GLAST Heat Pipe Center

Manufacturing Readiness Review

December 16, 2003

Outline

- MRR Objective
- Engineering
- Producibility/Processes
- Tooling
- Facilities
- Risk Mitigation
- Schedules
- Cost
- Material
- Personnel
- Supporting Organizations
- Actions/Issues

MRR Objective

Establish Product Center readiness to manufacture GLAST Variable Conductance Heat Pipes (VCHPs)

This covers requirements different from the GLAST Constant Conductance Heat Pipe (CCHP) MRR conducted on 7-28-03

On selected charts, items in red are additions to the items covered in the earlier CCHP MRR

MRR Checklist

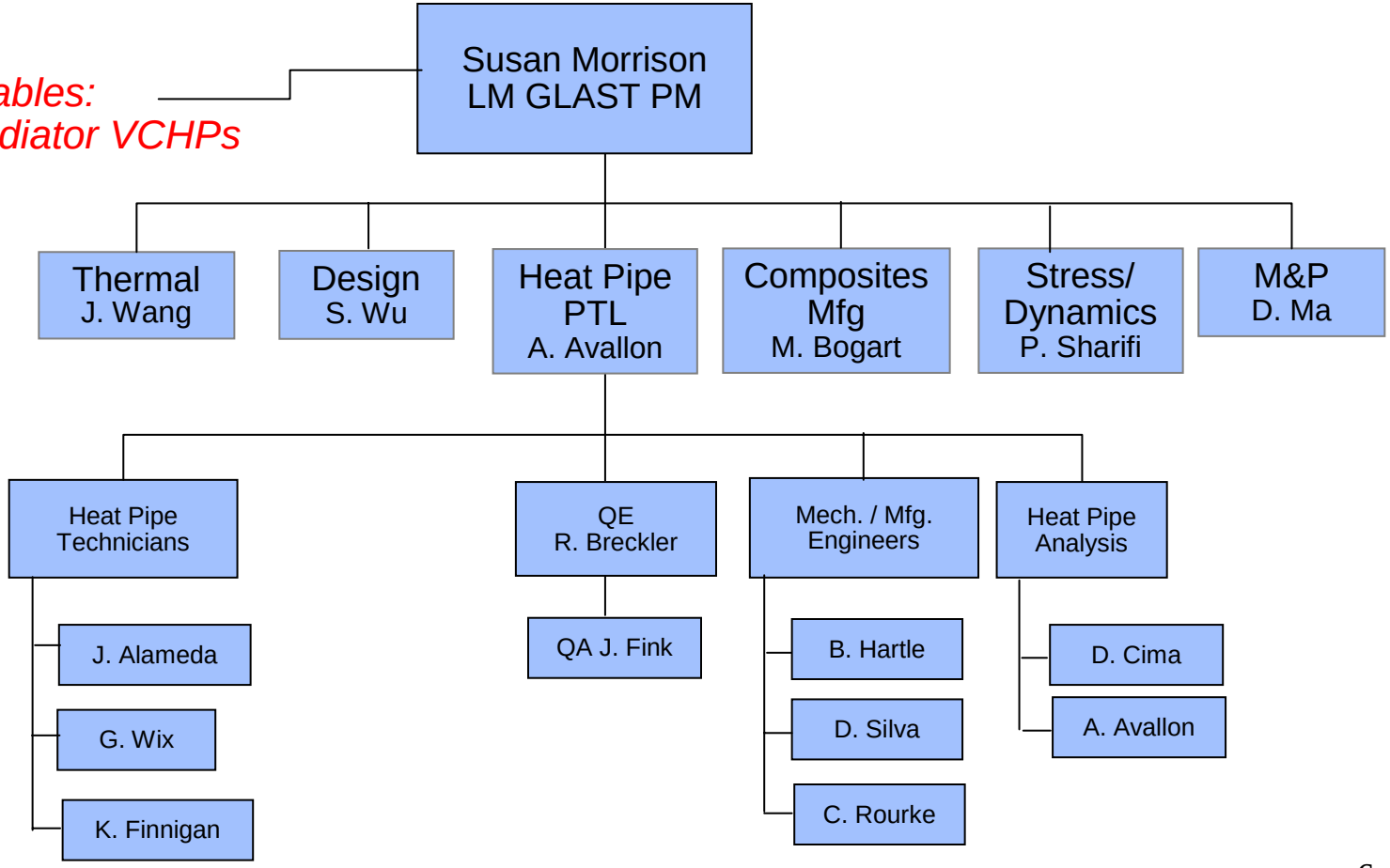
	Requirement	Covered	Notes
Overview			
1	IPT Structure	X	TPC Command Media
2	Hardware Drawings	X	TPC Command Media
3	SOW	X	TPC Command Media
4	Program Schedule	X	TPC Command Media
5	Cost Quote	X	TPC Command Media
6	Reporting Metrics	X	TPC Command Media
Engineering			
1	Drawings Reviewed by Engineering	X	
2	Mfg/Producibility Problems Resolved	X	
3	Specifications Reviewed	X	
4	Drawing Release Status/Required Plans	X	
5	Program Specific Guidelines/ Documentation Reviewed/Understood	X	
6	Test Plans/Procedures Approved	X	
7	Test Equipment in Place	X	
Producibility/Processes			
1	Drawings Reviewed for Producibility	X	
2	Mfg Processes Validated	X	
3	Process Flow Charts Updated	X	
4	MPS's & PIB's Complete	X	
5	Repair Standards Approved	X	
6	Acceptance/Workmanship Standards Identified/Reviewed	X	TPC Command Media
7	Quality Plan Approved	X	TPC Command Media
Planning			
1	MWI's Approved	X	
2	Unique Quality System & Traceability Req'ts Understood/Implemented	X	
3	MWI's Validated against MPS/PIB/Docs by Mfg Personnel	X	
4	Outside Manufacturing Commitments in Place	X	
Tooling			
1	Project Tooling Proofed & Tool List in Place	X	Tooling in review
2	Mfg Aids Proofed	X	Tooling in review
3	Special Standard Tools Identified/Available	X	Tooling in review
4	Shipping Containers & Packaging Ready	X	Tooling in review

