detected by visual inspection. A cylinder with a .030" thick pre-cured NBR shear ply between the silica-phenolic and the carbon fiber epoxy, Cylinder 6B, was then overwrapped and cured. It cracked when it was removed from the vacuum bag. Since a crack appeared in cylinder 6B, cylinder 8A has been wound with a 0.120 inch thick NBR ply. Cylinder 6C has been wound and cured with Owens Corning 449™-250 yards/lb. The lower yield fiberglass was more difficult to process than Zentron™ because of catenary. This lower yield S2 glass overwrapped cylinder, Cylinder 6C, was oven cured. Overwrapped and started cure of Cylinder 8A, the cylinder with a 0.120" thick silica filled NBR ply between the silica-phenolic and the carbon-epoxy overwrap. Cylinder 8B was placed in a 500°F dry cycle. A ¼ °F per minute ramp rate was used for this cycle but the cooling rate was changed to 1°F per minute once the oven cooled past 300°F.

TD FPM-25 BANTAM COMPOSITE RP-1 TANK

Thiokol has been asked to fabricate belly band specimens for the RP-1 Tank investigation. MSFC has set up a test plan that defines six different processing combinations with 5 samples from each. The panels for producing the specimens were cured and machined. The belly band configurations were then laid up and cured. The thirty belly- band samples were machined from these panels and have been delivered to MSFC. Nine sets of five double notch shear specimens and tensile buttons were also requested to evaluate effects of processing on the strength of the belly band bond. These panels were laid up and cured. The forty-five specimens were machined from the panels and delivered to MSFC. MSFC has requested tensile, compression and double notch shear samples to be fabricated from the failed hardware and "Pathfinder" tank walls. A shop traveler will be written for this task. MSFC has requested closure for the "Handling Damage" portion of the RP-1 Tank failure tree. Thiokol has ordered 1000 lbs. of T650/35-3K/UF3325 in preparation for manufacturing a replacement tank. The 1000 lbs. is sufficient for fabrication of two tanks.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. CATIA has been purchased and installed. Training on CATIA and the new Cincinnati Milacron Acraplace software should be purchased to ensure maximum use of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	High	Basic Effort	Fiberplace SCMT and Cylinders
FPM23	High	Liquid Comb Chambers	Support Chamber Investigation
FPM25	High	Composite RP-1 Tank	Failure Investigation/Fab samples

Approved by:

L. I. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
March 1998

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for March 1998. The following paragraphs summarize the significant accomplishments during the work period beginning in March, discusses recommendations for NASA/MSFC consideration, and lists the upcoming work to be performed in April 1998.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

Thiokol is continuing to support the 60K liquid engine combustion chamber investigation by providing information to the Tiger Team as requested. This includes cylinder fabrication to simulate the combustion chamber throat condition and alternate overwrap material property specimens. Thiokol is supporting the composite RP-1 tank failure investigation.

Modification 30 was reviewed authorizing the performance of permeability testing (approximately 220 specimens) through September 30, 1998.

2.1 BASIC MACHINE OPERATIONS

SEMI-CONFORMAL MINI TANK

Generated machine programs and process documentation for the fiber placement of the 30.5 inch cylinder. The foam tool was then loaded into the fiber placement machine. Fiber placed a [90, 30, -30], layup onto the supplied 30.5 inch foam cylinder. The part was removed from the machine and delivered to NASA/MSFC. Received NASA/MSFC applicable documents for the processing of the Semi-Conformal Mini Tank. Fabrication shop travelers are being generated to conform to the specification.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

Liquid Engine Combustion Chamber Status

The combustion chamber bonding fixture was fabricated by NASA/MSFC with Thiokol ordering only a few non-substore items. It was initially assembled onto 60K #07 for fixture checkout. The fixture was then reassembled on 60K #09 with shim stock and Coe-Flex to determine the proper bondline for the Thrust Vector Control ring. Started the bonding process on 60K #09 which includes fixture checkout.

Overwrapped and oven cured 60K Combustion Chamber #09. This chamber had a "flap" placed in the throat region between the liner and the overwrap. The flap consisted of two layers of NBR, a layer of Teflon tape and then two additional layers of NBR. This flap configuration was cured prior to overwrap. Started fabrication of Combustion Chamber 60K #010. The NBR of the flap deformed during cure due to the loss of the compaction wrap. This flap will be removed from 60K Liner #10. Proceeded with the processing of 60K Liner #11 when it was determined the flap

on 60K Liner #10 would need to be redone. The dry cycle on 60K Liner #11 was performed and the adhesive film placed under where the NBR is laid in the throat. Placed and cured the NBR flap on 60K #011. The flap cured correctly so 60K #011 proceeded and was overwrapped, vacuum bagged and oven cured. This chamber has been removed from the overwrap mandrel and will be delivered to NASA/MSFC for machining. The 60K Liner #14 (15 to 1) was tape wrapped using the "new" FM-5504. The billet was wrapped using the new 15 to 1 tape wrap mandrel. Liner #14 (15 to 1) FM-5504 CC Liner was then autoclave cured and is ready for the OD contour to be machined for overwrap. 60K Liner #13, 30 to 1 MX 2600, has been contour machined and returned to 4707 unnl ready to overwrap.

Test Specimen Fabrication: A sample of lower yield Zentron™ fiberglass was requested from Owens Corning. The sample will be two ends of 750 yds/lb. material wound together on 3 in. rolls to make 375 yds/lb. yield material. Tensile and shear samples were machined from the initial high yield, 750 yds/lb. Zentron S2 glass epoxy panels. These samples were tested but failed in the grips so a tabbed configuration will have to be determined. One pallet of 750 yds/lb. yield Zentron™ fiberglass was received.

Throat Simulation Cylinders

Filament wound Cylinder 9A, the cylinder with a 200°F overwrap cure, vacuum bagged it and placed it in for cure. Performed dry cycle and overwrapped Cylinder 9B which had a Zentron 721B-AA (Catenary-Free S2 Glass)/EPON 828-Curing Agent W overwrap. This cylinder was oven cured it at 200°F for 12 hours. Differential Scanning Calorimetry was being performed to determine the degree of cure this cycle would yield. The "new" FM-5504 silica/phenolic 7.6" test cylinder billet (#10) was tape wrapped and machined into three 12 inch cylinders. Have run a dry cycle on Cylinder 11C, the old MX 2600, and Cylinder 9C, a standard MX 2600 cylinder. Cylinder 10A, the new FM 5504, was placed in dry cycle, filament wound using the standard T300/828-W overwrap system and oven cured. This cylinder was not cracked when it was removed from cure or after the ends were machined off. It did however, possess delaminations in the overwrap so it was decided to alter the vacuum bag to drive out the wrinkles. Overwrapped Cylinder 10C, new FM 5504 with bagging technique to trap resin in, vacuum bagged and placed it in for cure. The tape wrap with 2.0" MX2600 tape and autoclave cure of test cylinder #12 was completed and the billet sent for machining. Overwrapped using the standard T300/828-W system and placed in cure Cylinder 12A from this billet. The tape wrap operation has been completed on test cylinders #13 and #14. Cylinder #13 has both FM-5504 and MX-2600 wrapped in it to determine if a stress crack starting in the MX-2600 material will continue on into the FM-5504 plies. Cylinder #14 is wrapped with 2.0" FM-5504 tape. Machined two MX 2600 rings and one FM 5504 ring from the ends of the cylinders used for this investigation. These were delivered to NASA/MSFC to be shipped to Southern Research Institute. The remainder of the Fiberite MX5504 tape order was received. The unsupported sample of EA9628-.030" arrived from Dexter Hysol Aerospace that was ordered for testing. Procurement for Fiberite MXSE65 2.5" tape was issued for testing as an alternate silica phenolic wrapping material.

TD FPM-25 BANTAM COMPOSITE RP-1 TANK

NASA/MSFC has requested and Thiokol is processing the tensile, compression, double notch shear and double lap shear samples to be fabricated from Tank 1 ("Pathfinder") and the failed hardware (Tank 2) tank walls. The tensile, permeability, double notch shear and double lap shear samples from the barrel sections of Tank 1 and Tank 2 have been machined and delivered. Two sets of compression samples have been delivered. The purpose of this testing is to compare the mechanical properties of Tank 1 and Tank 2. One set of double lap shear samples from Tank 1(Pathfinder) will be subjected to a dry cycle before laying the belly bands.

Tank 1 will be finished and tested to evaluate design and process changes before the manufacturing of the new tank. A schedule for test sample fabrication and the processing of Tank

1 has been given to NASA/MSFC. Tank 1 is scheduled to be finished the first week of April. The traveler for the assembly of Tank 1 was distributed by NASA/MSFC to all interested parties for their review and comment. The traveler for Tank 1 went through a peer review. Tank 1 will be used as a test article for changes that will be integrated into the processing of Tank 3. A traveler was written for the disassembly of the Tank 2 manhole hardware and the hardware disassembled per this traveler. The manhole ring and the remaining polysulfide was removed from this hardware. This hardware will be reused for the completion of Tank 1.

NASA/MSFC has requested 15 double notch shear and 15 compression specimens made from IM7/8552. The IM7/8552 is scheduled to be used for the build-up plies at the skirt to tank transition on Tank 1 due to limited availability of T650/TCR. Two IM7/8552 panels were autoclave cured. Machining of the required specimens is being performed. A procurement request was issued for FM-300-2K-.08 from Cytec Fiberite. This adhesive film will be used to bond the belly band and the mid section of the tank.

TD FPM-28 X33 PERMEABILITY TESTING

Received 12 materials for permeability testing. The specimens have been machined into triplicate test samples. An initial round of permeability testing at 30 psig has been completed. Due to the impermeable nature of most of the samples, the room temperature testing will be repeated at 100psig. The CSI-135 permeability tester is being modified to allow the higher pressure testing.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. CATIA has been purchased and installed. Training on CATIA and the new Cincinnati Milacron Acraplace software should be purchased to ensure maximum use of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	High	Basic Effort	Fiberplace SCMT and Cylinders
FPM23	High	Liquid Comb Chambers	Support Chamber Investigation
FPM25	High	Composite RP-1 Tank	Failure Investigation/Fab samples
FPM28	Medium	Permeability Testing	Material Testing

Approved by:

L. I. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
April 1998

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for April 1998. The following paragraphs summarize the significant accomplishments during the work period beginning in April, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in May 1998.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

Thiokol is continuing to support the 60K liquid engine combustion chamber investigation by fabricating cylinders to simulate the combustion chamber throat condition and alternate overwrap material property specimens. A manufacturing recovery plan to fabricate chambers at the rate of one chamber per week was developed and presented to NASA management. This plan would require a second shift, more tooling, and additional manpower to be successful. Thiokol is supporting the composite RP-1 tank failure investigation by completing fabrication of Tank 1 and fabricating test specimens.

2.1 BASIC MACHINE OPERATIONS

SEMI-CONFORMAL MINI TANK

Fiber placed the six-ply, LM 002, inner skin for the Semi-Conformal Mini Tank (SCMT). The part has been turned over to the customer for dome fabrication and core lay-up. The outer skin fiber placement will occur once these steps are complete. Fiber placed one six-ply, LM 002, inner skin SCMT witness panel. Also fiber placed a 16-ply LM 002 witness panel.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

Liquid Engine Combustion Chamber Status

Bonded the G-G band and Thrust Vector Control (TVC) to 60K #009. A discrepancy report was generated for the location of the TVC ring and concurred by the Propulsion Lab. 60K #011 was delivered to the machine shop for final machining. Combustion chamber liner #15 (15 to 1 tape wrapped on the 30 to 1 mandrel) has been autoclave cured and delivered to 4705 for contour machining. Combustion Chamber 60K -014 was overwrapped with Zentron 721B-AA EPON 828 - Curing Agent W and oven cured. 60K-014 is the first liner to use the new FM5504 material. It was removed from the mandrel and delivered to the machine shop. Sectioned 60K - 012 to determine overwrap thickness in the Thrust Vector Control (TVC) region. Combustion Chamber Liner #16 (15 to 1) with FM-5504 material has been autoclave cured and delivered to 4705 for machining. Started overwrap process of 60K # 010. Liner #10 was damaged in the machine shop. Laid-up and oven cured NBR flap in the throat region on this liner. The modified flange was

placed on the liner and the EA 9628 laid on the external surface except for the NBR flap region which is painted with resin. The forward winding dome was modified with 60K #10 being the first chamber to use this dome to position the flange relative to the centerline of the liner throat.

Throat Simulation Cylinders

Cylinder 11A, the old MX 2600, and Cylinder 12A, 2" MX 2600, both produced with the standard overwrap were cracked when removed from cure. Examined the overwrapped, new FM 5504 cylinders. Cylinders 10B and 14A-C. Cylinder 10B was overwrapped with Fortafil 3C 50K/UF 3339-95, Cylinder 14A with Zentron 721B-AA/828-W, Cylinder 14B with AS4/828-W and Cylinder 14C with T300 impregnated with toughened epoxy. All the carbon fiber overwraps had delaminations while the Zentron did not. Test cylinders #15 and #16 have been tape wrapped and autoclave cured. Both cylinders were wrapped with 2.0" wide FM-5504. Test cylinders #17 and #18 have been tape wrapped and autoclave cured. Both cylinders were wrapped with 2.5" wide FM-5504 tape. Overwrapped throat simulation cylinder 13C, a 12-inch MX 2600 cylinder, with T300/828-OPPI. OPPI is the designation given to the initiator added to the 828 resin that permits curing by E-Beam. Overwrapped Cylinder 15A, a 12 inch FM 5504, with the T300/828-OPPI. Packaged these two cylinders along with two plates wound with T300/828-OPPI for shipment to be cured. Overwrapped Cylinder 15C, FM 5504, with Zentron 721B-AA/828-W. Throat simulation cylinders #17 ,#18,and #19 have been autoclave cured and delivered for machining. All three cylinders were wrapped with 2.5" wide FM-5504 tape. Overwrapped Cylinder 16A, a 12 inch FM 5504 cylinder, with T300/828-W using the modified wind angle.