MRR Checklist (cont'd)

	Requirement	Covered	Notes
Facilities			
1	Dedicated Facilities Ready	X	
Risk Mitigation			
1	FMEA Plan in Place	X	PIB Function
2	Action Plan	X	TPC Command Media
Schedules			
1	Detailed Fab Schedules (1-8-5) in Place & Achievable	X	
2	Schedule Commitments by Supporting Activities	X	
3	Schedule Tracking Plan in Place	X	
4	Schedule Assumptions Reviewed, Re-Assessed, Documented	X	
5	Shop Loading Plan Developed & Coordinated with Shops	X	
Cost			
1	Cost Assumptions Reviewed, Re-Assessed, Documented	X	TPC Command Media
2	Cost Commitments Understood by Team Members	X	
3	Cost Tracking Method/Responsible Person in Place	X	TPC Command Media
Material			
1	Supplier Plans/Schedules Integrated	X	
2	Raw Material Available or Scheduled	X	
3	Purchased Parts Identified & Scheduled	X	
4	MSPs Identified & Scheduled	X	
5	Customer or Engineering Furnished HW/Tools Commitments Documented	X	
6	"As Required" Materials Identified & In Place	X	
7	Material Shortages Identified and Plan in Place	X	
Personnel			
1	Required Manpower Available	X	
2	Training Complete or Planned	X	
Supporting Organizations			
1	EHS Review Complete	X	Part of City Inspection/Buyoff
2	Supporting Organization Schedule/Cost Commitments in Place	X	Part of quotes

Thermal Center / GLAST IPT Organization

Deliverables:
(14) Radiator VCHPs



Design Drawing Status

DRAWING #'s		QTY.	PART NAME	REL. STATUS
2A15703			Top Flange	Released
2A15704			X-LAT	Released
2A15705			Down Spout	Released
8558549			End Cap and Fill Tube	Released
Spec #'s				
2A15699			Top Flange	Released
2A15700			X-LAT	Released
2A15701			Down Spout	Released
ATP's				
2A15707			Top Flange	Released
2A15708			X-LAT	Released
2A15709			Down Spout	Released
Shop Orders				
N83716		5	Top Flange	Complete
N83717		10	X-LAT	Complete
N83718		7	Downspout -501	Complete
N83719		7	Downspout -502	Complete
N83720		18	Fill Tubes	Complete
N83721		30	Fill Tubes	Complete
N83722		18	End Caps	Complete
N83723		12	End Caps	Complete

Drawing Release Status/Required Plans

DRAWING #'s	TITLE	REL. STATUS
2A15706	GLAST Radiator VCHP Assembly	Released, Revision N/C
2A15722	GLAST Reservoir Assembly 75cc	Released, Revision A
2A15723	GLAST Reservoir Wick Assembly	Released, Revision N/C
SPECIFICATIONS		
2A15702	GLAST LAT Radiator Variable Conductance Heat Pipes	Released, Revision N/C
TEST PROCEDURES		
2A15710	GLAST Radiator Variable Conductance Heat Pipes	Approved, Revision N/C
SHOP ORDERS		
N83877	VCHP, 2A15706-503	Completed
N83878	VCHP, 2A15706-505	Completed
N83879	Reservoir Wick, 2A15723	Completed
N83776	Reservoir Assy, 2A15722	Completed

VCHP Costs – Estimated Labor Hours

	VCHP Fabrication and Test
Non-Recurring	732
Recurring	1422
Total	2154

Drawings Reviewed by Engineering and Producibility

•Per TPC-3000 Heat Pipe Products Design Implementation and Control, Integrated Product Team shall conduct a design review for each design at the completion of detailed design development

•Program-led Integrated Product team includes representatives from thermal, structures and materials engineering; Product Center provides design, manufacturing and producibility expertise

•Program and Product Center have reviewed all released drawings, assembly and piece-part level

VCHP Relevant Specifications Reviewed

Processes

- LAC 3158 Heat Pipe Cleaning
- LAC 3575 Marking Methods
- LAC 3601 Machining
- LAC 3865 Orbital Arc Welding of CRES and Titanium Alloys
- AMS 2770 Heat Treatment of Aluminum Alloys
- MIL-C-5541 Surface Treatment

VCHP Relevant Specifications Reviewed

Purchasing

- EPS 04-024 Aluminum 6063 Extruded Heat Pipe Casings
- EPS 06-025 Aluminum 6061 Extruded Bar
- EPS 31-722 Ammonia
- ASTM A269 Seamless and Welded Austenitic Stainless Steel Tubing for General Service
- QQ-S-763 Steel Bars, Wire, Shapes and Forgings, Corrosion Resistant
- AMS-5518 Steel Sheet, Corrosion Resistant

Test Equipment in Place

- All required test equipment is in place, calibrated and/or certified:
  - Proof Pressure/Burst Test Cell
    - Pressure Gauge (MSL101561) Cal. Due 12/14/03
    - Pressure Gauge (MSL185166) Cal. Due 12/14/03
  - Heat Treat Oven (M096702) Cal. Due 11/23/03
  - NCG Test Station-Omega (C027888) Cal. Due 3/14/04
  - Performance Test Stands
    - Fluke (M238550) Cal. Due 7/31/03
    - Labview (M262093) Cal. Due 11/9/03
  - Surface Tables – No Cal. Required
  - Leak Tester (M261424) Cal. Due 11/2/03
  - Digital Thermometer (MSL 08651700) Cal. Due 11/19/06
  - Scale (S503653) Cal. Due 5/20/05
  - Gruenburg Oven (M095979) Cal. Due 11/23/03

Manufacturing Processes Validated

Process	Where Performed	Equipment	Process Proofed	Certified Process
Machine Reservoir	Machine Shop	Lathe	X	
Weld Reservoir	Outside Vendor	Vendor Equipment	X	MIL 1252
Preclean Parts	B195B Cleaning Facility	Flush Box	X	LAC 3158
Wick Installation	TPC	NA		NA
Orbital Arc Weld	TPC	Arc Machines Welder	X	LAC 3865 - Pending

Process Instruction Bulletins (PIBs) Complete

PIB No.	PIB Title	Rev.	Status
575	Reservoir Wick Height Test	A	Approved
626	Variable Conductance Heat Pipe Charging	-	Approved
648	Orbital Arc Welding using AMI Welder	N/C	In Work

Rework Standards in Place

- Standard leak rework procedure used on all programs for transition/fill tube/reservoir welds
- Standard leak rework procedure used on all programs for fill tube pinch off
- Called out directly on heat pipe drawings

Acceptance/Workmanship Standards Identified/Reviewed

- TPC-5000 Heat Pipe Manufacturing, Test & Process Control Operating Procedure, defines minimum requirements for product qualification, acceptance and Operator Verification Instructions
- Quality engineer and PTL jointly define QA inspect points in process flow

Quality Plan Approved

- PTL must ensure that product complies with LM Product Delivery System Manual
- Product Center Quality Engineer reviews program quality plan and ensures compliance
- TPC-2000 Program Planning Operating Procedure specifies additional Quality plan requirements and Product Center specific requirements

Tooling Summary

•All GLAST CCHPs use previously-developed tooling (except for bend tooling).