TD FPM-25 BANTAM COMPOSITE RP-1 TANK

The double lap shear samples from the barrel sections of Tanks 1 and 2 have been completed and delivered. NASA has requested 15 double notch shear and 15 compression specimens made from IM7/8552. These samples have been delivered. A resin flow test has also been run on this material. The nozzle flange split ring has been salvaged from Tank 2 for use on Tank 1. The manhole build up plies have been laid and autoclave cured. The inside of the bottom tank half has been coated with Shell RSL2704/RSC2705. After coating, a vacuum bag placed on the outside of the tank held vacuum. Four rolls of T650/TCR 60" arrived and the laying of the skirt to tank build-up plies for Tank 1 has begun. The machining of the manhole on the top tank half of Tank 1 has been completed. The belly band simulation panel with embedded flaws for NDE has been laid-up. NASA has requested 12 single lap shear tensile samples for RP soak testing. The panel for these samples has been laid-up.

TD FPM-28 X33 PERMEABILITY TESTING

The residual gas analyzer (RGA) was started and then shut down for installation of new inlet connection parts. Also, the room temperature permeability test apparatus was down for pressure leakage repairs. Both units will be operational this month and testing will resume.

Also, the permeability calculation software has been translated to an Excel spreadsheet format and has added the capability to account for inertial flow effects.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. CATIA has been purchased and installed. Training on CATIA and the new Cincinnati Milacron Acraplace software should be purchased to ensure maximum use of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	High	Basic Effort	Fiberplace SCMT and Cylinders
FPM23	High	Liquid Comb Chambers	Fab Chamber/Support Investigation
FPM25	High	Composite RP-1 Tank	Failure Investigation/Fab samples

Approved by:

L. I. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
May 1998

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for May 1998. The following paragraphs summarize the significant accomplishments during the work period beginning in May, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in June 1998.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

Thiokol is fabricating 60K liquid engine combustion chambers and continuing to support the 60K liquid engine combustion chamber investigation by fabricating cylinders to simulate the combustion chamber throat condition. Thiokol has returned to fabrication of combustion chambers to support program needs. Currently, Thiokol SEHO is producing a 15:1 chamber at the rate of one per week. Thiokol is supporting the composite RP-1 tank failure investigation by completing fabrication of Tank 1 and fabricating test specimens.

Thiokol reached an agreement on remaining GFY 98 Combustion Chamber Fabrication proposal. An unsolicited proposal for Advanced Composite Processing, which is a follow-on effort to Contract NAS8-39749 for operation/maintenance of the Thiokol-owned Fiber Placement Machine, was submitted this month.

2.1 BASIC MACHINE OPERATIONS

SEMI-CONFORMAL MINI TANK

NASA/MSFC has completed dome fabrication and core lay-up for the Semi-Conformal Mini Tank(SCMT). Cincinnati Milacron (CM) is generating programs for the fiber placement of two shear plies as well as a 6 ply outer face sheet doubler for the forward flange end of the Semi Conformal Mini Tank (SCMT).

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

Liquid Engine Combustion Chamber Status

Overwrapped 60K #010 with T300/828-W. This chamber had an MX 2600 liner with an NBR flap laid in the throat. After this chamber was removed from the mandrel, there was extensive cracking in the exit cone that initiated at a point where the liner had been damaged during handling by the MSFC machine shop. The modification to the forward dome cracked and deflected and had to be repaired prior to fabrication of the next chamber, 60K #15.

60K #015 was overwrapped with T300/828-W, vacuum bagged, and oven cured. When it was removed from the mandrel, it had a crack in the aft end of the exit cone. The overwrap mandrel

for all future chambers will have the extension ring which will distribute the load over a larger area and minimize the loading placed on the aft edge of the exit cone.

60K #016 was contour machined and measured using the Coordinate Measuring Machine (CMM). When Flange #16 was mated with this liner in preparation for overwrap, the flange would not seat flush with the machined end of the liner. It was determined through review of CMM measurements that the liner was too large of diameter at the forward end and too small in diameter at the transition point. The flange was machined to the high end of the allowable tolerance but still did not seat properly on the liner. Liner #16 was sent back to the machine shop to bring the flange seating area to within drawing tolerance.

60K #017 and #018 was tape wrapped and autoclave cured.

The fwd segment of the "old" 60K tape wrap mandrel has been salvaged and refurbished to wrap an insert billet for 60K chamber #14 that has had two 20 second test firings.

Received and stored ≈ 1900 lbs. of FM-5504 silica/phenolic bias tape (1160 of 2.5", 721 of 3.5" and 41 of 3.0") Lot # 411288.

Working on planning for bonding the bellyband and TVC attachment rings to the 60K chambers. Will also generate a shop traveler for installation of the shear pins in the Actuator Attachment Ring.

60K Investigation/Tiger Team Support

The new Silica/Phenolic materials. 800 lbs. of MXSE-65 from Fiberite and 200 lbs. of F554 from Fibercote Corporation have been received and stored. Also received and stored 1200 lbs. of FM-5504 from Fiberite Corp. The 7.6" MX-2600 cylinder test billet that was tape wrapped and autoclave cured by NACCO (North Alabama Composites Co.) has been received and removed from the wrap mandrel. The billet is approximately 16" long and, from visual inspection, appears to be similarly processed to what Thiokol is producing. Two 7.6" cylinder billets have been tape wrapped using these new silica/phenolic materials (MXSE-65 from Fiberite and of F554 from Fibercote Corporation). These cylinders, #20, the MXSE-65; and #21, the F554, were autoclave cured. Two additional 7.6" cylinder billets, #22 and #23 were tape wrapped from the FM-5504 silica/phenolic material and autoclave cured.

Overwrapped Cylinder 15B, FM 5504, with 250 yield Zentron S2 fiberglass. This cylinder was oven cured and the ends machined off. Placed through the dry cycle Cylinders 16B-C and 17A-C,12 inch FM 5504 cylinders. Wound Cylinder 16B using the modified 70 degree overwrap with two layers. The overwrap displayed wrinkles when removed from cure so it was decided to repeat this configuration. Overwrapped Cylinder 16C with the modified pattern with two unidirectional plies between the layers. This was placed in for cure along with Cylinder 17A, which was wrapped with the modified pattern three times. Wound Cylinder 17B, a FM 5504 cylinder using the modified 70 degree overwrap pattern with the low temperature curing epoxy from Bryte. The resin quantity obtained was sufficient for the 77-degree winding configuration but was not enough for the new 70-degree pattern. One and a half layers were all that was wound with the T300/low temperature cure epoxy. The cylinder was cured and the ends cut off. No delaminations were apparent in the overwrap. This low temperature curing epoxy requires a post cure to whatever temperature is desired as a glass transition temperature. Overwrapped Cylinder 17C with the 70-degree pattern using the standard T300/828-W materials. The pattern was only used twice for this cylinder which gave a pre-cured thickness of 0.50" on the radius. This cylinder is being used to determine at what thickness does the overwrap start to delaminate.

Investigated the installation of the Bernina sewing machine(s) in the high bay of 4707. In process of providing an estimate of the work required to install the sewing machines.

TD FPM-25 BANTAM COMPOSITE RP-1 TANK

NASA has decided to use Tank 1 as a test article for changes that will be integrated into the processing of Tank 3. The build-up plies for the skirt to tank transition on Tank 1 have been cured. Both tank halves have been machined. The inner belly band surface has been grit blasted for both tank halves. The tank halves have been aligned and bonded. During grit blasting of the outer belly band surface, a 0.75 inch gap was discovered in the EA9394 adhesive used to bond the tank halves together. The gap was filled with EA9394, which was cured at room temperature overnight. The outer belly band surface was then grit blasted again. The outer belly band plies for Tank 1 were then laid and have been cured. After cure, the outer bellyband underwent NDE. The cured EA9394 in the butt joint at the inner bellyband has been sanded and all low spots in the adhesive have been refilled. The refilled areas will be sanded and the tank will be dried for the lay-up of the inner bellyband.

The belly band simulation panel with embedded flaws for NDE has been delivered. NASA requested 12 single lap shear and 12 tensile samples for RP soak testing. These panels have been cured, tabs applied and the samples machined. The 24 samples have been delivered for testing. NASA also requested FM300-2K lap shear samples to be produced. FM300-2K (new lot) lap shear samples were laid up with the outer bellyband. These samples were also completed and delivered. Results of the lap shear tests showed no significant difference between the shear strength of the new FM300-2K (Lot# 282) and the 13 month old FM300-2K (Lot#269).

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. Training on CATIA and the new Cincinnati Milacron Acraplace software should be purchased to ensure maximum utilization of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	Medium	Basic Effort	Fiberplace SCMT and Cylinders
FPM23	High	Liquid Comb Chambers	Support Chamber Investigation
FPM25	High	Composite RP-1 Tank	Failure Investigation/Fab samples

Approved by:

L. I. Pelham
Program Manager

Monthly Technical Progress Report on
Operation/Maintenance of Fiber Placement Machine

Larry I. Pelham

Thiokol Space Operations
Huntsville Office
P. O. Box 9033
Huntsville, AL 35812

TWR 64634

Marshall Space Flight Center
Marshall Space Flight Center, AL

NASA - See Handbook NHB2200.2

Fiber Placement

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OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
June 1998

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for June 1998. The following paragraphs summarize the significant accomplishments during the work period beginning in June, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in July 1998.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

Thiokol is fabricating 60K liquid engine combustion chambers and continuing to support the chamber investigation by fabricating throat simulation cylinders. The FM 5504 has been baselined as the silica/phenolic that will be used to produce the chamber liners. None of the FM 5504 cylinders that have been overwrapped have failed in the silica/phenolic. The focus of the present cylinders is to find an overwrap material/overwrap technique that prevents delamination of the overwrap for the cylinders.

Thiokol completed the bonding/fabrication of the composite RP-1 tank, Tank 1. The tank is now ready for testing when the NASA test facility becomes available.

2.1 BASIC MACHINE OPERATIONS

SEMI-CONFORMAL MINI TANK

Generated memo detailing shear ply, outer face sheet and outer doubler ply fabrication. This memo was concurred by NASA/MSFC and forwarded to Cincinnati Milacron. Received Cincinnati Milacron (CM) FPM programs for these outer skin fiber placement tasks. Revising the shop traveler for the outer skin of the Semi-Conformal Mini Tank (SCMT) to include the shear plies and doubler fiber placement. Upon receipt of the outer skin programs, generated a memo also concurred by NASA/MSFC EH33 to close the work order for CM. The customer is performing work on the end fittings of the SCMT which will need to be completed prior to outer skin fiber placement.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

Liquid Engine Combustion Chamber Status

The actuator attachment ring was bonded onto 60K #11. The chamber was then delivered to the machine shop were the shear pin holes were drilled. The chamber was returned and the shear pins bonded into the nozzle.

60K #16 was remachined in the flange bonding area to drawing tolerance. Performed dry cycle and overwrapped Liner #16 using the Zentron 721B-AA/828-W material. The new overwrap pattern that simulates the 30 to 1 chamber overwrap pattern was used. This liner used Flange #17 that was not available when Liner #17 was overwrapped. 60K#17 had used Flange #16. 60K #16 was removed from the mandrel after oven cure and visual inspection revealed no cracks at the aft end. The liner had been machined to a blunt edge at the aft end prior to overwrap. Also, the rubber placed on the aft overwrap ring was changed from cured rubber to two uncured plies of NBR that could flow under the pressure generated during the overwrap cure cycle.

Performed dry cycle on and overwrapped 60K Liner #17. Mated Flange #16 with Liner #17 due to Flange #17 not being available for use. Used two layers of EA 9628.06 between flange and liner for this chamber. 60K #17 used the T300/828-W material system for the overwrap but also used the 30 to 1 simulation pattern. When 60K #17 was removed from the mandrel after oven cure, there was a crack located in the nozzle end of the chamber. This was attributed to tooling/liner machining configurations. However, visual inspection did not reveal any cracks in the silica/phenolic in the throat region of this chamber.

The autoclave cure cycle was completed on 60K Combustion Chamber Liner #18. The billet was delivered to the machine shop where it was contour machined. It was then overwrapped with Zentron 721B-AA 750/828-W. This chamber used Liner #18 with Flange #18. This chamber was oven cured, removed from the mandrel, and delivered to the machine shop.

60K Combustion Chamber Liner #19 has been tape wrapped, vacuum bagged, and autoclaved cured. Liner #19 was picked up from the machine shop after the tagend was machined off. The liner billet was removed from the mandrel and returned to the machine shop where the contour machining was completed. After receipt of the machined liner, a dry cycle was performed on it and the overwrap process using Zentron 721B-AA 750/828-W was started. This chamber used Liner #19 with Flange #19.

The forward segment of the "old" 60K tape wrap mandrel was used to wrap an insert billet that was autoclave cured with 60K Liner #19. The billet was machined and the silica/phenolic insert bonded into the forward end of 60K #14. The chamber was then returned to the 4705 Machine Shop for re-machining of the ports/contour for additional testing.

60K Silica/Phenolic Combustion Chamber Liner #20 has been tape wrapped, vacuum bagged and autoclaved cured. The cure cycle was completed and the billet was delivered to the 4705 Machine Shop for forward end machining. The tagend was machined off, the liner billet removed from the wrap mandrel and returned to 4705 for completion of the contour machining.

The tape wrap of 60K Silica/Phenolic Combustion Chamber Liner #21 (30 to 1) has been completed and the billet will be autoclave cured. The 60K 15 to 1 mandrel will be reassembled and the tape wrap of Liner #22 will be started the first week of July.

Received and stored approximately 1300 pounds of FM-5504 silica/phenolic bias tape, Lot #411319. A numerical pattern for a 15 to 1 nozzle has been developed for cutting adhesive on the Cutting Edge knife. The Cutting Edge knife was used to cut the EA9628 adhesive for the overwrapping of 60K #19.

60K Investigation/Tiger Team Support

Overwrapped Cylinder 9C, MX 2600, with T300/low temperature curing epoxy. The cylinder cracked before it was machined. Cylinders 10A and 10C are being used to define low density indications from CT evaluation on carbon/epoxy overwraps. Holes were drilled in the cylinders and the holes were filled with resin. These cylinders will be scanned to establish a standard by which previous and future CT scans can be evaluated. Performed a dry cycle on Cylinders 18A-18C, 12" FM 5504 cylinders. These were vacuum bagged after the cycle was performed and will remain/remained under vacuum until immediately prior to the overwrap process. Overwrapped Cylinder 18A, a FM 5504 cylinder, with T300/828-W. After every layer plus one circuit were wound, unidirectional T300/828-W prepreg tape was hand laid on the cylinder. This cylinder was oven cured, the ends machined off, and delivered for inspection. Overwrapped Cylinder 18B, a 12-inch FM 5504 cylinder, with multiple unidirectional plies hand laid between winding layers. This cylinder differed from 18A in that the vacuum bagging process was changed to allow entrapped air to escape. The cylinder exhibited some slight wrinkles in the overwrap and, by visual inspection, appears to have delaminations or voids in the overwrap. Generated shop travelers for the fabrication of the next two throat cylinders which will be 21A, F554 silica phenolic with the T300/828-W overwrap, and 18C, FM 5504 with a Kevlar 149/828-W overwrap. Cylinders #19 and 23, also FM 5504 silica-phenolic material, were machined into 12" cylinders. Overwrapped and cured Cylinder 20A, the MXSE 65 modified silica/phenolic cylinder. The standard T300/828-W was used as overwrap for this cylinder. The North Alabama Composites fabricated cylinder, a MX 2600 billet, was also machined to 12 inches.

Zentron™ 721B-AA /828-W fiberglass-epoxy prepreg was produced, staged and test panels layed-up and cured from it. These test panels will be used to develop material properties for the fiberglass overwrap. Upon completion of X-ray inspection of the panels, tabs will be bonded to them and the machining of individual specimens will begin. Thiokol has ordered the strain gages and related accessories. The strain gage application will be performed by NASA. One pallet of Zentron™ 721B-AA has been ordered with delivery expected in early July. Discussions with personnel at Owens Corning indicated that they are unable to produce the Zentron™ roving on three-inch spools. They are also not set up to re-spool the roving onto three inch spools from six-inch spools.

Will investigate Kevlar 149 as a possible overwrap reinforcement fiber. Ordered 40 pounts of the Kevlar 149 tow. DuPont has indicated that this is the highest modulus, approximately 21 MSI, form of the aramid fiber. The 167 pounds of MXSE65 silica phenolic of 2.5 inch tape was received and placed in the cooler. The 205 pounds of MXSE65 silica/phenolic broadgoods was shipped back to Fiberite because it was delivered as broadgoods instead of tape as ordered.

TD FPM-25 BANTAM COMPOSITE RP-1 TANK

Tank 1 was dried and the previously grit blasted surface for the inner belly band sanded to prepare for lay-up. The inner belly band was laid and cured. The inner tank surface was coated with RSL2704/RSC3705 epoxy resin. The inner surface was coated twice with this resin, a Shell research resin which is basically EPON 828 modified for higher elongation. Both coats were post cured. The manhole bolt ring and clamp ring have been installed and sealed with PR1422 polysulfide. The nozzle split ring flange has been installed and bonded in place. Polysulfide was applied to the edges of the inner belly-band to enhance the seal and will be completely cured within one week at ambient lab conditions. This requirement will easily be met by the expected proof test schedule of mid-July. Thermography was conducted on the inside belly band. Tank 1 will be ready for transport to the test area after NDE is completed.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. Training on CATIA and the new Cincinnati Milacron Acraplace software should be purchased to ensure maximum utilization of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	Medium	Basic Effort	Fiberplace SCMT and Cylinders
FPM23	High	Liquid Comb Chambers	Support Chamber Fabrication
FPM25	High	Composite RP-1 Tank	Failure Investigation

Approved by:

L. I. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
July 1998

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for July 1998. The following paragraphs summarize the significant accomplishments during the work period beginning in July, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in August 1998.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

NASA/MSFC successfully test fired two 60K Combustion Chambers and Nozzles for 150-seconds each. Both chambers appeared to have no significant erosion or cracks after posttest inspection. The first chamber was fabricated using 5504-silica/phenolic liner with an S2-fiberglass/epoxy overwrap. The second chamber was fabricated using 5504-silica/phenolic liner with a T300-graphite/epoxy overwrap. The FM 5504 silica phenolic has eliminated the cracking problem that had been witnessed with the MX 2600 material, as is now the baseline for chamber fabrication. NASA is planning to use the 60K Combustion Chambers on the X-34 vehicle.

Thiokol completed the bonding/fabrication of the composite RP-1 tank, Tank 1. The tank is now ready for testing when the NASA test facility becomes available.

2.1 BASIC MACHINE OPERATIONS

SEMI-CONFORMAL MINI TANK

Due to cracks in the forward end ring of the Semi-Conformal Mini Tank (SCMT) work has been placed on hold. Fabrication of the outer skin, shear plies and doubler will continue when a decision is made on how to repair the cracked ring.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

Liquid Engine Combustion Chamber Status

Updated travelers for bonding of actuator attachment ring and belly-band to 60K#16. Bonding of the actuator attachment ring and the belly-band to 60K#16 was completed. The coordinate measuring machine (CMM) was used to verify positioning of the belly band during dry fit. The CMM was also used to verify positioning of the belly-band and the actuator attachment ring after bonding. The belly-band has a rotational positioning tolerance of ±0.5°. The actual measurement was 0.7° from nominal. A discrepancy report was issued for two out-of-tolerance conditions for the positioning of the GG/Turbopump Support Band and two out-of-tolerance conditions for the positioning of the Actuator

Attachment Ring for 60K#16. These discrepancies were caused by the limitations of the temporary bonding fixture. The temporary bonding fixture is not capable of assuring alignments within drawing tolerance. Fabrication of the permanent bonding fixture is in process. The completed bonding traveler for 60K#16 with summary sheets has been turned in to NASA for review.

Overwrapped with Zentron 721B-AA 750/828-W and oven cured 60K #19. This chamber used Liner #19 with Flange #19. It was removed from the overwrap mandrel and delivered to the machine shop.

Overwrapped and oven cured 60K #20. This chamber used T300 12K 309NT/828-W for the overwrap. Removed this chamber from the overwrap mandrel. Visual inspection revealed no cracks in the throat region or the aft end of the nozzle. The liner of this chamber had been machined to a blunt edge instead of the tapered end that had apparently served as a crack initiation site for the chambers with the NBR flap.

The autoclave cure was completed on 60K silica/phenolic combustion chamber liner #21 (30 to 1), and a liner "insert" billet made from FM 5504. These were delivered for machining. After machining, 60K Liner #21 was placed on the overwrap mandrel and a dry winding pattern check out performed on it. This was stripped off and a dry cycle performed on the liner. Due to problems with the filament winding machine, it was placed on the overwrap mandrel, vacuum bagged and left under vacuum.

The tape wrap of 60k silica/phenolic combustion chamber liner #22 (15 to 1) has been completed and autoclave cured. The liner has been delivered for machining.

The tape wrap and autoclave cure of 60K Silica/Phenolic Combustion Chamber Liner #23 (15 to 1) has been completed. This chamber was tape wrapped on the 30 to 1 mandrel. The billet was then delivered to the machine shop for machining. Once the forward end was machined, this liner was picked up from the machine shop, removed from the mandrel and delivered back for contour machining.

The tape wrap and autoclave cure of 60K silica/phenolic combustion chamber liner #24 (15 to 1) has been completed. The billet was delivered to the machine shop.

The 60K tape wrap mandrel was reassembled to wrap silica/phenolic combustion chamber liner #25 (15 to 1).

The second overwrap mandrel has been completed and the components need to be Teflon coated. A collar was machined to prevent the washers at the forward end of the overwrap mandrels from being locked in by the material during cure of a 30 to 1 chamber.

60K Investigation/Tiger Team Support

Overwrapped and cured Cylinder 18C, an FM5504 cylinder with Kevlar 149/828-W. The Kevlar 149/828-W overwrap was difficult to machine as expected but when the ends were cut off, the overwrap was well compacted with no evidence of delamination. Performed a dry cycle on Cylinder 19A, a 12-inch FM 5504 cylinder. Due to the limited availability of the filament winder this cylinder was vacuum bagged and maintained under vacuum until immediately prior to overwrap. It was then filament wound with T1000GB/UF 3323

prepreg. This resin system required a 24 hour hold at 270°F. The T1000GB carbon fiber possesses an equivalent cross-sectional area to the 6K T300 tow. The area also more closely simulates that of the Kevlar 149 and Zentron 750 yield S2 glass tow which had not revealed delaminations in the overwrap. However, upon inspection after cure, Cylinder 19A had bondline regions between the silica phenolic and the overwrap that had separated. Overwrapped and cured Cylinder 21A, a F554 silica phenolic with the T300/828-W overwrap.

The Zentron™ 721B-AA /828-W fiberglass-epoxy test panels have been machined and tabs applied to them. Individual specimens test specimens were then machined from the tabbed panels. These test specimens will be used to develop material properties for the fiberglass overwrap. The strain gages have been received and will be applied by NASA. Initially the specimens were required to be tested at ambient and 250°F. NASA requested another set of specimens for a low temperature (-65°F) condition. These specimens were also machined and delivered to NASA for instrumentation.

NASA requested sectioning of chamber 60K#02 for char measurements. This chamber was sectioned and strips cut from each section.

One pallet of Zentron™ 721B-AA has been received. Received and stored approximately 1000 pounds of silica phenolic bias tape from Culver City Composites.

TD FPM-25 BANTAM COMPOSITE RP-1 TANK

Tank 1 is ready for transport to the test area. A portion of the nozzle end of the failed tank (Tank 2) was cut out and delivered per NASA request.

TD FPM-27 FABRICATION OF COMPOSITE BONDED JOINT TEST ARTICLES

Met with NASA principal investigator to define project goals. The material system used will be IM7 carbon fiber with the Hexcel 8552 epoxy resin system. The material used will be both towpreg and prepreg fabric that is currently on hand at MSFC. Bottles will be wound using the towpreg. These will be cured, the domes cut off one end and two segments spliced together using the fabric placed by hand lay-up. A total of 3 bonded articles are proposed to be fabricated for this effort. Initially, a sample of the IM7/8552 was wound and cured to verify that the material is still usable. The trial cylinder has both helical, ±30-degree, and hoop plies/layers. This bottle was sectioned to determine the cured ply thickness. During winding of the test cylinder, the pre-preg tape adhered to itself as it fed from the spool. This resulted in the breaking of some fibers within the tape. The creel cabinet on the EnTec horizontal winder will be modified to permit cooling of the cabinet when winding this and other prepregs that exhibit similar tack. This should minimize or eliminate the problems witnessed with processing the IM7/8552 material.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. Training on CATIA and the new Cincinnati Milacron Acraplace software should be purchased to ensure maximum utilization of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	Medium	Basic Effort	Fiberplace SCMT and Cylinders
FPM23	High	Liquid Comb Chambers	Support Chamber Fabrication
FPM25	High	Composite RP-1 Tank	Failure Investigation
FPM27	Medium	Bonded Joint Test Article	Filament Wind Tanks

Approved by:

L. I. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
August 1998

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA39749) for August 1998. The following paragraphs summarize the significant accomplishments during the work period beginning in August, discusses recommendations for NASA/MSFC consideration, and lists the upcoming work to be performed in September 1998.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

Reviewed fully executed modifications descoping the 10K combustion chamber effort and authorizing the fabrication of 60 composite quasi-isotropic panels, composite bonded joint test articles, and compatibility and joint technology specimens.

2.1 BASIC MACHINE OPERATIONS

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

Liquid Engine Combustion Chamber Status

Unbagged 60K Liner #21, a FM 5504 30 to 1 liner, and placed the EA 9628.06 NW adhesive film on it. Started overwrap of the liner but, upon completion of the first layer, the pattern had not closed and was stripped off. Adjustments were made to the mandrel/liner configuration and one layer of the pattern completely dry wound before proceeding with the overwrap process. Completed overwrap of 60K Liner #21 with T300/828-W. This chamber used Flange #21. Oven cured 60K #21 and removed it from the overwrap mandrel. There were no visible discrepancies.

Started overwrap of Liner #22, a 15 to 1 FM 5504 liner, with Zentron 721B-AA 750/828-W. A refurbished flange, Flange #12, was used for this chamber. Upon completion of the third layer, the pattern had not closed and was stripped off. Adjustments were made to the overwrap mandrel to secure the aft ring to the shaft. This was the first use of the overwrap mandrel fabricated by NASA/MSFC in 4705. Completed overwrap and oven cure of 60K #22 and removed it from the mandrel with no discrepancies visually detected.

Completed overwrap of 60K Liner #23 with T300 12K 309NT/EPON 828 – EPI Cure W. This chamber used refurbished Flange #09 which had been used for 60K #12. Due to 60K #12 cracking after removal from the mandrel, the part was not delivered for final machining so no ports had been drilled in the flange. 60K #23 completed oven cure, was removed from the mandrel and delivered to the machine shop.

60K#24 silica/phenolic combustion chamber liner (15 to 1 billet) was removed from the mandrel and returned to 4705 machine shop for contour machining. After contour machining, the liner was obtained from the machine shop and overwrapped with Zentron 721B-AA 750/828-W. Flange #22 was used for this chamber. The aft ring slipped on the shaft and the first layer had to be stripped off. Nearing completion of the second layer it was noticed that the mandrel was starting to rotate again so, once the hoop plies were wound, the aft ring was secured using a bolt that was tapped into the shaft. This should prevent the problem from reoccurring, which was reinforced by the additional layers being wound without any slipping revealed in the overwrap.

60K25 silica/phenolic combustion chamber liner (15 to 1 billet on the 30 to 1 mandrel), has been tape wrapped and autoclave cured. The billet was delivered to NASA/MSFC for machining the forward end to length.

60K Liner #26 (15 to 1) has been tape wrapped and autoclave cured. The liner was delivered for machining the forward end to length. The billet was then removed from the mandrel and returned for contour machining.

60K Silica/Phenolic Combustion Chamber Liner #27 (15 to 1 on the 30 to 1 mandrel), has been tape wrapped and autoclave cured. The liner/mandrel was delivered for machining the forward end to length.