•Minimal re-work required to accommodate design changes

Tool Number	Tool Name	Status
ISBA158-301-01-32F	Weld Fixture(SA7-140)	in-house
SA7-140-01-99U	Valve Support Fixture	in-house
SA7-152-01-31F	Bend Tool(Rad.1.64")	built and checked
SA7-140-152-01-31F	Bend Tool(Rad.1.25")	built and checked
RH100	Pinch	in-house
	Weld Alignment Tool	in-design

Mfg Process Risk Mitigation

Process	Potential Failure Mode	Potential Effect(s) of Failure	Recommended Action
Machining of Parts	Parts out of tolerance	Product doesn't meet spec.	**Manufacturing spares available**
Welding	Helium Leak	Product doesn't meet spec.	**One weld rework available, mfg spares (NO re-work available for Top Flange)**
NCG Test	Excessive NCG	Product doesn't meet spec.	**Contingency re-charge**
Functional Test	Low transport	Product doesn't meet spec.	**Contingency re-charge**
Ammonia Leak Test	Ammonia Leak	Product doesn't meet spec.	**One pinch rework available**
Bending	Parts out of tolerance	spec.	**Manufacturing spares available**

Material

commercial	Ammonia gas	1	Airgas	In House
commercial	Helium gas	1	Airgas	In House
commercial	Neon gas	2	Airgas	In House
SA7-152	6063-T6 per AMS 4156 extrusion (qty. in lengths of 10 feet)	14	TDA	In House
AMS-5518	301 CRES 1/2 Hard , 0.016" THK (qty. in sheets)	1		In House
AMS-A269	321 CRES Seamless Tube 9/16 O.D., 0.109 Wall (qty. in feet)	10		In House
06-025-0400860	6061-T6511F 4.0" Diam. Bar per AMS-QQ-A-200/8 (qty. in feet)	10		In House
06-025-0300860	6061-T6511F 3.0" Diam. Bar per AMS-QQ-A-200/8 (qty. in feet)	10		In House
06-025-6282564	6061-T6511 0.6282 square bar(qty. in inches)	180	Lusk Metals	In House

Personnel

- Three full-time heat pipe technicians trained in all aspects of heat pipe manufacturing
- Two full-time engineers trained in design, analysis and manufacturing
- One Q/A trained in all aspects of heat pipe manufacturing

Personnel Training

Process	Training Completed	Certified
Weld	Wix, Alameda, Finnigan	Wix,Alameda, Finnigan
Leak Test	Wix, Alameda, Finnigan	N/A
Pinch	Wix, Alameda, Finnigan	Wix, Alameda
Tri-Tool	Wix, Finnigan	N/A
Proof Pressure Bench	Wix, Alameda, Finnigan	N/A
Charging Station	Wix, Alameda, Finnigan	N/A
Heat Treat	Wix, Alameda, Finnigan	N/A
Gruenberg Oven	Wix, Alameda, Finnigan	N/A
NCG Testing	Wix, Alameda, Finnigan	N/A
Functional Testing	Wix, Alameda, Finnigan	N/A

End Item Data Package

- Required by the SOW:
  - Heat Pipe as built drawing package
  - Copy of shop orders used for Heat Pipe fabrication
  - Copies of all Heat Pipe discrepancy reports
  - Test reports for Heat Pipe environmental or performance tests
- Required by LMSSC Command Media “Hardware Certification”:
  - Signed product certificate for Heat Pipes
  - As-designed vs. as-built comparison for Heat Pipes

Actions/Issues

Issue #2 – VCHP Control Gas

- LM produces VCHPs with either nitrogen or mixed gas as the control gas
- All heat pipes are verified to meet a minimum helium leakage rate of 10^{-8} scc/s
- For VCHPs subjected to system-level tests (i.e. GLAST), LM typically uses a control gas mixture containing helium to eliminate natural convection effects in ground test
- Natural convection cells have been shown by LM to substantially increase heat leak from reservoir to pipe during cold-blocked testing, resulting in increased heater power requirement
- GLAST LAT has ACD subsystem which is sensitive to minute quantities of helium
- Nitrogen control gas can be used, but with the impact of reduced validity of subsequent Thermal Control Subsystem (TCS) verification tests
- TCS performance would normally be adequately verified in an engineering/qualification phase, reducing program technical risk (as strongly recommended by LM Thermal Products for GLAST Program)
- GLAST uses protoflight verification strategy-