The 15 to 1 mandrel was re-assembled and loaded into the tape wrap machine in preparation for wrapping liner #28.

The new fixture for bonding actuator attachment rings and G.G. bands has been delivered to Building 4707.

Revising overwrap shop traveler for conformance to the NASA/MSFC process specification.

60K Investigation/Tiger Team Support

Another set of Zentron™ 721B-AA /828-W fiberglass-epoxy double notch shear specimens has been machined and delivered to NASA/MSFC for testing. NASA/MSFC requested resin content and density values for the Zentron™ 721B-AA /828-W fiberglass-epoxy test panels. Density tests have been completed. Resin content is continuing. Data obtained to this point has been relayed to NASA/MSFC. This testing will be used to develop material properties for the fiberglass overwrap.

TD FPM-27 FABRICATION OF COMPOSITE BONDED JOINT TEST ARTICLES

A test cylinder has been wound using IM7 carbon fiber with Hexcel 8552 epoxy resin. The cylinder was cured and sectioned to determine the ply thickness. The section was photographed under a microscope to measure the individual layers. The IM7/8552 material used will be both towpreg and prepreg fabric that is currently on hand at NASA/MSFC. A portion of the test cylinder was given to the principal investigator. Creel coolers have been installed on the filament-winding machine. During the winding of the test cylinder, the IM7/8552 towpreg material adhered to itself as it fed from the spools.

The creel coolers should alleviate this problem. The Thiokol IR & D inflatable mandrel will be used for winding of the bottles to make the joint specimens.

TD FPM-29 FABRICATION OF COMPOSITE QUASI-ISOTROPIC PANELS

The tape layer will be used to fabricate six large twelve ply panels that will be cured and cut into sixty 10 in. x 15 in. panels.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. Training on CATIA and the new Cincinnati Milacron Acraplace software should be purchased to ensure maximum utilization of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	Low	Basic Effort	Fiberplace SCMT and Cylinders
FPM23	High	Liquid Comb Chambers	Support Chamber Fabrication
FPM27	Medium	Bonded Joint Test Artcl	Filament Wind Tanks
FPM29	Medium	Quasi-Isotropic Panels	Fabricate Large Panels

Approved by:

L. I. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
September 1998

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for September 1998. The following paragraphs summarize the significant accomplishments during the work period beginning in September. discusses recommendations for MSFC consideration. and lists the upcoming work to be performed in October 1998.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

Per discussions with NASA/MSFC procurement and technical personnel. we have agreed on an approach relative to the extension of the existing contract and schedule for establishing a new. follow-on contract.

Received a request for ROM from NASA/MSFC EH33 for the fabrication of an advanced subscale composite cryogenic tank. Estimate was developed. priced and a ROM was dispatched for the fabrication of the article.

2.1 BASIC MACHINE OPERATIONS

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

Liquid Engine Combustion Chamber Status

Thiokol has established a central location for the shop travelers for the tape wrap, overwrap and bonding processes. This will facilitate tracking of the hardware and enable integration of material certifications in the individual travelers.

The new bonding fixture was used for the first time on 60K #18. The actuator attachment ring and GG/Turbopump belly band bonding travelers were updated to reflect the new procedures that will be required. The new bonding fixture was not properly aligned on initial installation. Optical alignment was then performed on the fixture. After completion of alignment, the actuator attachment ring (AAR) was dry fit and installed on 60K#18. A discrepancy report will be generated for voids in the AAR bondline. An insufficient amount of adhesive was applied leading to a void area that is approximately 3% of the total bond area. The bonding fixture has been modified with the addition of two surfaced plates to the top of the fixture. This will aid in the measurement for the positioning of the actuator attachment ring. Adjustments were required for the belly band bonding plate. The turbopump/G.G. belly band for 60K#18 was then bonded. The bonding fixture was determined to possess a mismatch between the height of the two linear actuator plates that position the two belly band halves. A .035-inch shim for the belly band linear actuating plate is being fabricated to correct this before the next chamber is bonded. AAR shear

bolts were bonded into 60K#18 and coordinate measuring machine measurements were made in preparation for shipment in early October. Bonding for 60K#19 will also commence in early October.

60K Combustion Chamber Liner #25 (15 to 1, FM 5504 silica phenolic) was overwrapped with T300 12K 309NT/EPON 828 – EPI Cure W. It was then oven cured, removed from the mandrel and delivered to the machine shop. Flange #23 was used for this chamber. One of the bolts used to secure the dome to the flange failed under torque load to remove the bolt. This will be removed by the machine shop. Digital photographs were taken. No damage was incurred by the chamber.

The overwrap of 60K Liner #26 was temporarily placed on hold due to the problems with the filament winding machine. The winder was repaired and 60K Liner #26 overwrapped with the T300 12K 309NT/828-W carbon/epoxy material. This chamber used Flange #24.

60K Liner #27 was removed from the 30:1 mandrel and returned to the machine shop for contour machining.

60K Liner #28 (15:1 billet) was tape wrapped using MXSE-65 silica tape. It was autoclave cured and delivered to 4705 for machining.

60K Liner #29 (30:1 billet) has been tape wrapped with FM-5504 silica phenolic tape and will be cured next week.

The next silica phenolic combustion chamber liner, 60K Liner #30, will also be a 30 to 1 billet and will be tape wrapped in early October.

60K Investigation/Tiger Team Support

Pieces of 60K#02 have been cut for thermocouple depth determination. Thermocouple installation records show the depths of the thermocouples relative to the plugs. The pieces have been sectioned to determine the depths of the plugs. This information as well as the plug remnants will be returned to NASA. Two-inch wide strips will also be cut from 60K#02 for char measurement. NASA has also requested the 2-inch strips from 60K#12 for overwrap thickness determination.

TD FPM-27 FABRICATION OF COMPOSITE BONDED JOINT TEST ARTICLES

A new delivery system for the winding machine was designed and fabricated that will facilitate the use of the 0.125 inch IM7/8552 towpreg. A work authorization request was issued to prepare the mandrel and polar bosses for winding. The polar bosses have been prepared but bottle fabrication is awaiting inflatable mandrel and filament winding machine availability.

TD FPM-29 FABRICATION OF COMPOSITE QUASI-ISOTROPIC PANELS

The panel sizes and lay-up sequence have been defined. Four panels will be tape layed, autoclave cured and cut into 60 10 inch x 15 inch panels. Difficulties with the VAX11/780 delayed the programming for the tape laying machine. The programming was

completed and bulk panel fabrication started. Two of the four bulk panels have been tape layed with autoclave cure scheduled for early October. Two autoclave cures will be required to accommodate all four panels.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. Training on CATIA and the new Cincinnati Milacron Acraplace software should be purchased to ensure maximum utilization of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	Low	Basic Effort	Fiberplace SCMT and Cylinders
FPM23	High	Liquid Comb Chambers	Chamber Fabrication & Bonding
FPM27	Medium	Bonded Joint Test Artcl	Filament Wind Tanks
FPM29	Medium	Quasi-Isotropic Panels	Cure & Fabricate Bulk Panels

Approved by:

L. I. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
October 1998

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for October 1998. The following paragraphs summarize the significant accomplishments during the work period beginning in October, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in November 1998.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

Completed bonding the actuator attachment ring (AAR) and the belly-band to 60K #19. The shear pins were installed and the drain tube support pads bonded to the nozzle region. 60K #19 was a 15 to 1FM 5504/Zentron 721B AA/828-W chamber/nozzle. Overwrapped 60K#'s 26, 27, 29 and 30. 60K #'s 26 and 27 used 15 to 1 FM 5504 liners while 29 and 30 are 30 to 1 configurations. All were overwrapped using T300 12K 309NT/EPON 828-EPI Cure W. Tape wrapped and cured Liner #31 and Liner #32 has been tape wrapped and is awaiting cure in early November 1998.

2.1 BASIC MACHINE OPERATIONS

SAND MANDREL FABRICATION

Fabricated the first of two 18-inch, solid sand mandrels. These sand mandrels were fabricated using existing tooling located at MSFC. Crates have been produced for the shipment of the two mandrels. Foil was successfully demonstrated on the first mandrel as a method to release the shaft from the sand.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

Liquid Engine Combustion Chamber Status

The actuator attachment ring has been bonded onto 60K#19. The belly band and drain tube support pads have also been bonded onto 60K#19. The coordinate measuring machine was used to verify the positioning of the actuator attachment ring, the belly band, and the drain tube support pads for 60K #19.

Encountered problems with the alignment of the plates that position the AAR that may require permanent additional reinforcement for bonding of subsequent chambers. The bonding fixture had a mismatch between the height of the two linear actuator plates that position the two belly band halves. Additional precision shim stock for placement under the belly-band linear actuators was ordered but has not been received. One of the linear actuating plates was not flat enough to hold tolerance. Both plates have been resurfaced to the correct height and flatness. Optical alignment will be used to verify the proper installation of the actuating plates. The two support beams that have a machined surface for holding the bonding plates in place have been resurfaced and remounted. The

coordinate measuring machine will be used to re-align the bonding fixture upon installation of the newly machined support beams.

Bonding of the actuator attachment ring to 60K#22 is scheduled to begin after the bonding fixture is properly aligned.

60K #26, which used Flange #24, completed oven cure, was removed from the mandrel and delivered to the machine shop with no known discrepancies.

Overwrapped 60K Liner #27 with the T300 12K 309NT/828-W carbon/epoxy material. This chamber used Flange #24 and was the first from the second shipment of T300. 60K #27 completed oven cure, was removed from the mandrel and delivered to the machine shop with no visible discrepancies.

Overwrapped 60K Liner #29 with T300 12K 309NT/828-W carbon/epoxy material. This chamber used Flange #26 and material from the third shipment of T300. Liner #29 was tape wrapped to the 30 to 1 configuration but will be truncated to a 15 to 1 nozzle due to an error in aligning the template while contour machining. The machining error left a step in the aft end of the nozzle that was filled with Hav-a-Flex. The chamber/nozzle being cut to a 15 to 1 allowed the inclusion of intentional defects (PTFE tape) in the bondline of the region that will be cut off when the chamber is machined to the 15 to 1 configuration. This should aid NASA non-destructive evaluation personnel in developing standards for chamber/nozzle bondline integrity. 60K #29 completed oven cure, was removed from the mandrel and delivered to the machine shop.

60K Silica/Phenolic Combustion Chamber Liner #30 (30:1 billet) was tape wrapped, autoclave cured, and delivered for machining. Upon completion of contour machining, it was overwrapped using T300/828-W and Flange #27. The T300 used for 60K #30 came from the third shipment of the carbon fiber.

60K Silica/Phenolic Combustion Chamber Liner #31 (30:1 billet) was tape wrapped, autoclave cured and delivered to the machine shop. After the forward end was machined, it was removed from the mandrel and returned to Building 4705 for completion of contour machining.

60K Silica/Phenolic Combustion Chamber Liner #32 (15:1 billet) has been tape wrapped and will be autoclave cured the first week of November 1998.

Two precision levels and Epon 828 resin were received last week. Eleven pounds of silica carbide filled RTV (DC 93-104) was ordered last week.

<u>60K Investigation/Tiger Team Support</u>

Sections have been taken from 60K #02 that contain the thermocouple plugs. Discussed with NASA thermal analysis personnel the appropriate technique to determine the thermocouple depth. They agreed that computed tomography (CT) should be used to determine the thickness of the liner at the point where the plugs are located. This measurement can then be correlated with the measurements taken from the base of the plugs to the outside contour of the liner to determine the thermocouple locations.

NASA has requested 2-inch strips from each quadrant of 60K#02 and 60K#06 for char measurement. NASA has also requested 2-inch strips from each quadrant of 60K#12 for overwrap/liner thickness measurement.

TD FPM-25 BANTAM COMPOSITE RP-1 TANK

Four rolls of T650-35 3K/UF3325-105, 60-inch broadcloth were received. This completes the order from TCR Composite Division.

TD FPM-27 FABRICATION OF COMPOSITE BONDED JOINT TEST ARTICLES

The first bottle has been wound with IM7/8552 on the IR&D inflatable mandrel and cured. One dome has been cut off of the first bottle (Bottle 1A) and the second bottle (Bottle 1B) has been wound and cured. After one dome has been cut off of Bottle 1B, the remaining barrel and dome of Bottle 1A and 1B will be aligned with the inflatable mandrel and spliced together with IM7/8552 prepreg fabric to form one long bottle. Three long bottles are required to complete the program.

TD FPM-29 FABRICATION OF COMPOSITE QUASI-ISOTROPIC PANELS

Completed tape laying of two bulk AS4/3501-6 panels. Due to the order of processing and the availability of the autoclave, the second and third bulk panels were autoclave cured together. The fourth bulk panel was cured by itself when a window opened up for the autoclave. A metal caul pad was used for cure of the fourth panel to help ensure flatness of the panel. The first panel that was tape layed, which had been stored in the freezer-awaiting cure, was also cured using the metal caul pad. A fifth bulk panel has been tape layed. After the fifth panel is cured, sixty 10-inch by 15-inch panels will be cut from the bulk panels.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. Training on CATIA and the new Cincinnati Milacron Acrapiace software should be purchased to ensure maximum utilization of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	Priority	Application	Work Activity
FPM00	Low	Basic Effort	Fiberplace SCMT and Cylinders
FPM23	High	Liquid Comb Chambers	Chamber Fabrication & Bonding
FPM27	Medium	Bonded Joint Test Article	Filament Wind/Bond Tanks
FPM29	Medium	Quasi-Isotropic Panels	Cure & Machine Bulk Panels

Approved by:

L. I. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
November 1998

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for November 1998. The following paragraphs summarize the significant accomplishments during the work period beginning in November, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in December 1998.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

60K#21 was fired for nine seconds on November 23, 1998, followed by a 150 second firing on November 24, 1998. This was the first 30 to 1 nozzle to be tested at MSFC. The objective of the 150-second test was to determine if a diffuser was required to test the altitude configuration nozzle at sea level. The NASA MSFC Materials and Processes nozzle lead reported, upon initial inspection after the second firing, that the nozzle performed successfully with no anomalous erosion witnessed. NASA did note the expected cool down cracks in the liner and degradation of the overwrap and bondline at the aft end of the nozzle.

2.1 BASIC MACHINE OPERATIONS

SAND MANDREL FABRICATION

Fabricated the second of two 18-inch, solid sand mandrels. These sand mandrels were fabricated using existing tooling at MSFC. The sand mandrels each weigh approximately 400 pounds. The outside surface of the mandrels was taped using polytetrafluoroethylene (PTFE) tape to facilitate processing. The mandrels have been placed in individual crates and are ready for shipment. A third sand mandrel may be fabricated in December 1998.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

Liquid Engine Combustion Chamber Status

Bonding of the belly-band and actuator attachment ring (AAR), and installation of the shear bolts, to 60K#22 has been completed. Final measurements have been taken with a coordinate measuring machine (CMM) on 60K#22 to identify the location and orientation of the bonded hardware.

Dry fit and bonding of the AAR and belly-band for 60K#23 has been completed. 60K#23 will be delivered for drilling of the AAR shear pinholes.

Bonding of the actuator attachment ring to 60K#24 has been completed. Measurements of the location and orientation of the AAR on 60K #24 have been taken using the CMM. 60K #24 will be used to perform a loads test on the AAR.

60K Liner #28, a 15:1 MXSE 65 liner, overwrapped with T300/828-W completed oven cure. This chamber/nozzle used Flange #27. It has been removed from the mandrel and delivered to the machine shop.

60K #30, a 30:1 FM5504/T300-828-W nozzle which used Flange #28, completed oven cure, was removed from the mandrel and delivered to the machine shop. Flange #28 was available before Flange #27 so it was used for 60K #30. 60K#30 is the first 30:1 configuration chamber/nozzle to go through the bonding procedure. The AAR for 60K#30 has been bonded and the first exhaust duct support bracket will be bonded in early December 1998.

Overwrapped 60K Liner #31, a 30:1 FM 5504 liner, with T300/828-W. This chamber used Flange #29. The overwrap was oven cured onto the liner and the chamber/nozzle removed from the mandrel and delivered to the machine shop.

60K Combustion Chamber Liner #32, a 15:1 FM 5504 silica-phenolic billet, has been autoclave cured and delivered for machining.

The next 60K CC Liner #33 will be started when the large autoclave refurbishment has been completed.

The CMM was used to re-align the bonding fixture after installation of the newly machined support beams. New pins for alignment of the nozzles into the bonding fixture have been fabricated. Support angles have also been fabricated to reinforce the belly band bonding plates. A go-no-go gauge has been produced to aid in the measurement of the distance from the forward flange to the belly band.

Two Zentron™ /828-W fiberglass test panels have been fabricated and delivered to NASA for bond testing. Two T300/828-W test panels were also requested for testing of the bondline between the Lytex™ pad and chamber overwrap materials. The carbon-epoxy prepreg was fabricated, staged and laid-up into the required two test panels. These panels were cured and delivered to NASA.

Received and stored approximately 3000 pounds of Cytec Fiberite FM 5504 silica/phenolic bias tape in the widths required for the next 60K CC Liners.

<u>60K Investigation/Tiger Team Support</u>
NASA requested two-inch strips from each quadrant of 60K #02 and 60K #06 for char measurement. The two-inch strips have been cut from each quadrant of 60K #02. NASA also requested sectioning of 60K #08 with NASA MSFC's Nondestructive Evaluation Branch to define the cut locations.

Thermocouple depth measurements have been calculated with the aid of computed tomography (CT) at the request of the NASA thermal analysis personnel. The locations of the K thermocouples had to be estimated because they were undetectable by CT. It was verified that thermal conductivity compound was injected into the 0.020 inch diameter holes in the silica-phenolic plugs prior to the thermocouples being bonded into place.

Set up to filament wind the FM 5504 cylinders using carbon-phenolic for the overwrap material. Determined that a new delivery system would have to be produced to handle the approximate 0.100" impregnated T300 tow. This will delay the winding of the

cylinders until mid-December. There are two carbon-phenolic materials that will be investigated. One material is T300 carbon fiber impregnated with SC 1008 resin while the other is T300 impregnated with a modified phenolic resin.

TD FPM-27 FABRICATION OF COMPOSITE BONDED JOINT TEST ARTICLES

One dome has been cut off of Bottle 1A and Bottle 1B. These bottles were fabricated on an inflatable mandrel with the rubber sleeve and were made using IM7/8552 prepreg that was on hand. The inflatable mandrel was also used to align the bottle halves to form Bottle 1. The primary investigator has inspected and approved the alignment. The bottle halves will be bonded together with an inner and outer belly band. Bottles 2A and 2B have been wound, cured and cut to length. Bottles 3A and 3B will be wound when the filament winder becomes available. Three 32-inch long, 18-inch diameter bottles are required to complete the project.

TD FPM-29 FABRICATION OF COMPOSITE QUASI-ISOTROPIC PANELS

One bulk panel remains to be cured awaiting availability of autoclave and cure plates. After this panel is cured, sixty 10-inch x 15-inch panels will be cut from the bulk panels.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. Training on CATIA and the new Cincinnati Milacron Acraplace software should be purchased to ensure maximum utilization of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	Priority	Application	Work Activity
FPM00	Low	Basic Effort	Fiber Place SCMT and Cylinders
FPM23	High	Liquid Comb Chambers	Chamber Fabrication & Bonding
FPM27	Medium	Bonded Joint Test Article	Filament Wind/Bond Tanks
FPM29	Medium	Quasi-Isotropic Panels	Cure & Machine Bulk Panels

Approved by:

L. I. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
December 1998

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for December 1998. The following paragraphs summarize the significant accomplishments during the work period beginning in December. discusses recommendations for MSFC consideration. and lists the upcoming work to be performed in January 1999.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

2.1 BASIC MACHINE OPERATIONS

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

Liquid Engine Combustion Chamber Status

NASA requested the sectioning of 60K#06 and 60K#11. The flange and actuator attachment ring sections have been cut from 60K#11. 60K#11 was used for load testing of the actuator attachment ring. 60K#08 has been sectioned with a cutting plan defined by NASA's EH13.

Actuator attachment ring shear bolts have been bonded into 60K#23. This 15:1 Block 5 (FM5504/T300-828-W) chamber/nozzle will be ready to be delivered to NASA upon completion of pad bonding.

The gaseous generator (GG)/turbopump bellyband has been bonded to 60K#25. This 15:1 Block 5 (FM5504/T300-828-W) chamber/nozzle is now ready to have the actuator attachment ring and pads bonded to it.

60K#30 was the first 30:1 configuration chamber/nozzle to go through the bonding procedure. The AAR was bonded to it following completion of the GG band bonding. Initial attempts to dry fit the first exhaust duct support bracket encountered difficulty. The exhaust duct support bracket is a solid ring and could not be positioned at the specified axial position on the nozzle. The dry fit indicated that the exhaust duct support bracket would be positioned approximately 0.265 inches forward of nominal which was deemed acceptable by NASA. Measurements from the coordinate-measuring machine also showed that the nozzle is slightly out of round. After resolution of the exhaust duct support bracket location. the remainder of the hardware was bonded to 60K #30. This included the exhaust duct support bracket. the valve bracket supports and the first Lytex™ drain tube support brackets.

A discrepancy report was generated for the as-received condition for Flange #30 due to damage to the forward surface. Flange #30 was then primed in preparation of fabrication of 60K #32 when a winding machine availability conflict was identified. 60K Liner #32 had also been placed through a dry cycle before the schedule conflict was discovered. The decision was made, based on previous chamber fabrication, that the flange could be used as long as it was kept protected until mating with the liner. It was also decided though, that the liner should be placed through an additional dry cycle so it could immediately go into the bonding process upon removal from the oven. 60K Liner #32, a 15:1 FM 5504 liner, was then removed from the oven after the second dry cycle and overwrapped with T300/828-W. 60K #32 completed oven cure, was removed from the mandrel and photo documentation of the seal surfaces of the forward flange performed. The chamber was then delivered for final machining.

Six each 9M30887-5 and -7 and 10 each 9M30887-1 and -3 Lytex™ brackets have been received from Thiokol/Utah. NASA has also requested that the stringer brackets that attach to the combustion chamber be fabricated from Lytex™. Sixty stringer brackets will be required.

In response to the processing of Flange #30 on 60K #32, a shop traveler was generated to investigate the shelf life of Cytec BR-127 primed hardware. The process specification for the Fastrac nozzle dictates that no more than 96 hours may pass between primer cure and adhesive application. The study detailed in the traveler will determine if there is any degradation of the bondline properties when stored for two, four or six weeks. The control group of the Cytec BR-127 primer evaluation buttons have been completed. These buttons were processed identical to the ideal chamber fabrication schedule where bonding begins the day after the hardware has been primed. These have been delivered to NASA.

Working on converting the shop travelers to the NASA Organizational Work Instruction (OWI) format. Continuing work on closing out discrepancy reports on chamber/nozzles that are being delivered.

60K Investigation/Tiger Team Support

Working on the design of a 0.100" delivery system for the phenolic impregnated T300 carbon tow. One material is T300 with neat SC 1008 while the other has a modified phenolic resin, HT 410Y.

TD FPM-27 FABRICATION OF COMPOSITE BONDED JOINT TEST ARTICLES

Three bonded 18-inch diameter bottles are required to complete this program. The overall length of the bonded articles will be 32 inches. Different splice lay-ups will be evaluated using the produced bottles. The fifth and sixth IM7/8552 bottles. Bottles 3a and 3b have been wound and cured. The next step will be to cut the domes off and bond the bottle halves together.

TD FPM-29 FABRICATION OF COMPOSITE QUASI-ISOTROPIC PANELS

The fourth bulk AS4/3501-6 panel was autoclaved cured. All of the panels were then machined into sixty 10-inch x 15-inch panels that are ready to be delivered to NASA.

NASA will subject the panels to impact testing and subsequent non-destructive evaluation (NDE). This fulfilled the requirements for this technical directive.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. Training on CATIA and the new Cincinnati Milacron Acraplace software should be purchased to ensure maximum utilization of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	Low	Basic Effort	Fab Sand Mandrel/Wind Cylinders
FPM23	High	Liquid Comb Chambers	Chamber Fabrication & Bonding
FPM27	Medium	Bonded Joint Test Artcl	Filament Wind/Bond Tanks

Approved by:

L. F. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
January 1999

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for January 1999. The following paragraphs summarize the significant accomplishments during the work period beginning in January, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in February 1999.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

2.1 BASIC MACHINE OPERATIONS

Alternative Mandrel Evaluation

The planning is being generated for fabrication of 5.75" diameter bottles that will be filament wound as part of an effort to evaluate alternative mandrel materials. The first bottle was to be wound prior to the winding machine upgrade but will now be delayed until after it is completed.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

60K Investigation/Tiger Team Support

The 60K Investigation has been officially closed and the 60K Tiger Team disbanded so all remaining action items will be covered under the Fastrac liquid engine combustion chamber fabrication effort.

Liquid Engine Combustion Chamber Status

Continuing to work on the Organizational Work Instruction (OWI) for the fabrication of the Fastrac combustion chambers. Incorporating quality buy-offs to comply with MSFC-2899, the Fastrac 60K chamber/nozzle process specification.

The actuator attachment ring and belly band have been bonded to 60K#25. The shear pins have also been bonded into the actuator attachment ring for 60K#25. The actuator attachment ring has been bonded to 60K#26.

The design for a bonding fixture for the valve bracket supports has been finished and fabrication has begun. The design of a bonding fixture for the drain tube support bracket is ongoing.

Thiokol is taking measurements of the overwrap thickness at the forward end for the carbon fiber overwrapped chambers. The data will be segregated for the 15:1 and 30:1 configurations to show the variation in the thicknesses for each winding pattern. This

information will be used to verify tolerances for the attachment hardware bonding processes.

Three Lytex™ pads have been turned over to NASA for insert pullout testing. Three Lytex™ pads will be bonded to scrap pieces of 60K nozzles for bond strength testing. Pieces have been cut from 60K#08 for this testing. Six Lytex™ valve bracket supports have been received from Thiokol Utah for testing. NASA has provided the revised design for the drain tube support bracket so Thiokol Utah can have the molds remade.

Photographs have been received of the cross-sectioned 60K-002 thermocouple plugs. The measurements of the thermocouple depths have been recorded and forwarded to NASA.

A section will be cut from 60K#11 for analysis of the failure surface between the actuator attachment ring and the nozzle surface. The metal actuator attachment ring yielded before the bondline failed.

The second group of the Cytec BR-127 primer evaluation buttons has been completed. These primed buttons had been maintained for 3 weeks and five days at ambient lab conditions before they were bonded. One layer of the EA 9628.06 NW film adhesive was laid onto the buttons and they were oven cured according to the overwrap cure schedule. These have been delivered to NASA. The third set of Cytec BR-127 primer evaluation buttons has also been laid-up. This set will reflect any degradation in bondline properties if primed stainless steel hardware is maintained at ambient lab conditions for one month prior to use. An additional set of buttons is also being fabricated as a control group to identify properties when the buttons start cure the same day the EA 9628.06 NW film adhesive is laid-up. The remainder of the evaluation buttons will be processed identical to the chamber schedule where cure is started four days after adhesive application.

The silicone pad for the aft end of the combustion is being reviewed by Torr Technologies for quoting purposes. A quote is expected in early February.

A test preparation sheet (TPS) has been signed-off for the load testing of the new lifting hardware. The hardware will be provided when the contractor is able to perform the testing. This additional hardware is being load tested to insure that all lifting operations performed to support the Fastrac chamber/nozzle fabrication are conducted with load-certified equipment.

Establishing a test matrix to qualify the new filament winder resin bath for chamber fabrication. This will include the production of double-notch shear and shear modulus specimens to determine if there is any difference in the fiber-matrix interface properties due to the new system.

As part of the alternate overwrap material study for the Fastrac chambers, two carbon-phenolic materials were purchased. One is the T300 carbon fiber impregnated with neat SC 1008 phenolic while the other is T300 impregnated with a modified phenolic resin, HT 410Y. Fabricated prepreg tapes from the two types of impregnated tow. These will

be used for resin flow tests immediately prior to winding of Fastrac throat test cylinders for the two materials.

TD FPM-27 FABRICATION OF COMPOSITE BONDED JOINT TEST ARTICLES

Three 32" long, 18" diameter bottles are being fabricated to satisfy the requirements for this program. Different splice lay-ups will be evaluated using the produced IM7/8552 carbon/epoxy bottles. Bottle halves 1a and 1b were aligned and bonded with EA 9394. The IM7/8552 cloth inner and outer belly bands were then laid and cured. The end bosses have been sealed with polysulfide and Bottle #01 is ready to deliver to NASA. The bottle halves for Bottle 2 have a diameter mismatch. NASA has decided the bottle halves should be remade. Bottle #3 will be joined and the belly bands will be laid up using a reverse pyramid stacking sequence. The belly bands for Bottle #1 used a standard pyramid stacking sequence.

TD FPM-29 FABRICATION OF COMPOSITE QUASI-ISOTROPIC PANELS

Sixty 10" x 15", tape-laid, AS5/3501-6 panels have been delivered to NASA. NASA will subject the panels to impact testing and subsequent non-destructive evaluation (NDE). This fulfills the contract requirements for this effort.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. Training on CATIA and the new Cincinnati Milacron Acraplace software should be purchased to ensure maximum utilization of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	Low	Basic Effort	Fab Sand Mandrel/Wind Cylinders
FPM23	High	Liquid Comb Chambers	Chamber Fabrication & Bonding
FPM27	Medium	Bonded Joint Test Artcl	Filament Wind/Bond Tanks

Approved by:

L. I. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
February 1999

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for February 1999. The following paragraphs summarize the significant accomplishments during the work period beginning in February, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in March 1999.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

2.1 BASIC MACHINE OPERATIONS

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

The upgrade to the EnTec horizontal winding machine was completed at the end of January. As part of the verification of the upgrade, the successful dry filament winding of one layer of T300 fiber on a 30:1 chamber/nozzle was to be completed. This was to verify that the upgrade did not alter the machine motion and, consequently, overwrap fiber alignment. It was to be judged as successful if the pattern completely covered the surface area of the liner. During and after this process there were two complications that occurred. The first complication was that initially the winding machine oscillated along the axis of the shaft of the mandrel when loaded with the 30:1 liner/overwrap mandrel assembly. The winding machine was tuned while the manufacturer was completing the upgrade but not with a mandrel/component that weighed nearly as much. The weight of the liner/overwrap mandrel assembly is in excess of 500 pounds. Adjustments were made to the machine to enable the successful winding but further improvements/tuning may be required. The second problem was that after the winding was completed and liner was to be removed from the mandrel, the nut used to secure the forward dome/flange and prevent rotation was stripped on the shaft and could not be removed. The assembly was delivered to NASA for removal of the nut.

The actuator attachment ring and bellyband were bonded to and the shear pins installed in the actuator attachment ring (AAR) of 60K#27.

The actuator attachment ring has been bonded to 60K#31. Bonding fixtures for the valve bracket supports and the drain tube support brackets were designed and fabricated. The bonding fixtures for the valve bracket support pads were used for the dry fit and bonding of the valve bracket supports on 60K#31. The dry fit indicated that 0.090 to 0.105 inches had to be machined from the surface of the pads. After the pads were machined, they were used to dry fit to four of the combustion chambers. The shear pins were then installed on 60K#31 along with the valve bracket supports. Bondline data for the

supports was collected which will be used to modify the design for future pads. The bondline on the valve bracket support pads for 60K#31 ranged from 0.011 to 0.054 in. The drain tube support brackets will be installed on 60K#31 in early March with the new drain tube support bracket-bonding fixture.

Support blocks have been machined for the bellyband-bonding fixture. These blocks will support the actuating plate used to mount the bellyband on 60K nozzles. Custom stamped stainless steel peelable shims have been ordered. These shims will be used when necessary to bridge the gap between the stringer brackets and the valve bracket supports.

Overwrapped 60K Liner #33, a 30:1 FM 5504 liner, with T300/828-W. This chamber, 60K #33, used Flange #31 and is the last to be fabricated to Thiokol documentation. All remaining chambers will be overwrapped using the NASA organizational work instruction (OWI). During the filament winding process, when starting the first circuit to lay immediately adjacent to another wound circuit, a gap was noticed. It was decided that the mandrel configuration had probably allowed some rotation of the mandrel/liner and that the nut at the forward end should be tightened. The nut was re-tightened but the machine automatically zeroed out its axes orientation and could not be restarted at the stopping point as the old control software had allowed. This problem/difference is being worked with EnTec, the winding machine manufacturer. The wound circuits were stripped off and the winding was restarted with no gapping occurring. The winding was completed on 60K #33, it was vacuum bagged and oven cured. The cool down rate criteria for both the overwrap cure cycle and the dry cycle will be established as having a maximum rate only due to the fact the Despatch Oven will not cool from 175 to 150°F within the range specified in the Fastrac process specification.

Performed two dry cycles on 60K Liner #34 due to no record of successful oven performance for the first cycle. Upon completion of the second cycle, the overwrap manufacturing process was started. The EnTec winding machine continued to have problems with bandwidth alignment and orientation. The first attempt to wind the initial layer on the chamber resulted in a gap between bands that should have been adjacent as the overwrap for 60K #33 had done. The first few circuits were stripped off, the layer restarted and it closed correctly. The problem is attributed mainly to the software not maintaining an absolute origin, a fixed 0° rotational orientation, like the old software did. The problem has not occurred while winding smaller parts but, when loaded with the weight of the 30:1 liner/overwrap mandrel, has occurred for both chambers processed since the upgrade.

The 60K CC Liner Tapewrap has been put on hold until NASA Quality Control reviews the 60K Organization Work Instruction (OWI). 60K CC Liner #36 will be started after NASA QC reviews the OWI.

The silica phenolic plies have been cut and vacuum bagged for six 60K CC liner exhaust duct flange heat shields. The billets will be autoclave cured.

Have completed production and testing of the final set of Cytec Fiberite BR-127 primer evaluation buttons. This test was to determine if there is any degradation of bondline properties when primed stainless steel hardware is maintained at ambient lab conditions

for up to two months. The preliminary results do not indicate a decline in bondline properties for this timeframe.

Torr Technologies indicated the extruded silicone pad that will be used for the aft end of the combustion chambers should be delivered in early March.

Designed and fabricated new resin bath combs that will permit the use of the four-inch wide roller setup. The four-inch configuration uses a smaller resin bath and thus less resin than the baseline new resin bath assembly that uses a 12-inch roller. The spacing of the pins on the comb from the resin bath currently used for Fastrac chamber/nozzle production was sufficient to enable the use of the four-inch rollers and was chosen to minimize the changes in the impregnation process. Wound the octagonal mandrel with T300/828-W using the old resin bath. The ±45° pattern will make the shear modulus samples that have been specified in the new resin bath comparison plan outlined by NASA. Also filament wound and cured a shear modulus sample part on the octagonal mandrel using the new resin bath setup.

Fabrication of the 0.100" delivery system for the filament winder has been completed. The rollers enabled the evaluation of two carbon-phenolic prepreg materials for potential use as the Fastrac overwrap. Attempted to wind Cylinder 23A, a FM 5504 cylinder, with the modified carbon phenolic towpreg, T300/HT410Y. The material broke repeatedly when coming off the spool so this material was classified as being unable to process in its current configuration. Successfully wound and cured the T300/SC 1008 carbon-phenolic towpreg on Cylinder 23A. There was only sufficient material to wind one layer onto Cylinder 23A.

TD FPM-25 BANTAM COMPOSITE RP-1 TANK

The burst test of Tank 3 ("The Pathfinder") was performed successfully. The tank ruptured at 180 psig (230% maximum design pressure, MDP). The preliminary assessment indicates the failure did not occur at the beilyband. Weeping was observed in a few locations prior to rupture. Prior to the burst test, the tank had been cycled to the proof test pressure (117 psi, 150% MDP) three times.

TD FPM-27 FABRICATION OF COMPOSITE BONDED JOINT TEST ARTICLES

Three 32-inch long, 18-inch diameter carbon epoxy bottles are required to complete this program. Bottle 1 has been bonded and is ready for testing. NASA plans to use the hydroburst cell to test this bottle and Bottle 3 which will be joined with the beily bands laid up using a reverse pyramid stacking sequence.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. Training on CATIA and the new Cincinnati Milacron Acrapiace software should be purchased to ensure maximum utilization of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	Low	Basic Effort	Miscellaneous Composite Fabrication
FPM23	High	Liquid Comb Chambers	Chamber Fabrication & Bonding
FPM27	Medium	Bonded Joint Test Artcl	Filament Wind/Bond Tanks

Approved by:

L. J. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
March 1999

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for March 1999. The following paragraphs summarize the significant accomplishments during the work period beginning in March, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in April 1999.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

In response to our submittal of a proposal for extension through December 31, 1999, NASA/MSFC has dispatched a letter indicating their interest in having the FPM transferred to them at no cost. A written Thiokol response is being prepared for dispatch this week offering the machine to them at no cost at the end of a multi-year follow-on contract. Our current contract period of performance expires March 31, 1999.

Received Modification 39 providing $110,000.00 in additional funding.

The X-34 structural test article is scheduled for rollout at the NASA Dryden Flight Research Center, Edwards, Calif., April 30, 1999. The X-34 will be powered by the Fastrac engine, which we fabricate the combustion chamber and nozzle at the NASA Marshall Space Flight Center, Huntsville, Ala. Fastrac is a single-stage main engine, which burns a mixture of liquid oxygen and kerosene. Six NASA centers, two Department of Defense installations and an industry team led by prime contractor Orbital Sciences Corp. are supporting the development and eventual flight testing of the X-34. Marshall manages the program for NASA

2.1 BASIC MACHINE OPERATIONS

Completed lay-up and autoclave cure of an IM7/977-6 development flange. This is to determine optimal lay-up and vacuum bagging techniques for the composite component.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

Received and stored a shipment of approximately 4200 lbs. of FM-5504 Silica/Phenolic tape (lot #412295) for 60K Liners (≈ 6 liners). Resin flow tests were completed and a panel was laid-up and will be cured along with 60K36 liner for Double Notch Shear (DNS) testing. Tape wrap and autoclave cure of 60K36, 60K37, and 60K38 was completed.

Completed dry cycle, overwrap, and oven cure of 60K34 and 60K35, 30:1 FM5504 liner overwrapped with T300/828-W. It was noted that the Despatch Oven is not cooling sufficiently to meet the FASTRAC process specification, MSFC – 2899. This condition was turned over to the facilities support contractor who is trying to ensure the baffles at the front of the oven will open properly on cool down.

Completed fabrication of filament wound parts to produce specimens for qualification of the new resin bath for the horizontal winding machine.

Worked with NASA/MSFC EH33 on revising the overwrap section of the Fastrac 60K process specification. The organizational work instruction for this process was also modified to comply with the revisions to the process specification.

Overwrapped Cylinder 23C, a FM 5504 cylinder, with T300/828-W using the new resin bath. The ends will be cut off and NDE performed. This cylinder is the final component to be wound as part of the verification that the use of the new resin bath will not cause any degradation to the overwrap material properties

The drain tube support pads were installed on 60K#31. These brackets were molded by Thiokol/Utah and modified here at SEHO. Inserts were also installed by SEHO. The actuator attachment ring, belly-band, shear bolts, valve bracket support pads, and drain line support pads were bonded to 60K32. The actuator attachment ring, exhaust duct support bracket, belly-band, shear bolts, and valve bracket support pads were bonded to 60K33.

NASA personnel bonded the first set of new valve bracket support pads to 60K16 and 60K18 at Stennis Space Center.

The molds for the valve bracket support pads and the drain line support pads have also arrived. SEHO is now molding Lytex™ brackets. The first sets of valve bracket support pads produced at SEHO were molded successfully and inserts were installed. Valve bracket support pads were bonded to 60K26 and drain tube support pads were bonded to 60K25. Valve bracket support pads were bonded to sections of 60K08 for pull tests.

Design was initiated for a rolling pallet that can be used to move 30 to 1 configuration chambers in and out of the bonding fixture. Due to height considerations, the 30 to 1 nozzles are currently placed on breather cloth to accommodate sliding the nozzle into the bonding fixture

TD FPM-25 BANTAM COMPOSITE RP-1 TANK

The burst test of Tank 3 ("The Pathfinder") was performed successfully. The tank ruptured at 180 psig (230% maximum design pressure, MDP). The preliminary assessment indicates the failure did not occur at the bellyband. Weeping was observed in a few locations prior to rupture. Prior to the burst test, the tank had been cycled to the proof test pressure (117 psi, 150% MDP) three times.

TD FPM-27 FABRICATION OF COMPOSITE BONDED JOINT TEST ARTICLES

NASA ED72 has picked up the hydroburst cell to test Bottle 1 and Bottle 3. The two halves of Bottle 2 were bonded together at the butt joint with EA9394.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. Training on CATIA and the new Cincinnati Milacron Acrapiace software should be purchased to ensure maximum utilization of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	Low	Basic Effort	Miscellaneous Composite Fabrication
FPM23	High	Liquid Comb Chambers	Chamber Fabrication & Bonding
FPM27	Medium	Bonded Joint Test Artcl	Filament Wind/Bond Tanks

Approved by:

L. I. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
April 1999

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for April 1999. The following paragraphs summarize the significant accomplishments during the work period beginning in April, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in May 1999.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

A request was received to provide NASA/MSFC the following and was supplied:

- The degree at which SEHO utilizes small businesses per the current contract
- The groups or companies that perform FPM maintenance
- A list of employees utilized on this contract and their job titles

Modification #40 allowing for a six month no cost/no fee extension of this contract through September 30, 1999, was completed and released. Additional funds of $110,000.00 were also included in this modification. It is anticipated that these funds will provide for performance through May 31, 1999.

Continued to provide information to David Morgan and Ketela White relative to NASA/MSFC completing a follow-on FPM contract. A meeting was held with Corky Clinton to discuss NASA/MSFC Procurement's plan to issue a fixed price IDIQ follow-on contract. Mr. Clinton was in agreement that this would not be beneficial to either Thiokol or Marshall and plans to meet with Kim Whitson, David Morgan, etc. to discuss his interest in establishing a cost reimbursable type contract similar to the one currently in place.

On Friday, April 30, at NASA's Dryden Flight Research Center at Edwards, Calif. the X-34 was unveiled to an audience of government and industry officials. The X-34 technology demonstrator will be the first in a series of experimental vehicles leading the way to a low cost, fully reusable, commercially developed and operated space fleet after the turn of the century. The Fastrac 60K engine that was designed and built at NASA's Marshall Space Flight Center will power the X-34 technology demonstrator.

2.1 BASIC MACHINE OPERATIONS

Filament wound a 5.75" diameter bottle on the segmented mandrel as part of a coating feasibility study. The mandrel had been coated prior to winding of the carbon epoxy material. The bottle was vacuum bagged and oven cured. The bottle, including the polar boss regions, was sectioned to visually inspect the cross-section. (S. Richardson)

Started discussions with the Nonmetallics Processes Branch on the fabrication of composite material property panels using the hand lay-up and fiber placement processing methods.

Hand-laid and autoclave cured a 48-ply composite panel for a coating development study. The panel was fabricated using TCR prepreg that was on hand but that had exceeded the recommended 1-year shelf life. The panel was cured at 30 psi with a target cure hold temperature of 270°F.

Conformal, Common Bulkhead, Aerogel-insulated Tank: Attended a meeting to discuss the possibility of fabricating either liquid hydrogen (LH_2) - liquid oxygen (LOX) or a RP-LOX with a common bulkhead tank. Aerogel is to be used as the insulation between the two tanks. Preliminary design reviews are leaning towards a tank-by-tank configuration. MSFC has inquired about the conformable tank work that Thiokol Utah presented in March. MSFC has inquired about the feasibility of fiber placing or filament winding all or part of the configuration.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

Tape wrap and autoclave cure of 60K39, 60K40, and 60K41 was completed. These liners were sent to 4705 machine shop for contour machining

Completed dry cycle, overwrap, and oven cure of 60K36, 60K37, and 60K 38, 30:1 FM5504 liner overwrapped with S2 glass/828-W 60K38 was overwrapped with T300/828-W.

Performed dry winding of tows over the backing film protected adhesive on 60K38. The machine is still having problems with the pattern closing. After repeating the dry winding process three times, the pattern closed. The backing was then stripped off of the adhesive and the filament winding of the three layers of T300/828-W was successfully completed

When the winding machine upgrade checkout was performed, dry winding of a complete layer to verify pattern closure, the machine continued to display tracking problems. The liner was then used to aid the machine manufacturer in trying to correct the problems.

The shear modulus samples for the resin bath comparison study were tested. The data showed closer correlation between the new and old resin bath material properties than the double notch shear test indicated. However, the samples produced from the old resin bath part in February as compared to the ones final machined in late March were significantly lower. Determination of cured resin content for the old and new bath components is ongoing.

The bonding fixture was modified to allow angular positioning verification of the three metal hardware pieces. Precision (.006 in) wire will be used to hang a plumb bob so the angular location of the hardware can be verified.

Valve bracket support pads and drain line clamps were bonded to 60K23 and 60K22. Bonding of 60K34 belly-band and actuator attachment ring was completed.

60K32, 60K33, 60K25, and 60K26 were shipped. 60K27, 60K29 are ready for final inspection.

Lytex™ pads bonded to sections of 60K08 were pull tested this week. The Lytex™ pads failed at 1700 to 2100 pounds

TD FPM-27 FABRICATION OF COMPOSITE BONDED JOINT TEST ARTICLES

The outer and inner belly-band for bottle #2 was laid and cured. Polysulfide was used to seal the polar boss joints.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. Training on CATIA and the new Cincinnati Milacron Acraplace software should be purchased to ensure maximum utilization of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	Low	Basic Effort	Miscellaneous Composite Fabrication
FPM23	High	Liquid Comb Chambers	Chamber Fabrication & Bonding
FPM27	Medium	Bonded Joint Test Artcl	Bond Tanks

Approved by:

L. L. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
May 1999

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for May 1999. The following paragraphs summarize the significant accomplishments during the work period beginning in May, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in June 1999.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

Received Technical Directives FPM-31 (Fabrication of Composite Elbow Ducts), FPM-32 (Fabrication of Composite Panels for X-33) and FPM-33 Fabrication of Composite, Cryogenic, Conformal, Common Bulkhead, Aerogel-Insulated Tank (CBAT)). NASA/MSFC was advised that the technical direction be considered out of scope. Prepared and dispatched Cost Plus Fixed Fee proposal in response to Technical Directive FPM-31 in the amount of $96,919. FPM-32 in the amount of $29,865, and FPM-32 in the amount of $29,865.

2.1 BASIC MACHINE OPERATIONS

The unidirectional panels, LM21CO3F-UNI-8-1 through 3, and the ±45 panel, LM21CO3F-±45-8-1, were hand laid and autoclave cured. The additional LM21CO3 fabric material received by the customer was 6K instead of 12K fabric and thus the fabrication of the quasi-isotropic fabric panels are on hold until 12K material arrives.

NASA's rapid prototyping group has produced a 1/5-scale model of the Conformal, Common Bulkhead, Aerogel-insulated Tank to be used for filament winding feasibility testing. The model was attached to a shaft for winding testing.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

Tape wrap and autoclave cure of 60K42, and 60K43 was completed. These liners were sent to 4705 machine shop for contour machining

The overwrap processing of the Fastrac chamber/nozzles is on hold pending completion of the repairs of the horizontal winding machine and the upgrade of the Despatch Oven.

Bonding of 60K34 and 60K35 was completed and all positioning was verified by CMM the belly band, actuator attachment ring and exhaust duct support were bonded to 60K36.

60K36 was delivered to the machine shop for shear bolt machining. Bonding for 60K38 has begun.

Initial testing of Lytex™ pads with mold-in inserts showed a substantial increase in strength. A set of smaller inserts will be ordered to eliminate the customizing of the inserts and more pads will be molded for testing.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. Training on CATIA and the new Cincinnati Milacron Acraplace software should be purchased to ensure maximum utilization of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	Low	Basic Effort	Miscellaneous Composite Fabrication
FPM23	High	Liquid Comb Chambers	Chamber Fabrication & Bonding

Approved by:

L. I. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
June 1999

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for June 1999. The following paragraphs summarize the significant accomplishments during the work period beginning in June. discusses recommendations for MSFC consideration. and lists the upcoming work to be performed in July 1999.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

The proposals for FPM TD-33 (CBAT Project) and FPM TD-23R6 (Fabrication of Liquid Engine Combustion Chambers) were completed and were dispatched to Ketela White. NASA/MSFC for review. Proposals were in the amount of $163.098 and $326.368 respectfully.

2.1 BASIC MACHINE OPERATIONS

The eight-ply quasi-isotropic panels (LM21C03F-QI-8-1 through 4) were laid-up and cured. The traveler for the 144 ply quasi-isotropic panel (LM21C03F-QI-144-1) was completed.

Laid-up and cured an eight-inch Composite Duct #1. Material for the first two layers of composite duct #1 were cut with the Cutting Edge/Gerber automated cutting knife.

NASA's rapid prototyping group fabricated a 1/5-scale mandrel to be used for filament winding feasibility testing. The mandrel was wound with IM7/8552(two tows) and cured. The mandrel collapsed under the pressure of the autoclave cure. Another rapid prototype 1/5-scale mandrel will be produced to use as a pattern for a sand mandrel

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

Tape wrap and autoclave cure of 60K44. and 60K45 was completed. These liners were sent to 4705 machine shop for contour machining

The overwrap processing of the Fastrac chamber/nozzles resumed with overwrap and cure of 60K39.

After review of the computed tomography (CT) results for 60K39. the decision was made to scrape excess resin during the winding of 60K40. Chamber/nozzles from which

the excess resin was not scraped during winding, showed a "swirl effect" in the CT scans just aft of the throat. The swirl effect has been attributed to resin build-up.

Bonding of 60K36 was completed and all positioning was verified by CMM. The actuator attachment ring, shear bolts, and valve bracket support pads were bonded to 60K38. The exhaust duct support bracket, belly-band and actuator attachment ring were bonded to 60K37.

The CMM has been shipped back to the manufacturer for renewal of the warranty and should be received back in early July

P50 cork will be used as TPS for the combustion chamber nozzles. The first set of cork was cut on the Cutting Edge/Gerber automated cutting knife. NASA successfully bonded the cork to 60K35. Some minor adjustments will be made to the cork cutting patterns to improve the fit for the next chamber/nozzle

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. Training on CATIA and the new Cincinnati Milacron Acraplace software should be purchased to ensure maximum utilization of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	Low	Basic Effort	Miscellaneous Composite Fabrication
FPM23	High	Liquid Comb Chambers	Chamber Fabrication & Bonding

Approved by:

E. I. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
July 1999

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for July 1999. The following paragraphs summarize the significant accomplishments during the work period beginning in July, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in August 1999.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

Met with NASA/MSFC's David Morgan and Sandy Presneil to discuss the status of the Fiber Placement Machine follow-on contract. The synopsis was posted on Thursday, July 15, and interested firms have 15 days to submit, in writing, their qualifications/capabilities.

Additional DD1861 forms were requested by Sandy Presneil per Technical Directive proposal's –31 (Composite Elbow Ducts), -32 (Composite Panels for X-33), and –33 (CBAT Project). This information was obtained and dispatched per her request.

2.1 BASIC MACHINE OPERATIONS

The 144 ply quasi-isotropic panel (LM21C03F-QI-144-1) was laid-up and cured. Laid-up and cured fiber placed panels (LM21CO3-UNI-8-1 and 2). One week during fabrication humidity levels in the fiber placement lab were out of the specified range so no panels were fiber placed that week. The humidity stayed around 58% in the lab and the specification requires a maximum of 50%.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

Tape wrap and autoclave cure of 60K46, 60K47, 60K48, and 60K49 was completed. These liners were sent to 4705 machine shop for contour machining

Completed dry cycle, overwrap, and oven cure of 60K40, 60K41, 60K42, and 60K43. 60K43 which is the beginning of a series of eight 15 to 1 configurations.

60K21 and 60K16 were sectioned for post fire evaluation. The design and analysis group is currently designing a holding fixture for sectioning of the nozzles. The process for sectioning 60K21 and 60K16 was reviewed by SEHO safety. Process redlines

required during sectioning of 60K21 were recorded and will be turned over to NASA for integration into the organizational work instruction (OWI).

Bonding of 60K37 was completed and all positioning was verified by CMM. The exhaust duct support bracket, belly-band and actuator attachment ring were bonded to 60K39.

G12 panels for the "old" and "new" resin baths were fabricated, machined and were turned over to NASA for testing. The double notch shear samples were machined. The double notch shear samples were turned over for testing.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. Training on CATIA and the new Cincinnati Milacron Acrapiace software should be purchased to ensure maximum utilization of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	Low	Basic Effort	Miscellaneous Composite Fabrication
FPM23	High	Liquid Comb Chambers	Chamber Fabrication & Bonding

Approved by:

L. J. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
August 1999

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for August 1999. The following paragraphs summarize the significant accomplishments during the work period beginning in August. discusses recommendations for MSFC consideration. and lists the upcoming work to be performed in September 1999.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

Technical Directives -31 (Composite Elbow Ducts). -32 (X-33 Panels). and -33 (CBAT Tank Project) have been approved by Justin Tidwell. Work orders will be assigned and the projects will proceed as directed. NASA/MSFC's Janice P. Burrough has been assigned as the new Contracting Officer on the FPM Contract

Dispatched memo 37C0-FY99-163:DMT stating that the FPM Contract has one month remaining until expiration and requesting that a period of performance extension and/or bridge be considered to ensure the Technical Directives currently in work be allowed to continue.

2.1 BASIC MACHINE OPERATIONS

Laid-up and cured fiber placed panels (LM21CO3-UNI-16-1).

The lay-up of eight-inch composite duct #3 was started. This duct will consist of all 45°-angle plies for ease of manufacture. Barbara Frame and George Wrenn of Oak Ridge National Labs visited and observe the lay up of composite ducts. They plan to lay up a composite duct to be e-beam cured.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

Tape wrap and autoclave cure of 60K50 was completed. This liner was sent to 4705 machine shop for contour machining. Completed dry cycle. overwrap. and oven cure of 60K44. 60K45. 60K46. and 60K47. The shear pins were bonded to 60K39.

The effort to refurbish the metal hardware (flange. TVC Ring. etc.) for the 60K Liners has been requested by NASA.

The number of completed 60K Combustion Chambers has grown to the point where additional wooden "transport pallets" had to be fabricated for in-process units. Approximately 20 additional pallets were fabricated.

The G12 samples for the "Old " and "New" resin bath were tested. There was no significant difference between the G12 values for each set. Due to voids within the double notch shear panel, only 5 samples were obtained for each condition. The 5 samples from the "new" resin bath set fractured during installation into the test fixture. More double notch shear samples have been machined and will be tested early next month.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. Training on CATIA and the new Cincinnati Milacron Acraplace software should be purchased to ensure maximum utilization of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	Low	Basic Effort	Miscellaneous Composite Fabrication
FPM23	High	Liquid Comb Chambers	Chamber Fabrication & Bonding

Approved by:

L. J. Pelham
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
September 1999

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for September 1999. The following paragraphs summarize the significant accomplishments during the work period beginning in August. discusses recommendations for MSFC consideration. and lists the upcoming work to be performed in October 1999.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

NASA/MSFC's Carolyn Griner has signed the required JOFOC for the Fiber Placement Machine (FPM).

We received a contract extension through December 1999. We plan to finalize our proposal for added scope under FPM-23 and submit it to NASA the first week of October. This proposal is significant. Our proposal for four additional units will also be submitted.

2.1 BASIC MACHINE OPERATIONS

No significant events – normal maintenance activities only were accomplished due to the high workload on the Technical Directives.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

The actuator rings, bellybands and exhaust support brackets were bonded on 60K41 and 42. The attachment actuator rings and bellybands were bonded on 60K43 and 44. 60K47, 48, and 49 were overwrapped and cured. 60K50 is awaiting resolution of flange refurbishment issues: it will also use the new resin bath. if it is approved. 60K51, 52, and 53 liners were tape wrapped and cured.

Tape wrapping of 60K54, 55, and 56 is scheduled to begin in October.

TD FPM-09 ADVANCED COMPOSITE ISOGRID STRUCTURE

The machining of the foam mandrel was completed. The mandrel will be coated with RTV silicone rubber and filament wound in October.

TD FPM-31 EIGHT-INCH COMPOSITE DUCTS

Eight-Inch Composite Duct #3 was laid up and cured. The duct consists of all 45°-angle plies. Fabrication of duct #4 will begin in October.

TD FPM-32 COMPOSITE PANELS FOR X-33 GTDP

All panels have been fiber placed and cured. The additional cure schedule has been increased from four extra hours to 18. These additional cures are scheduled to be completed the first week of October.

TD FPM-33 CONFORMAL, COMMON BULKHEAD, AEROGEL-INSULTAED TANK (CBAT)

It was decided to use Macrolite mandrels for this program. The M&P group in Utah will be assisting in mandrel fabrication to transfer the technology to SEHO. The mandrel mold will be fabricated by Smith Pattern and Tooling in Utah.

The 1/5 scale model wound using the polar winder with Newport WDE-3D12K (34700) has been sectioned for thickness evaluation.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software
It is recommended that the tape laying software be ported to the Silicon Graphics machine. Training on CATIA and the new Cincinnati Milacron Acraplace software should be purchased to ensure maximum utilization of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	Low	Basic Effort	Miscellaneous Composite Fabrication
FPM09	Med	Isogrid Structures	Fabricate composite isogrid structure
FPM23	High	Liquid Comb Chambers	Chamber Fabrication & Bonding
FPM31	Med	Composite Ducts	Fabricate composite ducts
FPM32	High	X-33 Panels	Fabricate composite panels and test material properties
FPM33	Med	Composite Conformal Aerogel Insulated Tank	Fabricate components

Approved by:

John E. Krawiec
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
October 1999

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for October 1999. The following paragraphs summarize the significant accomplishments during the work period beginning in September. discusses recommendations for MSFC consideration. and lists the upcoming work to be performed in November 1999.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

Fiber Placement Contract – Our revised proposals separating work that can be completed by 12/30/99 and work to be completed beyond 12/30/99 were submitted to the contracting officer. Discussions were held with the contracting officers concerning receiving proper contract authorization to do work. NASA and Thiokol are working to clean up the current contract as soon a possible. The follow-on contract will be performance based. Thiokol was requested to provide recommendations as to how this type of contract can be structured for the type of Technology Programs we are involved with.

2.1 BASIC MACHINE OPERATIONS

No significant events – normal maintenance activities only were accomplished due to the high workload on the Technical Directives.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

The overwrap for 60K50 was completed. 60K50 was the first chamber/nozzle to use a refurbished forward attach flange. It is also the first chamber/nozzle to employ the "new" resin bath. 60K Liners 54 and 55 are completed through the first machining. Bonding of the actuator attachment ring and bellyband have been completed for 60K48. Shear bolts were bonded to 60K41 and 42. The Organizational Work Instruction (OWI) for fabrication of the Lytex drain line and valve bracket support pads was released. Lytex drain line pads for 60K41. 42 and 46 were fabricated and bonded. Lytex valve bracket support pads for 60K40 and drain line brackets for 60K48 were fabricated.

Fabrication of a silica/phenolic test panel was initiated to undergo tensile and adhesion testing for the liner.

The last 60K liner is scheduled to be tape wrapped at the beginning of November.

TD FPM-09 ADVANCED COMPOSITE ISOGRID STRUCTURE

Isogrid structure #1 was successfully fabricated.. The 5.75-inch isogrid #2 mandrel was fabricated, machined, and coated with RTV. NASA has initiated the fabrication of the 18-inch foam mandrel.

TD FPM-31 EIGHT-INCH COMPOSITE DUCTS

Eight-Inch Composite Duct #4 was laid up and cured. A 4-ply 24 inch panel was also laid up with IM7/977-6 and autoclave cured with Duct #4. NASA has also requested a 12-inch long, two-inch diameter, 4-ply tube made from IM7/977-6.

TD FPM-32 COMPOSITE PANELS FOR X-33 GTDP

All fabric panels and fiber placed panels and specimens have been completed and delivered. Work was begun on the requested density, void, fiber content, and glass transition temperature testing for the fabric and fiber placed panels.

TD FPM-33 CONFORMAL, COMMON BULKHEAD, AEROGEL-INSULTAED TANK (CBAT)

The mandrel mold design has been completed and sent to Smith Pattern and Tooling for fabrication. The design of the cart, fixture tooling and skirt tooling is continuing.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software – It is recommended that the tape laying software be ported to the Silicon Graphics machine. Training on CATIA and the new Cincinnati Milacron Acraplace software should be purchased to ensure maximum utilization of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

Composite Panels for X-34 – Thiokol has been asked to quote on fabricating 14 composite panels for the X-34 program. That quote was submitted.

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	Low	Basic Effort	Miscellaneous Composite Fabrication
FPM09	Med	Isogrid Structures	Fabricate composite isogrid structure
FPM31	Med	Composite Ducts	Fabricate composite ducts
FPM32	High	X-33 Panels	Fabricate composite panels and test material properties

FPM33	Med	Composite Conformal Aerogel Insulated Tank	Fabricate components
FPM23	High	Liquid Comb Chambers	Chamber Fabrication & Bonding

Approved by:

John E. Krawiec
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
December 1999

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NASA-39749) for December, 1999. The following paragraphs summarize the significant accomplishments during the work period beginning in November, discusses recommendations for MSFC consideration, and lists the upcoming work to be performed in January, 2000.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

Fiber Placement Contract – Modification 45 to the Fiber Placement Contract for $242,000 of incremental funding was signed off. Modification 46 to the contract extended it to January 14, 2000 in order to allow enough time to negotiate and finalize the new contract.

Composite Panels for X-33 GTDP TD FPM-32: Work was completed on the density, void and fiber content and glass transition temperature testing for the fabric and fiber placed panels. The results were turned over to NASA. This completes this task.

2.1 BASIC MACHINE OPERATIONS

No significant events – normal maintenance activities only were accomplished due to the high workload on the Technical Directives.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

CMM measurements were made for determining the thickness of the thermal protection system over the exhaust duct support bracket for 60K35. The bonding operation is on hold until hardware is available.

The overwrap of 60K53 has been completed and cured. Overwrap of 60K54 will begin the second week of January 2000.

60K Silica Liner #56 has been removed from the Tape Wrap Mandrel and returned to 4705 for contour machining.

TD FPM-09 ADVANCED COMPOSITE ISOGRID STRUCTURE

Fabrication of the composite isogrid #2 is complete. Isogrid #2 has .250 in. high isogrids while isogrid #1 has .125 in. high isogrids. The overwrap of isogrid #2 was very successful but the isogrids showed poor compaction in the hoop portions.

Foam billets were received for the 18" isogrid mandrel. We are working on a cutting plan for the foam billets.

TD FPM-31 EIGHT_INCH COMPOSITE DUCTS

Eight-inch composite ducts #6 and #7 have been fabricated and cured. Eight-inch Composite duct #6 has been fabricated from IM7/EX-1522-5HS with +/-45° lay-up and Eight-inch Composite duct #7 was fabricated from IM7/EX-1522-8HS with a +/-45° lay-up.

Machining of the flange holes was initiated. The completion is awaiting the delivery of new diamond coated core drills. Tooling repairs were also started, with completion awaiting the delivery of new bolts and inserts.

TD FPM-32 COMPOSITE PANELS FOR X-33 GTDP

Work was completed on the density, void and fiber content and glass transition temperature testing for the fabric and fiber placed panels. The results were turned over to NASA. This completes this task.

TD FPM-33 CONFORMAL, COMMON BULKHEAD, AEROGEL-INSULTAED TANK (CBAT)

Work is continuing on the first stage of fabricating aerogel-insulated honeycomb test panels for the Conformal, Common Bulkhead, Aerogel-insulated Tank (CBAT) project, TD FPM-33. The processing methodology is currently being modified to attempt to eliminate an issue with bowing seen in previous panels.

MSFC has requested a "drape test" for IM7/8552-5HS. Scrap material was used to determine the conformability of the 5HS fabric on a 36-inch spherical tool.

Drawings for the winding shaft and mandrel mold tapered plug were released and provided to NASA-ED34 for determining cost and schedule for fabrication in the 4705 machine shop. Design of the mandrel shaft, mandrel washout tooling, cart, fixture tooling and skirt tooling is continuing. A preliminary design review was held to determine priority and schedule. The schedule and priority will be updated as fabrication details are finalized.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

Software

It is recommended that the tape laying software be ported to the Silicon Graphics machine. Training on CATIA and the new Cincinnati Milacron Acraplace software should be purchased to ensure maximum utilization of the Fiber Placement Machine's capability.

4.0 UPCOMING WORK

The work to complete this contract follows. It is hoped to complete the contract by January 14, 2000.

FPM-09 - Complete the second 5.75-inch and the 18-inch isogrid structures.

FPM-23 – Complete fabrication of 60K#49, 50, 51, 52, and 53 through overwrap processing. Complete fabrication of 60K#53, 54, 55, and 56 through overwrap and cure. Section four combustion chamber nozzles for post test evaluation and hardware reclamation. Refurbish one bellyband, one TVC ring, and five attach flanges.

FPM-31 – Complete fabrication of three more composite elbow ducts.

FPM-32 –Complete the report

FPM –33 – Complete six panels. Complete the mandrel mold and tooling design.

4.1 FUNDED AND AUTHORIZED

TD	PRIORITY	APPLICATION	WORK ACTIVITY
FPM00	Low	Basic Effort	Miscellaneous Composite Fabrication
FPM09	Med	Isogrid Structures	Fabricatecompositeisogrid structure
FPM31	Med	Composite Ducts	Fabricate composite ducts
FPM32	High	X-33 Panels	Testing complete, complete the report
FPM33	Med	Composite Conformal Aerogel Insulated Tank	Fabricate components
FPM23	High	Liquid Comb Chambers	Chamber Fabrication & Bonding

Approved by:

J. E. Krawiec
Program Manager

OPERATION/MAINTENANCE OF THE FIBER PLACEMENT MACHINE AND OTHER RELATED ADVANCED COMPOSITE EQUIPMENT

MONTHLY TECHNICAL STATUS REPORT
January 2000

1.0 INTRODUCTION

This report summarizes the technical program activities on the Fiber Placement Machine (FPM) Operations and Maintenance Project (Contract No. NAS8-39749) for January 2000. The following paragraphs summarize the significant accomplishments during the work period beginning in December and discuss recommendations for MSFC consideration.

2.0 SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS AND EVENTS

Fiber Placement Contract – The Fiber Placement Contract was extended to January 31, 2000 in order to allow time to negotiate and finalize the new contract. The follow-on Fiber Placement Contract was signed on February 1, 2000.

2.1 BASIC MACHINE OPERATIONS

No significant events – normal maintenance activities only were accomplished due to the high workload on the Technical Directives.

2.2 TECHNICAL DIRECTIVE STATUS

TD FPM-23 LIQUID ENGINE COMBUSTION CHAMBER FABRICATION

Bonding of the exhaust duct support bracket and the belly band was completed on 60K51 and 60K52.

The overwrap of 60K54 has been completed and cured. Overwrap of 60K55 will begin the first week of February 2000.

60K Silica Liner #56 has been returned from contour machining in B4705. Overwrap of it is on hold until a forward flange can be refurbished.

60K09 has been sectioned. The forward flange will be refurbished the first week of February 2000 and used in the overwrap of 60K56. 60K18 has been marked for sectioning.

TD FPM-09 ADVANCED COMPOSITE ISOGRID STRUCTURE

Six 19" diameter foam disks were machined and bonded to form the 19" diameter billet for the 18" foam mandrel. The 18" foam mandrel was machined to shape and the isogrids machined into the surface. The isogrids are 0.25" wide by 0.25" deep and spaced approximately 3" apart. However, due to the necessity to work on higher priority

tasks. the 18" component could not be fabricated. This work will have to be tasked under the new contract for completion.

TD FPM-31 EIGHT_INCH COMPOSITE DUCTS

The IM7/EX-1522-8HS material was cut on the Gerber knife in preparation for manufacturing the next duct. Fabrication is expected to commence in early February.

Machining of the flange holes for the first seven ducts is complete. The tooling was reworked after resin flowed through the joints in the tooling and into the inserts. This effort was completed late in the month on one tool and it will be used in early February to restart fabrication of the ducts.

TD FPM-32 COMPOSITE PANELS FOR X-33 GTDP

Complete.

TD FPM-33 CONFORMAL, COMMON BULKHEAD, AEROGEL-INSULTAED TANK (CBAT)

The processing methodology for the test panels has been modified. NASA/MSFC will now send NASA/ARC the honeycomb without either face sheet bonded for the aerogel processing. The face sheets will be bonded after the insulated honeycomb is returned to NASA/MSFC. The warping effect was caused by a difference of CTE's of the components: cool down after cure residual stress caused the panels to warp.

The face sheets for the panels were fabricated the week of January 10 and machined the week of January 17. The honeycomb was sent to NASA/ARC the week of January 17 for the incorporation of the Aerogel.

The "drape test" for IM7/8552-5HS requested by MSFC was completed. It verified their model.

Design of the mandrel shaft and mandrel washout tooling has been completed. The design of the cart, fixture tooling and skirt tooling is continuing. Information for the Macrolite™ material was received from Thiokol S&E in Utah. A technical interchange is scheduled with them on February 17 to facilitate exchange of that technology.

3.0 RECOMMENDATIONS/GENERAL ACTIVITIES

None: contract NAS8-39749 has been completed.

4.0 UPCOMING WORK

None: contract NAS8-39749 has been completed.

4.1 FUNDED AND AUTHORIZED

None: contract NAS8-39749 has been completed.

Approved by:

J. W. Dillard

T. W. Dillard
Program Manager